

# Petroleum activities, wetland utilization and livelihood changes in Southern Akwa Ibom State, Nigeria: 2003-2015

**Koffi Unwana Saturday**

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2015

Department of Physical Geography and Ecosystem Science

Lund University

Sölvegatan 12

S-223 62 Lund

Sweden



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FACULTY OF GEO-INFORMATION SCIENCE AND EARTH OBSERVATION



# Petroleum activities, wetland utilization and livelihood changes in Southern Akwa Ibom State, Nigeria: 2003-2015

by

Koffi Unwana Saturday

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Thesis submitted to the department of Physical Geography and Ecosystem Science, Lund University, in partial fulfilment of the requirements for the degree of Master of Science in Geo-information Science and Earth Observation for Environmental Modelling and Management

Thesis assessment Board

First Supervisor: *Associate Professor, Jonathan Seaquist* (Lund University)

Co-supervisors: *Professor, Petter Pilesjö* (Lund University)

Exam committee:

Examiner 1: Professor, David Tenenbaum,

Examiner 2: Abdulghani Hasan

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## Abstract

The state of Akwa Ibom, Nigeria is known as one of the wetlands rich in biodiversity as well as oil and gas reserves. Its wetland ecosystem is noted for its primary support it has provided for the people living in this area. However, this wetland has also been a reservoir for Nigeria's crude oil contributing a prominent share of petroleum product to the country's GDP, total revenue to the government through exports and other fiscal surpluses, making it Africa's largest economy. But back home where the resources is harnessed to achieved and attained the height of this economic successes the situation is a direct contrast, petroleum activities is mostly synonymous to environmental pollution, degradation, conflicts and crises. Wetland is not left out of these adverse effects. Therefore this study was based on the impact of petroleum activities and its effects on wetland, agricultural practices within the wetland, people's livelihood as well as strategies for sustainable management of wetland in the study area. GIS and Remote Sensing was used, by adding ancillary data from ground truth points and other reference sources to the thematic LULC satellite images of the study area. Erdas Imagine and ArcMap were used in processing, monitoring and mapping the wetland changes caused by petroleum activities and the consequent effects of these actions by assessing the pattern of distribution of the affected wetland, taking into consideration the baseline data such as vegetation types, densities, phenology, as well as land use cover types. Livelihood changes were measured by conducting interviews to different stakeholders in the course of this research. The result showed that there has been a significant change in the wetland area of Southern Akwa Ibom State though more than 68% of the wetland mapped had not changed. While wetland was increasing in some areas others experienced a decrease. Livelihood changes in the area shows that petroleum activities have benefited the people in areas of employments both directly and indirectly although they are still expecting an improvement in areas such as provision of farm inputs, health and housing facilities from the Multinational Oil Companies. It was observed that management of the wetland was majorly based on traditional methods of total and periodic restrictions to some community preserved areas as well as periodic fallowing. The traditional management strategies of seasonal restrictions and buffers is not sustainable enough to protect and preserved the wetlands from complete degradation and as such measures should be taken to sensitize all stakeholders in the study area to adhere to the government laid down laws and regulations in order to protect, preserve and ensure a sustainable wetland for future generations.

**KEYWORDS:** Wetland degradation, Nigeria, Petroleum, Remote Sensing, Land Cover Change, Wetland agriculture, Sustainable management, Livelihood changes



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## Acronyms and Abbreviations

CRBDA-	Cross River Basin Development Authority.
CSR-	Corporate Social Responsibilities
ETM-	Enhanced Thematic Mapper Plus
FAO-	Food and Agricultural Organization
GIS-	Geographic Information System
GPS-	Global Position System
IFAD-	International Fund for Agricultural Development
IGBP DIScover-	International Geosphere Biosphere Program Data and Information System
LCCS-	Land Cover Classification System
LGA-	Local Government Area
LUCC-	Land Use Cover Classification
MOCs-	Multinational Oil Companies
NESREA-	National Environmental Standards & Regulations Enforcement Agency
NIMET	Nigerian Meteorological Agency
OLI-	Operational Land Imager
PAH -	Polycyclic Aromatic Hydrocarbon
PRA-	Participatory Rural Appraisal
RS-	Remote Sensing
SL-	Sustainable Livelihood
TIRS-	Thermal Infrared Sensor
UNEP-	United Nations Environmental Programme
UNIUYO-	University of Uyo
USGS-	United State Geological Survey
UTM+-	Universal Transverse Mercator



## CHAPTER ONE

### 1 INTRODUCTION

According to (Best et al., 1993) wetland covers about 6% of the total surface of the Earth and is found on every latitude. The Millennium Ecosystem Assessment (MEA) (Duraiappah and Naeem, 2005) examined the importance and value of ecosystem services provided by wetlands to the livelihood and wellbeing of the inhabitants, but despite these valued services, wetlands were amongst the endangered ecosystem globally from the perspective of agriculture and water management (Falkenmark et al., 2007).

The state of Akwa Ibom, Nigeria is known as one of the wetlands rich in biodiversity as well as oil and gas reserves. Its wetland ecosystem is noted for its primary support it has provided for the people living in this area. However, this wetland has also been a reservoir for Nigeria's crude oil contributing a prominent share of petroleum product to the country's GDP, total revenue to the government through exports and other fiscal surpluses (Omotor, 2009), making it Africa's largest economy (Kende et al., 2014). But back home where the resources is harnessed to achieved and attained the height of this economic successes the situation is a direct contrast, petroleum activities is mostly synonymous to environmental pollution, degradation, conflicts and crises. Wetland is not left out of these adverse effects. Activities supported by wetland such as agricultural practices which forms the main means of livelihood within the local communities are on the decline, thus triggering a decreasing multiplier effects to the alternative livelihood opportunities at the local level.

According to Adekola and Mitchell (2011), "The wetlands' ecosystem services are being eroded through oil and gas exploration, dredging, invasive plant infestation and wetland reclamation." This is intensified by rising demand for oil, population growth and weak governance. Mass fish migration, water pollution and reduction of wetland area are also evident, impacting ecosystem services and traditional livelihood system

The Nigerian government, realizing the environmental problems associated with these activities in the Niger Delta wetland, set up Ministries and Commissions to partner with other stake holders such as (oil multi-nationals, research institutions, resident communities, etc.) to looks into the conservation, management and development of this wetland region.

This thesis will use a remote sensing based approach to mapping and monitoring Land Use Land Cover Change (LULCC) to describe the environmental changes caused by petroleum

activities and the consequent effects of these actions on wetland of the Akwa Ibom State by identifying the driving forces, assessing the pattern of distribution of the affected wetland, by taking into consideration the baseline data such as vegetation types, densities, phenology as well as land use cover types.

The choice of a remote sensing methodology for mapping the effects of oil activities on the study area wetland was due to the proven technology behind remote sensing in land cover mapping and change detection especially on anthropogenic interactions with natural resources (Berntsen et al., 2004). The technology allows measurements and observations of spatial characteristics and has ability to track occurring changes at any place on the biophysical space at any given time at which imagery is available. It also allows simulation of observed changes in the biophysical characteristics (Crowl et al., 2008). Teferi et al., (2010) conducted a similar study on the quantification of wetland dynamics and loss around the Choke Ranges near the river Nile using RS from a period of 1986 to 2005. The study obtained Landsat images of the years in consideration and used GIS and RS software such as ArcMap and ERDAS IMAGINE to process those images to acquire a land cover change of the wetland area under consideration. Given the accuracy level of over 90% for both images and Kappa Coefficient of 0.908 and 0.913, the study concludes that the use of RS in the research reduces cost and enhances accuracy compared to ground based survey techniques even with the study's limitations. This is the rationale for making remote sensing a key part of this study.

In addition, there was also a need for the design of a geo-spatial data infrastructure (GDI) in the study area. Woldai and Schetselaar (2002) emphasized the need to facilitate and promote the sharing of data through the use of the concept. They further stressed that "if designed and implemented properly, GDI can provide a much better information ground on which the regional development plans and subsequent effective decisions can be based on."

Therefore this study addressed the impact of petroleum activities and its effects on wetland, agricultural practices within the wetland, people's livelihood as well as strategies for sustainable management of wetland in the study area. This perceived environmental impact was then summarized into the main and the specific objectives of Study.

#### Main Objective

To assess the extent of wetland utilization and livelihood changes as a result of petroleum activities in the study area.



## Specific Objectives

- (i) to understand the characteristic changes brought about by the impact of petroleum activities on wetlands and agricultural practice within the wetland over the last decade between 2003-2015
- (ii) to assess also the impact of petroleum activities on livelihood opportunities
- (iii) to assess the current wetland agricultural management practices in the study area.

### **1.1 SIGNIFICANCE OF THE STUDY**

Despite the significance of wetland in the oil and gas production within the study area, the region is still lacking sustainable environmental management of the available wetlands since the discovery of oil. The level of understanding of the value of wetlands and their importance to different stakeholders has also influenced their attitude towards its sustainability within the region. Without adequate awareness of the relationship between wetlands and livelihoods of the different stake holders and political will power on the part of government, development initiatives that aim at tackling the challenges of wetland degradation faced by communities, may not be sustainable or successful.

Wetlands degradation in Southern Akwa Ibom State is an ongoing problem that calls for concern. Crude oil [petroleum hydrocarbon] spills, gas leaks and flare, blowouts, canalization and the discharge of wastes and effluent from oil and gas operations directly into surface water bodies and the land surfaces has also contributed to its degradation (Akpoborie and Akporhonor 2008).

Studies show that only a small amount of oil profit in the study area is channeled into the local communities (Akpoborie and Akporhonor 2008). The region is characterized by the lack of availability of the basic living requirements such as access to clean water, standard health facilities, quality and affordable education, amongst others. Therefore some of these issues need urgent attention in order to achieve any sustainable development initiatives by way of improving the livelihood of the local people as well as preserved and restored the degraded wetlands and their ecosystem services.

In view of the above, the study provide ways to assess the extent of changes on its wetland area due to petroleum and other activities within the period of consideration through the application of remote sensing based LULCC characterization techniques, while seeking to promote

agricultural activities, better livelihood changes as well as sensitizing all stakeholders on the need to adopt a more sustainable management strategies. This is very vital as it looks in-depth into the stakeholders' interest in the way the wetland ecosystem is being harnessed and managed. This can form the basis to review the memorandum of understanding (MoU) or at best implement it maximally given the level of interaction that the oil multinationals have impacted on the wetland areas.

## **1.2. PROBLEM STATEMENT**

### *1.2.1 Pollution of Wetland Areas as a result of Oil Production activities*

Accidental discharge of petroleum hydrocarbon during operation into the environment has been an occurring incidence since the discovery and operationalization of oil activities in Akwa Ibom State. According to (Ite et al., 2013), incidence of oil spills associated with petroleum activities has been a common occurrence in the oil rich Niger Delta region of Nigeria and it has been an affliction to the host local communities since 1956

Studies carried out by Edoho (2008) estimate that the entire Niger Delta region have recorded over 2,567,966 barrels of crude oil spills in over 5733 incidents from 1976-2000, of which about 549,060 barrels were recovered while 1,820,411 barrels has been absorbed by the environment.

Even at that, there are cases of oil spills that have not been reported as a result of the classification scheme of the Nigerian National Petroleum Corporation Inspectorate Guidelines. This guideline groups oil spillage into minor, medium, major and disaster classes (Ite et al., 2013).

Accidental discharges of petroleum products which results in the pollution of the environment in the Niger Delta area of Nigeria are often caused by failure in the equipment in use, due to the age of the equipment, leakage from the aged corroded pipelines and flow stations, leakage from operational disasters as well as vandalism of oil equipment and facilities (Nwilo and Badejo, 2006). Thus the present cause of environmental pollution of the wetland areas of Akwa Ibom State is attributed to laxities on the part of the oil multinational in their handling of the production, transportation and distribution activities as well as sabotage by criminal agents who engage in unholy acts like bunkering, illegal refining of crude oil and oil theft operations. This has a debilitating effect on the land, wetland/aquatic environment, freshwater and human health. According to Osuji et al. (2007), when there is an incidence of oil spills onshore or near

onshore, the soil and the rest of the terrestrial ecosystem components in the spill environment are inevitably affected.

The freshwater environment is also contaminated by polycyclic aromatic hydrocarbon (PAHs) which are discharged to the environment during the spills, causing low water solubility (Coker and Arbabi, 2011). Ebeku (2002), in his study, finds out that the oil multinationals have created burrow pits in the study area where the petroleum hydrocarbons and other contaminated waste are discharged which overflow into the environment sources of usable water during rainfall seasons polluting them. This results not only in the pollution of marine environment but also the groundwater aquifers (Ayotamunua et al., 2006).

### *1.2.2. Loss of Farmlands and Biodiversity*

The terrestrial ecosystems of the oil producing communities of Akwa Ibom State are areas of significant agricultural practices, with the local farmers continually cultivating the land for economic support. Spillage of crude oil with its adverse impact on agricultural land has been recorded since 1971 after a few researchers carried out a study in the larger Niger Delta region (Odu, 1978). It is on record that crude oil spillage on agricultural wetland will impact adversely by adding more of toxicity to it which will cause low performance in the germination and growth of agricultural crops which gives rise to poor yield during harvest (Oyedeji et al., 2012). Osuji et al. (2007), in his view, states that a far reaching implication is always associated with crude oil spillage on agricultural land with its multiplier effects on the living wellbeing of the local people.

Other petroleum activity in the wetland of the study area that has impacted negatively on poor agricultural yield in the area is gas flaring. Dung et al. (2008) investigated the spatial variability effects of gas flaring on the growth and development of some farm crops indigenous to the study area. These crops included cassava (*Manihotesculenta*), waterleaf (*Talinumtriangulare*), and pepper (*Piper spp.*). The result shows that a spatial gradient exists in the effects of gas flares on crop development (Dung et al., 2008).

### *1.2.3. Loss of Major Source of Livelihood for Residents*

Before the discovery of oil in the Niger Delta area, the traditional occupations of the vast majority of the inhabitants were farming and fishing, but the trend had shifted over the years majorly as a result of loss of biodiversity and ecological devastation that is associated with the activities of petroleum activities by oil multinationals in the area (Ndidi et al., 2015). In Akwa Ibom State, the contamination of the wetlands and marine environments by oil activities has

reduced the productivity of the major sources of livelihood of the local people which are farming and fishing. This leads to loss of income as a result of low yield (Ifunanya 2010; Kadafa 2012).

### **1.3. LIMITATIONS OF STUDY**

During the study, some limitations were encountered and these included the high cost of acquiring high-resolution images of the study area. This led to the acquisition of free low resolution images from Landsat. Also, some of the areas were inaccessible during ground truth field work, due to the muddy sinking nature of the terrain. Moreover, the 2002 Map from CRBDA has no information on image accuracy and lastly, the time for fieldwork was insufficient.

### **1.4. RESEARCH DESIGN**

In this research, both qualitative and quantitative data was used to describe the extent of wetland utilization and livelihood changes as a result of petroleum activities in Southern Akwa Ibom State. These led to the understanding of the characteristic changes brought about by the impact of petroleum oil activities on wetlands over the last decade from 2003-2015. Livelihood opportunities, as well as the current wetland management practices, were also assessed.

The whole design of this research is shown in Figure 1, which illustrates the steps followed in this research. Before embarking on fieldwork, there was an identification of problem, from background studies and justification, this gives rise to research objectives and questions. Fieldwork preparation followed with selection of study area, preparation of likely questions for interviews, identification of data and data collection methods. Communications with supervisors was by email. During fieldwork, both primary and secondary data was collected, and during this phase literature was also reviewed. The last part is the post fieldwork phase, when the research analysis and findings led to results and discussion, from which conclusions and recommendations was derived, and finally the thesis was compiled and written.

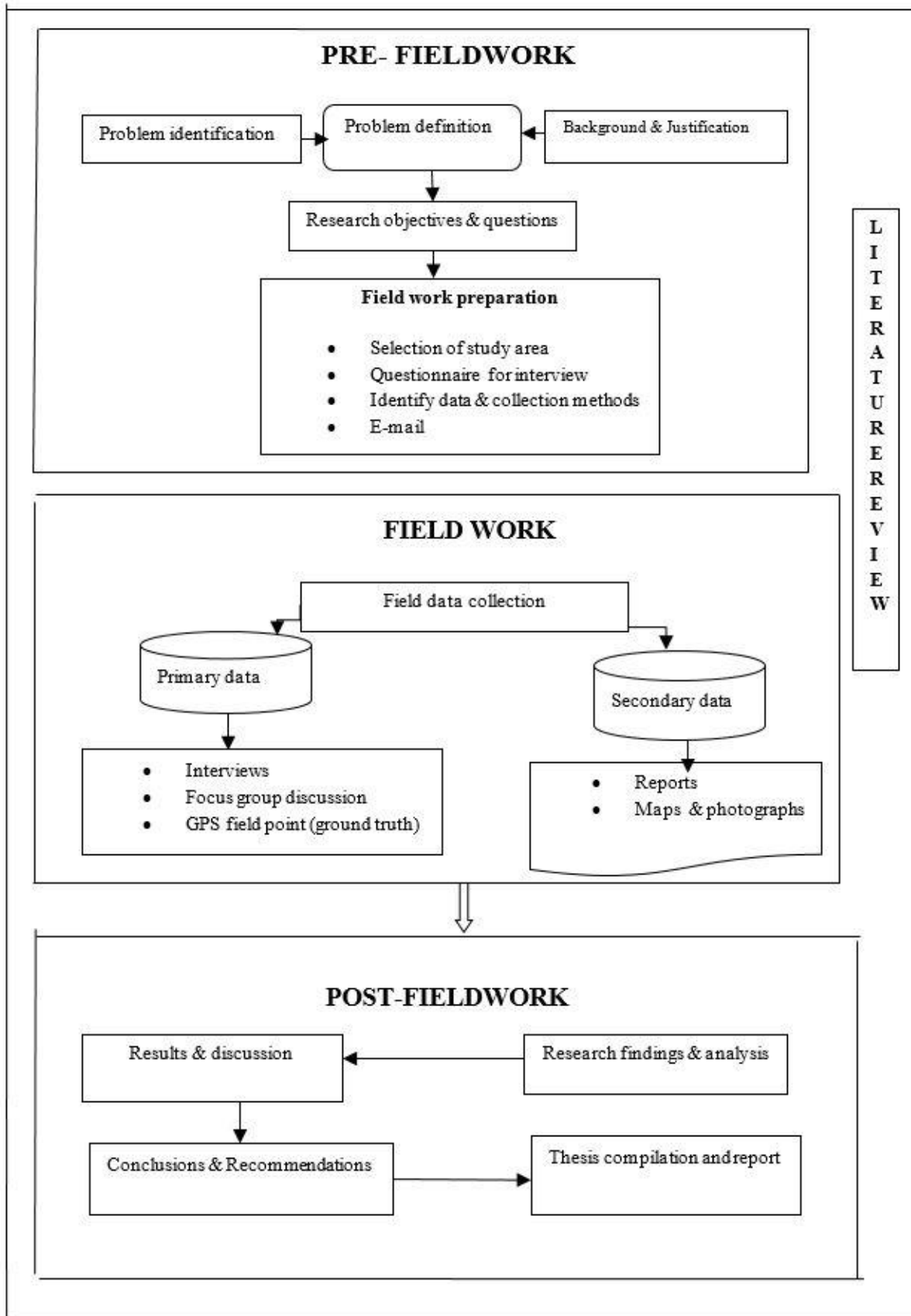


Figure 1: Research Design showing pre-fieldwork, fieldwork and post-fieldwork.

