ASSESSMENT OF DESERTIFICATION IN THE CROP-RANGELAND AREA OF YOBE, STATE NIGERIA

BY

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M.TECH/SSSE/2005/1436

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A THESIS SUBMITTED TO POSTGRADUATE SCHOOL IN PARTIAL FULFILMENT OF REQUIREMENTS FOR THE AWARD OF THE DEGREE OF MASTER OF TECHNOLOGY (M. TECH.) IN GEOGRAPHY WITH REMOTE SENSING APPLICATIONS

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DECLARATION

I hereby declare that this research was conducted by me in the Department of Geography under the supervision of Dr.P.S AKINYEYE. The information derived from the literature has been duly acknowledged in the text and list of references provided. No part of this thesis was previously presented for another degree or diploma at any university.

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30/10/08

Signature & Date

CERTIFICATION

This Thesis titled: Assessment of desertification in the crop-rangeland area of Yobe, State Nigeria by: Bukar, Shaib (M.Tech/SSSE/2005/1436) meets the regulations governing the award ~~the award~~ of the degree of Masters of Technology (M.Tech) of the Federal University of Technology, Minna and is approved for its contribution to scientific knowledge and literary presentation.

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DEDICATION

This research work is dedicated to late Alh. Waziri. K. Mohammed.

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ABSTRACT

One of the most important recent issues facing Yobe State, North Eastern Nigeria as well as sub-Saharan Africa is the threat of continued land degradation and desertification, as result of climatic factors and human activities. Remote sensing and satellites imageries with temporal and synoptic view play a major role in developing a global and local operational capability for monitoring land degradation and desertification in dry lands as well as in Yobe State. The process of desertification in Yobe State, especially in Yusufari, Nguru, Karasuwa and Bade areas has increased rapidly, and much effort has been devoted to define and study its causes and impacts. This study intends to improve the monitoring capability afforded by remote sensing to analyse and map the desertification processes in Yobe State. Three cloud free Landsat MSS, TM and ETM+ scenes covering the study area were selected for analysis. The imageries were acquired during the dry and rainy seasons in the study area for the years 1973, 1986 and 2006, respectively. Supervised classification by Maximum likelihood technique was adopted for the image analysis. Application of multi-temporal remote sensing data on this study demonstrated that it is possible to detect and map desertification processes in the study area as well as in arid and semi-arid lands at relatively low cost. The results of the data show that desert encroachment covered about 40.16% of the total area between the period 1973 and 1986 and 32.72% during the period 1986 to 2006. The study comes out with some valuable recommendations and comments which could contribute positively in reducing sand encroachments as well as land degradation and desertification processes in Yobe State.

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ABBREVIATION

ETM	:	Enhanced Thematic Mapper
FCC	:	False Colour Composite
GEF	:	Global Environment Facility
GIS	:	Geographic Information Systems
ITCZ	:	Inter-Tropical Convergence Zone
M.A.R	:	Mean Annual Rainfall
MSS	:	Multi Spectral Scanner
N.A.C.C.O.N	:	National Conservation Council of Nigeria
N.E.A.Z.D.P	:	North East Arid Zone Development Project
RBV	:	Return Beam Vidicon
TM	:	Thematic Mapper
UNEP	:	United Nations Environmental Programme

GLOSSARIES

ArcView - Is the entry level licensing level of ArcGis desktop, a geographic information system software product produced by ESRI.

Climate - Climate is the weather in an area averaged over some long period of time.

Desertification - This is the diminution or destruction of the biological potential of the land that can lead ultimately to desert-like condition.

GIS – Geographic Information System integrates hardware, software and data for capturing, managing, analyzing and displaying all forms of geographical referenced information.

Soil – Soil is the naturally occurring, unconsolidated, loose covering on the earth surface.

CHAPTER ONE
INTRODUCTION

1.0 Background of the Study

Nigeria is confronted with a number of serious environmental problems these include; drought, desertification (i.e. land degradation in dry-lands), sheet, gully and coastal erosion (i.e. land degradation in the humid and wetlands) and loss of bio-diversity. Others are poor environmental health and safety, urban waste, pollution, climate change and ozone depletion

Forest Reserves in Nigeria occupy approximately 10 per cent of total landmass of 924,000 km^2 by 1997, and it has been estimated that the remaining forest is likely to disappear by 2020 if the current rate of forest depletion continues unabated (UNEP, 1992).

Deforestation due to agriculture, infrastructure development, excessive wood extraction for construction, and poverty, among others, lead to cultivation of marginal lands, which are exacerbating the rate of land degradation in the country.

Drought and desertification have become major environmental problems in the northern part of the country, so also persistent flood, particularly along the banks of River Niger in the central part of the country which has become a serious environmental hazard. Yet the flood plains could become major means of sustainable livelihoods for the rural poor if properly managed.

Desertification in Nigeria is overwhelmingly visible only in some states. The sand dunes, the windstorm, the rains that shower only three or four times throughout the raining season, the poverty and the degradation of the soil and environment. This is a scary reason why if something drastic and urgent is not done now to stop the menacing advance of this monstrous process, about 30 million Nigerians will be at risk of or dependent on international food aid.

The Federal Government of Nigeria in collaboration with Niger Republic have initiated programmes to combat desert encroachment, although the funds are being sought from the United Nations Environmental Programme (UNEP), the World Bank and the Global Environment Facility (GEF) to combat the menace of desertification at their borders. Their strategy was to establish shelter-belts for controlling land degradation, and development of environmentally sustainable model villages in Kano, Zamfara, Adamawa, Borno, Kaduna, Niger States and Yobe State.

In Nigeria, the mere mention of the word 'environment' (even among 'educated' Nigerians) immediately brings to mind that whole area of human activity that is preoccupied with designing and erection of physical structures, and for 'environmental protection', it also conjures the picture of weekly or monthly sanitation exercise; if not, then the activities of those government agencies whose duty is to keep the physical cleanliness and maintain "the aesthetic beauty of Nigeria's cities," and at a slightly higher wavelength, the imperative to clean oil spillage or treat the fishing and farming communities of the Niger Delta like human beings.

It is sad to note that even educated Nigerians display a high sense of ignorance on environmental issues. Engagements with respected citizens of our today's society in discussions in respect of the increased depletion of the ozone have shown that most 'learned individuals' just don't comprehend either the consequences of the ozone depletion on marine life, terrestrial organisms, human health or its evapo-transpiration effect on dry land and desertification.

With this level of ignorance one can categorically state that; even the phenomenon, desert and desertification are not understood in our society. The picture that desertification or desert encroachment creates is one of sand dunes advancing over agricultural/and around the edges of desert. This is however misleading as it implies a single process instead of a constellation of processes. The desert edge does not advance intact. It is rather the combined effect of accelerated wind and waste erosion, woodland destruction, water logging and salinization of irrigated land. In other words, desertification is an embodiment of well defined processes, which operate singly, or in combination on dry land region to cause environmental degradation; natural processes exacerbated under adverse climatic conditions by population pressure.

Generally speaking, over cultivation, woodland destruction, poor irrigation practices, overgrazing, unsustainable development/public policy, alienated land ownership structure/ legislations and wasteful energy policy all add to accelerate the processes already common in dry land. These are the physical and biological degradation of soils, wind and water erosion, and soil salinization even though the intensity and combination of causes and processes differ under different land uses.

Available statistics show the Sahel Savannah has now extended down close to places slightly above 10 degree of latitude (at latitudes between 20 and 32 degrees) towards the equator. Soils are extremely dry at these latitudes because the potential for evaporation and transpiration is generally greater than the average rainfall.

The areas that are mostly affected by desert encroachment include most part of Katsina, Kano, Borno, Sokoto, Kebbi, Jigawa, Zamfara, Yobe and Bauchi states of Nigeria. It should as a matter of fact be noted that the major factors precipitating environmental degradation in these areas are of natural and anthropogenic origin. Perhaps, the biggest source of worry for the authorities concerned (among all the anthropogenic causes of desertification and environmental degradation in general) is the other twin evil of poverty and the unchecked population growth in the area under consideration.

This project therefore is aimed at modeling the extent of desertification encroachment in the crop-rangeland of Northern Nigeria, with emphasis in Yobe State area, in order to provide accurate remote sensing information on the increasing trend of desertification to support decision in desertification encroachment combating programs in Nigeria.

1.2 Statement of Problem

It is no longer news in Nigeria that the Sahara Desert is moving southwards at a rate of 0.6km yearly (UNEP, 1992). What is news is that about 30 million people in northern Nigeria are suffering from the effects of desertification, and the menace is posing a serious threat to the nation's economy, food security and employment.

In Northern Nigeria there is widespread land degradation mainly attributed to deforestation, increasing agricultural intensity and over-grazing livestock, combined with increasing demands for fuel wood have led to a rate of deforestation estimated to be about 3.5 per cent which is one of the highest in the world(UNEP, 1993). For example, from 1978 to 1992, in Jigawa State, the area of land used for intensive agriculture increased from 36.8 per cent to 69 per cent and undisturbed forest decreased from approximately 1 .1 per cent to .01 per cent. Livestock densities are high, the majority owned by the nomadic Fulani, who retain large herds for security (Thambyphillay, 1987).

Soils in the region are ferruginous tropical soils, generally of poor structure and low fertility. The hot and dry climate causes bare, unvegetated soils to easily heat up, especially during the dry season, resulting in soil baking. Coupled with high evaporation rates, the soil becomes powdery and easily blown away by the wind. Thus, in the absence of vegetation, wind and water erosion on exposed soils have had extremely detrimental effects, limiting plant growth and productivity. In the far northern areas, increasing sand dune formation is evident.

Until the early 1980s, the forestry sector in Nigeria had been a low government priority, comprising only 2.4 per cent of Federal budgets. There was an inadequate national forest policy and improper forestry management strategies, as manifested in overexploitation of forest resources and lack of inventory to ensure sustained yield. Forest revenue systems were outdated, which tended to treat forest resources as free commodities, and State forestry departments had not been managing forest reserves systematically (N.E.A.Z.D.P 1990).

