THE USE OF REMOTE SENSING TECHNIQUE FOR EVALUATING THE IMPACT OF ILLEGAL GOLD MINING ACTIVITY IN MINNA AND ENVIRONS

BY

UMARU HELEN WILLIAM (MRS)
M.TECHN/SSSE/97/108
B.Sc.GEOG (A.B.U., ZARIA)

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ABSTRACT

The most fundamental factor that determines the quality of the environment is the use of land. The use and misuse of land have serious effects on the environment. Mining is the removal of minerals from the earth crust (land) for the service and benefits of manking. This removal is generally accompanied by some sort of impact on the environment.

This study was therefore to detect, identify and map out area of illegal gold mining in Minna and environs. It equally tries to evaluate the impact of illegal gold mining on the environment; which in turn affects the different landuse/landcover category of the area. The mapping of the different categories of landuse/landcover was carried out with the interpretation of airphotograph, topographic map and metric sheets of Minna.

Visual interpretation was used, Ground truthing was carried out at different stages to verify doubtful features. Two maps were generated and the area extent of each category of landuse/landcover identified and mapped was determined by grid in square meters to get the hectare of each category of landuse/landcover.

The result indicate that within 15 years, there has been a tremendous increase in Agricultural land, followed by Built up land and water body while Range land, Barren land and Forest land exhibit decrease in the areal extent of hectare. Reasons for increase and decrease in the areal extent of hectre of the different landuse/landcover category were suggested in this work. Equally important to note are proffered solution on how to curb this menance on the environment.

The result of the study and the recommendation are useful because the environment belongs to all generations present and future and therefore must be protected.

DEDICATION

TO EMMANUEL OMONOM OUR PRECIOUS GIFT FROM GOD.

ACKNOWLEDGEMENT

I am most grateful to Almighty God who in his infinite mercy spared my life and granted me sound health and a peaceful home during my course of study.

This work would not have been accomplished without the full cooperation and assistance of my Superior, Dr. U.T. Umoh. I am indeed grateful for his criticism and advice. I equally commend the contribution of Dr. M.T. Usman and Dr. Ms. A. A. Okhimamhe who was ready to give assistance at all times.

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My unreserved thanks goes to my dearest sister Mrs. Z.J. Matane for her sisterly cooperation, infact she is one in a million, also are my parents Mr. and Mrs Ali Giwa, mother inlaws

and especially bross Bello B. Paiko and Badaki Shuaibu whose financial assistance made this study a success.

Finally, my husband whose encouragement made me carry on with this study; my brothers and sisters and to every other person who has contributed in one way or the other towards successful completion of this work, but whose names cannot be mentioned here. May the Good Lord in his Infinite mercy reward you accordingly to the measure of your deeds.

Amen.

CERTIFICATION

This is to certify that this research was carried out by UMARU HELEN WILLIAM(MRS) of the Department of Geography, School of Science and Science Education, Federal University of Technology, Minna under the supervision of Dr. U. T. UMOH.

Dr U.T.Umoh
Research Supervisor

26-04-99
Date

Dr G.N. Nsofor
Head of Department

28/4/99
Date

Dean,Post Graduate School

1/9/99
Date

Prof. S.O. Ojo
External Examiner

Date

TABLE OF CONTENTS

	PAGES
TITLE	i
ABSTRACT	ii
DEDICATION	iii
ACKNOWLEDGEMENT	iv - v
CERTIFICATION	vi
TABLE OF CONTENT	vi - xi
LIST OF PLATES	ix
LIST OF TABLES	x
LIST OF FIGURES	xi
CHAPTER ONE	
1.1 INTRODUCTION	1 - 2
1.2 STATEMENT OF THE PROBLEM	3
1.3 OBJECTIVE OF THE STUDY	3 - 4
1.4 JUSTIFICATION AND SIGNIFICANCE OF THE STUDY	4 - 5
1.5 SCOPE AND LIMITATION OF THE STUDY	5
1.6 THE STUDY AREA	5
CHAPTER TWO	
LITERATURE REVIEW	[illegible]
2.1 OVERVIEW	6 - 8

2.2 HISTORICAL BACKGROUND OF GOLD MINING IN NIGER 8

2.3 MINERAL DEPOSITS OF NIGER STATE 8

2.4 LOCATION OF GOLD DEPOSITS 8-11

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 RATIONALE FOR USING VISUAL INTERPRETATION 12-13

3.2 DATA TYPE 13

3.3 DEVELOPMENT OF LANDUSE/LANDCOVER CLASSIFICATION 13-14

3.4 DATA INTERPRETATION 15-16

3.5 GROUND TRUTHING 16

3.6 METHOD OF ANALYSIS 16

3.6.1 1974 LANDUSE/LANDCOVER SITUATION 17

3.6.2 1982 LANDUSE/LANDCOVER SITUATION 17

CHAPTER FOUR

ANALYSIS AND DISCUSSION

4.1 PREAMBLE 18

4.2 VISUAL INTERPRETATION OF THE AIR PHOTOGRAPH 18-20

4.3 CHANGES OBSERVED BETWEEN THE PERIOD 1982 WHEN THE AIRPHOTOGRAPH WAS TAKEN AND PRESENT FIELD OBSERVATION. 23

4.3.1 INCREASE IN THE BUILT UP LAND 23-24

4.3.2 SCENIC EXPRESSION OF THE ENVIRONMENT 25

CHAPTER FIVE

IMPLICATION AND APPLICATION OF THE STUDY

5.1 PREAMBLE 30

5.2 IMPACT OF ILLEGAL GOLD MINING ON THE ENVIRONMENT 31

5.3 ENVIRONMENTAL IMPACT ASSESSMENT 31-33

5.4 SOLUTIONS TO GOVERNMENT ON HOW TO CURB THIS MENACE ON THE ENVIRONMENT 33-35

5.4.2 POWER OF THE AGENCY 36

5.4.3 SOLUTIONS 37

CHAPTER SIX

SUMMARY, CONCLUSION AND RECOMMENDATION

6.1 SUMMARY 38-40

6.2 CONCLUSION 40

6.3 RECOMMENDATION 41-42

BIBLIOGRAPHY 43-46

APPENDIX

LIST OF PLATES

PLATE I	AIRPHOTO OF MINNA	
PLATE II	PHOTOGRAPH SHOWING HOW FLAT ONE OF THE BANK OF THE RIVER IS	25
PLATE III	PHOTOGRAPH SHOWING THE FORMATION OF GULLIES	26
PLATE IV	PHOTOGRAPH SHOWING THE FILLING UP OF THE RIVER BED WITH LATERITIC SOIL	27
PLATE V	PHOTOGRAPH SHOWING CHILDREN ENGAGING IN GOLD MINING FOR THEIR SUSTENANCE.	28

LIST OF TABLES

TABLE 3.1	DATA TYPE	13
TABLE 3.2	THE USGS LANDUSE/LANDCOVER CLASSIFICATION	14
TABLE 4.1	VISUAL INTERPRETATION OF THE AIRPHOTOGRAPH	19
TABLE 4.2	LANDUSE/LANDCOVER SITUATION IN 1974	20
TABLE 4.3	LANDUSE/LANDCOVER SITUATION IN 1982	21
TABLE 4. 4	LANDUSE/LANDCOVER CHANGES	22

LIST OF FIGURES

FIGURE 1 GEOLOGICAL MAP OF NIGER STATE SHOWING MINERAL DEPOSITS

FIGURE 2 MAP OF NIGER STATE SHOWING THE STUDY AREA

CHAPTER ONE

1.1 INTRODUCTION

Remote sensing could simply be defined as the science, art and Technology of obtaining reliable information about earth objects, area or any phenomenon through the analysis of data acquired by a device that is not in physical contact with the phenomenon under investigation. In order words, remote sensing is the science of acquiring and interpreting information about the earth environment from measurements made without physical contact. The human eye is the most common remote sensing device, but it is restricted to obtaining local information in the visible part of the spectrum. This capability can be extended by using instruments on board air crafts and the field of view can be enlarged (even further) when the instruments are placed in orbit about the earth.

Mining is the removal of minerals from the earth crust for the service or benefit of mankind. This removal is generally accompanied by some sort of impact on the environment. There are a number of ways in which mining affects the environment; these include direct hazards to people's life and property. Less direct hazards include pollution of water, damage to croplands, unpleasant sight of the mining area, formation of deep gullies, sedimentation of river beds due to the collapse of large chunks of soil, land shrinkage etc.