## 1.5. REVIEW OF LITERATURE

### 1.5.1 *Petroleum Activities*

The importance of petroleum in the affairs of man took a different dimension in the late 1800s when it replaced coal which was the most common and primary source of energy for industries and transportation (Fagan, 1991). In Nigeria, petroleum was discovered in 1956 after 50 years of exploration. The major reservoir of Nigeria's petroleum is the Niger Delta region which is located at the southern part of the country and extends to the offshore part of her geographical boundary (Saidu et al., 2014)

Nigeria is one of the world's prominent petroleum producers with over 6000 oil wells that produces about 2.5 million barrels of crude oil daily and also has about 187 trillion cubic feet of gas (cfg) as reserve, making this the largest natural gas reserve in Africa (Adeyemo, 2008).

Nigeria's economy is largely dependent on oil and gas, to the tune of over 90% of her total revenue, and a number of studies have shown the positive impact of the industry on Nigeria's economy, yet the negative impact seems to fall up on the people of the Niger Delta region (Akpabio et al., 2010; Akpan 2010).

The people of the region depends more on the environment for their livelihood, mostly in areas of farming, fishing and other small-scale commerce. These activities are highly threatened by the exploitation as more of the wetland and other land cover such as forest have been altered through deforestation due to petroleum infrastructure installations as well as pipeline routes with buffered zones has greatly deprived the host communities access to their productive land in the Niger Delta (Wunder, 2003).

Spillage is perhaps the worst environmental effect of the industry to the host communities. Most of the spillage has not been accounted for; according to (Kadafa, 2012) over 1.5 million tons of crude oil has been spilled so far from inception up on the ecosystems of the region. Apart from the spills recorded, gas flaring is another major effect on the region's environment. The numerous gas pipelines (Kadafa, 2012) crisscrossing the region sometimes cause fire incidence through leakage, setting farmlands and natural forest ablaze, destroying biodiversity and sometime causing human fatalities. Apart from accidental fires, the actual flaring generates heat and emits carbon into the atmosphere destroying vegetation, especially wetlands, suppressing growth of crops, contaminating both surface and underground water, contributing to global warming as well as causing skin and other associated diseases.

Nevertheless, petroleum with most of its negative effects still plays an important role in the generality of the wellbeing of Nigerians with regards to energy within and without the host region. (Fagan, 1991) concluded that ongoing research by many countries to find alternative energy source with less environmental effects has been a challenging task.

### *1.5.2. Wetland Utilization*

Activities, such as agriculture, have been in practice since the time of earliest cultivation (Ambujam and Anuradha, 2013). Right from inception, food production from cultivation and human settlements was developing primarily along fertile riverine wetlands and floodplains in the early beginning of agricultural practices. This was largely due to depositions of sediments on the flood plains creating a fertile area for agricultural practices to thrive, in addition to easy accessibility due to the present of waterway transportation (Verhoeven et al., 2010).

As technology increased and agricultural practices became sophisticated, wetlands have been reclaimed, causing the loss of natural ecosystems, leading to a loss of performance to functions other than crop productivity (Hassan et al., 2005).

According to the Millennium Ecosystem Assessment (2005), an estimation of more than 50% of the total wetland areas quantified so far from several regions of North America, Europe and Australia shows a reduction of area, mostly due to conversion to intensive agriculture.

Hassan et al. (2005) also states that although the protection of wetland has been made priority by 159 countries as at 2009 after the Ramsar Convention in Iran, wetlands have continued to be threatened by reclamation. He projected that population increase will also add more pressure to the wetlands as food production is expected to increase by 50% more by the end of 2030.

FAO (2003), in its report, states that there is a shortage of plant food supply, forcing a change of trend to more animal-based food. A reversal will mean more demand for cultivated land, which will leads to more land reclamations by which wetlands will be affected.

Smeets et al. (2007) states that there has been an initiative to reduce carbon emissions with growing energy crops for biofuel use as well as climate neutral economic activities, hence the planting of trees and forest even on the non-forested wetlands. Additives such as fertilizers caused disturbances to its natural ecosystem by interfering with the natural characteristics of the wetland.

In Nigeria, the Niger Delta wetland region is endowed with abundant mineral and organic matter, with a huge deposit of fossil fuel in an area that also supports plant cultivation (Imogie et al., 2012). But the fifty nine years of activities of oil multinationals has gradually changed the wetland physical and chemical properties, making it a threat to the natural biodiversity and human livelihood (Ndidi et al., 2015).

It has obviously becomes necessary to protect our wetlands from all human activities that are not sustainable, while optimizing measures to regenerate the already damaged wetlands, for a more efficient, effective and environmental friendly ecosystem services.

### *1.5.3 Wetland Vegetation and Petroleum Impact*

Understanding the relationship between oil activities and wetland vegetation, most especially in the area of impact assessment, is particularly important as this affects crop health and productivity, as well as the attitude of the local farmers to agriculture. In general, vegetation response such as recovery rate, to incidence of oil spills due to petroleum activities is dependent on many factors which include the type of crude oil, the level of toxicity of the spilled crude, the spatial extent of the spill, the volume of the spill, the type or composition of species in the vegetation, the season of the spill, and the cleanup responses (Lin and Mendelssohn, 1996; Pezeshki et al., 2000).

Crude oil activities such as canalization, blowout, and flare also impact wetlands, effecting the vegetation cover by slowing down the rate of photosynthesis. Carbon assimilation and respiration is impaired, thus impacting negatively on the growth of the plants, and this may even cause plant death. When there is a case of repeated oil spills, the effluent volume increase causes an increase of assimilation into the soil. Apart from causing an increase in the oiling and coating of plants, underground nutrients reserves meant for plants growth and regeneration are affected. The consequences are seen in the level of plant mortality over the affected area. Although many conclude that all species of plants will have a similar vulnerability to oil spills, Lin and Mendelssohn (1996) are of the opinion that different species respond differently to such incidences. Cases like these and many other scenarios are important reasons to assess the effect of petroleum activities on wetlands, how they affect livelihood such as farming, and the need to identify strategies that will help in protecting the biodiversity of wetlands while encouraging sustainable practices within the oil industry which will benefit the socio-economic and socio-cultural well-being of the local people.



#### *1.5.4. Livelihood Changes*

According to Mahdi et al. (2009), livelihood improvement of the local people has been given growing attention globally in the last two decades by way of changing both the external factors and the internal factors; the external factors being management of natural resource and the internal factors being livelihood capital assets which include human, natural, physical, financial and social assets. He further stressed that the interaction established between the internal factors and the external factors of livelihood will determine livelihood strategies as access to assets and scope is majorly influenced by the policies, institutions and/or governance.

Livelihood improvement has to be sustained, Chambers et al. (1992) maintain that livelihood sustainability is the household ability to cope with stress and shocks while retaining its assets without ruining the chances of losing its capital base.

In Nigeria's Niger Delta livelihood systems are much more than just economic and material conditions, it also includes the attachment of the locals to their environment with culture playing a major factor but unfortunately this is threatened by the devastating environmental degradation that is prominent in the region thereby making livelihood security vulnerable (Onakuse, 2007).

Onakuse (2007) further states that the traditional livelihood base of the region, which is primarily farming and fishing with small scale processing and distribution of the produce, has been greatly hampered by incidents of environmental degradation of the region by petroleum activities of various multinationals. This has a negative implication to the general economic social and political cohesion in the region creating avenue for physical conflicts which further deteriorates the already weakened system, causing productivity loss and loss of potential opportunities.

#### *1.5.4. Integrating Impact on Livelihood Changes*

According to Maltby (2009), crude oil's impact on the functions and the ecological structure of wetland ecosystems may alter the ecosystem services that could be provided for the benefit of human wellbeing. Maltby (2009) went on further to state the significance of a functioning wetland area for local, regional and national economies. He maintained that oil spillage can alter the positive importance of ecosystem services to the wellbeing of people, leaving behind adverse consequences.

The concept of ecosystem services gained prominence in 2005 when the United Nations Millennium Ecosystem Assessment (MEA) structured the services provided into four

categories, namely provisions, regulating, supporting and cultural with the sole aim of improving the livelihood standard of the society in various region by effecting a positive change on societal, economics, culture services and environmental quality (Duraiappah and Naeem 2005). This will also be applied in the wetland ecosystem, as it will improve the both the marketed and non-marketed traditional values of the local communities.

The wetland areas of Akwa Ibom State equally support significant ecosystem services which ensures the provision of food through cultivation of various crops. The wetland is also rich in supporting agricultural cultivation for both food and cash crops in the study area and also support an abundant source of aquatic life which also benefits the livelihood of the inhabitants (Ekeke et al., 2008).

These wetland ecosystem services are important for household consumption, income generation and fulfillment of social and cultural obligations. These services also serve as a source of raw materials for the various small scale and large scale manufacturing and businesses within and outside the region. This creates employment among the inhabitants though no proper inventory has been done in this regard to determine the level of contribution from these services, but the importance of the wetland to the local people cannot be underestimated.

In Akwa Ibom State, the petroleum resources should imply enormous development socially, economically and otherwise to improve the livelihood wellbeing of the people. “Instead the people remain poor, marginalized and restive. Resort to conflicts has been taken as the only way of expressing grievances in oil-rich communities in the region. The conflict situation has been a cause for alarm since 1999 with kidnapping of oil company workers, bombing of oil facilities and confrontation with state law enforcement agents. These happenings have had serious implications for the economy” Akpan and Akpabio, (2009).

As Idemudia (2010) rightly puts it, “the pervasive degradation of the environment by oil exploration has led to pervasive poverty culminating in a sense of relative deprivation and a perception of alienation within the host communities.”

The federal government of Nigeria has launched some intervention programmes aimed at developing the region by creating a commission and a ministry to oversee the affairs of the region regarding petroleum activities. Ibeanu (1997) states that the communities benefit to a small extent from multinational petroleum activities.

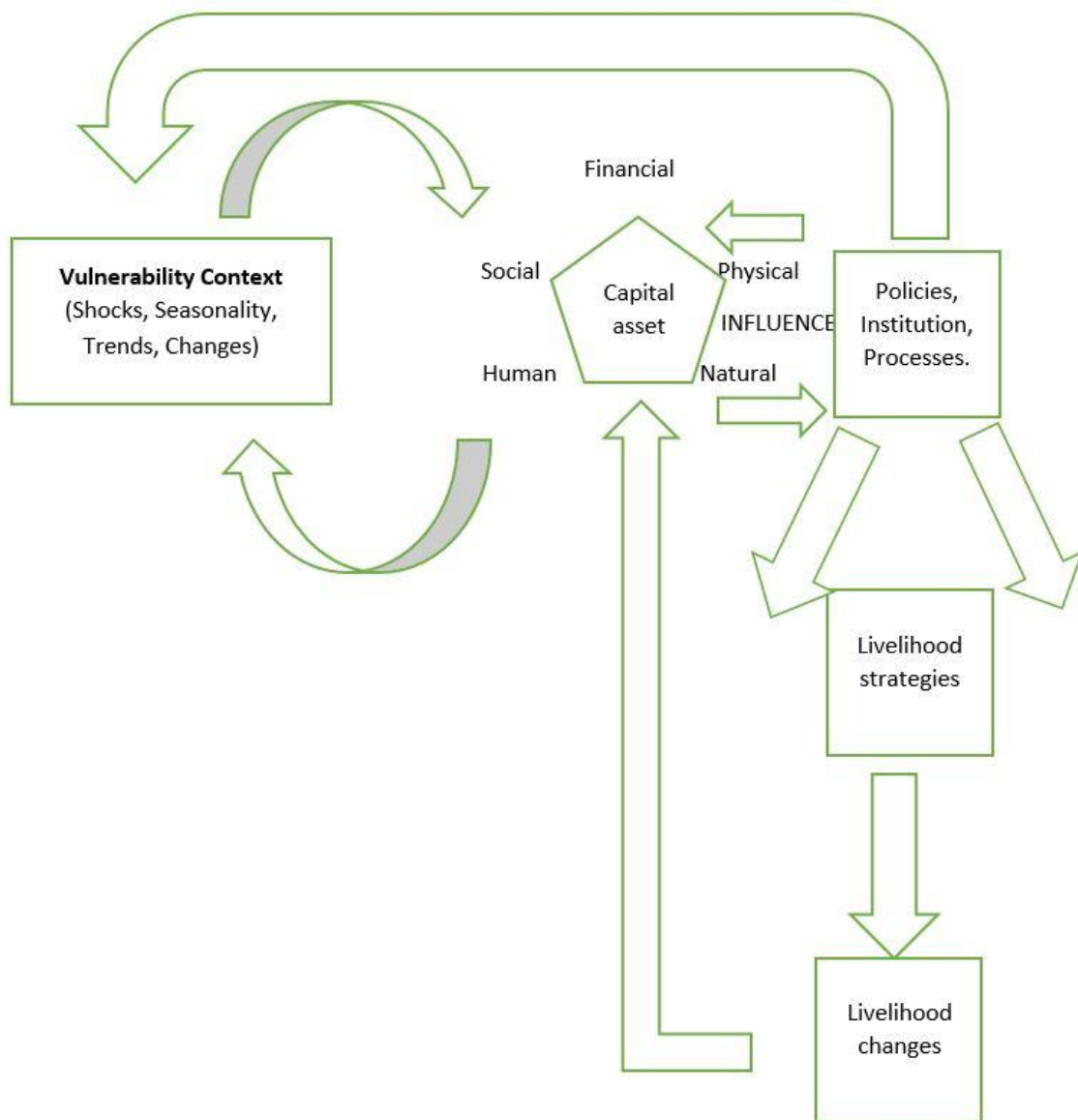
## **1.6. CONCEPTUAL FRAMEWORK**

### *1.6.1. The Concept of Sustainable Livelihood*

Sustainable livelihood is an approach whereby development methods are systematically integrated to ensure poverty reduction, encourage empowerment process to achieved sustainable development (Hoon et al., 1997). The concept has many interactive steps such as risk identification, asset availability, livelihood activities, and the general awareness of the immediate environment by individuals as well as communities within the regional scope under consideration. It also analyses micro- (individuals and communities), meso- (local government, authorities or region) and macro- (National and international) level policies and programs that influence people's livelihood. It also assesses the main technology available, investment opportunities and duration in real time. Other important interactive elements include cultural, social, physical, religious and political elements, all of which help in shaping the livelihood of a community. These interactive elements guide policy makers to formulate suitable programs and projects that will ensure an adaptive Sustainable Livelihood (SL). It is noted that the concept is aimed at making livelihood cope with stress, recovers from shocks and sustained as well as improved its capacities for the present and the future (UK's Department for International Development (DFID)). The concept's micro to macro link approach is essential, as it has been established that one of the major obstacles to development is the lack of linkages between the policies, services and programs as they affect the people's lives and best practices. This is why it is necessary to understand the realities of people's livelihood at the micro level, while the intervention plans is at the meso and macro levels, which will invariably influence the policy decision at the macro level.

The alternative approach is the strength-based approach that is also useful, as it considers understanding the operations of policies, designing and monitoring of programs as well as evaluating the workability of such programs. The strength-based approach considers first the community's or region's resource available capacity starting where there is abundance of resources and capacity to where there is limited resource and capacity either in an individual or as a community.

Finally this concept can help government and communities plan efficiently on programs and outcomes that will enable the empowerment of the people by way of responsive services and policies which ensures real opportunities of making a living



**Figure 2: Sustainable Livelihood Approach Diagram**

**Source:** IFAD SL Framework – (Townsend 2004)

*1.6.2 Applying the Concept to the Study.*

Looking at the Akwa Ibom State scenario, the risk here is potential loss of wetland, oil becomes the available asset, stakeholders within this region that are performing different tasks are those involved in livelihood activities and they need to be aware (sensitive) to what is happening to their environment given their activities. Looking at this concept again from the perspective of micro, meso and macro, one will note that the programs of government, especially the federal government, are designed to be carried out at the micro level which are the communities governed by a smaller authority and reporting the same through that pathway, but in reverse.

The technology mentioned in the concept could be likened to RS and GIS for monitoring and mapping of resources to be tapped as well as other technology which will help harmonize the outcome of monitoring to optimized operations and services within the sampled area. Understanding of the community, such as the study area and especially by the MOCs and the governments, will help rescue the communities from unnecessary shocks of degradation and abandonment.



## CHAPTER TWO

### 2. MATERIALS AND METHODS

This chapter considers all the methods used in collecting and analyzing data as set up in the aims and objectives. It is organized in three sections. A brief discussion of the study area is contained in the first section.