At least 50,000 farmers in about 100 villages scattered along the desert fringes of the northern part of Yobe state,(one of the eight states affected by desertification), are currently at risk of abandoning this year's farming season due to sand dunes. The dunes have covered a large expanse of agricultural farmlands (TerraViva, 2002)."The dunes are threatening life supporting oasis, burying water points and in some cases engulfing major roads in the affected areas. Trees planted by government as shelter belts to check the advancing dunes are withering due to lack of attention," (TerraViva, 2002).

The document, compiled by the Ministry of Environment in Yobe State, reveal that aerial photographs taken have indicated that productive and mass land occupied by the dunes have increased from 25,000 hectares to more than 30,000 hectares, with its attendant negative impact on food and livestock production."Considering a conservative production of five bags of 100 kg of grain of millet or sorghum per hectare in the area, it means the 30,000 hectares destroyed by the dunes is capable of producing over 1,500 bags of millet. With an average grain requirement of one bag of 100 kg of millet per family of four per month, it then follows that 150,000 bags can support 12,500 families of four or 50,000 people per year. The big question is how do these 50,000 people survive in this area?" (Yobe State Ministry of Environment, 2001).

The destruction of the 30,000 hectares of agricultural land has a negative impact on livestock survival in the state, which has a high concentration of animals in the vast West African country. 'Losing 30,000 hectares of grazing land annually means denying grazing land for 3,000 head of cattle annually," (Yobe State Ministry of Environment, 2001).Cases from the other seven states bordering the desert are not different either.

The shelter belts established by government along desert fringes of eight northern states including Borno State under the World Bank-assisted afforestation program have not been very effective as the trees have been felled for firewood, while some have withered due to high temperature, inadequate rainfall and drought.

Streams or ponds that are silted and rendered not viable for water supply are indicators of drought conditions, which are symptoms of desertification. A report from the Federal Ministry of Environment reveals that Nigeria plunders its forest by more than 30 million tonnes for firewood annually due to pressure on the urban poor who resort to the cheapest means of cooking. "The rate of fuel wood consumption far exceeds replenishment rate. The consequence of human dependence on wood for fuel and construction is that about 350,000 hectares of land is under the threat of deforestation annually, while the annual rate of reforestation is estimated at about 30,000 hectares," (Yobe State Ministry of Environment, 2001). President Olusegun Obasanjo recently ordered one billion tree-seedlings to be planted and distributed to farmers over the next five years.

Apart from the Federal government's programmes of producing tree seedlings for planting in the shelter belt as part of the afforestation programme, the eight states bordering the desert have also taken bold steps to check the movement of the desert.

1.3 Research Questions

i. Is It Possible to model Desertification trend using multi-temporal satellite data, based on analysis of Desertification in terms of causes and trends?

ii. How can desert encroachment be reduced based on information gathered from satellite data

1.4 The Aim and Objectives of the Study

The aim of this project is to Model the extent of desert encroachment in the crop rangeland of North Eastern Nigeria, Yobe area, with a view to providing accurate information on the increasing trend of desertification to support decision in desert encroachment combating programmes in Nigeria. The stated aim shall be achieved through the following specific objectives:

1. To identify and map the boundary of desertification encroachment inYobe State between 1973 to 2006.
2. To compute the extent of desert encroachment in this area.
3. To proffer planning solution toward combating and abating this environmental menace in this region.

1.5 Justification

Nigerians from the northern part of the country like to speak with pride about the vastness of their region. But the truth is that there is less to talk about than there really is. Much of the vast northern part of Nigeria has been turned into wasteland by the Sahara Desert, which has continued to consume land as it moves southward. During the rainy season, there is a temporary respite for the region, but once the rains subside and the dry season is expected, the situation can only get worse.

Desert encroachment in northern Nigeria has been noticed since 1920 and it has worsened since then as a result of the increase in population, climatic factors, and pressure on land and vegetation. For example, the low rainfall in the region which is said to be below 400mm per annum, coupled with wind erosion which easily tears away the sandy soil in the area have all exacerbated the desert march. "Nigeria is presently losing about 351,000 square kilometers of its land mass to the desert which is advancing southward at the rate of

0.6 kilometer per year". "Entire villages and access roads have been buried under sand dunes in the northern part of the country" (UNEP, 2001).

According to Dr. Kabir Abdulkadir, the spokesman of the National Conservation Council of Nigeria (NACCON) in a TV interview said; "over the years drought and indiscriminate construction of dams have been fingered as factors which have accelerated the pace of deforestation in the northern region. He also stated that deforestation has also been identified as the single largest cause of desertification".

Deforestation in the arid northern region could be difficult to control unless something is done about Nigerian's dependence on fuel wood as a source of energy. It is estimated that 90 per cent of Nigerians rely on fuel wood which is relatively cheaper than other sources of energy, including petroleum products.

Desertification can be curbed only if the common people can be encouraged to use coal instead of fuel wood as source of energy. "The fight against deforestation cannot yield positive results without finding means of substituting coal for firewood for our energy requirement", (Abdulkadir, 2002). "Coal is better, cheaper and easily affordable, for use as domestic fuel than even kerosene, gas and firewood, which have been popularized without consideration for the effects of their use".

Nowhere is the effect of desertification more telling and devastating than Yobe State on the northeastern fringe of Nigeria. Already 50 per cent of the state landmass has been gobbled up by the desert, a situation that is aggravated by deforestation in the state.

The Yobe State governor, Bukar Abba Ibrahim believes that in the next 100 years, 50 per cent of the country, which virtually represents the entire northern Nigeria, may be lost to the desert. He argued that massive international financial assistance from the World Bank and other UN agencies are needed to stop the advancing desert.

All efforts put in place so far to curb desert encroachment have failed to yield significant positive results. The most widely accepted method of combating desertification in Nigeria is a tree planting campaign, but this is taken more as a grand gesture rather than a planned continuous, year round programme. The tree planting campaign doesn't usually go beyond the annual tree planting day when top government officials engage in the yearly ritual. It amounts to a meaningless promise, and nothing happens until the next annual tree planting day.

The consequence is that the rate of afforestation is a far cry from the rate of deforestation so much so that for each new tree planted, 10 other are felled for fuel wood. Therefore, an accurate and adequate data about this environmental menace is needed to effectively combat the situation.

1.6 Scope of the Study

This project would present interpretation techniques that emphasize the discrimination of the desertification processes in remotely sensed images. The project would also address the multi-temporal monitoring of landscape degradation, which is commonly included in desertification processes. Analysis of changes in 33-years (1973-2006) based on satellite images would be conducted with emphasis on Yobe state area in the Northern part of the country. Efforts were limited to Yusufari, Nguru, Karasuwa and Bade Local Government Areas of the state.

1.7 Structure of the project

The project work is divided into six parts from chapter one to six. Chapter one is titled "Introduction"; it presents an overview of Desertification in the Crop Rangeland Area of Yobe State Nigeria. It also includes the Statement of Problem Research Questions, the Aim of the Study, Specific Objectives of the Study, Justification and Scope of the Study.

Chapter two is titled the study area it deals with the description in terms of the location and extent, Relief and Drainage, Soil, Vegetation, and Climate Characteristics (Rainfall, Temperature).

Chapter three covers literature review which deals extensively with the review of relevant and related literatures on the subject of research of the study.

Chapter four covers the research methodology, comprised research materials used, principles and types of interpretation used.

Chapter five contains the discussions of result and presentations analysis from the field data. And lastly the

Chapter six contains the summary findings conclusion and recommendations, as well as the suggestion for future studies.

1.8 Background of the Study Area

1.8.1 Location

The area encompasses the semi-arid region of Yobe State located on latitude 11°45' N to latitude 13°30'N and longitude 9°30' E and 12°30'E (figure 1.1a,b & c). The Eastern boundary is immediate to Borno State, to the West is Jigawa and Bauchi States and to the north boundary with the international border with Niger Republic. Due to the aridity of the region the Federal Government of Nigeria in conjunction with the European Economic Community (E.E.C) in 1992 provided funds to address the problem of development and to reduce the social impacts of aridity on the population in the area. More than 90% of the population depends on rain fed agriculture, with millet and sorghum as the major grain crops and cowpea and groundnuts as the major legumes.

