AN ASSESSMENT OF THE INCIDENCE OF DESERTIFICATIO IN THE NORTHERN PARTS OF KATSINA STATE

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BY

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BEING A THESIS SUBMITTED TO THE SCHOOL OF POSTGRADUATE STUDIES AHMADU BELLO UNIVERSITY, ZARIA

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DEPARTMENT OF GEOGRAPHY,
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FEBRUARY, 2015

DECLARATION

I declare that the work in this thesis entitled 'An Assessment of the Incidence of Desertification in the Northern parts of Katsina State' has been performed by me in the Department of Geography. The information derived from the literature has been duly acknowledged in the text and a list of references provided. No part of this thesis was previously presented for another degree or diploma at this or any other Institution.

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Name of Signature Date

CERTIFICATION

This thesis entitled "AN ASSESSMENT OF THE INCIDENCE OF DESERTIFICATION IN THE NORTHERN PARTS OF KATSINA STATE" by Blessing Limwakat GAKKUK meets the regulations governing the award of the Master of Science Degree in Geography of the Ahmadu Bello University, and is approved for its' contribution to knowledge and literary presentation.

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DEDICATION

To God Almighty, Whose invisible hand has seen me through my educational pursuits.

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ABSTRACT

This study was conducted on 'An Assessment of the Incidence Desertification in the Extreme Northern Parts of Katsina State'. Satellite imageries were used to obtain results for vegetation decline using Normalized Difference Vegetation Index (NDVI). The satellite imageries used were Landsat Mss 1976, Landsat TM 1988, Landsat TM 1999 and Landsat ETM^{+}. The observed change for vegetation in hectares was 85.7% in 1976, 77.9% in 1988, 58.2% in 1999 and 50.5% in 2006 which showed that the vegetation was declining while vegetation was increasing. Rainfall data was also used to test for relationship between NDVI and rainfall. The result showed that there was decline in vegetation from each decade. There was a positive correlation between the NDVI and rainfall. Questionnaires were administered to capture people's perception of desertification and its impact on yields. The results showed that desertification is a menace which the people are aware of and have strategies to keep it under control. The study also showed that desertification has negative impact on agricultural yields. Recommendations proffered include improved agricultural practices, tree planting campaigns, participation in the great green world programme, alternative forms of energy for cooking, awareness to climate change, availability of remotely sensed data and poverty reduction.

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ACRONYMS

ARR : Africa Regional Review Report on Energy for Sustainable Development

CFCs: Chlorofluorocarbons

CCIR : Climate Change Information Resources

ETM : Enhanced Thematic Mapper

FAO: Food and Agriculture Organization

FRN : Federal Republic of Nigeria

GIS : Geographic Information Systems

IPCC : Intergovernmental Panel on Climate Change

JICD : Joint International Conference on Desertification

KSHBRS : Katsina State Household Baseline Survey Report

NDVI : Normalized Difference Vegetation Index

NIMET : Nigeria Meteorological Agency

MSS : Landsat Multispectral Scanner

TM : Thematic Mapper

UNCOD : United Nations Convention to Combat Desertification

UNEP : United Nations Environmental Protection

WMO : World Meteorological Organization

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background of the Study

Arid and semi arid environments cover more than 40% of the global land surface (Deichman and Eklundh, 1991) and provide habitat to more than 1 billion humans (Reynolds and Smith, 2002). Rural people in these regions ultimately depend on the effective use of natural resources (Reynolds, 2001). It is widely recognized that these lands are prone to severe land degradation, often referred to as desertification. Desertification is one of the most serious problems facing the world today. Large parts of the dry areas that cover more than one- third of the earth's land surface are being degraded with serious effects on the environment, food production and the lives of millions of people (Grainger,1990).

Many civilizations on the planet are thought to have met their demise because of desertification of the land they inhabited and their inability to move with the shifting climatic regimes. Among civilizations thought to have been lost to the sands of encroaching deserts are several Indian cultures of the American Southwest such as the Anasazi, and many peoples of the Sahel region of West Africa, where up to 250,000 people, about 3.5 million cattle, and countless sheep, goats and camels are thought to have perished in droughts in the late 1960s and early 1970s (Kusky, 2005; Zeng, 2003).

The Sahel tragedy prompted the United Nations to convene a Conference on Desertification (UNCOD) in Nairobi in 1977 to agree on a plan of action to combat desertification and bring it under control by the year 2000. The extensive scientific investigations which preceded UNCOD showed that the Sahel tragedy was not just caused

by lack of rainfall, but the result of a chronic process of land degradation in which people had a key role (Grainger 1990 pg 1). Desertification, characterized by the degradation of soil and vegetative cover, can occur in any dry area, not just on the fringes of natural deserts. It is a global phenomenon, affecting both developed and developing nations and is a particular problem in Africa, The Middle East, India and Pakistan, China, Australia, USA, Latin American countries such as Brazil and Chile and European countries such as Greece, Spain and Portugal (Grainger, 1990).

Two thirds of Africa is classified as deserts or dry lands. These are concentrated in the Sahelian region, the horn of Africa and the Kalahari in the south. Africa is especially susceptible to land degradation and bears the greatest impact of drought and desertification. It is estimated that two-thirds of African land is already degraded to some degree and land degradation affects about 65% of the entire African population (UNCCD, 2004). Climate change is set to increase the area susceptible to drought, land degradation and desertification in the region. Under a range of climatic scenarios, it is projected that there will be an increase of 5-8% of arid and semi arid lands in Africa (IPCC 2007).

Desertification, like climate change and loss of biodiversity, is a global problem. However, its causes are complex, frequently local, and vary from one part of the world to another. The severity of impact also varies, with less developed countries experiencing greater human misery than those with the resources to provide short and long term relief to affected populations (Pickup, 1998).

While the extent and severity of desertification in Nigeria have not been fully established, nor the rate of progression been fully documented, there is general consensus

that desertification is by far the most pressing environmental problem in the dry lands parts of Nigeria (Federal Republic of Nigeria, 2000), where no fewer than 35million people are located and are facing threats of hunger and extreme weather conditions due to desert encroachment on arable land (Danjuma, 2012). According to Mohammed Bashir the permanent Secretary, ministry of environment in the National Mirror newspaper of 28/6/2011, desertification threatens human security by depriving the people of their means of livelihood as it undercuts food production, access to water and the means of economic activity.

1.2 Statement of the Research Problem

Drought and desertification have become major environmental problems in northern parts of Nigeria. Desertification in Nigeria is overwhelmingly visible only in the extreme northern states (Musa and Sahib, 2010). The extent and severity of desertification in Nigeria has not been fully established neither the rate of progression properly documented. Nevertheless, there is a general consensus that desertification is by far the most pressing environmental problem in the dry lands parts of the country. The visible sign of this phenomenon is the gradual shift in vegetation from grasses, bushes and occasional trees, to grass and bushes; and in the final stages, expansive areas of desertlike sand (FME, 2000 pp11).

Borno, Jigawa, Kano, Katsina, Kebbi, Sokoto, Yobe and Zamfara are among the worst hit States. According to Oladipo (1993), about 140,000km^2 of Nigeria is prone to severe desertification, particularly areas of latitude 12^{o}N. These desertification frontline States have a total landmass of 393,000km square and form a grazing area for about 90% of cattle population in the country. According to Brown (2006), the Nigerian livestock

population grew from 6million to 66million between 1950 and 2006, an eleven (11) fold increase while her human population grew from 33million in 1950 to 140 million in 2006, a four-fold expansion which has forced farmers to plough marginal land under the pressure to meet food needs. As a result, the country is slowly turning into a desert. The survival of humans and livestock are being threatened by desertification in these frontline States. These areas in the desert frontline States are characterized by a short erratic or uncertain rainfall period and long dry season. The annual precipitation in these areas could be as low as 200mm while the peak is about 600mm (Otegbeye, 2004).

Katsina State is one of the States experiencing desertification. The Katsina State commissioner for environment admitted in the Leadership newspaper of 01/03/2012 that desert control remains one of the major challenges facing the State. Scores of farmers and their families have been forced to move off land that has become barren principally by desertification. The nomadic Fulani are also heading south in search of grazing areas for their herds. The loss of arable land and pastures are threatening the economy of this predominantly farming areas thereby increasing poverty and hardships on the rural poor who are struggling to survive in a limited natural resource base. This can also said to be a threat to national food supply of Nigeria as a nation. The Katsina State government has been devising means of combating desert encroachment which has so far yielded little result, as the menace of desertification is still threatening the economic survival of both humans and animals hence, the necessity of this research.

This study is another attempt to look at desert encroachment and its effects in some parts of Katsina State, as well as the perception of the people that are affected. The study intends to contribute to the filling of some of the following gaps in the study area:

i. The use of, Remote sensing and GIS technique to determine the extent of decline in vegetation cover

ii. Involving the affected people in developing a strategic approach for the management of desertification in the study area using bottom-up rather than the usual top to down approach. In this regard, this study will look at the people's perception of desertification and the indigenous strategies in which they adopt to curb desertification.

The research problem of this study is summarized by the following research questions:

i. What is the extent of decline in vegetation cover (as an indication of land degradation and desertification) in the area between 1976 and 2006?

ii. To what extent is the observed change in vegetation related to rainfall?

iii. How do the people perceive desertification and its causes?

iv. What is the impact of desertification on the socioeconomic life of the people with reference to agricultural yields?

1.3 Aim and Objectives of the Study

The aim of this study is to assess the incidence of desertification in the northern parts of Katsina State. Specific objectives of the study are to:

i. assess the extent of decline in vegetation cover in the area between 1976 and 2006

ii. assess the effect of rainfall pattern on desertification in the area from 1976 to 2006

iii. examine the people's perception on the causes of desertification

iv. evaluate the impact of desertification on the quantity of agricultural produce

1.4 Significance of the Study

About 95% of the State's populations are engaged in subsistence agriculture namely farming and animal rearing (Fadama III, 2013). Both food and cash crops are produced in the state. However, the source of livelihood of these people is being threatened by the menace of desertification as farmlands which use to be productive are gradually becoming unproductive wastelands thereby bringing untold hardship to the people especially in the area of agriculture. The government of Katsina in collaboration with non-governmental organizations and international organizations has embarked on various projects and campaigns to manage desertification but such efforts has not yielded sustainable results.

It is hoped that this study will provide practicable management approach that will be beneficial for the government and communities in the area and that of other desertification frontline States to fight desertification.

1.5 Scope of the Study

The study covered three LGAs in northern parts of Katsina State namely Mashi, Mai Adua and Zango LGAs because these areas at the extreme north are more prone to desertification than the LGAs in the southern parts of the State. The study focused on how the indigenous people perceive desertification and its effects on their socioeconomic life. The climatic factor used in this study is rainfall data only from 1976 to 2006. Analyzing the impact of desertification on agriculture was limited to yields per hectare/ bags.

1.6 Organization of the Study

Chapter one consists of the introduction of the study, statement of the research problem, aim and objectives, significance and scope of the study.

Chapter two focused mainly on review of various literature on desertification, drought, its impacts on agriculture, economic growth, poverty reduction, water, migration and biodiversity. It also looked at the meaning of perception, remote sensing and GIS and finally in this chapter is the review of various studies carried out by various scholars.

Chapter three focused on the study area mainly its Physiography, Climate, Location, Relief, Soils and Vegetation, People and Economic activities. The methodology explained the various data used in the study which includes remotely sensed images, rainfall data, sampling design and questionnaires. This chapter also explained the technique of data analysis.

Chapter four primarily focused on the results obtained from the satellite images, rainfall data and questionnaires, discussion were made on each result.

Chapter five the last chapter consists of the summary, conclusion and recommendations.

CHAPTER TWO

2.0 CONCEPTUAL FRAMEWORK AND LITERATURE REVIEW

2.1 Concept of Drought and Desertification

Drought may be defined as a climatic event involving a shortage of rainfall sufficient to affect adversely water supplies and crop and livestock production, causing much disruption of economic activities and producing some temporary ecological changes in the affected areas (Oladipo, 1993). According to Grainger (1990), drought refers to the naturally occurring short-term (1±2 years) phenomenon when precipitation is significantly below normal recorded levels or a sequence of dry years. However, it does not, necessarily follow that drought per se will give rise to or cause desertification in dry land areas. Much depends on the resource management in these areas. When human misuse or mismanagement of land weakens the natural system, drought leads to desertification. Therefore, drought creates the condition whereby human impact on the land increases and the capacity of the land to accommodate it decreases. Drought like other climatic conditions such as temperature and wind may accelerate the phenomenon of desertification.

A major difficulty in formulating appropriate methodologies to overcome the problem of drought and desertification concerns their definitions. Both possess many common characteristics although desertification is now realized to be a more deadly enemy to the environment than drought. Because drought and desertification are intertwined, they tend to be confused with each other and used interchangeably, thereby complicating efforts at their definitions (Oladipo, 1993).

A drought is primarily a natural climatic event with a subtle beginning and insidious progress, but its consequences can be significantly altered by man. The degree of impact of a particular drought on the environment and the extent to which it may be a disaster for the human population depends on a number of factors, such as the length of the period separating the drought from a previous one, the severity of rainfall deficit relative to a given mode of land use, the level of population pressure, and agricultural and water management practices.

Desertification, as an environmental term, became very popular during the widespread and debilitating Sahelian drought of 1968-1973, although it was first used in 1949 by Aubreville to describe the savannization of tropical and subtropical forests in Africa in areas characterized by severe soil erosion, changes in the physical and chemical properties of the soils, and invasion of more xeric species (Verstraete, 1986). Since then, definitions as well as conceptualization of desertification by individual scientists have been value-loaded because the degree to which there is professional agreement on its indicators, nature, processes, causes and reversibility is limited. Nonetheless most of the definitions emphasize three aspects of the problem: (a) partial or total loss of biological productivity; (b) both climate and human activity as essential causal elements; and (c) vulnerability of the arid and semi-arid ecosystems. Considerable differences in opinion exist among scientists with regard to the meaning of desertification; Oladipo (1993) defined desertification as a process of sustained land degradation (loss of primary production) that results in the inability of the environment to sustain the demands being made upon it by socio economic systems at the existing levels of technology and economic development and under prevailing climatic conditions especially recurrent drought. Otegbeye (2004)

reports that desertification is a process of turning a tract of land into an arid barren one that can no longer support any considerable population without an artificial water supply. Desertification is a gradual process and it operates through systems of land use that overtax the inherent bio-productive capacity of land (Oppong, 1993). Hillel and Rosenzweig (2002), observed that desertification is an environmental term that covers a wide variety of effects involving the actual and potential biological productivity of an ecosystem in arid, semi-arid and dry sub- humid regions.

The 'Earth Summit', of the UN Conference on Environment and Development (UNCED, Agenda 21) in Rio de Janeiro in 1992 defined desertification as: land degradation in arid, semi-arid and dry sub-humid areas resulting from various factors including climate variation and human activities. From the various definitions, desertification simply means land degradation by which biodiversity of land is reduced. Desertification is a gradual process which manifests itself after a long period of time.

2.2 Causes of Desertification

Desertification is, first and foremost, the outcome of resource management failure (Kelly and Hulme, 1993). It is caused by multiple direct and indirect factors. It occurs because dry land ecosystems are extremely vulnerable to over-exploitation and inappropriate land use that result in underdevelopment of economies and in entrenched poverty among the affected population. Its anthropogenic processes include over cultivation, overgrazing, deforestation, and poor irrigation practices (UNEP, 1992a, b and c) These processes are the result of excessive pressures on ecosystems, goods and services.

2.2.1 Deforestation

Deforestation is defined as the process whereby trees and vegetation are removed for various purposes leaving the land partially or completely exposed to the elements. The role that trees and forests play in the ecological-well-being of the earth is well known. Apart from providing a habitat for wildlife, they contribute to stable water supplies, conserve the soil, clean the air and help to regulate the climate (Penny, 2007).

Deforestation, especially to meet energy needs and expand agricultural land is a serious direct cause of desertification. Globally, there is evidence demonstrating a heavy negative impact of the energy sector on forests and other vegetation cover and land productivity. More than 15million hectares of tropical forests are depleted or burnt every year in order to provide for small-scale agriculture or cattle ranching or for use as fuel wood for heating and cooking (UNCCD, 2004).

Biomass constitutes 30 percent of the energy used in Africa and over 80 percent used in many sub-Saharan countries such as Burundi (91 percent), Rwanda and Central Africa Republic (90 percent), Mozambique (89 percent), Burkina Faso (87 percent), Benin (86 percent), Madagascar and Niger (85 percent) (ARR, 2005).

The use of fuel wood is more in rural area than urban constituting 92.0% of fuel wood because of its availability, cheapness, tradition and because other sources of domestic fuel are nearly absent. On the whole, kerosene constitutes about 54.1% of fuel for cooking in urban areas. This is not because it is available and affordable, but because wood is scarce due to high urbanization and near absence or scarcity of other sources of domestic energy. At the national level, electricity and gas used for cooking constitute only 0.7%

each; kerosene, 22.9%, wood, 74.1% and coal, 1.6%. Kebbi State has the highest % of fuel wood consumption (99.2%) in the country, while Gombe has the least (92.4%) among the desert prone areas (Audu, 2013).

The effects of this continuous and increasing harvesting of fuel wood is increasing desertification which is leading to the near absence of trees in the extreme northern Nigeria and as such leaves, sticks and animal dungs among others are increasingly being used as domestic fuel (Ayuba and Dami, 2011). Nigeria is losing about 38% of its total landmass to desertification. Presently, the spread of desert – like condition is alarming and is extending to states like Kaduna, Niger, Kwara, Adamawa and Taraba. While the northern part of Nigeria is facing desertification, the southern part is facing deforestation leading to savannazation of the forest zone as signs of it are already very obvious in states like Edo, Enugu, Anambra, Osun, Ekiti, Ondo and so on. In other northern states not witnessing pronounced desertification, there is the depletion of vegetation resources due to fuel wood harvesting leading to an imbalance or disequilibrium in the ecosystem. It is also feared that if the current rate of tropical forests deforestation is maintained, the tropical forests could be almost entirely harvested by the year 2050, thus devastatingly contributing to climate change, loss of biodiversity, land degradation and desertification (UNCCD, 2004).

Without alternatives poor people are forced to exploit land resources including fragile lands, for survival. Given that most dry lands in Africa are poverty hotspots as well, the risk of desertification is high in many of these areas, as the poor inevitably become both the victims and willing agents of environmental damage and desertification.

As population increases, wood will become more scarce. Pressure on wood resources becomes more severe during a drought because it can, paradoxically, increase demand for wood. As fuel wood becomes scarcer during drought, prices may become so high so that it is very profitable for entrepreneurs to bring in trucks and transport fuel wood to the cities from far distances in the countryside. In addition, farmers need to make money for food during drought and may have to do this by selling wood cut off their farm trees (Oladipo, 1993).

2.2.2 Trend and extent of desertification in Nigeria

It is difficult to estimate how fast desertification is advancing in Nigeria. This is because various state governments, until recently have not seen desertification as a problem requiring high priority attention. Hence, there has not been real monitoring of the rate at which arid and semi arid areas of the country are being degraded. However, estimates by scientists vary from less than 1 Km to about 15 Km per year. On the other hand, other scientists contend that it is not moving along a linear front but occurs in patches, which expand in various directions and at rates that vary considerably. Recent estimates put the area already lost to desertification at about 351,000 Km^2 of the country's landmass (Nwafor, 2006).

