

**EFFECT OF LIMESTONE MINING ON VEGETATION COVER IN MBAYION,  
GBOKO LOCAL GOVERNMENT AREA, BENUE STATE, NIGERIA**

*BY*

**Abigail Ngukuran MKAANEM**

DEPARTMENT OF GEOGRAPHY  
FACULTY OF SCIENCE  
AHMADU BELLO UNIVERSITY, ZARIA  
NIGERIA.

JULY, 2015.

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BY

Abigail Ngukuran MKAANEM, B Sc. (B.S.U. Makurdi) 2007  
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A THESIS SUBMITTED TO THE SCHOOL OF POSTGRADUATE STUDIES, AHMADU  
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AND GIS.

DEPARTMENT OF GEOGRAPHY  
FACULTY OF SCIENCE  
AHMADU BELLO UNIVERSITY, ZARIA  
NIGERIA.

JULY, 2015.

## **DECLARATION**

I declare that the work in this thesis entitled “EFFECT OF LIMESTONE MINING ON VEGETATION COVER IN MBAYION, GBOKO LOCAL GOVERNMENT AREA OF BENUE STATE, NIGERIA” has been performed by me in the Department of Geography. The information derived from the literature has been duly acknowledged in the text and a list of references provided. No part of this thesis was previously presented for another degree or diploma at this or any other Institution.

**Abigail Ngukuran MKAANEM**

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Name of Student

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Signature

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Date

## CERTIFICATION

This thesis entitled “EFFECT OF LIMESTONE MINING ON VEGETATION COVER IN MBAYION, GBOKO LOCAL GOVERNMENT AREA OF BENUE STATE, NIGERIA”, by Abigail Ngukuran MKAANEM meets the regulations governing the award of the degree of Master of Science (GIS and Remote Sensing) of the Ahmadu Bello University, Zaria and is approved for its’ contribution to knowledge and literary presentation.

**Dr. I. J. Musa**

\_\_\_\_\_  
Chairman, Supervisory Committee

\_\_\_\_\_  
Signature

\_\_\_\_\_  
Date

**Dr. B. Akpu**

\_\_\_\_\_  
Member, Supervisory Committee

\_\_\_\_\_  
Signature

\_\_\_\_\_  
Date

**Dr. I. J. Musa**

\_\_\_\_\_  
Head of Department

\_\_\_\_\_  
Signature

\_\_\_\_\_  
Date

**Prof. A. Z. Hassan**

\_\_\_\_\_  
Dean, School of Postgraduate Studies

\_\_\_\_\_  
Signature

\_\_\_\_\_  
Date

## **DEDICATION**

This work is dedicated to the Almighty God, my lovely parents Mr and Mrs Mkaanem, Dennis Tyoparegh and my adorable husband Mr James Nguuma Sombo.

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## ABSTRACT

Mbayion district which hosts one of the cement companies in the country is seen to be undergoing changes in various land-use/land-cover types especially with the commencement of mining in the area in 1980. With subsequent increase in mining activities especially around 2004, noticeable environmental problems among others include extensive vegetal clearance/deforestation, conversion of lush green landscape into mine spoils as well as degradation of agricultural lands. Although, mining companies are mandated to put in place measures that could cushion the environmental effect of their activities, the sincere adherence to such policies is an issue of great concern. This study is therefore aimed at assessing the effect of limestone mining on vegetation cover in Mbayion, Gboko LGA of Benue State with specific objectives which are to: characterize the land-use /land-cover of the area, determine the extent of vegetation cover of the area, analyse the rate of vegetation change as well as to determine the extent to which mining has affected vegetation cover in the area. Using Remote Sensing/GIS functionalities, satellite images acquired for the area in 1976, 1986, 2001 and 2011 were each classified into five land-use/land-cover classes so as to determine the spatial coverage of each land-use class. Overlay analysis was also carried out to determine the extent to which mining activities has displaced vegetation cover over the study years. The results obtained from the analysis shows that vegetated land has continually reduced over the study period from 190.15 km<sup>2</sup> in 1976 to 130.18 km<sup>2</sup> in 2011 while waste land increased from nothing in 1976 to 1.24Km<sup>2</sup> in 2011. It also revealed that about 0.88km<sup>2</sup> of vegetation cover was displaced by waste land in 1986, 0.95 km<sup>2</sup> in 2001 and 1.1km<sup>2</sup> in 2011. This decrease in vegetated land in conjunction with an increase in wasteland denotes land degradation which is capable of creating unfavourable condition for future re-vegetation and if proactive measures are not put in place to checkmate this trend, a large portion of the study area will be gradually degraded. It is therefore recommended that Stringent and rigorous efforts of re-afforestation and land reclamation should be intensified especially around the mine area. The use of Remote Sensing and GIS techniques in order to enhance a holistic land-use/land-cover change monitoring and management especially around mine areas is also recommended.

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## **CHAPTER ONE**

### **INTRODUCTION**

#### **1.1 BACKGROUND TO THE STUDY**

Mining is any activity that involves excavating the earth surface for the purpose of exploiting its mineral wealth. This could be for local economic and industrial development or for export purposes (David, 2002). If properly coordinated, its positive socio-economic impact cannot be overemphasized as it provides natural resources for consumption, offers jobs, as well as a source of revenue and foreign exchange. It also leads to the development of some socio-economic infrastructures like roads, schools, hospitals, among others (David, 2002; Hilson, 2002).

The industry has been, and in many cases remains important to the socio-economic development of many developed and industrialized countries such as Australia, Canada, Sweden, and the United States. Various cities and regions have built their wealth and industrial development at least in part, on mining. Historical examples include Monterrey in Mexico, Colombia among others (Akande & Idris, 2005; Imasiku, 2008). In developing countries also, mining will continue to provide technological development and employment. According to Imasiku (2008), large-scale mineral exploitation has contributed over 90% of all foreign exchange earnings, 60% of Gross National Product, 50% of total government revenue and 30% of total employment in some Southern African Countries. Similarly, small scale-mineral exploitation provides a source of livelihood for those in rural and semi-urban Africa.

If not properly organized however, it can result to various environmental problems, this according to Maponga (1995), has made mineral exploitation to be of global interest. The industry's operations ranging from prospecting to excavation are seen to be causing several environmental problems ranging from erosion, pollution, formation of sinkholes, vegetation loss, bio-diversity loss, heavy metal and organic contamination of groundwater and surface water (Mason, 1997). Kiranmay (2005) also asserted that mining causes massive damage to landscape and biological community as plant communities get disturbed and subsequently become impoverished thus presenting a very rigorous condition for its growth. According to the author, the dumping of mine overburden results into several destruction of surrounding vegetation and this leads to severe soil and water pollution.

Vegetation, which refers to the plant cover of the earth, according to Kumi-Boateng, Boye and Issaka (2012) displays patterns that reflect a wide variety of environmental characteristics as well as temporal aspects operating on it. According to the authors, this is due to the fact that it supports critical functions in the biosphere by regulating the flow of numerous biogeochemical cycles like that of water, carbon, and nitrogen; it is also of great importance in local and global energy balance. Vegetation also strongly affects soil characteristics, including soil fertility, chemistry and texture (Adekeye, 2001; David & Mark 2005).

Though vegetation is of high environmental and biological importance, it is often under intense human pressure in mining areas especially where surface mining and illegal small scale mining activities are prevalent resulting into changes in land-use/land-cover of mine areas. Directly or indirectly, mining has been seen to be a major factor responsible for

vegetation loss in mining areas the world over (Maponga, 1995; Adekeye 2001; David & Mark 2005). Directly, it is caused by vegetation clearance for various mining activities and indirectly, with dust pollution as plenty of dust is discharged into the air during the process of quarrying. This eventually gets deposited on the leaves of plants and flowers as well as the soil supporting the plants. The overall effect of this is that the photosynthetic and fruiting ability of the plants is impaired. Adekeye (2001) and Maponga (1995) asserted that when calcium, sulphur-dioxide among other chemical constituents enter the plants through the stomata pores it leads to the destruction of chlorophyll and disruption of photosynthesis in plants subsequently leading to stunted growth or death.

The exploitation of mineral resources has assumed prime importance in several developing countries including Nigeria which is endowed with abundant mineral resources; this has contributed immensely to the socio-economic status of the country (Ajakaiye, 1985; Adekoya, 2003). Irrespective of the socio-economic importance of mineral resources, Aigbedion and Iyayi (2007) stated that the three stages of mineral development (i.e exploration, mining and processing,) however have caused different types of environmental damages, which include ecological disturbance, destruction of natural flora and fauna, pollution of air, land and water, among others. According to Aigbedion (2005), the scale of operations involved in each stage of mineral development however determines the intensity and extent of vegetation loss and subsequent environmental degradation. Thus a greater damage is witnessed most specifically in the localities where the minerals are been mined.

In Nigeria, the situation of vegetation especially in mining regions over the years has been deplorable, in his work Aigbedion (2005) stated that large-scale mining of tin and associated minerals in the Jos Plateau has given room to high degree of degradation of arable land, vegetation and landscape resulting into several other environmental problems. According to the author, vegetation in form of natural forest or crop plantation is usually the first casualty to suffer total or partial destruction during the exploration and exploitation of minerals in a locality. For example, in the Niger Delta where oil is mined, oil spillage on vegetation has caused loss of palm tree plantations within the area (Tolulope, 2004). Recent environmental impact studies of limestone mining in Sagamu has also revealed a decline in kola nut output from the plantations within a few kilometers radius of the mine (Adekoya, 2003; Tolulope, 2004; Aigbedion, 2005)

Within the Jos Plateau, Adekoya (2003) stated that large amount of vegetation was stripped due to the open cast mining method employed by the miners. This has given rise to the destruction of the scenic landscape which is replaced by unsightly large irregular holes and heaps of debris produced by the opencast method of mining. The alteration of the landscape invariably creates a problem of erosion in the mining localities with the result that most of the opencast pits are filled with water. According to Aigbedion and Iyayi (2007) also, a similar situation exists in all the limestone and marble quarries in differing proportions at Ewekoro, Sagamu, Nkalagu, Gboko, Ashaka, Kalambaina, Okpilla, Jakura among others.

Following the discovery of limestone traces in Mbayion, Gboko Local Government Area, Benue State of Nigeria in 1960, a cement plant was established within the region and it commenced operation in 1980. Subsequently, in 2004 with Dangote Industries Plc. as the new management of the company, an aggressive upgrading and rehabilitation of the plant was carried out and this has subsequently transformed the company into a new state-of-the-art cement factory with two 1.4 million tonnes lines (Vetiva Research, 2010).

Due increase in quarrying activities caused by the upgrade of the processing plant within the study area, the natural vegetation belt of the area which is characterised with the presence of tall grasses and tall trees is been threatened as it has to be cleared to give room for mining activities. The consequences of vegetal deterioration within the study area are however enormous with various environmental and economic implications as agriculture is the main source of income for people living within the study area. Against this backdrop, the assessment of the effect of mining within the area especially as it affects vegetation becomes necessary.

Remotely sensed data which facilitates the synoptic analysis of earth's systems patterning to change at local, regional and global scales as stated by Burrough (2000), has therefore provided an opportunity for a prompt and accurate access to data that is needed to assess such changes. According to Muchoney and Haack (1994), satellite imageries have proved to be very valuable tools for studying various aspects of vegetation such as vegetation character, vegetation change, vegetation degradation and percentage cover of vegetation. This is due to

the fact that satellite sensors are capable of discerning many of the changes in physiognomy characteristics of vegetation through spectral radiance measurement.

Conversely, voluminous data gathered from different sources including Remote Sensing are better handled and utilized with the help of Geographical Information Systems (GIS) which provides great flexibility for the storage, analysis and modelling of such geographic data. Against this backdrop, the successful application of Remote Sensing/GIS by various researchers to promptly and accurately monitor various environmental components around mine areas including vegetation cover has therefore provided an opportunity for the extensive usage of these technologies in assessing the effect of limestone mining on vegetation cover within the study area.