About one half of the land mass of Niger State is underlain by the basement complex rocks, while the other is occupied by the Cretaceous sedimentary rocks of the Bida Basin. The boundary between these runs in Northwest-south east direction with the basement rocks to the North and the sedimentary formation to the south.

The basement rocks consist of a suite of Precambrian gneisses, migmatites and

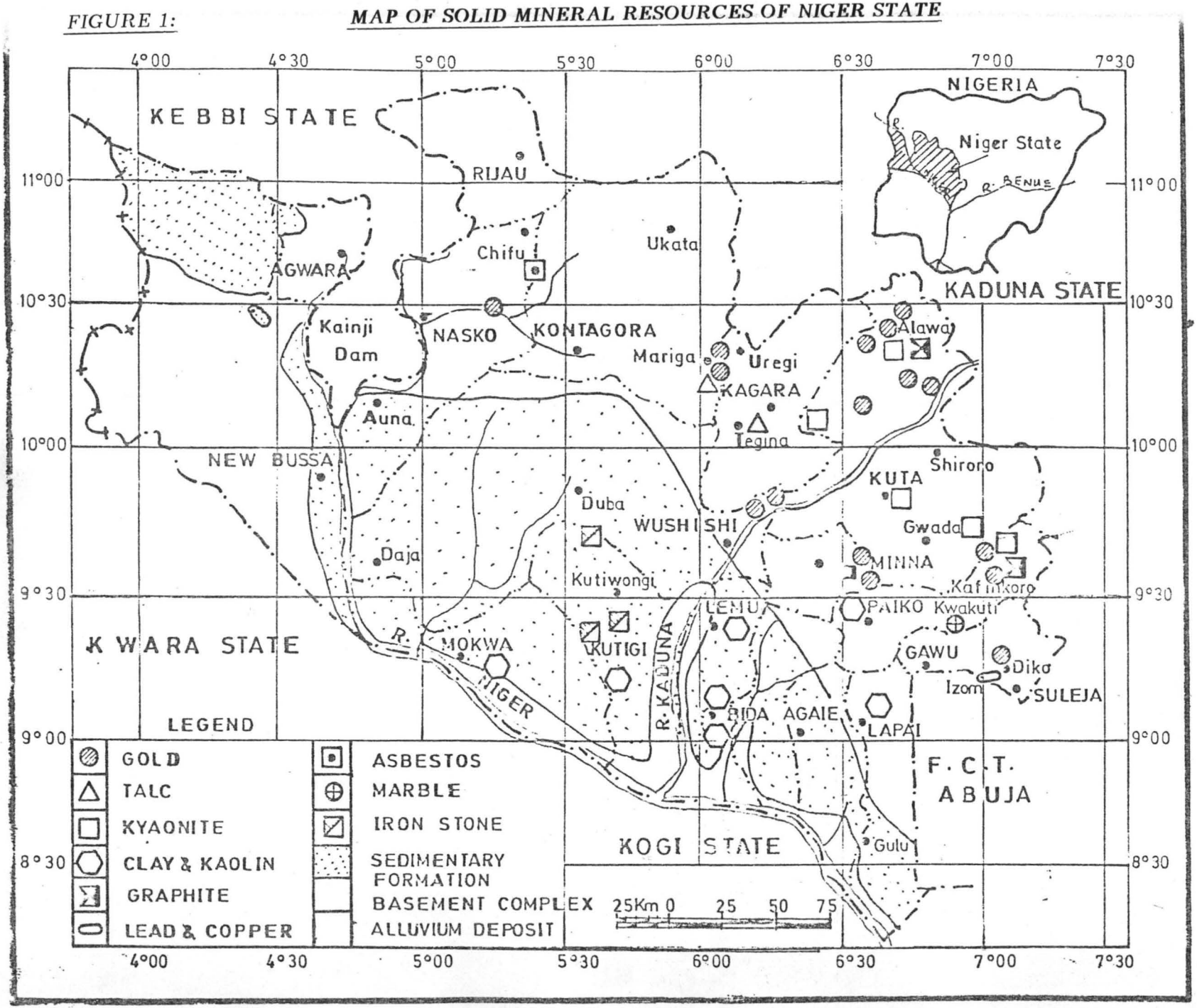
metasedimentary schist cross cut by intensive granitoids (Oyawoye 1972 and McCurry 1976). The gneiss and the Metasedimentary schist which constitute the host rocks to the granitods and are found mostly as flat lying outcrops, are often ill exposed except along river channels and road cuttings.

The sedimentary formation on the other hand consists of loosely cemented sandstones of varying grain sizes, silt stones, clays and shale, and/or ironstone concretious particularly in upland areas (Shekwolo 1992). A typical weathered profile of the basement rocks consist of two main zones, firstly, the surficial zone which may range from a few meters to over 20 meters in place. Products of weathered granites and gneisses are usually loose aggregates of medium to coarse sand, while the weathered products of schist is generally made up of clayey sand. The weathered zone is the host for minerals.

Mineral deposits that are found in Niger State and which are shown on the Map (fig 1) are gold, Talc, Kyanite, Marble/Dolomite, Graphite, Galena, Iron Ore and Silica sand. For the purpose of this study mineral deposits of Niger State will briefly discussed but much emphasis will be limited to gold the precious mineral deposit whose exploitation has resulted into environmental degradation.

The resolution of Nigeria's environmental problems must not and cannot be left to the government alone. In view of the immense tasks facing us in the field of environment and given limited national resources, the Nigerian Government must count on the goodwill and support of all citizens,. There is a need to educate people, especially at the grassroots level to be aware of their responsibility for nurturing and wisely utilizing the environment and taking urgent step towards restoring environmental balance wherever such balance has been upset.

FIGURE 1: ***MAP OF SOLID MINERAL RESOURCES OF NIGER STATE***



1.2 STATEMENT OF THE PROBLEM

Mining activities have literally moved mountains and some surface excavations are so vast as to resemble craters on the moon. Mining destroys the protective vegetation cover, and the solid and rock overlying the mineral deposits frequently left in massive piles cast into adjoining land. The result is drastic reshaping of the surface and subsurface drainage patterns. Effect of mining upon the environment vary widely, depending upon the steepness of the terrain, amount of precipitation, temperature, chemical characteristics of the mineral and method of mining.

Mining affects the environment in three major ways namely to some degree; it influences the quality of our air, land and water and through these man, animals and plant life.

Application of remote sensing technique in environmental degradation in Nigeria lack the sophistication of developed and even some developing countries within Africa. The reason for this is the exorbitant costs of image acquisition and processing.

Against this background, remote sensing data would be used to identify and detect mining parameters, evaluate the impact of illegal Gold mining on the environment and proffer solution to government on how to curb this menace.

1.3 OBJECTIVE OF THE STUDY

The main objectives of this study are:

1 To detect, identify and map out area of illegal Gold mining in Minna and environs.

2 To evaluate the impact of illegal mining on environment in terms of

- the extent this illegal gold mining activities affected the environment generally.

- the proportion of the area been damaged due to the formation of gullies.
- how this activity affected land use.
- how government can curb this menace.

3 To proffer solution to the government on how to curb this menace.

1.4 JUSTIFICATION AND SIGNIFICANCE OF THE STUDY

The study of man's environment is the central theme of Geography, while land use is the most important way by which man is related the environment. The economic status of any nation is always a direct result of the use it makes of the available natural resources and poor decisions regarding resource allocation and use can lead to decline in resources quality, and economic productivity.

Importantly, in Nigeria where mineral industries are often of greater economic importance, government is often reluctant to put non-essential restraints on its main earners of wealth. There are typical examples of mining activities of importance to government whose sites and now degraded landscapes. Such places include the Jos tin mines and the Enugu coal mines. In both examples, the sound practice of land reclamation which is an integral part of the mining cycle has not been observed.

In minna, the Niger State Capital, the illegal gold mining activity is of direct economic benefit to the miners and not the government. This is so because these mineral deposits are scattered all over the place in patches in quartz veins or in quartzite schist formations. Also, there are alluvial gold found in river/stream beds around old river valleys and present river channels as is the case behind the Army Barracks at Chanchaga, around the Boy Scout (Bahovin camp) and at Shango along river Gora.

It is, therefore, very necessary to have a comprehensive and current information about the hazards caused to people's lives and the environment in general; in terms of formation of gullies, deshaping the land surface of the area, mass wasting which is resulting into the siltation of river Gora upstream of the Chanchaga river where it has been damed. This may eventually damage the efficiency of the dam if not checked. other hazards caused to the environment include pollution of water, and damage to agricultural land.