In the desertification map of the world produced by Food and Agriculture Organization (FAO), the World Meteorological Organization (WMO) and U.N. E.S.C.O, about 15% of Nigeria is prone to desertification. It subsumes both arid and semiarid areas where the evidences of true desertification are showing up on an extensive scale. In some

of these areas, shrubs have largely replaced grasses or have spread to such an extent that they dominate the flora (Emodi, 2013).

Sheet, wind and water erosion have largely denuded the land of vegetation and gullies are present, salinity has reduced crop yields.

An indisputable fact is that most of the region north of latitude 12^{o}N is vulnerable to ecological degradation. For example, more than 65 percent of Sokoto State is said to be under threat, while about 55 percent of Borno State is affected. In Gidan Kaura, a village 90 Km northwest of Sokoto, Sand dunes have been reported to have invaded vast areas of farmland and swept a whole village of nearly 300 houses out of existence. In the extreme northern part of Yobe State communities such as Bulatura, Kaska, Bukarti Toshu, Tulotuwa, Yunusari, among others, have been either completely surrounded by sand dunes or are about to be buried by them (Emodi, 2013). In this state, people have been moving southwards to areas around Gashua, Nguru, Kukuna in Yobe State and Monguno in Borno State which themselves are within the fragile environment. In Katsina State, communities like Jibiya, Daura, Mashi, Mani, among others have been adversely affected. Today, it may be said that hundreds of thousands of square kilometers of arable land have been lost to desertification states in such as Sokoto, Zamfara, Katsina, Jigawa extreme North of Kano, Yobe and Borno States (Emodi, 2006).

2.2.3 Over grazing

Overgrazing occurs where too many animals are concentrated in small areas, such as around artificial water holes or kept on the same land for a long period (Goldsmith and

Hildyard, 1990, Grainger, 1990). When livestock density becomes excessive and too many animals are grazed on the same area of rangelands, valuable perennial grasses are depleted and replaced by less nutritious annual plants, and the density of vegetation is reduced (Grainger, 1990). As a consequence, the land is laid bare, the soil becomes vulnerable to severe erosion, excessive compaction and sealing resulting from the trampling of livestock (especially near waterholes), and pioneer vegetation regrowth is retarded, all leading ultimately to desertification (Grainger, 1990).

Tivy (1990) has also pointed out that overgrazing in semi-arid areas has a deleterious impact on the hydrological cycle. Exposed surfaces become susceptible to sun-baking, soil sealing by torrential rain storms and to compaction by animals and human trampling. As a result, the infiltration capacity of the soil is reduced, and water loss by surface evaporation and surface runoff is increased with a decline in available precipitation.

The dry lands of Nigeria is said to support much of the country's livestock economy, hosting about 90 % of the cattle population, about two-thirds of the goats and sheep and almost all donkeys, camels and horses(FME, 2000). In the Sudan and the Sahel zones, which carry most of the livestock population, nomadic herdsmen graze their livestock throughout the area and are constantly in search of suitable pastures (FME, 2000).

According to Oladipo (1993), overgrazing becomes more destructive during drought when large areas that would normally have been available for grazing dry up. At this time, the pastoralists concentrate on the limited grazing resources to be found, thereby

often grazing the land beyond recovery. Animals are forced to eat every available scrap of edible vegetation they could find. When pastures do not have enough time to recover between droughts, overgrazing then results as the animals, especially goats, graze the remaining grasses even closer and browse shrubs and trees ruthlessly and destructively. Pastoralists help in this process by lopping off leaf-bearing branches and even by chopping down entire trees for animal feeding during drought. This was particularly intense during the catastrophic 1969-1973 Sahelian drought as it was the only source of food for livestock in some areas. The resulting pressure from overgrazing, over browsing and lopping of vegetation for fodder may lead to the destruction of the capacity of the plants to regenerate (Oladipo, 1993).

2.2.4 Over cultivation

Over cultivation occurs when farmers try to crop the land more intensively than permitted by its natural fertility, and fail to compensate for the export of the nutrients in the soil by using artificial fertilizers or fallowing the land so that its fertility can regenerate naturally. Over cultivation therefore, reduces the fertility of the soil, damages its structure, and exposes it to erosion. It is caused by the breakdown of traditional rain- fed cropping systems, either by outside pressures or because they are unable to produce enough food to sustain high population densities (Grainger, 1990). Traditional systems of rain-fed cropping were developed over thousands of years to make the best use of limited rainfall and to sustain food production even in the most adverse climatic conditions. Long fallows were used so that fertility could regenerate. During this fallow period, the soil was protected from erosion by tree cover, falling leaves built up litter layer so that vital nutrients and humus accumulated in the top soil, and fertility was also enriched by nitrogen

fixing bacteria in the tree roots. Traditional rain-fed cropping systems are now breaking down as rising demand for food to feed growing populations forces farmers to increase production, either by reducing fallow periods or by increasing the area cultivated (Grainger,1990).

Due to the lack of alternative survival strategies, farmers tend to relentlessly exploit natural resources (food crops, water for drinking and washing, firewood) to the point that they are often over-exploited and cannot regenerate naturally. Soil nutrients and organic matter begin to diminish as intensive agriculture removes quantities of nutrients greater than the soil's natural regeneration capacities. As a consequence, the soil is unable to recover, as it does during fallow periods, resulting is an increasing spiral of environmental degradation and poverty.

In the dry lands of Nigeria, in periods of higher than normal rainfall, people tend to extend farming activities into the marginal areas. When the years of plenty are followed by dry years, exposed land with very little vegetal cover is at the mercy of the winds. The fine clays and silts are carried away as dust, and the sand drifts into dunes (FME, 2000).

2.3 Concept of Land Degradation

African Development Bank (ADB) defined land degradation as a reduction in the productivity of land resulting form soil loss, breakdown in soil structure salinization, water logging, nutrient loss, and pollution from toxic substance ADB (1995). Land degradation is also defined as long term loss of ecosystem function and productivity caused by disturbances from which the land cannot discover unaided (Bai *et al*, 2008). Land degradation occurs slowly and cumulatively and has long lasting impacts on rural people who become increasing vulnerable (Muchena, 2008).

Anthropogenic activities can degrade land and negatively impact on water and biological resources thus affecting the lives of vulnerable communities. According to UNEP (1992), land degradation is the reduction of resource potential by a combination of processes acting on land. Land degradation has been a major global issue during the 20th century and will remain high on the international agenda in the 21st century (Eswaran *et al*., 2001). Desertification is the most severe form of land degradation.

2.4 Climate Change and Desertification

Many experts believe that climate change is now unequivocal as humans are now feeling the ill effects brought by this major environmental problem. There is therefore growing consensus in the scientific literatures that in the coming decades, the world will witness higher temperatures and changing precipitation levels (Akpata, 2011).

The historical climate record for Africa shows warming of approximately 0.7°C over most of the continent during the 20th century, a decrease in rainfall over large portions of the Sahel, and an increase in rainfall in east central Africa. Climate change scenarios for Africa, based on results from several general circulation models using data collated by the Intergovernmental Panel on Climate Change (IPCC) Data Distribution Center (DDC), indicate future warming across Africa ranging from 0.2°C per decade (low scenario) to more than 0.5°C per decade (high scenario). This warming is greatest over the interior of semi-arid margins of the Sahara and central southern Africa (IPCC, 2007).

Based on the IPCC projection, the humid tropical zone of southern Nigeria which is already too hot and too wet is expected to be characterized by increase in both precipitation

(especially at the peak of the rainy season) and temperature. Already, temperature increases of about 0.2^{o}C - 0.3^{o}C per decade have been observed in the various ecological zones of the country, while drought persistence has characterized the Sudan-Sahel regions, particularly since the late 1960s. For the humid zones of Nigeria, precipitation increases of about 2 - 3% for each degree of global warming may be expected. Thus, it is reasonable to expect that the precipitation would probably increase by approximately 5 - 20% in the very humid areas of the forest regions and southern savanna areas. In contrast, the savanna areas of northern Nigeria would probably have less rainfall, which, coupled with the temperature increases, would reduce soil moisture availability. This situation may be worsened by the expected decrease in rainfall with greater drought probabilities and larger inter-annual variability.

The presence of greenhouse gases in the atmosphere is a natural component of the climate system and helps to maintain the Earth as a habitable planet. Greenhouse gases are relatively transparent to incoming solar radiation, allowing the sun's energy to pass through the atmosphere to the surface of the Earth. The energy is then absorbed by the Earth's surface, used in processes like photosynthesis, or emitted back to space as infrared radiation.

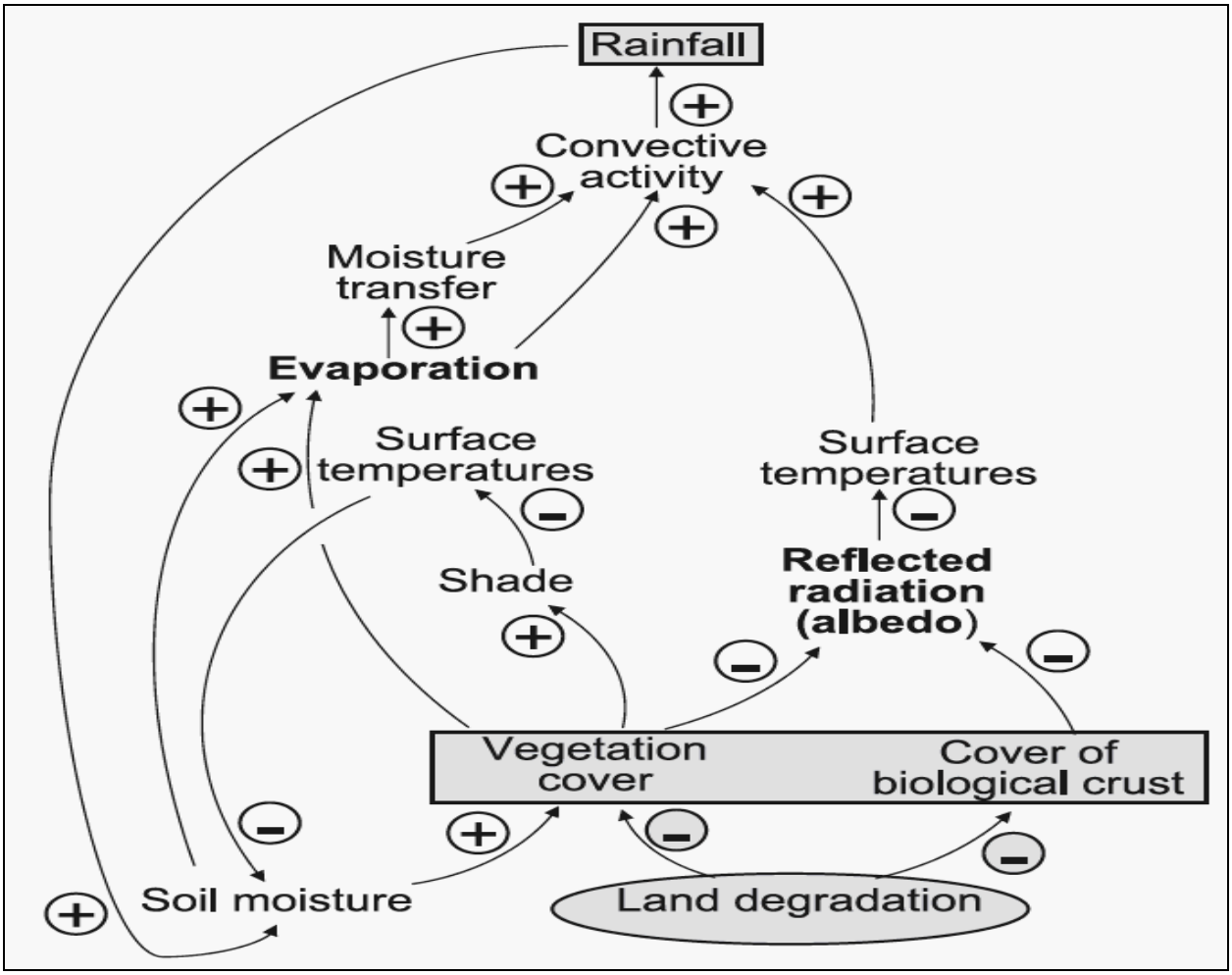
According to CCIR 2005, some of the emitted radiation passes through the atmosphere and travels back to space, but some is absorbed by greenhouse gas molecules and then scattered in all directions. The effect of this is to warm the Earth's surface and the lower atmosphere. Water vapor (H_2O) and carbon dioxide (CO_2) are the two largest contributors to the greenhouse effect. Methane (CH4), nitrous oxide (N_2O), chlorofluorocarbons (CFCs) and other greenhouse gases are present only in trace amounts,

but can still have a powerful warming effect due to their heat-trapping abilities and their long residence time in the atmosphere. Without the greenhouse effect, Earth's average temperature would be -0.4°F (-18°C), rather than the present 59°F (15°C). Concentrations of greenhouse gases – and especially carbon dioxide– have risen over the past two hundred and fifty years, largely due to the combustion of fossil fuels for energy production. Since the Industrial Revolution in the eighteenth century the concentration of carbon dioxide in the atmosphere has risen from about 270 parts per million (ppm) to about 370 ppm. Concentrations of methane have also risen due to cattle production, the cultivation of rice, and release from landfills. Nearly one-third of human-induced nitrous oxide emissions are a result of industrial processes and automobile emissions. The combustion of fossil fuels is not the only anthropogenic source of carbon dioxide. When ecosystems are altered and vegetation is either burned or removed, the carbon stored in them is released to the atmosphere as carbon dioxide. The principal reasons for deforestation are agriculture and urban growth, and harvesting timber for fuel, construction, and paper. Currently, up to a quarter of the carbon dioxide emissions to the atmosphere can be attributed to land use change (CCIR, 2005).

However, as time goes by and as industrialization gives its fair share of toxic gases, the gases "trapped" in the atmosphere has become over saturated that the warming of the earth is now beyond normal; thus, the global warming and the occurrence of climate change (Green earth choice, 2011).

Projected warming in the 21st century is expected to be greatest over land and at the highest northern latitudes. For the next two decades a warming of about 0.2°C per decade is projected. Increases in the amount of precipitation are very likely in high

latitudes, while decreases are likely in most subtropical land regions. Drought-affected areas will likely increase in extent. It is very likely that hot extremes, heat waves and heavy precipitation events will continue to become more frequent. Given these projections of future climate change, there will be increased land degradation owing to droughts and increased soil erosion owing to heavy rainfall events (WMO, 2007).



Source: http//oceanworld.tamu.edu/resources/environment

Figure 2.1 Service of Climate Regulation in Dry lands

The central grey box—the components of biodiversity involved in service provision maintenance of soil moisture (bottom left) and modulation of rainfall (top). In bold—the major alternative/complementary function involved in the effect of live vegetation cover on rainfall; successive multiplication of signs along each trajectory generates an increase in rainfall (+) when service is ameliorated and a decrease in rainfall (–) when land is degraded. Land degradation (grey circle) degrades the service through affecting surface temperature; when surface temperatures increase along the albedo trajectory, it decreases along the evaporation trajectory; this trend is reversed when land is not degraded (MEA, 2005).

A degraded vegetation cover leads to reduced shade, increased surface and near surface temperatures, and a rapid decrease in soil moisture which leads to reduced evaporation. This reduction in overall evaporation links to reduced rainfall generation- low evaporation, reduced water flux into the atmosphere, a decrease in the amount of energy used to evaporate or transpire water, and reduced convective heating all combine to produce less rainfall (Williams and Balling, 1995).

In climate modulated both by albedo and evaporation, lower rainfall further reduces soil moisture and vegetation cover and induces further degradation in service provision. The prevalence of the climate regulation service is demonstrated by a few amelioration cases, such as 10-25% increase in rainfall in the northern Negev of Israel attributed to reduced albedo resulting from controlled grazing, afforestation, and irrigated agriculture in a semi arid region (Otterman *et al* 1990).

2.4.1 Nigeria's vulnerability to climate change

According to Oladipo 2010, climate change will affect everyone. Both the rich and the poor stand to loose. Those already affected by poverty, malnutrition and disease will face displacement and new hardships. All sectors of our socio-economic development, including the natural ecosystems, are vulnerable to climate change. In general, climate change presents significant threats to the achievement of the Millennium Development Goals especially those related to eliminating poverty and hunger and promoting environmental sustainability. Climate change would increase vulnerability and hinder or reverse the development process. In Nigeria, the sectors which are considered most vulnerable to climate change are agriculture, water resources, public health, and habitat (particularly the urban centres along the coast). Vulnerable regions are coastal regions (including deltas, especially those affected by storms and storm-induced floods) and erosion and desertification-prone areas in the South-eastern and Northern parts of the country. Vulnerable communities includes farmers, fishermen (especially those living in vulnerable region), the elderly, women, children and poor people living in urban areas (Oladipo, 2010).

Climate change will have direct impacts on biodiversity – from ecosystems to species level – and vary from region to region. While some species, like grasshoppers or other pests may increase in abundance or range, climate change will increase existing risks of extinction of many threatened species or lead to loss of biodiversity.

Changing rainfall patterns could devastate the rain-fed agriculture on which so much of the population of Nigeria depends to survive. Increased occurrence of drought

may lead to declining agricultural yields and diminished food security. Water supplies may also be altered, primarily through changes in temperature and rainfall. Using the scenario analysis for temperature and rainfall for the vegetation zones of Nigeria which was extensively discussed in the First Communication of Nigeria to the United Nations Framework on Climate Change Convention (UNFCCC), Oladipo (2008) has shown that all sectors of Nigeria's socio-economic development, including the natural ecosystems, are vulnerable to climate change. A recent document by HBS Nigeria (2009) has also documented evidences of Nigeria's vulnerability to climate change. The following is a summary of what is at risk in Nigeria in the face of climate change.

2.4.2 Increase in the occurrence of extreme weather events

i. The frequency and intensity of extreme events, such as floods and droughts, has increased in many parts of Nigeria over the past few years. The country will fit into the following categories of extreme events depicted by IPCC (2007).

   Warmer and more frequent hot days and nights over most land areas;

ii. Warmer and more frequent hot days and nights over most land areas;

iii. Warm spells / heat waves - Frequency increases over most land areas;

iv. Heavy precipitation events - Frequency (or proportion of total rainfall from heavy falls) increases over most areas;

v. Area affected by droughts increases.

It is reasonable to say that climate change will magnify natural disasters 'severity in terms of intensity and frequency in Nigeria, but the nature and severity of the changes must be properly diagnosed.

2.5 Impacts of Drought and Desertification

It is common knowledge that land degradation and desertification constitutes major causes of forced human migration and environmental refugees, deadly conflicts over the use of dwindling natural resources, food insecurity and starvation, destruction of critical habitats and loss of biological diversity, socio-economic instability and poverty and climatic variability through reduced carbon sequestration potential. The impacts of drought and desertification are among the most costly events and processes in Africa. The widespread poverty, the fact that a large share of Africa's economies depend on climate-sensitive sectors mainly rain fed agriculture, poor infrastructure, heavy disease burdens, high dependence on and unsustainable exploitation of natural resources, and conflicts render the continent especially vulnerable to impacts of drought and desertification. The consequences are mostly borne by the poorest people and the Small Island Developing States (SIDS). In the region, women and children in particular, bear the greatest burden when land resources are degraded and when drought sets in. As result of the frequent droughts and desertification, Africa has continued to witness food insecurity including devastating famines, water scarcity, poor health, economic hardship and social and political unrest.

2.5.1 Impact of climate change and desertification on agriculture

Rough estimates suggest that over the next 50years or so, climate change may likely have a serious threat to meeting global food needs than other constraints on agricultural systems (IPCC, 2007). A large share of Africa's economy depends on rain-fed agriculture which makes dry areas in the region vulnerable to drought and desertification.