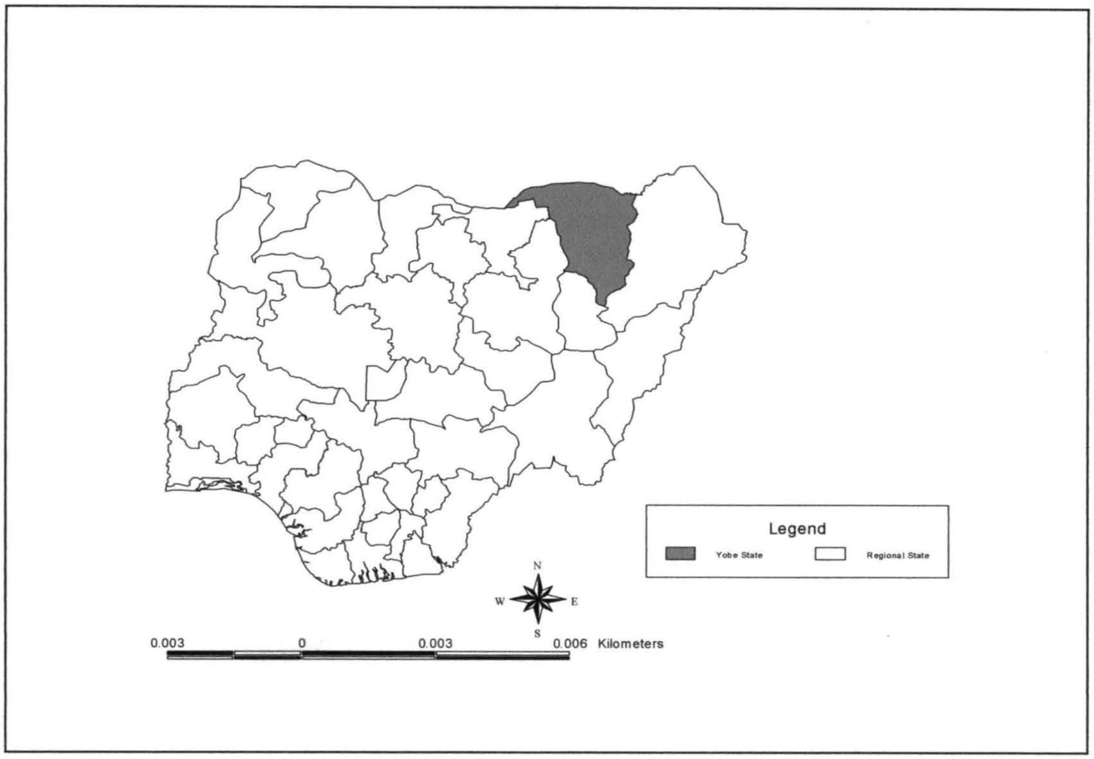

Fig 1.1a: Map of Nigeria Showing the Location of Yobe State

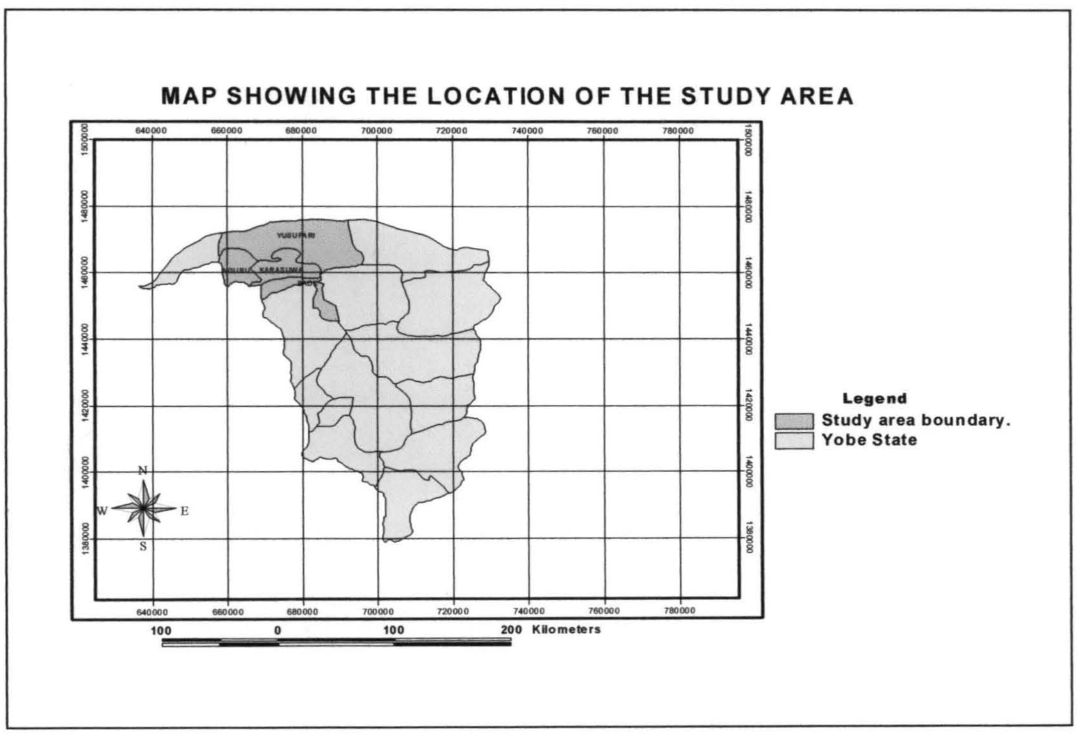

Fig 1.1b: Map of Yobe State Showing the Location of the Study Area

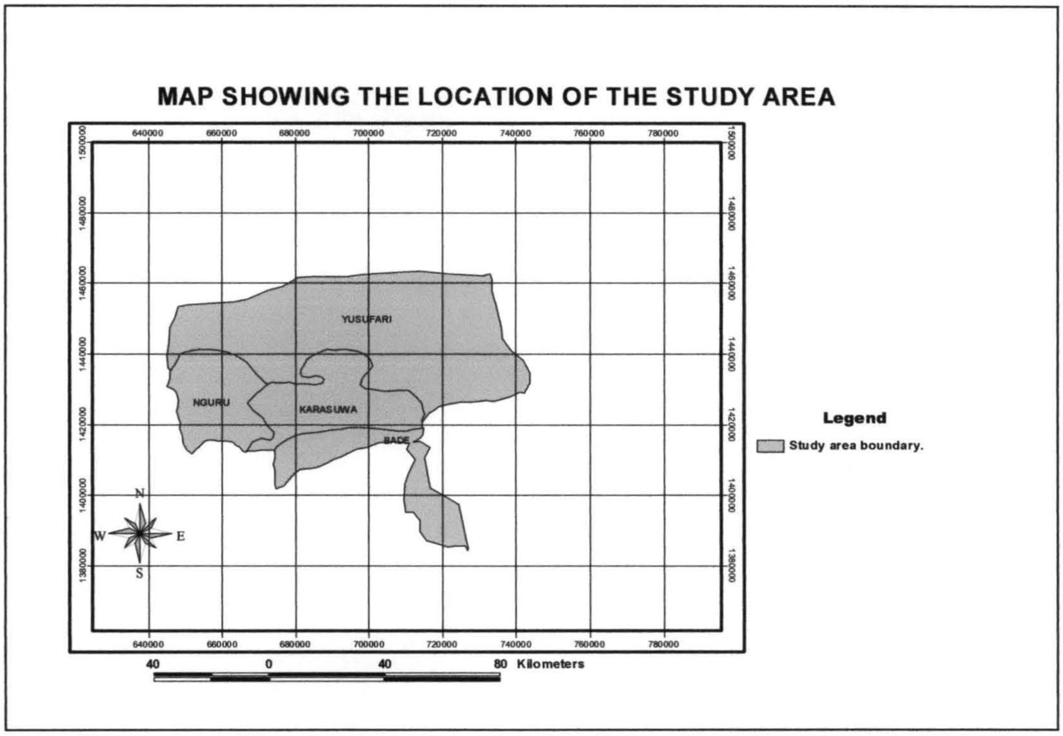

Fig 1.1c: Map of the Study Area Showing the Location of the Local Government Area

1.8.2 **Relief and Drainage**

In general the landscape of the area is flat to gently undulating plain with the river system dissecting the dune fields. In the Northern part of the area, there are extensive rolling sand plain with superimposed relict dunes. In the Southern part of the area, the relict dunes are more pronounced partly due to changed climatic conditions with increased drought. The dunes have started to move in some places encroaching against villages. Associated with rivers are the 'Fadamas' on flood plains which are depressions connected to the rivers by shallow channels.

In the wet land areas, flow is divided up between numerous small channels. The precise drainage is probably changing all the time as some channels silt up while others assume new importance. A notable example is the Burum Gana which was formerly a major drainage channel parallel to and to the North. Now virtually all of its flow is captured by the marma channel which flows into Nguru Lake. Figure 1.2 clearly depicts the areas drainage

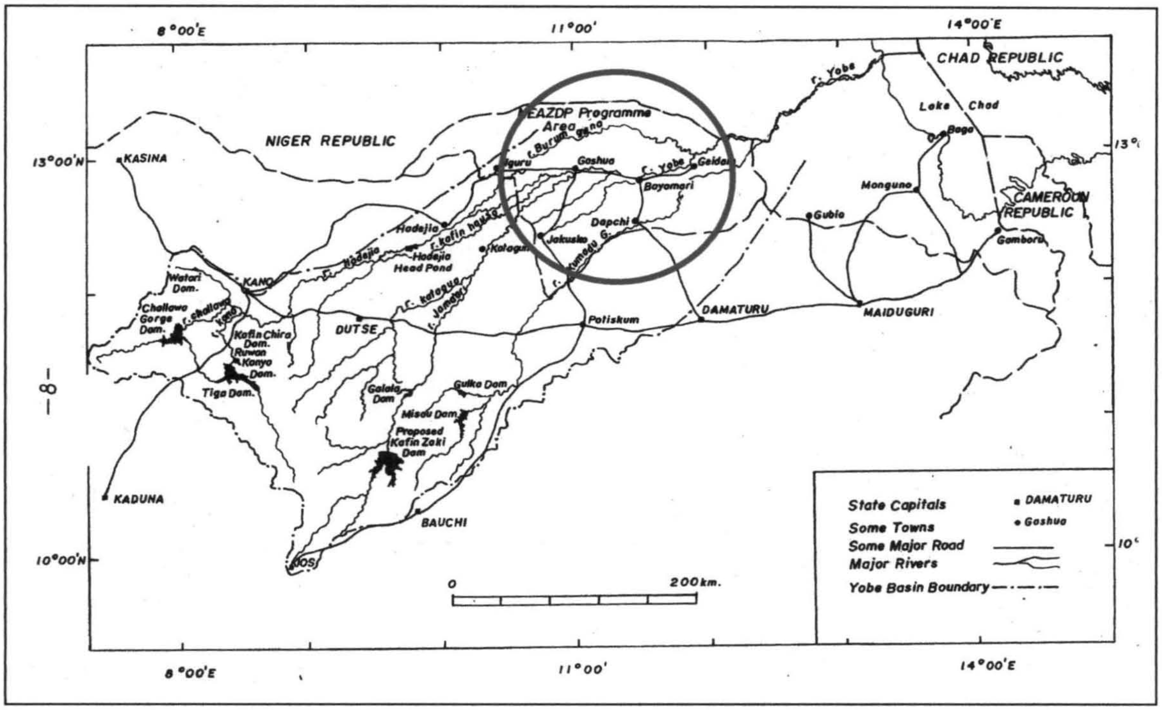

Fig.1.2: Map Showing the Drainage pattern in the Study Area enclosed in Red Circle

1.8.3 **Soil**

Soil of the area varies; the Northern part has halomorphic soils rich in sodium and from which evaporation crusts of potash are collected. The majority of the flood plain soils are weakly developed and allomorphic soils of alluvial origin, which can be variously clayey, sandy loamy and may be alkaline.