## **1.2 STATEMENT OF THE RESEARCH PROBLEM**

Generally, industrialization like every phenomenon that has benefits also has negative consequences. The impact of mining activities on water, land and vegetation including forest ecosystems has become a matter of serious concern. Acknowledging the economic contributions of mining, however, several economies lost sight of environmental effects associated with mining activities.

In many parts of the world, particularly in developing countries, where minerals are extracted using crude mining methods, or even, operating outside the legal and regulatory frame-work, it results into pollution, direct dumping of waste and effluents into rivers, improperly constructed dams, river damage in alluvial areas, river siltation, erosion, deforestation,

vegetation loss, landscape destruction among others as cited by Hentschel, Hruschka and Priester (2002); Mason (1997) and Maponga (1995). Nigeria being a developing country belongs to where these types of activities have the potential to thrive and indeed are thriving Adekeye (2001).

In Nigeria however, the history of mining dates back to the colonial era and it has generated substantial revenue to the government and contributed immensely to the socio-economic development of their host communities (Adetunji, Osiyanbola, Funtua, Olusunle, Afonja and Adewoye 2005). These desirable effects of mining can however be overshadowed by adverse effect if not checkmated as outlined by Mokobia and Balogun (2004); Aigbedion and Iyayi (2007); Olaleye and Oluyemi (2010) to include geological disturbances, destruction of fauna and flora, air pollution, landscape degradation among others.

As a bold attempt in controlling such effect by the Nigerian Government, the Federal Environmental Protection Act of 1987 was enacted as a requirement for the establishment of companies with such noxious effect as cited by Adekeye (2001). Although, several mining companies in the country claim to have responded to this act by instituting and implementing several measures to reduce the negative environmental effect of their activities, whether some of these measures have or are capable of reducing the negative effect of mining on the environment and surrounding communities is a matter of great concern as mining operations in many developing countries are mostly carried out outside the legal and regulatory framework of such countries (Hentschel, Hruschka & Priester, 2002).

This could be seen in the findings of research works conducted around mine areas in order to assess the effect of mining on various components of the environment. One of such research was conducted by Ramachandra and Savitha (2000) on vegetation analysis in Uttara Kannada district using GIS and Remote Sensing techniques. The research classified the land-use of the study area as urban area, water bodies, agricultural land, forest cover, and waste land. However, further classification was carried out on the basis of forest type where forest vegetation were categorized as semi-evergreen, evergreen, moist deciduous, dry deciduous, plantations and scrub, thorny and non-forested area. From the assessment, it was observed that considerable decrease of natural forest occurred within the area as a result of increase plantations and social forests. This study however did not focus on determining the extent, pattern and trend of vegetation cover change within the area.

In the same vain Kumi-Boateng, Boye, and Issaka (2012) applied the use of Remote Sensing and GIS techniques to assess the impact of mining on vegetation in the Tarkwa Mining Area (TMA) of Ghana. The researchers discovered that there was observable impact of mining on vegetation. According to the authors, about 378 km<sup>2</sup> of closed canopy of the study area were transferred to open canopy between 1986 and 1990. During that same period about 24 km<sup>2</sup> of closed canopy was converted to mining areas. Between 1986 and 2007, a total of 229.07 km<sup>2</sup> of various land-use/cover types were transferred to mining areas. Even though this study employed the use of supervised classification, it was conducted in a different geographical area where different land-use/land-cover types could be identified during the analysis.

Anil and Katyar (2010) also analysed the impact of open cast mines on land-use/land-cover in Chandrapur District of Maharashtra State. From the study, the results showed that there were enormous changes especially in vegetation and agricultural area as areas of dense vegetation were converted either into mine land or artificially created mountains of mine overburden. The water bodies were also observed to increase from 151.898 km<sup>2</sup> to 321.568 km<sup>2</sup> due to excavation of huge quantity. The author also observed that water bodies seems to be increased in the study area from 151.898 km<sup>2</sup> to 321.568 km<sup>2</sup> with the observed change has occurring not because of natural water surface bodies but due to excavation of huge quantity of material below the earth surface. Even though this research work concentrated on the use of Remote Sensing and GIS techniques, there is a variation in the classification technique as unsupervised and ISODATA cluster algorithm method were unlike the supervised and maximum likelihood technique that was used in this present research work in order to solve the problem of ambiguity which is associated with unsupervised classification. This is due to the fact that supervised classification unlike the unsupervised technique gives room for defining classification classes, this helps in improving the ability of the researcher to differentiate between classes during analysis, thereby producing a more accurate and reliable result as compared to the unsupervised method.

Aribigbola, Fatusin and Fagbohunka (2012) also carried out a research on health and environmental challenges in Ewekoro, Ogun State. The researchers discovered that mining activities have resulted into the conversion of farmlands into quarry sites. Deforestation and loss of vegetation cover within the mine area was eminent as this was necessitated by the need

to move equipments to the site, removal of the topsoil or overburden, stemming of explosives and removal of blasted lime stones as well as the rise of dust during blasting and hauling of the mineral. Using questionnaire and field survey, the research focused more on the health challenges that are associated with the mine area hence it could not determine the spatial extent of the environmental impact.

From the aforementioned research works, it is eminent that mining has greatly affected several environmental components especially vegetation cover around mine areas. The severity of the effect however depends on the methods used in mining the ores as well as the scale of the mining (Fyles, Fyles and Bell, 1985). It therefore implies that surface mining method (opencast method) which is the mining method employed by the mining company (Vetiva Research, 2010) which involves the process of breaking up of overburden soils and rocks by explosives coupled with expansion in mining activities beginning from 2004, several environmental problems could be envisaged within the study area among which are pollution, soil degradation, vegetal clearance and deforestation.

Recent observations have also shown an alarming rate of vegetal clearance/deforestation due to this increase in quarrying activities within the area. This has posed a major issue of concern as land is extensively cleared to give room for mining activity as well as movement of heavy duty equipment's and vehicles such as bull-dozer, pay-loaders, excavators, trucks among others to the site. This has resulted in large scale depletion of vegetal cover, erosion of top soil, degradation of agricultural lands as well as the conversion of original lush green landscape into mine spoils. These changes in the long run are capable of creating very serious

environmental problems like deterioration of the land, environmental damage, famine and/or other unanticipated and undesirable effects.

Although literatures abound the world over on the use of Remote Sensing and GIS techniques in assessing the effect of mining activities on vegetation, to the best of the researcher's knowledge, none of these studies is concerned with the use of Remote Sensing and GIS in assessing the effect of limestone mining on vegetation cover in the study area. It is in view of the above fact that the researcher seeks to assess the effect of mining activities on vegetation cover in Mbayion, Gboko Local Government Area of Benue State using Remote Sensing and GIS.

In line with the problem outlined above, some key research questions to which answers would be sought are:

1. What are the land- use/land-cover classes of Mbayion in 1976, 1986, 2001, and 2011?
2. What was the extent of vegetation cover in the area in 1976, 1986, 2001, and 2011?
3. What are the changes that have occurred in the land-use/land-cover classes of the area between the study years?
4. What is the rate of change in vegetation cover of the area between 1976 to 2011?
5. To what extent is mining responsible for the change in vegetation cover within the study area?

### **1.3 AIM AND OBJECTIVES OF THE STUDY**

The aim of the study is to assess the effect of limestone mining on vegetation cover in Mbayion, Gboko LGA of Benue State. This aim was achieved through the following objectives:

- i. characterize the land-use /land-cover of the area in 1976, 1986, 2001, and 2011
- ii. determine the extent of vegetation cover in the area in 1976, 1986, 2001 and 2011
- iii. determine the land-use /land-cover change in the area between the study years
- iv. analyse the rate of vegetation change in the study area between 1976 to 2011
- v. determine the extent to which mining has affected vegetation cover in the area between 1976 to 2011

### **1.4 THE SCOPE OF THE STUDY**

The spatial scope of this study covers the whole of Mbayion district, Gboko Local Government Area of Benue State. In terms of content, the study will assess the effect of limestone mining on vegetation cover in the study area for the time period of 35 years, that is, from 1976 to 2011, using 1976 as the base year as mining started within the area in 1980.

### **1.5 SIGNIFICANCE OF THE STUDY**

Mining is essential in the economic development of any country endowed with mineral resources. This is due to both internal and external economic benefits that are made available to countries that are involved in the extraction of mineral resources. Internally, there is the creation of employment and revenue generation among others while externally; a substantial foreign exchange is available to such countries. However, looking at the socio-economic

importance of the industry, most countries lose sight of the ensuing effect that might be accrued to an area as a result of the mining activities.

Based on the aforementioned, a research of this nature is significant as it will seek to provide an empirical data to ascertain whether or not mining activities has affected land-use/land-cover of the area in general and on vegetation in particular. Assessing the effects of limestone mining on vegetation in Mbayion will also provide large volume of data which could be used for mining development, planning and management in Nigeria, Benue State and the study area in particular.

A study of this nature will also add to the wealth of knowledge as regards the use of Remote Sensing and GIS technique in assessing the impact of several developmental projects within and outside of Benue State as the technique is capable of assessing large area within a short period with high level of accuracy and reliability of its result. This will therefore help policy and decision makers in taking prompt decision as regards such projects within good time.

## **CHAPTER TWO**

### **CONCEPTUAL FRAMEWORK AND LITERATURE REVIEW**

#### **2.1 INTRODUCTION**

This chapter is subdivided into two sections with the first part reviewing literature on the concept of mining, vegetation, Remote Sensing (R/S), Geographic information System (GIS) and Importance of R/S and GIS in Environmental Impact Assessment. The second section of this chapter deals with the review of previous works on the application of Remote Sensing and GIS in detecting vegetation change in mining areas.

#### **2.2 CONCEPTUAL FRAMEWORK**

##### **2.2.1 Mining**

Mining generally refers to the extraction or removal of ore from the ground. According to Acheampong (2004), it is the removal of minerals from the earth crust in the service of man. It is the selective recovery of minerals and materials, other than recently formed organic materials from the crust of the earth. From the above definitions, it can be deduced that mining is a human activity that deals with the excavation and extraction of valuable materials from the earth crust other than agricultural products. Such materials mined by humankind are broadly grouped as fuels, metals, and non-metallic minerals. Metallic ores/minerals are those ores of the ferrous metals like iron, manganese, molybdenum, and tungsten, the base metals like copper, lead, zinc, and tin, the precious metals like gold, silver, the platinum group metals, and the radioactive minerals like uranium, thorium, and radium. The Non-metallic minerals also known as industrial minerals are the nonfuel mineral ores that are not associated

with the production of metals. These include among others phosphate, potash, halite, trona, sand, gravel, limestone, sulphur. Fossil fuels also known as mineral fuels are the organic mineral substances that can be utilized as fuels, such as coal, petroleum, natural gas, coal bed methane, gilsonite, and tar sands among others (Adekoya, 2003; Kesler, 1994).

According to Akabzaa and Darimani (2001) the process of excavating the earth surface for valuable materials employs the use of two main methods which include Open cast and Underground mining. Open-casting or surface mining is a type of strip mining that involves the extraction of ore deposit that are located near the earth surface or ones that has a low stripping ratio. This method which excavate and extract ore/mineral deposits at a substantial underground depth necessitate the removal of layer upon layer of overburden as well as the creation of a pit that extends below the groundwater table. The removal of overburden usually involves logging of trees and clear-cutting or burning of vegetation above the ore deposit with the use of heavy machinery like bulldozers and dump trucks, this renders it as the most environmentally destructive type of mining, especially within tropical forests. Irrespective of its environmental destruction nature, open cast mining is however the predominant exploitation procedure used worldwide to excavate and extract almost all minerals excluding petroleum and natural gas (Fyles, Fyles & Bell, 1985; Akabzaa & Darimani, 2001; Aigbedion & Iyayi, 2007). According to reports of National Mapping Division, U.S. Geological Survey (1995), it produces about 85% in the United States with about 98% of metallic ores, 97% of non-metallic ores and 61% of coal. Its major advantage over the underground mining method however includes high productivity, low operating cost as well as good safety conditions. This

is the most common method used for mining limestone within the country in general and the study area in particular.