This study is undertaken to highlight the dangers of environmental degradation due to the impact of illegal mining and also call for adequate awareness by the generality of populace of the hazards of illegal mining and need for environmental protection.

1.5 SCOPE AND LIMITATION OF THE STUDY

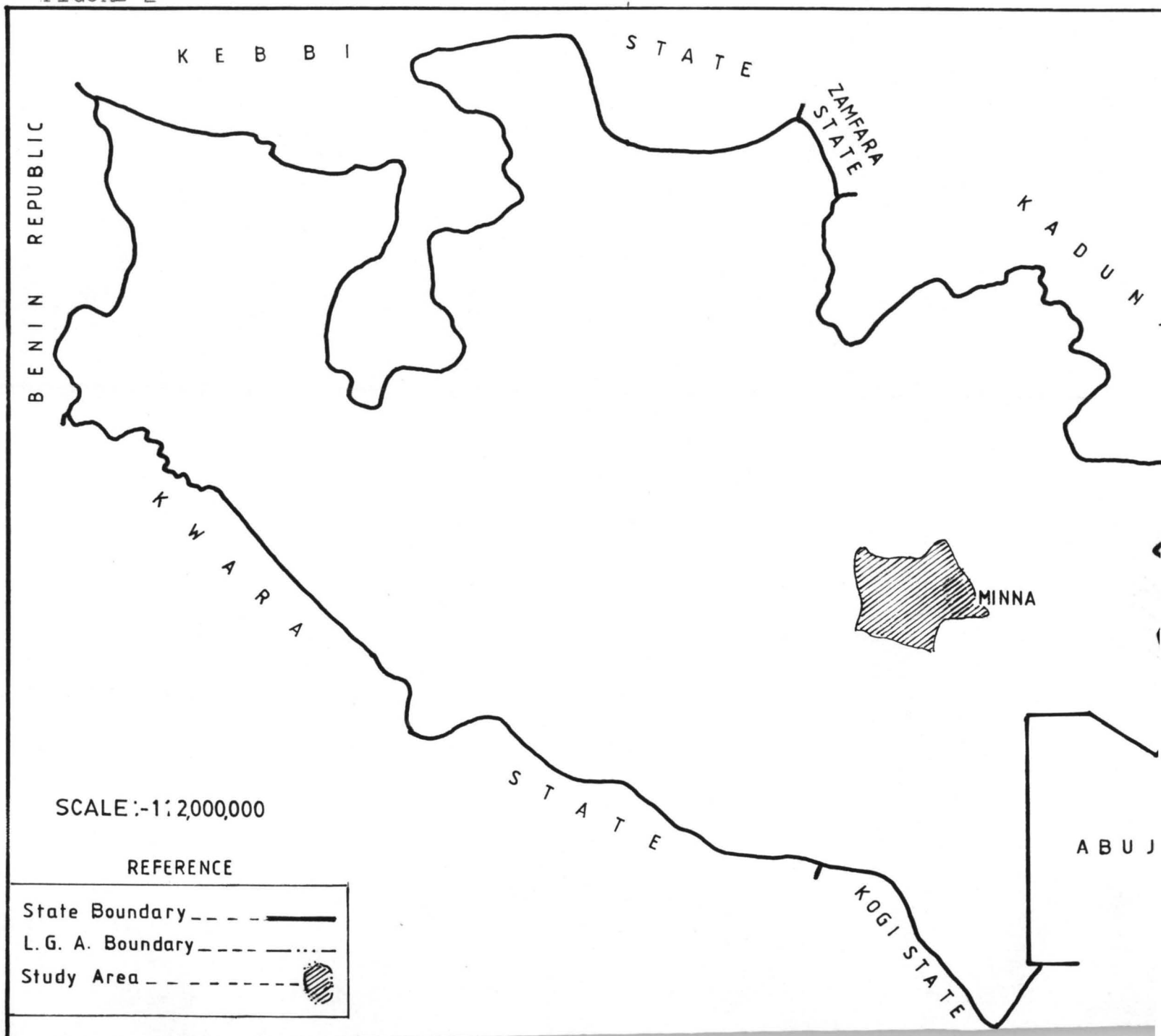
The study will be centered within Minna and its environs due partly to the limitation of available air photos. Results and conclusions here will then be used to make inferences about other parts of Niger State. This is based on the assumption that Socio-economic and environmental factors in these areas are same or similar.

THE STUDY AREA

The study area is Minna and its environs. It is located on longitude 6° 33'E and latitude 9°35'N. The position of the study area in shown on Fig 2. The extent of the study area is about 1,235km^2 with population of 35,000 {local government source}.

FIGURE 2

MAP OF NIGER STATE SHOWING THE STUDY AREA



CHAPTER TWO

LITERATURE REVIEW

2.1 OVERVIEW

According to Curtis (1973) the most important and fundamental of all factors that determine the quality of an environment is land use activities . Although not much research has been done on the impact of illegal mining on environmental degradation. There are however, related literature's on use of aerial photographs on land degradation to assist in this regard. Knowledge of what currently exist is often a necessary condition for answering questions relating to environmental degradation as it affects peoples live and safety. This studies have attain a high level internationally but the levels is still low locally.

The earliest form of remote sensing is aerial photograph. (crater (1958) uses vertical photography to study sheet and gully erosions in Eastern Nigeria around River Njaba. He found that large potential agricultural land were damaged due to the nature of shape, runoff and human activities. He concluded that these conditions of land can be monitored through frequent aerial photography and photo interpretation. Similarly and more recently Patrick (1987) used aerial photographs and rainfall data to assess the impact of gully erosion in parts of former Gongola and Bauchi States. He also concluded that aerial photographs are useful tool for monitoring erosion hazard and land cover.

Also, Norman et al (1975) used photographs to monitor factors that affect slope instability in an area near seven oaks in Kent. In another development, Parry et al (1971) employ the use of infrared photographs to monitor changes in catchment characteristics. Their work shows how photographs can be used to carry out reliable analysis of drainage basin.

Koopmans (1982] carried out a comprehensive assessment of SLAR and air photograph images for geomorphic and geologic interpretation. He found that both photographs and radar image are important tools for mapping land features, and they can complement one another. And Vink (1982) concludes that landscape ecology can be mapped so easily within a short duration using aerial photographs and radar images.

Ihemadu (1985) concludes that aerial photographs are capable of satisfying most of the mapping assessment and producing needs of environmental hazards accurately, reliably, timely, cost effectively and can be available as and when required. On a related development, Patrick and Abdulhamid[1989] employed the use of photographs and questionnaire methods to assess the impact of dam construction on the downstream morphology and agricultural productivity in Kano State. The use of aerial photographs in mapping and predicting floods, water lodging and erosion risk has also been discussed in the work of Abdulkadir (1986).

It is therefore significant to notice and appreciate the tremendous application of aerial photos in the study of multiple land degradation problems. The extent of use may however, vary with the special quality of the photographs, the nature of the environment, especially vegetal cover and land use.

However, there are equally other related studies on environmental problems of mining edited by the Nigerian environmental study Action team (NEST) on Nigerian's threaten environment. A National profile (1991). As edited by NEST (1991), there are numerous problems which beset mining in Nigeria. This problem include low foreign demand for some minerals, gross domestic under utilization of some of them, even in the face of great potentials for industrial and other uses, illegal mining inadequate government control; and inadequate

manpower technological and financial input.

2.2 HISTORICAL BACKGROUND OF GOLD MINING IN NIGER STATE

Mining is known to have place taken in Beni. Kazai and Minna in the 1930s. Russ (1955) worked around Kazai, Beni and Minna in both eluvial and alluvial deposits with a measure of success. Since then gold mining has been taken over by local prospectors working mainly alluvial and colluvial material using gold pans.

2.3 MINERAL DEPOSITS OF NIGER STATE

The early geological investigation of the Precambrian of Nigeria especially that of North-Western Nigeria by Falconer followed by Dunstun (1911) triggered off a great deal of interest in gold exploration and prospecting in the region. The search for gold in Niger State dates back to this period.

Based on preliminary work by the mineral survey of Northern Nigeria, instituted by the colonial office in 1904, Dunstan (1911) started gold investigation in the then Niger, Sokoto and Zaria provinces and found gold in many quartz veins or in quartzite schist formation. Alluvial gold was also found in river stream beds around Koriga and Minna especially from Boy Scout camp[Baovin) all through to Shango along river Gora channel behind the Army Barrack along the old river valley of river Gora.