1.8.4 **Vegetation**

In the North where the mean annual rainfall (M.A.R) fall between 250mm and 500mm lies the belt of Acacia-dominated tree and shrub Savanna' and its anthropic derivatives. The central section of the woodlands and anthropic derivatives dominated by species of the family leguminosae.

1.8.5 **Climate Characteristics**

1.8.5.1 **Rainfall**

Yobe State is located in the Sahel Savanna climatic Zone (Thambyphillay 1987) as a result of this it should be expected that the climate characteristics of the area should be similar to that found in any other Sahel savanna. According to Gates (1975), the area can be said to fall within the koppens, tropical wet and dry (AW) climate. This is due to the rapid decrease in seasonal rainfall which is strongly influenced by the migration of the inter-tropical convergence Zone (ITCZ).

The ITCZ reaches its most Northerly position to the North of Nigeria in July or August at this time moist air are drawn into the region from south bringing rain. The convergence Zone normally crosses Northern Nigeria during April and October which makes the beginning and end of the wet season. The wet season normally lasts from June to September with 70% of the total rain falling in July and August and normally growing. The period November to March is almost invariably rain less, but small isolated showers may occur in April, May and October. Open water evaporation for the study area is in the region of 2700mm per year and rainfall supplies moisture for only about 3 to 4 months annually (N.E.A.Z.D.P. 1990).

1.8.5.2 **Temperature**

Air temperature is generally high with 31°C in April and a low of 23°C in January. According to Sweet (1992) maximum air temperature can reach 50°C in April and May fall close to 10°C at night during December and January.

CHAPTER TWO
LITERATURE REVIEW

2.0 Environmental Change Detection

Desertification has been variously defined in the Literature with no single definition being unanimously accepted. According to UNCOD (1977), it refers to the diminution or destruction of the biological potential of the land that can lead ultimately to desert-like conditions. This definition is adopted here with the modification that the process is limited to an arid environment. The expansion of desertified areas or their rehabilitation to productive use is inevitably accompanied by changes from vegetated to denuded cover or vise versa. Monitoring of these changes is ideally accomplished from multi-temporal remotely sensed data. Remote sensing has successfully been applied to the monitoring of desert expansion (Luk, 1983). And to the assessment of the factors that may cause desertification (Hanan, 1991). Visual interpretations of Landsat images enable us to identify areas endangered by desertification in Desert areas.

Remote sensing and GIS are land-related technologies and are therefore very useful in the implementation of the land component of a suitable development strategy (Anthony Gar-on Yeh and Li, 1996). Change detection involves the use of multi-temporal data sets to discriminate areas of land cover change between dates of imagery (Lillesand and Kiefer,1994).

Goossens and Van Ranst (1996) showed the possibility of multi-temporal analysis using TM and MSS classification images in the Nile delta in Egypt. Ideally, a change detection method should be based on a system that 1) has a systematic period between over flights (e.g.18 days), 2) reduces displacement effect, 3) records imagery of the same area at the same time of the day each time to minimise the sun angle effects, 4) keeps the same scale and, 5) records reflected radiant flux in useful spectral regions. Ideally, change detection methods should involve data acquired by the same sensor with the same spectral and spatial resolution. Agricultural crops typically have unique crop calendars in each geographic region. Analysis of two-date imagery of the same area and the same time can provide information on how some land cover types are changing in a period. It should be noted that the nature of change detection problem in general is so that digital change detection is complex (Jensen, 1983), especially change detection methods that use two different remote sensor data. When two different remote sensor data are used some important considerations, such as difference in resolution must be taken into account.

2.2 Causes of Desert and Desertification

Over the past two decades there has been an increase in the number of definitions of the word desertification. The following four main themes can be selected:

1. Desertification can be considered as a set of biological, chemical and physical processes which converge to create desert-like conditions (Rozanov 1990);
2. Desertification is a social problem, involving people at all stages, as a cause and as victims, also one of lower agricultural return and increasing poverty (Spooner 1987, 1989);
3. Desertification occurs at the moment when land becomes irreversibly sterile in human time terms and with regard to reasonable economic limitations (Mainguet 1994);
4. Desertification is the diminution or the loss of the potential for sustainable use (Warren and Agnew, 1987).

The simplest and most useful definition of desertification, proven by field observations, aerial photographs and satellite imagery analysis, rejects the perception of growing deserts but refers to transformation of vegetated productive land into bare and unproductive land and, more precisely, to the appearance of desert-like landscapes and surface dynamics in semi-arid and dry sub-humid ecosystems.

Dregne (1984), once revealed that, the difficulty of seed germination is another fundamental criterion of desertification, to which should be added characteristics of degrading soil:

i. Loss of soil aggregation, a key indicator for resilience of a dry ecosystem;
ii. Decrease of general topsoil infiltration capacity;
iii. Decrease of soil water storage;
iv. Loss of resistance against mechanical disturbance (splash erosion);
v. Surface redistribution and profile redistribution of water;
vi. New threshold of runoff initiation.

In fact, seed germination, seedling establishment, production and reproduction potential of plant cover are hampered by all these changing soil characteristics, which all lead to the general expression of loss of resilience.

In the 1960s, after the complex processes of decolonization, the trend was to attribute land degradation to sectorial development during colonization. In a second phase, during the 1970s, essentially because of efforts by the United Nations Environment Programme (UNEP), middle-term climate changes and short-term droughts were taken in account as causes of desertification. Currently, a third phase has been reached with "the consensus view of the last decades that desertification is primarily human-induced" (Hulme 1989). This trend is well illustrated by a UNSO-UNDP survey, which also attempts to assess the degree to which local people perceive the present status of their environment and habitat, and also their degree of consciousness of the rate at which the environment is changing, and the risk of occurrence of desertification in the future.

The two last questions cannot be answered by the farmers or even by scientists. "It has become fashionable these days to speak of poverty as the cause and consequence of environmental degradation and thereby to focus efforts at combating environmental degradation on the poor" (Masse Lo 1994). In other words, to shift "the burden of the thought to subsistence-oriented peasants, pastoralists and rural workers," as Barraclough states (1994).

Speaking of man-induced desertification means to attribute to human activities the responsibility of irreversible land degradation and to assess that socio-economically driven environmental degradation has a greater impact than climatically driven environmental change.

The concept of desertification should be approached through the notion of irreversibility, meaning that one human generation is not able to rehabilitate the land degraded during the same time-scale: twenty-five years, superposed on to age-old degradation which has reached an unbearable threshold.

2.3 Distinction of the Effects of Traditional Indigenous Land Management and of Imported Exogenous Land Management vis-à-vis Man-induced Desertification

The approach to man-induced desertification requires another differentiation between:

a. The environmental impact of traditional models of land utilization. However, these may have become anachromic in view of the ever growing population pressure. This fits into the hypothesis of "accelerated slow mining": rapid and recent socio economic mutations might just accelerate the ongoing process of land degradation.

b. The environmental impact of exogenous (imported) techniques and models of management through bilateral or international development projects. These techniques and projects have been implemented in wetter ecosystems: one of the most convincing examples is given by the former USSR, when, in the 1960s and the 1970s, Moscow exported to the Aral Sea basin all kinds of irrigation methods and canals, responsible for the Aral ecological tragedy (Létolle and Mainguet 1993).

In the example of the Gulf War, where human settlements were systematically destroyed, oil fields burned (in 1991; Wafra was the first oil well to be burned), and telephone and electricity lines in Kuwait cut, it is easy to determine degradation of soils resulting from the digging of trenches and erection of elevation pits, walls and berms, the explosion of bombs and mines, trampling of troops, and transport of heavy vehicles. But, a short time after the war, it was difficult to differentiate the part of soil degradation directly resulting from the war effects, and land degradation which occurred after the two droughts preceding the war (one from 1960 to 1970 - except 1961 and 1967 - and the other from 1983 to 1987), exacerbating the overuse of land by grazing and the building of human settlements (Dumay 1993). In addition we might suggest the idea of human accelerated mining of the environment and land degradation.

The Gulf War resulted in a man-made environmental disaster, aggravating the previous human-induced land degradation mainly by increasing the load of mobile sand for Aeolian deflation and soil loss. In semi-arid Tunisia, twentieth-century human activities led to the same reactivation and remobilization of the previously fixed sand-dunes.

2.4 Definition of Desertification

Desertification is the diminution or destruction of the biological potential of the land, and can lead ultimately to desert like conditions.

Desertification can also be described as a process of impoverishment of arid, semiarid and some sub-humid ecosystems by the combined impacts of man's activities and drought.

Desertification has also been defined as a process leading to reduced biological productivity, with consequent reduction in plant biomass, in the land's carrying capacity for livestock, in crop yields and human well being leading to the intensification or extension of desert conditions.

Desertification (desertization) was defined as the spread of desert-like conditions in arid or semi-arid areas due to man's influence or to climatic change.

It is implicitly understood that desertification leads to long lasting and possibly irreversible desert like conditions. "Decreasing productivity" is a key process included implicitly or explicitly in all definitions.

2.5 Case Study:

2.5.1 Sahara Encroachment

A stratification of a transect through Northern Kordofan was carried out based on Landsat false colour composites (FCC) (188/49, 51, 52) and one MSS 5 image (188/50) recorded Nov. 9, 1972 and compared with a corresponding stratification based on Landsat imagery (MSS 5 and RBV imagery) recorded Jan. 25, 1979 .All imagery were in the original scale of 1:1Million superimposed on maps of the same scale.

The desert boundary, defined as the border between semi-desert bush/shrub, grassland and with a more or less continuous vegetation cover, and areas with no or very scattered vegetation cover were mapped together with a delineation of other strata. It was not possible to identify any significant shifts in borders between 1972 and 1979. Neither was it possible to find any significant differences in the delineation of the desert margin/semi desert when the maps were compared to the location of the desert margin, based on Landsat imagery from 1976. The border coincides roughly with the 100mm isohyet at latitude 16 degrees north.

The 1975 desert boundary was mapped by Lamprey and compared with the one presented on a vegetation map of the Sudan 1958. Lamprey based his map on a combination of reconnaissance flights and ground based surveys from a car. He concluded that the Sahara desert had advanced 90-100 km between 1958 and 1975. The 1975 border fluctuates around latitude 16 degrees N roughly corresponding to the 100 mm isohyet and in rough accordance with the Landsat based results.