The second section describes more of the types of data acquired, the source of data acquisition, the characteristics of each of the datasets and the reason for the choice of the data. Fieldwork methods form an integral part of this second section, and these included observation, guided interview (semi-structured interview) and group discussions approaches.

The third section centers on the methods, the types of methods used and the reasons for the choice of methods.

#### 2.1. STUDY AREA

##### 2.1.1. *Location and Description of Study Area*

Akwa Ibom State lies entirely on the coastal plain of southern Nigeria also known as the Niger Delta region. It is located between latitudes 4°30' and 5°30' N and longitude 7°30' and 8°15' E. It has a total land area of 6772.089 kilometre square and an estimated population of 3,902,051 people. The selected study area of Eastern Obolo, Ibeno and Esit Eket is situated at the Southern part of Akwa Ibom State and lies between latitude 4°30' and 4°42' N and longitude 7°35' and 8°15' E, with a total land area of 535,382 kilometre square and a population of 198,168 people (National Population Commission, 2010). The area experiences a mean annual rainfall that decreases from the coastal area to the north with the figures ranging from about 2100mm to about 4050mm. (Udoh and Udofia, 2014) It is noted for its abundant wetlands, saline mangroves, fresh and salt-water swampy forests, sandy coastal ridge barriers, as well as low land rain forest. Large number of rivers, streams, canals and creek are many prominent features of the area with a history of frequent flooding, erosion both gully and coastal and crude oil spillages and gas flaring since the discovery of oil and gas in the area. Apart from crude oil, the area is also rich with many other natural resources, such as natural gas, forest and marine resources, etc.

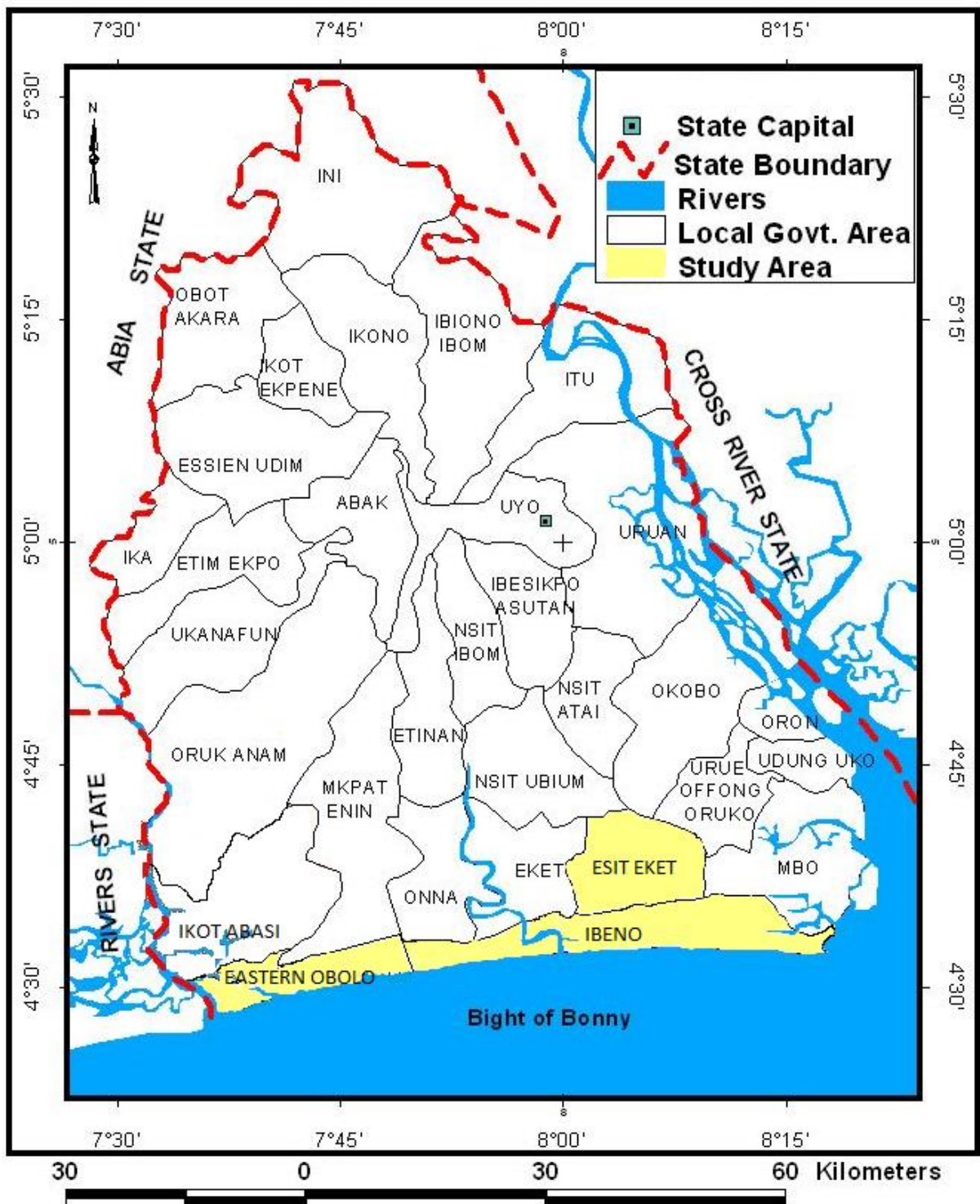
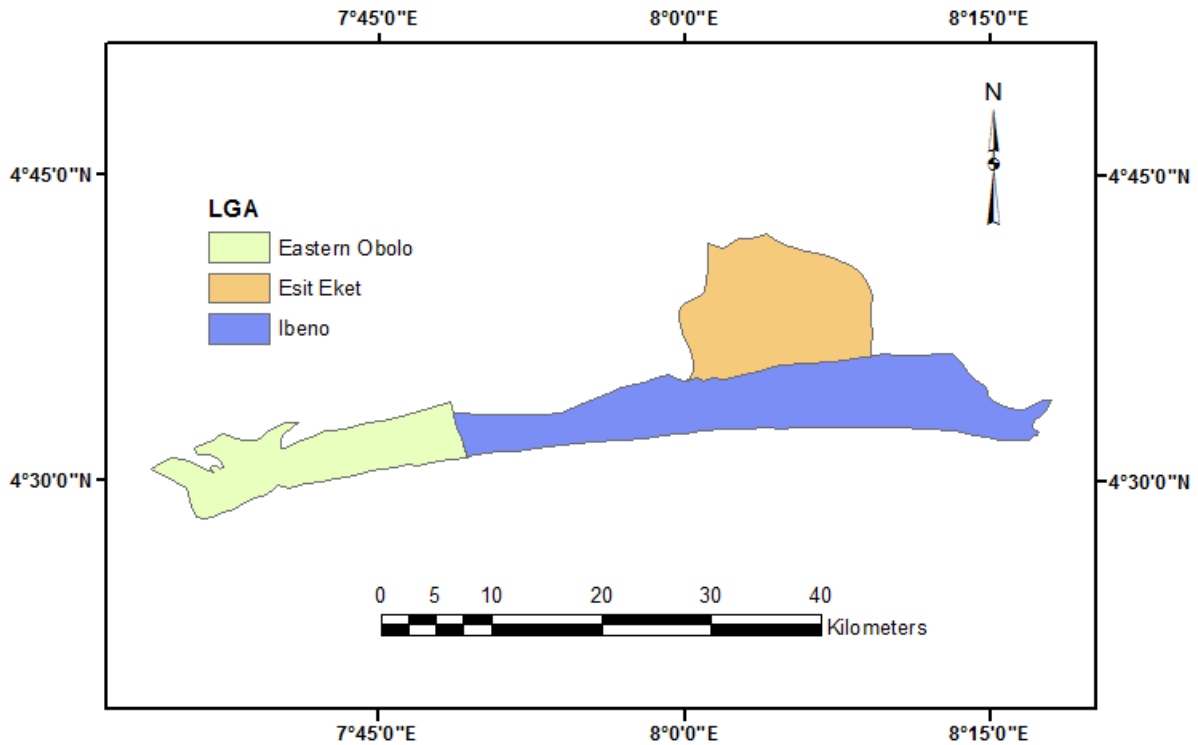


Figure 3: Map of Akwa Ibom State showing study area.



## EXTRACTED STUDY AREA MAP ON LGA BASIS



**Figure 4: Study Area Map showing local government areas.**

## 2.2 DATA COLLECTION AND SAMPLING STRATEGY

### 2.2.1. Sampling Method

**Interviews:** The Participatory Rural Approach (PRA) was used in collecting information through questionnaire administration (see Appendix A) to targeted individuals and focus groups. The targeted individuals and groups were interviewed based on their direct involvement and specialized knowledge of the study. While the interviewing of individuals was done selectively, that of the focus groups was an arrangement with the leader of youth forum in the sampled communities within the three selected local government areas. The arrangement was done by the field assistant who is also from the community. Three field assistants from the three selected local governments were employed as they were given the duty of directing the research team to the actual locations of wetlands where there were changes. A surveyor was part of the research team in the field who assisted in mapping the observed change locations by taking coordinate points. Apart from the youths, the group also comprised representatives from women and elders. Altogether, a total of 60 questionnaires were administered to individuals in the 3 local governments of the study area covered. These

individuals were selected from study sites within each of the 3 local government areas of the study. Focus group sessions were useful as a method of cross checking opinions held by different people or groups of village members. Consequently, a purposive random sampling technique was used in the administration of the questionnaire in each of the local government areas of the study area.

**Observation Method:** This was carried out to verify and confirm the actual changes in the wetland situations in 2015; ground reference was identified for land cover classes within the study area. Assessment of the infrastructure on ground for livelihood improvements in the oil producing communities was also observed. Published and unpublished information on infrastructures and programs aimed at improving livelihood of the host communities by the oil multinationals was also obtained. Accuracy assessment and the knowledge of the area under mapping was very important since independent field observation had enhanced field knowledge. Photographs were also taken at different location to further validate the field work. Thus, the essence of the fieldwork was mainly focused on observing and collecting data relating to impact of petroleum activities on the wetland area as well as livelihood of the local people within the oil communities.

**Ground Truth Data:** Within each land cover class, more ground points were sampled using a GPS receiver. Garmin GPS map 76CSx was used in the field for marking and recording of all the 241 coordinate points mapped. A stratified sampling method was adopted based on the six homogenous spectral characteristics classes identified using the 2015 Landsat image and ground sample points were collected. As expected, some of the areas mapped were inaccessible, and as such, a linear transect method was adopted in taking several points. 5 identified land cover classes were on land while one was on water.

Each of the 5 identified image classes apart from water body had not less than 40 training sample points' mapped. The field assistants from each of the LGAs, in addition to a land surveyor, were part of the field visit and ground truth exercise throughout the duration of the fieldwork. The GPS setting projection name and parameters used is given below;

Projected Coordinate System:	WGS_1984_UTM_Zone_32N
Projection:	Transverse_Mercator
Projection Parameters	
- false_easting:	500000.

- false\_northing: 0.
- central\_meridian: 9.
- scale\_factor: 0.9996
- latitude\_of\_origin: 0.
- Linear Unit: Meter

Geographic Coordinate System: GCS\_WGS\_1984

Datum: D\_WGS\_1984

Prime Meridian: Greenwich

Angular Unit: Degree

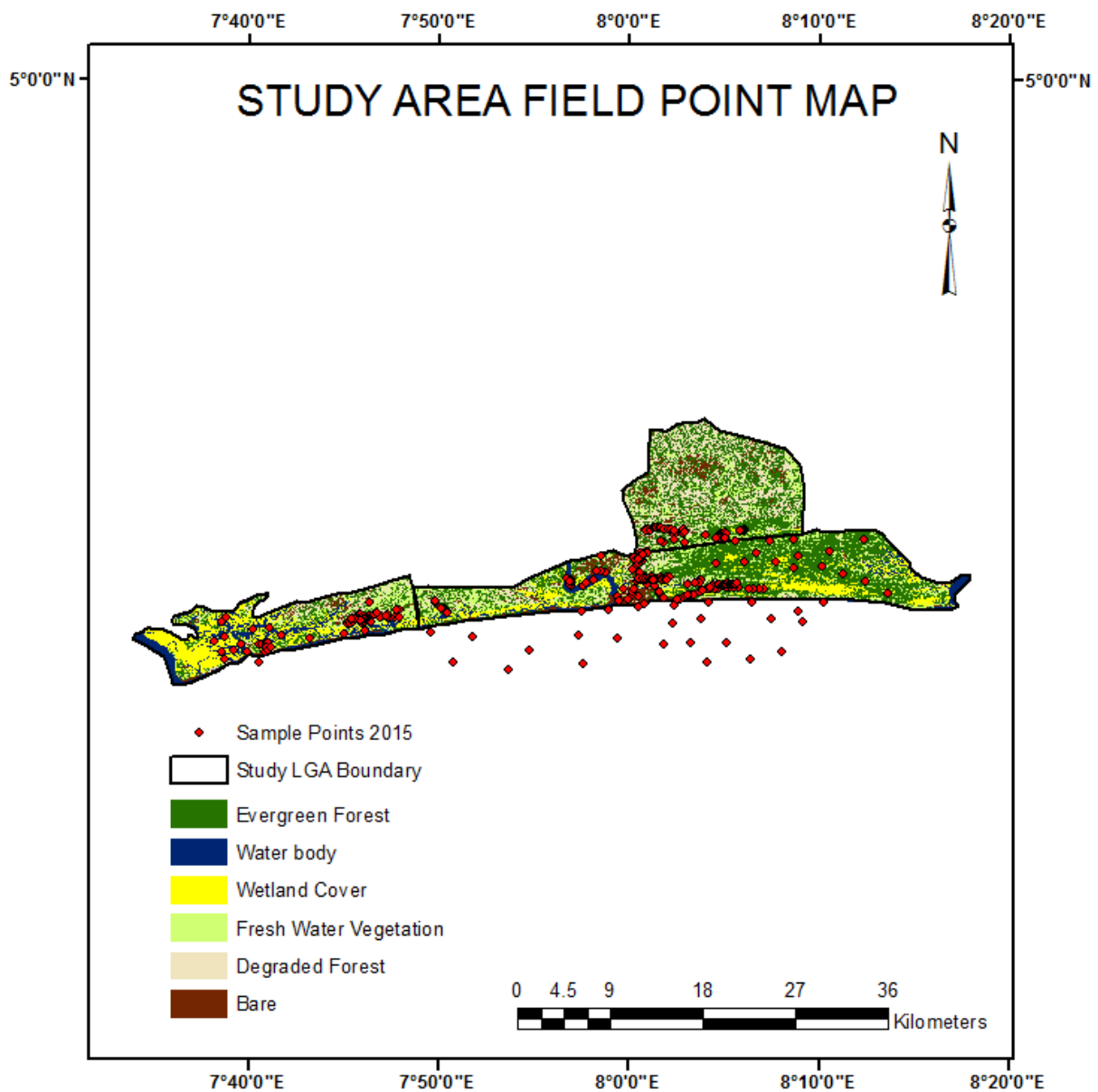


Figure 5: Study Area map showing GPS acquired field points.

### *2.2.2 Secondary Data Collection*

Secondary data used included a classified November 2002 Landsat image which was obtained from the GIS department of the University of Uyo, Nigeria. The image was used as a reference data to validate the six classified classes of January 2003 Landsat image. The reason being that the November 2002 Landsat image and January 2003 Landsat image were obtained during the dry seasons of the study area. The images have similar weather conditions as shown in (Table 1). These included a maximum average temperature of 31.5 degrees centigrade for both November 2002 and January 2003 Landsat images, a minimum average temperature of 23.3 degrees centigrade for November 2002 Landsat image and 22.8 degrees centigrade for January 2003 Landsat image, monthly average relative humidity of 77% for November 2002 Landsat map and 73% for January 2003 Landsat image, and a monthly average rainfall of 49.8 millimeters cubed for November 2002 Landsat map and 46.9 millimeters cubed for January 2003 Landsat image. The fact that it was the only available and nearest classified image from ground truth to the January 2003 also provided a good reason it was chosen as a reference data for January 2003 Landsat classified image. A vegetation map of 2002 was also obtained from the Cross River Basin Development Authority for comparison of the classified November 2002 Landsat Image collected from University of Uyo. January 2015 Landsat image from USGS was acquired.

Reports, laws and regulations, policies and guidelines with particular reference to wetlands was obtained from the Forestry Department of Akwa Ibom State Ministry of Environment as well as downloaded from the website of National Environmental Standards and Regulations Enforcement Agency (NESREA). A report on inventory of infrastructure provided by the multinational oil companies (MOC) was obtained from the officials of the MOCs through the supervising Ministry (Petroleum Resources). A Google Earth 2015 image of a resolution of 0.9 meters was used also for identification of more details during the process of classification (see Appendix F).

Table 1: Showing weather condition of 2002 and 2003 (NIMET-Nigerian Meteorological Agency, Akwa Ibom State Meteorological Inspectorate, Uyo).

Average maximum temperature in degrees centigrade of Eket zone Akwa Ibom State by month and year 2002 and 2003													
Year	Month												Mean
	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec	
2002	34	34.6	34.5	31.6	31.6	30.3	29.7	28.9	28.9	30.9	31.5	32.2	31.63
2003	31.5	35.4	33.5	32.7	32.1	30.5	29.4	29.3	31	31.5	32.2	35.5	32.05
Average minimum temperature in degrees centigrade of Eket zone Akwa Ibom State by month and year 2002 and 2003													
Year	Month												Mean
	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec	
2002	21.9	25.3	25.3	23.7	24	23.4	23	22.5	23.3	23.3	23.3	24	23.58
2003	22.8	23.5	24.1	23.9	23.2	23.4	23.3	23.3	23.3	23.9	24.3	23.6	23.57
Monthly average relative humidity in percentage of Eket zone Akwa Ibom State in the year 2002 and 2003.													
Year	Month												
	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec	
2002	76	74	76	79	82	85	88	87	86	84	77	71	
2003	73	75	75	77	81	86	86	89	84	82	79	72	
Monthly average amount of rainfall in millimeters cubed in Eket zone Akwa Ibom State for the year 2002 and 2003													
Year	Month												Mean
	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec	
2002	37.3	17.3	134.9	218.6	375.4	329.9	275.7	485.1	145.2	192.1	49.8	49.8	192.59
2003	46.9	58	63.5	165.4	224.5	368.5	226.9	276.5	214	210	40.5	0	157.89

Table 2: Showing weather condition of October 2014 to January 2015 (NIMET-Nigerian Meteorological Agency, Akwa Ibom State Meteorological Inspectorate, Uyo).