Agricultural production in many African regions is projected to be severely compromised by climate variability and change. The area suitable for agriculture, the length of growing seasons and yield potential, particularly along the margins of semi- arid and arid areas, are expected to decrease (WMO, 2007).

If land degradation continues at the current pace, it is projected that more than a half of cultivated agricultural area in Africa could be unusable by the year 2050 and the region may be able to feed just 25 percent of its population by 2025 (JICD, 2006). Agriculture being one of the main economic activities in Africa (which represents around 40 percent of the region's GDP and employs about 60 percent of the active labour force), this would lead to a catastrophe with unprecedented repercussions.

2.5.2 Impact of desertification on economic growth and poverty reduction

The majority of the populations in most African countries live on marginal lands in rural areas practicing rain-fed agriculture. Desertification threatens agricultural production on these marginal lands (UNCCD, 2004), exacerbating poverty and undermining economic development. Growing levels of entrenched poverty, environmental degradation, desertification, and underdevelopment of rural areas characterize most rural areas of the African countries. The impact of drought and climatic variability in both economic and mortality terms is generally larger for relatively simple and predominantly agricultural economies. These types of economies dominate Africa. In 2004, the UNCCD estimated that some six million hectares of productive land was being lost every year since 1990, due to land degradation. This in turn had caused income losses worldwide of US$ 42 billion per year. With two-thirds of arable land expected to be lost in Africa by 2025, land

degradation currently leads to the loss of an average of more than 3 percent annually of agriculture GDP in the Sub-Saharan Africa region.

2.5.3 Impact of desertification on water

Both drought and desertification influence water availability, which is projected to be one of the greatest constraints to economic growth in the future. In Africa, climate change is expected to intensify the continent's increasingly critical water situation. Reduced annual average rainfall and its run-off would worsen desertification in southern Africa. This sub region being one of many water-stressed regions could thus see a further decrease in streams flow and the ability of groundwater to 'recharge'. Furthermore, it is projected that by 2025 Southern Africa will also join most countries in North Africa that can already be classified as having absolute water scarcity today. This means that countries in these regions will not have sufficient water resources to maintain their current level of per capita food production from irrigated agriculture - even at high levels of irrigation efficiency - and also to meet reasonable water needs for domestic, industrial, and environmental purposes. By the year 2025, it is thus estimated that nearly 230 million Africans will be facing water scarcity, and 460 million will live in water-stressed countries. Already, 14 African countries are subject to water stress or water scarcity, increasing to 25 countries by 2025, (UNCCD, 2004) a situation that will further exacerbate desertification, perilous food security and economic underdevelopment.

2.5.4 Impact of desertification on migration

The effects of desertification extend beyond the affected dryland areas. As the level of vulnerability due to the combined impacts of desertification and socio-economic susceptibility increase, the greater the probability of human migration (Acosta-Michlik, *et al.,* 2005). Desertification is displacing big population of people and forcing them to leave their homes and lands in search of better livelihoods. Desertification and drought related migration takes many forms the majority occurring as internal migrations that is, displacements of populations within national boundaries (Mora and Taylor, 2006).

At greatest risk are those at the low end of the socio-economic spectrum, both in developed and developing regions. In developing regions, the poorest inhabitants are often forced to live on marginal land outside urban areas or coastal zones potentially prone to desertification. Migration is often a coping mechanism, with little faith in finding permanent residence (Mutton and Haque, 2004). Availability of natural resources for example prompts pastoralists along the borders of Ethiopia, Kenya and Uganda to migrate away from areas of dwindling resources; thus raising competition over finite resources with incidence of conflict increasing when these individuals move into areas of crop growing communities (Meier and Bond, 2005). It is estimated that 135 million people - the combined populations of France and Germany - are at risk of being displaced by desertification. The problem appears to be most severe in sub-Saharan Africa, the Sahel and the Horn of Africa. Some 60 million are estimated to eventually move from the desertified areas of sub-Saharan Africa towards Northern Africa and Europe by the year 2020 (UNCCD, 2004).

2.5.5 Impact of desertification on biodiversity

Biodiversity existing in dry lands and other habitats underpin ecosystem services that are vital for livelihoods of millions of people in Africa. It is the foundation for sustainable development in the region and globally. The dry areas of the world are the origin of a large number of globally important cereals and food legumes, such as barley, wheat, faba beans and lentils.

According to Africa Review Report on Drought and Desertification, Four hundred million people, two thirds of sub-Sahara African population, relies on forest goods and services for their livelihood. Drought, land degradation and desertification have had serious impact on the richness and diversity of Africa Diversity. These factors remain some of the most serious threats to the management, sustainable use and equitable sharing of benefits of biodiversity. The projected devastating impacts of climate change in the region including exacerbating these factors will escalate biodiversity degradation and loss associated with drought, land degradation and desertification. These factors affect biodiversity directly and indirectly. On site impacts include habitat and species degradation and loss, leading to overall loss of economic and biological productivity. For instance on rangelands, overgrazing not only reduces the overall protective soil cover and increases soil erosion, but also leads to a long-term change in the composition of the vegetation.

Plant biodiversity will change over time, unpalatable species will dominate, and total biomass production will be reduced. These in turn trigger and contribute to indirect or offsite impacts. Soil erosion will contribute to denudation and pollution of wetlands and water bodies. As biological and economic productivity deteriorates, communities are

forced migrate to other areas or engage in other coping activities that too contribute biodiversity degradation.

According to the Africa Environment Outlook II, approximately half of Africa's terrestrial eco- regions have lost more than 50 per cent of their area to cultivation, degradation or urbanization. It also states that some ecoregions such as the Mandara Plateau mosaic, Cross-Niger transition forests, Jos Plateau forest-grassland mosaic, and Nigerian lowland forests have gone more than more than a 95 percent transformation. Nine other eco-regions have lost more than 80 per cent of their habitat, including the species-rich lowland Fynbos and Renosterveld and the forests and grasslands of the Ethiopian Highlands; the Mediterranean woodlands and forests have lost more than 75 per cent of their original habitat, and the few remaining blocks of habitat are highly fragmented.

2.5.6 Impact of desertification in the dry lands of Nigeria

In the Sudan and Sahel zones of Nigeria, the countries major livestock producing region and one of the important food and cash crops producing zones desertification constitute severe hazards that pose a great threat to the country's food security and wetland conservation. The magnitude of the huge efforts to boost agricultural production through river basin development in the two zones is quite impressive. In the 1970s and 1980s robust development of river basin projects for hydro-electricity power generation and large scale irrigation schemes were mitigated in Nigeria. The move was in response to increasing demand for food by rapidly increasing population, increase in demand by agro-allied industries for raw materials at home and abroad and crop failure due to desertification. The approximately one million hectares of land which we put under irrigation by the mid 1980s

were located in the Sudan and Sahel zones. The most important of these are the Niger valley projects, the Sokoto-Rima (Bakalori) project, the Gongola River project, the Bagauda (Hadejia) project and the lake-Chad Basin project (Emodi, 2013). The threat to the above projects from desertification is foreshadowed by the declining fortunes of wetland development in these two zones. A striking example provided by Ajayi (1996) is that of the drastic impact of drought and desertification on the Hadejia/Nguru/Kirri-Kissama wetland project for the conservation of water flows. The wetland had a flood plain of about 84,143.8 Km^2.

The steady decline in the extent of inundation of the plain due to both drought and construction of several dams (for farm irrigation purposes) upstream led to the reduction of the flood plain. With the completion of the Hadejia, Kafin Zaki and Chalawa Gorge dams, added to the existing Tiga dam, the flooding area of the wetland has been further reduced. The social-economic impact on the over one million inhabitants on the periphery of the floodplain who depend on the wetland for their livelihood, such as fishermen, farmers and cattle rearers has been severe.

Another indicator of the adverse impacts of drought and desertification in the Sudan and Sahel zones is in the area of fish production from Nigeria's rivers, lakes, Swamps and flood plains. It has been estimated that the combined production from all fresh water sources showed a decline of 54% in annual yield between 1980 and 1985 (Ajayi, 1996). The discussion above underscores the great potential of drought and desertification to hobble sustainable development and imperil the well being of the affected population. Hence, the adverse environmental impacts of drought and desertification are numerous, ranging from the ecological to the social-economic and, in some cases to the

survival of large segments of the population who are engaged in agriculture in the rural areas. Besides, the impact of drought on a natural ecosystem is measured by plant cover and biomass production and, of course, by the disruption of food production systems (Mortimore, 1989). Hence drought generates much human suffering particularly socio-economic dislocation. Also major agricultural and hydroelectric power generating projects in the northern part of the country are at great risk from drought. Furthermore, the drastic reduction in the size of Lake Chad is partly attributable to drought.

2.6 Perception

Perception refers to the way we try to understand the world around us. We gather information through our five sense organs, but perception adds meaning to these sensory inputs. The process of perception is essentially subjective in nature, as it is never an exact recording of the event or the situation. According to Quick and Nelson, 1997 perception is the process of interpreting information about another person." What this definition has clearly highlighted for our attention is that the opinions we form about another person depends on the amount of information available to us and the extent to which we are able to correctly interpret the information we have acquired. In other words, we may be in possession of the same set of information that other people have on a particular situation, person or group but still arrive at different conclusions due to individual differences in the capacity to interpret the information that we all have.

Perception is also the process whereby people select, organize, and interpret sensory stimulations into meaningful information about their work environment." According to this definition, perception is the single most important determinant of human

behavior, stating further that "there can be no behavior without perception, Rao and Narajana (1998). One of the most important aspects to analyze, when studying environmental phenomena, is the one of perception. As Simoni et al 1998 say "…People interact on the basis of the meanings they assign to the world around them. Individuals respond to each other in terms of their perceptions..." and "...Even if people are "mistaken" in their interpretation of a situation, such interpretations, nevertheless, have a "real" consequences...".

Knowledge of perception can provide information on facts and elements, which were not equated, "Thus people's perceptions of the risks are informed by a number of factors that may not seem relevant to experts making technical assessments of the same risks and individuals and communities respond to risk and risk information according to their perceptions and understanding of the risk, though the links may be complex"(Brandt and Geeson, 2001). To comprehend potential or even probable responses by agriculturalists to global warming requires understanding how farmers form their perceptions of climate change from the influences of actual climatic shifts, scientific information, and socio-cultural factors.

It is therefore important that we understand the community's perceptions *vis- a- vis* the multiple processes that lead to environmental degradation if effective plans are to be drawn up to counter any negative factors (IISD,1993).

Diggs, (1991) suggests that farmers' awareness and perceptions of living in a semiarid environment affects their management style. Farmers in marginal regions are cognizant of climatic variability. They are concerned more with survival than wealth, and

therefore emphasize avoiding risk over maximizing outputs through perceptual processes. Perception is seen for the purpose of this research as the way things are seen and understood by people based on their past experiences. It is a reflection of the personal reality of an individual not necessarily the way things necessarily are (objective reality). A farmer for example may perceive a drought to be worst even when rainfall records clearly show this not to be the case or may perceive rainfall to be below average in a normal year due to desertification.

2.7 Remote Sensing and Geographic Information Systems

Satellite remote sensing in conjunction with GIS, has been widely applied and has been recognized as a powerful and effective tool in detecting landscape change (Cai, 2001, Musa and Shaib, 2010).

The definition of Remote Sensing in the broadest sense, the measurement or acquisition of information of some property of an object or phenomenon, by a recording device that is not in physical or intimate contact with the object or phenomenon under study; e.g., the utilization at a distance (as from aircraft, spacecraft, or ship) of any device and its attendant display for gathering information pertinent to the environment, such as measurements of force fields, electromagnetic radiation, or acoustic energy. The technique employs such devices as the camera, lasers, and radio frequency receivers, radar systems, sonar, seismographs, gravimeters, magnetometers, and scintillation counters (Levin, 1999).

According to Matzler (2008) there are four requirements for any remote sensing method:

1. An instrument on a given platform is needed that can detect and measure the information carrying signal. The signal must be calibrated to defined standards to allow reproduction of the observation under the same conditions. Errors (geometry, timing, radiometry, spectrum, polarization) should be specified.
2. A signal from the object to the observer must be propagated in an unambiguous way and without serious loss. Ideally, the propagation is along a straight line with constant velocity and without attenuation. In other words, the propagation medium should be transparent and homogeneous, like free space for electromagnetic waves.
3. An interaction must exist between the sensing wave and the object to be measured. The interaction can be emission or scattering of radiation, or it can be a modulation (scintillation) or delay of a propagating wave.
4. The signal must be unambiguous to allow extraction of the correct information. We say that the signal must contain some sort of an object signature. The transformation from the calibrated sensor signal to the object information is called inversion. The link between the object and the signal is a model that is able to simulate the signal from the object information. Such forward models are based on the physics of the interaction between the object and the sensing waves. The development of forward models is a main task in remote sensing.

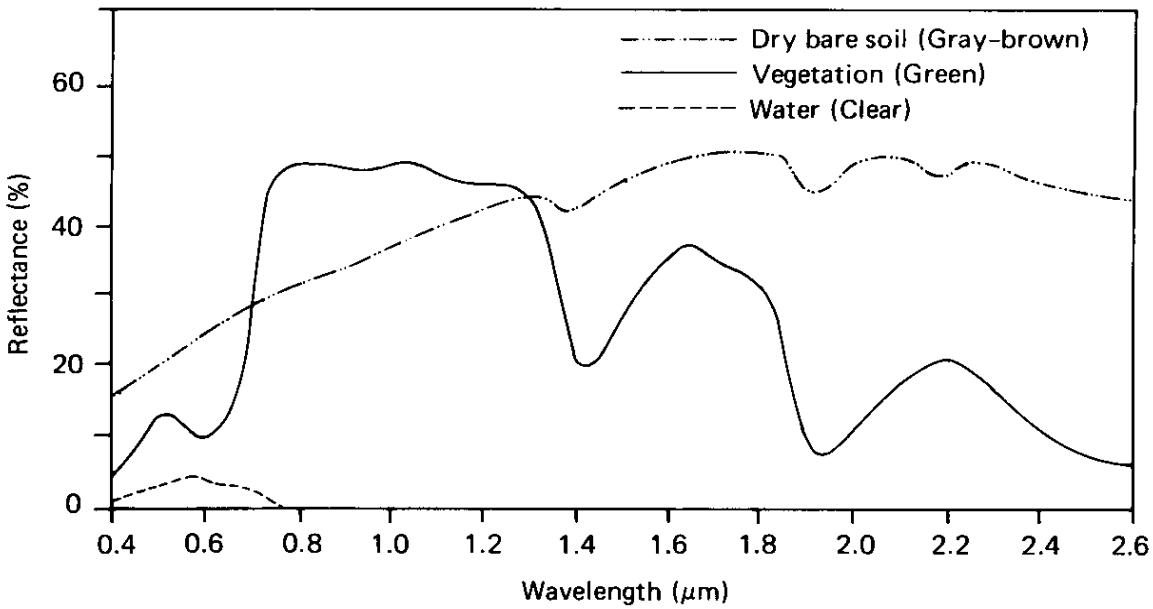
Models derived from physical principles are more general than empirical rules, but both types exist. The forward models are also useful to assess the sensitivity of a signal at a special frequency and polarization to a given perturbation of the environment. In this way the models contribute to the optimization of existing methods and development new methods.

Remote Sensing is not a scientific discipline in the classical sense; it is rather a collection of a large variety of diagnostic methods, mainly using electromagnetic waves covering the spectrum from radio waves (wavelength $\lambda > 1$ m) to gamma rays ($\lambda < 10\text{-}12$ m). In some cases sound waves or other elastic waves are also in use, especially where electromagnetic methods fail. It is obvious that very different techniques and skills are required in the different parts of remote sensing. Not only the techniques are multidisciplinary, the applications cover a wide range of human disciplines, e.g. archaeology, botany, climatology, geology, hydrology, meteorology, security aspects, etc.

2.8 Normalized Difference Vegetation Index (NDVI) and Phenology

The NDVI is a measurement of the balance between energy received and energy emitted by objects on Earth. The Normalized Difference Vegetation Index (NDVI) gives a measure of the vegetative cover on the land surface over wide areas. Dense vegetation shows up very strongly in the imagery, and areas with little or no vegetation are also clearly identified. When applied to plant communities, this index establishes a value for how green the area is, that is, the quantity of vegetation present in a given area and its state of health or vigour of growth.

Figure 2.2 shows graphically, a typical vegetation curve for vegetation, soil and water.



Source: Lillesand and Kiefer, (1994)

Figure 2.2 Typical Vegetation Curve for Vegetation, Soil and Water

By combining the two channels in a ratio or difference, allows the response to vegetation growth to be distinguished from the background signal. The method, developed by NASA is known as the Normalized Difference Vegetation Index (NDVI) and is given by the equation (NIR-RED/NIR+RED), where RED and NIR correspond to channels 1 and 2 respectively. By normalizing the difference in this way, the values can be scaled between a dimensionless index value of -1 to +1(Menses, 2011). This also reduces the influence of atmospheric absorption.

In a practical sense, the values that are below 0.1 correspond to bodies of water and bare ground, while higher values are indicators of high photosynthetic activity linked to scrub land, temperate forest, rain forest and agricultural activity .

Table 2.1 indicates the various cover types values in the red, near infrared (NIR) and NDVI.

Table 2.1 Typical NDVI Values for Various Cover Types

	RED	NIR	NDVI
COVER TYPE			
Dense vegetation	0.1	0.5	0.7
Dry bare soil	0.269	0.283	0.025
Clouds	0.227	0.228	0.002
Snow and ice	0.375	0.342	-0.046
Water	0.022	0.013	-0.257

Source: Holben, (1986)

Phenology involves studying the timing of life cycle events of plants and animals, and in particular, in relation to changes in season and climate. The concept of vegetation indices used to depict the large scale distribution and phenological changes of vegetation cover over particular area is that green vegetation absorbs and reflects more radiance in the visible red and near infrared wavelength (Meng *et al*, 2006). In the case of annual crops, observing change in images is relatively easy. Changes in reflectance of light over the course of crop growth are evident and occur over short periods of time. In the case of forest ecosystems, the natural processes, and the approaches to observing them, are protracted. Behavior in an individual takes place over a longer period (5 to 25 years), which also applies to forest plantations that are "pure ecosystems" (i.e. same-age stands). Over this period of time, the phases of planting, establishment of seedlings and active growth up to

the time of commercial maturity can be distinguished, encompassing the more complex dynamics of flowering ,fruiting, change of leaves and branches, and thickening of the trunk, in a constant process of change in the above-ground living matter, or aerial biomass (Menses, 2011).

2.9 A Review of Studies on Desertification

Studies on desertification have been carried out by different researchers. Eltahir and Nagi (2010) in a study Landscape Change and Sandy Desertification Monitoring and Assessment in Northern Shaanxi Province, China found that in 1987, the area of sandy desertified land in the study area was 12,006.11km (57.17%) of the total sandy area but increased to 13,782.30km (65.63%) in 1999. The result demonstrates that land cover changes during the study period 1987-1999 was caused by land desertification on farmland and grassland in the area due to inappropriate land use and invasion of wind-blown sand.

Tanimu, (2006) studied the Physical Planning Inputs in Managing Desertification in Jibia LGA of Katsina State. The study looked at the attempts and achievements of governmental and non-governmental agencies in combating desertification. According to the study, physical planning approaches were not taken into consideration in the various projects embarked to combat desertification by these agencies thus, leading to the failure of such projects.