Underground mining on the other hand refers to any sub-surface vertical or horizontal excavations that are made for the extraction of minerals. This method has little effect on the vegetation and the ecosystem in general as a minimal amount of overburden is removed to gain access to the ore deposit. Access to ore deposit using this method is however gained through tunnels or shafts. Although underground mining is a less environmentally destructive, it is often more costly and entails greater safety risks than open-pit mining. While most large scale mining projects involve open-pit mining, many large underground mines are in operation around the world (Akabzaa & Darimani, 2001).

Historically, Mining operation is second only to agriculture as the world's oldest and important activity and its history is parallels to the history of civilization (Sarma & Kushwaha, 2005). In its simplest form, mining began with Paleolithic humans during the Stone Age where pieces of loose masses of rock outcrops were used as crude materials for chipping and shaping flint into tools and weapons (Lewis & Clark, 1964). However, the oldest known underground mine, a hematite mine at Bomvu Ridge, Swaziland is from the Old Stone Age (Gregory, 1980). Metallic minerals also attracted the attention of prehistoric humans where metals were obtained by washing river gravel in placer deposits. With the advent of the Bronze, Iron Ages and Nuclear Age, however, humans discovered smelting and learned to reduce ores into pure metals or alloys, which greatly improved their ability to use these metals

resulting into advancement of the mining industry (Lewis and Clark, 1964; Gregory 1980; Raymond, 1984).

The history of organized mining in Nigeria however dates back to the colonial era around 1903 with the creation of Mineral Survey of the Northern and Southern Protectorates by the British Colonial Government. Subsequently, in 1940s, Nigeria was a major producer of tin, columbite, and coal but with the discovery of oil in 1956 more concentration was subsequently given to oil extraction to the detriment of solid mineral extraction industry (Ministry of Solid Minerals Development, 2000; Adekeye, 2001; Adetunji, *et al.*, 2005; Aigbedion & Iyayi, 2007). After Nigeria's Independence the major economic policies emanating from the new government was that of import substitution with emphases on local production of hitherto imported consumers' goods. According to Oyebanji (1983) and Adekeye (2001), these policies encouraged investments not only in the oil and gas sector but also in the solid mineral sector so as to reduce the Country's over dependence on revenues from oil and gas which was the main stay of the economy.

Consequently, several large scale industries were built by the various levels of governments within various states of the federation including Benue state. This was made possible within Benue State as the discovery of limestone traces in Mbayion; Gboko Local Government Area of the State in 1960 sprouted both the Federal and State Government to initiate a plan of building a cement plant within the region. Eventually, Benue Cement Company (BCC) was founded on July 1975 with its first operation on August 1980 with the Factory Premises

situated by Kilometre 72 Makurdi-Gboko Road, Tse-Kucha, Gboko Benue State (Vetiva Research, 2010).

### **2.2.2 Vegetation**

The term vegetation is used in ecology to describe the overall characteristics of plant cover in an area by referring to dominant plant growth, forms or structural characteristics. According to Archibold (1994) it refers to the assemblage of plant species and the ground cover they provide encompassing the term flora which is referred to only species composition. In the context of this research work however, the word will be used in its general sense to refer to plant life or total plant cover of the earth which includes both the natural and cultural vegetation cover.

Vegetation ranges from natural to cultural with natural vegetation referring to vegetation that develops naturally with little or no influence or modification by humans like native species of plants. Cultural vegetation on the other hand is vegetation that is planted and maintained by humans, often with considerable input of energy as the species involved in this type of vegetation are often not native to the area. Together with physiography, vegetation constitutes the most observable element of the landscape as it expresses and reflects environmental conditions of the area particularly that of climate (Adia and Rabi, 2008).

With the similarity in both climate and vegetation of regions, there is a conspicuous variation in the world vegetation belts as classified by Archiboid (1994) to include tropical forest, tropical savannah, arid (desert) regions, Mediterranean ecosystems, temperate forest,

temperate grass land, coniferous forest, tundra terrestrial wetlands, freshwater ecosystem and coastal/marine vegetation. Considering this link between climate and vegetation Africa and West Africa is said to have four main vegetation types identified to include desert, semi desert, savannah and the forest vegetation belt (Archiboid, 1994; Breckle, 2001; Iwena, 2008). The west-to-east zonation of vegetation belts within Nigeria also reflects this close link giving rise to two main belts of vegetation namely, forest and savannah (Iwena, 2008). Alongside those two main vegetation belts, the author also identified mountain vegetation which is said to be found within the isolated high plateau regions in the central and far eastern parts of the country.

The Forest belt of vegetation type includes areas of plant formations in which trees are the dominant species. Three forest zones are identified from the coast inland to include Saline water swamp, Freshwater swamp, and Tropical evergreen rainforest. Saline Water Swamp vegetation type is restricted to the coastal strip. It is pronounced where the fresh water from the rivers meets and mixes with the salt water from the sea, forming brackish swamps. The low-lying nature of the Nigerian coastal zone allows for the influx of saline water through tidal movements into the lagoons, creeks and extensive brackish wetlands. This has encouraged the growth of different species of mangrove vegetation, typical in the wetlands of the backshore areas. The mangrove vegetation is a hydromorphic forest type characterized by an entangled dense growth (Iwena, 2008).

Freshwater Swamp Forest vegetation belt on the other hand is restricted to freshwater wetlands located further inland beyond the reach of tidal waters as there is an enormous supply of fresh water from the inland rivers and run-off from abundant rainfall in the area. According to Iwena, (2008), the Tropical Evergreen Rainforest is the upland last belt of forest vegetation and it comprise of tall trees with dense undergrowth of shorter species dominated by climbing plants. This luxuriant vegetation is favoured by prolonged rainy season, resulting in high annual rainfall above 2000mm in this area which ensures adequate supply of water and promotes perennial tree growth. The tropical evergreen rainforest accounts for a great number of plant species classified by their layering structure into three, namely: lower, middle and top layers (Iwena, 2008).

Savannah vegetation which is the second main vegetation belt of the country generally describes areas within the tropics with a mixture of grass and scattered trees. In Nigeria, this vegetation belt consists of three major zones, from south to north, viz: Guinea Savannah, Sudan Savannah and Sahel Savannah. Within the country, Guinea Savannah is located in the middle of the country and it is the most extensive vegetation belt covering nearly half of the country. It extends from Ondo, Edo, Anambra and Enugu States in the south, through Oyo State to Zaria in Kaduna State including Benue State (Iwena, 2008).

Sudan Savannah vegetation belt is found in the north-west stretching from the Sokoto plains in the west, through the northern sections of the central highland. It spans almost the entire northern states bordering the Niger Republic and covers over one quarter of Nigeria's total

area. The low annual rainfall of usually less than 1000 mm and the prolonged dry season (6-9 months) sustain fewer trees and shorter grasses than the Guinea savannah. It is characterized by abundant short grasses of 1.5-2m and few stunted trees hardly above 15m. Trees within this vegetation zone include the acacia, the Shea-butter, baobab and the silk cotton among others (Iwena, 2008). Sahel Savannah which is the last vegetation belt to the north of Nigeria is located close to the fringes of the fast-encroaching Sahara desert around the extreme north-eastern part of the country, close to Lake Chad. Within this area, the dry season lasts for up to 9 months and the total annual rainfall is hardly up to 700mm (Iwena, 2008). According to the author, this low annual rainfall has resulted into very short grasses of not more than one meter high located in between sand dunes in the region.

### **2.2.3 Remote Sensing (RS)**

Remote sensing (RS), also called earth observation simply refers to obtaining information about objects or areas at the earth's surface without being in direct contact with the object or area. Broadly defined, it could be seen as the technique(s) for collecting images or other data about an object from measurements made at a distance from the object including satellite imagery, aerial photographs or ocean bathymetry explored from a ship using radar data. Campbell (2002) defined Remote Sensing as the practice of deriving information about the earth's land and water surfaces using images acquired from an overhead perspective, using electromagnetic radiation in one or more regions of the electromagnetic spectrum, reflected or emitted from the earth's surface. According to Reddy (2008), it is the science and art of obtaining information about an object, area or phenomenon through an analysis of the data

acquired by a device which is not in contact with the object, area or phenomenon under investigation. As a science it involves the sensing and recording of reflected or emitted energy and processing, analysing, and applying that information for various environmental analyses involves gathering data and information about the physical world without direct contact by detecting and measuring signals composed of radiation, particles, and fields emanating from objects. Chuvieco (2006), on the other hand defined remote sensing as a set of techniques for obtaining information of land surface objects from images or other forms of data, as a result of measurements made at a distance from the surface and the processing and analysis of these data.

From these definitions, it can be deduced that the collection of data from a distance using remote sensing techniques is done by sensing and recording reflected or emitted energy and processing, analysing, and applying that information to the study of earth components. According to Curran (1992) and Campbell (2002), in recording of emitted energy, a remote sensing device (sensors) like camera, scanners, radiometers, radar, and lasers are used to record responses based on many characteristics of the land surface, including natural and artificial cover after which the recorded observations are transmitting to a ground receiving station for further processing, interpretation and analysing. In interpreting the recorded observations, an interpreter uses the element of tone, texture, pattern, shape, size, shadow, site and association to derive information about the various land-use/land-covers. Compared to traditional mapping approaches such as terrestrial survey and aerial photo, satellite imagery derived from Remote Sensing are powerful sources of data for surveying, mapping and

monitoring earth resources as it has the advantages of low cost, large area coverage, repetitively, and computability (Franklin, 2001).

The identification of vegetation from Remotely Sensed data provides a lot of information about the vegetal cover of an area. Even though conventional photographs are very useful in interpretation and monitoring vegetation and it changes, satellite imageries proved to be a very valuable tool for studying various aspects of vegetation such as vegetation character, vegetation changes, vegetation degradation and percentage cover of vegetation (Adeniyi, 1982; Onyebuchi, 1985; Khouria, 1993; Osterlund, 1992). This is made possible as satellite sensors are capable of discerning many changes in the physiognomy characteristics of vegetation through spectral radiance measurement along the electromagnetic spectrum. Using the visible infrared bands on the electromagnetic spectrum, multispectral satellite sensors provide an opportunity to easily monitor vegetation greenness as more of green vegetation is absorbed in the visible band as compared with the near infrared band of the spectrum. This variation in spectral radiance measurement along the bands is caused by the presence of chlorophyll and water content present in green leaf's internal spongy mesophyll layer (Myers, 1983; Halilu, 1993; Jones, 1997).

Remote sensing has therefore proved to have some fundamental advantages that make it a veritable tool in environmental monitoring and management. This according to Barret and Curtis (1976) include among others its ability to record more promptly and permanently, detected environmental patterns. This has made it a veritable tool for obtaining baseline

information on an area at the pre-project analysis stage, as well as monitoring changes in the environmental conditions of such an area after the project has been established. The discipline of Remote Sensing is therefore an important relative of GIS and the two are thus highly recommendable in studying environmental impact of projects like mining within environments.

#### **2.2.4 Geographic Information System (GIS)**

Different schools of thought have had different and varied definitions of Geographic Information System, (GIS), some view it as a computer assisted system for the acquisition, storage, analysis and display of geographic data, others view it as a system of hardware, software and procedures to facilitate the management, manipulation, analysis, modelling, representation and display of geo-referenced data to solve complex problems regarding planning and management of resources. It is an essentially systems for collecting, storing, retrieving, managing, analysing and disseminating spatial data from the real world for a particular set of purposes (Burrough and McDonnell, 1998; Tomlin, 1990). Fazil (2008) defined it as a system for capturing, storing, checking, integrating, manipulating, analysing and displaying data which is spatially referenced to the earth. From the above definitions, one could say that a GIS is a computer-assisted system for the acquisition, storage, analysis and display of data that is spatially referenced, simply put, it is a computer based technology that is compatible with geographic data.

A major distinguishing attribute of GIS with other information systems lies in its ability to provide powerful analytical and modelling capabilities for spatial and attribute data by integrating various spatial data within a common framework to form a unified database system as well as to compare different entities based on their common geographic occurrence through the overlay process (Goodchild, Steyaert, Parks, Johnston, Maidment, Crane, and Glendinning, 1996). Due to its flexibility in integrating data from different sources, easy updateability and other features that enables it to analyse different databases within a short period, GIS technology is therefore a great tool in monitoring several environmental components. A combined usage of Remote Sensing and GIS technologies therefore has great potentials in efficient monitoring of mining activities on the landscape. This is because Satellite Remote Sensing can provides globally, consistent, repetitive measurements of the earth surface conditions relevant for monitoring such changes while GIS can efficiently capture, analyse, retrieve, transform, and display such voluminous geographic data (Bedendo, 1990; Tomlin, 1990; Burrough and McDonnell, 1998; Fazil, 2008).