Monthly average maximum temperature in degrees centigrade of Eket zone Akwa Ibom State from October 2014 to January 2015				
Year	Month			
	Oct	Nov	Dec	Jan
2014	30.1	30.7	32.2	
2015				32.9
Monthly average minimum temperature in degrees centigrade of Eket zone Akwa Ibom State from October 2014 to January 2015				
Year	Month			
	Oct	Nov	Dec	Jan
2014	22.8	23.1	23.1	
2015				23.2
Monthly average Relative Humidity in percentage of Eket zone Akwa Ibom State from October 2014 to January 2015.				
Year	Month			
	Oct	Nov	Dec	Jan
2014	87	84	80	
2015				75
Monthly average amount of rainfall in millimeters cubed in Eket zone Akwa Ibom State from October 2014 to January 2015.				
Year	Month			
	Oct	Nov	Dec	Jan
2014	190.1	79.8	61.4	
2015				41.3

### 2.3 DATA

This study was centered on Remote Sensing images (see Appendices B through D), interviews and literature review. Satellite images data of 2003 and 2015 were obtained from Landsat 7 ETM+ and Landsat 8 OLI (Operational Land Imager) and TIRS (Thermal Infrared Sensor) respectively (Table 3 and appendices B and C), the cloud free images was downloaded from United States Geological Survey (USGS). The choice of Landsat data was as a result of availability, and their data is multispectral to support a land-use land cover change analysis for the purpose of the study which is locating wetland and its change over time (Wang et al., 2009). The cost of getting the image of the study location was also a major factor that was considered. The Landsat images of 2003 and 2015 were of the same month of different years (January of each of the years), making it reasonable to carry out a change detection considering the similarity in environmental condition characteristics.

As shown in Table 1 and 2, the last three months of 2002 and 2014 (October, November and December) recorded the following weather conditions; For 2002, the average monthly weather data were, 30.9, 31.5 and 32.2 degrees Celsius in maximum temperature; 23.3, 23.3, 24 degrees Celsius in minimum temperature, 84, 77, 71 percentages in average relative humidity; and 192.1, 49.8, 49.8 millimeters cube in average amount of rainfall. For 2014 they were, 30.1, 30.7, 32.2 degrees Celsius in maximum temperature; 22.8, 23.1, 23.1 degrees Celsius in minimum temperature; 87, 84, 80 percentages in average relative humidity; and 190.1, 79.8, 61.4 millimeters cubed in average amount of rainfall.

Then in January of the years considered for the study, 2003 recorded a maximum temperature of 31.5 degrees Celsius, while 2015 recorded a maximum temperature of 32.9 degrees Celsius. A minimum average temperature of 22.8 degrees Celsius for 2003 and 23.2 degrees Celsius for 2015 were recorded; 73 and 75 percent average relative humidity were recorded for 2003 and 2015; and 46.9 and 41.3 millimeters cubed were recorded for average rainfall for 2003 and 2015 in the chosen month.

**2003 image and map:** A classified November 2002 Landsat image (see Appendix D) from the University of Uyo and a vegetation map (see Appendix E) from the Cross River Basin Development Authority (CRBDA) were obtained and used as guides and reference data to the January 2003 Landsat 7 ETM+ downloaded from USGS.

All the images and maps used were projected into Universal Transverse Mercator (UTM) map coordinates, a coordinate system that matched the GPS settings mentioned earlier in the chapter.

Table 3: Attributes of the Landsat 7 ETM+ and Landsat 8 OLI and TIRS Imagery used in the Study

Acquisition	Sensor	Spatial Resolution(30m)	Path/Row
2003-01-08	7 ETM+	30	188/057
2015-01-17	OLI_TIRS	30	188/057

The study adapt the Food and Agriculture Organization and United Nations Environment Programme (FAO\UNEP) land cover classification system (LCCS), which is widely accepted as a standard for LUCC studies.(Anderson et al., 1976; Loveland et al., 1997). (Table 4)

Table 4: Description and Definitions of Land Use/Land Covers Classes(Anderson Et Al. 1976), (Hansen & Reed 2000).

	IGBP DISCover classes	Definitions	Equivalent of UN land cover classification system (LCCS) classes
1	Dense Forest	Evergreen Forest, Mixed Forest and Deciduous Forest	Evergreen Forest
2	Water	Canals, Streams, Bays and Estuaries, Lakes and Reservoirs	Water Body
3	Wetland	Forested and Non-forested Wetland.	Wetland
4	Freshwater Swamp Forest	Forests which are inundated with freshwater, either permanently or seasonally(Ayuba 2012).	Fresh Water Vegetation
5	Agricultural Land	Cropland, Rangeland, Orchards, Pasture, Vineyards, Confined Feeding Operations, Ornamental Horticultural Areas, Herbaceous Rangeland, Groves, Nurseries, Shrub, Brush Rangeland, Mixed Rangeland and Other Agricultural Land.	Degraded Forest
6	Built-up and Barren Land	Mixed Urban or Built-up Land, Dry and Salt flats, Beaches, other Sandy Areas, Residential, Commercial, Industrial , Transportation, Communications, Utilities, Urban, Bare Exposed Rock, Strip Mines, Quarries, Gravel Pits, Transitional Areas, Mixed Barren Land.	Bare

#### 2.4. MAPPING THE IMPACT ON AGRICULTURAL PRACTISE AND LIVELIHOOD OPPURTUNITIES

Beside the land cover change mapping, other indicators that measure the impact of petroleum activities on agricultural practices within the wetland of Akwa Ibom State were the level of total yield of harvested crops per year in kg, the rate of regeneration and recovery of the degraded wetland ecosystem, the rate of depletion of the wetland per year, the wetland management strategies that has been in practice, the number of people in percentage that are involved in agriculture in the selected oil communities, the opportunities that are available as



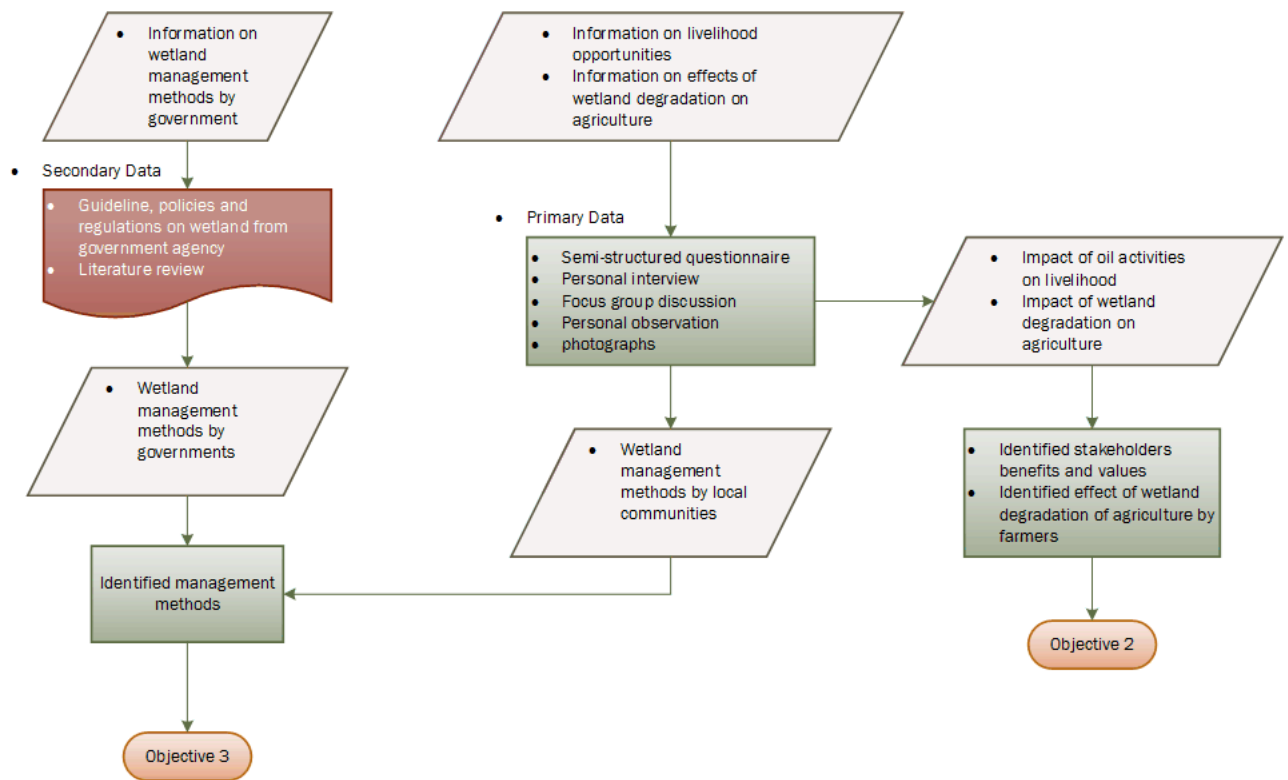
a result of petroleum activities in the selected communities, and the abundance of available biodiversity. These indicators were also used in measuring the impact of livelihood changes in the wetland areas of Akwa Ibom State. The source of these indicators was information obtained from interviews with selected individuals, and existing records available with relevant agencies like the Ministry of Petroleum Resources who is tasked with obtaining reports from the yearly operations of the oil multinationals (ie Exxon Mobil, Total E & P Nigeria Limited etc.). A list of available community development projects by MOCs that are at various levels of completion was collected from the Ministry. (See Appendix G)

The method described here was applied during field data collection with the sole aim of mapping the outcome of the activities of oil in the study area and how they affect the livelihood opportunities at the community or local level. The data collected from the two time periods of 2003 and 2015 forms a major determinant for the decision and the result of the objective listed.

Stakeholders were asked to validate the major livelihood opportunities from the benefits of petroleum activities in the study area with a ranking from the most important livelihood opportunities provided. This was used to validate changes that occurred in the declining patronage of wetland agricultural farming practice during the period of years that is taken into consideration (2003-2015). The end result of this exercise determined the degree of awareness of the opportunities of livelihood in the study area and also defines the perception of the community people on the oil multinationals operating in their area.

## **2.5 QUALITATIVE TECHNIQUES**

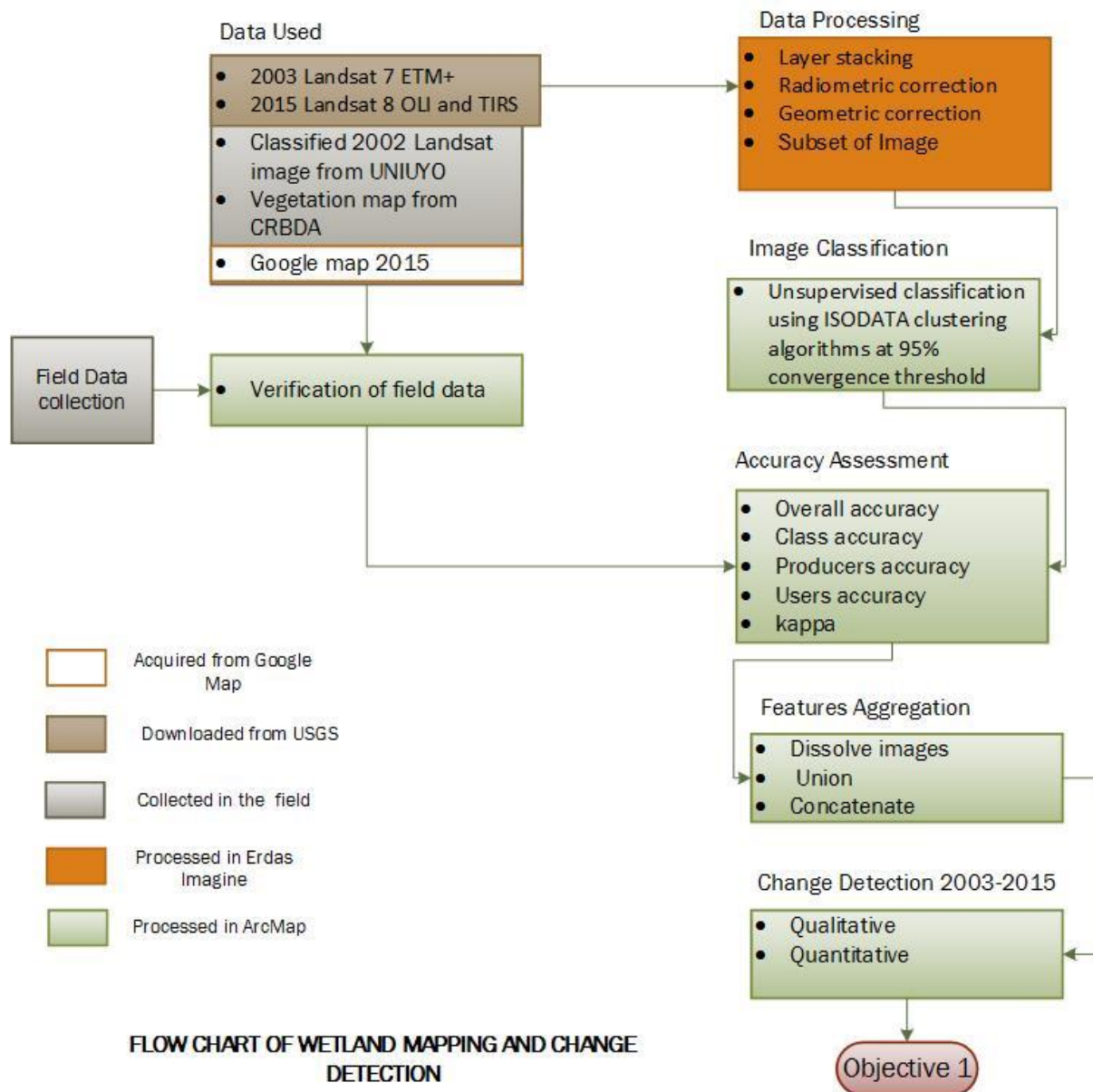
Because of the direct contact with the real world in real time as individuals and groups, researchers using qualitative methods carry out their own assessment with objectivity considering people's perceptions, understandings and hypotheses. It also gives meaning to experiences by measuring facts or findings that are discovered during the course of research. This approach is also suitable for both dynamic and static case studies. This approach seeks to establish new concepts rather than imposing preconceived concepts of the subject under research (May, 2002). Thus, this qualitative method was considered for this research given the dynamic nature of people's perception, understandings and hypotheses on issues affecting their livelihood due to petroleum activities, then relating these to the outcome of the remote sensing and change detection of the study.



**Figure 6: Flow Chart on Objective two and three**

## 2.6. METHOD OF DATA ANALYSIS AND PROCESSING

The two time series Landsat images of January 2003 and 2015 were processed. While the 2015 Landsat image was post classified, that of January 2003 was classified and validated with the classified November 2002 land cover image. The choice of using the November 2002 classified image for validation was due to its similar weather conditions as shown in (Table 1) and the fact that it was the only available and most pertinent classified image available for a date close to the January 2003 chosen Landsat image used for the study. The selection of these two images (January 2003 and 2015) was based largely on the favorable atmospheric (100% cloud free) and radiometric (stripping line free) conditions, the availability of the same month in different years, similarity of preceding monthly weather conditions and the low cost of the images.



**Figure 7: Flow Chart of Objective One**

According to Bakx et al. (2012), there are five major stages for an image to be processed for a change detection to be achieved; these are data selection, the preparation stage, the classification stage, the accuracy assessment stage, and then the process of identification and detection of the changes. This study was conducted according to these stages. The Landsat images of 2003 Landsat 7 ETM+ and 2015 Landsat 8 OLI and TIRS of the same month (January) were downloaded respectively from USGS. Southern Akwa Ibom State land cover image was produced from these. The downloaded images were a seven channel TIFF file for 2003 image and an eight channel TIFF file for 2015 image, with an extent larger than the actual

study area. The separate channels were layer stacked using Erdas Imagine 2014. After layer stacking, the images were subset using the bounding box from the geometric group of Erdas Imagine. Unsupervised classification was employed to classify the images using the ISODATA clustering algorithms with a maximum number of classes of 15 and an iteration count of 10 with a 95% convergence threshold. Each of the resultant clusters were classified as a land cover according to the knowledge of the researcher of the area. The classified raster was later reclassified to six classes by aggregating the 15 clusters to these classes, namely Evergreen Forest, Water Body, Wetland Cover, Fresh Water Vegetation, Degraded Forest and Bare. The actual boundary of the study area was determined by clipping the digitized polygon shape file of the study area from the study area map obtained from the University of Uyo with the subset classified raster, producing the resultant image that covered the 3 local government areas of the southern part of Akwa Ibom State, namely Esit Eket, Ibeno and Eastern Obolo. Classification was quite challenging, but ancillary data, knowledge of the study area and a Google Earth 2015 image were also used to aid in classification decisions.

In the field, 341 training points were obtained from the named classes of the 2015 image with a GPS receiver, and due to the difficulty of traveling in the terrain, most of the points were collected linearly. These points were spatially joined with the 2015 classified raster image.

31 random sample points were selected from each of the five classes of the classified January 2003 images of Evergreen Forest, Water Body, and Fresh Water Vegetation, Degraded Forest as well as Bare Cover and 151 random sample points from Wetland Cover class. These points were chosen across the thematic 2003 classified Landsat image based on the nearest neighboring pixel. These points were spatially compared with the reference map of classified November 2002 Landsat image.