Elhag (2006), UNEP (1992) and FRN (2000) estimated that roughly 70% of all agriculturally used dry lands are degraded to some degree, in terms of their soils and plant

cover, and up to 4 million hectares of rainfed croplands are being lost each year in the world's dry lands, chiefly as a result of accelerated soil and increasing urban growth.

Haruna and Shaib (2010) in a study titled Integrated Remote Sensing Approach to Desertification Monitoring in the Crop-rangeland area of Yobe State, Nigeria found that sand encroachment increased rapidly during the study period. It also noted that, the rangeland degradation in the study area was aggravated by the expansion of the areas under shifting cultivation leading to the destruction of vegetative cover in the area. Billy (2011) in his study employed the use of remote sensing and GIS in assessing the magnitude and rate of desertification in Yobe State between 1970 and 2005. According to his study, efforts have been made to stabilize sand dunes by settlers and the government but with little or no result. His study showed that mobile sand dunes increased by about 1,323.74km square (2.89%) during the study period, from 3,124.99km square to 4,448.74km square. All these studies indicate that desertification is a complex process with multi-dimensional correlates that must be studied on a continuous basis.

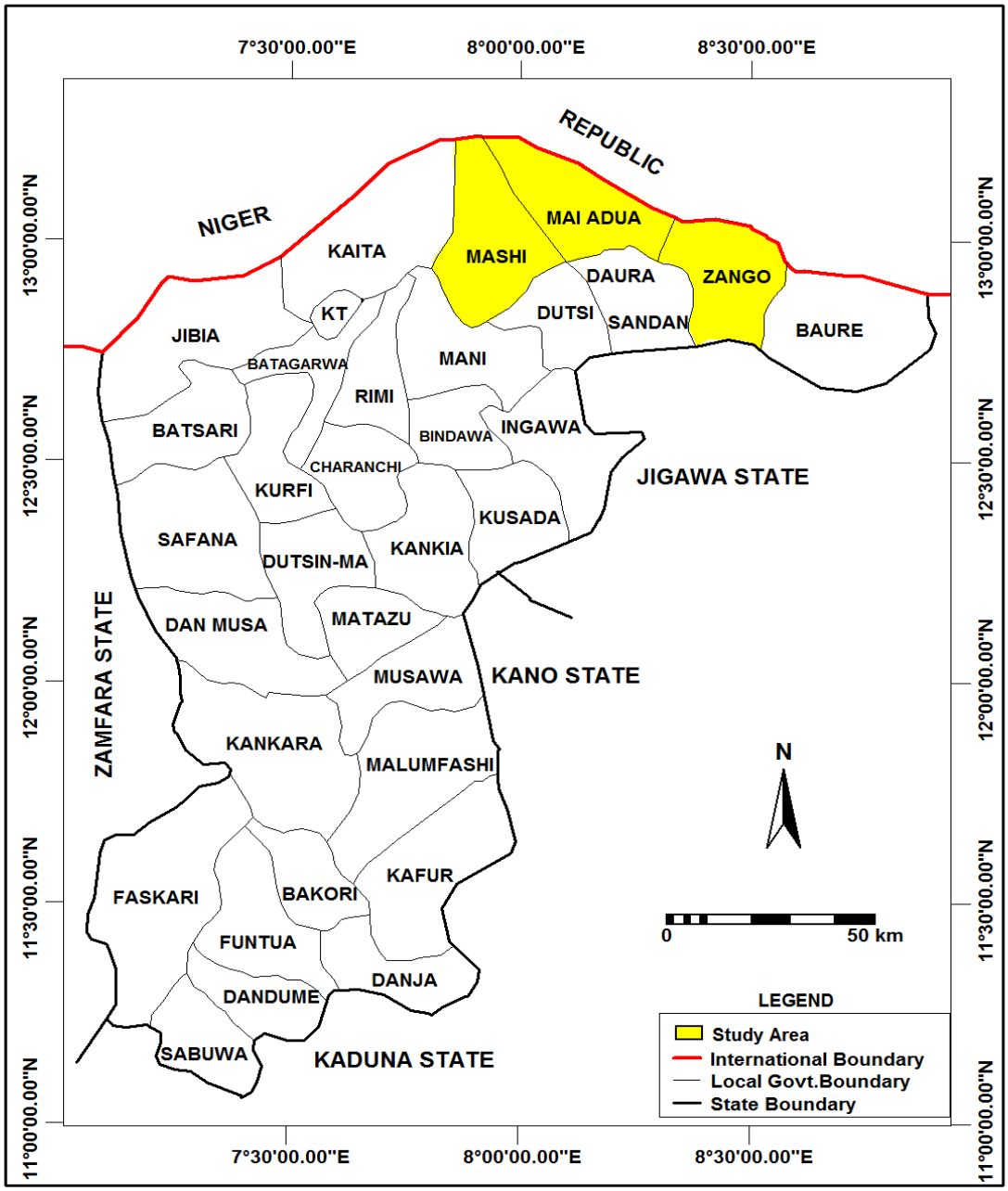
CHAPTER THREE

3.1 THE STUDY AREA AND METHODOLOGY

3.2 Location

The study area lies between latitudes $12^{o}45´N$- $13^{o}15´N$ and longitude $7^{o}45´E$ – $8^{o}30´E$. It covers Mashi, Mai'Adua and Zango LGAs. Katsina State has a land area of approximately 24,000 kilometers square with approximately Mashi; 349km^2, Mai Adua; 204km^2 and Zango; 232km^2 making a total study area of 785km^2. It is bounded by Kaita LGA and Niger Republic to the west, Niger Republic to the north and Baure LGA to the east and Mani, Dutsi and Daura to the south and south east. Katsina State has a population of 5,801,584 million (NPC, 2006).With the capabilities of Remote Sensing and GIS, the three LGAs areas was captured on land sat satellite imageries.

Figure 3.1 shows the map of Katsina State with the study area highlighted in yellow which covers Mashi, Maiadua and Zango LGA.



Source: Adapted from Administrative Map of Katsina State 2013

Figure 3.1: Katsina State showing the Study Area

3.2.1 Climate

The area is dry (500 to 550mm average annual rainfall distributed over 65 to 100 days) located in the tropical wet/dry climate of the Aw type. Wind and water erosion are major problems and there is severe land degradation particularly of communal lands. Generally, climate varies considerably according to months and seasons. They are: a cool dry (harmattan) season from December to February; a hot dry season from March to May; a warm wet set season from June to September, a less marked season after rains during the months of October to November characterized by decreasing rainfall and a gradual lowering of temperature (Ati *et al,* 2009). Temperatures are high before the rains, averaging a maximum of 39^{o}C in April and declining to 14^{o}C (KTSHBRS, 2004).

3.2.2 Relief

The relief of the study area is of the lower Chad plains with monotonous rolling to undulating plains. The relative relief falls within the average of about 15 to 20 metres above sea level, the landform is sandy plains where great sand sheets occupy most of the area.

3.2.3 Soils and vegetation

The soils (tropical ferruginous soil) are generally light and sandy, poor in structure and organic content with low to moderate inherent fertility (KTSHBRS, 2004). This type of soil is formed from the deposition of eroded materials over sedimentary formation. The northern districts consist of trees that grow long tap roots and thick barks that make it

possible for them to withstand the long dry seasons and bush fires. Examples of such trees are baobab, acacias *Albida (Ana tree) and Seyal (Gum arabic),* neem (Azadrita indica).The grass cover here too has durable roots which remain underground after stalk are burnt away or wilted in the dry seasons only to germinate with the first rain. Grasses in the area hardly grows up to 1m at maturity. Pasture in the area is very low due to intensive grazing and over cultivation.

3.2.4 People and economic activities

The people of Mashi, Mai Adua and Zango LGAs are predominantly Hausa and Fulani living together. According to 2006 census figure, Mashi has a population of 173,134, Mai'adua has 201,178 and Zango has 154,743 people (NPC, 2009). Majority of the people in the area are farmers, sorghum, millet, cowpea, maize, and groundnut are the major crops cultivated in the area. They also keep livestock like cattle, sheep and goats. These are usually moved by herders from one place to the other in search of pastures especially during the dry season. Irrigation farming is also carried out along river banks in the area. Small scale businesses like mechanic services, furniture making and various forms of trading activities are also carried out in the area.

3.2.5 Ecological problems

Drought and desertification are serious ecological challenge and threat facing the area. Agriculture which is the major source of livelihood in the area is being threatened as farmlands are being over taken by shifting sand thereby exacerbating poverty and undermining economic development.

3.3 Methodology

3.3.1 Data used in the study and their sources

Satellite imageries namely Multi Spectral Scanner MSS 1976, Thematic Mapper TM 1988, Thematic Mapper TM 1999 and Enhanced Thematic Mapper ETM+ 2006 were all sourced from the Global land cover facility of the University of Maryland. The information derived were used in deriving NDVI statistics.

Rainfall data was sourced from Nigeria Meteorological Agency Abuja. It was used to test relationship between rainfall and NDVI.

Literatures from journals, text books, internet materials, conference papers, newspapers, unpublished dissertations and thesis were also consulted.

Questionnaires were administered to capture the people's perception of desertification and crop produce.

Photographs were used for visual understanding of the problem of desertification.

3.3.2 Sampling design for questionnaire administration

According to the 2006 census, Katsina State has a population of 5,801,584 million (National population commission). Mashi has a population of 173,134; Mai Adua 201,178 and Zango; 154,743 bringing the total population of the study area to 529,055. The views of the people on desertification were captured using questionnaire administration in the three selected sample areas because the areas in the extreme north are more prone to desertification. To determine the sample size for this research, Krejcie and Morgan's

(1970) method of determining sample size was adopted; where population size of 500,000-1,000,000 is represented by a sample size of 384.

Table 3.1: List of Selected LGAs in the Study Area and proportion of respondents taken

SN	LGA	POPULATION(2006)	PROJECTED POPULATION(2012)	SAMPLE SIZE
1.	MASHI	173,134	207,276	126
2.	MAI ADUA	201,178	240,853	146
3.	ZANGO	154,743	185,261	112
	TOTAL	529,055	633,390	384

The projection of the population is based on the Katsina State population growth rate of 3% (NPC, 2009) using the formula: $P_{t+n} = P_t e^{r n}$

Where:

P_{t+n} = future population (2012)
P_t = base year population (2006)
r = growth rate (3%)
n = interval between future population and base year population
(2012 – 2006) = 6 years
e = exponential

In selecting the respondents, purposive sampling technique was employed for residents and farmers who have lived in the area or have cultivated land in the study area for at least 10 years or more. The 384 questionnaires were distributed to the respondents but some could not be retrieved.

Table 3.2: Questionnaires Distributed and Retrieved

LGA	Town/villages	Number of Questionnaires distributed	Number of Questionnaires retrieved
Mashi	Mashi Town	51	47
	Birnin Kuka	36	31
	Gidan Mutum Daya	17	15
	Babaye	22	19
Total		126	112
Mai'adua	Mai'adua town	69	64
	Maikoni	46	42
	Bum Bum	31	28
Total		146	134
Zango	Zango Town	52	43
	Dasha	25	19
	Yan Daji	35	29
Total		112	91

From Table 3.2, questionnaires were distributed in the following proportion. In Mashi Town 51 questionnaires were distributed and 47 were retrieved, 36 questionnaires were administered in Birnin Kuka while 31 were retrieved. In Gidan Mutum Daya 17 questionnaires were administered while 15 were retrieved and 22 questionnaires were administered in Babaye while 19 were retrieved. A total of 126 questionnaires were administered in Mashi LGA while 112 questionnaires were retrieved.

Table 3.2 also showed that in Mai'adua Town, 69 questionnaires were administered and 64 questionnaires were retrieved, in Maikoni 46 questionnaires was administered and 42 were retrieved while 31 questionnaires were administered in Bum Bum and 28 questionnaires were successfully retrieved. A total of 146 questionnaires were administered in Mai'adua LGA and 134 questionnaires were retrieved'.

In Zango Town 52 questionnaires were administered and 43 questionnaires were retrieved. In Dasha village, 25 questionnaires were administered and 19 questionnaires were retrieved while 35 questionnaires were administered in Yar Daji and 29 questionnaires were retrieved. A total of 112 questionnaires were administered in Zango LGA and a total of 91 questionnaires was retrieved.

As indicated in Table 3.2, a total of 337 questionnaires were successfully retrieved during the period of field survey which lasted for almost three (3) weeks with the help of two research assistants who are conversant with the area and the peoples' culture. Forty seven (47) questionnaires were not properly filled or the information supplied was of doubtful authenticity like crop yield production in bags. The interview aspect was achieved through the use of structured open ended and closed ended questions. Purposive sampling

technique was employed to interview people who have lived or have cultivated land in the area for more than ten (10) years. The reason for this is that such people would have experienced climatic variation and human activities as it affects their environment

The people were very cooperative as they saw the interview as a medium of making their grievances and problems known to the government of Katsina State and Nigeria.

A summary of the methodology in image processing of satellite imageries is given in figure 3.2

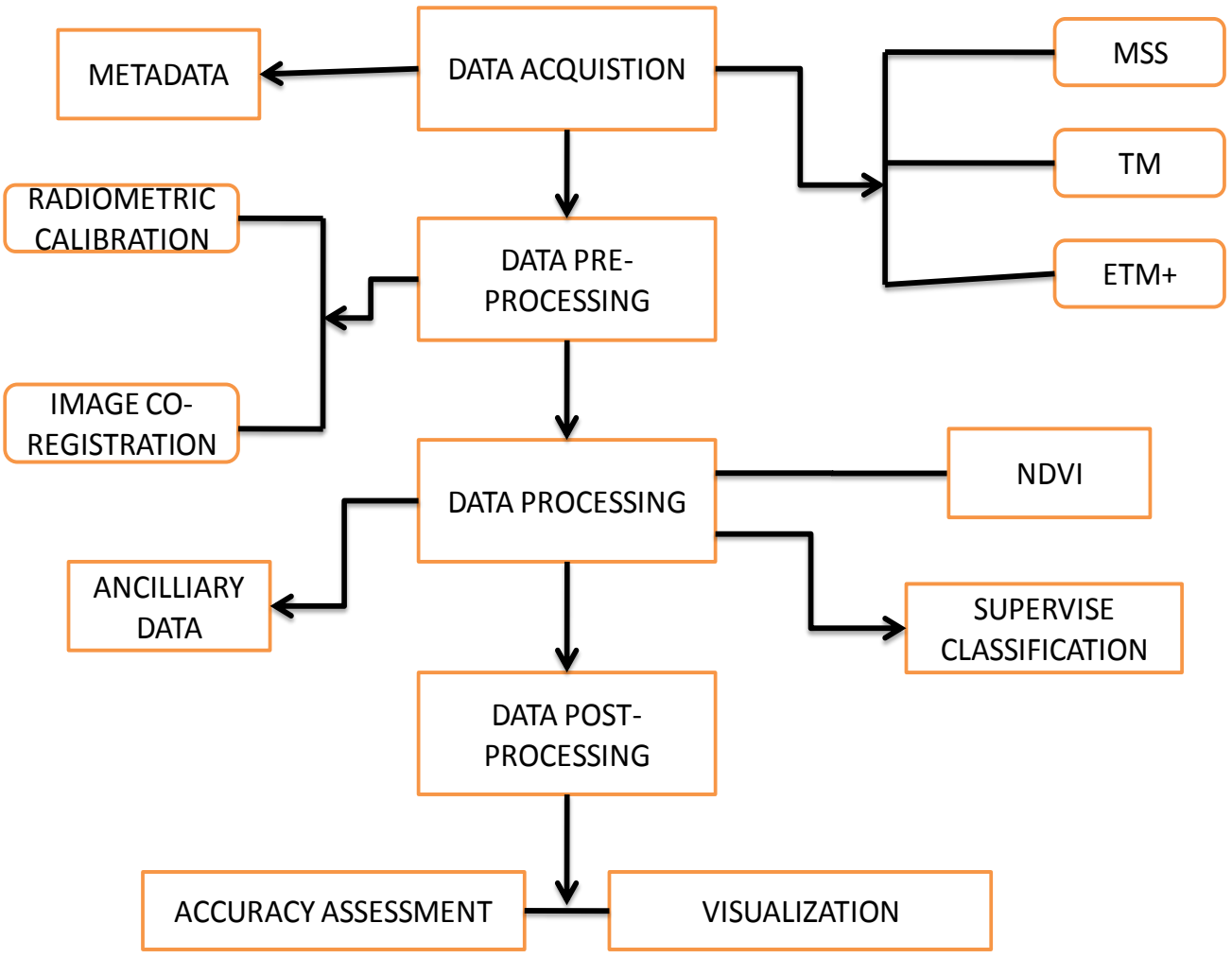


Figure 3.2: Diagrammatic presentation of methodology for satellite image processing

3.4 Methods and Procedure of Data Collection

In order to achieve the stated objectives, the following data were collected in line with the stated objectives of the research.

3.4.1 Assessment of the extent of decline in vegetative cover

According to Oppong, (1993) and Eltahir and Nagi (2010), the most conspicuous feature of desertification includes the rapid reduction in the amount of vegetative cover. The Normalized Difference Vegetation Index (NDVI) is a commonly used vegetation index derived from remotely sensed measurements of electromagnetic energy in the red and near-infrared spectral regions. Healthy vegetation absorbs most of the incident visible red light (emitted by the sun), and reflects a large portion of the near-infrared light. Non-green or sparse vegetation reflects more visible red light and less near-infrared light. This difference in reflectance for different wavelengths, allows remote sensing instruments to measure the relative presence or absence of healthy, green vegetation, by simply measuring and comparing the reflectances.

The satellite imageries were geometrically corrected for errors due to sensor geometry. Furthermore, the imageries were checked and corrected for radiometric errors (Sallaba, 2009). This was necessary because imageries need to be radiometrically corrected for comparism of surface features over time (Schowengerdt, 2007), also a radiometric correction helps to ensure that the detected change can be taken for real instead of errors caused by differences in sensor calibration and sun angles (Sallaba, 2009). The radiometric correction employed in this study includes a conversion from a calibrated digital number

(DN) to radiance, and a spectral radiance to 'Top of Atmosphere' reflectance as recommended by Chander and Markham (2003).

3.4.2 Conversion to spectral radiance

The calculation of spectral radiance in W/ (m^2 /st/μm) is used to place different imagery into a common radiometric scale and to take sensor related effect into account (Chander and Markham, 2003).

This was achieved through equation 1 below

Eqn1 $$L_\lambda = ((L_{max} - L_{min}) / (Qcal_{max}) * Qcal + L_{min})$$

Where L_λ = Spectral Radiance at the sensor aperture in W/ (m^2 /st/μm)

L_{min} = the spectral radiance that is scaled to QCALMIN in watts/(meter squared * ster * μm)

L_{max} = the spectral radiance that is scaled to QCALMAX in watts/(meter squared * ster * μm)

Qcal = Quantized calibrated pixel value in digital number (DN)

$Qcal_{max}$ = Maximum quantized calibrated pixel value (corresponding to LMAXλ) in DN

= 255

$QCAL_{min}$ = Minimum quantized calibrated pixel value (corresponding to LMINλ)

The advantage of NDVI is that it has less influence from sun angle and illumination and provides relatively reliable information about vegetation cover dynamics. Therefore, NDVI was used in this study to depict change in vegetation cover of the area.