Most of GIS software contains analytic capabilities for reclassifying and overlaying maps and this provides an opportunity to sequentially study and monitor various environmental parameters (Burrough and McDonnell, 1998). Mapping mining activities and evaluating its associated environmental concerns are difficult problems to handle due to extensive areas that are affected as well as the large size of individual mines. This has given rise to difficulties encountered in monitoring and controlling changes around mine areas owing to the cost and time needed to produce reliable and up-to-date mapping of such vast areas. In order to tackle

the challenge of monitoring such environments, urban planners and decision makers need to have accurate and up-to-date information which can be easily and accurately generated from GIS analysis.

The application of GIS in environmental assessment studies, is therefore a veritable tool for generating terrain maps for vegetation, slope and drainage analysis, land resource information system for land management, soil information system for geo-scientific modelling of geological formations, disaster planning related to geographically localised catastrophe monitoring development, contamination and pollution monitoring, flood studies among other functions (Jones, 1997).

### **2.2.5 Importance of Remote Sensing and GIS in Environmental Impact Assessment**

Environment simply means 'surrounding', According to Williams and Peter (2002) an environment is the combination of all of physical, biotic and social factors that act on a living being, residents, or ecological society and power its endurance and growth. According to the author, environment is divided into physical environment (non-living things like land, water and air conditions), biotic environment (living things including plants and animals) and Social (environment which is created by man through his different social and cultural activities like historical, cultural, political, moral, economic aspects of human life constitute the social or cultural environment). Man's interactions with his environment in an attempt to utilise his natural environment generate both positive and negative impact on the entire functioning of the system. Environmental impact therefor is any alteration of environmental condition or creation of new set of environmental conditions, adverse or beneficial, caused or

induced by the action or set of actions under consideration. Environmental Impact Assessment (EIA) on the other hand is defined as a process of identifying, predicting, evaluating and mitigating the biophysical, biological, hydrological, ecological, meteorological, economic, social, and other relevant effects of development project as well using the conclusions as a tool for further planning and decision-making.

Remote Sensing and GIS functionalities have been used in various parts of the world in order to demonstrate the usefulness of these technologies in the assessment of various component of the environment ranging from biotic to abiotic component making it easier and effective to carry out Environmental Impact Assessment (EIA) of various developmental projects including that of mining. It has become a versatile tool for assessing and monitoring environmental impacts of various natural and manmade activities like land, water, air and vegetation among others. Identification of vegetation which is a component of the biotic environment from Remote Sensing data gives a lot of information about the vegetal cover of an area.

Even though conventional photographs are very useful in interpretation and monitoring of vegetation and it changes Satellite sensors have higher capacity in discerning many of the changes in Physiognomy characteristics of vegetation through spectral radiance measurement of the electromagnetic energy. Satellite imageries have proved to be a very valuable tool for studying various aspects of vegetation such as vegetation

character, vegetation changes, vegetation degradation and percentage cover of vegetation (Onyebuchi, 1985; Adeniyi, 1988; Osterlund, Rosenqvist and Engberg, 1992, Khouria, 1993).

In agreement with this assertion, Koruyan, Deliormanli, Karaca, Momayez and Yalcin, (2012) using Remote Sensing and GIS in the Management of mining Land and proximate habitat in order to determine the extent of marble quarries expansion over the study discovered that the land areas exploited between 2001 and 2009 reveals a five-fold increase in quarrying activity in the intervening eight years with the rate of increase from 0.54 per cent in 2001 to 2.89 per cent in 2009 over of the entire study area with the expansion been attributed to increase in existing quarry activities. It was observed that vegetation around the quarries was influenced by the mining operations as most vegetation near the expansion areas of quarries was damaged.

Akabzaa and Darimani (2001), in their research on the Impact of Mining Sector Investment in Ghana: A study of the Tarkwa Mining Region using Remote Sensing and GIS techniques also discovered that extensive areas of land and vegetation in the study area have been cleared to make way for surface mining activities. According to the author, open pit mining concessions had taken over 70% of the total land area of Tarkwa. The change in land cover as a result of anthropogenic activities has played a major role in global environmental change and has become a hot spot for researchers (Liu, Skidmore, and Oosten, 2002). It is from this backdrop that this research intends to assess the effect of limestone mining on vegetation cover in the study area.

## **2.3 LITERATURE REVIEW**

### **2.3.1 Application of Remote Sensing and GIS in Detecting Vegetation Change in Mining Areas**

In order to effectively and efficiently determine the effect of any developmental project like mining, it is expedient to first of all assess and analyse both the negative and positive changes that introduced to the environment are as a result of the said project. Change detection is therefore crucial in environmental impact assessment of any phenomenon of interest as it provides information about the negative and positive environmental implications of such phenomenon or developmental project to the environment in order to aid policy and decision makers in planning and management. Change detection is the process of identifying differences in the state of an object or phenomenon by observing it at different times (Singh, Mukherjee and Shrivastava, 1997). According to the authors, change detection is an important process in monitoring and managing natural and man-made phenomenon as it provides quantitative analysis of the spatial distribution of the natural phenomenon of interest. The process of change detection therefore forms an important part of the process by which plans on the use and management of natural resources can be reviewed and up-dated.

It is expedient to state that detecting changes that occur as a result of any developmental project as it provides the basis for coordinated policies and strategies to guide development both at local authority level and within the framework of selecting short-term actions to provide solutions for immediate problems (Sarma and Kushwaha, 2005). Change detection may also reveal the spatial pattern of development within an area depending on whether it is

positive or negative as this knowledge will enable planners to modify strategies accordingly. Additionally, change detection may identify areas where particular types of change should be encouraged or discouraged (Lambin, Turner, Agbola, and Angelsen, 2001).

The basis of using Remote Sensing data for change detection therefore lays in the fact that changes in land-cover result in changes in radiance values which can be remotely sensed and used for analysis. Using such remotely sensed data (Remote sensing) in conjunction with a computer based Geographical Information Systems will therefore facilitate the use of combined data sets, as well as the use of up to date information on changing elements in the analysis and as such, give room for more accurate result. This is evident as the result of an image overlay provides the most accurate identification of spectral changes. Using spectral signatures from images taken for the same area in different time periods to generate Land-use/land-cover maps, overly analysis in GIS superimposes such maps over each other to effectively find the change (Lambin *et al.*, 2001; Sarma and Kushwaha, 2005).

The value of Remote Sensing along with GIS in mapping any landscape attribute such as vegetation cover via land-use/land-cover change analysis is therefore clear enough as no other technique offers the capacity of detailed spatial coverage and analysis of ecological phenomenon at a cost comparable to satellite Remote Sensing and GIS, against this framework, several research works have been conducted around the world in order to determine the impact of mining on various environmental components including that of vegetation.

Singh, Singh, and Singh, (2010) researched on the impact of Coal mining and industrial activities on land use pattern in Angul-Talcher region of Orissa, India using Remote Sensing and GIS techniques. The study revealed that mining alongside its allied industrial activities brought about an alteration in land use pattern of the study area especially on forest cover and agricultural land. This was evident as areas under forest cover and agricultural land decreased from 38.67% to 27.96% and 42.14% to 28.92% over the study period (1973 – 2007). Water bodies slightly decreased to 0.07% from 1973 to 2007 while mining areas increased from 0.04% to 1.70% from 1973 to 2007. The areas under settlements/industries and barren land showed an increasing trend from 6.22% to 13.27% and 5.5% to 20.78% during the time period respectively.

Sarma and Kushwaha, (2005) analysed the impact of coal mining on land-use/land-cover in Jaintia hills district of Meghalaya, India, using Remote Sensing and GIS techniques from 1975 to 2007. The study revealed that forest cover which occupied about 25% of the total area in 1975 decreased to 12.4% in 2007. Settlement however showed an increasing trend of 4% to 7% from 1975 to 2007 while cropped area showed a decreasing trend in the time sequence. The researchers concluded that there was four fold increases in mining area from 1975 to 2007 accompanied by a threefold decrease in forest area.

Another study carried out by Ololade, Annegarn, Limpitlaw and Kneen (2008) on land-use/cover mapping and change detection in the Rustenburg Mining Region using Remote Sensing and GIS techniques between 1973 to 2005 revealed a significant land-cover change within the study area as the area coverage of open cast mines, tailing dams; mine dumps and

return water ponds were at an increase. Consequently, vegetation according to the authors was observed to be on a decrease as woodland and grassland were observed to have changed to cultivated lands. An expansion of the built-up area was also observable in the study as the results revealed an increase in the development of transport networks and settlement developed due to the immigration of mine workers in the area.

Biswajit (2010) in his research on land-use and land-cover change detection in Sukinda valley using Remote Sensing and GIS also revealed that there was a rapid change of quarry and dense forest. According to the study, quarry area increased by 10.8 Km<sup>2</sup> while dense forest area saw a decrease during the same period from 204 Km<sup>2</sup> to 172.5 Km<sup>2</sup>. Water body on the other hand increased from 1.0 Km<sup>2</sup> to 1.37 Km<sup>2</sup> during study period. A general increase in non-forested area was observed during the study period and this increase according to the author may be attributed to increase in settlement area, barren land and deforestation activities.

In the work of Sourav (2014) on change detection analysis of Talcher coalfield using Remote Sensing and GIS between 1973 and 2009 discovered that forest cover within the study area decreased to 43km<sup>2</sup> in 2009 while area coverage of settlements increased to 28 km<sup>2</sup> between 1973 and 2009. This finding according to the author indicated that large scale mining within the area has subsequently led to massive deforestation which according to the author has led to drastic increase in settlements and a steep drop in the total forest cover. The author however

noted that non-forest and water body did not record any significant change over the study period.

Edward, Jerry and Seth (2009) researched on open pit gold mining and land-use changes in Bogosu-Prestea area, South West Ghana. The findings revealed that mining increased within the study area by 12.1 % from 1986 to 2006 resulting into an inverse increase of settlement from 0.45% in 1986 to 4.95% in 2006 due to rural – urban migration. An observable decrease in agricultural land-use was also discovered as agricultural land decreased from 97.8% to 82.7% in 2006.

Musa and Jiya (2011) used Remote Sensing and GIS techniques to assess the impact of mining activities on vegetation in Bukuru, Plateau State. The findings revealed that in 1975, NDVI values covered the range of 0.04 to 0.63 while in 1986; the values covered the range of 0.04 to 0.58, indicating 0.05 decreases in vegetated surface. Subsequently, changes were still observed between 1986 and 2007 in vegetated surface as NDVI values further decreased by 0.08.

Adia and Rabi (2008) researched on change detection of vegetation cover, using multi-temporal Remote Sensing data and GIS techniques in Bukuru, Jos. The results showed that vegetation changed considerably between 1986- 2001. This is evident as the research revealed a remarkable decrease in cropland/grassland to 0.86%, 2.02% decrease of less dense shrubs and 4.3% increase of dense shrub land in 1986-2001. The authors however attributed this

decrease in vegetation cover to increase in anthropogenic activities like population increase which was caused by the introduction of mining within the study area.

Even though many researches have been carried out around the world on the use of Remote Sensing and GIS in monitoring and assessing the effect of mining activities of various environmental components within mining regions, reviewed literatures have shown that much emphasis has been laid generally on land-use/land-cover changes as well as on the health challenges of people around mine areas. This research work however is centred on the use of these techniques in monitoring the changes in vegetation that can be attributed mainly to mining activities within the study area.

## **CHAPTER THREE**

### **THE STUDY AREA AND METHODOLOGY**

#### **3.1 INTRODUCTION**

This chapter looks into the general background of the study area as it relates to immediate environment. It also considers the methodology adopted for the study. The procedure adopted in this research work forms the basis for deriving statistics of vegetation dynamics and subsequently in the attainment of the set objectives.

