ASSESSMENT OF SPATIO-TEMPORAL VARIATION OF VEGETATION COVER IN BAUCHI STATE, NIGERIA

BY

Modibbo SALEH
(B.Sc. Geography BUK, 2000)
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DECLARATION

I declare that the work in this dissertation entitled Assessment of spatio- temporal change of vegetation cover in Bauchi State, Nigeria has been carried out by me in the Department of Geography and Environmental Management. The information derived from the literature has been duly acknowledged in the text and a list of references provided. No part of this Dissertation was previously presented for another degree or diploma at this or any other institution.

Modibbo Saleh______	______________________	__________________
Name of Student	Signature	Date

CERTIFICATION

This dissertation entitled ASSESSMENT OF SPATIO-TEMPORAL VARIATION OF VEGETATION COVER IN BAUCHI STATE, NIGERIA by Modibbo SALEH meets the regulations governing the award of the degree of Master of Science in (Remote Sensing and GIS) of the Ahmadu Bello University, and is approved for its' contribution to knowledge and literacy presentation.

Prof. S. A. Yelwa_______________ ____________________ _______________
Chairman, Supervisory Committee (Signature) (Date)

Prof. E. O. Iguisi______________ ____________________ _______________
Member, Supervisory Committee (Signature) (Date)

Dr. A. K. Usman______________ ____________________ _______________
Head of Department (Signature) (Date)

Prof. S. Z. Abubakar___________ ____________________ _______________
Dean, School of Postgraduate Studies (Signature) (Date)

DEDICATION

This dissertation is dedicated to my parents, Malam Saleh Isah and Aisha Mohammed.

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I am deeply grateful to Almighty Allah, the Lord of the world, the Beneficent. the Most Merciful, Who in His boundless mercy gave me the privilege, strength, wisdom and courage to complete my study successfully. I wish to heartily acknowledge my supervisors, Professor S. A. Yelwa and Professor E. O. Iguisi whose opinions and counsel of prudence were immeasurable. I must confess that, I benefited immensely from their constructive criticism, observations and their in-depth knowledge of research techniques. I will ever remain grateful to them, may God bless them abundantly, amen. I am also indebted to my lecturers and the entire members of staff of the Department for their various encouragements throughout my study period in this great University.

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ABSTRACT

Bauchi State of Nigeria has undergone rapid land cover changes from natural and anthropogenic sources from 1976 to 2015. This in turn affects the natural resource base, hence a threat to the entire ecosystem. The study assesses the spatio-temporal changes of the vegetation cover in Bauchi. Remote Sensing, GIS techniques and questionnaire administration were employed to collect the data needed to address the research objectives. Multi-temporal satellite data (Land Sat Multi Spectral Scanner 1976 and Operational Land Imager 2015) were used for land cover-land cover (LULC) classification using Maximum Likelihood Classifier (MLC) tool resulting in land cover map of 1976 and 2015. They were further analysed for changes using the Post-Classification Comparison Technique. The SPOT-NDVI data of 1998 and 2014 with 8km resolution were used to generate vegetation density map using NDVI differencing method resulting in four density classes: low (0.1-0.2), medium (0.2-0.3), high(0.3-0.4) and very high (>0.4). A regression statistics was used to test for relationship between NDVI, rainfall and temperature. The data on the driving factors of vegetation changes were obtained through semi-structured questionnaire. The Findings revealed that the settled/cultivated land increased by 3918.4 km^2 (35.8%) with an annual rate of changes of 14.32% followed by Shrubbed Woodland Hills by 1550.4 km^2 (14.2%) with annual rate of changes of 5.60%. While, the other vegetation cover types decreased. The results also indicated that the area coverage very high NDVI density class had decreased by -2991 km^2 (50%) with annual rate of change of -8, NDVI high density class had increases by +1615 km^2 (27%) with annual rate of change +4.3, NDVI medium density class had increased by 1099 km^2 (18.4%) with annual rate of change of +2.9 and NDVI low density class had increased by +277 km^2 (4.6%) with annual rate of change + 0.74. The regression coefficients showed a strong relationship between NDVI, rainfall and temperature from 1998 to 2014 because of regression coefficient (R^2 = 0.72) recorded in 1998, (R^2 = 0.64) in 2006 and (R^2= 0.5) in 2014. The study further established a strong effect of anthropogenic activities on vegetation cover changes as majority of the respondents (99%) used fire wood in the study area. Therefore, awareness of the reality, magnitude and implications of vegetation cover changes should be raised among vegetation resource users, and the need for government to improve on shortfall of supply of other forms of alternative domestic energy source in the study area, areas part of recommendations made in this study.

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CHAPTER ONE

INTRODUCTION

1.1 Background to the Study

Vegetation can be simply defined as the plant cover of the earth consisting of assemblages of plants (Adeyewa and Aweda, 2011). Together with physiography, it constitutes the most observable element of the landscape. It expresses and reflects environmental conditions, particularly climate. Vegetation is the primary producer of any ecosystem. Therefore, the natural vegetation could be considered as one of the most important components on the earth's surface as it influences all forms of life (Adeyewa & Aweda, 2011). Vegetation provides food, oxygen, soil fertility and the life support for all living beings on the earth's surface. Growth and vigour of vegetation cover are controlled by factors such as climate, soil and topography. In general, climatic factors are the most influential among these factors.

Climatic factors such as rainfall and surface temperature determine the availability of moisture for physical, biological and chemical activities to occur plants that can ultimately lead to its healthy growth (Houghton *et al* 2001). Steffen and Tyson (2001) stressed that vegetative surface cover has an important function on the earth surface because it is linked via several feedback mechanisms to hydrological and climatological processes. Vegetation cover is also a key factor influencing the frequency, intensity and spatial distribution of wind erosion events (Shao, Leys, McTainsh & Tews, 2007). Levels of vegetation cover are directly influenced by both climate and land management practices (Wilson & Graetz, 1979).

At a global scale, vegetation change is principally determined by two interwoven factors: environmental and anthropogenic. The environmental factors observed by World Conservation Monitoring Commission (1992) include soil, slope, aspect, topography and climate (e.g. temperature, rainfall, relative humidity and sunshine). The anthropogenic factors on the other hand, include human activities, such as agriculture, urbanization, bush burning, road construction, mineral exploitation, industrialization among others as the driving processes of vegetation change.

Adeola, Ogunleye, Ojo & Aduradola (2004) expressed that scientific studies of vegetation in Nigeria have illustrated the apparent effect of farming activities, resulting in the modification of the original vegetation while some vegetation resources such as wildlife have gone extinct. For example, the Nigerian Environmental Study/Action Team, NEST (1991) indicated that over 350,000 hectares of vegetation in Nigeria is lost annually due to farming alone. The evidence above presents a significant and direct role of human activities, culminating in vegetation change.

It has also been established by Sigwa Consult Nigeria Limited (2001) in an Environmental Impact Assessment of the imminent explosion of Lake Nyos in Cameroon and its consequences on the Benue valley that the highest rates of vegetation modification in Bauchi State occur mostly on forest lands for subsistence and heavy dependence on shifting agriculture. Related to that, over the past century, many scholars such as Myers (1989), Adeola *et al* (2004) and Madulu (2004) maintained the thinking that rapid population growth is the major cause of much vegetation resource degradation especially in developing countries like Nigeria.

Similarly, vegetation is highly sensitive to the behaviour of the prevailing temperature and rainfall of any area as these elements are necessary for the development and growth of plants. For example, more frequent and prolonged drought and expanding desertification are being experienced in the Sahel Savanna region of Nigeria and Africa as a whole due to rising temperatures and reduction in rainfall (Goudie, 2002; NEST, 1991; Obioha, 2005; Tegen & Fung, 1994). Equally, the reduction of rain-days and rainfall in some parts of Northern Nigeria is threatening food production in the area (Umar, 2010). Madu & Ayogu (2010) also stressed that rainfall variability accounts for 70% of variation in crop production in Northern Nigeria while Morishiona & Akasaka (2008) noted that the great extent of rainfall variability has accounted for variation in rice production in Philippine.

Adeofun, Oyedepo, & Ogunsesan (2011) conducted a research on assessment of human perturbation of Nigerian terrestrial ecosystems for twenty years (1976 to 1995). The study revealed that the eco-climatic and agro-ecological zones (AEZ) have gone through noticeable transition due to large scale land-cover transformations across the country. Adeyewa and Aweda (2011) also opined that natural vegetation over a geographical area is essentially a response to the climate in that area. Nigeria's vegetation belts reflect this very close link between vegetation and climate, hence, the similarity in the west-to-east zonation of both climate and vegetation. With the south to north progressive decline in total rainfall and length of wet season, vegetation belts are demarcated on west-to-east zonation pattern characterised by transitional zones from one belt to another.

Assessing and monitoring the state of vegetation cover on the earth’s surface is a key requirement for global change research (Jung, Churkina,& Henkel, 2006; Lambin, Turner & Helmut, 2001; National Research Council, 1999; Xie, 2008). Classifying and mapping vegetation is an important technical task for managing natural resources as vegetation provides a base for all living beings and plays an essential role in affecting global climate change (Xiao, Zhang & Braswell, 2004; Xie, 2008). Applied remote sensing became more and more inevitable technology contributing to human's progress toward sustainability by support solving environment related tasks on local, regional and global level (Zoran & Anderson, 2006). Geographic Information System (GIS) allows the storage, processing and manipulation of data from different sources, and over many time sequences. This provides decision makers with relevant information for the protection of vegetation and its resources in order to ensure environmental sustainability.

Bauchi State with an estimated population of 4,676,465 million people and a annual growth rate of 3.0%, with economic active population constituting 41.2%. The rural population account for 84% most of whom farming activities (Bauchi State Economic Empowerment and Development Strategy (BASEED), 2005). As population increases, the amount of forest land usually decline, because demand for land for food production and other uses. When land is intensively cropped, the natural tree cover and soil fertility may be lost, leading to changes in the quality and quantity of the vegetation (BASEED, 2005). Intensive and extensive agricultural practices have reduced the natural vegetation and undisturbed forest of the state to less than 1% of the total land area of 66,000 km^2 between 1976/78 and 1993/95. The intensive agriculture increased from 20,026 km^2 to 27,338 km^2, while extensive agriculture on the other hand, rose from 16.7% to 18.3% and woodland declined from 14,754 km^2 to 3,571 km^2 (Forestry Management Evaluation and Coordinating Unit FORMECU, 1998).

Similarly, FOMECU (1998) stressed that population pressure has accelerated the rate of deforestation through the search for cultivable land and grazing in Bauchi State. The effect of this intense demand results in a decline of vegetation and impoverishment of the soil and a general deterioration of environmental conditions. It is against this background that the research attempts to assess the spatio- temporal changes of vegetation in Bauchi State using remotely sensed data.

1.2 Statement of the Research Problem

Globally, increased rainfall variability, climate change and increased human activities have been and will continue to adversely modify the natural resource and the environment as a whole. Climate exerts a strong influence on relevant socio-economic sector and people's livelihood in sub-humid and semi-arid zones of northern Nigeria where the dry condition has been on the increase. These changes are occurring at unprecedented rate thereby drastically reducing bio-productivity of the physical environment. This uncoordinated process of change is a threat to food security and apparent poverty level typical of northern Nigeria (Food and Agriculture Organisation (FAO), 1996). These changes are rather complex and have attracted research interest in the last four decades (Goldewijk & Ramankutty, 2010).

At the global level, the total net change in forest area in the period 2000–2010 is estimated at -5.2 million ha per year, which is equivalent to a loss of more than 140 square kilometres of forest per day (FAO, 2010). The study maintained that, this figure is lower than the total forest net change obtained from 1990 to 2000 (-8.3 million ha per year). Similarly, The Global Forest Resources Assessment of 2010 carried out by the Food and Agricultural Organisation (FAO), (2010) estimated the forested areas in West Africa at 74.25 million hectares; corresponding to about 11% of the total land area in the sub region and 0.02% of global forest area.

Also, a regional analysis by FAO (2010) revealed that as at 1990, the total forested area in West Africa was 91,589,000 hectares, which was reduced to 81 979,000 hectares in the year 2000, and 73 234,000 hectares in 2010. By implication, these records indicated an annual rate of change of -1.10% in the 1990–2000 periods, and -1.12% in the 2000–2010 periods. This trend, according to Benton (2010); Clarke & Crame (2010); Lyon, Wagner & Dzikiewicz (2010), is the result of past environmental conditions and evolutionary constraints undergone by world vegetal cover.

Based on the above, it is noted that the World's terrestrial ecosystem and Nigeria inclusive, is going through monumental perturbations from natural and anthropogenic sources. Similarly, Bauchi state vegetation pattern presents a substantive evidence of the resulting transitions. Currently, the terrestrial ecosystem has been degraded and depleted as a result of Agricultural activities, firewood extraction, urbanization and population explosion which leads to increasing demands by people for water, food, fuel, shelter and income (FORMECU, 1998). The intensive and extensive agricultural practices have also reduced the natural vegetation and undisturbed forest of the state to less than 1% of the total land area of 66,000 km^2 between 1976/78 and 1993/95. Intensive agriculture increased from 20,026 km^2 to 27,338 km^2, while extensive agriculture rose from 16.7% to 18.3% and woodland decline from 14,754 km^2 to 3,571 km^2. Intense demand results in decline of vegetation cover, impoverishment of the soil and a general deterioration of environmental condition (FORMECU, 1998). Despite the vulnerability of vegetation cover in Bauchi State, there has been little attempt at assessing the spatio-temporal changes of vegetation in relations with climatic variables and human activities in the study area. This is the gap that this research intends to fill.

In view of the above, the study would attempt to answer the following research questions:

i. What is the areal extent of vegetation types in the study area from 1976 to 2015?
ii. What is the spatio-temporal trend of vegetation density in the study area from 1998 to 2014?
iii. What is the relationship between NDVI and rainfall and temperature in the study area from 1998 to 2014?
iv. What are the effects of human activities on vegetation cover in the study area from 1976?

1.3 Aim and Objectives of the study

The aim of the study is to assess the spatio-temporal changes of the vegetation cover in Bauchi. The specific objectives of this study are to:

i. map and analyse the aerial extents of vegetation types in the study area from 1976 to 2015.
ii. determine the spatio-temporal trend of vegetation density in the study area from 1998 to 2014.
iii. determine the relationships between NDVI and rainfall and temperature in the study area from 1998 to 2014.
iv. examine the effects of human activities on vegetation cover from 1976 to 2015 in the study area

1.4 Scope of the Study

The study covers the entire Bauchi State. The study focuses on the assessment of spatio-temporal changes of vegetation cover in Bauchi State. It involves examining the extent of the vegetation cover changes from 1976 to 2015, Spatio-temporal pattern of the vegetation density change, relationship between NDVI and rainfall and temperature and effects of human activities on the vegetation density changes in the study area. The study covers a period between 1976 and 2015. While 1976 and 1998 served as the baseline of the study for the vegetation cover types and the density changes, 1976 presents period of Bauchi State creation, and 1998 was chosen because of the inability to obtain NDVI data that covers the entire period of the study.

1.5 Justification of the Study

The importance of investigating the land cover dynamics as a baseline requirement for sustainable management of natural resources and has been highlighted by many researchers involved in global change studies (Chen, 2002; Jensen & Gregoria, 2002; Martens and Lambin, 2000; Sererneels, 2001; Read and Lan, 2002). These scientists have argued that a more focused management intervention requires information on the rate and impact of land cover change as well as the distribution of these changes in space and time. Assessing and monitoring the state of the earth's surface is a key requirement for global change research (Jung, Churkina, & Henkel, 2006; Lambin, Turner and Helmut., 2001; NRC, 1999; Xie, 2008). Vegetation mapping is an important technical task for managing natural resources as vegetation provides a base for all living beings and plays an essential role in affecting global climate change (Xiao, Zhang, and Braswell, 2004; Xie, 2008). Vegetation extraction from remote sensing imagery is the process of extracting vegetation information by interpreting satellite images based on the interpretation elements and associated information (Xie, 2008).