It seems, however, that the desert boundary described in the vegetation map from 1958 was defined to follow the 75 mm isohyet, located 90-100 km north of the 100 mm isohyet, rather than actually mapped .It might explain why Lamprey found the 1958 desert boundary to be located 90-100 km north of the boundary defined in 1975. There does not seem to be any evidence for the Lamprey conclusion that the Sahara desert had advanced 90-100 km in the area during the period 1958-1975. The vast Sahara dune complex encroachment was mapped.

2.5.2 Facets of Desertification Observed in North Burkina Faso

Lindqvist and Tengberg(1994) brought new evidence of desertification in the Sahel of Burkina Faso and have confirmed that desertification is not a linear and univocal phenomenon, but should be nuanced according to several facets. They show in fact that noticeable environmental degradation took place between the late 1960s and 1990s with a more severe degradation occurring during the first of a series of droughts (1968-1974), when large areas of bare ground developed mainly in the range lands on the plains surrounding the ancient dunes - a west to east longitudinal dune system. According to

Lindqvist and Tengberg, after the first drought, say the situation stabilized and even "a recovery of the vegetation during the last decade can be observed in depressions whereas it is seen that the interfluves are subject to enhanced erosion" due to increased run-off.

The bare surfaces, despite increased rainfall since 1985, did not recover, indicating a loss of resilience and real desertification. The development of the bare surfaces is, according to the two scientists, the result of decreased rainfall in a 20-year period combined with grazing pressure, fuel wood consumption and other human activities.

CHAPTER THREE
MATERIALS AND METHODS

3.0 Data acquisition and pre-processing

Three cloud free Landsat MSS, TM and ETM+ scenes covering the study area were obtained for analysis. The images were acquired in January and August, the dry and rainy season of the study area in 1973, 1986 and 2006, respectively. The MSS image consists of four bands; the characteristic of this image compared to the others is low in terms of spatial ground resolution and band widths (Figures 3.1a, 3.1b, 3.1c and Table 3.1). Multispectral sensors collect data in a few spectral bands which cover important regions of the reflected solar spectrum (about 350 to 2500µm). Because these sensors provide data in multiple bands, the ground resolution is degraded and total number of pixels per line for these sensors is less than that of panchromatic sensors. This is due to both the decreased light energy available in each band as well as bandwidths. Therefore, the spectral resolution for spaceborne multispectral sensors is usually poorer than for panchromatic sensors. Multispectral sensors have been used effectively in studies of land degradation in arid and semi-arid lands.

TM and ETM+ imagery were acquired in seven and nine bands respectively, covering the visible, near and mid infrared region of the electromagnetic spectrum. The utility of Landsat imagery for studying environmental changes in arid regions has long been suggested as a time and cost-efficient method. There are several justifications for the use of MSS and TM imagery in studies concerning human dimensions of environmental change.

Other material used for this project include: Topographic map at 1:250.000 scale, Published reports and Field survey.

Table 3.1: The main characteristics of the imagery used in the study

Instrument	MSS	TM	ETM+
Landsat	Landsat 2	Landsat 4	Landsat 7
Acquisition date	14 Jan 1973	20 Jan 1986	13 August 2006
Path / row no	188/50	175/50	175/50
Spectral bands((µm)	4 bands 1. 0.5-0.6 (green) 2. 0.6-0.7 (red) 3. 0.7-0-0.8 (near-infrared) 4. 0.8-1.1 (near-infrared)	7 bands 1. 0.45-0.52 (blue) 2. 0.52.0.60 (green) 3. 0.63-0.69 (red) 4. 0.76-0.90 (near-infrared) 5. 1.55-1.75 (mid-infrared) 6.10-4-12.5 (thermal) 7. 2.08- 2.35 (mid-infrared) 2.0	9 bands same as TM , except : - Optical bands - Thermal - Panchromatic
Ground resolution	79m*79m	30m*30m	30m*30m
Dynamic range(bit)	7 bit	8 bit	8 bit

Source: Fundamentals of Remote Sensing, 2007

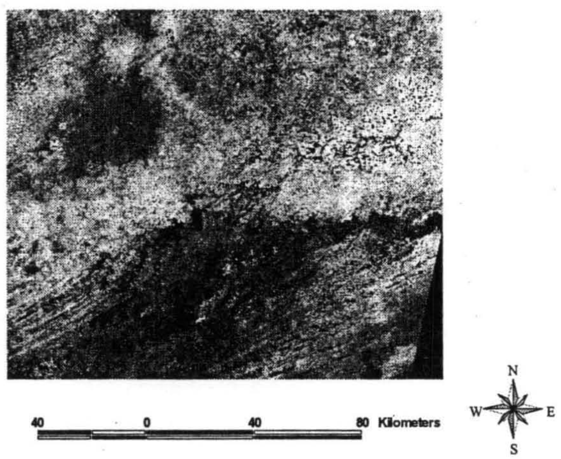

Fig 3.1a: Landsat 1 Multispectral Scanner MSS image, acquired 14 January 1973(Band3)

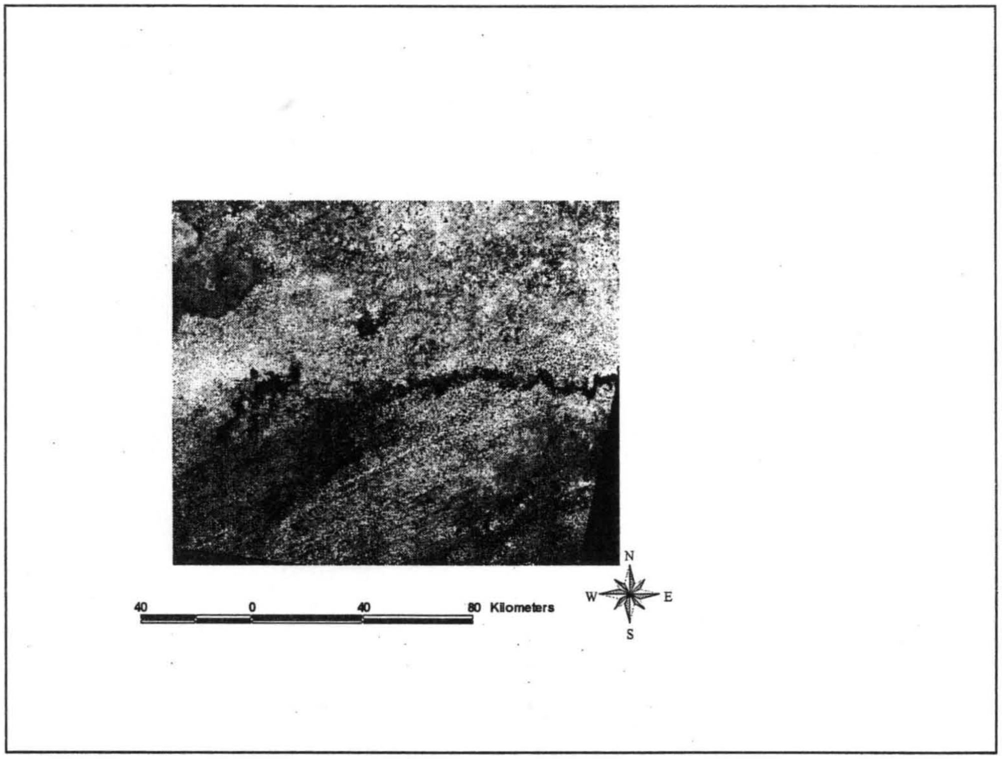

Fig 3.1b: Landsat 4 Thematic Mapper TM image, date of acquired 20 January1986 (Band3)

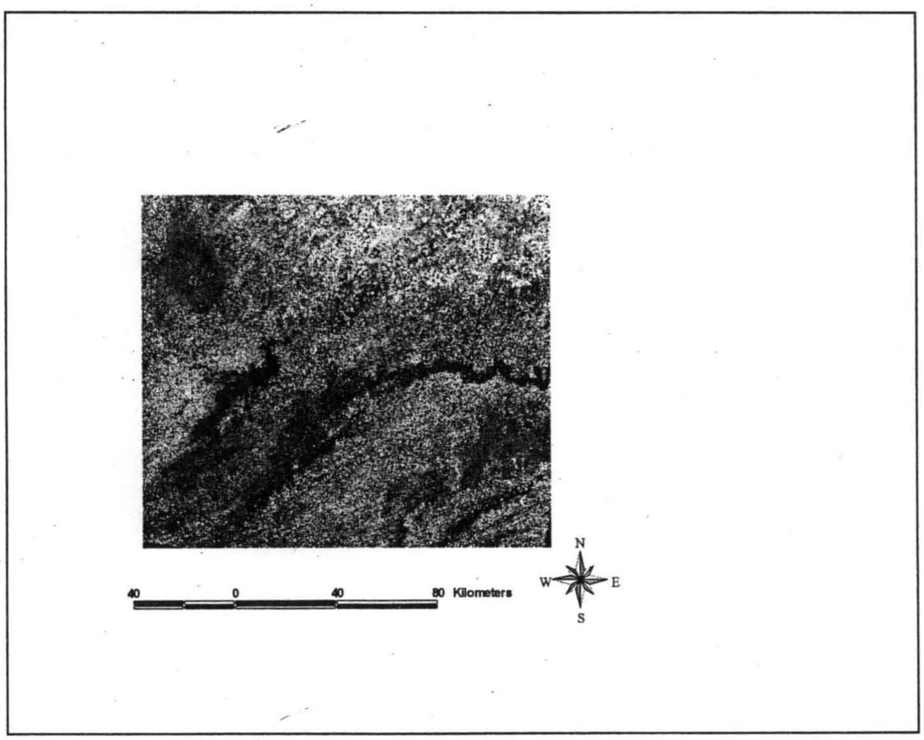

Fig 3.1c: Landsat 7, Enhanced Thematic Mapper ETM+, acquired on 13 August 2003(Band3)

3.1 Software Used.

The software's used were IDRISI Andes, and ArcVIEW 3.3, in processing the image data of MSS, TM and ETM+ data.