#### **3.2 THE STUDY AREA**

##### **3.2.1 Location and Extent**

The Local Government which is located in the Northern part of the State is situated between latitudes  $7^{\circ}08'$  and  $7^{\circ}31'N$  of the equator and longitudes  $8^{\circ}37'$  and  $9^{\circ}10'E$  of the Greenwich Meridian. It is made up of five (5) Districts namely: Mbatyav, Mbayion, Mbatyerev, Yandev and Ipav. Mbayion which is among the five (5) districts and the study area is situated between latitudes  $7^{\circ}16'$  and  $7^{\circ}28'N$  of the equator and longitudes  $8^{\circ}48'$  and  $9^{\circ}00'E$  of the Greenwich Meridian. It shares common boundaries with Takar Local Government in the North, Yandev in North-East, Ipav in South-East, Ushongo Local Government in the South, Mbatyav in South-West and Mbatyerev District in the North-Western part of the Local Government as shown in Fig. 3.1 and 3.2.

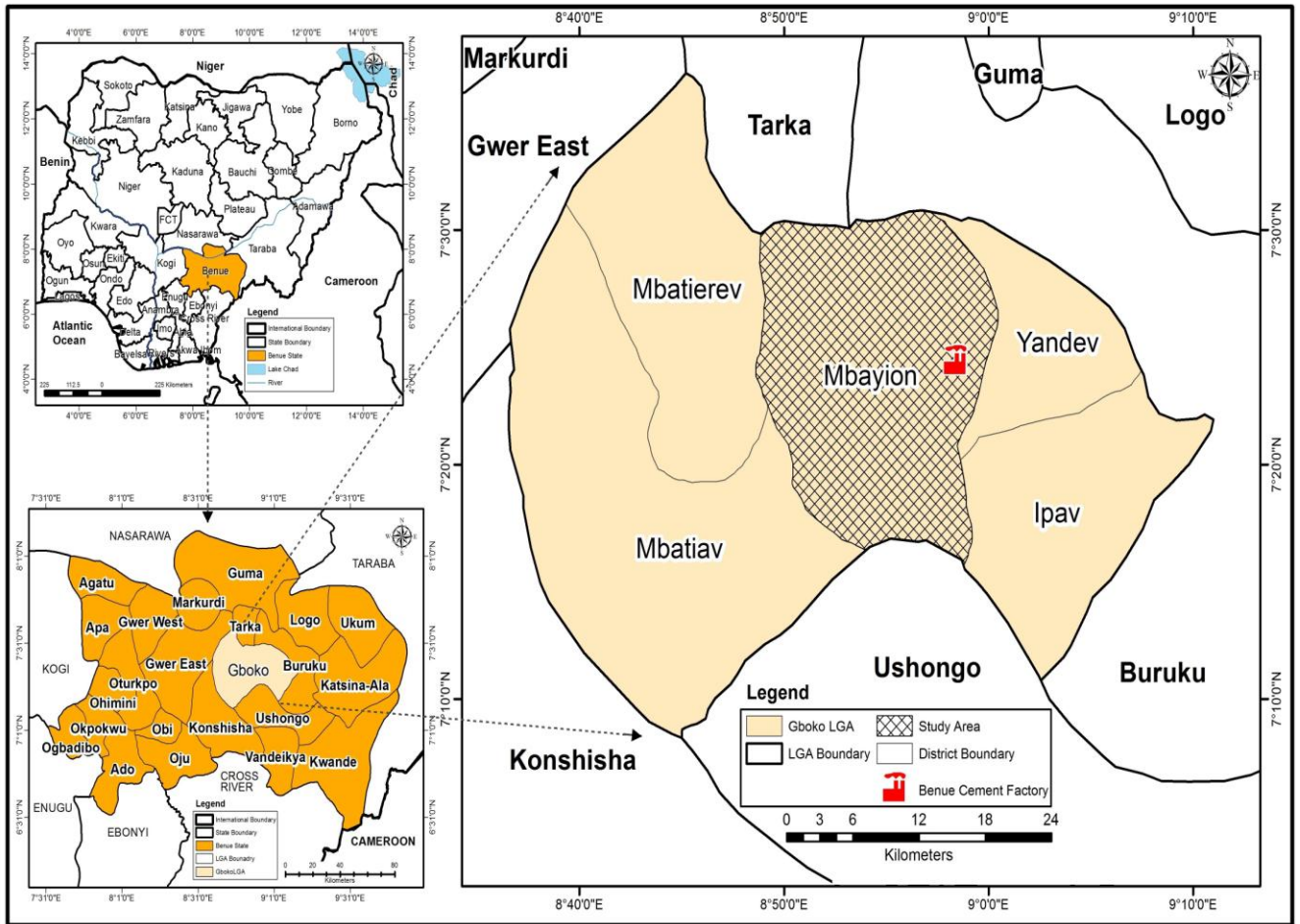


Fig. 3.1 Gboko LGA Showing Study Area  
 Source: Modified from the Administrative Map of Gboko LGA, 2014

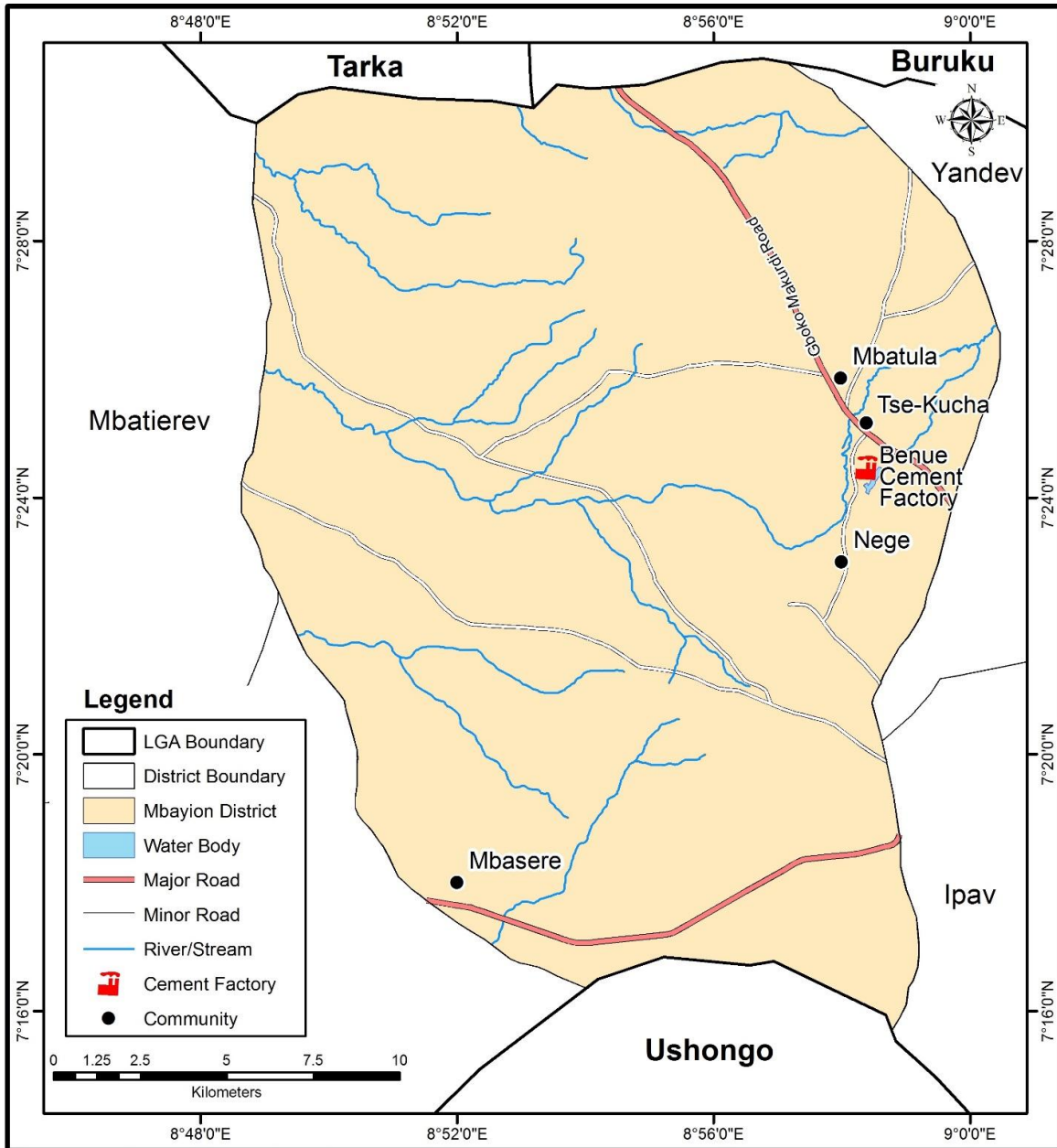


Fig. 3.2 Mbayion District (Study Area)

Source: Modified from the Administrative Map of Gboko LGA/Google Maps, 2014.

### **3.2.2 Soil and Vegetation**

The predominant factors that have influenced the distribution of soils within the study area are relief and vegetal cover. Within the area, the predominant soil is tropical ferruginous soils; coarse loamy soils, laterite soils as well as sandy soils (Benue State Economic Empowerment and Development Strategy (BENSEED), 2004; Iwena, 2008). According to BENSEED (2004), the presence of clay soils near streams and valleys, are however mixed with a reasonable amount of sandy soil and as such most parts of the area is adequately drained and free from water.

With respect to vegetation, the area belongs to the Guinea Savannah belt and as such, it is made up of a lot of grasses which are interspersed with trees as trees grow side by side with tall grasses giving the area a luxuriant vegetation cover (Iwena, 2008). According to the author, this vegetation belt serves as a transitional belt between the tropical rain forest in the South and the open grassland in the North of Nigeria. Within this vegetation belt, several grain and root crops are produced in commercial quantities and the study area is known for the cultivation of crops like maize, guinea corn, millet, rice, yam, cassava among others. Also tree crops like oranges, mangoes among others are also produced commercially in Gboko local government (Ministry of Information and Orientation, 2012).

### **3.2.3 Climate**

The study area is located within a sub-humid tropical region around the tropical wet and dry climate which is designated as AW by Koppen's climatic classification. It generally has an annual mean temperature range of 23°C to 34°C (Iwena, 2008). In general, the study area is

characterized by two distinct seasons: the dry and wet season. The dry season, starts from late November and last till March. During this period, the tropical continental air mass, dominates the area and Harmattan winds, which are characteristically dry, cold and hazy, prevail. The wet/rainy season on the other hand starts from April to November and it is characterized by the tropical maritime air mass which brings rainfall and wet conditions to the area (Iwena, 2008; Ujoh & Alhassan, 2014). Rainfall reaches its peak between the months of July to September, spreading between 6 to 8 months yearly. The rains which are usually torrential in nature are accompanied with a lot of lightning and thunder, associated with occasional thunderstorms of short duration especially when raining season is at its peak (Ministry of Information and Orientation, 2012). The mean annual precipitation according to Ujoh and Alhassan (2014) is about 1,370mm and it is described by Ojanuga and Ekwoanya (1994) as having a bimodal pattern. The average wind speed over the study area is about 1.50 m/s, while the average ambient air temperature is about 30°C (Nigeria Meteorological Agency, 2012).

#### **3.2.4 Geology and Drainage**

Around the East-central part of the Local Government which comprises basically of the study area (Mbayion), basement complex rock outcrops cover an area of about 100Km<sup>2</sup> consisting majorly of granites and gneisses with the body been surrounded by early cretaceous sediments. These sediments where deposited around the Gboko area along a steepened slope consisting of three main deposition centres such as the Tse-kucha deposition centre within Mbayion District (the study area), Akpagher deposition centre as well as the Mayange deposition centre which were formed during the cretaceous. During the period, the sub-basins

where filled with shale, clays and carbonates. According to Petters, (1982); Najime, (2010) and Najime *et al* (2006), the deposition of these mineral which further resulted to the formation of limestone intervals in Gboko (which contains calcareous benthic foraminifers' species and a lagoonal or estuarine condition for the non-carbonate intervals) was due to the south Atlantic sea rise and subsidence along the Benue Trough during the middle Albian. According to Ikejiaku, (2007), subsequent intrusions that punctuate the gently undulating terrain of the area, further caused these deposits to be backed giving rise to the formation of limestone, clay and shale within the region.