Current interests in the habitability of the earth and environment have stimulated a host of global monitoring programmes to examine the possible consequences of variations in prime ecosystem parameters such as rainfall, temperature, atmospheric gas concentration, radiation levels, land cover and the like (Hansen, 1981; Woodwell *et al*., 1984). However, in the course of such works, many deficiencies have appeared in the understanding of vegetation dynamics due to the unavailability of continuous streams of data and it is now recognized that a better assessment of natural or man-made changes in the vegetation cover and their controlling factors is needed for better understanding of the role of plant communities in climatic, hydrologic and geo-chemical cycles (Hamilton & King, 1983). Also, Steffen and Tyson (2001) indicated that the vegetation surface cover has an important function in the earth surface because it is linked via several feedback mechanisms to hydrological and climatological processes.

Thus, by monitoring vegetation cover change of Bauchi State, nature and rate of environmental degradation would be identified and proper strategies aimed at mitigating and avoiding devastating consequences of such environmental degradation. Also, it is possible to obtain vegetation indices and relate them with climatic variables such as rainfall and temperature. Long term analysis of climate and vegetation will be helpful in deriving mathematical relationships between NDVI and some selected climatic variables. In addition, the study would be useful to geographers, natural scientists taking courses, carrying out research and working in the field of the environmental management.

CHAPTER TWO

CONCEPTUAL FRAMEWORK AND LITERATURE REVIEW

This chapter presents the conceptual framework of variables that affect spatio-temporal changes of vegetation cover as well as review of literatures related to study.

2.1 CONCEPTUAL FRAMEWORK

One of the fundamental characteristics of vegetation is its susceptibility to change. Based on the conceptual framework of complex environmental interaction, variation in vegetation is the result of complex and great number of interacting environmental variables (Millennium Ecosystem Assessment (MA), 2005). Therefore, the composition and structure of any given vegetation community reflects the interaction between its components members and their environment through time. Hence, any natural or anthropogenic changes will definitely result in corresponding minor or major changes in the affected vegetation community (Jibrin, 2009).

Singh (1999) define change detection as the processes of identifying differences in the state of an object or phenomenon by observing it at different times. Macleod & Congalton (1999) list four aspect of change detection which are important when monitoring natural resources:

i. detecting the change that have occurred;
ii. identifying the nature of the change;
iii. measuring the area extent of the change ; and
iv. assessing the spatial; pattern of change.q

2.1.1 Global Characteristics of Vegetation

Vegetation is a general term for the plant life of a region; it refers to the ground cover provided by plants, and vegetation dynamics corresponds to changes in species composition and/or vegetation structure in all temporal and spatial possible extent. The geographical distribution (and productivity) of the various biomes (Figure 2.1) is controlled primarily by the climatic variables: precipitation and temperature (Pidwirny 2006). A biome is a large geographical area of distinctive plant and animal species, which are adapted to that particular environment (Kulawardhana, 2008).

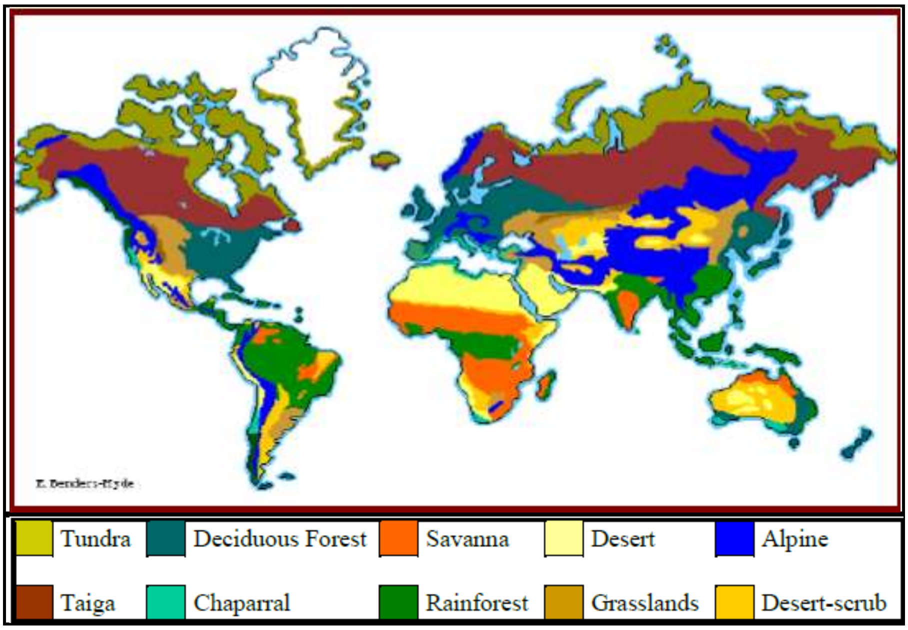


Figure 2.1: Global vegetation types
Source: Benders-Hyde (2010)

Therefore, a broader definition of vegetation and where this study falls within this definition is quite important (given the broader concept of vegetation) in order to provide a context for the study. Land cover is the observed bio-physical cover on the earth's surface (Di Gregorio & Jansen, 2000). This definition incorporates both natural and manmade features on the earth surface as land cover.

There have been numerous land cover classification systems (LCCS) that have resulted in either classifying only natural vegetation types, agricultural areas or broad land cover classification types (Di Gregorio & Jansen, 2000). The differences in the resulting classification systems derived from differing organisational requirements. Di Gregorio and Jansen (2000) designed a multi- user-oriented classification system that resolves discrepancies between the various organisational classification systems, through a process of standardisation. In the initial phase of their classification they identified major land cover types, as follows;

i. Cultivated and Managed Terrestrial Areas
ii. Natural and Semi-Natural Terrestrial Vegetation
iii. Cultivated Aquatic or Regularly Flooded Areas
iv. Natural and Semi-Natural Aquatic or Regularly Flooded Vegetation
v. Artificial Surfaces and Associated Areas
vi. Bare Areas
vii. Artificial Water Bodies, Snow and Ice
viii. Natural Water Bodies, Snow and Ice

The second phase of the classification categorised vegetated areas into four broad classes each with subclasses contrary to the conventional way of classifying vegetated areas as mentioned earlier. The main domains are:

i. Grasslands: defined as plants without persistent stem or shoots above ground and lacking definite firm structure (Scoggan, 1978 in Di Gregorio & Jansen, 2000).

ii. Shrublands: defined as plants with persistent woody stems and without any defined main stem structure (Ford-Robertson, 1971 in Di Gregorio & Jansen, 2000).

iii. Woodlands: defined as perennial plants with stem(s) and branches from which buds and shoots develop (Ford-Robertson, 1971 in Di Gregorio & Jansen 2000).

iv. Forest: defined as perennial plants where trees cover more than 10 percent of the ground (Wright & Muller-Landau, 2006).

v. Trees: defined as woody perennial plants with a single, well defined stem carrying a more-or-less-defined crown (Ford-Robertson, 1971 in Di Gregorio & Jansen, 2000) and being at least 3 to 5 m tall (Di Gregorio & Jansen, 2000, p. 86 & Wright & Muller-Landau, 2006)

2.1.2 Global Climatic Characteristics

Climate is the average weather conditions in a particular location or region at a particular time of the year of at least 30 years. This includes the region's general pattern of weather conditions, seasons and weather extremes like hurricanes, droughts, or rainy periods. Two of the most important factors determining an area's climate are air temperature and precipitation. World biomes are controlled by climate. The climate of a region will determine what plants will grow there, and what animals will inhabit it. Hence, climate, plants and animals are interwoven to create a biome (Kulawardhana, 2008).

According to Pidwirny (2006), the Köppen system recognises five major climate types (Figure 2.2). Climate group A corresponds to Moist Tropical Climates that extend northward and southward from the equator to about 15 to 25° of latitude. In this type of climat,e all months should have average temperatures greater than 18°C and annual precipitation should be greater than 1500 mm. Based on the seasonal distribution of rainfall,l there are three minor climate types under climate group A: tropical wet, tropical monsoon, and tropical wet and dry; similarly, latitudinal extent, subgroup climate type, temperature and the amount of rainfall would define the other climate groups. B-Dry Climates have deficient precipitation during most of the year when potential evaporation and transpiration exceed precipitation; C-Humid Middle Latitude Climates have warm and humid summers with mild winter; D-Continental Climates have warm to cool summers, cold winters and the average temperature of the warmest month is greater than 10° C, while the coldest month is less than -3° C. Finally, E-Cold Climates have year-round cold temperatures with the warmest month less than 10° C and vegetation is dominated by mosses, lichens, dwarf trees and scattered woody shrubs.

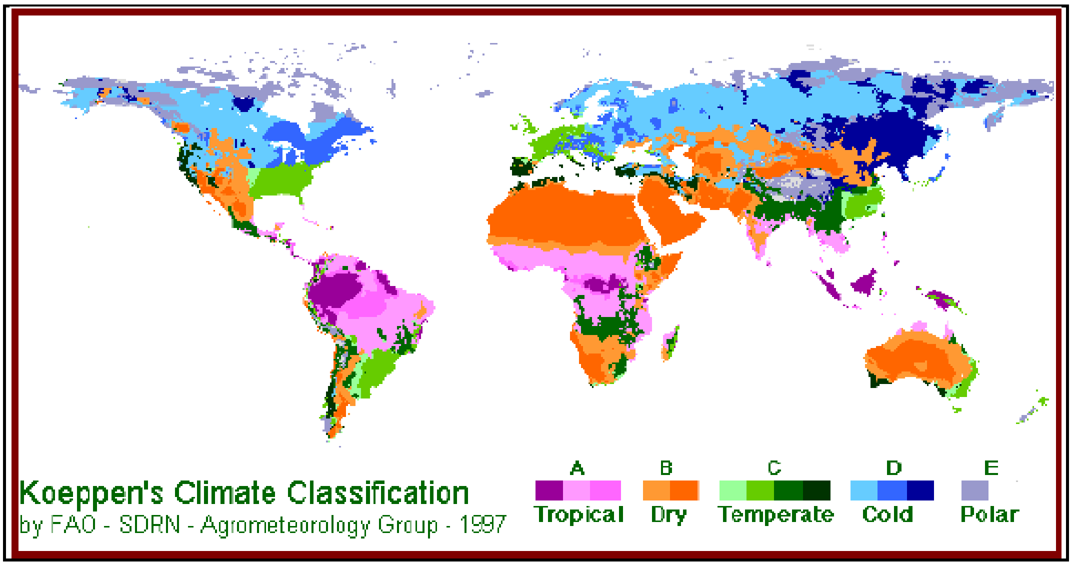


Figure 2.2: Global Köppen Climate Classification
Source: Benders-Hyde (2010)

2.1.3 Global Changes in Vegetation Parameters

The dynamic variability of climatic parameters can also have significant implications for the vegetation cover on earth. According to the (IPPC, 1996) second assessment report, a substantial elevation shift of ecosystems in the mountains and uplands of tropical Asia is expected with the changing climatic conditions. It also predicts that the changes in the distribution and health of rain forest and drier monsoon forests will be complex. These changes in the vegetation cover could be considered as one of the most sensitive indicators of climatic variability and could be used in monitoring the climate changes at different spatial scales. Hence, it is necessary to identify the different relationships that could exist among different climatic variables and vegetation dynamics. These relationships can have differences in their patterns as well as in magnitude at different spatial and temporal scales.

The effects of climate change on vegetation have been studied by numerous researchers. Justice, Townshend, Holben & Tucker (1985) clearly showed that the application of vegetation index provides unique insights on vegetation dynamics from regional to continental and global scales. Sarkar & Kafatos (2004) have shown that changes in vegetation in the Indian sub-continent are affected more by the local climatic prevailing in the region. They established changed in vegetations index as result of climatic variables reflected by the impacts of the 1982-1983 droughts over South and South East Asian countries. While, Malingreau (1986) reported the destruction of large area of the tropical forests of eastern Indonesia as result of drought and fire.

Sanchez-Azofeifi (1998) carried out a study on fragmentation and deforestation inside and outside protected areas in Serapigui region of Costa Rica. The findings revealed that deforestation rates were between 3.6 % and 3.2 % and the number of fragmentations increased from 537 % to 1,231 % in 1996 outside protected area. Pavel, Martin & Nadiya (2006) conducted a study to examine temporal responses of vegetation to climatic factors (precipitation and temperature) in Kazakhstan and Middle Asia from 1981 to 1998. The results indicated a strong correlation between NDVI and these two climatic parameters at inter-annual and within-seasonal scales. Temperature was found to be the leading climatic factors that controlled both inter annual and within-season NDVI dynamics. The results also indicated that response of vegetation to climatic factors increased in order from forest to semi-desert and steppe, to desert and shrubs vegetation. Farooq (2012) conducted a time-series study to detect changes in vegetation cover in the of District Sargodha, Pakistan. In that study, a multi-temporal Landsat ETM+ images and multi-spectral MODIS (Terra) EVI/NDVI data were utilised. The study indicated that the results can also be utilized as a temporal land use change model for Punjab province of Pakistan to quantify the extent and nature of change and assist in future prediction studies.

Wenbin, Aifeng & Shaofeng (2011) carried out a research on spatial distribution of vegetation and the influencing factors in Qaidam Basin, Beijing, China. Low vegetation coverage was observed in the basin. They cited precipitation, hydrological conditions, altitude and human activities as the four main factors that affected the spatial distribution of vegetation coverage in that Basin. Leilei, Jianrong & Yang (2014) conducted a study on the analysis of the spatial-temporal distribution of vegetation cover, land surface temperature, rainfall and their relationships in Tibet, China using the NDVI, land surface temperature from MODIS and rainfall from 2000 to 2011. Their result indicated that the correlation coefficient between vegetation index and the rainfall was the strong in September than in other months. It also showed that vegetation was influenced greater by the rainfall than land surface temperature from April to October in that area.

2. 1.4 Vegetation Characteristics of Nigeria

Adeyewa and Aweda (2011) stressed that the vegetation over a geographical area is essentially a response to the climate in that area. Thus, Nigeria's vegetation belts reflect this very close link with climate as evident the similarity in the west-to-east zonation of both the climate and the vegetation. With the south to north progressive decline in total rainfall and length of wet season, vegetation belts are demarcated on west-to-east zonation pattern, characterised by transitional zones from one belt to another. Nigeria consists of various vegetation belts with their specific characteristics in terms of variation of rainfall and vegetation properties Adeyewa and Aweda (2011).

A number of classifications of Nigerian vegetation have been published since the 1950s. The development of categories reflects changing perceptions of the significance and value of such classifications. Combined effects of temperature, humidity and rainfall, and particularly, the variations that occur in the rainfall that govern the natural vegetation zones exert a major influence on the types of indigenous plants that grow or the exotic types that can be introduced successfully into the country. However, Iloeje, (2001) grouped the country into (A) forests and (B) savannah zones. These two major zones were further sub-divided into three zones each such as (A) Forests that consist of: salt-water swamp; fresh-water swamp; high forest and (B) Savannah zone that consist of: guinea savannah; Sudan savannah and Sahel savannah (Figure 2.3).

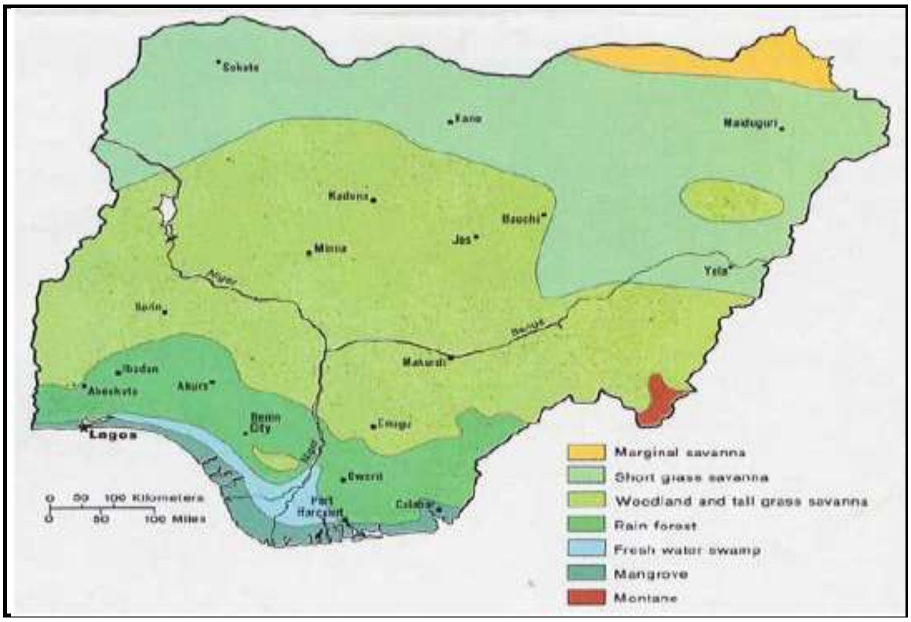


Figure 2.3: Vegetation Zones of Nigeria
Source: Federal Ministry of Environment of Nigeria (2003)

2. 1.5 Climatic Characteristics of Nigeria

Nigeria, by virtue of its location, enjoys a warm tropical climate with relatively high temperatures throughout the year and two seasons – the rainy or wet season lasts from mid- March – November in the south and from May to October in the north; and the dry season occupies the rest of the year (Iloeje, 2001). However, in a country like Nigeria, where the temperatures do not fluctuate regularly, constant elements such as relative humidity and rainfall heavily rely on differences between the season and climatic zones. The climate of the country is influenced by the interaction of two air masses: the relatively warm and moist tropical marine mass which originates over the Atlantic Ocean and it is associated with southwest winds in Nigeria, and the relatively cool, dry and relatively stable tropical continental air mass that originates from the Sahara Desert, and it is associated with the dry, cool and dusty North-East Trades (*harmattan*).