This was achieved by using the formula below:

NDVI = NIR – R/NIR + R

This equation produces NDVI values which lie in the range of -1.0 to +1.0 with the denser vegetation having higher positive value. The NDVI was used to separate vegetation information and non-vegetation information from land cover. The NDVI statistics were derived from the following satellite images covering four decades LANDSAT MSS of 1976, LANDSAT TM of 1988, 1999, and 2006 ETM^{+}

3.4.3 Interpretation of NDVI

The physical NDVI values are between -0.1 and 0.92, where higher values indicate denser and healthier (higher green density) vegetation. Table 3.6 is the NDVI interpretation table which interprets vegetation health and density using indicators like 'very good, good, normal, poor and very poor'. NDVI values of 0.1 and below, for instance, typically correspond to areas with little or no vegetation (rocks and desert). Moderate values (around 0.2 and 0.3) correspond to shrub and grasslands and high values (0.5 and above) typically correspond to dense vegetation like rain forests. In the legend of the image viewer, the NDVI is not given as physical value, but as a qualitative indicator.

Table 3.3: The NDVI Statistics Interpretation Table

Vegetation health and density	Physical NDVI value
Very good	0.72 till 0.92
Good	0.42 till 0.72
Normal	0.22 till 0.42
Poor	0.12 till 0.22
Very poor	-0.10 till 0.12

Source: Over space summer institute 2004

3.5 Technique of Data Analysis

3.5.1 Development of classification scheme

A supervise classification approach was carried out by training our spectral classes of interest using Earth Data Acquisition Resources ERDAS IMAGINE 9.2 creating spectral signature classes in an iterative process and its objective is to aggregate a set of statistical data that describe the spectral signature of each information class (Florian, 2009).

A maximum likelihood algorithm was use to separate the various spectral classes into a homogenous set representing our classes of interest. The maximum likelihood algorithm is the most widely used and it is perceived as the mostly widely used and it is perceived as the most accurate classification algorithm (Ojigi, 2006).

The NDVI was used to find out quantitative changes in the areas of the various vegetation cover categories using the post- classification procedure. The area statistics for the vegetation was derived from the classification of the images for each decade (1976, 1988, 1999, 2006).

The percentage change for vegetation was thus calculated by expressing the ratio of vegetation and total land coverage in each year as a percentage. This is given by the formular below.

$$\%change = \frac{x}{y} \times 100$$

Where:

X= Observed change for vegetation in hectares

Y= Sum of change in hectares.

For **objective II**, rainfall data obtained from NIMET were analyzed on Microsoft excel spread sheet by calculating the moving average for each year. Rainfall average for each year and NDVI values were transferred to SPSS to test for relationship between rainfall and NDVI graphically by means of correlation.

Objectives III and IV were achieved through questionnaire administered to the people in the three LGAs and responses were analyzed on SPSS and results displayed on tables and charts.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 Presentation of Results

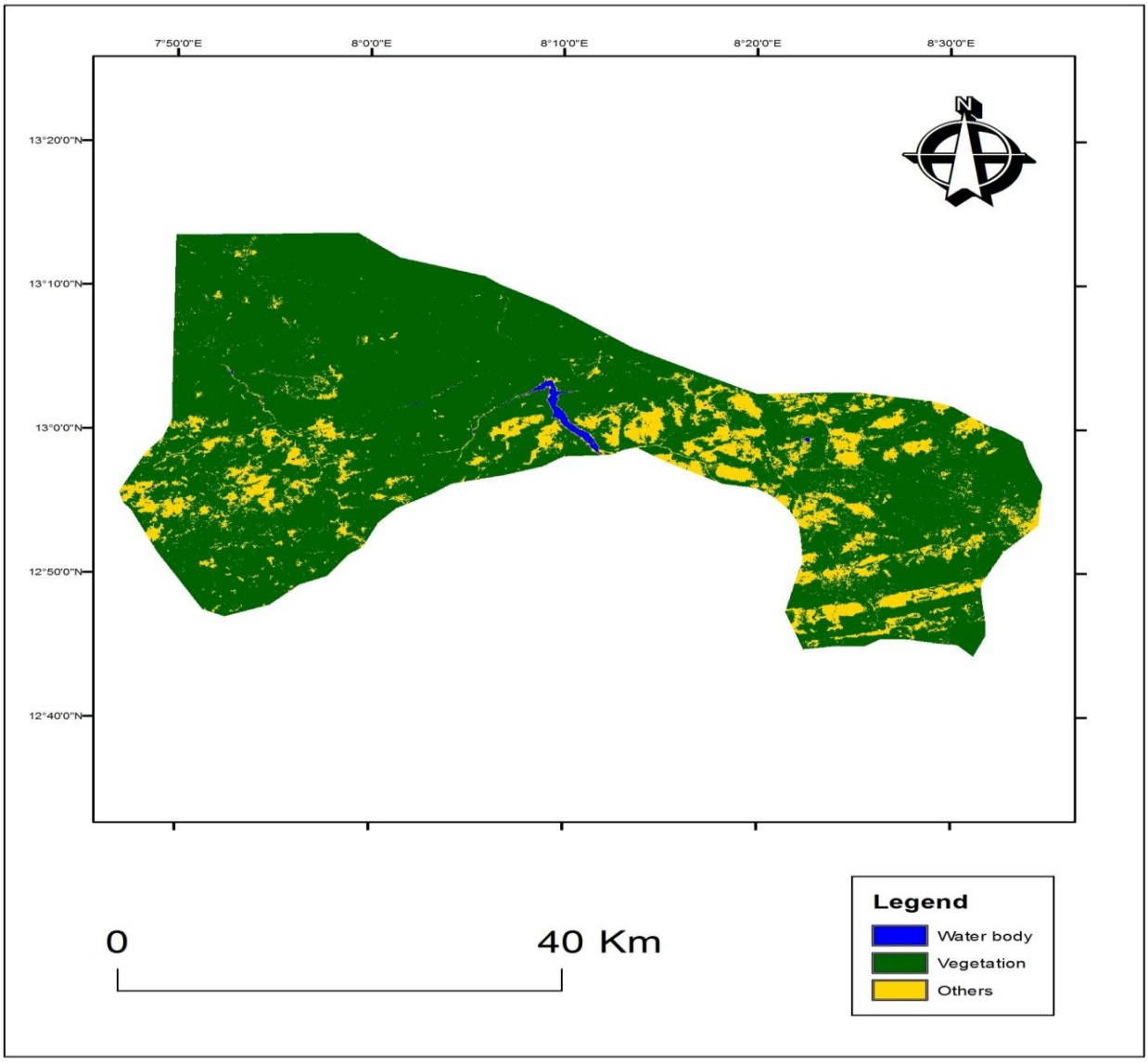


Figure 4.1 Land use Land cover 1976 from Landsat MSS

(Date of acquisition: 1976-01-29)

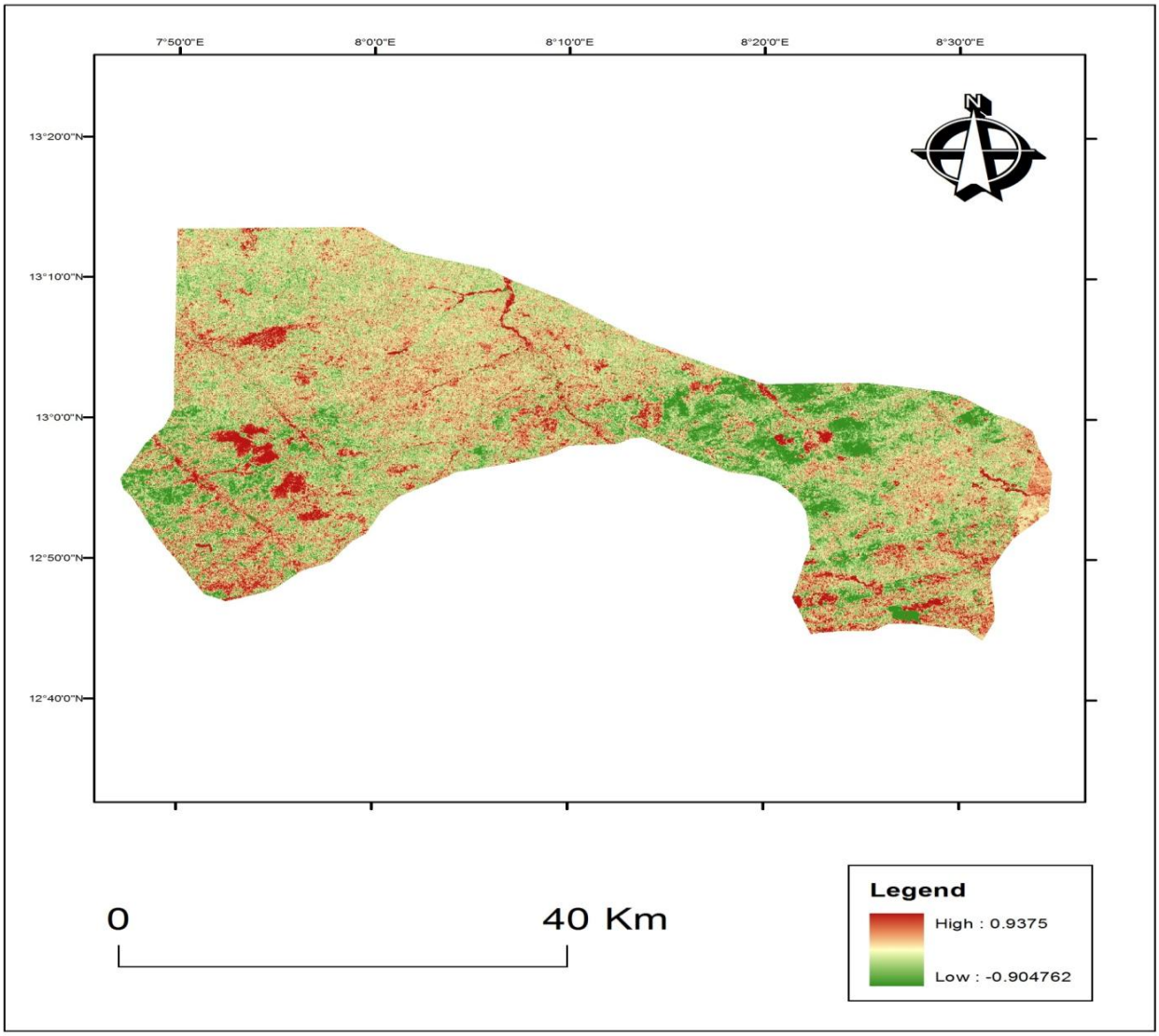


Figure 4.2 Normalized Difference Vegetation Index (NDVI) 1976

From the NDVI interpretation table, the NDVI value for the year 1976 was 0.9375 which is rated as 'very good' indicating healthier and denser vegetation in the area. Despite the sahelian drought of the late 1960s and early 1970s which humans and animals lost their lives, the area was able to recover with average rainfall of 567.9mm in 1976, 597mm in

1977 and 526mm in1978. This corroborates Oladipo (1993 p.237) that except in times of severe persistence, drought usually cures itself, sometimes tumultuously, by giving way to abundant rainfall for a season or two. The high vegetation density could also be as a result of low population density in the 1970s which could also mean less anthropogenic activities on the environment.

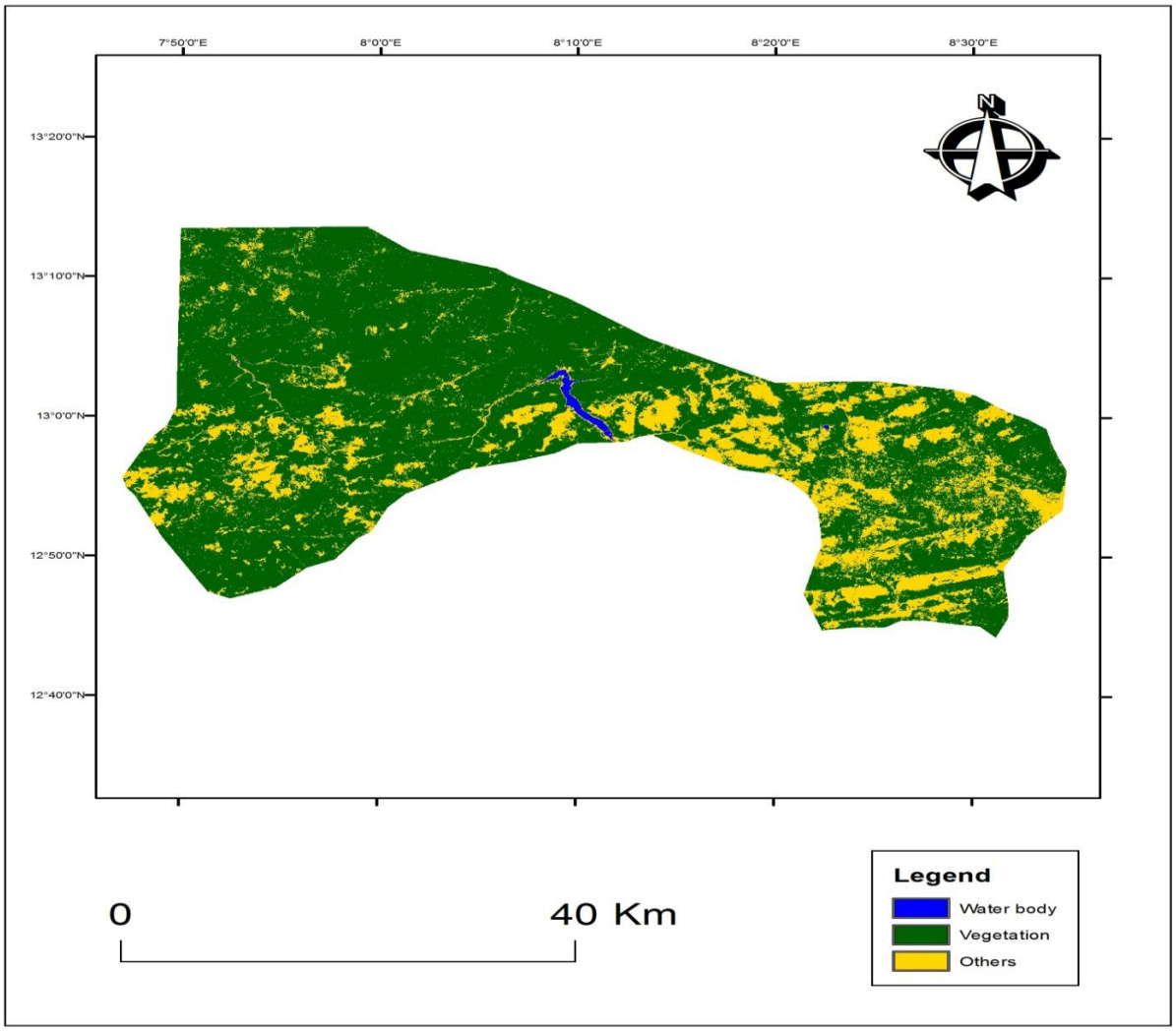


Figure 4.3 Land use Land cover 1988 from Landsat TM of the study area

(Date of acquisition: 1988-02-23)

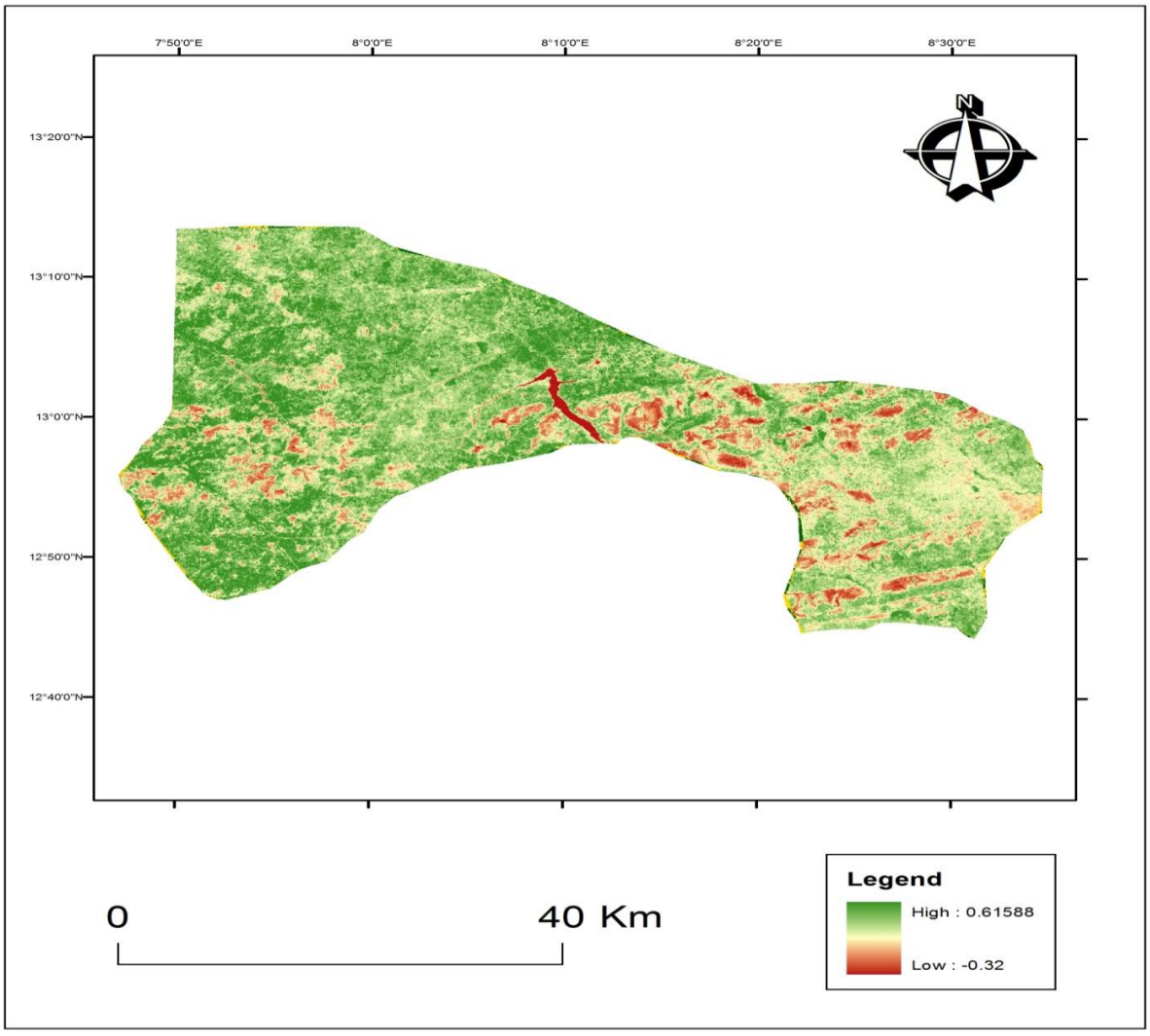


Figure 4.4 Normalized Difference Vegetation Index (NDVI) 1988

The NDVI value for 1988 is 0.615385 for high and -0.32 for low. Based on the NDVI interpretation table, 0.615385 is rated as 'good'. This is less than what was obtained in 1976. The difference in value between 1976 and 1988 is 0.322115. The total rainfall for

1988 was 684.1mm which was higher than 567.9mm of 1976. This could be attributed to high rainfall as a factor of high or healthier vegetation density in the area.