2.4 LOCATION OF GOLD DEPOSITS

Most part of Niger State lies within the schist belt of North Western Nigeria, known to be gold bearing. Gold in Niger State occurs in both primary and secondary forms. In the primary form it is associated with quartz veins within the quartzite rich schist formation.

The weathering of this rock leads to the release of Gold contain in it. During transport

of the weathered materials, local concentrations of gold and other heavy and resistant minerals to as traps. These form the main targets of geological and geophysical survey.

These secondary accumulation of minerals are known as placer deposits. They could be inform of eluvial, alluvial or colluvial. Gold is recovered from these by panning method. The alluvial gold occurs under the river alluvial cover. The changes in the river patterns during the Paleozoic and Cretaceous times,led to the concentration of gold in the alluvial covers along old river valleys.

The content of gold in alluvial deposits is directly related to the concentration of gold in source or primary auriferous rock. Large grains or course gold occurs at the base of a sequence or at the upstream reaches of the river channel, while the finer grains are found in the lower reaches as floats. The occurrence is usually irregular throughout the alluvial sequence.

Alluvial gold is found in both old river valley and present river systems of Kaduna Maru and Niger. Localities known to be rich in alluvial gold deposit include Kazai, Beni, Gurmana, Alawa, Kamberi, Erena, Galadima Kogo, and Zungeru Primary deposit associated with quartz veins are known to occur in Minna, Kambari, Tunga Goro, Alawa and Madaka.

Gold researches at any locality is not uniformly distributed. Recoveries of about 1.0 ounces per kilograms of sediment is common in most localities.

Numerous problems beset mining in Nigeria. However, the environmental problems associated with the exploration, mining processing, transportation and storage of minerals are of immediate concern. General land degradation is quite pronounce in some mining regions, typified by large stretches of the Jos Plateau where open cast mining of tin have been going on for several decades.

On the Jos Plateau, in particular, there is a tremendous amount of scarification of the land surface resulting in the existence of numerous mines pits of various sizes. Some of this abandon pits contains permanent water bodies which are a veritable breeding grounds for mosquitoes that cause malaria and yellow fever.

All of them constitute a permanent physical danger for both human beings and livestock. Among this pit and ponds are hills formed by the material excavated during mining operations.

Even at small scales (that is in Minna) and apart from the spoilage of the appearance of the land surface very critical problems occasionally occur as when a mine pit caves in; some people get killed as was the case of women buried alive in Minna as reported in National Concord News Paper of 20th July, 1990; while they engage in illegal mining for gold.

The major law controlling mining and reclamation of derelict land in Nigeria is the mineral act of 1964. it affirms that the entire ownership and control of all mines and mineral oils in Nigeria are vested in the state. The act rest the responsibility for restoring and reclaiming mined land on the companies. Most unfortunately, compliance with the provision of the Act, in so far as land reclamation and restoration are concerned is often ignored with the matter.

There is an urgent need to revise very drastically the 1946 Act in the light of today's environmental and economic requirements and Technological advancements. A law that suited pick-axe and bucket mining operations is clearly inadequate for sophisticated activities based on the stream shored and chemical solvent extraction methods.

The stagnant blatant disregard for effective land restoration practices and the free wheeling excoriation and mutilation of prime quality agriculture land in mining operation should

be checked. This can be achieved through appropriate and enforced legislation backed with attractive incentives and adequate education campaigns.

It was NEST 1991 stated report on the impact of illegal mining activities on the environment as it affects people's life and safety; that made the government of Niger State under the leadership of Colonel C.K. Emein in 1991 to first blast illegal miner at Shango and behind the Army Barracks and at the time set up a task force to control the activities of illegal miners. Also in 1996 the government of Niger State under the leadership of Police Commissioner Simeon Oduoye, made an unscheduled visit to Gurmana and at that site arrested the illegal miners.

This attempts by government can be said to revise very drastically the 1946 Act in the light of today's environmental; and economic requirement and technological advancements. But still one most important of the issue is left untouched, that is to see to the restoration of the damaged sites where this practices took place.

This study has attempted to take advantage of the advances in remote sensing technology as have been applied in studies described above to further enhance our knowledge on environmental degradation in Minna; and to detect and identify areas of illegal gold mining; and to evaluate its impact on the environment; and to produce site map of the area and proffer solution to the government on how to curb this menace.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 RATIONALE FOR USING VISUAL INTERPRETATION

Conventionally, environmental degradation is excessively dependent on ground survey which has limited coverage. It is equally labourious, costly and time consuming. The utilisation of remote sensing technique for example aerial photograph, has a synoptic coverage. Data could be collected in remote areas like jungles which are impenetrable and also inaccessible high rocky areas. Remote sensing has broader view and more selective ability to detect and identify variation in environment and land scape.

Furthermore, remote sensing help man to know the location, quantity, quality of resources at his disposal at a given time. Air photographs provides the perspective from viewing regional problem hence the use of remote sensing in the evaluation of the impact of illegal gold mining on the environment in this study. Permanent, spatial and temporal records are available for detailed information about the area. This permits rapid in house assessment of resources with reduced field information which leads to consistent and reliable results.

Visual interpretation of air photos is a realistic alternative to numerical resources and environmental degradation. One great advantage of the visual interpretation method is that the same equipment used for conventional interpretation of maps can be used for interpretation of aerial photographs. Therefore competent staff with a good knowledge of the local conditions would produce the best results.

Visual interpretation makes use of low-cost material and the intermediate technology used for interpretation purpose offer particular advantages for inventories in developing countries of

the world. Computer based studies often rely on foreign equipment's there is also the uncertainty of obtaining acceptable and deliverable products from digital analysis.

3.2 DATA TYPE

The data type that were used for this study consist of the following:

1. Topographical map sheet of Minna SW (1967)
2. Metric sheets of Minna (34 and 36A) based on air photo of 1974
3. Airphotograph of Minna (1982)
4. Other instrument include magnifying glass (mirror stereoscope), plastic overlays (transparency and tracing sheet planimeter, rotring pens with ink and pencils.

Table 3.1: DATA TYPE

DATA TYPE	DATE	ACQUISITION SOURCE
Topographical map of Minna SW sheet 164 Scale 1:50,000	1967	Dept. of lands and surveys Niger State Ministry of Works, Housing and Environment, Minna
Metric sheets of Minna 34 and 36A scale 1:2,500	1974	
Air Photograph	1982	Dept. of Geography Federal University of Technology Minna.

3.3 DEVELOPMENT OF A LANDUSE/LANDCOVER CLASSIFICATION

The development of classification for landuse/landcover was done through the selection of a classification scheme which is basic to any landuse and landcover situation. This regard is to organize the needed information into a structure which would meet the research problems and objective of the study area.

According to Adeniyi (1978b) there is no landuse/landcover classification for Nigeria,

though standardized landuse/landcover classification schemes have been developed for general purpose (Anderson et al 1972) in order to make to the classification schemes clear for understanding the table below i.e. Table 3.2. show the different categories of landuse/landcover as observed from the airphoto.

The landuse/landcover classes is identify by two-digits symbols or codes indicating that primary categories (levell] and secondary categories (level II) of landuse/landcover will be interpreted from the airphotograph and metric sheets.

Table. 3.2 THE USGS LANDUSE/LANDCOVER CLASSIFICATION SYSTEM USED

MAJOR LAND USE AND MANUAL LANDCOVER CLASSES	MANNUAL/VISUL CLASSIFICATION
LEVEL I	LEVEL II
1. Built up land	11. Residential
	12. Commercial and service
	13. Transportation and Communication
2. Agricultural land	21. Crop land
	22. Swamp land
3. Range land	31. Shrub range land
	32. Mixed range land
4. Forest land	41. Decidious forest land
	42. Mixed forest land

5. Water	51. River
	52. Streams
6. Barren land	61. Lateritic surface and sandy area

3.4 DATA INTERPRETATION

A reconnaissance survey before a actual interpretation as well as the use of relevant collateral materials such as topographical map and the guidance of an experienced interpreter all helped to a great degree of accuracy in the interpretation.

A total of two photographs were interpreted using mirror stereoscope, transparency acetate overlays were placed over each photograph interpreted on which landuse and landcover boundaries where delineated. This process was carried out on a light table. The knowledge of airphoto reading method with such elements as shape, size, pattern etc, and also airphoto measurement which is the extraction density etc. was used in the interpretation of the airphotograph.