The seasonal pattern of the South differs from that of the North and the South has four seasons: the long wet season that starts in Mid-March and lasts till July is a season of heavy rains and high humidity. Plants and pasture are fresh and green, grasses and weeds grow rapidly and look attractive which is a planting season, the short dry season is the August break and it starts from July to August and lasts for about one month. The short wet season, which follows the August break and lasts from September to October, during this period rainfall is not usually heavy compared to the first wet season and the total amount of rainfall is less; the long dry or *harmattan* season which continues from November to mid-March, *harmattan* mornings are usually cool and misty, however the mist disappears after sunrise, the afternoons are full of haze due to dust in the air brought by winds from the North. At this period of the year grasses die off and leaves of some trees turn brown and later fall (Oyenuga, 1967 and Ileoje, 2001).

In the North, the long dry season starts earlier and ends later. There is nothing like the August break in the North (Iloeje, 2001). Hence, the two wet seasons become one. Therefore, two seasons are prominent – a long dry season spaning from October to April, and a wet season for the remaining five months. In the long dry season, there is lack of rainfall and the dry conditions that prevail cause cracks to develop on clay soils. However, this season is welcome because nights are cool and afternoon haze helps to wind off the sun’s heat. (Iloeje, 2001).

Rainfall varies from place to place and from season to season (Figure 2.4). In the wet season, the full effect of the tropical maritime air mass brings rainfall, while in the dry season the rainfall is less. The total annual rainfall decreases from the South to the North. The southern two-thirds of the country have double peak rainfall while the northern third has a single peak (Iloeje, 2001). July is the middle of the wet season and the relative humidity is usually high because of the warm wet air that prevails. Humidity is over 80% in the South and never goes below 60% in the North. Over 80 % of the rains fall within the wet months of April – September. In the South, the figure is above 70 % and in the North nearly 100 % of the rains are during these months (Iloeje, 2001).

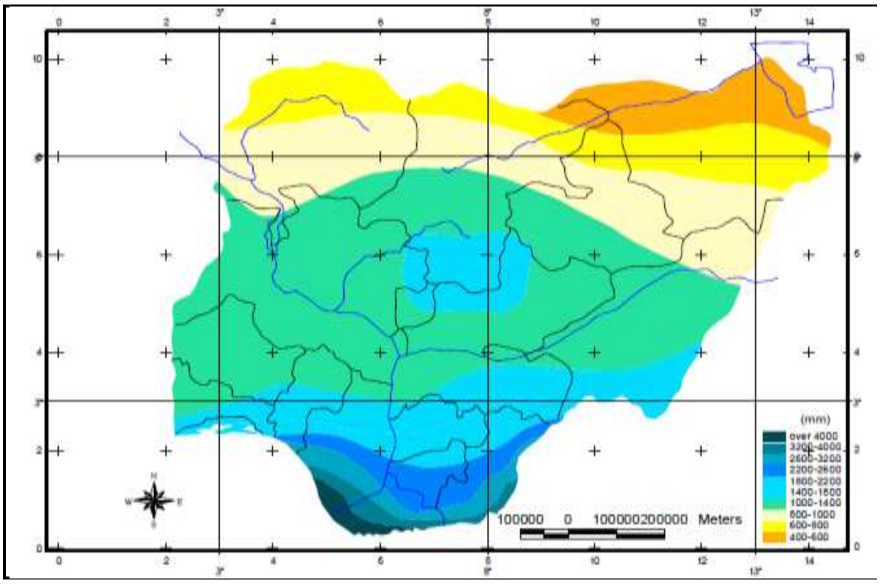


Figure 2.4: Spatial Variation of Annual Rainfall in Nigeria
Source: Federal Ministry of Environment of Nigeria (2003)

Temperature also varies from place to place and from season to season (Figure 2.5). It has been observed that there are considerable contrasts between the coastal areas and the interior, as well as between the high plateau and the lowlands. On the plateau, the mean annual temperature varies between 21^{o} C and 27^{o} C. In the Jos area, temperatures are between 20^{o} C and 25^{o} C. On the lowlands such as the Sokoto Plains, the Chad Basin and the Niger- Benue lowlands, the mean annual temperature is 27^{o} C. The coastal fringes have lower means than the interior. It appears therefore that altitude and proximity to the seas determine to a large extent the distribution of the temperature in Nigeria. Generally, temperatures are high throughout the year because

Nigeria lies within the tropics and the mean monthly figure could go above 27^{o}C, while daily maximum temperatures can go between beyond 35^o C – 38^o C depending on the location (Iloeje, 2001). There is hardly any dry season in the extreme southern tip of the country. The wet season hardly lasts for more than three months in the north-eastern part. Similarly annual rainfall totals range from 2 500 mm in the south to less than 400 mm in parts of the extreme North (Federal Ministry of Environment of Nigeria, 2001)

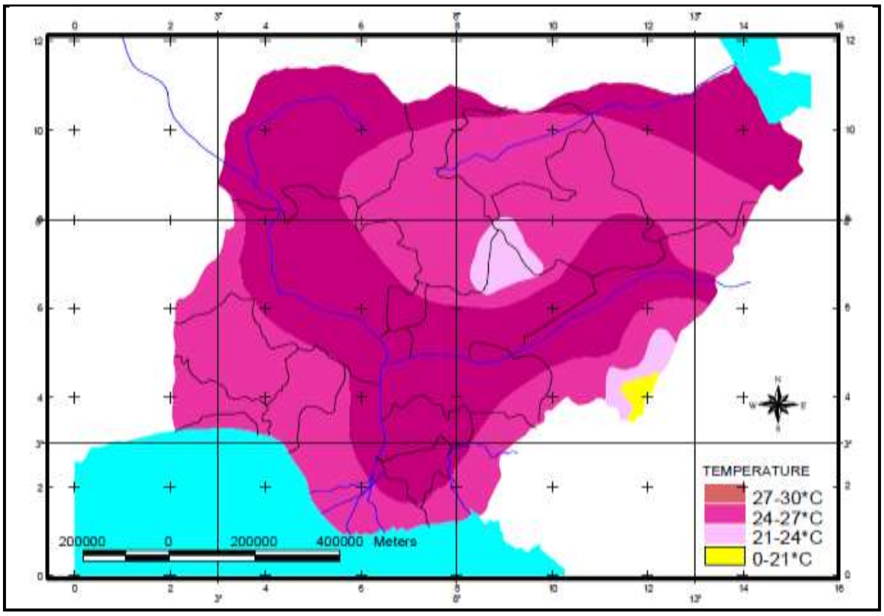


Figure 2.5: Spatial Variation of Mean Annual Temperature in Nigeria
Source: Federal Ministry of Environment of Nigeria (2003)

2.1. 6 Changes in Vegetation Characteristics in Nigeria

Generally, vegetation is highly sensitive to the behaviour of the prevailing temperature and rainfall of any area as these elements are necessary for the growth and development of plants. For example, more frequent and prolonged drought and the expanding desertification are being experienced in the Sahel Savanna regions of Nigeria and Africa as a whole due to rising temperatures and reduction in rainfall (NEST, 1991; Tegen & Fung, 1995; Goudie, 2002, and Obioha, 2005). Similarly, Ati, Stigter, Eguisi and Afolayan (2009) reported a significant increase in the rainfall over nine stations in northern Nigeria between 1953 and 2002. The results showed a general decline of dry season′s contribution to annual rainfall i.e. dry period is getting drier. Equally, the reduction of rain-days and rainfall in some parts of Northern Nigeria is threatening food production in the area (Umar, 2010). Madu & Ayogu (2010) showed that rainfall variability accounts for 70% of variation in crop production in Northern Nigeria.

Similarly, Oguntunde, Abiodun & Lischeid (2011) analyzed rainfall trends over Nigeria using 1901–2002 rainfall data from Global Gridded Climatology of Climate Research Unit Time series (CRU TS.2.1). It was concluded that the annual rainfall has been reduced significantly over 20% of the landscape and the amount of annual rainfall reduced by 50–350 mm in 64 % portion of the landscape of Nigeria. Chima, Ijioma, Nwagbara & Nwaugo (2004) examined the extent of vegetation response to decadal variations of temperature and rainfall over Northern Nigeria using mean statistical technique. The results showed compelling evidence that the vegetation is sensitive to the decadal variations of temperature and rainfall during the period of the study. Gadiga, Adesina & Orimoogunje (2007) carried out a study on spatial-temporal analysis of vegetation dynamics in Yobe State (a Semi-Arid Belt of Nigeria). Findings showed a significant relationship ($p < 0.05$) between rainfall and NDVI while the other vegetation indices showed no significant relationships ($p > 0.05$) in the period spanning between 1972 and 2007. This showed that rainfall is not the major determinant of vegetation cover dynamics in the study area in spite of increase in the rainfall between 1972 and 2007. It thus, appears that other factors like human activities might have influenced the changes in the vegetation cover in that area. On the other hand, Usman, Yelwa & Gulumbe (2012) assessed the vegetation cover changes across Northern Nigeria using trend line and principal component analysis using NDVI from NOAA-AVHRR and AQUA/MODIS-NDVI dataset from 1981 to 2010 so as to assess. Findings identified some underlying negative and positive trends in NDVI vegetation productivity across the study area as a result of both climatic and anthropogenic factors. In general thoughts, Nigerian forest cover has consistently declined since the 1990s, at an average of -410,000 hectares (ha) per annum (FAO, 2009a). Table 2.2 shows that Nigeria is among the top five countries in the world with the largest net loss of forest areas since 1990.

Table 2.1: Ten Countries with Largest Annual Net Loss of Forest Area, 1990-2010

Country	Annual change 1990–2000		Country	Annual change 2000–2010	
	1 000 ha/yr	%		1 000 ha/yr	%
Brazil	-2 890	-0.51	Brazil	-2 642	-0.49
Indonesia	-1 914	-1.75	Australia	-562	-0.37
Sudan	-589	-0.8	Indonesia	-498	-0.51
Myanmar	-435	-1.17	Nigeria	-410	-3.67
Nigeria	-410	-2.68	U. R. Tanzania	-403	-1.13
U. R. Tanzania	-403	-1.02	Zimbabwe	-327	-1.88
Mexico	-354	-0.52	D. R. Congo	-311	-0.2
Zimbabwe	-327	-1.58	Myanmar	-310	-0.93
D. R. Congo	-311	-0.2	Bolivia	-290	-0.49
Argentina	-293	-0.88	Venezuela	-288	-0.6
Total	-7 926	-0.71	Total	-6 040	-0.53

Source: FAO (2010)

2.1.7 Application of Remote Sensing (RS) in vegetation change detection

There is the need for frequent study of land cover change in the developing countries using Remote Sensing (RS) due to their continually changing vegetation patterns as a result of deforestation (Nelson & Geoghegan, 2002 & FAO, 2010). Through such studies, priority locations that require urgent intervention can be identified and effectively managed. For example, Helldén and Tottrup (2008) use the National Oceanic Atmospheric Administration's (NOAA) Normalized Difference Vegetation Index (NDVI) Global Inventory Modelling and Mapping Studies (GIMMS) data from July 1981 to December 2003 that were generated from Advanced Very High Resolution Radiometer (AVHRR) to show that the forest areas of most arid zones of the world are not decreasing, but rather increasing. Although the resolution of the sensor they used in their study is quite large and may not necessarily be optional for the study of forest change, especially at local level, their results yielded new findings at the regional level. For example, the southern Sahel regions, previously regarded as a fragile area in terms of land degradation (deforestation) have recorded an increase in vegetation cover over the period of twenty two years. However, whether this increase was the result of natural regeneration or re-afforestation programmes were not demonstrated (FAO, 2010).

While the study of land cover is progressing in most developing countries, such studies in Nigeria are regarded as inconsistent and insufficient compare d to the country's needs (Okude, 2006, cited in Ademiluyi et al., 2008). For example, the first comprehensive land cover and land use map of Nigeria, which constitutes the only national database of the country's forest environment using RS techniques, is the Nigerian Radar project (NIRAD). This project was conducted between 1976 and 1978 using a RADAR sensor (sideways-looking airborne radar) (Parry & Trevett, 1979). The project faced criticism after the submission of the report (Blair-Rains et al., 1979). These criticisms included the choice of sensor for the project, overlaps between land use and land cover classification and the scale (1:250,000) at which the final map was produced. The second most comprehensive land use/land cover inventory project conducted in Nigeria after the NIRAD project was carried out by the FORMECU in 1996 (Ademiluyi et al., 2008 The task was accomplished using different sensors, such as AVHRR, Satellite Pour l'Observation de la Terre (SPOT), Landsat- Multispectral Scanner (MSS), Thematic Mapper (TM) and Enhanced Thematic Mapper Plus (ETM+), European Remote Sensing Satellite 1 (ERS-1 RADAR), Japanese Earth Resources Satellite 1 (JERS-1 RADAR) and NOAA. The project faced similar criticisms to that of the NIRAD project. Therefore, the NIRAD project still remains the most comprehensive land cover inventory ever undertaken in Nigeria using RS.

The incorporation of RS in the study of forest change has improved the way information about forest extraction (Olsson, 1985). As such, RS application in the area of vegetation cover inventories have proven to be important in recent times (Chowdhury, Ademiluyi, Okude & Akanni, 2008), with most applications aiming at monitoring environmental performance (Innes and Koch, 1998). RS sensors such as Advanced Very High Resolution Radiometer (AVHRR), Satellite Pour l'Observation de la Terre (SPOT), Landsat- Multispectral Scanner (MSS), Thematic Mapper (TM) and Enhanced Thematic Mapper Plus (ETM+) and RADAR have been used to monitor forest conditions in terms of land cover richness and vegetation clustering with great success in many parts of the world. Some of the qualities of the RS as a means of extracting information as reported by Chowdhury (2006) and Sader and Legaard (2008) are briefly highlighted below.

The RS data can provide information on the spatial organisation and structural elements of the landscape across a large area far greater than could be provided by ground assessment alone. In addition, the assessment of the structure and spatial organization of landscapes is much faster and geographically more accurate when analysed by the RS rather than ground survey alone. Innes and Koch (1998) showed that the RS methods can effectively provide the necessary information on land cover characteristics across large areas. In this study, Landsat satellite imageries (MSS and OLI) and SPOT-NDVI were used to assess spatio-temporal variation of vegetation cover and its relationship with rainfall in Bauchi state. This study adopted Landsat and SPOT/NDVI because they are the only available data to the researcher despite other alternative RS data.