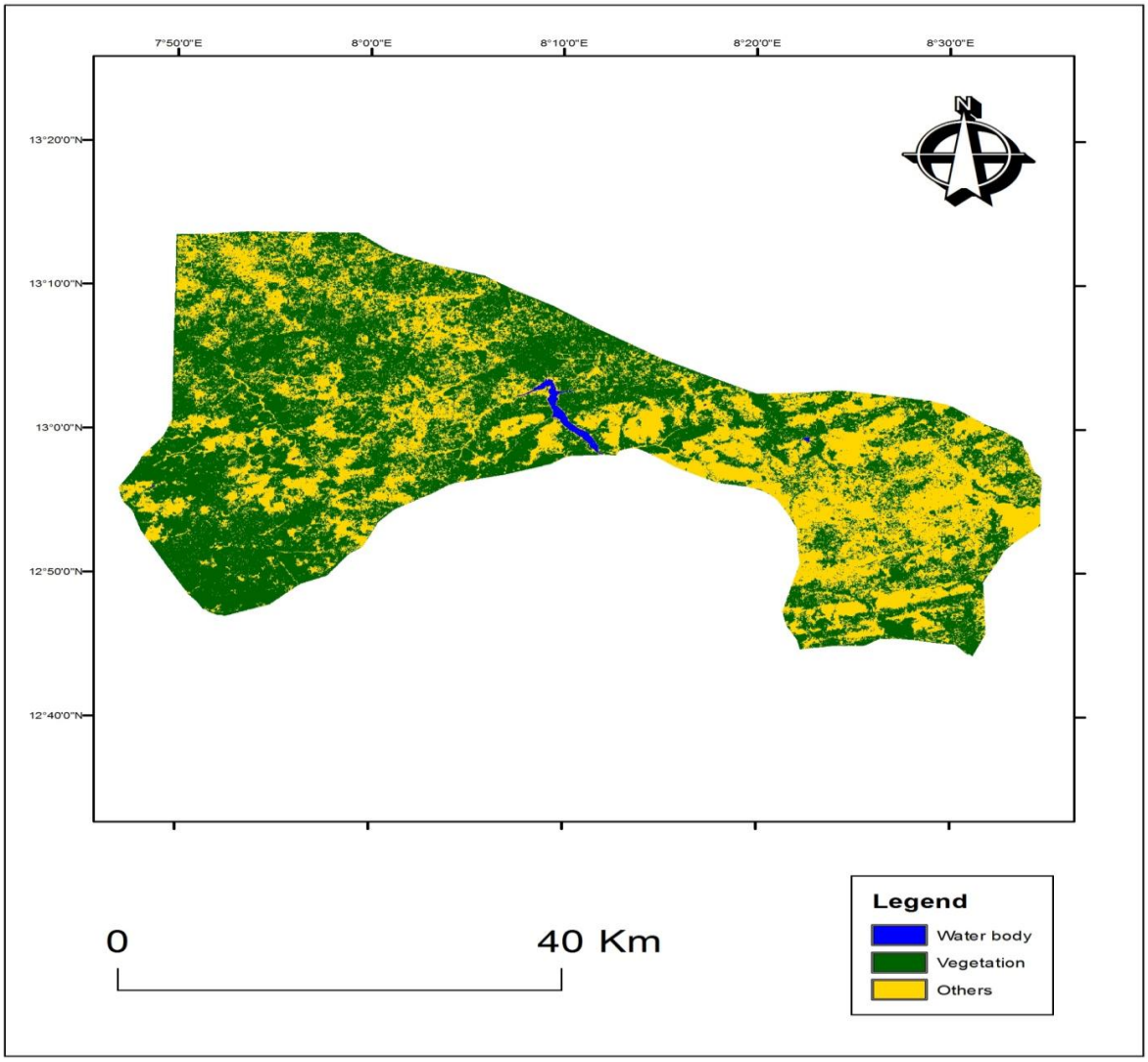


Figure 4.5 Land use Land cover 1999 from Landsat TM of the study area

(Date of acquisition: 1999-10-19)

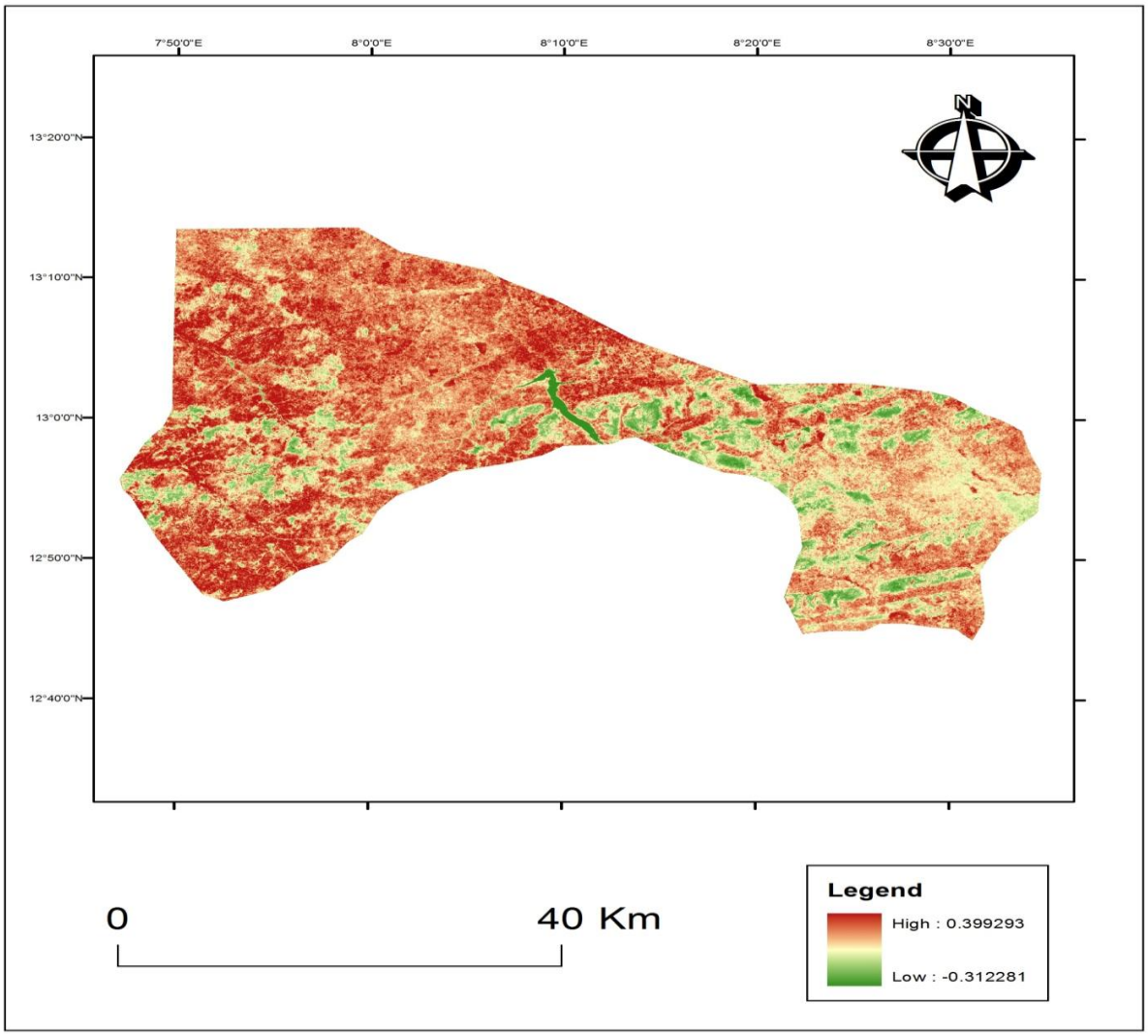


Figure 4.6 Normalized Difference Vegetation Index (NDVI) 1999

From the figure 4.6, the higher value of NDVI is 0.399293 which the table interprets as 'normal' and its low value at -0.312281. This shows a decrease in NDVI value

from what was obtained in 1988 with a difference of 0.216092. The total rainfall for 1999 was 518.9mm lower than 684.1mm of 1988 and 567.9mm of 1976.

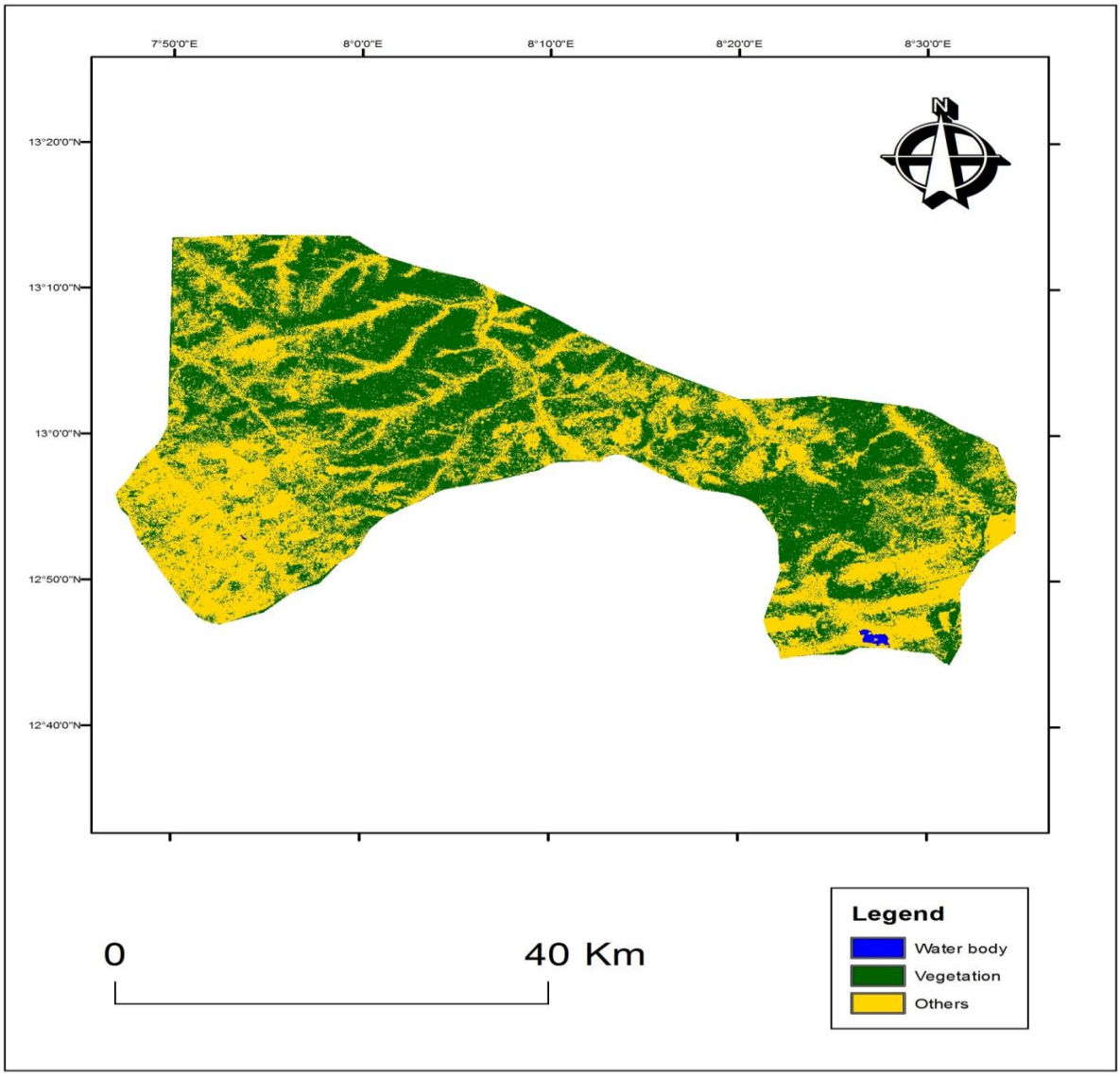


Figure 4.7 Land use Land cover 2006 (Date of acquisition: 2006-11-07)

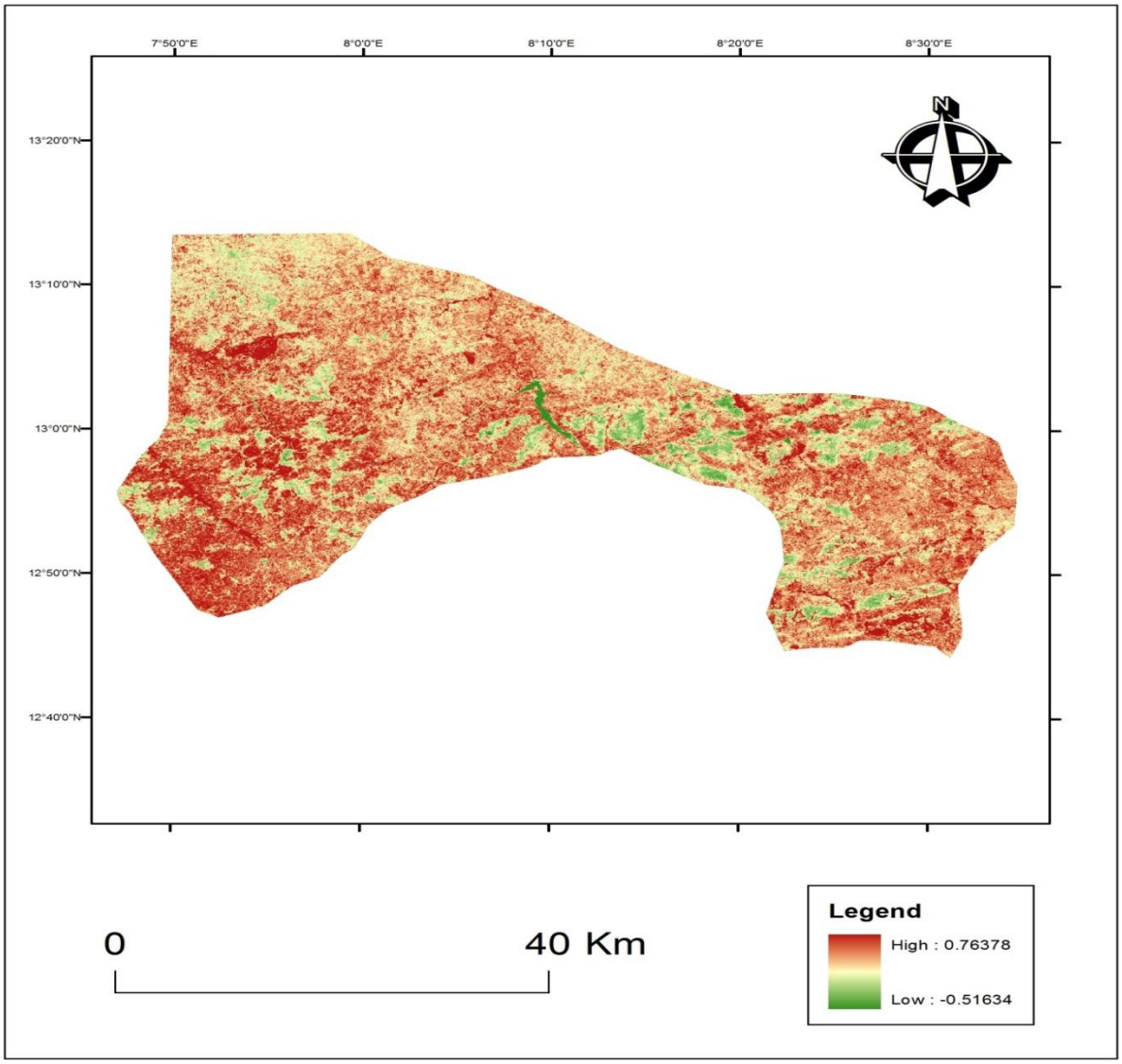


Figure 4.8 Normalized Difference Vegetation Index (NDVI) 2006

For the year 2006, Figure 4.8 shows high NDVI to be 0.76378 which is interpreted as 'good' and its low value -0.51634. It is questionable for the value of vegetation to be high in the area based on the NDVI values after a period of 30 years with anthropogenic activities going on the area. A simple explanation to this is that the total rainfall for 2006 was 726.5mm. This is the highest total rainfall when compared to the total obtained in 1976, 1988 and 1999 which are 567.9mm, 684.1mm and 518.9mm respectively. Another

explanation could be that the time of acquisition of the image was in September at the peak of the raining season.

4.2 Vegetation Change Detection (1976-2006)

The various vegetation cover rate of increase or decline is discussed here.

The data were re-classified in ERDAS IMAGINE 9.2 Software using supervised classification), three classes water, vegetation and others were trained in ERDAS IMAGINE editor toolset. The result was subjected to further threshold processing to obtain the attribute values of each class. For each category, the total area coverage for vegetation was found to be 1834.17km^2, 1666.5km^2, 1245.81km^2 and 1081.48km^2 for the year 1976, 1988, 1999 and 2006 respectively

The percentage change in vegetation cover for each year is presented in Table 4.1

Table 4.1: Decadal percentage of vegetation change

YEARS	% CHANGE
1976	85.7%
1988	77.9%
1999	58.2%
2006	50.5%

Table 4.1 shows the decadal percentage of vegetation change. The baseline is that for each decade, the percentage of vegetation change detection is taken. In 1976, the

vegetation rated very high at 85.7%. In 1988, vegetation was 77.9%, 58.2% in 1999 and 50.5% in 2006. There was a gradual decline in vegetation from 1976-2006.

The percentage vegetation change by classification for the period of the study is presented in Table 4.2

Table 4.2: Classification, Change and Percentage

Class/Years	1976(km^2)	%change	1988(km^2)	%change	1999(km^2)	%change	2006(km^2)	%change
Water	9.7101	0.43%	8.8245	0.41%	9.0423	0.42%	9.14525	0.42%
Vegetation	1834.17	85.7%	1666.5	77.9%	1245.81	58.2%	1081.48	50.5%
Others	29581	13.8%	46437.2	21.7%	88472.1	41.4%	104907	49%
Total	2139.6901	99.93%	2139.6905	100.01%	2139.5733	100.02%	2139.69525	99.92%

Table 4.2 presents classification, change and percentage in the study area. In 1976, water bodies in the area occupied 9.7101km^2, vegetation 1834.17km^2, others 29581km^2. In 1988, water bodies was 8.8245km^2, vegetation was 1666.5km^2 and others 46437.2km^2. In 1999, water was 9.0423km^2, vegetation was 1245.81km^2, others 884721.1km^2. In 2006, water was 9.14525km^2, vegetation 1081.48km^2 and others 104907km^2.