Spectral and land cover features as well as pixels changes with a recognized pattern in the 2003 reference map provided a degree of confidence in the classification of the 2003 image. Jiang et al. (2012) also proposed a similar method.

A classification accuracy of 2003 and 2015 images were calculated. Table 5 (below) shows how the error matrix tables were calculated. The producer's, user and kappa accuracies were produced both for the individual and the overall land cover (Yang et al., 2002).

For the 2003 Landsat image, the sample of random points of not less than 31 per class and the reference map was used for the calculation of the accuracy level.

Features of the two time series images were aggregated separately at this time by dissolve before a geometric union of the two images was conducted. The class name as described by each GRIDCODE was concatenated to create a combined attribute field where the change detection can be visibly viewed on the map attributes, both qualitatively and quantitatively.

**Table 5: Error matrix table for accuracy assessment**

Field Class	Map Class						User accuracy
	1	2	3	4	5	6	
1	A <sub>1</sub>	E <sub>12</sub>	E <sub>13</sub>	E <sub>14</sub>	E <sub>15</sub>	E <sub>16</sub>	C <sub>1</sub>
2	E <sub>21</sub>	A <sub>2</sub>	E <sub>23</sub>	E <sub>24</sub>	E <sub>25</sub>	E <sub>26</sub>	C <sub>2</sub>
3	E <sub>31</sub>	E <sub>32</sub>	A <sub>3</sub>	E <sub>34</sub>	E <sub>35</sub>	E <sub>36</sub>	C <sub>3</sub>
4	E <sub>41</sub>	E <sub>42</sub>	E <sub>43</sub>	A <sub>4</sub>	E <sub>45</sub>	E <sub>46</sub>	C <sub>4</sub>
5	E <sub>51</sub>	E <sub>52</sub>	E <sub>53</sub>	E <sub>54</sub>	A <sub>5</sub>	E <sub>56</sub>	C <sub>5</sub>
6	E <sub>61</sub>	E <sub>62</sub>	E <sub>63</sub>	E <sub>64</sub>	E <sub>65</sub>	A <sub>6</sub>	C <sub>6</sub>
Producer accuracy	B <sub>1</sub>	B <sub>2</sub>	B <sub>3</sub>	B <sub>4</sub>	B <sub>5</sub>	B <sub>6</sub>	N

$$\text{User accuracy} = \frac{A_i}{C_i}$$

$$\text{Producer accuracy} = \frac{A_i}{B_i}$$

$$\text{Mean accuracy} = \frac{2 \times A_i}{B_i + C_i}$$

$$\text{Area difference} = \frac{C_i - B_i}{B_i}$$

$$\text{Kappa} = \frac{(N \times A_i) - (C_i \times B_i)}{(N \times B_i) - (C_i \times B_i)}$$

$$\text{Overall accuracy} = \frac{A_1 + A_2 + A_3 + A_4 + A_5 + A_6}{N}$$

Where,

$$N = \sum A + \sum E$$

A = Accurate identification by both field and map class

B = Producer accuracy

C = User accuracy

E = Error identification by map class

**Source:** (Congalton, 1991; Petter Pilesjo 2015)



## CHAPTER THREE

### 3. RESULTS AND DISCUSSION

#### 3.1. Accuracy Assessment

After classification of the January 2003 Landsat image, its accuracy was assessed by using the November 2002 Landsat classified images as the reference data, an approach selected based on the fact that the November 2002 Landsat image was processed and classified using ground truth points by the University of Uyo GIS department, and because it was the only available classified image with a date close to that of the January 2003 image, and similar weather conditions between November 2002 and January 2003 (Table 1). The following accuracy assessment results were obtained, the overall accuracy was 68%, with an overall kappa at 60%. The user class accuracy for Evergreen Forest was 100%, Water 95%, Wetland Cover 44%, Fresh Water Vegetation 95%, Degraded Forest 70%, and Bare 100%. The producer accuracy for Evergreen Forest was 55%, Water 50%, Wetland Cover 95%, Fresh Water Vegetation 81%, Degraded Forest 41%, and Bare 73% (Table 6).

The overall accuracy assessment of 2015 was 88%, with an overall kappa coefficient was 85%. The user class accuracy for Evergreen Forest was 64%, Water 93%, Wetland Cover 87%, Fresh Water Vegetation 95%, Degraded Forest 80%, and Bare 93%. The producer accuracy for Evergreen Forest was 86%, Water 100%, Wetland Cover 92%, Fresh Water Vegetation 74%, Degraded Forest 85%, and Bare 92% (Table 7). Thus the producer's and user's accuracy had higher values, and these results indicate that the accuracy level of the 2015 image classification with selected ground points was sufficient.

**Table 6: Showing accuracy results for 2003 land cover classification**

	<b>Map Class</b>						
<b>Field Class</b>	Evergreen Forest	Water Body	Wetland Cover	Fresh Water Vegetation	Degraded Forest	Bare	<b>Grand Total</b>
Evergreen Forest	31						31
Water Body		30	1				31
Wetland Cover	14	30	70	4	25	8	151
Fresh Water Vegetation	5			26			31
Degraded Forest	6		2	2	18	3	31
Bare						31	31
<b>Grand Total</b>	56	60	73	32	43	42	<b>306</b>
Classes	Producer	Mean	User	Areal	Kappa(i)	SD Kappa(i)	
Evergreen Forest	0.5535	0.7126	1	-0.4464	0.5391	0.0668	
Water Body	0.5	0.6557	0.9523	-0.475	0.4660	0.0456	
Wetland Cover	0.9589	0.6069	0.4439	1.1598	0.9213	0.0253	
Fresh Water Vegetation	0.8125	0.8776	0.9541	-0.1484	0.7893	0.0377	
Degraded Forest	0.4186	0.524781	0.703125	-0.4046	0.3322	0.0335	
Bare	0.738095	0.849315	1	-0.261905	0.677505	0.031566	
	Value	SD					
Overall Accuracy	0.687879	0.014727					
Overall Kappa	0.60724	0.01863					



**Table 7: Showing accuracy assessment results for 2015 land cover classification.**

	<b>Map Class</b>						
<b>Field Class</b>	Evergreen Forest	Water Body	Wetland Cover	Fresh Water Veg	Degraded Forest	Bare	<b>Grand Total</b>
Evergreen Forest	43		4	3			50
Water Body		44	2				46
Wetland Cover			65	7			72
Fresh Water Vegetation	6			32			38
Degraded Forest	1			1	24	4	30
Bare					4	47	51
<b>Grand Total</b>	<b>50</b>	<b>44</b>	<b>71</b>	<b>43</b>	<b>28</b>	<b>51</b>	<b>287</b>
	Producer	Mean	User	Areal	Kappa(i)	SD Kappa(i)	
Evergreen Forest	0.86	0.7350	0.6417	0.34	0.84960	0.052	
Water Body	1	0.9670	0.9361	0.068182	1	0	
Wetland Cover	0.915493	0.8944	0.8744	0.046948	0.89023	0.024	
Fresh Water Vegetation	0.744186	0.8366	0.9552	-0.22093	0.70313	0.036	
Degraded Forest	0.857143	0.8304	0.8053	0.064286	0.83118	0.034	
Bare	0.921569	0.9276	0.9337	-0.013072	0.88605	0.021	
	Value	SD					
Overall Accuracy	0.883385	0.0103					
Overall Kappa	0.852732	0.0129					

### 3.2. WETLAND COVER

The results of the Wetland Cover extent presented in Table 8, show the amount of change in this land cover classes in 2015 from 2003. But for the purpose of this study, the highlighted brown part of the table show where Wetland Cover has changed to other land covers. It was observed that Wetland Cover was gradually being overtaken by species of trees that are canopy covering in about 2,806.42 hectares of the total wetland area of 21364.18 hectares in the study location (see Appendix H1). Also 4154.04 hectares of land has been inundated by water.

**Table 8: Showing observable changes in Wetland Cover per hectare for the two time periods**

FID	x	y	FID_2003_D	GRID_COD E	ClsName03	FID_2015_D	GRIDCO DE_1	ClsName15	Concatenat	change_Ha
0	355272	499545	0	1	Evergreen Forest	0	1	Evergreen Forest	Evergreen Forest - Evergreen Forest	54112.6
1	355272	499545	0	1	Evergreen Forest	1	2	Water Body	Evergreen Forest - Water Body	439.1
2	355272	499545	0	1	Evergreen Forest	2	3	Wetland Cover	Evergreen Forest - Wetland Cover	2438.6
3	355272	499545	0	1	Evergreen Forest	3	4	Fresh Water Vegetation	Evergreen Forest - Fresh Water Vegetation	13517.2
4	355272	499545	0	1	Evergreen Forest	4	5	Degraded Forest	Evergreen Forest - Degraded Forest	43269.0
5	355272	499545	0	1	Evergreen Forest	5	6	Bare	Evergreen Forest - Bare	13116.9
6	355272	499545	1	2	Water Body	0	1	Evergreen Forest	Water Body - Evergreen Forest	472.0
7	355272	499545	1	2	Water Body	1	2	Water Body	Water Body - Water Body	61064.5
8	355272	499545	1	2	Water Body	2	3	Wetland Cover	Water Body - Wetland Cover	1418.7
9	355272	499545	1	2	Water Body	3	4	Fresh Water Vegetation	Water Body - Fresh Water Vegetation	246.2
10	355272	499545	1	2	Water Body	4	5	Degraded Forest	Water Body - Degraded Forest	56.6
11	355272	499545	1	2	Water Body	5	6	Bare	Water Body - Bare	224.4
12	355272	499545	2	3	Wetland Cover	0	1	Evergreen Forest	Wetland Cover - Evergreen Forest	2806.4
13	355272	499545	2	3	Wetland Cover	1	2	Water Body	Wetland Cover - Water Body	4154.0
14	355272	499545	2	3	Wetland Cover	2	3	Wetland Cover	Wetland Cover - Wetland Cover	12629.1
15	355272	499545	2	3	Wetland Cover	3	4	Fresh Water Vegetation	Wetland Cover - Fresh Water Vegetation	1231.4
16	355272	499545	2	3	Wetland Cover	4	5	Degraded Forest	Wetland Cover - Degraded Forest	302.8
17	355272	499545	2	3	Wetland Cover	5	6	Bare	Wetland Cover - Bare	240.4
18	355272	499545	3	4	Fresh Water Vegetation	0	1	Evergreen Forest	Fresh Water Vegetation - Evergreen Forest	14481.1
19	355272	499545	3	4	Fresh Water Vegetation	1	2	Water Body	Fresh Water Vegetation - Water Body	511.2
20	355272	499545	3	4	Fresh Water Vegetation	2	3	Wetland Cover	Fresh Water Vegetation - Wetland Cover	1809.3
21	355272	499545	3	4	Fresh Water Vegetation	3	4	Fresh Water Vegetation	Fresh Water Vegetation - Fresh Water Vegetation	10824.7
22	355272	499545	3	4	Fresh Water Vegetation	4	5	Degraded Forest	Fresh Water Vegetation - Degraded Forest	3620.4
23	355272	499545	3	4	Fresh Water Vegetation	5	6	Bare	Fresh Water Vegetation - Bare	421.0
24	355272	499545	4	5	Degraded Forest	0	1	Evergreen Forest	Degraded Forest - Evergreen Forest	10368.0
25	355272	499545	4	5	Degraded Forest	1	2	Water Body	Degraded Forest - Water Body	96.6
26	355272	499545	4	5	Degraded Forest	2	3	Wetland Cover	Degraded Forest - Wetland Cover	61.3
27	355272	499545	4	5	Degraded Forest	3	4	Fresh Water Vegetation	Degraded Forest - Fresh Water Vegetation	970.6
28	355272	499545	4	5	Degraded Forest	4	5	Degraded Forest	Degraded Forest - Degraded Forest	9148.7
29	355272	499545	4	5	Degraded Forest	5	6	Bare	Degraded Forest - Bare	8033.9
30	355272	499545	5	6	Bare	0	1	Evergreen Forest	Bare - Evergreen Forest	1878.6
31	355272	499545	5	6	Bare	1	2	Water Body	Bare - Water Body	110.3
32	355272	499545	5	6	Bare	2	3	Wetland Cover	Bare - Wetland Cover	30.2
33	355272	499545	5	6	Bare	3	4	Fresh Water Vegetation	Bare - Fresh Water Vegetation	176.3

3	3552	49954								
4	72	5	5	6	Bare	4	5	Degraded Forest	Bare - Degraded Forest	1626.8
3	3552	49954								
5	72	5	5	6	Bare	5	6	Bare	Bare - Bare	4254.8
						Total	5758.14		Other land covers in 2003, now Wetland Cover in 2015	
						Total	8735.06		Wetland Cover in 2003, now other land covers in 2015	
						Total	12629.11		No change	

Fresh Water Vegetation has gradually grown to cover about 1231.38 hectares, Degraded Forest and Bare Covers occupy 302.85 and 240.39 hectares respectively.

Similarly, the highlighted green part of the table shows where other land covers have changed into wetland area. As observed, 2438.55 hectares have changed from Evergreen Forest to Wetland Cover, 1418.68 hectares have changed from Water Body to Wetland Cover, while Fresh Water Vegetation has changed to Wetland Cover with about 1809.38 hectares. Wetland area also takes over 61.38 hectares of Degraded Forest and 30.24 hectares from areas that were Bare in 2003. Notwithstanding all the changes, the blue color strip of the table shows where there are no changes, which includes 12,629.11 hectares or nearly 60% of wetland on the study location in 2015.

Table 9 show the amount of change of Wetland Cover to other land covers from 2003 to 2015. It has been observed that there was a conversion of about 8735.06 hectares or 40.88% of the wetland area present in 2003 to other classes in 2015.

Table 10, on the other hand, shows the areas in 2015 which are classified as Wetland Cover which were other land covers in 2003, an area of 5758.14 hectares or a 31.31% increase of Wetland Cover in 2015 from 2003.

Thus, from the above findings, 8735.06 hectares that was Wetland Cover in 2003 are now other land covers in 2015 and 5758.14 hectares that were not Wetland Cover in 2003 are now Wetland Cover in 2015.

Table 11 shows the difference in Wetland Cover between 2003 and 2015 within the study area. About 8735.06 hectares of decreasing Wetland Cover was subtracted from about 5758.14 hectares of increasing Wetland Cover and a net decrease of about 2976.92 hectares of Wetland Cover have been lost within the period of consideration.

**Table 9: Showing observable decrease in total wetland area from 2003 to 2015**

Area (Ha)	2003 Wetland Cover to 2015 other feature classes
Decrease	8735.06 (40.88%)
No Change	12629.10 (59.11%)
Total	21364.17 (100%)

Wetland Cover to Evergreen Forest
Wetland Cover to Water Body
Wetland Cover to Fresh Water Vegetation
Wetland Cover to Degraded Forest
Wetland Cover to Bare

**Table 10: Showing observable increase in total wetland area over the last 12 years**

Area (Ha)	2003 other feature classes to 2015 Wetland Cover
Increase	5758.14 (31.31%)
No Change	12629.10 (68.68%)
Total	18387.25 (100%)

Evergreen Forest to Wetland Cover
Water Body to Wetland Cover
Fresh Water Vegetation to Wetland Cover
Degraded Forest to Wetland Cover
Bare to Wetland Cover

**Table 11: Showing net change in area per hectare of Wetland Cover between 2003 and 2015**

Area (Ha)	2003 Wetland Cover to 2015 other feature classes	Area (Ha)	2003 other feature classes to 2015 Wetland Cover	Net Change (Ha)
Decrease	8735.06	Increase	5758.14	2976.92