2.2 LITERATURE REVIEW

Quite a number of studies have been carried out by many researchers on finding the practical method for analyzing and assessing the effect of climatic variables and human activities on spatio temporal distribution of vegetation covers. However, some of these studies were based on Normalized Difference Vegetation Index (NDVI) with weather parameters. This present study has adopted a conceptual framework that link weather parameters (rainfall and temperature) human activities and spatio-temporal distribution of vegetation cover in Bauchi State, Nigeria. From these references there is much evidence from vegetation studies that weather parameters and human activities have pervasive influence on change and distribution of vegetation (Hirosawa et al., 1993; Yang, 2001 and Hall-bayer, 2003)

2.2.1 Vegetation Trend

Kiprotich (2016) assessed the effects of human activities on the density of forest cover in Chepalungu forest of Kenya, the findings revealed a significant decreased in forest cover due to human activities such as tree cutting and trampling from 1985 to 2010. A similar research by Unanaonwi and Amonum (2014) revealed that, changes in the tropical forest resulted to negative implication on the Environmental and Socio-economic activities of people in tropical environment. Babatunde, Christine & Pierre (2014) assessed trends in vegetation dynamics in the Guinea savannah region of Nigeria. Finding revealed a significant relationship between vegetation greenness and rainfall distribution across the study period (1983 to 2011), the results further, reported an increase in the vegetation greenness in the study area for the period of study. Jibrin (2009) assessed vegetation cover change in Kpashimi forest reserve in Nigeria between 2001to 2007 using satellite imageries. The finding revealed a significant shrinking in the savanna woodland with an annual rate of change (-2.8%) and Riparian forest with annual rate of change (-2.1%) with a corresponding expansion in degraded forest, Bare surface and scrubland classes.

2. 2.2 Relationships between Vegetation and Climatic Variables

Many studies have established relationships between different climatic variables and vegetation characteristics. For examples, these relationships could vary at different regions across the world as Shukla (1975) has shown that the influence of the sea surface temperature (SST) over the Arabian Sea has been an important factor for explaining the changes in the summer monsoon circulation and rainfall over India. According to Sarkar and Kafatos (2004), the monsoon precipitation and land surface temperature over the Indian sub-continent land mass have significant impact on the distribution of vegetation. Their findings showed that the local climate anomaly is seen to be more effective in determining the vegetation change than any global teleconnection effects.

Belda and Melia (2000) on the other hand studied the relationships between NDVI and rainfall over different zones in China. It was observed that the levels of correlations between the NDVI and the rainfall were relatively low in areas with high rainfall. However, Wang, Price & Rich (2003) studied the relationship between NDVI and rainfall for different vegetation types over the central Great Plains in USA for the period of 1989 to 1997. They study found out that highest correlation coefficient between NDVI and rainfall in for dry years and relatively low correlation coefficient for the wet years. Similar findings have been reported by Malingreau (1986), Hess, Stephens & Thomas (1996), Bayarjargal, Adyasuren & Munkhtuya (2002). Both studies cited variations in the agro-ecological zones, the rainfall availability and the length of dry periods as the cause of differences in the relationships.

Many researchers have studied the relationships between NDVI and rainfall. For example, Justice, Townshend, Holben and Tucker (1985) clearly indicated that the application of the vegetation index approach provides unique insights on vegetation dynamics from regional to continental and global scales. Cihlar, Laurent and Dyer (1991) observed that, NDVI well correlated with the physical climate variables including rainfall, temperature and evapotranspiration in a wide range of environmental conditions. Similarly, different studies have been undertaken over a wide range of temporal and spatial scales and therefore have established different relationships among the NDVI and climatic variables that could exist under a variety of environmental conditions (Plessis, 1999; Belda & Melia, 2000; Hess, Stephens & Thomas, 1996; Cihla, Laurent & Dyer, 1991; Foody, 2003; Wang, Price & Rich, 2003; Li, Tao & Dawson, 2002; Grist & Nicholson, 1997; Eklundh, 1998). The findings of studies by Wang, Price & Rich (2003), Grist & Nicholson (1997) varied. Both studies established strong positive relationship between NDVI and rainfall.

Similarly, Nicholson, Davenport & Malo (1990) established positive relationship between NDVI and climate parameters (rainfall and temperature) in their studies. While Zhong, Ma, Salama &Su (2010) found negative between NDVI and climate parameters (rainfall and temperature) because of geographical position, geomorphology, vegetation type, climatic condition of the area of their study. Chima (2011) also conducted a study to examine the extent vegetation has responded to decadal variations in temperature and rainfall over Northern Nigeria from 1971 t0 2004. Results obtained showed a compelling evidence that the vegetation of Northern Nigeria is sensitive to the decadal variations recorded in the region's temperature and rainfall during the period studied

2.2.3 Effects of Anthropogenic Activities on Vegetation

Globally, land cover today is altered primarily by direct human use (Yang, 2001). Any conceptualization of global change must include the pervasive influence of human action on land surface conditions and processes (Yang, 2001). Boakye, Odai, Adjei & Annor (2008) explained that vegetation changes are often the result of anthropogenic pressure (e.g. population growth) and natural factors such as variability in climate. Due to increasing population growth rates, there have been increasing rates of conversion of forest and woodlands in developing economies all over the world, mainly for the slash-and-burn farming practice (Groten, Immerzeel & Leeuwen, 1999).

Harvesting and unregulated exploitation of forest products have been major factors of changes in species composition and distribution of forest vegetation (Colombo, Cherry & Graham 1998). FAO (2007) estimated that 1.5 billion of the 2 billion people worldwide who rely on fuel wood for cooking and heating are overcutting forests. This problem is worst in drier regions of the tropics (FAO, 2007). Wood is the major source of fuel for domestic cooking for nearly half of the world's population, and as they are removed, the forest vegetatively undergoes alteration. In some parts of West Africa, availability of fuel wood is an essential element in community welfare

(Nwoboshi, 2002). According to FAO (2007), more than 90% of the trees cut in Africa are burnt as firewood. Cline-Cole (1994) observed that the fuel wood - human needs relation does impede forest conservation/protection and gradually alters the composition of the forest vegetation. Apart from domestic fuel demand in Africa, Fairhead & Leach (1997) reported that the highest cause of forest and tree depletion in the region, resulting in vast changes in vegetation composition is timber export to the Western countries. Geist and Lambin (2002) also stressed that agricultural activities and expansion, infrastructural extension and wood extraction are the proximate causes of change common to tropical deforestation

Adeola *et al* (2004) and Madulu (2004) stressed that the rapid population growth is the major cause of much vegetation resource degradation especially in developing countries like Nigeria. Myers, (1988) stressed that, the rate of vegetation destruction and change in Benue State, Nigeria is considerable due to rapid population growth and land use change. Also, Adeola *et al* (2004) opined that the vegetation in Nigeria illustrate the apparent effect of farming activities resulting in the modification of the original vegetation while some vegetation resources such as wildlife have gone to extinct.

Similarly, NEST (1991) indicated that over 350,000 ha of the vegetation in Nigeria is being lost annually due to farming alone. The evidence above presents significant and direct role of human activities culminating into vegetation change. It has also been established by SIGWA (2001) that the highest rates of vegetation modification in the State occur mostly on forest lands for subsistence and heavy dependence in shifting agriculture. Myers (1989) and Daniel & Ayobami (2007) assessed changes in the land use/land cover in some parts of South-Western Nigeria over a 16- year. The result indicated that disturbed/degraded forest constituted the most extensive type of land use/land cover in the study area. The increasing population and economic activities were noted to be putting pressure on the available land resources. It was also observed that 98.3% and 63.3% of the area covered with high forest in Ikeji forest reserve and Akure forest reserve respectively were converted to scrublands/farmlands complex over the period of 16 years. Musa and Jiya (2011) carried out an assessment of mining activities impact on the vegetation in Bukuru Jos, Plateau State, Nigeria from 1986 t0 2017. The study revealed a declined in vegetated surface in the area is as a result of the intensive mining and the cultivation.

Garba, Babanyara, Ibrahim & Isah (2013) assessed the impact of anthropogenic activities on the land cover in Guinea Savannah region of Nigeria using multi-temporal Landsat data of 1986, 1999 and 2006. The study established a decline in the natural vegetation from 308,941.48 hectares in 1986 to 278,061.21 in 1999 and then to 199,647.81 in 2006. It also showed that cultivated area increased from 259, 346.80 hectares in 1986 to 312,966.27 hectares in 1999 and then to 341.719.92 hectares in 2006. In addition, it revealed a gradual increase of built up areas and bare surface due to the reduction in vegetative cover.

Naibbi (2013) conducted a study on fuel wood and vegetation change in Northern Nigeria, using multiple methodologies of Remote Sensing (RS), Geographical Information Systems (GIS) and a local survey (household survey, focus group discussion and participant observation). Results indicated that the vegetation of the area has drastically reduced since 1970s especially in the year 1978 to 1984 and 1987 to 1999 by 20.7% and 17.8% respectively. Similarly, it showed that fuel wood collection is the major factor of deforestation, mainly due to lack of alternative energy sources in the region.

CHAPTER THREE

STUDY AREA AND METHODOLOGY

3.1 Study Area

3.1.1 Location and Size

Bauchi is bounded by latitudes 9° 30' - 12° 30' N and longitudes 8° 50' - 11° 0' E which marks the points of longest and widest stretches of the state (Figure 3.1). The State occupies a total land area of 49,119 km² representing about 5.3 % of Nigeria's total land mass (BASEED, 2005). The State has an estimated population of 4,676,465 million people and a growth rate of 3.0 % (National Population Commission, 2006), with economic active population constituting 41.2%. About 84% of the population lives in the rural areas, while 75-80 % of the inhabitants engage in farming. The state is bordered by seven states, Kano and Jigawa to the north, Taraba and Plateau to the south, Gombe and Yobe to the east and Kaduna to the west. The state is located in the North-Eastern part of Nigeria (with Bauchi as the capital)i. The state was formed in 1976 when the former North-Eastern State was broken up. It originally included the area now in Gombe State, which became a distinct state in 1996. (Bauchi State Government, BASG, 2012).

During the colonial era up till independence, it formed part of the Bauchi Plateau of the then Northern Region, until the 1967 state creation exercise when Bauchi, Borno, and Adamawa provinces constituted the former North-Eastern State. With the creation of Bauchi State in 1976, comprising present Bauchi and Gombe States, it included 16 local government areas. The number increased to 20 and later to 23. However, in 1996 when Gombe State was created out of Bauchi and additional local governments created in the country, Bauchi State was left with 20 local Governments (BASG), 2012).

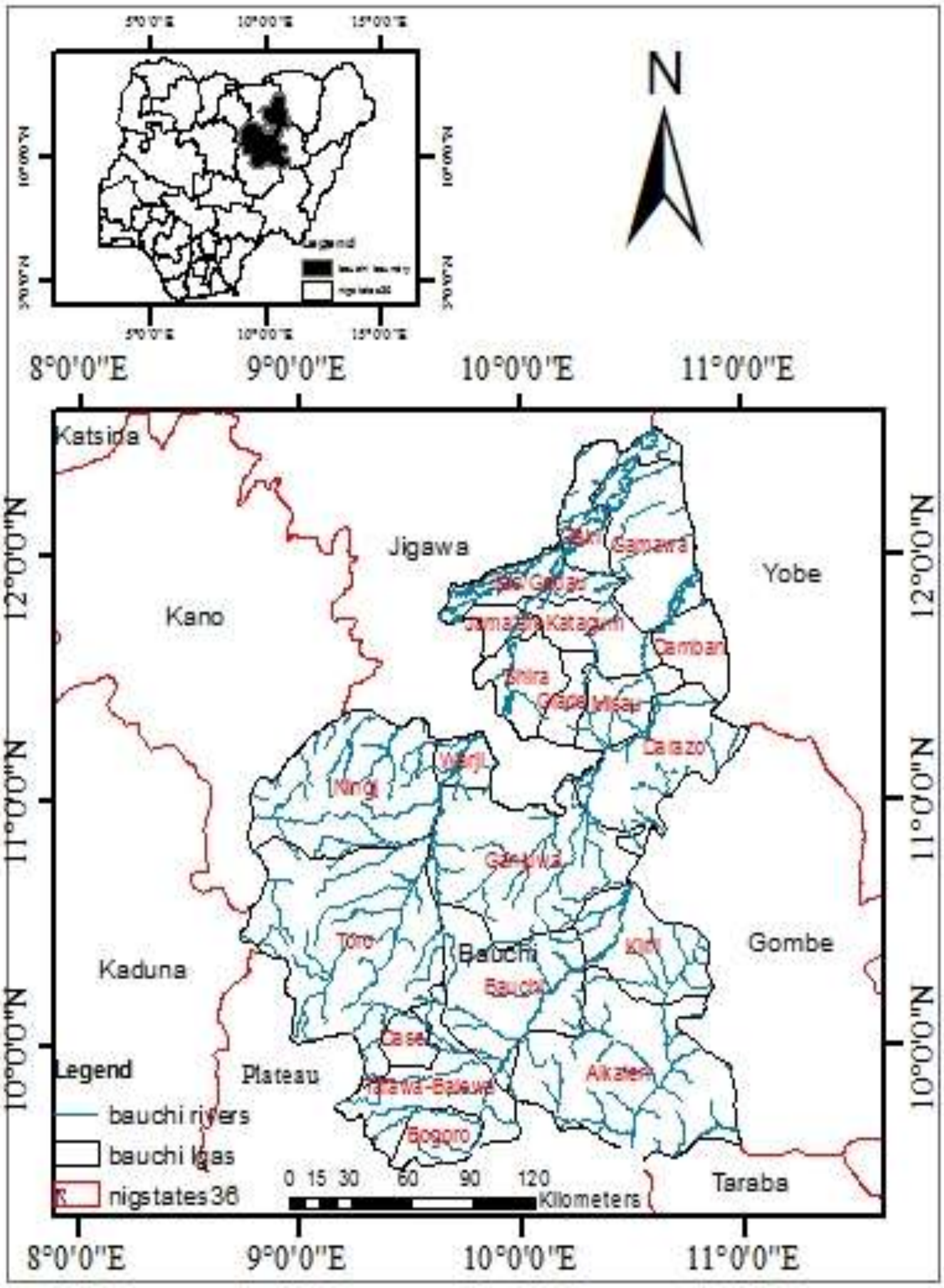


Figure: 3.1 Study Area

Source: GIS Lab. Dept of Geography and Environmental Mgt. ABU, Zaria

3.1.2 Vegetation

Bauchi state is one of the states in the northern part of Nigeria characterized by two distinctive vegetation zones: the Sudan Savannah in the North and the Guinea Savannah in the South. Generally, the vegetation gets richer and richer towards the south but less uniform and grasses are shorter than what grows even further south, that is, in the forest zone of the middle belt. The Sudan type of savannah becomes manifest from the middle of the state as one moves from south to the northern part of the state. The vegetation types composed of scattered trees, shrubs and flat lying grasses (BASG, 2012).

The vegetation pattern is conditioned by climatic factors. For instance, the rainfall in the study area ranges between 700 mm per annum in the extreme north and 1300 mm per annum in the south. The pattern is because in the West Africa sub-region, rains generally come from the south as influenced by the south -westerlies. There is therefore a progressive dryness towards the North, culminating in desert condition in the far North (BASG, 2012). The vegetation is deeply degraded and depleted as a result of Agricultural activities, firewood extractions and population explosion in the study area (BASG, 2012). Agricultural activities have reduced the vegetation to less than 1% of the total land area of 66,00 km^2 and woodland have declined from 14754 km^2 between 1976/78 and 1993/95 (FOEMECU, 1998).

During the rainy season, the whole zone is green and covered with tall grasses that grow and reach maturity rapidly and thus become fibrous and tough. In the dry season they tend to die and disappear and one can see for kilometres. This clearing is due to several periodical bush-burning that occurs during the dry season between November and April, carried out to either assist in farm clearance or hunting (Saleh, 2010).