Objective II

4.3 Relationship between NDVI and Rainfall

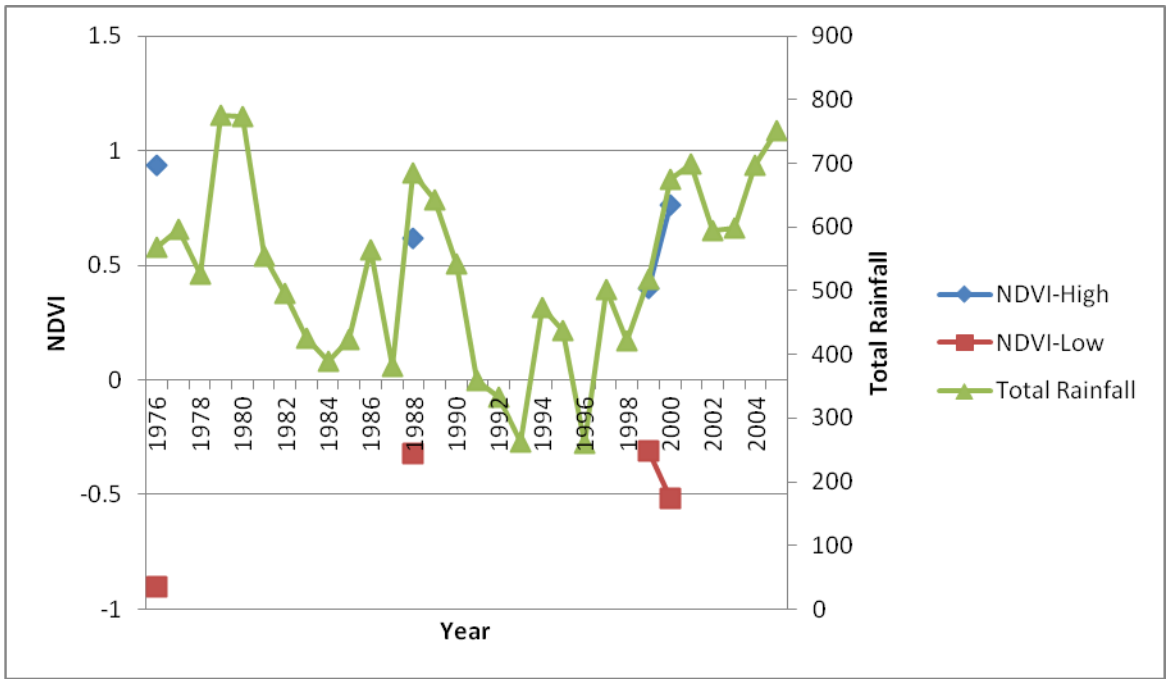


Figure 4.9 The Relationship between NDVI and Rainfall

The time series graph shows the pattern of rainfall in the study area across a period of thirty years from 1976-2006 and how it correlates with vegetation greenness of the area. It shows a positive correlation between amount of rainfall and vegetation, r=0.494, and the relationship is significant because p<.05. This implies that the more the rainfall the more the vegetation of an area or the dense vegetation of an area is largely reliant on the amount of rainfall. The up and downward trend of the graph shows an unequal pattern of rainfall in 30 years. The highest rainfall on average was in the year 1979 and 1980, and the least amount of rainfall was in the year 1993 and 1996. However, from the year 2002 up to 2006, the rainfall pattern maintained an upward trend.

This corroborates a study carried out by Wang *et al*, (2001) which results showed that NDVI depends largely on precipitation. A study also carried out by Nicholson *et al* 1990 showed that NDVI exhibits a saturation response to rainfall, leveling off as rainfall increases and remaining relatively constant after a certain threshold value is reached. According to the study, the most likely reason for this is found in the relationship between NDVI and vegetation growth which is exponential. NDVI which physiologically is a measure of the photosynthetic capacity of the plant canopy increases in proportion until some threshold value of NDVI is reached.

4.4 Results of Responses from Questionnaire

The Administered questionnaire were analysed to answer objective III and IV

4.4.1 Distribution of respondents by gender

The distribution of respondents by sex is presented on Table 4.3

Table 4.3: Sex of respondents

	Number of respondents	Percentage
Male	318	94.4
Female	19	5.6
Total	337	100.0

Source: Field survey (2013)

The male respondents were more willing to be interviewed than the females in all three (3) LGAs. Though the women are involved in one traditional form of resource management or the other, majority of them refused to be interviewed which is due partly to religious and cultural beliefs. However, the few that were interviewed outlined some

contributions of women in drought prone areas. It is far from easy to grasps the full complexity of the nature of gender relations between men and women (Agarwal, 1997). Though it is not part of the objectives of this research to analyze this issue in depth, the role of women in dry lands cannot be overemphasized. This point has further been buttressed by Poulsen, 2003 and IFAD 2010 that the roles of women in resource management and food security are crucial as they are often affected when erosion and diminished soil fertility results in decreased productivity and lessens the sources of income derived from these products.

4.4.1.2 Distribution of Respondents by Age and Education

Table 4.4 shows the age and educational level of the respondents across the study area. The age range is between 21 to 60 years and the educational qualifications are primary, secondary, tertiary and quaranic education.

Table 4.4: Distribution of Respondents by Education and Age

EDUCATION		Number of respondents	Percentage
Primary	21-30Years	1	4.3
	31-40 Years	16	69.6
	41-50 Years	4	17.4
	51-60 Years	2	8.7
	Total	23	100.0
Secondary	21-30 Years	1	1.9
	31-40 Years	28	52.8
	41-50 Years	22	41.5
	51-60 Years	2	3.8
	Total	53	100.0
Tertiary	31-40 Years	1	50.0
	41-50 Years	1	50.0
	Total	2	100.0
Quaranic	21-30 Years	3	1.2
	31-40 Years	35	13.5
	41-50 Years	119	45.9
	51-60 Years	77	29.7
	60 Above	25	9.7
	Total	259	100.0

Source: Field survey (2013)

From table 4.4, 259 of the respondents which is 76.9% across the three LGAs have not had any formal education but have attained quaranic education. Those that have attended secondary school make up 15.7% which is 53 respondents, primary school had 23 respondents which is 6.8% while those with tertiary make up 0.6% of the respondents

which is just 2 respondents. All the respondents said they have attended quaranic schools. It was also observed that those with secondary school education fall mostly between the age range of 31- 40 years and 41-50 years. This could be an indication of awareness of the importance of formal education.

4.5.1.2 Occupation of Respondents

The distribution of respondents by occupation is presented in Table 4.5

Table: 4.5 Occupation

	Number of respondents	Percentage
Farmer	280	83.1
Trader	19	5.6
Civil servant	28	8.3
Housewife	10	3.0
Total	337	100.0

Source: Field survey, (2013)

The result of this survey indicates that 83.1% of the total respondents across the three (3) LGA engage in farming as a major occupation. 5.6% engage in trading, 8.3% Civil servants and 3.0% for housewives. However, from the questionnaires, it was deduced that all respondents are involved in one form of agriculture to supplement their income. According to the responses by the civil servants, they all own farms as their meager income alone cannot cater for their families. Traders also engage in farming, most times with hired labour so that they can have time for their businesses. The women who responded said they assist in one form or the other to meet the needs of their families.

4.5 Experiences in Farming

Table 4.6 shows the duration the respondents have been involved in farming in the area using 5 years interval. It shows the duration in years, the frequency which is the number of respondents and the percentage.

Table: 4.6 Experiences of Respondents in Farming in the Study Area

Duration		Number of respondents	Percentage
	10-15Years	106	31.5
	16-21Years	94	27.9
	22 Above	135	40.1
	Total	335	99.4
Missing	System	2	0.6
Total		337	100.0

Source: Field survey (2013)

Table 4.6 shows that of the 337 respondents across the 3 LGAs, 40.1% have been farmers in the area for 22 years and above, 31.5% have been farmers in the area between 10-15years and 27.9% between 16-21years. The interest of the researcher was to target respondents who have lived in the area for more than 10years and this was achieved with those who have been in the area for 22years and above having the highest percentage of respondents. However, the table also shows that 2 persons which is 0.6% of the respondents did not answer the question asked.

4.6 Level of Involvement in Farming

Table 4.7 shows the level of involvement of respondents in agricultural practices which is either subsistence or commercial farming.

Table: 4.7 Level of Involvement of Respondents in Farming

	Number of respondents	Percentage
Commercial	19	5.6
Subsistence	318	94.4
Total	337	100.0

Source: Field survey (2013)

Subsistence farming is a kind of farming that generates only enough to feed the farmers family and 94.4% of the respondents said they are involved in subsistence farming and 5.6% engage in commercial farming. From questionnaires administered, everyone who responded was involved in one form of farming to another and the major reason is to sell off produce and meet other needs. Farming is indeed the life wire of the people in the three LGAs. It was also observed that majority of the farmers practice mixed farming that is, growing crops and keeping livestock at the same time. These animals are used for ploughing at the start of farming seasons. Their dung is also transported to the farm as manure.

4.7 Methods of farming used by Respondents

Table 4.8 shows the type of farming method being used in tilling the land in the study area. The table shows the method of farming, the number of respondents and the percentage.

Table 4.8 Tilling Method used by respondents

Method		Number of respondents	Percentage
Valid	MANUAL	37	11.0
	PLOUGH	297	88.9
			.
	Total	334	99.9
Missing	System	3	0.1
Total		337	100.0

Source: Field survey (2013)

Table 4.8 shows that 88.9% use machine in their farms while 11.0% use the manual system. However, it should be noted here that the machines used are not big machines like tractors and harvesters but rather animal- driven machines like the Emcot plough used normally at the start of the farming season to plough. Some also use Hand-driven machines like Knapsack for spraying pesticides against infections. It was noted during that those involved in the use of machines also use crude implements as well.



Plate 1: Lack of Trees as an Indicator of Desertification, near Gidan Mutun Daya Village, Mashi



Plate II: Decline in vegetation, Birnin Kuka area, Mashi

4.8 Types of Crop Cultivated

Figure 4.10 shows the major types of crops produced in the area. These crops are mostly grains and leguminous crops which thrive well in the savanna region.

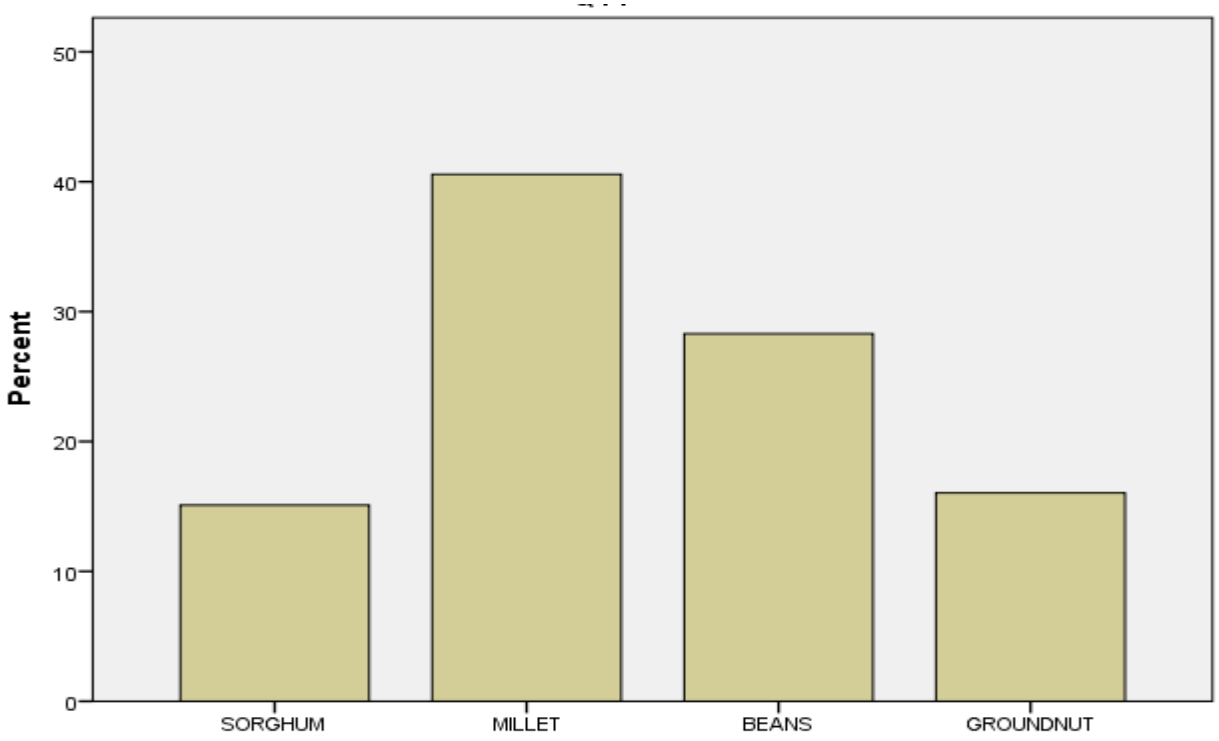


Figure 4.10 Type of crops produced

Source: Field survey (2013)

The bar chart in Figure 4.10 indicates millet as the most grown crop across the study area. From interviews with the farmers, the researcher found out that the farmers normally practice mixed farming that is, planting grain crops and leguminous ones. The highest number of bags of the crop cultivated was recorded as the major crop cultivated by the farmer. Millet ranked the highest at 39.8% among crops produced because according to the farmers, it is versatile in terms of adaptability to moisture stress. Cowpea had 30 respondents which is 27.8%, sorghum 16 respondents which is 14.8%, groundnut 17

respondents which is 15.7% .2 missing system was observed which falls at 1.9%. Grain crops forms the staple and traditional food of the people in the area so it is cultivated more. Millet and sorghum are seen as drought tolerant crops in the area.

4.9 Previous Yields

Table 4.9 below shows the farm yields of the farmers in the last farming season measured in kg bags which are the common way of packaging yields (grains) in the area.

Table: 4.9 Last Farm Yields in 100kg bags

Yields in kg bags		Number of respondent	Percentage
Valid	5-10	244	72.4
	11-15	89	26.4
	16-20	4	1.2
	Total	337	100.0

Source: Field report (2013)

According to table 4.9 ,72.4% of the respondents said their last farm output was between 5-10 100kg bags, 26.4% said their yields was between 11-15bags and 1.2% said their yields was between 16-20bags.

Table 4.10 shows the crop yields of the farmers fifteen years ago. Yields are also measured in kg bags.

Table 4.10: Yields 15 years ago

Yields in kg bags		Number of respondent	Percentage
Valid	5—10	9	2.7
	11-15	50	14.8
	16-20	105	31.2
	21 above	103	30.6
	Total	267	79.2
Missing	System	70	20.8
Total		337	100.0

Source: Field report 2013

Table 4.10 shows that 31.1% of the respondents said their yields 15years ago was between 16-20kg bags, 30.6% of the respondents said in the past, they get as much as 21kg bags and more, 14.8% said their yields use to amount to 11-15kg bags and 2.7% said they get between 5-10kg bags. From this interpretation, the land produced more in the past decades than now. Respondents blamed poor and declining yields to uncertain rainfall pattern and various factors that will be highlighted as this analysis progresses. The table also shows 70 missing system which means 70 people did not respond to this question because they either have not cultivated the area up to 15years or they said they cannot really remember past yields.

4.10 Awareness to Land Degradation

Table 4.11 shows response of the people's awareness to land degradation in the area

Table 4.11: Response to the awareness of the problem of land degradation in the area

Awareness		Number of respondent	Percentage
Valid	Yes	324	96.1
	No	11	3.3
	Total	335	99.4
Missing	System	2	.6
Total		337	100.0

Source : Field work report (2013)

From table 4.11, 96.1% said they observe land degradation in varying degrees while 3.3% said they don't observe problem of land degradation on their land. Two persons which is 0.6 did not respond to the question.

4.11 Causes of Land Degradation

Figure 4.11 shows the various major causes of land degradation in the area. The people's response is shown in percentages in the Y-axis and causes of land degradation on the X-axis.

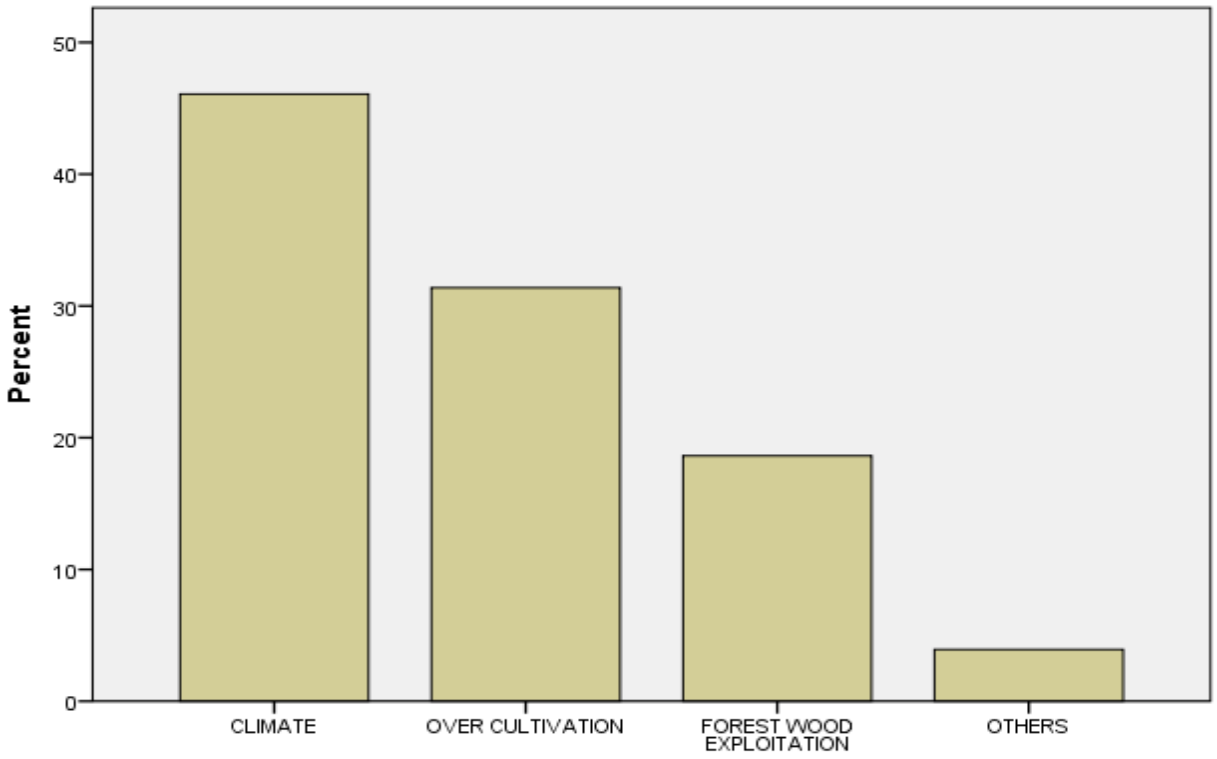


Figure 4.11 Causes of land degradation

Source: Field survey (2013)

From the bar chart in figure 4.11, 153 respondents (42.4%) said climatic factors are the main causes of land degradation in the area, chief among these climatic factors is uncertain pattern of rainfall. 124 respondents (36.8%) said over cultivation is the major cause of land degradation in the area, according to the farmers, over cultivation makes farmlands to be impoverished producing at a very low capacity. 50 respondents (14.8%) said forest wood exploitation while 10 respondents (3.0%) attributes land degradation to other factors like over grazing.

4.12 Awareness to Drought

Table 4.12 shows the level of awareness of the respondents to drought as a contributor to desertification.

Table 4.12: Awareness if drought or lack of moisture contributes to the problem

Awareness		Number of respondent	Percentage
Valid	Yes	323	95.8
	No	3	.9
	Maybe	11	3.3
	Total	337	100.0

Source: Field survey (2013)

Table 4.12 shows that the people are aware of constant drought and lack of moisture prevalent in their environment. 95.8% respondents said drought and lack of moisture has contributed to the problem of land degradation in the area, 3.3% of the respondents were not so sure if drought and lack moisture contributes to the problem while 0.9% of the respondents said no.

4.13 Intensity of Desertification

Table 4.13 shows the response on the intensity of desertification whether the problem is decreasing or increasing.

Table 4.13: Intensity of the problem of desertification

Response		Number of respondent	Percentage
Valid	Increasing	288	85.5
	Decreasing	36	10.7
	Total	324	96.1
Missing	System	13	3.9
Total		337	100.0

Source: Field survey 2013

Table 4.13 shows that 85.5% of the respondents agree that the problem increases with each passing year as the land gets drier with less moisture they also said last year's rain was high compared to past years leading to floods in some areas especially in Mai'Adua LGA, 10.7% said the problem is decreasing because they now have access to fertilizers. A total of 13 respondents 3.9% did not comment on whether the problem is increasing or decreasing.

4.14 Response to Change in Rainfall

Table 4.14 shows the response of the people to changes in rainfall. The response is either yes, no or not sure.