3.2 Field Work and Representative Training Sites

The field work as one of the most important steps was carried out in order to: choose representative training sites; and to overcome the problems of time and season differences between the fieldworks and when the remotely sensed data were collected. The desertification conditions were carefully studied with attention being paid to stabilized sandy surface, region of loose vulnerable soil, disturbed and non disturbed area.

3.3 Techniques of Image Processing:

3.3.1 Spectral signature evaluation

The validity of the training data was evaluated both from visual examination and from quantitative characterization. The spectral signatures of the training samples were evaluated by using the reflective spectral response.

3.3.2 Satellite Image Sampling Techniques

Lillesand, and Kiefer (1994), indicated that all spectral classes constituting each information class must be adequately represented in the training set statistics used to classify an image. In this study the training samples were taken on the conventional False Colour Composite (FCC) where field observations were made. A large enough sample is often needed because the distributions of the sample mean approached normality as the size of the sample increased. The sampling was performed by displaying the conventional FCC on the colour monitor and then the training samples carefully assigned.

3.3.3 **Regrouping:**

The classified Image can be regrouped on the purpose of use. High classification accuracy is needed otherwise an accurate result for change detection can not be obtained. It was therefore necessary to regroup the classified image into broad classes in order to increase the classification accuracy. It is also very important to note that the classified images were regrouped in a logical manner to be comparable with the other classified image for different periods. For the purpose of this study, a comparison of the four classified images will be validated to provide a comparison of changes in the landscape between these periods.

3.4 Image Classification and Accuracy Assessment

The training samples used to estimate the statistical characteristics of the spectral classes were typical and represent the norm for each class. The MSS, TM and ETM band combinations were examined for classification of MSS, TM and ETM imagery with the same method. The accuracy per category was computed by the number of correctly classified pixels by the total number of pixels that were classified in each category (row total). The overall accuracy was also computed by dividing the total number of the correctly classified pixels of each class to the total number of classes.

CHAPTER FOUR

RESULTS

4.0 Extent of Desertification for the of period 1973 to 1986

The Classified land use/ land cover maps of the study area for the periods between 1973 and 1986) are produced as shown in Figure4.1a&b. The classified maps show the magnitude and direction of desertification conditions for the period. Table 4.1 shows the aerial extent of each class of landuse / land cover expressed in percentage. Photographs are produced and presented in plates 1, 2a, and b, showing the situation of the desertification in the study area.

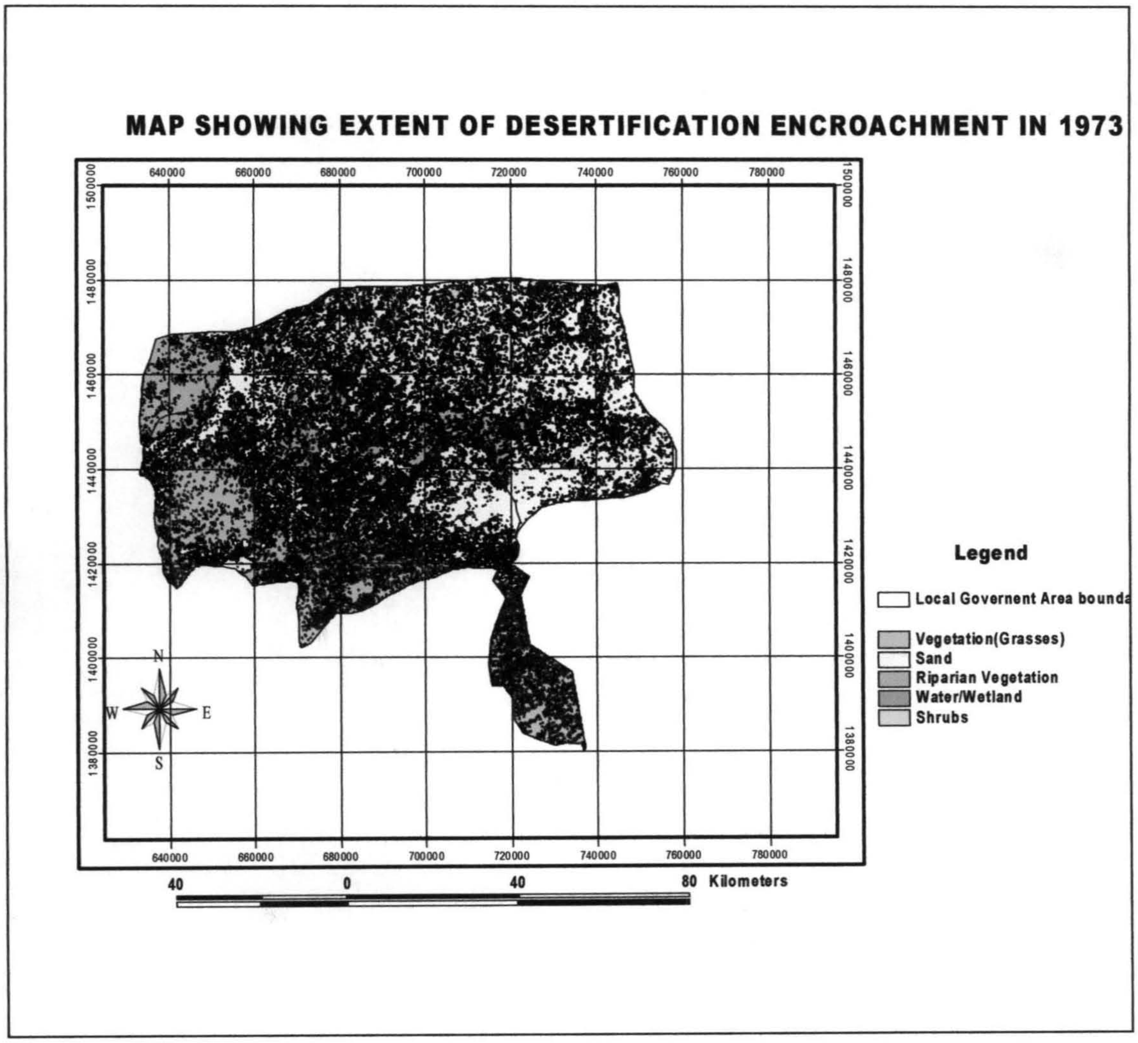

Fig.4.1a: Classified image of Desertification Extent for periods 1973

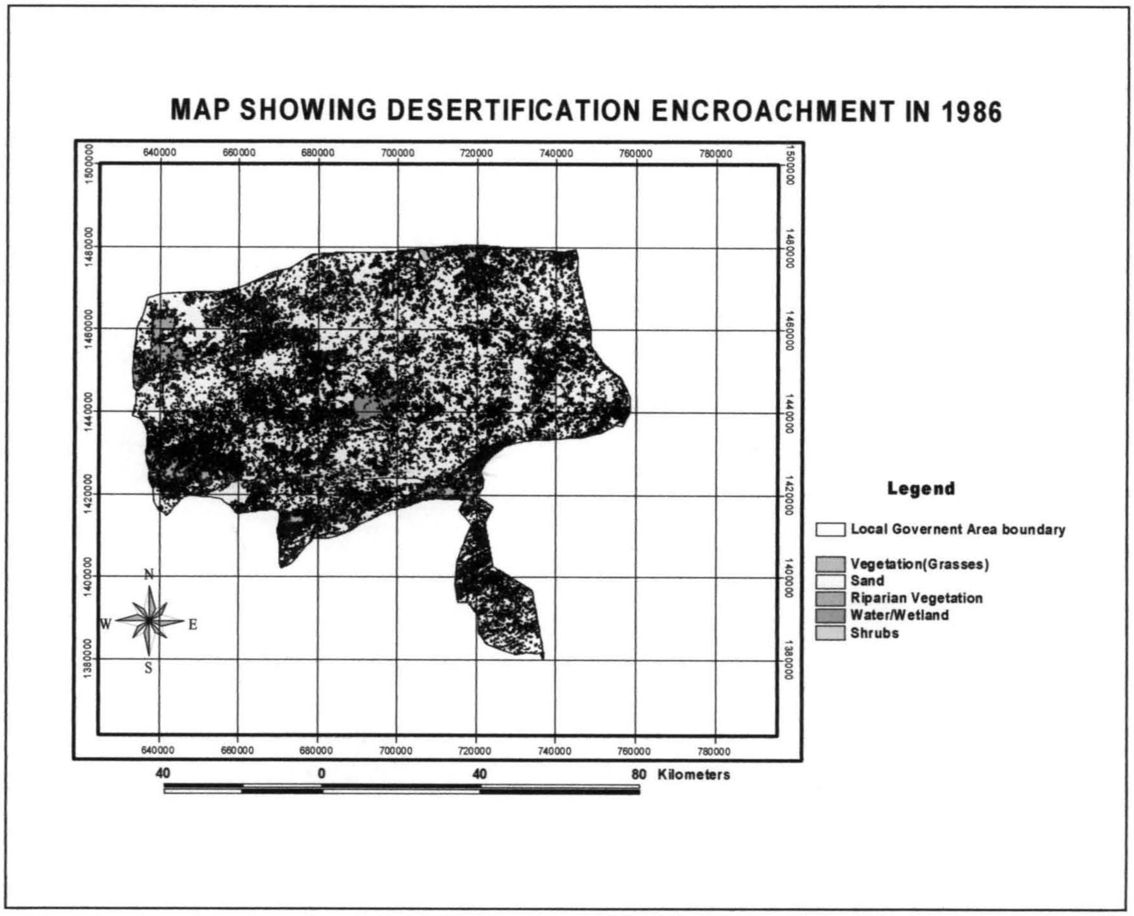

Fig.4.1b: Classified image of Desertification Extent for periods 1986

Table 4.1: Distributions of classes of change image 1973 and 1986

Class name	Area (M^2)	Area (%)
Vegetation(Grasses)	384613	23.99
Sand(Desertified)	643801	40.16
Riparian Vegetation	189433	11.82
Water/Wetland	272089	16.97
Shrubs	113179	7.06
Total	**1603115**	**100.00**