The trees species found in the area include: *Adansonia digitata* (Baobab tree; Kuka), *Mangifera indica* (Mongo tree; Mongoro), *Parkia biglobosa* (Locust beans tree; Dorawa), *Tamarindus indica* (Tamarind tree; Tsamiya), *Azadiracta indica* (Neam tree; Darbejiya), *Faidherbia albida (*Winter thorn; Gawo), *Diospyros mespilifomis* (Monkey guava; Gwaban Biri).*Cajanus cajan* (Pigeon pea; Aduwa), *Anogeissus leiocarpus* (chewstic tree; Marke), *Vitex doniana* (Black plum; Dinya), *Ziziphus sapina-chrioti* (Christ thorn; Kurna), (Horse redish; Zogale), *Diospyros mespiplformis* (West africa ebony; Kanya). The Shrubs are: *Piliostigma reticulatum* (Dafo), *Ziziphus mauritiana* (Jujubr; Magarya), *Jatropha curcas* (Bini da Zugu), and the Grasses are: *Hyphaena thebaica* (Young dunb palm; Kaba), *Dactyloctenium aegyptium* (Yabururu), *Alysicarpus vaginalis* (Gadagi), *Andropogangayanus* (Gamba grass; Gamba), *Leonotis spp* (Thief head; Kan barawo)

3.1.3 Climate

According to the Köppen Climate Classification system, Bauchi has a tropical savanna climate, abbreviated "Aw" on climatic maps. The rainy season months are May to September, when humidity ranges from 37% to 68%. Monthly rainfall ranges from 0.0 mm in December and January, to about 343 mm in July. Onset of rain is often in April but it ends virtually by October. However, the time of start and end of rainfall and its distribution have been affected by climate change.

Consequently, rains start earlier in the southern part of the state, where rain is heavier and longer in duration. Here the rains start in April with the highest record amount of 1300 mm per annum. In contrast, the northern part of the state receives rains late, usually around June or July, and records the highest amount of 700 mm per annum. In the same vein, the weather experienced in the South and North varies considerably.

While it is humidly hot during the early part of the rainy season in the South, the hot, dry and dusty weather lingers up north. The mean daily maximum temperature ranges from 27^{o} C to 29^{o} C between July and August and 37.6^{o} C in March and April. The mean daily minimum ranges from 22.0^{o} C in December and January to about 24.7^{o} C in April and May (Saleh, 2010). The sunshine hours ranges from about 5.1 hours in July to about 8.9 hours in November. October to February usually record the longest sunshine hours in Bauchi. The humidity ranges from about 12% in February to about 68% in August (Saleh, 2010).

3.1.4 Relief and Drainage

The study area is drained by river Gongola which originates in the Jos Plateau area and river Jama'are. The Gongola River crosses the study area in Tafawa-Balewa Local Government Area in the south and in Kirfi and Alkaleri Local Government Areas in the eastern part of the study area. River Gongola and its tributaries are of great importance to the study area; for instance, the impounding of Gubi to provide pipe-borne water. A substantial part of Hadeja-Jama'are River basin cuts across a number of local Government areas in the northern part of the study area, its floodplain provides land for irrigation activities. The rivers are further supported by the number of dams meant for irrigation and other purposes. These include the Gubi and Tilden-Fulani dams. There are also lakes such as the Maladumba Lake in Misau Local Government Area that further provides the necessary conditions to support agriculture. The study area generally lies at an altitude of 600m above sea level of the central Nigeria highlands and Jos plateau complex. The base of the hills ranges at 600m level, while rise to 700.6m on the peak, and 729.3m on the Bunsil hills. Also, isolated hills punctuated the high plain in several places in the study area, and reach heights of 798.5m on the Lamurde hills and 816.4m on Ligri hills. Most of the isolated hills in the study area are above 760m (Saleh, 2010).

3.1.5 Geology and Soil

The study area is basically composed of crystalline rocks in the basement complex of Nigeria, mostly Precambrian in age. The rocks include the mixture of granites, gneisses, pegmatite and some amount of charnokite at the margin around the area. Granites are coarse grained and are composed of quartz, alkali, feldspar, biotite and muscovite with ancestry hornblende and hematite. Pegmatite veins within the gneisess are composed of potash feldspar and very large crystal may form. A charnokiti rock occurs around the margin where it forms small outcrops. Crystalline rocks underlie the western part of the study area; the rest is Cretaceous to Recent sediments with rare volcanic. Migmatites and gneisses are intruded by Older Granite suite rocks (foliated porphyritic granites and bauchites) and Younger Granite suite rocks. (Modibbo and Sumi, 2014).

The east and north-east of the study area belong to the Benue and Gongola Cretaceous rift system and consist of folded marine and continental sequences. A central belt of unfolded Tertiary continental sediments overlaps both crystalline and Cretaceous rocks. In the north, the Quarternary lacustrine sediments overlap crystalline and Tertiary rocks. The study area is also made up of shallow soil such as sandy, clay, and loamy soil in iron pan, underlined by crystalline rocks, hills, mountains, which consist of rock elements on slope of hills and mountains. Its vast fertile soil supports cultivation of crops such as maize, rice, millet, ground-nut, guinea corn (Modibbo and Sumi, 2014).

3.2 Methodology

This Section describes the methodological approach to the study of spatio- temporal changes of vegetation cover. Figure 3.2 shows the flow chart illustrating the research design adopted for this study. It describes the type and sources of data need\8ed, Sample Size and Sampling Technique, data processing and method of data analysis.

3.2.1 Reconnaissance

For the purpose of this study, a reconnaissance survey was carried out. The main objective of the visit was to be familiar and acquainted with the study area in term of geographical landscape. It helped to identify the nature of the vegetation cover and verify orally how it was in the 1970s. It also served as a guide for the selection of the training sites and the method of classification scheme to be adopted for the study.

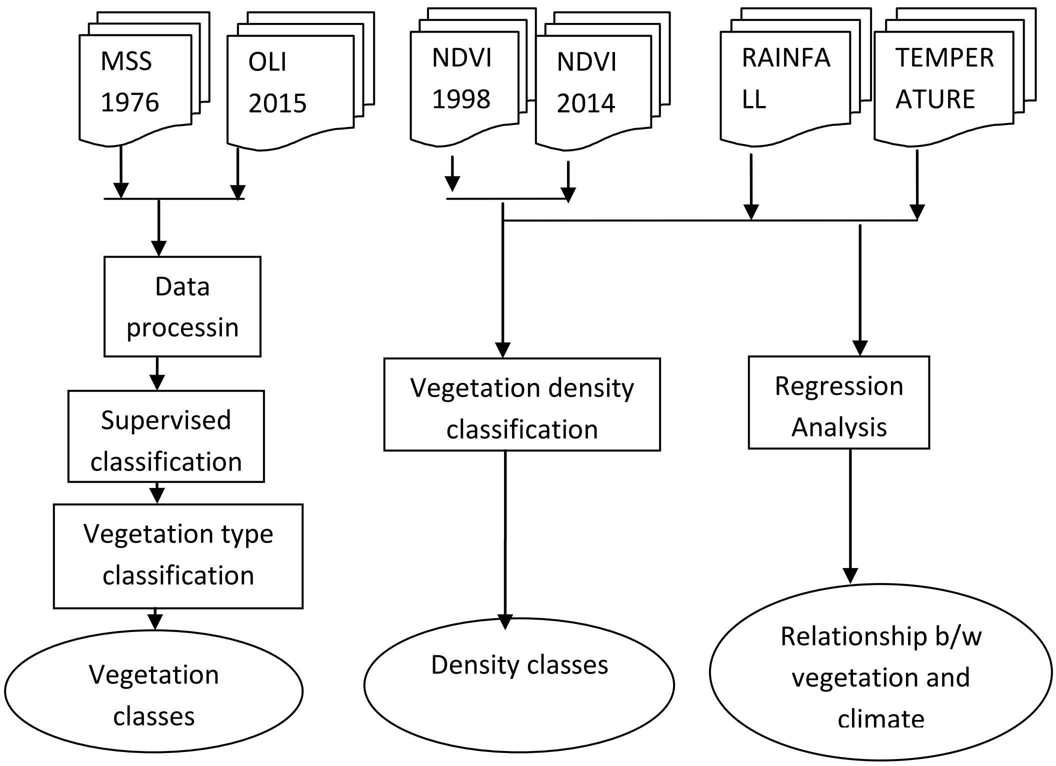


Figure 3.2: Flow chart of Research Design
Source: Authors Compilation

3.2.2 Materials and Methods

3.2.1.1 Types and Sources of Data

Both primary and secondary data were used in this study to achieve the aim and objectives earlier outlined. The types, sources, resolution and uses of data required for this study are summarised in Table 3.1.

Table 3.1: Characteristics of Data

S/N	Data	Resolution	Source	Use
1.	Landsat Multispectral Scanner (1976)	80m	USGS	Vegetation types classification
2.	Landsat Operational Land Imager (2015)	30m	USGS	Vegetation types classification
3.	SPOT-NDVI (1998) True color composite	8km	GIMMS/ NDVI3g	Vegetation density classification
4.	SPOT-NDVI (2006) True color composite	8km	GIMMS/ NDVI3g	Vegetation density classification
5.	SPOT-NDVI (2014) True color composite	8km	GIMMS/ NDVI3g	Vegetation density classification
6.	Bauchi State Veg. Map (1978)	-	Bauchi State Min. of Land and Survey	Selection of Training Class
7.	Rainfall and Tempt.	-	NIMET Bauchi	Relationship with NDVI
8.	Human activities on vegetation cover changes (1976 to 2015)	-	Questionnaire	Examine effects of human activities on vegetation cover changes

Source: Author's compilation, 2015

3.2.3 Sample size and Sampling Technique

The twenty (20) Local Governments Areas (LGAs) in the study area formed the sample frame for this study. In each LGA the study considered age and years of respondents' residency in the area. Purposive sampling through random sampling technique was used to select respondents that can better identify the human activities that affect vegetation cover changes in that area. The State population figure of 2006 (4,676,465) was used to determine the sample size for this study. The population of each LGA was computed and projected to 2015 refer to Table 3.2, using an exponential method with 3.0% growth rate for Bauchi State (NPC,2006).

$P_n = P_i \left(1 + \frac{r}{100}\right)^{en}$

Where:

P_n=Population at the future date (2015)

P_i= Base year population (2006)

e = exponential sign

r = growth rate (3.0%)

n = interval between the base year and future year (10 years)

Yamane (1967) formula was used to determine the sample size with 95% for the entire study area confidence level and 5% sampling error assumption. The formula is stated as:

$$n = \frac{N}{1 + N(e)^2}$$

Where:

n = Sample size,

N = Population size

e = Sample error (set at 0.05 significant level for this study)

Thus, the sample size for questionnaire administration for this research is 400 respondents.

In determining the sample size for each LGA as seen in Table 3.2, Yamane (1967) formular for determining sample size was used. It is given as:

Sample Size per Local Government

$$= \frac{\text{Local Government Population x Sample Size}}{\text{Local Government Total Population}}$$

Table 3.2: Population of the study area and Sample Size

S/N	Local Government	Population (2006)	Projected Population (2015)	Sample Size (No. of Respondents)
1.	Alkaleri	329,424	442,718	28
2.	Bauchi	493,810	663,639	42
3.	Bogoro	84,215	113,178	07
4.	Dambam	150,922	202,827	13
5.	Darazo	251,597	338,125	22
6.	Dass	89,943	120,876	08
7.	Gamawa	286,388	384,882	24
8..	Ganjuwa	280,468	376,926	24
9.	Giade	156,969	210,873	13
10.	Itas-Gadau	229,996	309,089	20
11.	Jama'are	117,883	158,425	10
12.	Katagum	295,970	397,759	25
13.	Kirfi	147,618	198,386	13
14.	Misau	263,487	219,713	23
15.	Ningi	387,192	520,354	33
16.	Shira	234,014	314,495	20
17.	Tafawa- Balewa	219,988	295,645	19
18.	Toro	350,404	470,914	30
19.	Warji	114,720	154,174	10
20.	Zaki	191,457	257,302	16
	Total	4,676,465	6,284,778	400

Source: Adopted and Modified from (National Population Commission, 2006)

3.2.4 Data Preprocessing

Landsat Multispectral Scanner (1976) and Landsat Operational Land Imager (2015) were downloaded from United State Geological Survey (USGS) archive covering five path and row namely: 187 051, 187 052, 187 053, 188 052 and imported into Arc GIS 10.1 environment on band by band basis. Null covers of the imageries were removed using raster calculator and re-class tool and then mosaiced using mosaic tool in ArcGIS 10.1. Then a true color composite was created from the satellite imageries.

3.2.4.1 *Image Sub- setting*

The study area was sub-set from the mosaiced data set using extract by mask sub menu of spatial analyst tools.

3.2.5 Image Classification

The two (2) image classification methods employed in this study are: supervised classification, and the NDVI differencing method. The two classifications were implemented at a certain stage of analysis. The supervised classification was conducted on the landsat MSS 1976 and OIL 2015 respectively by classifying the imageries into various land cover classes while, the NDVI differencing method was applied on the SPOT-NDVI by classifying the NDVI into various vegetation density classes refer to section 3.2.5.1 and 3.2.5.2.

3.2.5.1 *Supervised Classification*

The landsat MSS imagery of 1976 was used for supervised classification. The imagery was classified using Maximum Likelihood Classifier (MLC) in ArcGIS 10.1 software into various land cover classes. A classification scheme of Bauchi State vegetation proposed by Department of Forestry, Ministry of Animal and forest resources Project Report (1978) was adopted for this study. The classification utilised seven land cover classes:

i. Shrubbed woodland hills and mountain complex,
ii. Shrubbed woodland lowland complex,
iii. Woodland Shrubbed land,
iv. Shrubbed grassland and grassland Shrubbed,
v. Woodland grassland,
vi. Riparian vegetation and
vii. Settle area/Cultivated land.

In this study however, the classification scheme was modified to represents: Shrubbed woodland hills, shrubbed woodland lowland, woodland shrubbed land, grassland and settle area/cultivated land. The reason for implementing the supervised classification in this study is to use the resulting image to detect changes that happen in the study area from 1976, as it is the start year of the study (base line).

3.2.5.2 NDVI differencing Method

The SPOT-NDVI of 1998 and 2014 data were used for the NDVI differencing method in this study. The SPOT-NDVI fractional vegetation cover (Brunsell and Gillies, 2003) was re-classified using the Arc GIS 10.1 software. A classification scheme of the DN values of the NDVI image after (Ehsan and Kazem, 2013) was adopted. The classification utilised four density classes as: low density (0.1-0.2), medium density (0.2- 0.3), high density (0.3-0.4) and very high density (>0.4).

3.2.6 Data Analysis

3.2.6.1 Mapping and analysis of areal extent of vegetation types (1976 and 2015).

This objective was achieved by classifying the Landsat MSS (1976) and Lanfsat OLI (2015) using the maximum likelihood classifier in the ArcGIS 10.1. The change detection technique was employed in order to investigate the change in each of the land cover types in the study area using post–classification comparison change detection algorithm. It is the most common approach used for monitoring land cover changes, as it provides more useful information on the initial and final land cove type in complete matrix (Yuang, Sawaya, Loeffelholz, and Bauer, 2005; Fan, Weng and Wang, 2007; Shalaby and Tateishi, 2007). The classified land cover maps of 1976 and 2015 were overlaid in ArcGIS software where change detection algorithm was applied. Percentage change and annual rate of change of the classified land cover classes were determined. The results were presented in tables and maps.

3.2.6.2 Analysis of spatio-temporal changes of vegetation density (1998 to 2014).

To achieve this objective, The SPOT-NDVI of 1998 and 2014 data were classified into four categories (areas with low, medium, high and very high NDVI values) using NDVI differencing method in this study. A classification scheme of the DN values of the NDVI image proposed by (Ehsan and Kazem, 2013) was adopted. The classification utilised four density classes as: low density (0.1-0.2), medium density (0.2- 0.3), high density (0.3-0.4) and very high density (>0.4). Change detection algorithm was used to determine the percentage change and annual rate of change of the classified vegetation density classes and the results were presented in tables and maps.

3.2.6.3 Relationships between NDVI and climatic variables (1998 to 2014).

To achieve this objective, regression analysis was performed between NDVI and mean annual rainfall and the mean annual temperature. Regression coefficient was used to show the relationship between NDVI, rainfall and temperature.The results were presented in tables.

3.2.6.4 Effect of anthropogenic activities on vegetation in the study area (1976 to 2015).

This was achieved through analysing the responses of the respondents obtained from the administered questionnaire. The results were presented using descriptive statistics of figures, tables and percentages and inference was made on the outcome.