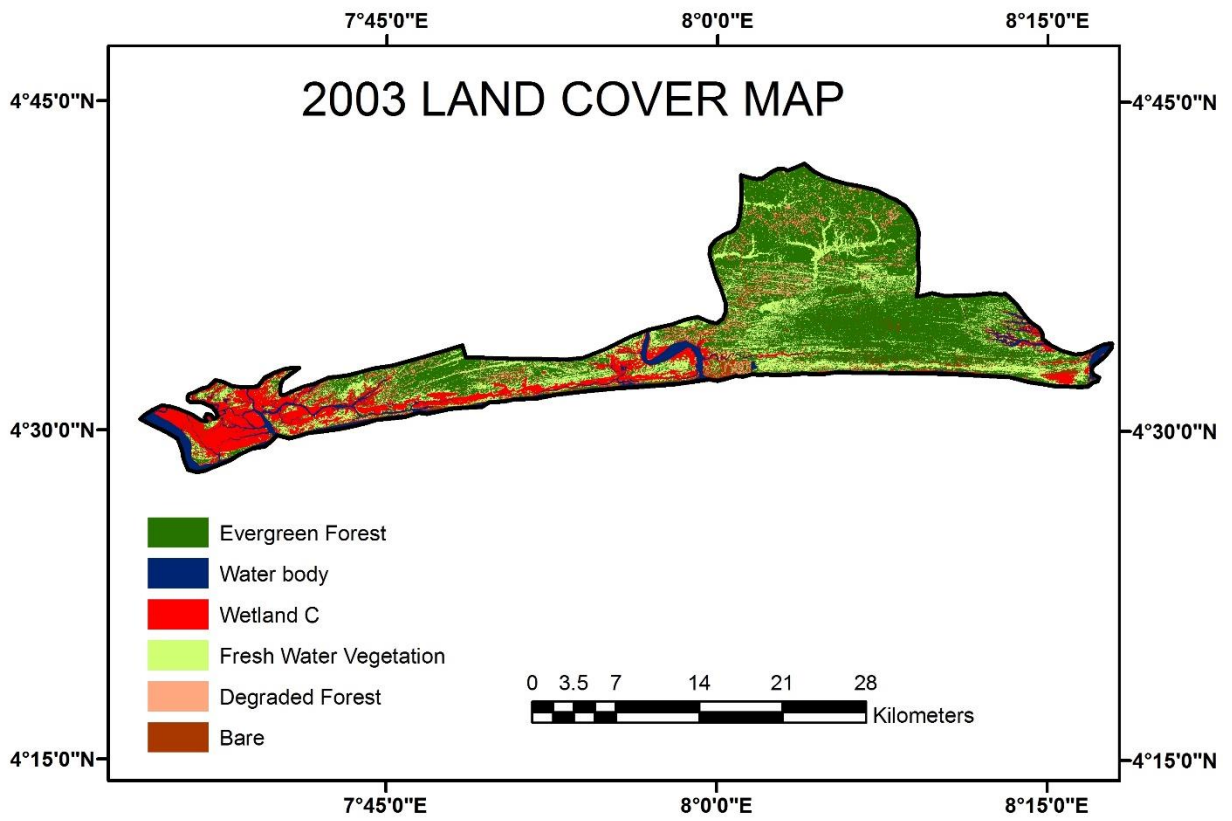


Figure 8: Map showing 2003 land cover classes

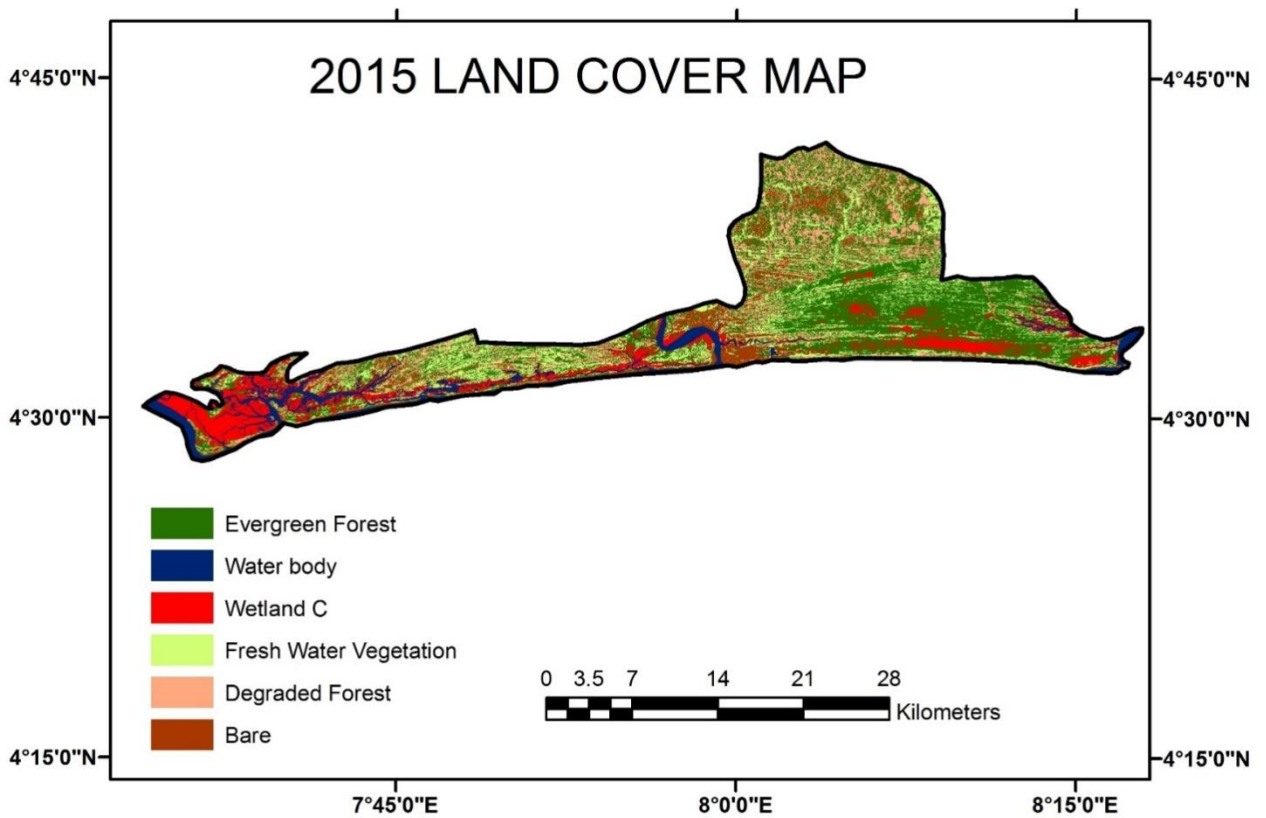


Figure 9: Map showing 2015 land cover classes.

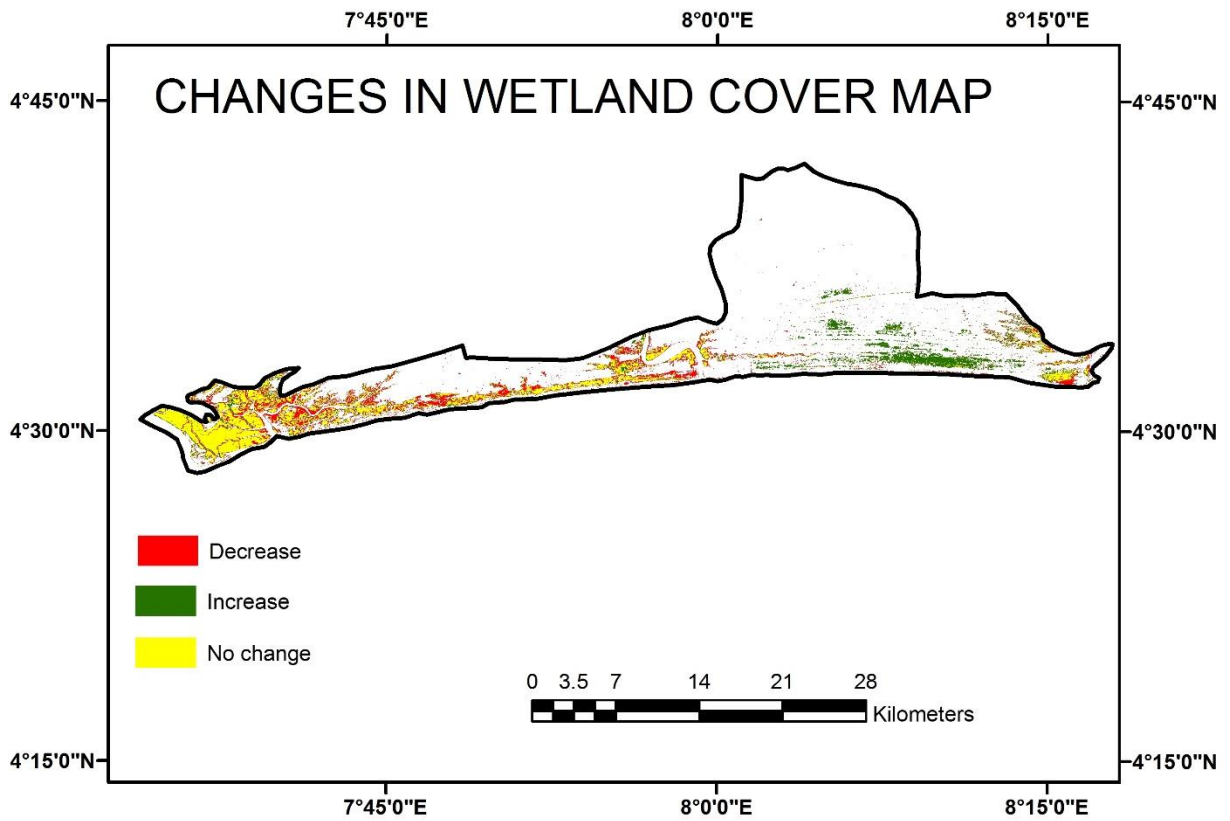


Figure 10: Map showing area of changes

### 3.3. DATA FROM FIELD INTERVIEWS ON IMPACT OF OIL ACTIVITIES ON WETLAND DEGRADATION AND AGRICULTURAL PRACTICES

Table 12: Occupation and percentage of respondents

Occupation	Response	%
Farming	25	41.666
Trading	20	33.333
Employed by multinationals	3	5
Employed by government	12	20
	<b>60</b>	<b>100</b>

During field interviews, 60 respondents were contacted, out of which 25 (42%) were farmers, 20 (33%) were traders, 3 (5%) were employed by the oil and gas multinationals, while the remaining 12 (20%) were employees of the government.

**Table 13: Showing Wetland support to agriculture in the study area**

<b>Wetland support to agriculture in the study area</b>	<b>Response</b>	<b>%</b>
Very supportive	4	16
Supportive	15	60
Somewhat supportive	5	20
Not supportive	1	4
	25	100

Out of the total 25 farmers interviewed on the level of wetland support to agriculture in the study area 16% agreed that wetland was very supportive to their livelihoods, 60% agreed that it was supportive, 20% agreed that it was somewhat supportive, while 4% are of the opinion that it was not supportive at all. According to Snapshot (2013) measuring the amount of support derived from land in agriculture is determined by the total number of hectares readily available for cultivation purposes.

**Table 14: Showing level of yield of harvested crops per year (in kg)**

<b>Level of yield of harvested crops per year (in kg)</b>	<b>Response</b>	<b>%</b>
Very high	0	0
High	9	36
Low	13	52
Very low	3	12
	<b>25</b>	<b>100</b>

On the level of yield during their harvest every harvesting season, none of the farmers interviewed accepted that they have recorded a very high yield, 36% indicated that their yield was high, 52% stated that their yield was low, while 12 complained that their harvest was very low during the year in consideration. On how yield was determined, inferences were taken from Fermont and Benson (2011) who maintained that yield is determined by the ratio of the amount of harvested product to the crop area.

**Table 15: Showing crude oil activities contribution to the degradation of the wetland of the area**

<b>Crude oil activities contribution to the degradation of the wetland of the area</b>	<b>Response</b>	<b>%</b>
Depleting the farmland areal extent	5	8.3333
Reduction of farm yield	23	38.333
All of the above	27	45
Destruction of biodiversity	5	8.3333
	<b>60</b>	<b>100</b>

Similarly, a question on how crude oil activities contribute to the degradation of the wetland was responded to by 60 selected respondents across the study area. 8% of the respondents indicated that there is a depletion in the total area of farmland available, 38% of the respondents stated that there is a general reduction in the amount of yield, 45% of the respondents are of the opinion that both depleting the farmland areal extent and a reduction of farm yield were the direct effects of the petroleum activities on the wetland environment, while 8% are of the opinion that those activities destroy not just the wetlands but the other biodiversity in the study area.

**Table 16: Showing observed changes on the wetland cover of study area over the years**

<b>Observed changes on the wetland cover of study area over the years</b>	<b>Response</b>	<b>%</b>
Increase in areal extent of cultivated farmland	4	10.256
Decrease in areal extent of cultivated farmland	9	23.076
Increased in the level of biodiversity	5	12.820
Decreased in the level of biodiversity	14	35.897
Increased in the level of degraded land size	7	17.948
Decreased in the level of degraded land size	0	0
	<b>39</b>	<b>100</b>
*Note that 21 respondents said they have not observed any change		

On observed changes in the current wetland cover of the study area over the years, 21 respondents are of the opinion that nothing has changed, while 39 insisted that there has been



a change. Out of the 39 respondents that agreed there was a change, 10% were of the opinion that the extent of the wetland was increasing, 23% of the respondents are of the opinion that the wetland was decreasing, while 13% of the respondent felt that there is an increase only in biodiversity. 36% of the respondents said that they observed changes on decreasing biodiversity, 17% respondents' observations were of an increase in the size of land that has been degraded, while no respondents indicated that degradation of the affected land size is decreasing.

### 3.4. DATA FROM FIELD INTERVIEWS ON IMPACT OF OIL ACTIVITIES ON LIVELIHOOD CHANGES

**Table 17: Showing benefits of petroleum activities and ranking of most important livelihood opportunities in the study area**

<b>Benefits of petroleum activities in the study area</b>	<b>Response</b>	<b>%</b>
Provision of employments	12	20
Provision of farm inputs	9	15
Financial assistance to the farmers	5	8.33333
Provision of standard health facilities	0	0
Provision of housing	0	0
Supporting quality and affordable education	10	16.6666 7
Financial assistance to small and medium scale enterprise	18	30
Electrification	5	8.33333
No known benefits	1	1.66666
	<b>60</b>	<b>100</b>

Out of the 60 respondents that were interviewed on the benefits of petroleum activities in the study area, 20% stated that some members of their community have benefited at some point in their life, and some were still benefiting as an employee of the oil multinationals, 15% of the respondents indicated that some of their farmers have benefited from various farm inputs, 8% were of the opinion that financial assistance was given to farmers to support their farming practice, and 17% of respondents opined that the oil multinationals have been supporting members of the community with scholarships and renovations of schools. On small and medium scale enterprises, 30% of the respondents are of the opinion that the community has

benefited from the oil multinationals, and 8% responded that their communities have benefited from donations of transformers. 2% of the respondents said that they have not seen any known benefits. No respondents indicated that there has been a provision of standard health facilities and housing.

**Table 18: Showing the supporting role of oil multinationals with respect to the local farmers**

<b>Supporting role of oil multinationals with respect to the local farmers</b>	<b>Response</b>	<b>%</b>
Provision of seeds and seedlings	0	0
Provision of fertilizers	30	50
Provision of farm other inputs	0	0
Organized training programs for local farmers	3	5
Financial assistance to farmers	14	23.3333
No known support	13	21.6666
	<b>60</b>	<b>100</b>

On a supporting role of the oil multinationals with respect to local farmers, 50% of the respondents stated there had been some provision of fertilizers, 5% of the respondents indicated they were aware of training programs organized for farmers, 23% stated there was financial assistance to farmers, while 22% said they are not aware of any known support.

**Table 19: Showing loss of source of livelihood for the residents**

<b>Loss of source of livelihood for the residents</b>	<b>Response</b>	<b>%</b>
Loss of cultivated farmland	21	42
Loss of biodiversity	3	6
Loss of aquatic life	13	26
Loss of man power in agricultural services.	4	8
Loss of employment on other ventures.	9	18
	<b>50</b>	<b>100</b>
*Note, 10 respondents said they lost nothing.		

On loss of source of livelihood due to the petroleum activities, 42% of the respondents stated there had been a loss of cultivated farmlands in the study area, 6% indicated a loss of biodiversity, 26% answered there had been a loss of aquatic life, 8% indicated a manpower loss in agricultural services, while 18% of the respondents answered there had been a loss of

employment in various other ventures. 10 respondents out of the 60 respondents interviewed said they lost nothing as a result of the presence of petroleum activities in the study area.

### **3.5. DATA FROM THE COMMUNITIES IN THE STUDY AREA AS WELL AS GOVERNMENT AGENCIES ON STRATEGIES OF WETLAND MANAGEMENT**

During the focus group interview, information on wetland management strategies by the communities included community preserved areas, periodic restrictions and periodic fallowing.

Regarding the effort of the government, environmental laws and regulations protecting wetlands in Nigeria have been developed through The National Environmental Standards and Regulation Enforcement Agency (NESREA). This regulation has been grouped under National Environmental (Wetlands, River Banks and Lake Shores) Regulations and is published in Federal Republic of Nigeria, Abuja, Official Gazette, Vol.96, (Ladan, 2012). The objectives of the regulation include, among others, the conservation wise usage of Nigeria's wetlands and their resources for tourism and ecological reasons. Wetland resources should be used in a manner that is sustainable and harmonious with the wetland's hydrological purposes and ecosystem services. All activities likely to have a negative effect on wetland must be assessed using EIA in concord with the relevant laws governing wetland activities and, finally, any person, community, or organization that is willing to undertake any activities, whether these include extractive or non-extractive utilization of Nigeria's wetlands must first obtain a permit granting such permission in accordance with the regulations.

In summary the laws and regulations are a management strategy of the government to conserve and protect wetlands and their biodiversity from unsustainable usage in Nigeria.

### **3.6. DISCUSSION**

The results clearly show that there were changes in the wetland cover in the study area as some of it has been converted to other land cover within the period of consideration. 8735 hectares of land was converted from wetland to other land cover types. The potential for the changes to have effects on biodiversity and agricultural activities in the region was noted. For instance, the conversion of wetlands into water bodies occurred mostly because of dredging of the fringe areas of the wetlands for oilfield infrastructure along what is known as right of way (ROW) on the facility sites, thereby transforming the wetland at those locations into water bodies. On the other hand, wetlands are reduced to bare cover as the heaps of dredged materials are most often deposited on the adjoining wetlands and sometimes are abandoned, thereby converting the

affected wetland area to bare cover, This also occurs during the laying of pipeline that requires a lot of sand filling for pathways that cross the wetlands. Ohimain (1996) conducted a study on the impact of dredging of the Niger Delta and concluded that it causes altered topography and hydrology, damage of vegetation and aquatic life, converted mangrove wetlands to bare heaps, grassland or freshwater forest after several years of natural weathering. His findings in the above scenario are very similar to the findings of this study. Other wetland converted into bare cover may have been caused as a result of migration of people (population expansion) due to the perceived potential of opportunities in the oil operation areas. Consequently, the conversion effects are seen in the reduction of wetlands, the destruction of fauna and flora, the reduction in wetland agricultural areas, the contamination of water and damage to aquatic life. A study conducted in eight tropical countries by Wunder (2003) concluded that more of the wetland and other land covers such as forest were altered through deforestation for reasons such as urbanization, agricultural expansion, petroleum infrastructure installation, as well as pipeline routes and buffered zones, and this has greatly deprived the host communities of access to their productive lands. The later scenario is much similar to the findings in the study area of this study.