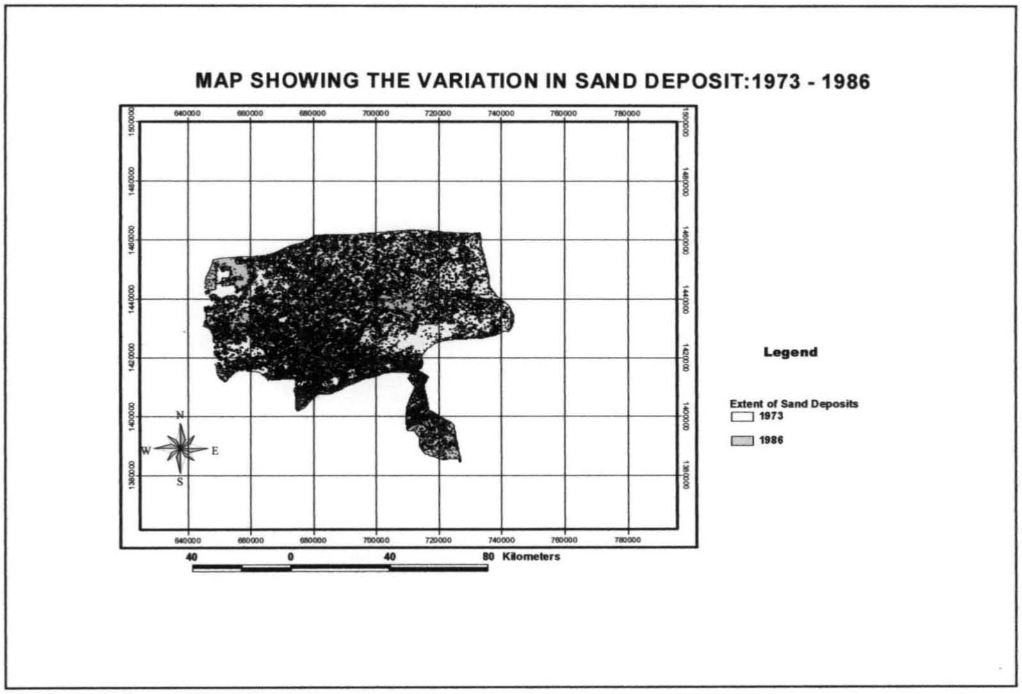

Fig.4.2: Variation of Desertification Extent for periods 1973-1986

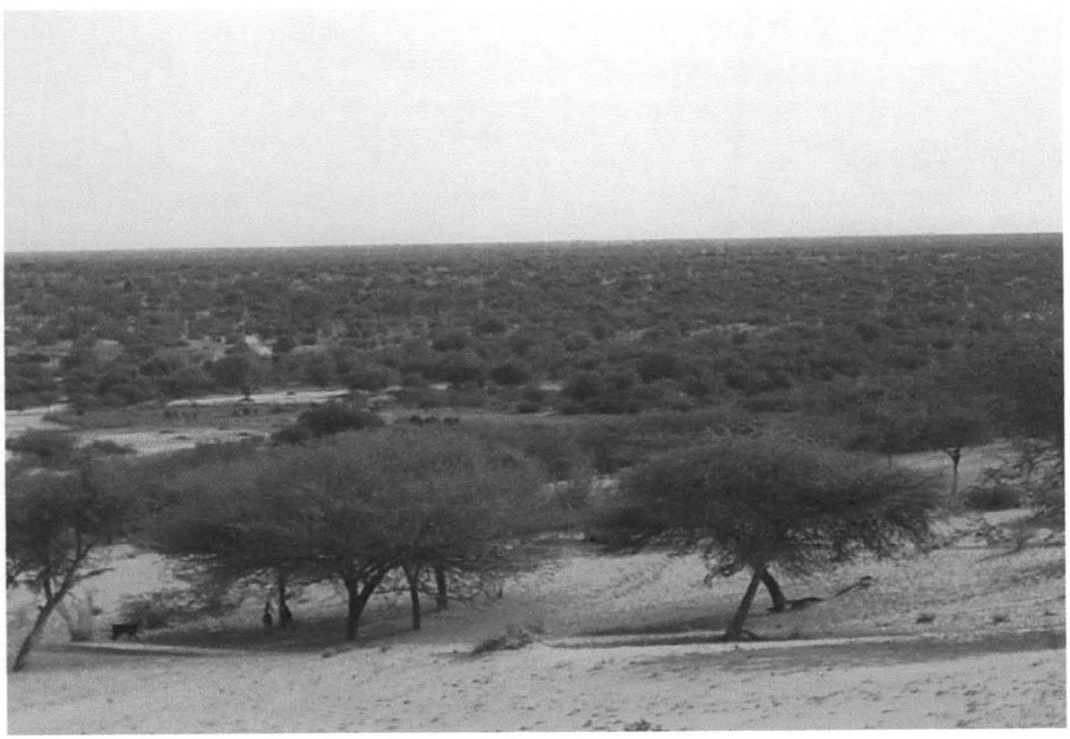

Plate I: Vegetation cover in Bad*e*, vegetation is denser and dominated by *Acacia tortilis* (Photograph by the author, southern part of *Bade,* July 2007, rainy season)

Plate IIa: clearance of trees for cultivation during dry Season around *Bade* area

Plate: IIb: Grazing in the *Jajimaji (Karasuwa)* area (Photograph by the author, Jan2007).

4.1 Extent of Desertification for the of period 1986 to 2006

The changes in the desertification pattern between 1986 and 2006 (Figure4.3 & 4.4) are identified. Table 4.4 shows the changes in terms of variations in aerial extent and percentage coverage.

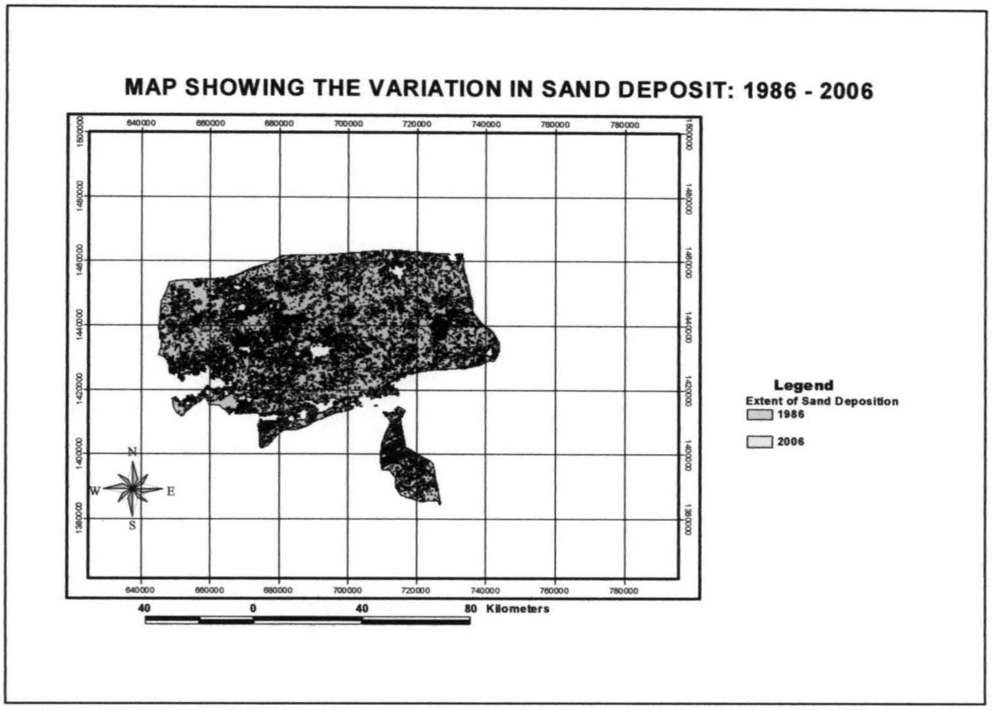

Fig.4.3: Variation of Desertification Extent in 1986 and 2006

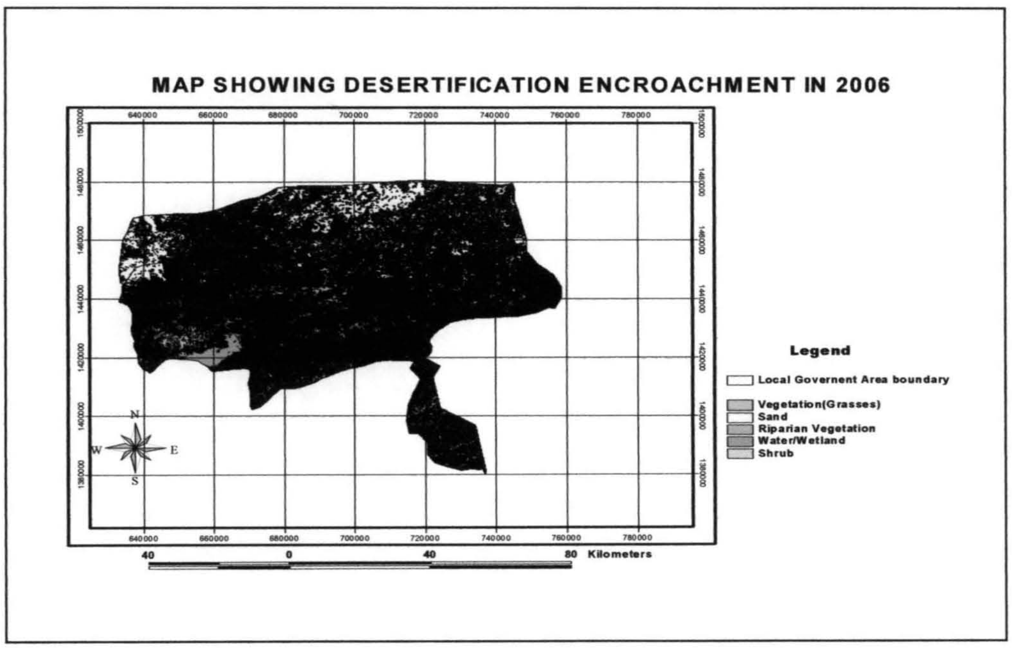

Fig.4.4: Classified image of Desertification Extent for period 2006

Table 4.2: Distributions of classes of change image 1986 and 2006

Class name	Area (M^2)	Area (%)
Vegetation(Grasses)	524529	32.72
Sand(Desertified)	613583	38.27
Riparian Vegetation	106756	6.66
Water/Wetland	231859	14.46
Shrubs	126388	7.88
Total	**1603115**	**100.00**

CHAPTER FIVE

DISCUSSION, SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Discussion of Data Analyses Result

5.1.1 Extent of Desertification for the of period 1973 to 1986

The classified image of magnitude and direction with reference to the years 1973 and 1986 (as shown in Figure4.1a&b) highlights intensive dynamics related to the different classes during this periods characterised by the increase of sand and decrease in vegetation cover in the study area. The change image as presented in Table 4.1 shows that the Sand (desertification) class covers about 40.16% of the total area. Meanwhile the vegetation and shrubs classes cover only 23.99% and 7.06% respectively. Wetland/water and riparian vegetation constitute 11.82 %(Plate I) and 16.97%. This indicates the trend of increasing sand encroachment in the study area during this period. Sand class in 1973 to 1986 covers 40.16% of the total area and it is dominant in Yusufari and *Karasuwa areas* in the northern and north-central part of the study area (Fig.4.2).The excessive sand encroachment might be due incessant rainfall, wind and Human impacts in the study area such as farming and grazing (Plate IIa and b).