The end of result of the visual image interpretation will lead to the production of the illegal site map. What will serve as a base map for this site map is the topographical map. The information derived from the air photo will be transferred by tracing using clear acetate paper by overlying on a lighted table.

The evaluation of the impact of illegal Gold mining activity on the area will be done based on the production of the area map. For instance, the river Gora channel which flows from Mapi village down on Shango and then extended up to behind Gold Field of 31 Artillery Brigade of Nigerian Army and then eventually drain into river Chanchaga has increased in width the

river bed filled with chunk of soil which caves into the rivers as a result of collapse of the bank of the river and also as a result of the panning activity of Gold mining. This aspect will be buttress by terrestrial photographs to show the extent of damage done on the environment.

3.5 GROUND TRUTHING

Ground truthing was often carried out to verify the delineated boundaries and doubtful features were checked. Classifications and verifications of the accuracy of the interpreted data were also used.

The Ground truth for this work was carried out between September and November 1998. During this period error detected were immediately corrected because of the time lag between the time the air photographs and the ground survey, intensive care was taken so that changes in landuse/landcover may not be taken as interpretation error.

3.6 METHOD OF ANALYSIS

The method of approach chosen for this study is the visual interpretation technique Generally air photo interpretation involves observation, detection, recognition or identification of

features. There are three major process involve in air photo interpretation.

a. Air photo reading-This corresponds to simple identification of objects using such elements as shape, size, pattern etc.

b. Air photo Measurement-Is the extraction of physical quantities e.g. length, location, height, density etc. by using reference data such as the topographic map deductively or inductively.

c. Air photo Analysis-Is the understanding of the relationship between interpreted information and the actual status and to evaluate the situation.

In summary therefore, visual image interpretation was employed for identification and detection of mining parameters.

3.6.1 1974 LANDUSE/LANDCOVER SITUATION

The metric sheets of Minna SW of 1974 was analyzed to show landuse/landcover situation and this was taken as the static year. The different categories of landuse/landcover were drawn on a generated map of 1974. The areal extent in hectare of each year categories were calculated by the use of the grid in square meters. The total hectares of all the categories of class was calculated and the percentages of each class of landuse/landcover were calculated. A table was used to show the situation of the static year.

3.6.2 19982 LANDUSE/LANDCOVER SITUATION

In order to illustrate the landuse and landcover situation of 1982, air photographs were used. Two air photograph of the study area were assembled in form of a mosaic to delineate the study area. A trail interpretation of the frames of photo was carried out, the area was visited for ground truthing in order to check the trial interpretation.

Using the devised classification scheme, manual/visual interpretation of landuse and landcover of the study area was performed. The different classes of landuse and landcover mapped was recorded and grid in square meters was used to calculate the hectares of each class. The total hectares of all classes were summed up and the percentages of the hectares of all the classes were calculated to get the total hectare. A table was drawn to show the situation of the year.

CHAPTER FOUR

ANALYSIS AND DISCUSSION OF RESULTS

4.1 PREAMBLE:

In this chapter, the analysis and discussion of the findings are made. This however is based on the objectives of the study as stated in chapter one section 1.3. Meanwhile, the following sub themes are addressed viz: Interpretation of 1982 Airphoto; changes observed between the period when Airphoto was taken and the ground truthing exercise (field trip).

4.2 VISUAL INTERPRETATION OF THE AIRPHOTOGRAPH

The airphoto was visually interpreted with the aid of a mirror stereoscope. In order to carry out the exercise the 1:50,000 topographical map was used as a base map. The base map also facilitated the interpretation of the cultural and natural features of the airphoto.

Airphoto reading method which correspond to simple identification of objects using such elements as shape, size, pattern etc.; and also airphoto measurement which is the extraction of physical qualities e.g. length, location, height density etc. using reference data such as the topographic map deductively or inductively, were employed in the visual interpretation of the March 9th 1982 airphoto of Minna. Plate I shows the airphoto of the study area.

Ground truthing was carried out on one hand, to assist in confirming the interpretation and on the other, to established the present condition of the area. I am quite sure that the interpretation is not too far from ideal landuse/landcover of such area (wet and dry part of Nigeria).

The description and identification of the study area as shown on both the airphoto and topographic map are described below. It is note worthy that this description agrees with what

is expected in a savannah environment.

Table 4.1

VISUAL INTERPRETATION OF THE AIRPHOTOGRAPH

	ELEMENT OF CLASS UNIT	ELEMENT OF AIRPHOTO INTERPRETATION	AIRPHOTO APPEARANCE
1.	Built up land	Shape, Size	This show's up as clustered blocks squares, in some cases rectangular or elongated in shape. hey are clearly identified on the airphoto because of the reflectivity of the roof. Also there are dark patches of round huts in the interior parts of the photograph depicting settlements.
2.	Agricultural land	Size, Pattern	This shown up as either elongated or squares with undulating dark lines which depict agricultural lands for crop cultivation. While swamp land usually appear dark.
3.	Range land	Location and density	This appears as dots of dark patches amidst land cover which depict boththe shrub and bush range land
4.	Forest land	Height, Density	This normally is very visible along the road leading into the Boy scout camp and also the Niger House Motel
5.	Water	Pattern, Length	This appears as dark meandering with white patches which indicate the sandy reflection of the area because the photo was taken at the on set of the rains. On the photo are still traces of the earth dams constructed by Kate Bahovin and on the tepomap it is known as venon earth dam
6.	Barren land	Location	The reflectivity of this area on the photo indicate its lateritic and sandy nature thereby making it infertile for agricultural practices.

On the whole, the study area was compared of landuse/landcover classes and the extent hectares calculated and its percentage determined as shown on the table below.

Table 4.2 Land use/ Landcover situation in 1974 based on the metric sheets 34 and 36A of Minna S.W.

LANDUSE/LANDCOVER CLASSES	EXTENT IN HECTARES	PERCENTAGE
11	10.85	5.70
12	8.95	4.70
12	1.01	0.53
21	35.55	18.68
22	2067	10.87
31	20.88	10.97
32	20.35	10.69
41	12.43	6.53
42	10.42	5.48
51	2.52	1.33
52	0.288	0.15
61	46.32	24.35
TOTAL	190.238	99.97

As shown in table 4.2 above, agricultural land dominated the study area with 29.55% followed by barren land with a percentage of 24.35. The next is the range land with 21.66%. Forest land has a percentage 12.01. While Built up land has a percentage 10.93 and water bodies covers a total percentages of 1.48 of the study area. Se Appendix B for the landuse/landcover map of 1974.

Table 4.3 Landuse/landcover situation in 1982 based on the airphoto

LANDUSE/LANDCOVER CLASSES	EXTENT IN HECTARES	PERCENTAGE
11	18.45	9.69
12	17.01	8.93
12	1.39	0.73
21	45.22	23.75
22	23.32	12.25
31	11.88	6.24
32	11.34	5.95
41	11.53	6.05
42	8.32	4.37
51	2.52	1.33
52	0.288	0.15
61	38.97	20.46
TOTAL	190.238	99.97

As shown on table above, the landuse/landcover situation of 1982 is shown. Agricultural landcovers about 36% of the total study area followed by Barren land with 20.46%. The next is the Built up land with 19.35%,Range land with 12.19%. While forested land covers 10.42% and water body still covers 1.47% of the total study area.

Table 4.4 Analysis of Landuse/Landcover sheets 34 and 36A of 1974 and airphoto of 1992.

Landuse/Landcover - categories	1974 Percentage	1982 Percentage	Magnitude of change (%)
Built up land	10.93	19.35	+ 8.42
Agricultural land	29.55	36.0	+ 6.45
Range land	21.66	12.19	- 9.47
Forest land	12.51	10.42	- 7.09
Water body	0.98	1.48	+ 0.50
Barren land	24.35	20.46	- 3.89

N.B. + Increase

- Decrease

Between 1974 and 1982, the area covered by built land (residential, commercial and service, transportation and communication) has increased by 8.42%. This is likely due to the discovery of alluvial gold deposits along the river Gora and its surrounding streams. Equally important to note is the increase in Agricultural land (crop and swamp) which has also increased by 6.45%. This increase in Agricultural land can be tied also to the influx of people to the area due mostly to the availability of gold deposits and fertile land for farming activities.