### *3.6.1. On Impact of Oil Activities on Wetland Degradation and Agricultural Practices*

The findings on the perception of the people living in the study area on the impact of oil activities on wetland degradation and agricultural practices show that wetlands play an important role in the community as a major support to agriculture. Agriculture provides a livelihood for the majority of the indigenous people within the study area. Even though the yield recorded within the period under consideration not very attractive in terms of output, a situation that many felt is connected to the petroleum activities within the area, as some portion of the biodiversity is being degraded and destroyed. Degradation depletes the suitable area for cultivation, as well as a general reduction in the available total hectares. Practices such as the slash and burn method of agriculture may have caused the failure of ecosystem to recover and regenerate faster, and could be seen as a driving force for the observed degradation within the wetlands. This is shown in (Table 8 and Appendix I) where wetland changes to degraded forest. Responses shows that crude oil activities (such as pipeline installations; see Appendix J) cause a reduction in yield, a reduction in suitable cultivated area, and a destruction of biodiversity (Table 15). This is in line with the study conducted within the Niger Delta by Kadafa (2012) which concludes that the laying of numerous gas pipe lines in the region sometimes causes

spillage and fire incidence due to leakages and vandalism, causing fire that destroyed both farmlands and biodiversity.

Some people within the study area believe, their farm sizes are increasing, while others believe it is decreasing, while others still feel that nothing has changed. Other findings in the study reveal the reason why some areas within the study area have an increase in wetland cover: Traditional management strategies have been adhered to in most of these areas, especially the periodic restrictions and periodic fallowing strategies. This periodic buffer improved and increased the suitable areas available for farming. It was also observed that the main oil wells and oil facilities were not located in these areas (villages), even though they are also within the catchment of the host communities.

### *3.6.2. On Impact of Oil Activities on Livelihood Changes*

Findings on livelihood changes showed that the petroleum activities have benefited the people in the area in terms of employment, both directly and indirectly. Assistance to local farmers by the provision of farm inputs, fertilizers, improved seedlings, finance as well as periodic training for farmers (though not regular) has been notable. Other livelihood services that attracted support of the multinationals within the host communities included the provision of academic scholarships, the renovation of primary and secondary schools and the provision of textbooks. In the area of health, they have provided mosquito nets to households and also have renovated health centers, even though the centers are still ill equipped. Small and medium scale enterprises are also an area that has gotten the attention of the oil multinationals. Financial assistance has been distributed to organized businesses like market women associations and others through micro finance banks, to help them improve their businesses and livelihoods. Open markets have been built to further encourage and expand their businesses. In the area of electrification, the oil multinationals have provided a few transformers at some locations in the communities. Appendices G and K have a list and some pictures of some of the physical infrastructure that the Multinational Oil Companies have provided in the study area. To say the least, the MOCs are showing concern by delivering part of their corporate social responsibilities (CSR), though the perception of the local people showed that the general performance of MOCs with respect to their corporate social responsibilities is far below expectations.



## CHAPTER FOUR

### 4.1 CONCLUSION

In conclusion, the wetland area extending along the southern part of Akwa Ibom State has experienced change. One of the drivers of wetland degradation is the petroleum activities. The study showed that about 8735 hectares of the mapped wetland has been converted to other land covers causing a loss of wetland in those areas, while about 5758 hectares of other land cover has been converted to wetland in our study area from the period of time under consideration (2003 to 2015) Nevertheless; about 68% of the mapped wetland areas have not experience any notable change. A net decrease of about 2976.92 hectares of wetland cover has occurred within the period of consideration.

Changes recorded in the wetland cover of the study area were caused by petroleum, as well as other anthropogenic activities such as the slash and burn method of agriculture. Others include population expansion from migration towards the region due to perceived opportunities. These have caused the degradation of biodiversity, the conversion of wetland into bare cover for residential purposes as well as the reduction of suitable areas available for cultivation. Repeated practices of these unsustainable activities leads to the failure of the ecosystem to recover and regenerate faster. The study showed that apart from petroleum activities by the MOCs, agriculture is the dominant occupation of the people, (although fishing is important as well). Consequently the changes observed in the region's wetland have a direct effect on agriculture as farmlands have been depleted, biodiversity has been destroyed and some farmers have partially lost their livelihood. Some of this is caused by the aggregation of activities such as canalization which brings salt water into fresh water zone, land reclamation, and laying of pipelines which destroys the ecological system (UNDP 2006). Losses incurred by some local farmers in the host communities due to MOCs activities has always made some of them to feel at conflicts with the MOCs, especially in the area of socio economic deprivation and perceived marginalization in their welfare programs.

Findings also confirmed that the petroleum activities are also perceived by locals as beneficial to the study area. According to responses from stakeholders interviewed, the MOCs have provided employment for the host communities, both directly and indirectly. Other benefits that interviews touched upon include educational support, support for farmers through their organized unions, as well as support of small and medium scale businesses. However, some of

these benefits were not sufficient for many farmers, as they have left their vocation to pursue other ventures that they feel will improve their livelihood.

Wetland management has been one of the critical parts of the activities in the study area. It was noted that some of the communities have been in the business of regulating the pressure on wetlands by their seasonal restrictions of the use of the wetlands. It was also noted that the government has laws and regulations on conserving and preserving the wetlands across the country for ecological and tourism purposes.

Finally, it is necessary that the wetlands should be protected from all degrading human activities and that sustainable practices should be encouraged, especially those measures that will rescue the already degenerating wetlands for sustainable and environmental friendly ecosystem services.

#### **4.2 RECOMMENDATIONS**

From the study it has been observed that some of the wetland areas are depleting, as such, it is highly recommended that the government should enforce the conservation regulations through NESREA, which is the government agency with these responsibilities.

Government should ensure that any MOCs that have operation bases in this region should adhere strictly to these laws and regulations of sustainable oil operations. Regulating agencies should be empowered to actually carry out their mandate of checking the unsustainable environmental practices of these MOCs, as the community has very little influence over their activities.

The indigenous people should also be better incorporated in the scheme of things through sensitization of available programs to create awareness and enlightenment on the need to preserve the wetlands and to discourage such actions that jeopardize the government's aim of preserving the wetland for ecological and tourism purposes.

Remote sensing monitoring and assessment should be incorporated into the methodologies of mapping monitoring and management of these wetland areas.

A more environmentally friendly approach towards petroleum activities should be adopted.

The MOCs should, as a matter of importance, live up their agreements with the host community, by adhering to every detail of their memorandum of understanding, and also fully



exercise their CSR. Host communities should be effectively compensated for their losses if they are caused by petroleum activities.

Finally, more research should be carried out on ways of finding an alternative energy source with less deleterious environmental impacts within the study area.



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## APPENDICES

### Appendix A. Questionnaire for Respondents

#### SECTION A: RESPONDENT BACKGROUND

1. What is your marital status?

- Married
- Single
- Divorce
- Widow/Widower

2. Gender

- Male
- Female

3. Age group

- 20-30
- 30- 40
- 40-50
- 50-60
- Above 60

4. Place of residence (Name of village required?).....

5. What is your Occupation (which kind of job do you have?)

- Farming
- Trading
- Employed by multinationals
- Employed by government
- Others specify.....

#### SECTION B: WETLAND

6. How has the wetland supported the agriculture in the study area? .....

7. What are the benefits of the wetland to the area?

- Support farming
- Support fishing
- Provide ecosystem services
- Provide employment
- Source of raw materials
- Recreation and tourism
- Others specify .....

8. Have you observed any decreased of agricultural wetland in your area?

- Yes
- No

9. If yes, what is the size of decreased? (Size of farm holdings in hectares)

.....

10. How has wetland support agriculture in your locality?

- Very supportive
- Supportive
- Less supportive
- Not supportive
- Others specify.....

11. What are the estimated % of people that is involve in agriculture in the selected oil communities?

- Above 75%
- 50-75%
- 25-49%
- 1-24%
- Others specify.....

12. What are the level of yield of harvested crops per year (in kg)?

- Very high
- High
- Low
- Very low
- Others specify.....

**SECTION C: ECOSYSTEM SERVICES**

13. What are the observed services provided by the wetland in your locality?

- Supporting services (primary production, soil formation)
- Provisioning services (food, raw materials, minerals, power, water, etc)
- Regulating services (pest & disease control, waste detoxification, water purification, climate regulation)
- Cultural services (spiritual & historical values, recreation, etc)
- None of the above

14. How will you rank the ecosystem services provided?

<b>ECOSYSTEM SERVICES</b>	<b>Strongly agreed</b>	<b>Agreed</b>	<b>Undecided</b>	<b>Strongly disagreed</b>	<b>Disagreed</b>
Supporting services (primary production, soil formation)					
Provisioning services (food, raw materials, minerals, power, water, etc.)					
Regulating services (pest & disease control, waste)					

detoxification, water purification, climate regulation)					
Cultural services (spiritual & historical values, recreation, etc.)					

**SECTION D: EFFECTS OF PETROLEUM ACTIVITIES**

15. What is the effect of petroleum activities on farmlands in the study area?

- Degrading farmland
- Reducing farm yield
- Has no effect on farmlands
- 
- Others specify .....

16. What supporting role is given by oil multinationals to the local farmers in the study area?

- Provision of seeds and seedlings
- Provision of fertilizers
- Provision of farm other inputs
- Financial assistance to farmers
- Organised training programmes for local farmers
- No known support
- Others specify .....

17. What are the benefits of petroleum activities to the study area and how will you rank the most important livelihood opportunities provided?

- Provision of employments
- Provision of clean water
- Provision of farm inputs
- Financial assistance to the farmers
- Provision of standard health facilities
- Provision of housing
- Supporting quality and affordable education
- Financial assistance to small and medium scale enterprise.
- No known benefits
- Others, specify.....
- Rank according to importance (multiple options is allowed).....

18. What are the opportunities that is available as a result of public awareness of petroleum activities in the selected communities?

- Improved Farming opportunities
- Increase in small and medium entrepreneurial services
- Employment opportunities by oil multinationals
- Awareness to farmers on improve farming techniques
- Others specify.....

19. Has crude oil activities contribute to the degradation of the wetland of the area?

- Yes
- No

20. If yes, how?

- Depleting the farmland areal extent.
- Polluting the farmland by spillage/other activities
- Reduction of farm yield
- All of the above
- Destruction of biodiversity.
- None of the above

21. How is the rate of spillage?

- Very high
- High
- Low
- Very low
- Others specify.....

22. Is there any loss of source of livelihood for the residents?

- Yes
- No

23. If yes, list the sources.

- Loss of cultivated farmland
- Loss of biodiversity
- Loss of aquatic lives
- Loss of man power in agricultural services.
- Loss of employment on other ventures.
- Others, specify.....

24. What are the level of effects of the loss?

- Very high
- High
- Low
- Very low
- Others specify.....

25. What are the rate of depletion of the wetland per year?

- Very high
- High
- Low
- Very low
- Others specify.....

26. What are the rate of regeneration and recovery of the degraded wetland ecosystem?

- Very high

- High
- Low
- Very low
- Others specify.....

**SECTION E: CHANGES IN LAND COVER**

27. What are the dominant land cover found in your locality?

- Swamps
- Natural grassland
- Forest/ woodland
- Wetland vegetation
- Water
- Others, specify.....

28. What economic activities is supported most by these dominant land cover.

- Crop production
- Fishing
- Land recreation
- Water recreation
- Habitat for important Plant species
- Habitat for Important bird/animal species
- Supporting services (primary production, soil formation)
- Provisioning services (food, raw materials, minerals, power, water, etc)
- Regulating services (pest & disease control, waste detoxification, water purification, climate regulation)
- Cultural services (spiritual & historical values, recreation, etc)
- Others, specify.....

29. Have you observed any changes on the wetland cover over of your locality over the years?

- Yes
- No

30. If yes, what changes?

- Increase in areal extent of cultivated farmland
- Decrease in areal extent of cultivated farmland
- Increased in the level of biodiversity
- Decreased in the level of biodiversity
- Increased in the level of degraded land size
- Decreased in the level of degraded land size
- Others, specify.....

31. How do changes in the land cover mentioned in question 30 affect ecosystem services in your locality?

Ecosystem services	Effects				
	Ecosystem service disappear from the location	Ecosystem service quality gets less (reduce)	Ecosystem services increase in number	There is no impact at all	Not applicable

Crop production					
Fishing					
Land recreation					
Water recreation					
Habitat for Important Plant species					
Habitat for Important birds/animals					
Supporting services (primary production, soil formation)					
Provisioning services (food, raw materials, minerals, power, water, etc)					
Regulating services (pest & disease control, waste detoxification, water purification, climate regulation)					
Cultural services (spiritual & historical values, recreation, etc)					

32. Which of the changes in ecosystem services mentioned in question 30 affected you and how?.....  
.....

**SECTION F: ECOSYSTEM SERVICES VALUATION**

33. Of the ecosystem services identified, what do you consider as the most important? Score them according to your preference.

Ecosystem services	Very important	Important	Less important	Not important at all
Crop production				
Fishing				
Land recreation				
Water recreation				
Habitat for Important bird species				
Habitat for important plants/animals				
Supporting services (primary production, soil formation)				

Provisioning services (food, raw materials, minerals, power, water, etc)				
Regulating services (pest & disease control, waste detoxification, water purification, climate regulation)				
Cultural services (spiritual & historical values, recreation, etc)				

34. If you would have to divide 100 points to indicate their importance, how many would you assign to the following ecosystem services? (The more points, the higher the importance). The total must sum up to 100.

<b>Socio-economic activities (Ecosystem services)</b>	<b>Score</b>
Crop production	
Fishing	
Land recreation	
Water recreation	
Habitat for important plant species	
Habitat for important birds/animals.	
Supporting services (primary production, soil formation)	
Provisioning services (food, raw materials, minerals, power, water, etc)	
Regulating services (pest & disease control, waste detoxification, water purification, climate regulation)	
Cultural services (spiritual & historical values, recreation, etc)	

35. What percentage income do you get from the ecosystem services listed in question 14?

- 0-10%
- 10 -20%
- 20-40%
- 50% and above

**SECTION E: CONFLICTS**

36. Are there conflicts as a result of the activities of the oil multinationals with the people’s way of life in your locality?

- Yes
- No

37. What are the causes of those conflicts?

.....

.....

38. How are conflicts usually or currently being resolved?

.....

.....

**SECTION F: MANAGEMENT STRATEGIES**

39. Are you familiar with the current management strategies such as guidelines and regulations in your locality?

- Yes
- No

40. If yes, how do you rate them?

- Very good
- Good
- Poor

41. What is the current management approach to wetland by the local inhabitants?

\_\_\_\_\_

42. How has it conform to the laid down policies of government?

\_\_\_\_\_

43. Has the management been efficient so far?

\_\_\_\_\_

44. In your opinion how can these strategies be improved?

\_\_\_\_\_

**GOVERNMENT AGANCIES**

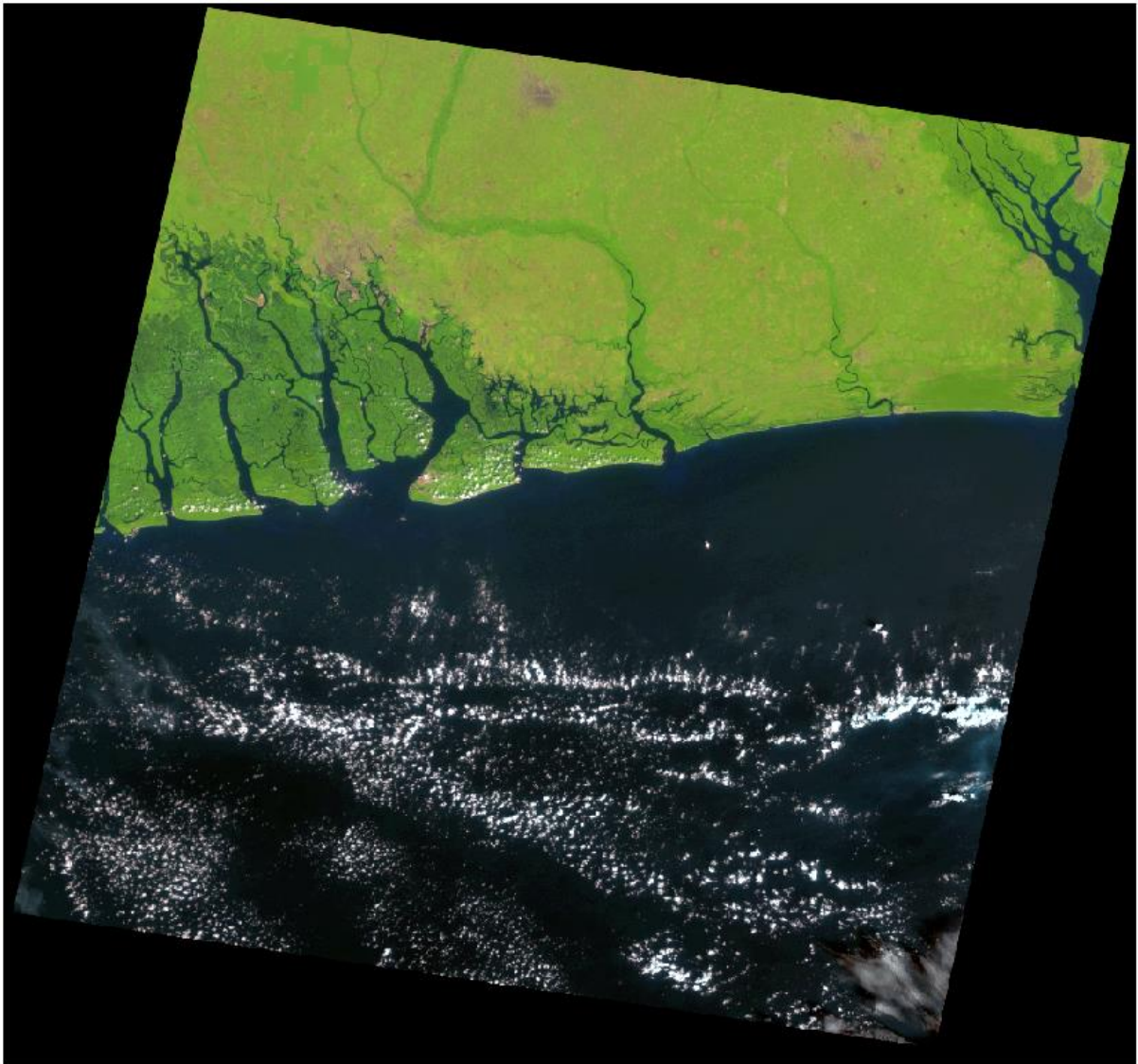
45. What is the government laid down policies governing the sustainable management of the wetland area?