5.1.2 Extent of Desertification for the of period 1986 to 2006

The change image referring to years 1986 and 2006 (Figure4.3) reflects different patterns of change in desertified (sand) and vegetation classes. The desertified class appears to have very high intensity in the northern part of the study area. Meanwhile the vegetation (re-growth) class dominated in the southern west part of the study area. Contrasting with the change map of 1973 and 1986 indicates increase in the vegetation (re-growth class) in the study area in the addressed period. Table 4.2 shows that the vegetation class covers 32.72 % in the period of 1986 and 2006 compared to only 23.99% in period 1973 and 1986.

Nevertheless, the Sand (desertified) class is decreased to 38.27% during the periods 1986-2006 from 40.16% during the period 1973-1986. Period 1986 to 2006 in comparison with period 1973-1986 witnessed decrease in desertified areas and increase in vegetation (re-growth) areas (Figure 4.4). The vegetation cover in 2006 revealed relatively good coverage compared to 1986. Thus, the amount of rainfall is suggested to be one of the most factors responsible for variability in re-growth of vegetation cover during the addressed periods.

In addition, shrubs areas relatively increased from 7.06% during period of 1976-1988 to 7.88% during the next period 1988-2003. While the riparian vegetation and wetlands class decreases to 6.66% and 14.46% during the periods 1986-2006 from 11.82% and 16.97% during the period 1973-1986 respectively.

5.2 Discussion of dynamics of change

5.2.1 Dynamics of change during the period 1973-1986

Based on the visual interpretation of the change map for the period 1973-1986, in addition to information obtained during field surveys, secondary data and relevant literature, it can be indicated that a rapid encroachment of sand and high decrease of vegetation cover in the study area is evident. Figure (4.1a &c), includes a subset of the change map of 1973-1986, showing the most affected areas with desertification in the northern part of the study area. In this regards, findings have illustrate that the sand soil has been rapidly increased during the period 1973-1986.

In the northern part of the study area the pattern of change evidently highlights the pressure of human interferences and its negative effects on fragile natural resources. These pressures are related to overgrazing by livestock and rainfed agriculture (plate2a & b). Continuous use of rangelands in Karasuwa area, particularly the heavy grazing during the wet seasons, when vegetation cover is actively growing, results in degradation of vegetation cover and exposition of soil to wind erosion. Rangelands degradation is further aggravated by expansion of the areas under shifting cultivation and thus leading to destruction of vegetation cover in these areas.

5.3 Summary of Findings

From the result of the data analysis result, the following findings were made;

1. The years 1973 and 1986 (Figure 4.1a&b) witnessed intensive dynamic change in desert encroachment in the study area, with the increase of sand and decrease in vegetation cover. The Sand (desertification) class covers about 40.16% of the total area. Meanwhile the vegetation and shrubs classes cover only 23.99% and 7.06% respectively. Wetland/water and riparian vegetation constitute 11.82 %(Plate 1) and 16.97%.
2. Sand class in 1973 to 1986 covers 40.16% of the total area and it is dominating in Yusufari and *Karasuwa areas* in the northern and north-central part of the study area (Fig.4.2).
3. In 1986 and 2006 (Figure4.3), the patterns of change reflect that the desertified class appears to have very high intensity in the northern part of the study area and the vegetation (re-growth) class dominated in the south western part of the study area.
4. The study also showed contrast with the change map of 1973 and 1986 indicating increase in the vegetation (re-growth class) in the study area in the addressed period. The vegetation class covers 32.72 % in the period of 1986 and 2006 compared to only 23.99% in period 1973 and 1986. The Sand (desertified) class is decreased to 38.27% during the periods of 1986-2006 from 40.16% during the period 1973-1986.
5. Period 1986 to 2006 in comparison with period 1973-1986 witnessed decrease in desertified areas and increase in vegetation (re-growth) areas (Figure 4.4).

6. The amount of rainfall is suggested to be one of the most dominant factors responsible for variability in re-growth of vegetation cover during the addressed periods in the areas.

5.3 Conclusions

Spatial data and multi-temporal analysis of remote sensing data were allocated to understand the phenomena of desertification processes in Yobe State. Supervised Classification by Maximum likelihood technique was adopted to map and analyse the desertification processes using the above mentioned data. Combinations of multispectral mixture analysis of Landsat imagery and field observations enlightened the nature and causes of desertification processes in the study area in the years 1973, 1986 and 2006. Dynamics of desertification in the relationships between man, animal, and vegetation, as determinant factors of desertification in the study area were analysed and discussed. The results show a noticeable significant decrease in vegetation fraction in 1973, 1986 and 2006, respectively, while sand fraction was rapidly increasing during the same periods. This concludes that desertification can be recognised by reduction of total vegetation cover and exposure of bare sand soil. The results emphasized the phenomena of sand encroachment from the northern part (Yusufari) to the southern part (Bade) following the wind direction. The Increasing wind speed during the dry season is mainly attributed to the increase of sand encroachment in the study area. Accordingly, the enquiry stated by this study about the extent and direction of sand encroachment could be verified. The results generated from analysis of Landsat imagery prove the viability of such method in monitoring desertification processes in relation to mismanagement of landuse in the study area.

5.4 Limitations of the study

Some of the limitations experienced in this study can be summarised as follows:

1. Low quality of the MSS image used.

2. Absences of spectrometer for field measurement of spectral signature of different land cover materials in the study area.
3. Limitation in the total number of bands in Landsat MSS.
4. Inaccessibility and security unrest in some locations of the study area during field surveys.
5. Lack of secondary data such as climatic data (rainfall and wind direction), agricultural statistics and some other socio-economic data.

5.5 Recommendations

Intensive landuse in fragile ecosystems, such as in Yobe State obviously accelerates desertification and the land degradation processes. The decrease in vegetation cover simultaneously with increasing exposure of soil surface will certainly increase the wind erosion and sand encroachment in the study area. Despite this severe problem, efforts should be exerted to study and assess desertification processes in Yobe as well as in arid and semi-arid regions in order to mitigate this problem. Based on the findings of the above mentioned limitations the following recommendations were made:

1. Application of remote sensing as accurate, low-cost and safe techniques to assess and monitor desertification processes in semi-arid areas provides valuable information on suitable landuse/landcover management to conserve the natural resources in the study area.
2. Training and capacity building of researchers in the application of remote sensing in natural resource management.
3. Application of remote sensing with extensive focus (*in situ*) on desertified areas is more effective than a widespread global one.
4. Use of high resolution and more advanced remote sensing data (such as hyperspectral imagery) for monitoring desertification and land degradation.
5. Establishment of more extensive regional monitoring network to collect baseline data relevant to all aspects of desertification specifically in the study area and Sahel region of the country in general.

6. Establishment of shelterbelts and windbreaks by cultivating suitable species such as *Maerua crassifolia, Leptadena pyrotechnica* and *Acacia tortilis* to avoid wind erosion and to protect the study area from desert encroachment.
7. To reduce impact of human activities on vegetation, restoration and re-vegetation programs around the settlements is well recommended especially in the areas which are subjected to sever agricultural activities.
8. Rationalization of policies towards more conservation programs for rehabilitation of desertified areas.
9. Improvement and management of the grazing activities.
10. Construction and maintenance of watering points in rural areas.
11. Enhancement of rehabilitation programs by forest administration and agricultural sector to protect the natural forest in the area with more emphasis on community participation.

5.6 Suggestion for further studies

Supervised Classification techniques used for this study are considered successfully adopted as remote sensing techniques in monitoring arid land environments. Accordingly, the present study applied such techniques for spatial analysis to resolve problems of desertification in Yobe State. No doubt, further and extended research efforts are needed to identify and maintain cheap and accurate methods for monitoring desertification in such areas. High resolution and more advanced remote sensing data such as hyperspectral imagery and spectrometry, can widely support in this context and increase the accuracy of monitoring drylands. The suggested scientific efforts should address and integrate geographic information systems (GIS) with some socio-economic parameters to map and interpret the dynamics of desertification particularly in areas of resource conflicts between resident farmers and animal herders. The concentrations of animals around the villages aggravate the problems due to narrow routes to watering points. The studies can also help in mapping animal routes to water and range sources and hence avoid some bloody conflicts between tribes.

Further studies could support a better understanding and can give clear diagnosis of the desertification processes as well as the related landcover changes. Moreover, there is an urgent need for establishing a centre for networking of regional monitoring and mapping hence detecting the long term trends of desertification processes. Establishment of "early warning systems" in such areas is urgently needed. Early warning could estimate the amount and duration of rainfall based on the statistical records, assess the soil moisture situation, detect change and provide information on trends of vegetation development in arid regions.

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