Also is the observed increase in the water body where the alluvial gold deposit is mostly present, although the magnitude of change is not very high because as at the time the airphotograph was acquired, illegal mining activity has not reached its peak as it was observed during the ground truthing exercise.

On interviewing some of the residence of the study area it was gathered that illegal gold mining activity got to it peak as at 1989 - 1992 and it is still continuing. It was edited in NEST (that in July 20th 1990 during illegal mining activities) it was reported then that during the

process of mining chuck of soil cave in and buried some women alive.

Other landuse/landcover categories which have negative magnitude of change is highlighted as thus: Range land (shrub and mixed range land) experienced a significant decrease of about 9.47%. Since, most of the residents especially at the Northern part of the river can be classified as rural settlement, must have been felling the shrubs for fire wood. Hence the significant decrease in range land.

Also important to note is the decrease in Forest land (Deciduous and Mixed forest land), with a percentage of 2.09. Most of this trees must have been fell for building and other domestic purpose. Hence the tremendous influx of people into this area calls for decrease in forest land.

Lastly is the decrease in the Barren land. The percentages magnitude of change is about 3.89. This category of landuse/landcover was also tempered with for settlement purpose, for instance, though this area is not fertile for agricultural practice; but its suitable for building purpose because of easy of getting hold of building materials such as stones, sand and laterites; so most of the rural settlement are found in such places.

4.3 CHANGES OBSERVED BETWEEN THE PERIOD 1982 WHEN THE AIRPHOTOGRAPH WAS TAKEN AND PRESENT FIELD OBSERVATION

Owing to the ground truthing exercise carried out to enable the visual interpretation of the airphotograph of the study area, it was c;early observed that changes have taken place, and these changes are going to be discussed under two separate headings viz:

4.3.1 INCREASE IN THE BUILT UP LAND (RESIDENTIAL, COMMERCIAL AND SERVICE; TRANSPORTATION AND COMMUNICATION

As observed during the field exercise, there is a tremendous increase in the built up land

as compared to what was observed on the airphotograph. The increase in the built up land which indicates a rapid influx of people to the area can be attributed to the presence of the alluvial gold deposits present along the river Gora channel and its stream. Like the common geological saying goes :There is gold in river Gora" and true to the saying people have been attracted in large numbers to cash in on the deposits.

It is equally of paramount importance to observe here that most of these new residents are retired uniform men and civilian who practice little subsistence farming to supplement their pension. These retired uniform men and civilian with their house holds are found engaging in this illegal gold mining activity to sustain themselves and also educated their children. Infact that is their only mean of sustenance especially during the dry season.

Equally important to note is the relocation of the Niger State College of Education. This relocation has led to a high increase in the built up land as both workers and student source for accommodation in this area because of proximity to their place of work and school. Some of the students because of the harsh economy also find themselves engaging in this illegal gold mining to supplement their livelihood.

PLATE I. AIR PHOTOGRAPH OF THE STUDY AREA.

4.3.2 SCENIC EXPRESSION OF THE ENVIRONMENT

Also noticed during ground truthing exercise, is an increase in the width of the river Gora channel. As observed on plate II below, one bank of the river (as you descend into the river) is barely flat and overgrown with weeds. While the other is widening as a direct impact of erosion and the tree on the photograph is almost at the verge of collapse all for gold. At a closer look a boy can be seen digging for gold.

Plate II: One bank of the river is barely flat and overgrown with weeds.

Also important to note is that farmlands are being affected by the same enomenon. The defacing of the bank of the river can also be observed on plate III. This entually gives rise or encourages the formation of gullies.

Plate III: Formation of gullies

Equally important to note on plate IV is the filling up of the river bed with lateritic soil which eventually reduces the amount of water in the river: This could lead to at the long run to the death of the river.

Plate IV: The filling up the river bed with lateritic soil.

Children can be seen on plate V below engaging in gold mining for their sustenance. On interview, they submitted that they needed to but books and pay for school fees.

Plate V: Children engaging in gold mining for their sustenance.

This activity must be checked, because it is more expensive to arrest or stop the formation of gullies where it is already formed. it is also necessary to reduce the amount of sediments that drain into river Chanchaga because this will eventually affect the capacity of the dam that is constructed along the river.

CHAPTER FIVE

IMPLICATION AND APPLICATION OF THE STUDY

5.1 PREAMBLE

This chapter places emphasis on the implication and application of the findings on chapter four. Meanwhile it shall be addressed under the following subhead issues: Impact of illegal gold mining on the environment; Environmental impact Assessment; and to proffer solution to government on how to curb this menace to the environment.

5.2 IMPACT OF ILLEGAL GOLD MINING ON THE ENVIRONMENT

The impact of illegal gold mining activity on the environment is of immense interest to ıll who are environment-friendly especially the enlightened populace who are aware of the ıdverse effects of this practice on the environment. Most people especially the semi literate and lliterate persons who engage in this act do not understand the hazards caused on the nvironment and that is why they continued to engage in it, to them it is a source of income for heir livelihood.

In this study however, it is revealed that illegal gold mining endangers the environment; ıat it leads to serious environmental degradation whose effects surpass the little financial enefits they are now enjoying. As reported in the British Geological survey Bulletin of July 998: Historically, Mining to extract metals has produced wastes which contain toxic chemicals. lthough the impact of the toxic chemicals might not be immediately felt, until possibly after bout 50 years before its manifestation. Its manifestation appear usually by coating the river bed ith an orange precipitate of ferric hydroxide and killing most of the aquatic life.

Equally important to note is that mining permanently alter the state of the ground. In

many coal fields, several seams have been extracted in extensive overlapping 'stacks' of working. Subsidence fractures extend upwards, not only causing damage to property on the surface, but creating path way for mine water movement. This mine water movement not only affects water courses but also poses a possible risk to the permo-Triassic water supply aquifers which over live the concealed coal field.

Farmland along the bank of the river as seen on plate III are on the verge of total destruction as the digging for gold continues. This menace if not checked would encourage erosion which eventually would lead to land wasting, because as chunks of soil continuous to fall into river, the size of the farmland will be reducing; thereby affecting the agricultural yield of the land.

However, the impact of illegal gold mining on the environment is regarded as a loss rather than advantage to the local subsistence farmer. Often it causes huge losses of land property and some times losses of life as well. Obviously if some thing tangible is not done by the government to abate continuous practices of illegal gold miners; more and more losses would be recorded on the environment as time goes on and in turn affect man and animals.

.3 ENVIRONMENTAL IMPACT ASSESSMENT (EIA)

The practice of EIA in developing countries such as Nigeria and in particular Minna has not been without difficulty and not without some concern for the effectiveness of current assessment models and procedures particularly where these are constrained by limited data or by a limited environmental mandate.

The United nation recently expressed this concern in pointing out that " That basic national, procedures and methodologies devised for environmental impact assessment have been

modeled largely on industrialised and developed countries, whereas the majority of developing countries in which they are performed are predominantly agricultural, developing towards industrialisation, with diverse natural and cultural background" (United Nation, 1991).

On a related theme, Stromquist (1992) stressed that assessments undertaken in developing countries using conventional methods have been significantly hampered in scope and perspective by the lack of time series data needed to support judgements on environmental change and by the inappropriateness of methods which rely heavily on processing of extensive quantitative data sets. Despite the lack of sufficient conventional background data, attempts have nonetheless be made to assess the environmental impact of illegal gold mining in Minna.

The six main activities involved in EIA as enumerated below defines its role and objectives and an environmental information gathering process, no matter which approach is followed nor what combination of methods are used:

. Identification of impact

. Estimation of impacts (when possible)

. Interpretation of Assessment results

. Presentation of assessment results

Identification of appropriate management plans and monitoring scheme

Communication of impact information in a form comprehensible to clients and decision makers. These activities are currently within a fiered set of procedure designed to facilitate the production and delivery of environmental information to the user at key decision points between initial proposal and final project design.

The procedures themselves have been considerably revised in attempts to fit the

information stream to the requirements of the decision makers.

The range and impact prediction and evaluation method drawn upon for use within these procedures are extensively discussed in the literature review chapter. The clearest message given by the literature review is that none of the methodologies either singly or in combination can be considered flexible enough to cope with the needs of most development programmes and project within agricultural, water resources, and landuse planning sectors.