The area according to Wright, Hastings, Jones and Williams (1985) is largely covered by Cretaceous continental sediments of basement complex rocks (to the north) and marine sediments of clay and shale (to the south) causing the limestone reserves within the study area to be mostly of Cretaceous sedimentary formation. According to Ikejiaku (2007) the average limestone within the area has a thickness of over 80m with a quarryable reserve area of 1.5Km<sup>2</sup> with the mineral reserve standing at over 35.4million metric tonnes. The calcium carbonate (CaCO<sub>3</sub>) content of the limestone within the study area according to the author is over 80% indicating that the mineral is suitable for cement production.

With respect to drainage, the major rivers that drain the state are the Niger-Benue River and Kastina-Ala rivers. According to Ujoh and Alhassan (2014), however, Mbayion the study area is about 532 feet above mean sea level and as such it is characteristically a flat plain without

hills or rocky outcrops. Having two most significant water bodies (streams) and these includes 'Ahungwa' and 'Oratsor'.

### **3.2.5 Population**

The 1991 National Population Census figures indicate that a greater percentage of the people within the study area live in rural areas with only 101,405 persons living in Gboko town. Based on the 2006 National Population Census figures however, Gboko Local government in general has a population of 358, 936 persons out of which 198, 320 represent the population for the male and 160, 616 represent the population for the female. This makes it the most populous local Government in Benue State. The Local government population however shows a slight imbalance in favour of male with 55.3% and women with 44.7 % (National Population Commission, 2009).

### **3.2.6 Economic Activities**

Agriculture generally forms the backbone of the Benue State economy, engaging more than 70 percent of the working population (Benue State Economic Empowerment and Development Strategy (BENSEED) 2004; Ministry of Information and Orientation, 2012). Within the study area also the inhabitants are largely pre-occupied in traditional subsistence agriculture/land cultivation and wildlife hunting. Important cash crops that are cultivated in the study area include soya beans, rice, groundnut and citrus. Other cash crops include melon, African pear, hot pepper, tomatoes and Benniseed. Food crops include yam,

cassava, sweet potatoes, beans, maize, millet and guinea corn (BENSEED, 2004; Ministry of Information and Orientation, 2012; Ujoh & Alhassan, 2014).

### **3.3 RESEARCH METHODOLOGY**

#### **3.3.1 Reconnaissance survey**

A reconnaissance survey was carried out in the area so as to enable the researcher familiarize with nature of vegetation and state of mining activities in the study area hence this knowledge is crucial in interpreting Remotely Sensed imageries.

#### **3.3.2 Data Types and Sources**

This research work was carried out using both primary and secondary types of data. The primary data that was used in this research work comprise majorly of digital satellite data. They was acquired from National Centre for Remote Sensing (NCRC) Jos. These data sets include:

- i. Landsat MSS (Multi-Spectral Scanner) of 9<sup>th</sup> January 1976 with spatial resolution of 79m. This was used as a control image.
- ii. Landsat TM (Thematic Mapper) of 12<sup>th</sup> December, 1986 with spatial resolution of 30m
- iii. Landsat ETM+ (Thematic Mapper plus) of 27<sup>th</sup> January, 2001 with spatial resolution of 30m
- iv. Nig. Sat X of 15<sup>th</sup> November, 2011 with spatial resolution of 22m
- v. Ground control points were obtained using a global positioning system (GPS) to validate the coordinates of the classified images.

The primary data were complemented by materials from secondary data such as administrative map of the area, textbooks, journals and other existing literature that are related to the research problem. This type of data was sourced from Benue State Ministry of Lands and Survey, library and the internet.

### **3.3.3 Data Processing**

Remotely sensed data are not free from internal and external errors such as radiometric and geometric distortions; many of these errors are systematic and are most times corrected before it gets to the users however, the major pre-processing that will be done on the images is enhancement. This was done to increasing the apparent distinction between the features in the scene in order to enable image classification process. Colour composites and band rationing will be the major enhancement technics to be used in this work.

Digital image-processing software Erdas imagine 9.2 and GIS software Arc GIS 10.1 were used for processing, analysis and integration of spatial data to reach the objectives of the study. Using Erdas Imagine 9.2 software, the images were rectified to a common Universal Transverse Mercator (UTM) projection/coordinate system after which they were re-sampled to a common spatial resolution of 22m using nearest neighbour technique.

After re-sampling was done, the images were used to generate land-use/land-cover maps of the study area. In doing this, Erdas Imagine 9.2 software was used to generate a false colour composite of each image, this was done by combing near infrared, red and green bands (i.e band 4, 3, 2) for those images. This was done to enhance vegetation recognition, hence

chlorophyll in plants reflects very well in the near infrared than the visible band (Curran, 1992). The false colour composite images were then imported into Arc GIS 10.1 for further processing and classification.

### **3.3.4 Image Classification**

#### **3.3.4.1 *Preliminary Image Classification***

Prior to fieldwork, a preliminary image classification was carried out using unsupervised classification where the Computer automatically categorize all the pixels in the images into land-cover classes or themes based on their reflectance values. This means that the computer was allowed to assign the image's pixel to a defined number of classes based on their value in different channels (i.e. no training areas used).

#### **3.3.4.2 *Supervised Classification***

In classifying the images into various themes, the supervised approach to classification was adopted using Arc GIS 10.1 software. The researcher supervised the pixel categorization process by specifying to the computer algorithm; numerical descriptors of the various land-cover types present in the scene so as to be able to ascertain the type and spatial extent of various land-use/land-cover types. To do this, representative sample sites of known land-cover types, called training areas or training sites, were used to compile a numerical interpretation key that was used to describe the spectral attributes for each feature type of interest. Each pixel in the data was then compared numerically to each category in the interpretation key and

labelled with the name of the category it looks most like. This classification is a modification of Anderson, Hardy, Roach and Witmer (1967) as shown in the table 3.1

**Table 3.1 Land Use-Land Cover Classification Scheme**

S/N	LAND-USE/LAND-COVER CLASS	DESCRIPTION
1	Built-up land	Lands used for residential and transportation/communication purpose (i.e. settlements and roads)
2	Agricultural land	Lands used as cropland and agricultural plantation (i.e. farmlands and orchards)
3	Vegetated land	Lands covered with natural forest and natural vegetation that is predominantly grasses, shrubs and grass-like plants
4	Waste land	Land occupied with strip mines, quarries, mine pits, mine wastes and overburden
5	Bare surfaces	Exposed soils, lands devoid of vegetal cover

**Source: Modified from Anderson (1967)**

#### **3.3.4.3. Accuracy Assessment**

In order to test the accuracy of the classification, 25 Ground truth points for each Land-use/Land-cover class were randomly collected from the field using a GPS; these ground truth points were further inputted into ArcGIS environment where the Kappa tool was used to test the accuracy of the

classification. The kappa coefficient according to Congalton, (1991) expresses the proportional reduction in error generated by a classification process compared with the error of a completely random classification. A Kappa coefficient value of 0.64 was obtained and this signifies that the classification accuracy was moderate (Anthony, Viera and Joanne, 2005).

### **3.3.5 Data Analysis**

To determine the Land-use/Land-cover of the area in 1976, 1986, 2001 and 2011 as well as to determine the extent of vegetation cover in the area in 1976, 1986, 2001 and 2011, each image set were broadly classified into five different categories/polygons as on table 3.1. After the classification was done, the area coverage (extent) of each land-use/land-cover type of the four time periods was ascertained by constructing the histogram of each classified image.

To determine the land-use/land-cover change of the study area between 1976 – 2011, the area coverage ( $\text{km}^2$ ) of each classified land-use/land-cover type for these time period was extracted from the images histograms prepared earlier, and the results was subsequently compared to calculated the area ( $\text{km}^2$ ) and percentage change of each land-use/land-cover type.

The change in square kilometres of a particular land-use/land-cover type were derived by subtracting the former area coverage (in  $\text{km}^2$ ) from the latter area coverage of that particular land-use/land-cover type.

Change in square kilometres = the latter area coverage of land-use/land-cover type of interest minus the former area coverage of the same land-use/land-cover type (for example, the area coverage of vegetated land in 1986 minus the area coverage of vegetated land in 1976).

To get the percentage change of each land-use/land-cover type between 1976 – 2011, the observed change was divided by the base year (area coverage of the base year) multiplied by 100.

$$\text{Percentage change of class} = \frac{\text{observed change (km}^2\text{)}}{\text{Base year}} \times 100$$

To analyse the rate of vegetation change in the study area between 1976 – 2011, the area, percentage and rate of vegetation change in the study area were determined. The area coverage of vegetation in kilometres as derived from the classified image statistics was used. The area change of vegetation was ascertained by subtracting the former area coverage of vegetation from the latter area coverage of vegetation.

The change in square kilometres (Observed change) = the area coverage of vegetation of the latter image minus the area coverage of vegetation of the former image (i.e 1976-2011).

Percentage change, was however determined by dividing observed change by sum of changes multiplied by 100

$$\text{Percentage change (trend)} = \frac{\text{Observed change}}{\text{Base year}} \times 100$$

In obtaining annual rate of change in vegetation, the percentage change of vegetation was divided by the number of study year, 1976 – 2011(25yrs).

$$\text{Annual Rate of change} = \frac{\% \text{ change}}{\text{No of study year}}$$

To determine the extent to which mining has affected vegetation cover in the area, the land-use/land-cover maps prepared from the images were used to assess changes in vegetated land and waste land. This was done by overlaying (clipping) the portion of the study area occupied by waste land for each study year on the vegetated land of the base image of 1976 (Original vegetation) so as to find out the amount of the original vegetation that was displaced by the waste land in each study year. The resultant map histogram was used to determine the aerial and percentage extent to which vegetated land has been displaced as a result of waste land. This was then used to determine the extent to which mining has affected vegetation cover in the study area over the years.