CHAPTER FOUR

RESULTS AND DISCUSSIONS

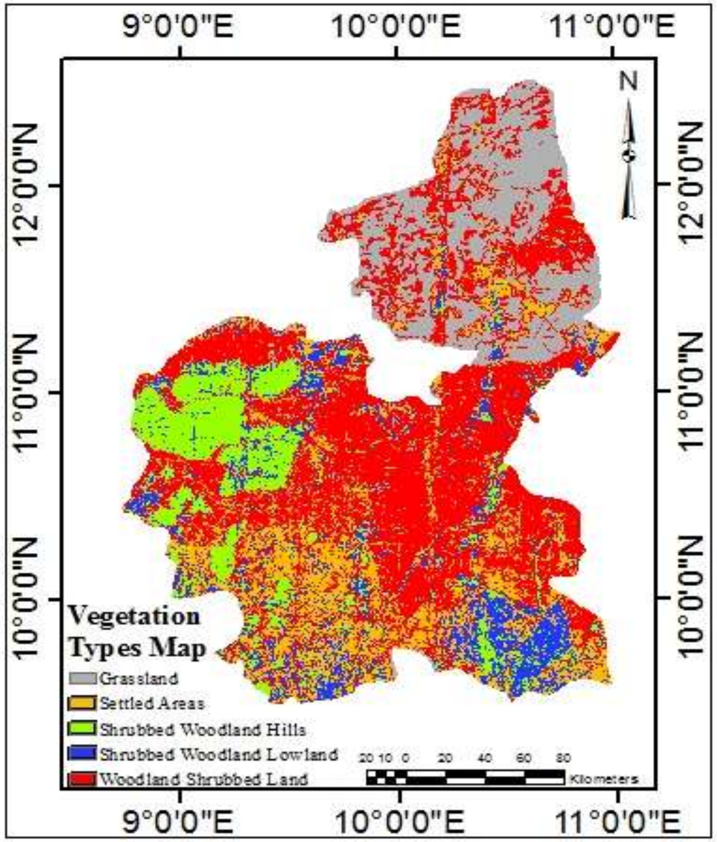
This chapter presents the land cover maps resulting from classification of satellite images, analyses of the magnitude, rate, nature and geographic distribution of the vegetation cover types and density changes. The relationships between NDVI and climatic variables are discussed. The findings on some of the driving factors of the vegetation density change as a result of anthropogenic activities are also presented.

4.1 Extent of Vegetation Types and Changes in the Study Area (1976 to 2015)

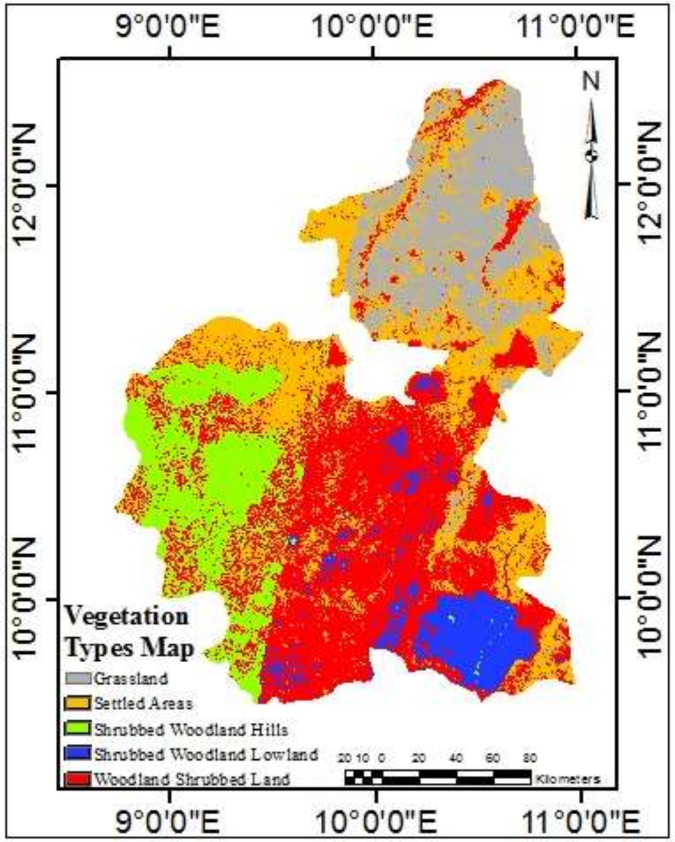
This presents vegetation classification from Landsat MSS and OLI and vegetation change in term of area change, percentage of area change and annual rate of change in the study area from 1976 to 2015.

4.1.1 Vegetation Classification from Landsat MSS and OLI (1976 and 2015)

Figure 4.1 (a & b) Presents the vegetation classes in the study area, classified from Landsat MSS and Landsat OLI of 1976 and 2015.



(a) Vegetation classess for 1976



(b) Vegettation clases for 2015

Figure 4.1(A&B): Vegetation classess in the study area (1976 and 2015)

Source: Author's Analysis, 2017

Figure 4.1 (a & b) shows the vegetation classes of the study area (1976 and 2014). It can be deduce from the two maps that grass is generally located in the northern part of the study area, shrubbed woodland hills is located in the north eastern part of the study area close to Jos Pateau, woodland shrubbed land is generally found in the middle part of the study area while vegetation shrubbed woodland lowland is generally located in the southern part of the study area. The location of each of these vegetation types is attributed to the geography and climate of that area especially rainfall. For example grassland is predominantly found in the northern part of the study area that receives less rainfall while vegetation class shrubbed woodland hills is located on the mountainous areas close to Jos Plateau which receives high rainfall coupled with less. This testifies to the studies by Adeyewa and Aweda (2011), Usman, *et al* (2012), Jianrong and Yang (2014). They observed vegetation cover over a geographical area is essentially a response to the climate of that area. Also by observing the two maps it is noted that settled/cultivated area has increases between 1976 to 2015 which means there is anthropogenic activities in the study area which could be farming, population increases firewood extraction and the culmination of these activates is reduction of vegetation type in the study area which will lead to environmental degradation.

4.1.2 Vegetation Change Detection in the study area (1976 to 2015)

Tae 4.1 presents the areal extent of each vegetation class, area change, and percentage of area change and annual rate of change of vegetation class from 1976 to 2015.

Table 4.1: Areal extent and vegetation change detection in the study area (1976 to 2015)

Vegetation Type	Year (1976)		Year (2015)		Year (1976-2015)		Year (1976-2015)
	Area (Km^2)	Area (%)	Area (Km^2)	Area (%)	Area change (Km^2)	% change in area (%)	Annual Rate of Change (%)
Shrubbed Woodland Hills	5762.5	12	7312.9	15.2	+1550.4	+14.2	+5.68
Shrubbed Woodland lowland	5326.3	11.1	3268.9	6.8	-2057.4	-18.8	-7.52
Woodland Shrubbed Land	20363.5	42.2	17737.9	36.8	-2625.6	-24	-9.60
Grassland	8160	16.9	7374.2	15.3	-785.8	-7.2	-2.88
Settled areas/ Cultivated land	8570.7	17.8	12489.1	25.9	+3918.4	+35.8	+14.32
TOTAL	48183	100	48183	100	10937.6		

Source: Author's Analysis, 2017

Table 4.1 shows that in 1976 the Shrubbed Woodland Hills class was 5762.5 km^2, the Shrubbed Woodland Lowland was 5326.3 km^2, the Woodland Shrubbed Land was 20363.5 km^2, the was Grassland 8160 km^2, and the Settled Areas/Cultivated Lands was 8570.7 km^2. In 2015, the Shrubbed Woodland Hills class was 7312.9 km^2, the Shrubbed Woodland Lowland was 3268.9 km^2, the Woodland Shrubbed Land was 17737.9 km^2, the Grassland was 7374.2 km^2, and the Settled Areas/Cultivated Lands was 12489.1 km^2.

It reveals that by 2015, the Settled Areas/Cultivated land had increased by 3918.4 km^2 (35.8%) with an annual rate of 14.32%, followed by Shrubbed Woodland Hills by 1550.4 (14.2%) with annual rate 5.68%, while, the Woodland Shrubbed Land has decreased by 2625.6 km^2 (24%), with annual rate of -9.60% and the Shrubbed Woodland Lowland by 2057.4 (18.8%) with annual rate of -7.52% and Grassland by 785.8 (7.2%) with annual rate of -7.2%. According to Aspinall and Hill (2008), an important challenge in reporting land cover change is discrimination of the different dimensions of change. In this study, therefore, the vegetation change is being reported in terms of the areal change (losses or gains) and dynamics (the annual rates of changes).

The main change in the vegetation type revealed by the vegetation change analyses results include: decreased in Shrubbed Woodland Lowland, Woodland Shrubbed Land and Grassland. On the other hand, the Shrubbed Woodland Hills and the Settled Areas/Cultivated lands exhibited an increase in the study area. Although, some of the resultant change in the rates, the nature and the magnitude of the vegetation in the study area especially the increases of Settled Areas/Cultivated lands by 35.8% had testifies to the other studies by FORMECU (1998), BASEED (2005) and BASG (2012) that, the study area is facing rapid landuse transformation as a result of

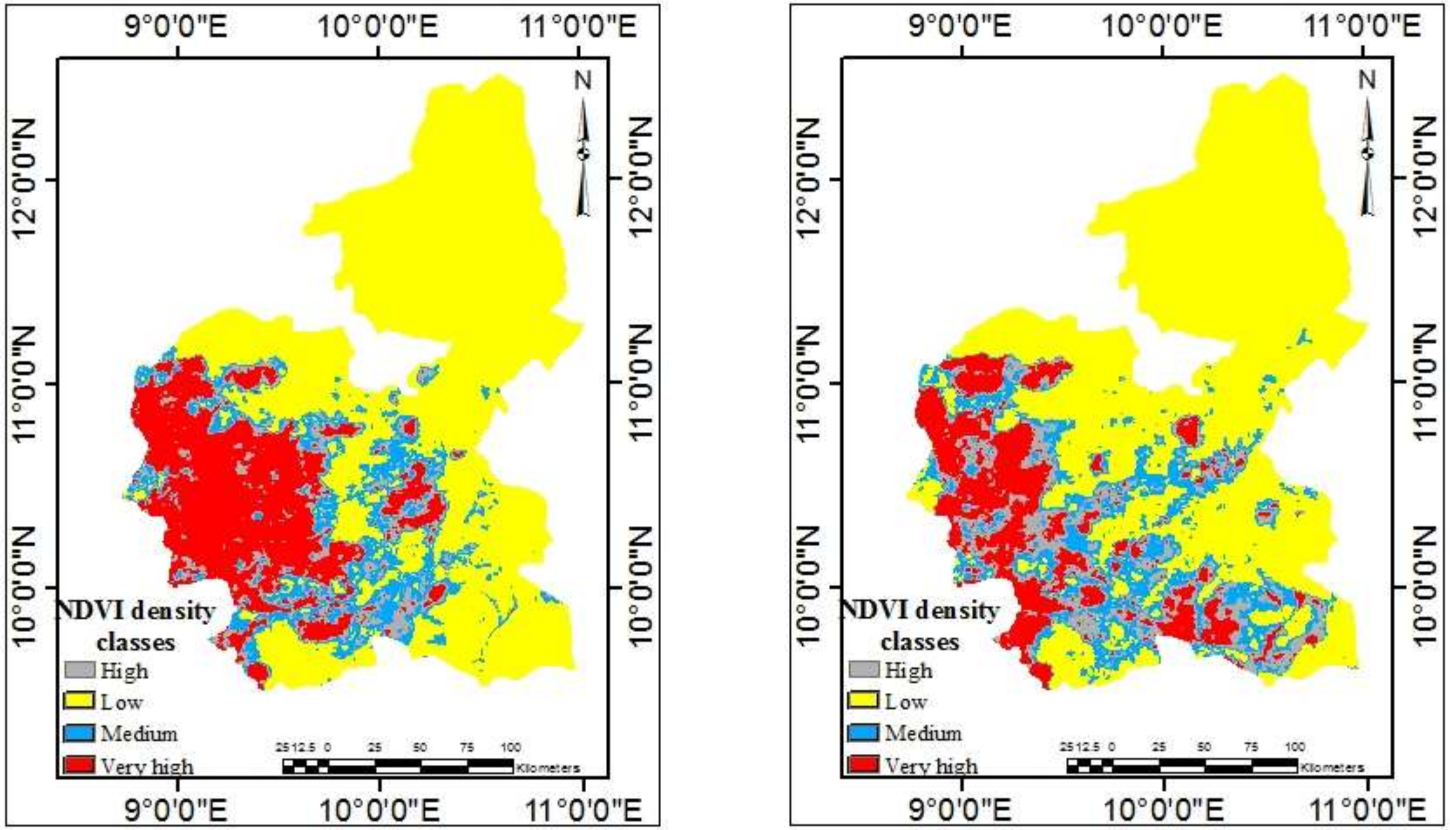
Agricultural activities, urbanization and population which resulted to the decline of vegetation. The study reveals that generally the vegetation type in the study area (1976 to 2015) exhibits decreases which could negatively affect the environment through soil erosion, flooding, dessert encroachment and other means of economic activities and livelihood of the residents such as rearing of animals, wildlife extinction, and energy supply.

4.2 Spatio Temporal Changes of Vegetation Density Changes in the Study Area (1998 to 2014)

This presents the NDVI density classes from SPOT-NDV and NDVI density change in term of area change, percentage of area change and annual rate of change in the study area from 1998 to 2014.

4.2.1 NDVI density classification from SPOT (1998 and 2014)

Figure 4.2 (a & b) presents the NDVI density class of the study area from1998 to 2014. The density has been categorised based on the DN values of the NDVI images as: low density (0.1-0.2), medium density (0.2- 0.3), high density (0.3-0.4) and very high density (>0.4).



(a) NDVI density class for SPOT 1998 (b) NDVI density class for SPOT 2014

Figure 4.2 (a & b) NDVI density classess in the study area (1998 and 2014)

Source: Author's Analysis, 2017

Figure 4.2 (a & b) shows the classified NDVI density map of 1998 and 2014 showing the extent of low, medium, high and very high vegetation density classes in the study area. The area coverage low density occupies the entire portion of the northern and central part of the study area which receives little rainfall. While, area coverage high and very high density occupies the southern part of the state, where rains starts earlier, heaviest and lasts longer in the study area as cited by BASG (2012). The reason the central and entire northern part of the study area exhibits' the NDVI value of low density is likely a result of the little rainfall received in those areas. The southern part exhibits medium NDVI density, high and very high NDVI density. Very high NDVI density is found at the extreme southern part of the study area, where rains start earlier, heaviest and longest. This finding also agrees with the previous findings such as Gadiga, Adesina, and Orimoogunje (2007); Adeyewa and Aweda (2011); Usman, Yelwa and Gulumbe (2012); and Jianrong and Yang, (2014) vegetation density of a geographical area is essentially a response to the climatic variability of that area. Also by observing the two maps it is noted that area coverage very high NDVI density has decreases between 1998 to 2014 which is likely a result of anthropogenic activities in the study area which could either be farming, logging and firewood extraction and the culmination of these activates is reduction of vegetation type in the study area which will lead to environmental degradation.

4.2 2 Change in NDVI Density in the study area from1998 to 2014

Table 4.2 shows the area coverage of NDVI density classes and NDVI density change in term of area change, percentage of area change and annual rate of change in the study area from 1998 to 2014.