Nevertheless, as already enumerated in the objective of this study, the third approach of the EIA method, that is the overlay mapping was what was employed in the methodology of this study. The overlay mapping approach has long history of use in environmental planning being ideally suited for observing the partial aspect of an impact. This method on a base map showing the outline of the project area. Overlays although particularly suitable for the presentation of partial dimensions of impact, are characteristics such as probability, time and reversibility.

.4 SOLUTIONS TO GOVERNMENT ON HOW TO CURB THIS MENACE ON THE ENVIRONMENT

Nigerians interaction with its environment is not a recent phenomenon. The sense of wareness of the environment could be found in traditional landuse and human settlement ractices.

Land resources degradation includes gully erosion, coastal erosion and desertification. mong the causes of these problems are improper construction techniques, poor farming chniques, overgrazing, mining activities such as the illegal gold mining activities, natural enomenon, wave action and so on (World Bank Report 1990:26).

The World Bank (1991) reported that environmental degradation directly affected the es of about 50 million Nigerians. In economic terms, Nigerians environmental losses

amounted to about #25 million or 13% of 1991 Gross National Project (GNP) (The Nigerians Environment, vol.3, No.1, March 1991) since then, Nigerian environmental degradation has worsened due to skyrocketing increase in petroleum and Kerosene prizes affecting the socio economic lives of the citizens. These observations were highlighted in 1985 by Mabogunje when he said that the next few years were going to witness tremendous efforts at increased production and enhanced productivity in the country with the following consequences:

> It will be so easy for people to become so exigent, worrying only about what to get out of the environment for their own immediate needs and uses, without caring very much for the consequences, especially for succeeding generation (Mabogunje, 1985).

Relatedly, the national policy on population for development (1988) observed that:

The present high rate of our population growth is already contributing Substantially to the degradation of the environment of the country.

Environmental issues are now recognised as an integral aspects of sustainable economic development. Further, it has been realised that the environment belongs to all generations present and future and therefore it must be protected.

Consequently the Nigerian Government established the Federal Environmental Protection Agency (FEPA) under decree No. 58 of December 30, 1988 as an autonomous body, charged with the legal responsibilities of the Nigerian environment.

Similarly the Niger State Environmental Protection Agency under the Military

Administration office was established to serve as the apex and rallying government organ in an attempts to combat both state and National Environmental problems.

The Former Administration in person of Police Commissioner Simeon O. Oduoye officially inaugurated the agency's governing council giving them all necessary support to operate on the 20th October, 1996.

5.4.1 FUNCTIONS OF THE AGENCY

The agency was given the following mandates;

a. protection of the environment and bio diversity, conservation and sustainable development in Niger State

b. regulate operational mechanism for refuse collection and disposal

c. promote environmental education and awareness

d. monitor environmental water, air, land and Natural resources quality

e. in conjunction with the existing bodies to co-ordinate urban and regional planning and liase with the federal, state, local governments, public and private organisations.

f. ensure implementation and enforcement of regulations of the Federal Environmental Protection Agency (FEPA)

g. conduct research on matters relating to environment

h. prevent any act of omission or commission on the consequences of which are likely to adversely affect the environment

i. collaborate with Federal Environmental Protection Agency in conducting public investigation on major environmental pollution.

5.4.2 POWER TO THE AGENCY

The agency is also mandated to:

a. Grant honour and give awards for projects that enhance State environmental protection objectives.

b. Encourage individual or group who have interest and ready to assist in environmental protection.

c. Monitoring and enforce all environmental laws and regulation stipulated in 1996 Niger State Environmental Protection Edit and FEPA decree No. 59 of 1992.

d. Make available basic scientific data and other information pertaining to environmental protection.

e. Advise government on bye-laws, policies and priorities on environment and natural resources and conservation.

Despite the seeming success of NISEPA, all is not well as far as environmental degradation in the state in concerned, and in particular Minna where illegal gold mining activity is still continuing.

This sate of affairs is not unconnected with the low level of awareness of modern environmental concerns. While materials poverty on the one hand affects the environment adversely, consumption pattern and greed of many rich people contribute to environmental degradation.

Equally important to note is the high level of illiteracy in the state and in particular, minna where this illegal gold mining is still continuing.

5.4.3 SOLUTIONS

a. Nigerlites and importantly the populace of Minna need to be sensitize to environmental issues and problems.

b. Public awareness at all level of the society is equally very essential.

c. Landuse decree of 1976 which is expected to accelerate development needs to be effected.

d. Decree 88 of 1992 on Environmental Impact Assessment (EIA) also needs to be effected.

e. A task force to be responsible for the monitoring of these areas where there are deposits of gold need to be constituted permanently to serve as checks.

f. To realise the purpose of (e) settlers around this deposits should be charge with the responsibility of protecting this areas where there are gold deposit, while government should give them all the necessary protection against any form of harassment.

CHAPTER SIX

SUMMARY, CONCLUSION AND RECOMMENDATIONS

6.1 SUMMARY

This study is designed to use remote sensing techniques in the study of environmental impacts of illegal gold mining in Minna. However, mining is known to be the removal of minerals from the earth crust for the service and benefit of mankind. This removal is generally accompanied by some sort of impact on the environment.

There are a number of ways in which mining affects the environment; these include direct hazards to people's life and property. less direct hazards include pollution of water, damage to croplands, unpleasant sight of the mining area, formation of deep gullies, collapse of large chunks of soil, land shrinkage etc.

The impact of illegal gold mining activity on the environment is of immense interest to all who are environment friendly especially the enlightened populace who are aware of the adverse effects of this practice on the environment.

The major thrust of the study are therefore, set to detect, identify and map out area of illegal gold mining; to evaluate the impact of illegal mining on the environment and to proffer solution to government on how to curb this menace.

Related literature were reviewed based on the objectives of the study. it was gathered that numerous problems be set mining in Nigeria because the major law controlling mining and reclamation of derelict land in Nigeria is the mineral act of 1946. Most unfortunately, compliance with the provision of the Act, in so far as land reclamation and restoration are concerned, is often ignored with the government seemingly helpless in the matter. There is an

urgent need to revise very drastically the 1946 Act in the light of today environment and economic requirements and technological advancements.

Experienced with remote sensing techniques in the study of environmental impacts of illegal gold mining in Minna; when reviewed shows that it is quite good to detect, identify,and map out area of illegal gold mining. For instance, it was easy to evaluate the impact of illegal gold mining on the environment.

On landuse/landcover situation, the review equally shows that the use of remote sensing techniques is quite adequate. For instance, combination of topographic map sheet 164SW of Minna and Aerial photograph 1982 with ground truthing observations were used to detect, identify, map out and evaluate the impact of illegal mining on the environment.

Equally important to note is Crater (1958) uses vertical photography to study sheet and gully erosions in the eastern Nigeria around River Njaba. He found that large potential agricultural land were damaged due to the nature of the shape, run off, and human activities. He concluded that these condition of land can be monitored through frequent aerial photographs and photo interpretation. Also Patrick and Abdulhamid (1989) employed the use of photographs and questionnaire methods to assess the impact of dam construction on the down stream morphology and agricultural productivity in Kano State.

It is therefore significant to notice and appreciate the tremendous application of aerial photos in the study of multiple land degradation problems. The extent of use may however, vary with spectral quality of the photographs, the nature of the environment especially vegetal cover and landuse.

In a nutshell, aerial/air photo graph of 1982 of the study area was visually/manually

interpreted. The landuse/landcover classification system was used and its classes calculated in hectares. The evaluation of the landuse/landcover of the area was carried out. Increase changes were recorded in the following landuse/landcover classes viz: Built up land, Agricultural land, water body, while there are considerable decrease in the classes of Range land, Forest land and Barren land.

6.2 CONCLUSION

This study revealed that illegal gold mining endanger the environment, that it leads to serious environmental degradation whose adverse effects surpass the little financial benefits they are now enjoying. It has also demonstrated the use of aerial photography, topographic map and metric sheets of Minna with ground truthing exercise to provide the bio-physical and human environment information necessary to detect, identify and map out area of illegal gold mining. The use of photograph. Topographic map and metric sheets of Minna with ground truthing exercise (terrestrial photos inclusive] is an improvement over the use of aerial photograph alone.

The increased changes observed in Built up land, Agricultural land and water body indicate that there is a rapid influx of people to the area because of the availability of the alluvial gold deposits. Consequently, the decrease changes observed in the range land forest land and Barren land, also depict the latter reason of why suddenly the place became well peopled.