\_\_\_\_\_

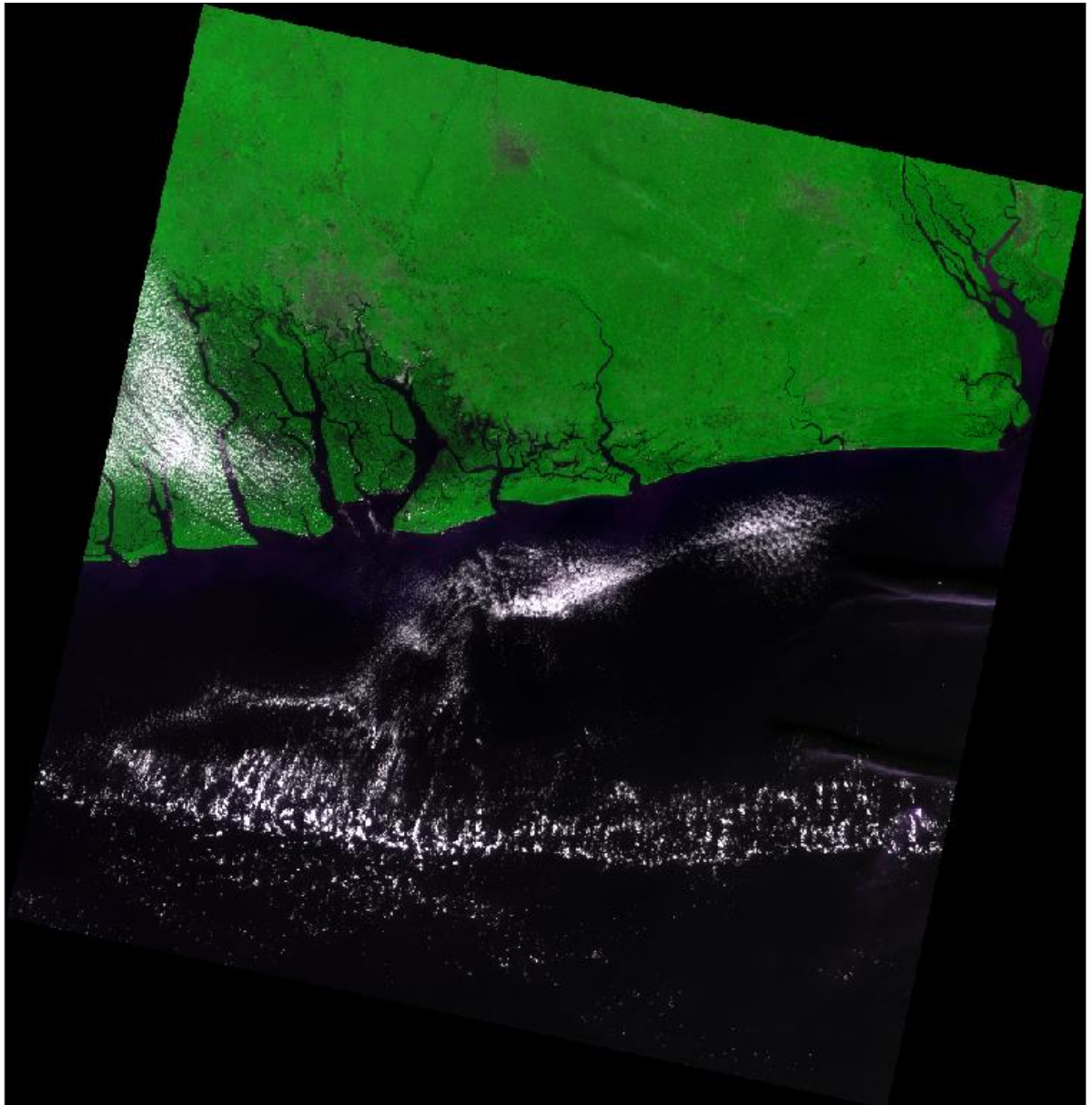
**THANK YOU VERY MUCH!**



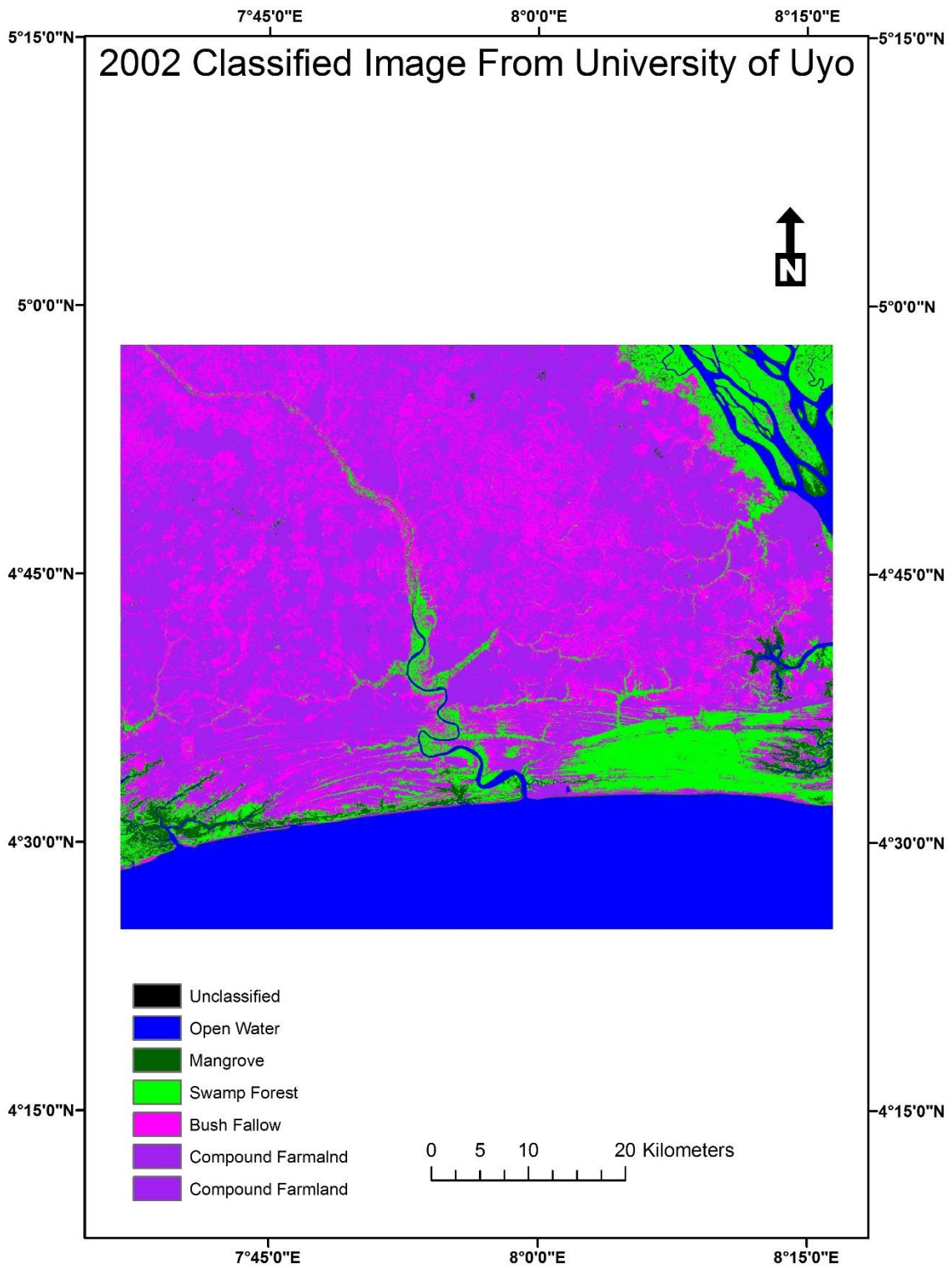
Appendix B. January 2003 Landsat 7 ETM+ image



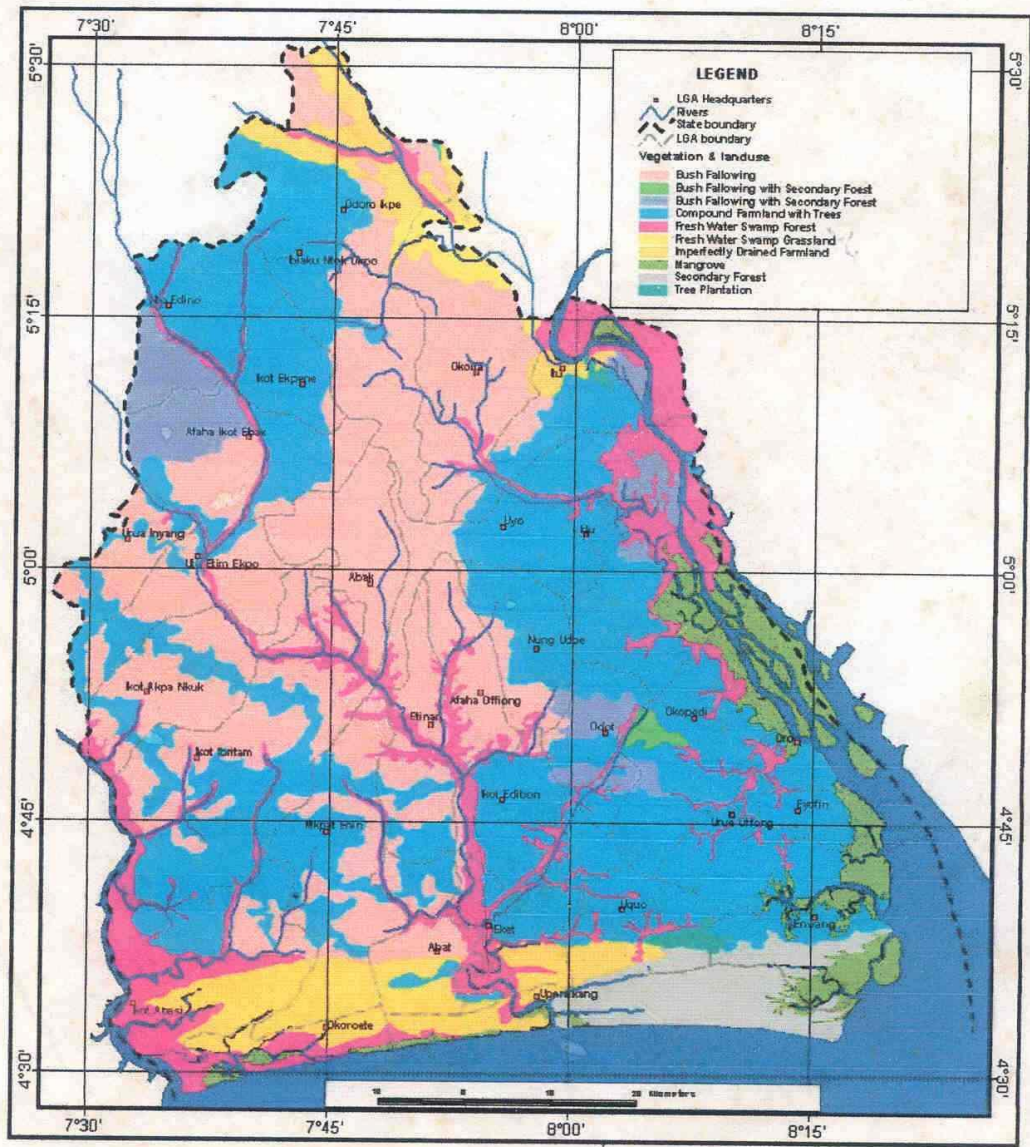
Appendix C. January 2015 Landsat 8 OLI (Operational Land Imager) and TIRS (Thermal Infrared Sensor).



Appendix D. November 2002 classified Landsat 7 ETM+ image from University of Uyo.

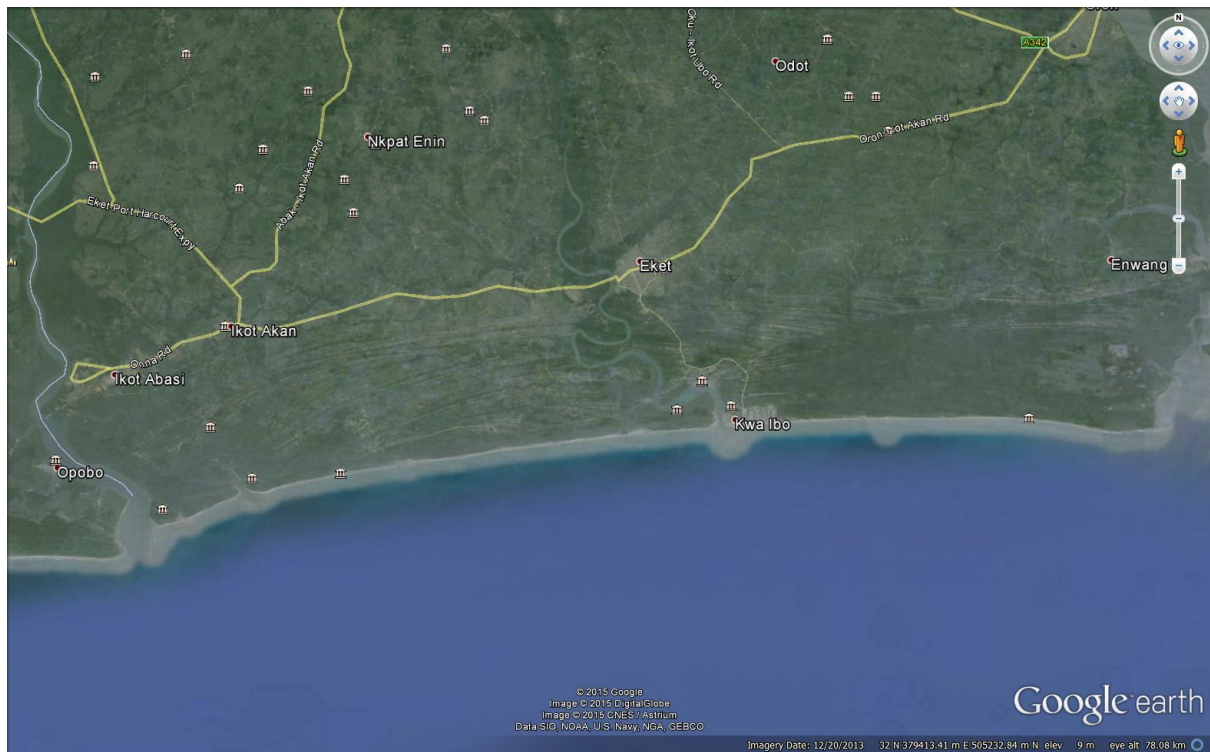


# AKWA IBOM STATE: VEGETATION AND LAND USE



SOURCE: Cross River Basin Development Authority

Appendix F. Google earth 2015 image with resolution of 0.9 meters



Appendix G. List of Projects embarked upon my Multinational Oil Companies (MOCs)

	LOCATION OF PROJECT	PROJECT DISCRPTIONS	PROJECT EXECUTORS
1	Iko, Eastern Obolo LGA	Renovation of six classroom block, community secondary school	Total E&P Nigeria limited
2	Iko, Eastern Obolo LGA	Renovation of science laboratory block	Amni Afren
3	Eastern Obolo LGA	Provision water	Shell Petroleum Development Company Nigeria limited (SPDC)
4	Eastern Obolo LGA	Provision of public library	Total E&P Nigeria limited
5	Esit Eket LGA, james town	Renovation/ re-roofing of education authority secretariat	Mobil producing Nigeria limited
6	Esit Eket LGA, Akpautong	Construction of six classroom block	Mobil producing Nigeria limited
7	Esit Eket LGA, urua okok	Construction of open market stalls	Mobil producing Nigeria limited
8	Esit Eket LGA, Etebi	Construction of nurses quarters in the health centre	Mobil producing Nigeria limited
9	Esit Eket LGA, mbak uyo	Perimeter fencing of health center	Mobil producing Nigeria limited
10	Esit Eket LGA, mbak uyo	Renovation of town hall.	Mobil producing Nigeria limited
11	Esit Eket LGA, nka akwata	Construction of four market stalls.	Mobil producing Nigeria limited
12	Esit Eket LGA, etebi	Construction of four classroom block at govt primary sch.	Mobil producing Nigeria limited
13	Esit Eket LGA, Epenedi	Construction of Primary health centre	Mobil producing Nigeria limited
14	Esit Eket LGA, urua okok	Water project	Mobil producing Nigeria limited
15	Esit Eket LGA, Ikpa	Renovation of police station	Mobil producing Nigeria limited
16	Esit Eket LGA,Ikpa	Perimeter fencing of union technical collage	Mobil producing Nigeria limited
17	Esit Eket LGA,Ikpa	Renovation of classroom blocks.	Mobil producing Nigeria limited
18	Esit Eket LGA, Ekpene obo	Renovation of town hall.	Mobil producing Nigeria limited
19	Esit Eket LGA	Perimeter fencing of paramount rulers palace	Mobil producing Nigeria limited
20	Ibono LGA	Construction of health centre	Mobil producing Nigeria limited
21	Ibono LGA	Provision of transformer	Mobil producing Nigeria limited

Appendix H. Some of the notable Wetland changes, from wetland to forest and from wetland to bare

(1)



(2)



(3)

Appendix I. Degrading wetland by slash and burn agricultural practices



Appendix J. Oil and Gas Pipelines are very common feature in the study area, cultivated wetlands have been lost to create 'right of way' for these oil facilities.





Appendix K. Some of the livelihood changing projects of the MOCs in the study area.



Electricity project at Ibenu



School block at Eastern Obolo



School block at Eastern Obolo



Renovation of Health Center at Ibenu



Water project at Ibenu



Market project at Esit Eket



**Department of Physical Geography and Ecosystem Science, Lund University**

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