## **CHAPTER FOUR**

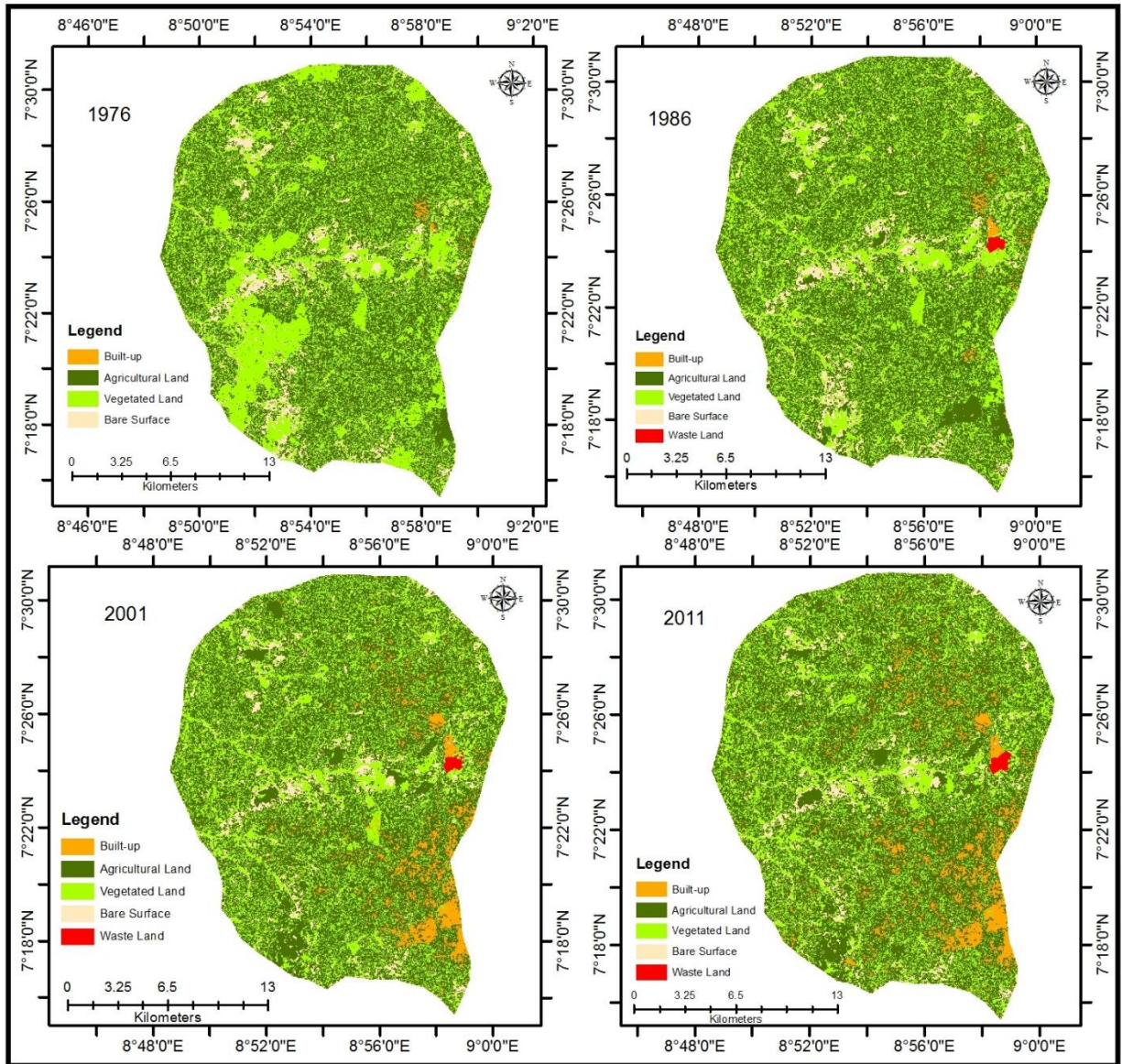
### **RESULTS AND DISCUSSION**

#### **4.1 INTRODUCTION**

This chapter deals with presentation and analysis of result obtained from the research analysis. The presentation and analysis of data were carried out under the following sub-themes: characterization of land-use/land-cover, extent of vegetation cover, land-use land-cover change, trend, pattern and rate of land-use/land-cover change as well as the extent to which mining has affected vegetation cover within the study area. The results of the analysis were then discussed and appropriate inferences were made to assess the impact of mining activities on vegetation cover within the study area.

#### **4.2 CHARACTERIZATION OF LAND-USE/LAND-COVER OF THE AREA**

The characterization of the land-use/land-cover classes of Mbayion in 1976, 1986, 2001 and 2011 using satellite images was classified into five prominent land-use/land-cover classes including built-up, agricultural land, vegetated land, waste land and bare surfaces as shown in Fig 4.1 and table 4.1.



**Fig 4.1: Land-use/ Land-cover Classes of Mbayan**  
**Source: Author's Analysis, 2014**

**Table 4.1 Land-use/Land-cover**

	<b>1976</b>		<b>1986</b>		<b>2001</b>		<b>2011</b>	
<b>Land use</b>	<b>Area</b>	<b>%</b>	<b>Area</b>	<b>%</b>	<b>Area</b>	<b>%</b>	<b>Area</b>	<b>%</b>
	<b>(Km<sup>2</sup>)</b>		<b>(Km<sup>2</sup>)</b>		<b>(Km<sup>2</sup>)</b>		<b>(Km<sup>2</sup>)</b>	
<b>Built-up</b>	1.17	0.26	2.88	0.64	22.51	5.00	34.91	7.75
<b>Agricultural Land</b>	227.66	50.55	254.15	56.43	259.07	57.52	265.27	58.90
<b>Vegetated Land</b>	190.15	42.22	162.73	36.13	141.65	31.45	130.18	28.90
<b>Waste Land</b>	0.00	0.00	0.92	0.20	1.02	0.23	1.24	0.28
<b>Bare Surface</b>	31.44	6.98	29.73	6.60	26.15	5.81	18.81	4.18
<b>Total</b>	450.41	100.00	450.41	100.00	450.41	100.00	450.41	100.00

**Source: Author's Analysis, 2014**

The Land-use/Land-cover maps depicting the five Land-use/land-cover classes were prepared for the four period viz. 1976, 1986, 2001 and 2011 as shown in Fig. 4.1. The area and percentage coverage of each of the class is further depicted in table 4.1. From the analysis, it was observed that built up areas increased from 1.17km<sup>2</sup> (0.26%) in 1976 to 34.91 km<sup>2</sup> (7.75%) in 2011. This increase in built-up within the study area could be as a result of increase in limestone mining and processing which has given rise to several socio-economic indices within the study area as well as the expansion of Gboko town into the study area as a result of urban expansion. Agricultural land also depicts an observable increase of 227.66 km<sup>2</sup> (50.55%) in 1976 to 265.27 km<sup>2</sup> (58.90%) in 2011. This increase could be attributed to

increase in the demand for agricultural produce/market gardening commodities due to increase in human population within the area as reflected in the increase of built-up. This has resulted into the conversion of areas that were left bare in 1976 to agricultural purposes in the subsequent years.

There was no identifiable waste land within the area in 1976. However, with the introduction of mining within the area in 1980, the land-use had an area coverage of 0.92 km<sup>2</sup> (0.20%) in 1986 with subsequent increase of 1.24 km<sup>2</sup> (0.28%) in 2011. The prominent increase in the land-use which occurred in 2011 and this could be attributed to increase in mining activities within the area which was triggered by increase Portland cement processing which is facilitated by the resuscitation and rehabilitation of the processing plant from 2004. Bare surfaces and vegetated land however indicated a noticeable decrease in area coverage during the study period. This is evident as bare surfaces decreased from 31.44 km<sup>2</sup> (6.98%) in 1976 to 18.81 km<sup>2</sup> (4.18%) in 2011 respectively. This decrease could be attributed to the fact that bare lands were successively converted to other land-use/land-cover types like built-up, waste land and agricultural lands.

Vegetated land also depicted a noticeable decrease of 190.15km<sup>2</sup> (42.22%) in 1976 to 130.18 km<sup>2</sup> (28.90%) in 2011. This observable reduction in the land-cover type could be attributed to urban expansion and the introduction of mining within the study area in the early 80s. Successive increase in mining activities has therefor resulted into the decrease in the vegetated land especially around the mines. This observable marginal decrease in vegetated land during the study period is an indication that there has been an encroachment into the land-cover type

by other land-use/land-cover classes. Due to the environment importance of vegetation, no matter how minimal the change seems to be, it is bound to exert a gradual effect on the de-vegetated land and this in the long run cause various environmental issues that might be difficult to deal with.

### 4.3. EXTENT OF VEGETATION COVER IN THE AREA

The result of the extent of vegetation cover in the study area between the study years is presented in Table 4.2.

**Table 4.2: Extent of Vegetation Cover in the Area**

EXTENT OF VEGETATION COVER								
Study Years	1976		1986		2001		2011	
Land use	Area Km <sup>2</sup>	%	Area Km <sup>2</sup>	%	AreaKm <sup>2</sup>	%	Area Km <sup>2</sup>	%
<b>Vegetated Land</b>	190.15	42.22	162.7	36.13	141.65	31.45	130.18	28.90

**Source: Author's Analysis, 2014.**

From the analysis, it can be observed that vegetated land had the highest spatial extent of 190.15Km<sup>2</sup>, which is about 42.22% of the total area in 1976, 162.7 Km<sup>2</sup> in 1986, 141.65Km<sup>2</sup> in 2001 and 130.18Km<sup>2</sup> in 2011 respectively. This has shown an overall decrease rate of 190.15Km in 1976 to 130.18Km<sup>2</sup> in 2011. This downward decrease in the extent of vegetation cover within the study area from 1976 towards 2011 could be attributed to the fact that the land-use was successively converted to other land-uses out of which waste land is

included as depicted in Table 4.1. This findings coincides with the findings of Kushwaha (2005) and Ololade *et al.*, (2008) where a decrease in vegetation within the mine areas where observed in successive years with the decrease been partly attributed to mining activities.

#### 4.4 LAND-USE/LAND-COVER CHANGE

The result of land-use/land-cover changes in the study area between the study years is presented in Table 4.3.

**Table 4.3: Land-use/land-cover change**

LANDUSE/LANDCOVER CHANGE								
Land use	1976-1986		1986-2001		2001-2011		1976-2011	
	km	%	km <sup>2</sup>	%	km <sup>2</sup>	%	km <sup>2</sup>	%
<b>Built-up</b>	1.71	146.15	19.63	681.53	12.40	55.10	33.74	2883.76
<b>Agricultural Land</b>	26.49	11.64	4.92	1.94	6.20	2.39	37.61	16.52
<b>Vegetation Land</b>	-27.42	-14.42	-21.08	-12.95	-11.47	-8.10	-59.97	-31.54
<b>Bare Surface</b>	-1.71	-5.44	-3.58	-12.03	-7.34	-28.07	-12.63	-40.17
<b>Waste Land</b>	0.92	0.00	0.10	11.30	0.22	21.09	1.24	0.00

**Source: Author's Analysis, 2014.**

The analysis as shown in Table 4.2 indicates that built-up witnessed the highest change with 1.71km<sup>2</sup> between 1976-1986, 19.63km<sup>2</sup> between 1986-2001 and 12.40km<sup>2</sup> between 2001-2011, with an overall change of over 200% between 1976-2011 (2883.76%). This high increase could be attributed to the fact that the introduction of the mining within the study area subsequently brought about an increase in several developmental projects like settlements, road networks among others. This assertion concords with the findings of Edward

*et al* (2009) which attributed settlement increase caused by rural – urban migration to increase in mining activities within the study area. This finding is also in line with that of Ololade *et al.* (2008) on land-use/cover mapping and change detection in the Rustenburg Mining Region where 45.6 % increase in built-up was noticed between the study years. This, the authors attributed to increase in the development of transport networks and settlement developed within the area which was caused by immigration of mine workers.

The study result further revealed that agricultural lands had a successive increase of 26.49km<sup>2</sup> between 1976-1986, 4.92km<sup>2</sup> between 1986-2001 and 6.20km<sup>2</sup> between 2001-2011. This indicates that between 1976-1986, the land-use rapidly increased but its increase slowed down between 1986-2001. This slowdown could be attributed to the fact that with the introduction of mining activities, areas that were originally agricultural lands in 1976 were further converted to other land-use types that were on the increase as a result of the influence of mining. Irrespective of the noticeable slowdown in the changing nature of the land-use, this research revealed that agricultural activities are still on the increase within the study area irrespective of the introduction of mining. This could be attributed to increase in the demand for agricultural produce/market gardening commodities which has been caused by increase in human population within the area as seen in the increase of built-up area. This has resulted into the conversion of areas that were left bare in 1976 for agricultural purposes in the subsequent years. This result however shows dissimilarity with the study of Edward *et al* (2009) on open pit gold mining and land-use changes in Bogosu-Prestea area, which revealed

that as mining activities increased by 12.1 % from 1986-2006, a noticeable decrease in agricultural land-use was observed from 97.8% in 1986 to 82.7% in 2006.

Waste land also recorded a gradual increase of 0.92km<sup>2</sup> between 1976-1986, 0.10km<sup>2</sup> between 1986-2001 and 0.22km<sup>2</sup> between 2001-2011 with an overall change of 1.24 km<sup>2</sup> (100%) in 1976-2011. This successive increase is as a result of the fact that there was no waste land within the study area in 1976 but with the introduction of mining in 1980, waste land took over some vegetated lands. This finding concords with the work of Joshi (2007), Sarma and Kushwaha (2005) and Ololade *et al.*, (2008) where a decrease in vegetation within the mine area was attributed to mining activities.

The area coverage of vegetated land and bare surfaces between 1976 and 1986 on the other hand witness a decrease as vegetated land decreased from -27.42 km<sup>2</sup> (-14.42%) between 1976-1986 to -59.97 km<sup>2</sup> (-31.54%) between 1976-2011 depicting a successive decrease. This observable reduction could be attributed partly to urban expansion as well as increase in mining activities which is evident in the increase in waste land. Bare surfaces indicates a decrease of - 1.71 km<sup>2</sup> (-5.44%) between 1976-1986, and -12.63 km<sup>2</sup> (-40.17%) between 1976-2011 respectively. This marginal decrease in bare surfaces especially between 2001-2011 is an indication that it has been successively converted to other land-use/land-cover types like built-up, waste land and agricultural lands.