The expansion in the width of the river Gora channel and its streams depicts the geological saying of "There is gold in river gora". At this juncture it is important to note that mining permanently alters the state of the ground. However, the impact of illegal gold mining on the environment is regarded as a loss rather then an advantage to all who are environment friendly.

6.3 RECOMMENDATIONS

Efforts could still be made to any researcher to acquire more detailed information on different components than was achieved by this study. Hence, efforts should be made to consider the following issues.

i. Efforts should be made to employ the combination of high resolution data such as SPOTXS, SPOT HR and landsat TM together with aerial photograph data. This would provide a more detailed and accurate environmental impact assessment for planning purposes.

ii To be able to study in detail as well as to understand the environmental degradation of the area, imageries of the area at two different dates should be acquired.

iii. To increase the use of the remote sensing techniques for a more detailed and accurate environmental degradation information gathering.

iv. To increase the use of remote sensing system, its awareness as a noble vehicle for data collection should nation wide be created through media, public lectures seminars and other viable channels.

v. The need to develop a user capability in remote sensing and so reliable data gathering of retrieval system in Nigeria as a whole; and in particular the state (Niger) cannot be over emphasized as the nation suffers a serious problem both in the rural area urban areas owing to inadequate scientific data and sufficient information on the environment. It is therefore recommended that as well as any interested individual organization should place serious emphasis than ever done on the use of remote sensing techniques to acquire data in the country.

vi. A data base centre for storing the information derived processing and analysing satellite data of the federation.

vii. guiding against the menace of illegal gold mining activity in the area, adequate enlightenment campaign against the danger done on the environment needs to be introduce to serve as checks. This enlightenment campaign needs to be backed up with a tax force charge with the responsibility of monitoring these areas.

viii. Efforts should also be made to encourage settlers around this deposits to also serve as checks while adequate protective measures should be put in place to protect them from harassment and embarrassment by the illegal miners.

ix. Finally, public awareness at all level of the society (both rural and urban) is very essential. The motive behind this is to sensitize the populace of Minna to environment issues and problems; especially the impact of illegal gold mining on the environment.

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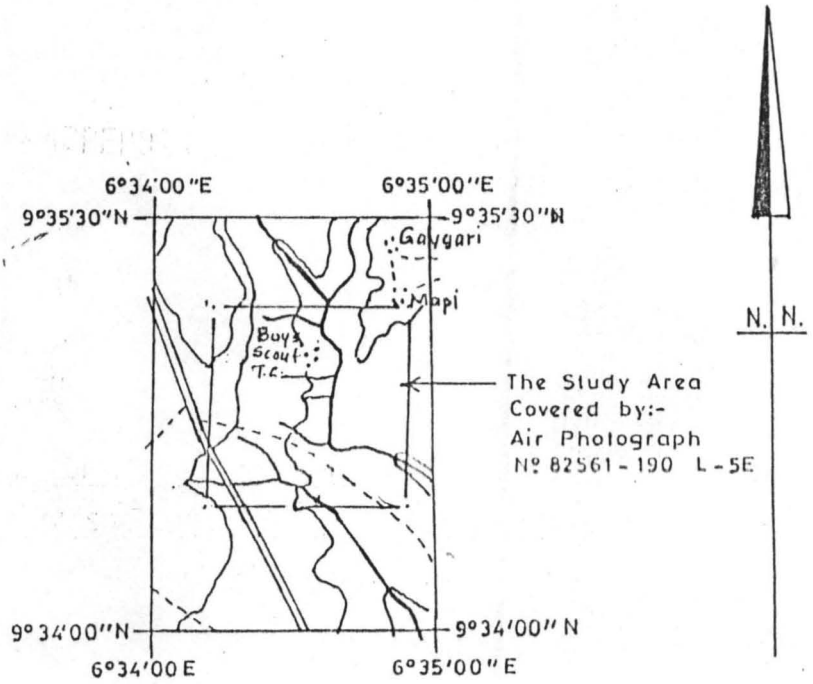
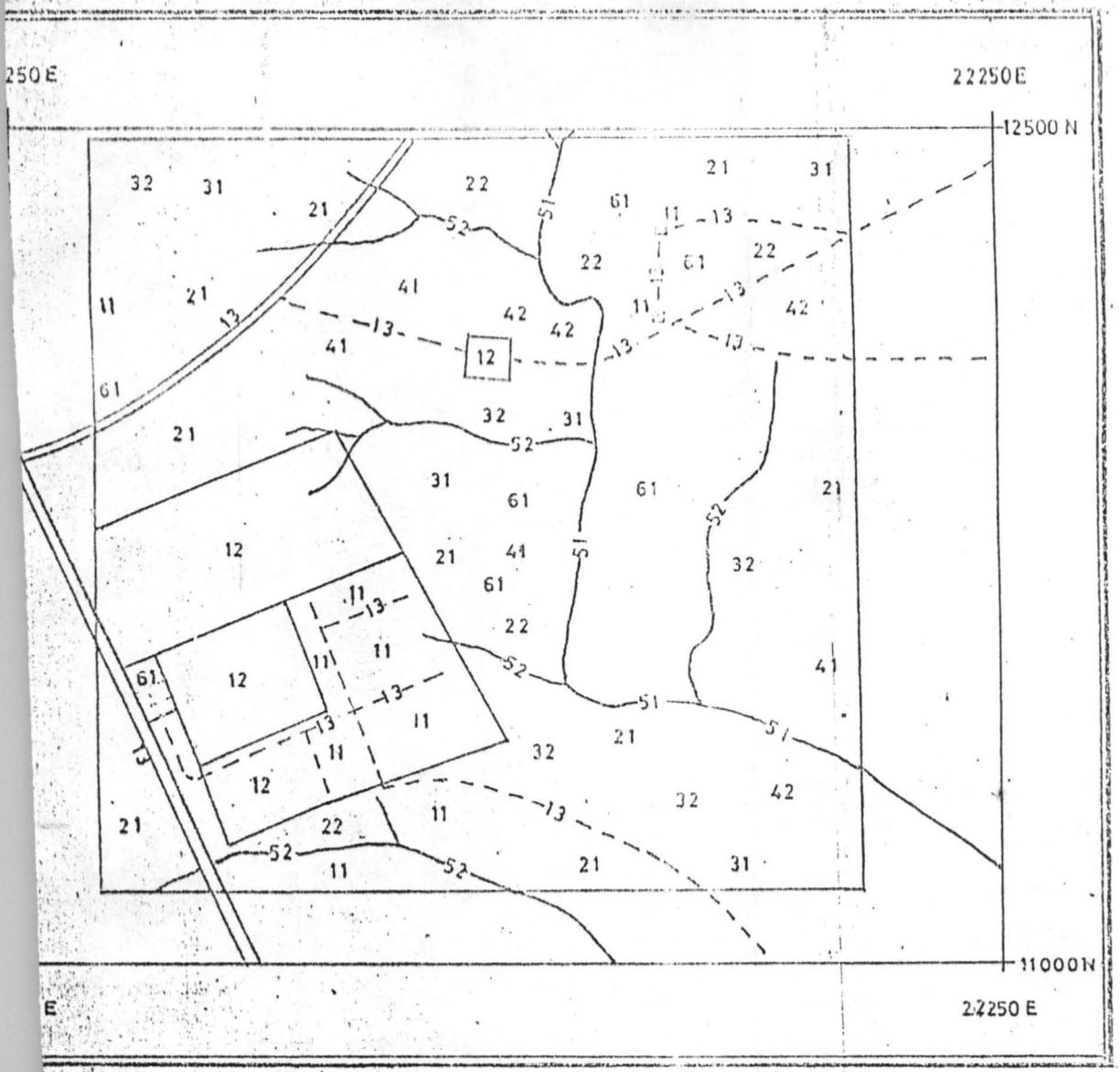
APPENDIX A

PART OF TOPOGRAPHIC MAP OF NIGERIA
SHEET 164 S.W. MINNA, OF SCALE:- 1:50,000 SERIES
PRODUCED IN 1967.



LAND USE / LAND COVER SITUATION OF 1974 APPENDIX B.



Minna Metric Sheets :-
Ld 36A

Scale:-1:1250

Metres 100 0 100 200 300 400 500 Metres

N N

REFERENCE

11....Residential
12....Commercial and Services
13....Transportation and Communication
21....Crop Land
22....Swamp Land
31....Shrub range Land
32....Mixed Range Land
41....Decidious Forest Land
42....Mixed forest Land
51....River
52....Stream
61....Lateritic Surface and Sandy Area