Table 4.2 NDVI density classes and change in NDVI density in the study area (1998 to 2014)

NDVI (Density Values)	Year (1998)		Year (2014)		Year (1998-2014)		Year (1998-2014)
	Area (Km^2)	Area (%)	Area (Km^2)	Area (%)	Area change (Km^2)	% change in area (%)	Annual Rate of Change (%)
Low (0.1-0.2)	29960.3	62.1	30237	62.8	+277	4.6	- 0.74
Medium (0.2-0.3)	5059.96	10.5	6158.8	12.8	+ 1099	18.4	-2.9
High (0.3-0.4)	3638.4	7.6	5253.1	10.9	+1615	27	-4.3
Very high (<0.4)	9524.7	19.8	6534.4	13.5	-2991	50	+8
Total	48183	100	48183	100	5980		

Source: Author’s Analysis, 2017

Table 4.2 shows that in 1998 the low NDVI density class was 29960.3 km^2, the medium NDVI density class was 5059.96 km^2, the high NDVI density class was 9524.7 km^2, and the very high NDVI density class was 9524.7 km^2. By 2014, low NDVI density class was 30237 km^2, the medium NDVI density class was 6158.8 km^2, the high NDVI density class was 5253.1 km^2, and the very high NDVI density class was 6534.4 km^2. It reveals that by 2014, very high NDVI density class had decreased by -2991 km^2 (50%) with annual rate -8, NDVI high density class had increased by +1615 km^2 (27%) with annual rate of +4.3, NDVI medium density class had increased by 1099 km^2 (18.4%) with annual rate of +2.9 and NDVI low density class had increased by +277 km^2 (4.6%) with annual rate + 0.74. The percentage and rate of change of NDVI very high density class from 19.8% in 1998 to 13.5 in 2014 with percentage change of area of (50%) is like a result of anthropogenic activities in the study area. This testifies to the studies by FORMECU (1998), BASSED (2005) and BASG (2012). They observed the study area is facing rapid landuse transformation as a result of agricultural activities, urbanization, firewood extraction and population explosion. The findings also agree with previous study of Kiprotich (2016) which observed significant decreased in forest cover due to human activities such as tree cutting and trampling from 1985 to 2010 in Chepolungu forest of Kenya. Similarly the decreased of NDVI very high density and increased of NDVI low density class could negatively affect the environment by causing dessert encroachment, shortage of firewood and other means of economic activities and livelihood of the residents such as rearing of animals, wildlife extinction and migration.

The analysis also reveals that the NDVI low density class has the greatest area coverage in the study area with 62.1% in 1998 1nd 62.8% in 2014. It covers the entire northern and central part of the study area. This is likely a result of the little rainfall received in those areas. This agrees with the previous studies of Garba *et al* (2013); Naibbi, (2013); Osunmadewa and Wessollek ((2014), Usman *et al* (2012) and Pavel *et al* (2014). Both studies opined that a wide range of temporal and spatial scales has established that natural vegetation over a geographical area is essentially a response to the climate of that area. The findings also reflect general over view of the study area as cited in the work of FORMECU (1998), BASEED (2005), and BASG (2012). They observed that vegetation cover in the study area is conditioned by climatic factors, as rains generally come from the south as influenced by the south –westerlies and progressively dries towards the north culminating in desert condition in the far north.

4.3 Relationships between NDVI and Climatic Variables in the study Area (1998 to 2014)

4.3.1 Relationship between NDVI and rainfall (1998 to 2014)

This presents the relationship between NDVI and rainfall in the study area from 1988 to 2014 using regression analysis. The relationship was determined using regression coefficient (R^2).

Table: 4.3 Relationship between NDVI and rainfall (1998 to 2014)

1998		2006		2014	
Regression Statistics		Regression Statistics		Regression Statistics	
Multiple R	0.8487406	Multiple R	0.82443095	Multiple R	0.80002364
R Square	0.7203607	R Square	0.649686392	R Square	0.540037825
Adjusted R Square	0.6203607	Adjusted R Square	0.579686392	Adjusted R Square	0.540037825
Standard Error	47.723519	Standard Error	44.23008162	Standard Error	46.63303075
Observations	11	Observations	11	Observations	11

Table 4.3 reveals the regression analyses between NDVI and rainfall in the study area. The highest regression coefficient (R^2 = 0.72) was recorded in 1998, (R^2 = 0.64) in 2006 and (R^2= 0.5) in 2014. The results shows high positive correlation (R^2 = 0.72) between NDVI and rainfall in 1998, and substantial positive correlation between NDVI and rainfall (R^2 = 0.64) and (R^2= 0.5) in 2006 and 2014 respectively. The highest regression coefficient recorded in 1998 is likely a result of highest rainfall receive in that year which higher than 2006 and 2014 (see appendix 2). The strong relationship between NDVI and rainfall in 1998 indicate that availability of water is one of the major factors that determine the density of vegetation in the study area. This testifies to the studies by Adeyewa and Aweda (2011), Yelwa *et al* (2012), Jianrong and Yand (2014) and Pavel *et al* (2014). Both studies opined that strong relationship between NDVI and rainfall in their studies. The results also corroborates with the study carried out by Wang *et al,* (2001) who 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.). This result testified the study by (Wang, Price and Rich 2003; Grit and Nicholsen, 1997; Belda and Melia 2010), which established positive relationship between the NDVI and the climatic variables under variety of environmental conditions. Furthermore, Usman, Yelwa and Gulumbe (2012) observed both negative and positive correlation in their study. While, contrary to that Gadiga *et al* (2007) Zhong *et al* (2010) cited negative correlation coefficients between the NDVI and climatic parameters in their study. The findings of the present study reflect a general overview of the previous study that rainfall is one of the major determinant factors for strong relationship between NDVI and rainfall.

4.3.2 Relationship between NDVI and temperature (1998 to 2014)

Table 4.4 presents the relationship between NDVI and temperature in the study area from 1988 to 2014 using regression analysis. The relationship was determined using regression coefficient (R^2).

Table: 4.4 Relationship between NDVI and temperature (1998 to 2014)

1998		2006		2014	
Regression Statistics		Regression Statistics		Regression Statistics	
Multiple R	0.880273777	Multiple R	0.901405964	Multiple R	0.90695654
R Square	0.774881923	R Square	0.812532711	R Square	0.82257017
Adjusted R Square	0.674881923	Adjusted R Square	0.712532711	Adjusted R Square	0.72257017
Standard Error	16.76536592	Standard Error	16.19140829	Standard Error	16.2217687
Observations	11	Observations	11	Observations	11

Table: 4.4 shows the regression analyses between NDVI and temperature in the study area. The regression coefficient (R^2 = 0.77) was recorded in 1998, (R^2 = 0.81) in 2006 and (R^2= 0.82) in 2014. The results show high positive correlation between NDVI and rainfall in study area. This had conformed to other studies that found significant relationships between this variable. For example, Guo *et al*. (2008) reported that NDVI variations were significantly correlated with temperature. Ichii *et al*. (2002) and Schultz and Halpert (1995) reported a strong positive correlation between NDVI and temperature in high-latitude districts of the northern hemisphere in both spring and autumn. Zhang *et al*. (2011) and Luo *et al*. (2009) reported a strong correlation between NDVI and temperature for different vegetation types in northeast China and observed that the effect of temperature on NDVI was more obvious than that of precipitation. Contrary to that Schultz and Halpert (1995) conducted a global analysis of the relationships between NDVI and temperature and found no significant relationship between them.

4.4 Effects of Human Activities on Vegetation in the Study Area (1976 to 2015)

This presents the analysis of human activities that affect vegetation in the study area using descriptive statistics of figures, tables and percentages.

4.4.1 Socio-Demographic characteristics of the respondents

Table 4.5 presents the distribution of socio-demographic characteristics of the respondents in terms of gender, age, educational level, marital status, occupational level and period of residency and how each could affect vegetation in the study area.

Table 4.5 reveals that 388 of the respondents which accounts for 97% are males. This has serious implication on the vegetation because the cultural belief have mandated male to provide everything for the family in the study area and one means of residents' livelihood is through extraction of vegetation resources which could leads to environmental degradation. Although women engaged in one traditional form of resource management or other, majority of them refused to be interviewed which is due partly to religious and cultural beliefs.. This has serious implication because it prevents them from providing necessary information needed for the study.

Table: 4.5: Socio- Demographic Characteristic of the respondents

Variables	Variable options	Frequency	Percentage (%)
Gender	Male	388	97%
	Female	12	03%
	Total	400	100%
Age	40-49	118	30%
	50-59	137	34%
	60-69	108	27%
	70-79	037	09%
	80 and above	-	-
	Total	400	100%
Educational Level	Non-formal	160	40%
	Primary	65	16%
	Secondary	32	18%
	Tertiary	143	26%
	Total	400	100%
Marital Status	Single	16	04%
	Married	372	93%
	Divorced	04	01
	Widowed	08	02%
	Total	400	100%
Occupation	Farming	189	47%
	Trading	081	36%
	Hunting	-	-
	Civil servants	127	20%
	Public Servant	03	01%
	Total	400	100%
Period of Residency	10-19 years	-	-
	20-29 years	-	-
	30-39 years	048	12%
	40 years and above	352	88%
	Total	400	100%

Source: Author's Analysis, 2017

The age of the respondents in the study area is skewed towards the age range of 40-49 (30%), 50-59 (34%) and 60-69 (27%). Since the respondent at the age of 40-49 are higher in number there will be destruction of vegetation because as a result of farming activities because categorically these are people that engaged in agricultural activities in the study area. The distribution of educational level of the respondents shows that non formal education accounts for the highest (40%) followed by primary education (26%), secondary education (18%) and primary education (16%). Since the percentage of the non-formal educated people in higher, this indicates that the destruction of vegetation cover will be high, because these are people that engaged in activities such as farming and rearing of animal. Distribution of marital status of the respondents in the study area indicates that 372 (93%) are married, these are categorically type of people that depend largely on vegetation resources especially firewood as the means of energy for cooking in their houses which directly affect the vegetation in the area. This testifies to the study by FORMECU (1998). They observed intense demand of vegetation resources have impoverishes and deteriorates the soil and environmental condition in the study area.

It is also reveals that farming is the main occupation of the respondents in the study area which accounts for ((47%), followed by trading (36%) and civil service (20%). This will seriously affects the vegetation of the area due to intense demands of more land for farming activities which will leads to environmental degradation. This testifies to the studies by BASEED (2005), BSG (2012) and FOEMECU (1998). They observed that vegetation in the study area is going through monumental changes as a result of farming activities. It is also supported by Adeola *et al* (2004) and NEST (1991) which cited farming as the reason of vegetation change in their studies in Olokemeji forest reserve, Nigeria.

4.4.2 Involvement of respondents in trees/grasses cutting

Figure 4.3 presents the responses of the respondents on their direct involvement in cutting trees/grasses as well as observing other people cutting tress/grasses in the study area. It is reveals that 58% of the respondents directly engaged themselves in cutting trees/grasses in the study area, while 42% of the respondents observed people cutting tress/grasses for various purposes.

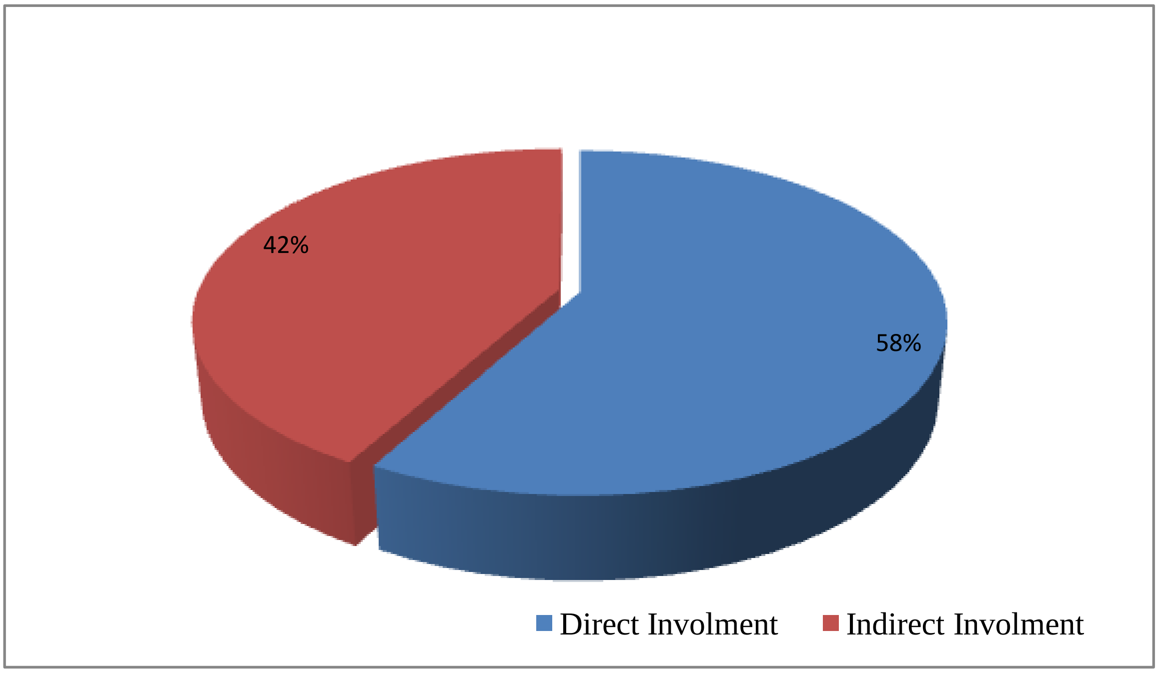


Figure: 4.3 Involvement of respondents in trees/grasses cutting

Source: Author's Analysis, 2017

Figure 4.3 reveals that 58% of the respondents have directly engages themselves in cutting trees/grasses in the study area while 42% of the respondents have observe people cutting tress/grasses for various purposes. The findings establish strong effect of anthropogenic activities on the vegetation cover in the study area. It is indicated that, trees/grasses cutting is one of the major human activities affecting the natural vegetation in the area. This action is likely a result of high demands of firewood, cultivable land, and construction purposes. This finding agrees with studies of FOEMECU (1998), BASEED (2005) and BSG (2012). They indicated that vegetation cover of the study area is going through monumental changes from anthropogenic sources. The finding also agrees with previous studies of Cline- Cole (1994), Geist and Lambin (2002), Nwoboshi (2002), FAO (2007) and Naibbi (2013). Both opined that firewood extraction/ usage as the main cause of vegetation cover changes in their studies. Similarly, Kiprotich (2016) also revealed a significant decreased in forest cover due to trees cutting and trampling from 1985 to 2010 in Chepolungu forest of

Kenya. The resultant effect of such action is decline in natural vegetation in the study area causing environmental degradation like soil erosion, flooding and dessert encroachment and other means of economic activities and livelihood of the residents such as rearing of animals, wildlife extinction, and energy supply.

4.4.3 Purpose of direct involvement of respondents in cutting trees/grasses

Table 4.6 shows that, the respondents engage themselves in cutting trees/grasses in the study area, citing the firewood extraction for self consumption (63%), farming (16%), house fencing(8%), firewood extraction for sale (8%) , house fencing/roofing (8%), and logging (5%).

Table 4.6: Purpose of direct involvement of respondents in cutting trees/grasses

Purpose	Frequency	Percentages (%)
Firewood (for self consumption)	253	63
Firewood (for sale)	032	08
House Fencing/ Roofing	032	8
Logging	021	05
Farming	062	16
Total	400	100

Source: Author’s Analysis, 2017

Table 4.6 indicates that firewood extraction and farming are the major human activities affecting vegetation in the study area as 63% of the respondents agreed to using firewood in their homes which is either extracted directly or bought from vendors. This establishes a strong effect of human activities on vegetation cover in the study area. This testifies to the previous studies conducted on the study area by FOEMECU (1998), BASEED (2005) and BSG (2012). Both indicated that vegetation cover of the study area is going through monumental changes from anthropogenic sources as result of intense demands of firewood and agricultural activities. It is also supported by Adeola *et al* (2004) and NEST (1991) which cited farming as the reason of vegetation change in their studies in Olokemeji forest reserve, Nigeria. The study also agrees with previous studies of Cline- Cole (1994), Geist and Lambin (2002), Nwoboshi (2002), FAO (2007) and Naibbi (2013). Both cited firewood usage as the main cause of vegetation cover changes in their studies. The implication of such action is decline in vegetation density in the study area causing environmental problem like soil erosion, dessert encroachment and affecting economic activities and livelihood of the residents such as rearing of animals, wildlife extinction, and energy supply.

4.4.4 Respondents' perceived of purposes of cutting trees/grasses cutting by other people

This presents the observations of respondents on the purposes of cutting tress/grasses by other people in the study area. Firewood extraction (48%), commercial purposes (21%) and house fencing/roofing (11%) are the main purposes identified by the respondents.