Table 4.14: Response to Change in Rainfall

Response		Number of respondents	Percentage
Valid	Yes	267	79.2
	No	12	3.6
	Not sure	52	15.4
	Total	331	98.2
Missing	System	6	1.8
Total		337	100.0

Source: Field survey (2013)

According to table 4.14, 79.2% respondents said they attribute changes in their environment to changes in climatic conditions over the years, 15.4% respondents said they are not sure while 12% of the respondents said no, 6 respondents which is 1.8% did not answer this question.

4.15 Perception of Climate Change as it Affects Desertification

Table 4.15 shows the various ways people perceive climate change as it affects desertification.

Table 4.15 Perception of climate change as it affects desertification

		Number of respondents	Percentage
Valid	More wind	36	10.7
	More rain	31	9.2
	Less rain	163	48.4
	Shorter growing season	37	11.0
	Total	267	79.2
Missing	System	70	20.8
Total		337	100.0

Source: Field survey (2013)

48.4% of the respondents in Table 4.15 said they perceive climate change to be less rain, 10.7% respondents said they perceive climate change as more wind, 11.0% respondents said shorter growing season while 9.2% said more rain. 20.8% did not respond to this question.

From the foregoing, the people in the area are aware that their climate is changing; they said it is getting warmer than the past years. They have been battling with drought for years but they said last year flood overtook villages and farmlands which took them unaware because they did not expect such change. It was more devastating in Mai'adua LGA.



Plate III: Trees planted inside Babaye village, Mashi to protect the village from strong winds and to provide shade.



Plate IV: Showing farmer's coping strategy of planting trees and leaving the farmland covered with grass to reduce erosion in Mai' Adua

4.16 Perception of Changes Observed as Affecting Yields

Figure 4.12 shows how people perceive changes as it affects yields and income.

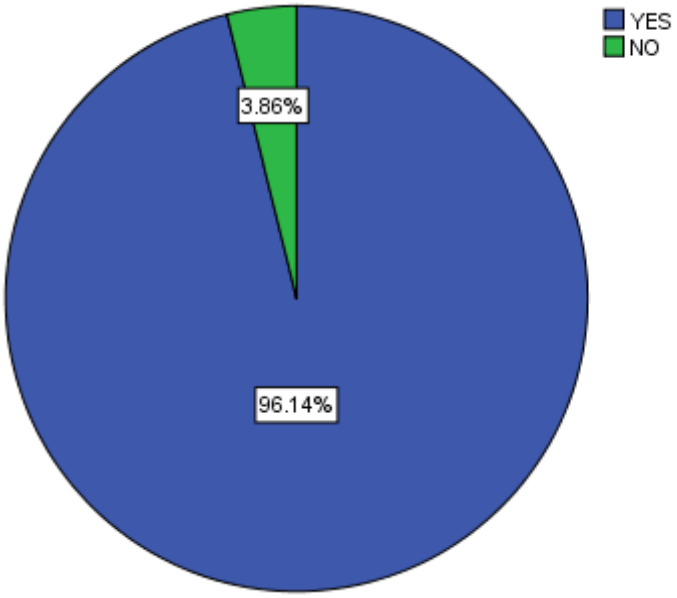


Figure 4.12 Perception of changes observed as affecting yields/income

Source: Field survey (2013)

From the Figure 4.12, 96.1% responded in affirmative that changes in land has affected yields, they said their lands is being taking over by loosed sandy soil while 3.9% responded negatively to the question.

4.17 Views on what Desertification is

Table 4.16 shows people's view of what desertification means to them

Table 4. 16: People's View of Desertification

	Number of respondents	Percentage
Drought and poor agricultural yields	106	31.5
Disappearance of trees	46	13.6
Productive land becomes unproductive	185	54.9
Total	337	100.0

Source: Field survey report (2013)

Table 4.16 shows that 54.9% of the respondents regard productive land becoming unproductive as desertification, 31.5% respondents regard drought and poor agricultural yields as desertification while 13.6% of the respondents regard desertification as disappearance of trees.



Plate V: Evidence of desertification around Yar' Daji in Zango

4.18 Causes of Desertification

Table 4.17: People's view of the causes of desertification in the study area

Table 4.17 what people see as the causes of desertification in the study area

Causes of desertification		Frequency	Percent
	Climate	150	44.5
	Over cultivation	124	36.8
	Forest wood exploitation	45	13.4
	Others	10	3.0
	Total	329	97.6
Missing	System	8	2.4
Total		337	100.0

Source: Field survey (2013)

Most of the respondents (150 respondents) attribute the cause of desertification to be impact of climate on their land such as drought and low rainfall. Over cultivation of land had 124 respondents, the respondents here noted that declining soil fertility as a result of over cultivation is associated with frequent drought. Felling of wood for fuel has 45 respondents, others like overgrazing and population pressure accounted for 10 respondents.



Plate VI: Animals grazing on little or no grasses intensifying land degradation.

4.19 Strategies to Reduce Land Degradation

Farmers in the study area employ different strategies to reduce land degradation. Table 4.18 shows the different strategies used in their farmlands.

Table 4.18: Strategies used to reduce land degradation

Strategies		Number of respondents	Percentage
Valid	Animal manure	77	22.8
	Planting trees	52	15.4
	Mixed cropping	93	27.6
	Crop rotation	74	22.0
	Digging the ground for moisture	40	11.9
	Total	336	99.7
Missing	System	1	.3
Total		337	100.0

Source: Field survey (2013)

From Table 4.18 mixed cropping or inter cropping has the 93 respondents, animal manure 77 respondents, crop rotation 74 respondents, tree planting 52 while digging the ground to ascertain moisture level has 40 respondents. However, from further questions asked, it was observed that these farmers do not practice each strategy in isolation but rather a combination of various strategies but the most preferred option was recorded as farm management strategy. Most of the strategies were handed down through oral history from their fore fathers, local expertise and little they said from agricultural extension workers who according to them visits once in a long while.

The major cropping pattern in the area is both sole and mixed cropping. Mixed cropping is used against total crop failure and also use for replenishing soil nutrients. Legumes are intercropped with grains. Millet is inter cropped with cowpea, cowpea is said to release nitrogen which is relevant for the vegetative growth and grain filling of the millet, the millet on the other hand provides shade for the cowpea thereby reducing impacts of excess temperature.

According to Liwenga (2003), crop rotation entails changing the type and pattern of crops in crops cultivated thereby enhancing soil fertility and reduction of pest and diseases. The farmers affirmed to this definition and further said it has been practiced in the area for generations and are indeed a sure strategy against land degradation. Fallowing which they said is good strategy of restoring soil fertility is no longer viable in the area due to pressure of meeting food needs and scarce land resource.

According to Mortimore (1989), yields are said to be lower in a dry year on manured than unmanured land. But the farmers said they still use animal dung to fertilize their farmlands. These manure are usually heaped on farmlands long before the start of rain, so that it can decompose before the rain starts properly.

Trees are also planted to give shade to crops and also to serve as wind breakers during strong and violent winds which has the capacity to sweep off loose soil in the farmlands.

Digging the ground to ascertain the level of soil moisture in the area is another strategy used by the farmers in the study area. According to them, sometimes when the first rains comes, farmers plant their seeds which might get burnt up and not germinate if the

rains does not continue. So to avoid loss of seeds which might lead to replanting of new seeds, the farmers dig the ground to be sure that the first rains had soaked the ground sufficiently before planting.



Plate VII: Heaps of animal dung on farmland (coping strategy for replenishing the soil) Zango

4.20 Managing Desertification

The menace of desertification in the study area is tackled by the government and the people in various ways. Table 4.19 shows the people's view of how desertification can be tackled.

Table 4.19: What should be done to fight the menace of desertification

		Number of respondents	Percentage
Valid	Sustainable tree planting	105	31.2
	Sensitization involving the people	213	63.2
	Total	318	94.4
Missing	System	19	5.6
Total		337	100.0

Source: Field survey (2013)

From table 4.19, 63.2% of the respondents want the government to carry the people along in sensitization tree planting campaigns, 31.2% respondents said sustainable tree planting activities should be practiced while 5.6% respondents did not comment.

The Katsina State government in its efforts to combat desertification raised 4.1million seedlings from 11 existing nurseries in 2011. The Katsina State commissioner for environment Alhaji Aminu Ibrahim Safana said 3.6 million where planted in 2011 (Danjuma, 2012). From observations and interaction with people in the area, the trees planted are not cared for and often die from harsh weather conditions. Most times the tree planting activities are just mere ceremonies captured on televisions but not really translated on ground so the government is actually fighting a grim battle to combat desertification without practical sustainable policies.

The people said they are not carried along in the tree planting campaigns so they see it as government projects not theirs.

CHAPTER FIVE

5.0 SUMMARY, RECOMMENDATIONS AND CONCLUSIONS

5.1 Introduction

This chapter presents the summary, conclusion and recommendations of the entire study

5.2 Summary

Normalized Difference Vegetation Index (NDVI) was used to assess the extent of decline in vegetative cover in Mashi, Mai'adua and Zango Local Government Areas of Katsina State. Satellite imageries of Landsat Mss 1976, Landsat TM 1988, Landsat TM 1999 and Landsat ETM^{+} were used in the analysis. Annual rainfall records from 1976-2006 were correlated with NDVI to determine the relationship between the two parameters. Questionnaires were distributed to respondents to capture their views on desertification and its impact on crop produce.

Results of the analysis showed that in 1976, the NDVI value was rated as high (0.9375) but reduced to 0.615385 in 1988 and 0.399293. However, there was an increase in NDVI Value in 2006 (0.76378). In 2006, high rainfall was recorded and the image was obtained at the peak of rainfall hence the high NDVI value.

The correlation result showed that there is a significant positive correlation between rainfall and NDVI ($r= 0.494$ and $p<.05$). This shows that NDVI depends largely on rainfall amount.

Results from the questionnaire administered showed that the people are aware of the menace of desertification in their area. They also agreed that there is climate change as their environment is becoming hotter and drier. Though the people have developed various strategies to fight desertification, this study found out that they on the other hand exacerbate the process through anthropogenic activities like fuel wood exploitation which is their main source of energy for cooking, over cultivation and over grazing.

Majority respondents were also of the view that there was better crop yields 15 years ago while some were of the opinion that yields are better now because of the use of fertilizers and improved plant species.

5.3 Conclusion

From this study, the physical indicator of NDVI over the period of 30 years did not show that vegetation was in a 'very poor state'. There was moderate correlation between rainfall and NDVI. The responses from the questionnaires showed that the people in the area are aware of desertification and its impacts on their livelihood. It also showed that the people have devised indigenous strategies to cope with desertification. However, a collective responsibility is needed from both the people and the government in the strive to achieve a sustainable and livable environment.

5.4 Recommendations

Based on the findings of this research, the following recommendations are suggested:

i Vegetal cover plays an important role in preventing land degradation, wind erosion, runoff reduction and can reduce evaporation. To reduce the rate of decline in vegetation

cover, Tree planting campaigns should be reviewed with a more realistic approach not tree planting jamborees by government officials captured on televisions and newspapers. The people should be involved in every stage of such projects so that they can feel a sense of belonging, they should be made to see the environment as their own and not just for the government.

i. The great green wall programme which is a planned project in collaboration with African Union to plant a wall of tree across Africa at the southern edge of the Sahara desert as a means of combating desertification should be pursued with a realistic approach and participatory approach to include women and youths to nurture these trees to maturity.

ii. The use of Remote Sensing in desertification is a welcome development in technological breakthrough. It can be used effectively to monitor vegetation conditions and provide early warnings on drought and famine. The relationship between NDVI and rainfall along with detailed characterization of spatial patterns could also provide the basis for the prediction of productivity at landscape scales under different climate regimes in Nigeria as a whole thereby promoting better agricultural strides by the government. The data obtained should be made readily available for researchers with less administrative bottlenecks to enable researchers in carrying out comprehensive and scholarly research which in turn will be beneficial to the country.

iii. More awareness should be made to the farmers and people of the area on climate change and its impacts. The Nigeria Meteorological Agency (NIMET) which has been making contributions in weather forecasting should be provided with the necessary technological equipment to be able to forecast flood and drought possibilities to give early warnings to the people in vulnerable areas.

iv. Katsina State being predominantly an agricultural based region serves as one of the origin of cereals, grains, legumes and livestock products in the Nigerian market. The use of manure and organic matter which the farmers use should be encouraged and improved methods could be researched into by agricultural research institutes and introduced to the people by agricultural extension workers who are ready to educate the farmers on new strategies to improve agricultural produce.. Also more research into drought-resistant species and cultivation methods should be looked into by KTARDA and agricultural research institutes.

v. The rural poor in the area make use of fuel wood as a source of energy for cooking as kerosene and gas is beyond their reach. Until another source of cleaner and renewable energy is made readily available to the people, laws enacted by the government to stop forest wood exploitation will only be a mirage. Over reliance of the people on fuel wood can only lead to its exhaustion thereby bringing more environmental calamities.

vi. The youths who are leaving the villages in droves to the cities in search for opportunities can be employed to nurture for young trees planted during campaigns for sustainability of these projects. Also funds allocated for desertification control policies and programs should be used judiciously.

Perhaps the most subtle and often neglected cause of desertification is poverty. Katsina State according to this report has 74.8% living below the poverty level. To a large extent therefore, these people depend largely on the natural resources of the area. Thus, the well-known interrelationship between poverty and environmental degradation obtains whereby poverty generates environmental degradation which in turn accentuates poverty. The government should introduce poverty alleviation programmes in the grassroots to improve the standard of living of the people.

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APPENDICES

Appendix I: QUESTIONNAIRE

This questionnaire is designed to obtain information for a research study titled : ***Severity of desertification in the extreme northern parts of Katsina State Nigeria***. All information provided will be used for academic purpose only and treated as confidential.

Fill in or tick [√] where appropriate

1. Name of respondent……

2. Sex : Male [ ] Female [ ]

3. Occupation …….

4. Age (i) 21- 30 years [ ]

   (ii) 31-40 years [ ]

   (iii) 41- 50 years [ ]

   (iv) 51 -60 years [ ]

   (v) 60 above [ ]

5. Town and LGA…….

6. Educational qualification: Primary [ ] Secondary [ ] Tertiary [ ] Koranic [ ]

7. How long have you been a farmer in this area?

   (i) 10-15 years [ ]

   (ii) 16-21 years [ ]

   (iii) 22 years above [ ]

8. Are you a Subsistence [ ] or Commercial [ ] farmer?

9. What is the size of your farmland (in hectares)?.....

10. What kind of farming system are you involved in?

    Manual [ ] Mechanized [ ]

11. What type of crops do you cultivate?

Sorghum [ ] Millet [ ] Beans [ ] Groundnut [ ] others [ ]

12. What was your last farm output (in 100kg bags)……

13. What used to be your farm output in the past 15years?.....

and above?.....

14. Do you observe any problem of land degradation?

Yes [ ] No [ ]

15. What do you think is the cause of land degradation? Climate [ ] poor irrigation practice [ ]

Over cultivation [ ] forest wood exploitation [ ] others specify…….

16. Has drought or lack of moisture/ rainfall contributed to the problem?

Yes [ ] No [ ] Maybe [ ]

17. Is the intensity of the problem increasing or decreasing? Increasing [ ] Decreasing [ ]

18. Will you attribute these changes to changes in climatic conditions over the years?

Yes [ ] No [ ] Not sure [ ]

19. If yes, what is your perception of climate change as it affects desertification?

More wind [ ] Less wind [ ] More rain [ ] Less rain [ ] Shorter growing season [ ] Longer growing season [ ] Others specify……

20. Describe any changes that you have observed about your land?

.....……
……
……
……

21. Have these changes affected the yields / income?

Yes [ ] No [ ]

22. Is desertification a problem in this area?

Yes [ ] No [ ]

23. If yes, what do you regard desertification to be?

Drought and poor agricultural yields[ ] Disappearance of trees [ ] productive land becomes

unproductive [ ] others specify…….

24. What are the causes of desertification in this area? Felling of wood for fuel [ ]

Overgrazing [ ] Population pressure [ ] Over cultivation of marginal lands [ ]

Others specify……..

25. What farm management strategies do use to reduce land degradation/ desertification?

……
……

26. What do you think should be done to fight against the menace of desertification?

Sustainable tree planting activities [ ] Sensitization campaigns involving the people [ ]

Others specify……

27. What should the State and Local Government do to mitigate the problem of desertification?

……
……
…….....**.....**
.....

28. What should the people do?**.....**

……
……
……

29. Any general comments?

Appendix II: Monthly Rainfall Distribution of the Study Area (1976-2006) from Katsina station

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1976	0	0	0	0	20.3	67.6	69.6	172.2	174.2	64	0	0	567.9
1977	0	0	0	0	10.2	54.2	168.3	276.8	87.5	0	0	0	597
1978	0	0	0	0.6	16.2	62.3	187.5	111.8	111.5	36.1	0	0	526
1979	0	0	0	7.2	30.2	111	297.2	249.3	81.4	0	0	0	776.3
1980	0	0	0	0	78.2	66.7	341	202.4	58.2	26.9	0	0	773.4
1981	0	0	0	11	37.5	78.5	186	128.7	113.1	0	0	0	554.8
1982	0	0	0	1.6	14.5	97.4	129.8	213.7	26.1	12.3	0	0	495.4
1983	0	0	0.1	0	0.4	113.1	109.4	101.1	101.2	0	0	0	425.3
1984	0	0	0	0	16.4	81.6	131.4	76.4	68.1	16.1	0	0	390
1985	0	0	11.2	0	33.7	83.2	98.8	123.1	73	0	0	0	423
1986	0	0	0	0	0.4	3.4	318.2	177.4	64.5	0	0	0	563.6
1987	0	0	0	0	0	41.5	107.5	149.7	83.4	0	0	0	382.1
1988	0	0	0	15.3	6.4	120.7	103.9	244.7	193.1	0	0	0	684.1
1989	0	0	0	0	2.9	79.8	152.1	266.3	66.4	74.8	0	0	642.3
1990	0	0	0	0	29.9	57.9	198.8	220.2	34.7	0	0	0	541.5
1991	0	0	10.8	12.2	73.5	58.8	71.5	109.7	21.1	1.4	0	0	359
1992	0	0	0	0	33.6	19.9	89.3	119.4	70.7	0.2	0	0	333.1
1993	0	0	0	0	4.5	42.3	69	94.5	51.7	0	0	0	262
1994	0	0	0	3.1	12.3	42.3	107.9	174.2	113.1	20.3	0	0	473.1
1995	0	0	0	12.6	7.7	60.6	149.8	129.4	70	7	0	0	437.1
1996	0	0	0	0	42.6	44.5	38.1	66.8	67.8	0	0	0	259.8
1997	0	0	7.2	9.5	89.5	30.4	91.1	153.7	113.1	8.3	0	0	502.8
1998	0	0	0	10.1	1.9	43.4	114.1	116.6	135.2	0.8	0	0	422.1
1999	0	0	0	0	4.2	22.4	133.2	89.8	250.9	18.4	0	0	518.9
2000	0	0	0	0	1.6	106.8	299.9	160.2	62.1	45	0	0	675.6
2001	0	0	0	16.9	83.9	110.8	176	240.9	70.6	0	0	0	699.1
2002	0	0	0	0	2.9	141.3	170.4	71.3	199.1	9.8	0	0	594.8
2003	0	0	0	4.0	52.8	57.2	118.2	275.5	75.1	16.4	0	0	599.2
2004	0	0	0	0	74.9	151.2	161.1	268.8	42	0	0	0	698
2005	0	0	0	14.8	18.4	83.2	173.7	216.1	194	50.4	0	0	750.6
2006	0	0	0	0	26.1	69.9	170.9	314.9	129.7	15	0	0	726.5

NIMET 18/01/12