#### 4.5 RATE OF VEGETATION CHANGE

The rate at which vegetation cover and waste land are changing between 1976 to 2011 is tabulated in square kilometres and percentage as shown in table 4.4:

**Table 4.4: Rate of Vegetation and waste land Change**

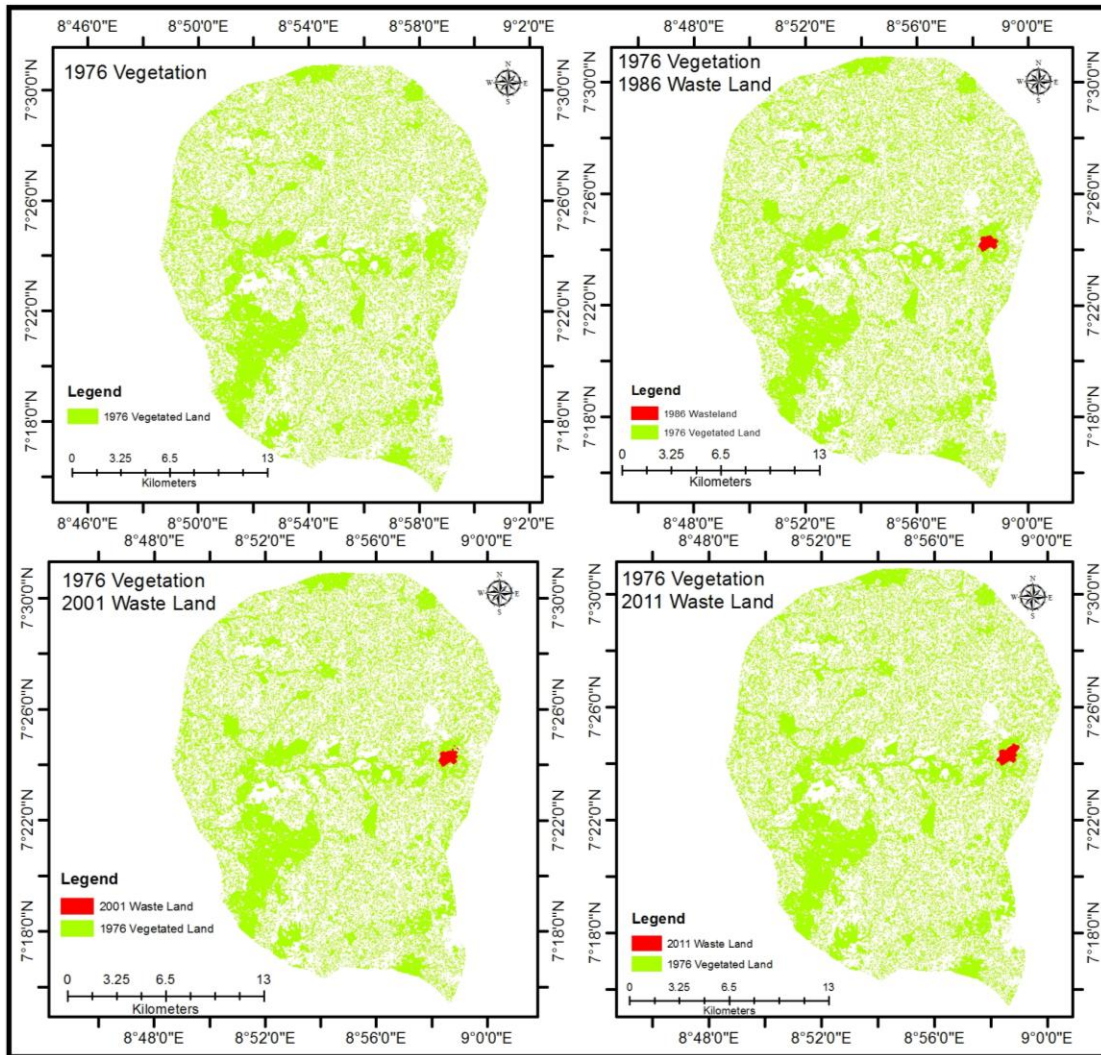
LAND-USE/LAND-COVER EXTENT			RATE OF CHANGE	
Study Years	1976	2011	1976 – 2011 (35 yrs.)	
Land-use	km <sup>2</sup>	km <sup>2</sup>	km <sup>2</sup>	%
<b>Vegetated Land</b>	190.15	130.18	-1.71	-0.90
<b>Waste Land</b>	0.00	1.24	0.04	-

**Source: Author's Analysis, 2014.**

It can be observed from Table 4.4 that between 1976 -2011, Waste land recorded a gradual increase rate of 0.04km<sup>2</sup> with zero percentage increase rate. This is due to the fact that in 1976, the land-use was alien to the study area, but with the introduction of mining within the area in the 1980's, the land-use became prominent. Vegetated land on the other hand experienced a decreasing rate of -1.71km<sup>2</sup> between 1976 to 2011. This implies that with the introduction of mining, apart from the identified land-use/land-cover types that existed in 1976, waste land also took over areas that were originally covered by vegetation.

#### **4.6 EXTENT TO WHICH MINING HAS AFFECTED VEGETATION COVER IN THE STUDY AREA**

Using overlay analysis the portion of the study area occupied by waste land for each study year was overlaid (clipped) on the vegetated land of the base year (1976) so as to find out the amount of the original vegetation that has been displaced by the waste land in each study year. This was done by using the vegetated map extract of 1976 (before the commencement of mining within the study area) as the base map where the map extract of waste land in each study year (i.e. 1986, 2001 and 2011) were separately overlaid on the base map in order to depict the change as shown in Fig. 4. 2 and Table 4.5:



**Fig. 4.2: Overlay Analysis**  
**Source: Author's Analysis, 2014.**

**Table 4.5: Extent of Waste land and Displaced Vegetated land**

Land use	1976		1986		2001		2011	
	Area Km <sup>2</sup>	%	Area Km <sup>2</sup>	%	Area Km <sup>2</sup>	%	Area Km <sup>2</sup>	%
Waste Land (Extent)	-	-	0.92	0.20	1.02	0.23	1.24	0.28
Vegetated Land Displaced by Waste Land	-	-	0.88	0.54	0.95	0.67	1.1	0.84

**Source: Author's Analysis, 2014.**

From Table 4.5, it was observed that no vegetated land was displaced in 1976 within the study area by wasteland. However, with the introduction of mining within the area in 1980, it was observed that in 1986, about 0.88 km<sup>2</sup> (0.54%) of vegetation was displaced by wasteland while in 2011, a greater portion of vegetated land was displaced (1.1Km<sup>2</sup> or 0.84%) by waste land. This indicates that there is a gradual increase in the extent to which waste land is taking over vegetation cover around the study area. This succession could be attributed to the company's attempt to meet up with the demand in Portland cement processing, which has been triggered by the rehabilitated and resuscitation of the processing plant at the beginning of 2004 hence the noticeable rate of increase during 2001.

To buttress this finding, some portion of the study area which were originally identified as vegetated land in 1976 ( via GIS analysis) were seen as at the time of field survey to be occupied by mine pits, mine waste and overburden as shown in Plate 4.1, 4.2 and 4.3:



**Plate 4.1a**



**Plate 4.1b**

**Plate 4.1: Land Occupied by Mine Pit within the Study Area**  
**Source: Photographed by Author, 2014**



**Plate 4.2a**



**Plate 4.2b**



**Plate 4.2c**



**Plate 4.2d**

**Plate 4.2: Degraded Land Parcels Devoid of Vegetal Cover within the Study Area**  
**Source: Photographed by Author, 2014**



**Plate 4.3a**



**Plate 4.3b**



**Plate 4.3c**

**Plate 4.3 Land Occupied by Mine Waste/Overburden within the Study Area  
Source: Photographed by Author, 2014**

From the above plates, it can be seen that some portions of the study area have been lost not only to other land-use/land-cover types but also to mining and its associated activities as vegetated land within the study area is seen to be converted into mine pits (with stagnant water) as shown in plate 4.1. In order to pave way for mining and the movement of associated machines within the mine site, lands parcels that were originally covered with vegetation in 1976 were seen during the field survey to be devoid of vegetation cover either by its total removal or by the deposition of mine waste/overburden on the existing vegetation as depicted in plate 4.2 and 4.3.

## **CHAPTER FIVE**

### **SUMMARY, CONCLUSION AND RECOMMENDATIONS**

#### **5.1 INTRODUCTION**

This chapter describes the summary of the major findings of this work, conclusion derived from the findings as well as recommendations for enhancing effective land-use/land-cover management within the study area in particular and the state in general.

#### **5.2 SUMMARY OF FINDINGS**

The study provided an insight on the effect of mining on vegetation cover in Mbayion, Gboko Local Government Area of Benue State. The research revealed that vegetated land has continually reduced over the study period as the land-cover had percentage coverage of 42.22% in 1976, 36.13% in 1986, 31.42% in 2001 and 28.90% in 2011. This gradually reduction in vegetated land within the study area which is attributed to the fact that other land-use/land-cover types are gradually taking over places originally occupied by vegetation as at 1976 has led to vegetal clearance and deforestation of the area in the successive years.

This assertion is further buttressed by the fact that wasteland which was not seen in the study area in 1976, surfaced in 1986 owing to the introduction of mining within the area in 1980. This brought about a successive increase in the area coverage of the land-use (wasteland) as it increased from nothing in 1976 to 0.92 Km<sup>2</sup> in 1986, 1.2 Km<sup>2</sup> in 2001 and 1.24 Km<sup>2</sup> in 2011.

This finding indicates that portions of the study area that were originally occupied by vegetation cover have been subsequently taken over by wastelands.

The research further revealed that about 0.88km<sup>2</sup> of vegetation cover was displaced by waste land in 1986, 0.95 Km<sup>2</sup> in 2001 and 1.1 Km<sup>2</sup> in 2011. This means that a greater portion of vegetation has been displaced in 2011. This further explains the fact that mining activities have been on the increase within the study area as this has led to the increase in the displacement of vegetation cover within the study area in the latter study years.

### **5.3. CONCLUSION**

This research work demonstrates the ability of using GIS and Remote Sensing for land-use land-cover change analysis. The results obtained from this study have shown that the study area has lost part of its vegetated land not only to settlement but also to mining activities as the inception of mining in 1980 has gradually given rise to the introduction and successive increase in waste land. It has also revealed that with the rehabilitation of the mine in 2004, there has been a changing increase in the land area occupied by mine waste especially from 2001-2011 as it records an increase of 0.22 Km<sup>2</sup> (21.09%) at a rate of 2.11% and an overall increase rate of 0.04 Km<sup>2</sup> between 1986 to 2011. If proactive measures are not put in place to checkmate this trend that is attributed to increase in mining activities, portions of the study area will be gradually degraded due to vegetal cover loss.

## 5.4 RECOMMENDATIONS

Based on the identified change in vegetation cover within the study area which has been attributed to mining activities, the following are recommended:

1. Proactive measure should be put in place by the management of the mining company, elders of Mbayion as well as Benue State Environmental Management Board for an effective and efficient management of various environmental challenges that might be associated with mining as being forearmed will help in urgently tackling any emergency environmental situation.
2. Stringent and rigorous efforts of re-afforestation and land reclamation aimed at restoring degraded lands should be intensified by the Company especially around the mine area so as to resuscitate lands that are devoid of vegetal cover. This could be done by using the mine spoils to fill up dug mine pits and the likes.
3. In order to deal with the changing nature of land-use/land-cover of areas within various developmental projects that are associated with such enormous long term effects, an urgent need for the use of Remote Sensing and GIS for proper monitoring and management of land within the state and the study area in particular is also recommended.
4. It is also recommended that further research should be conducted within the study area to determine whether there are intervention measures put in place by the company in order to tackle various environmental challenges that are associated with their

operations and if there are any, the level of implementation and the success of such measures.

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