Table: 4.7 Purposes of cutting trees/grasses by other people

Purposes:	Frequency	Percentages (%)
Firewood (self consumption)	352	48
Firewood ((sale)	158	21
House Fencing/ Roofing	081	11
Logging	041	06
Farming	046	06
Animal Feeds	042	06
Sanitation	08	01
Total	728	100

Source: Author's Analysis, 2017

Table 4.7 shows respondents' perceived purposes of tree/grass cutting by other people in the study area. The respondents identified firewood extraction for self consumption (48%), for sale (21%) and house roofing (11%) as the main purposes of tree/grass cutting in the study area. The study agrees with previous studies of Cline- Cole (1994), Geist and Lambin (2002), Nwoboshi (2002), FAO (2007) and Naibbi (2013). Both cited firewood usage as the main cause of vegetation cover changes in their studies. The problems of such action culminate to reduction in natural vegetation in the study area causing environmental problem like dessert encroachment and affecting economic activities and livelihood of the residents such as rearing of animals and energy supply

4.4.5 Firewood usage by the respondents

Figure 4.8 shows the usage of firewood by the respondents in study area. The result reveals that 99% of the respondents use firewood in their houses.

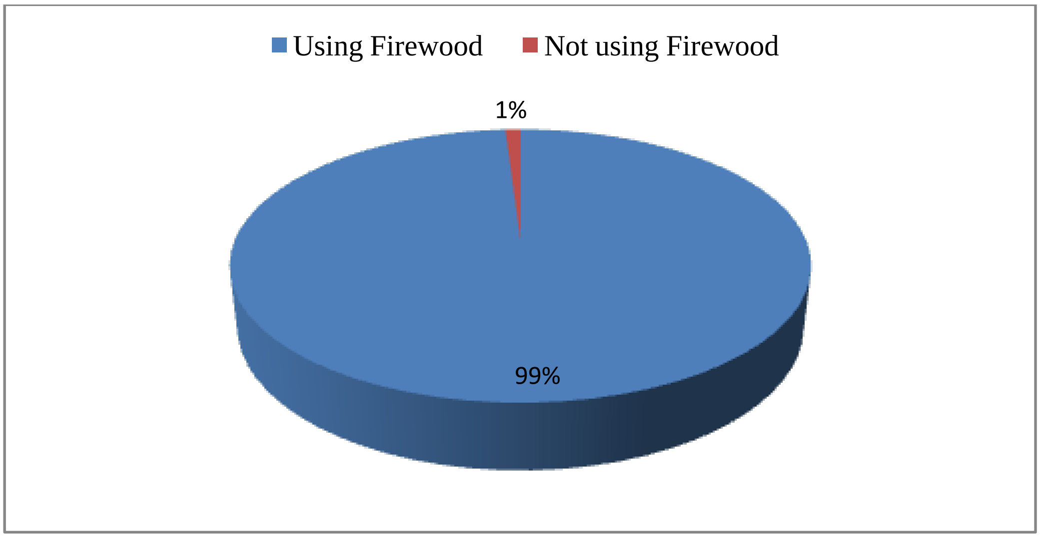


Figure: 4.4 Firewood usage by the respondents

Source: Author's Analysis, 2017

Figure 4.4 established a strong effect of anthropogenic activities on the vegetation density in the study area. It reveals that the firewood extraction and the farming are the major human activities affecting the natural vegetation in the area, as 99% of the responses indicate using the firewood in their houses in the study area. This testifies to the studies by Cline- Cole (1994), Nwoboshi, (2002), Geist and Lambin (2002), FAO, (2007) and Naibbi (2013). They observed firewood extraction/usage as the main cause of vegetation cover changes in their studies. Similarly, Kiprotich (2016) also revealed a significant decreased in forest cover due to trees cutting and trampling from 1985 to 2010 in Chepolungu forest of Kenya. The resultant effect of such action is reduction in natural vegetation resources in the study area causing environmental degradation like soil erosion, flooding and dessert encroachment and other means of economic activities and livelihood of the residents such as rearing of animals, wildlife extinction, and energy supply.

4.4.6 Respondents' perception on vegetation changes and the year it started

This presents the perception of the respondents on vegetation change in the study area. All of the respondents (100%) have noticed the changes in vegetation density in the study area. The finding reveals that majority of the respondents (54%) perceived vegetation changes started 30 to 39 years ago.

Table 4.8: Perception of respondents on years vegetation changes started

Years	Frequency	Percentages (%)
20- 29	180	45
30- 39	217	54
40- 49	03	01
Total	400	100

Source: Author's Analysis, 2017

Table 4.8 reveals that all of the respondents agreed to have noticed change in vegetation in the study area. Majority of the respondents (54%) perceived that vegetation changes in study area started 30 to 39 years ago. This is likely as a result of human activities or climatic changes. This testifies to the previous studies conducted on the study area by FOEMECU (1998), BASEED (2005) and BSG (2012). Both indicated that vegetation cover of the study area is going through monumental changes from anthropogenic sources as result of intense demands of firewood and agricultural activities. The effects of these changes will result to environmental problems like soil erosion, flooding and dessert encroachment and other means of economic activities and livelihood of the residents such as rearing of animals, wildlife extinction, and energy supply.

4.4.7 Respondents opinions on the human activities that affect vegetation cover changes

This presents the perception of the respondents responses on the most human activities that could likely resulted in vegetation cover changes in the study area. Respondents see firewood extraction (29%), farming activities (26%) as the most likely human activities that result in vegetation cover changes in the study area.

Table 4.9: Respondents opinions on the human activities that affect vegetation cover changes

Activities:	Frequency	Percentage (%)
Farming	332	26
Grazing	071	06
Logging	051	04
Firewood extraction	377	29
Urbanisaton	212	16
Rapid population	183	14
Bush burning	051	04
Limited land	10	001
Total	1290	100

Source: Author’s Analysis, 2017

Majority of the respondents (table 4.9) has the opinion that firewood extraction (29%) and farming (26) are the most likely human activities that result in vegetation changes in the study area. However, from further questions asked, it was observed that most of the implication do not practice in isolation but rather a combination of various implications but the most preferred option were recorded. This testifies to the studies by Nwoboshi (2002), FAO (2007) and Naibbi (2013). They observed firewood extraction/usage as the main cause of vegetation cover changes in their studies. On the other hand NEST (1991) and Adeola *et al* (2004)) cited farming as the reason of change vegetation in their studies. Similarly, related to this study, Boakye, Odei, Adjaidens and Annor (2008) and Garba, Babanyara, Ibrahim and Isah (2013) observed anthropogenic pressure (population growth and economic activities) as the driving force for decline of the natural vegetation in their studies. Other studies conducted within the area (FOEMECU, 1998; BASEED, 2005; BSG, 2012) have shown that vegetation of the area is going through monumental changes from anthropogenic sources. Their studies indicated that the greater population (84%) of the area lives in rural areas, and 75-80% of them engaged in farming activities. The coupling of this and population explosion lead to increasing demand for food, fuel, shelter and income. These lead to reduction of the natural vegetation and undisturbed forest of the area.

4.4. 8 Respondents awareness on the impact of vegetation changes on the environment

This presents respondents' awareness on the effect of vegetation changes on the environment. The respondents submitted that shortage of firewood (37%) and loss of biodiversity (35%) have the greatest impact of vegetation change on the environment.

Table 4.10: Respondents' perceived impact of vegetation changes on the environment

Impacts	Frequency	Percentage (%)
Loss of biodiversity	051	07
Shortage of firewood	284	37
Loss of wildlife habitat	264	35
Desert encroachment	161	21
Total		100

Source: Author's Analysis, 2017

Table 4.10 shows that shortage of firewood (37%) and losses of biodiversity (35%) have the greatest impact of the greatest impact of vegetation on the environment as submitted by the respondent. However, from further questions asked, it was observed that most of the implication do not practice in isolation but rather a combination of various implications but the most preferred option were recorded. This testifies to previous study by FOEMECU (1998) that vegetation of the study area is going through monumental changes as a result of agricultural activities and population explosion leading to increase demand for firewood.

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 Summary

This chapter presents the summary, conclusion and recommendations on vegetation change detection, change in vegetation density classes, relationship between NDVI and climatic variables (Rainfall and Temperature) and effects of human activities on vegetation cover from 1976 to 2015.

On the pattern of vegetation changes (1976 to 2015), the results revealed an increase in the Settled Areas/Cultivated land had increased by 3918.4 km^2 (35.8%) with an annual rate of 14.32%, followed by Shrubbed Woodland Hills by 1550.4 (14.2%) with annual rate 5.68%, while, the Woodland Shrubbed Land has decrease by 2625.6 km^2 (24%), with annual rate of -9.60% and the Shrubbed Woodland Lowland by 2057.4 (18.8%) with annual rate of -7.52% and Grassland by 785.8 (7.2%) with annual rate of -7.2%. The increasing rates and magnitude of the change of Settled Areas/Cultivated land and shrubbed woodland hills as the other vegetation cover types decreased could have been precipitated by anthropogenic influences (fire wood extraction) and/or climatic variables (shortage of rainfall).

The total area, percentage and annual rate of change for each NDVI density classes in the study area reveals a decrease in area coverage of very high NDVI density class by -2991 km^2 (50%) with annual rate of -8, NDVI high density class had increases by +1615 km^2 (27%) with annual rate of +4.3, NDVI medium density class had increased by 1099 km^2 (18.4%) with annual rate of +2.9 and NDVI low density class had increased by +277 km^2 (4.6%) with annual rate of + 0.74. The percentage and rate of change of NDVI very high density class from 19.8% in 1998 to 13.5 in 2014 with percentage change of area of (50%) is likely a result of anthropogenic activities in the study area. The percentage of area coverage of NDVI low density class in the study area with 62.1% in 1998 and 62.8% in 2014, covering the entire northern and central part of the study area is likely a result of the little rainfall receives in those areas.

The study shows strong relationship between NDVI, rainfall and temperature from 1998 to 2014. The regression coefficient (R^2 = 0.72) in 1998, (R^2 = 0.64) in 2006 and (R^2= 0.5) in 2014 was recorded between NDVI and rainfall. Also regression coefficient (R^2 = 0.72) in 1998, (R^2 = 0.81) in 2006 and (R^2= 0.82) in 2014 was recorded between NDVI and temperature. The findings indicate that rainfall and temperature are the factor for the vegetation growth for study periods because of the high positive correlation between NDVI and rainfall in 1998 and substantial positive correlation in 2006 and 2014 and high positive correlation between NDVI and temperature for entire period of study.

The present study also established a strong effect of anthropogenic activities on the vegetation density in the study area. It is indicated that the firewood extraction and farming are the major human activities affecting the natural vegetation in the area as 99% of the respondents agree do using firewood in their homes. Firewood is either directly extracted or bought from vendors. The respondents cited that the vegetation density in the area in 1970's as more trees, more grasses and more shrubs, while, less trees, less grasses and less shrubs as the present vegetation density in the area. These are also confirmed by responses elicited from the residents on the driving forces of vegetation cover changes. For instance, firewood and farming came out explicitly as major driving forces of vegetation cover change in the area, followed by urbanization and the rising population.

5.2 Conclusions

Based on the results and their analyses from this study, the following conclusions are drawn:

i. The dominant nature of change occurring in the study area has been the increases of the settled land/cultivated land and the Shrubbed Woodland Hills, and conversely the decreases of the other vegetation cover types.

ii. The decrease in area coverage of very high NDVI density class has been the major changes of NDVI density classes in the study area. It is also reveal that NDVI low density class occupies the larger portion of the study area.

iii. The study showed strong relationship between NDVI, rainfall, temperature in the study area. The regression coefficients showed that rainfall and temperature are the major factor that determines vegetation density for the entire period of the study**.**

iv. Firewood usage and Farming are the major driving forces that influence vegetation cover change in the study area.

5.3 Recommendations

In view of the conclusions drawn, the following recommendations are made:

i. Awareness of the reality, magnitude and implications of vegetation loss should be raised among vegetation resources users in the study area. This will enable them adopt necessary preventive and protective measures while utilising it.

ii. There is a need for government to improve on shortfall of supply of other forms of alternative domestic energy source in the study area, which will relieve the pressure on the forest resources.

iii. There is a need for provision of improved and affordable stoves that would require little biomass for domestic energy provision by government and stakeholder

iv. There is a need for a follow-up research using finer resolution satellite imagery in order to achieve mapping at detailed level, so as to derive long-term impression of the vegetation cover changes and enhance the inventory of land resources in the study area for planning and monitoring.

v. There is need for exploration of other classification approaches that might yield better results taking into consideration the complexity of land cover types within study area.

vi. Meteorological station should be provided in various part of the study area by state government and the information of those stations should be made readily available to famers and researchers for proper and effective usage.

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APPENDIX 1

QUESTIONNAIRE

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

SECTION A

Socio-Economic Characteristics of the Respondents

1. Sex: Male ( ) Female ( )

2. Age: 40-49 ( ) 50-59 ( ) 60-69 ( ) 70-79 ( ) 80 and above ( )

3. Marital Status: Single ( ) Married ( ) Divorced ( ) Widowed ( )

4. Level of Educational: Primary School ( ) Secondary School ( ) First Degree ( ) Postgraduate ( ) Others Specify…………………………………………………………..

5. Major Occupation of the residents: Farming ( ) Trading ( ) Hunting ( ) Civil Servant ( ) Others specify………………………………………………………………

6. Period of Residency (years): 10-19 ( ) 20-29 ( ) 30-39 ( ) 40 and above ( )

SECTION B

Effects of human activities on vegetation cover changes

7. Do you cut tress/grasses in your area? Yes ( ) No ( )

8. If yes, for what purposes? If no go to question 9…………………………………………………………………………………………...

9. Have you seen or notice people cutting trees or grasses in your area?

Yes ( ) No ( )

10. If yes, for what purpose? If no go to question 11……………………………………..

11. Do you use firewood or grasses in your house? Yes ( ) No ( )

12. If yes, where do you get it? If no go to question 13

Self procurement ( ) Always buy ( ) Sometime buy ( )

13. Have you noticed any changes in the vegetation density around this area compared to the past years? Yes ( ) No ( )

14. If yes, what is the pattern of vegetation density in the area for the past 40 years? If no go to question 16 More tree ( ) Fewer trees ( ) More shrubs ( ) Less shrubs ( ) More grasses ( ) Less grasses now ( ) others specify……………………….

15. What do you think these changes started in the area? 0-9 yrs ( ) 10-19 years ( )

20-29 years ( ) 30-39 years ( ) 40-49 years ( ) 50 years and above ( )

16. What is the present pattern of vegetation density in the area? More trees now ( ) Fewer tress now ( ) More shrubs now ( ) Les shrubs now ( ) More grasses now ( ) Less grasses now ( ) others specify ……………………………………………………

17. How do you think human activities affect vegetation changes in your area?

Farming ( ) Grazing ( ) Logging ( ) Fire wood extraction ( ) urbanization ( )

Limited Land ( ) Bush Burning ( ) Rapid population growth ( )

Others

specify……...

18. What do you think are the impact of vegetation cover change to the environment in your area? Loss of biodiversity ( ) Shortage of fire wood ( ) Loss of wild life habitat ( ) Dessert encroachment ( ) others specify ………………………………………...

19. What measures do you think should be implemented by the Government to Combat/prevent vegetation cover changes in your area? Strong enforcement of Law ( ) Least Government Land ( ) Proper settlement and policies ( ) Coordination between key stakeholders ( ) others specify …………………………………………..

20. What is the measure livelihood options do you think could be consider combat/prevent vegetation cover changes in your area? Implementation of micro finance programme ( ) Implementation of community initiated employment opportunities ( ) providing training on skills enhancement ( ) Provision of Gas, Kerosene, electricity and alternates energy promotion ( )

Others

specify...

APPENDIX 2

NDVI, Mean Annual values of Maximum Temperature and Rainfall of the Study Area

1998

Location	X	Y	Temp (°C)	Rain (mm)	NDVI Values
Azare	9.6625	10.1974	32.50	86.00	0.62
Alkaleri	10.652	12.335	29.18	94.42	0.155
Zaki	10.3125	10.4597	36.25	83.96	0.475
Toro	10.3125	11.7086	26.13	98.41	0.155
Ningi	9.6875	11.0841	35.97	82.90	0.155
Misau	9.6875	10.1474	35.36	75.25	0.475
Liman Ktg.	10.3125	11.3964	37.37	75.10	0.155
Lame Bura	10.625	11.0841	37.19	87.29	0.155
Gamawa	9.6874	10.4597	35.72	85.42	0.475
Darazau	9.375	10.4597	34.79	79.13	0.475
Bauchi	10.625	12.0206	27.77	95.12	0.155

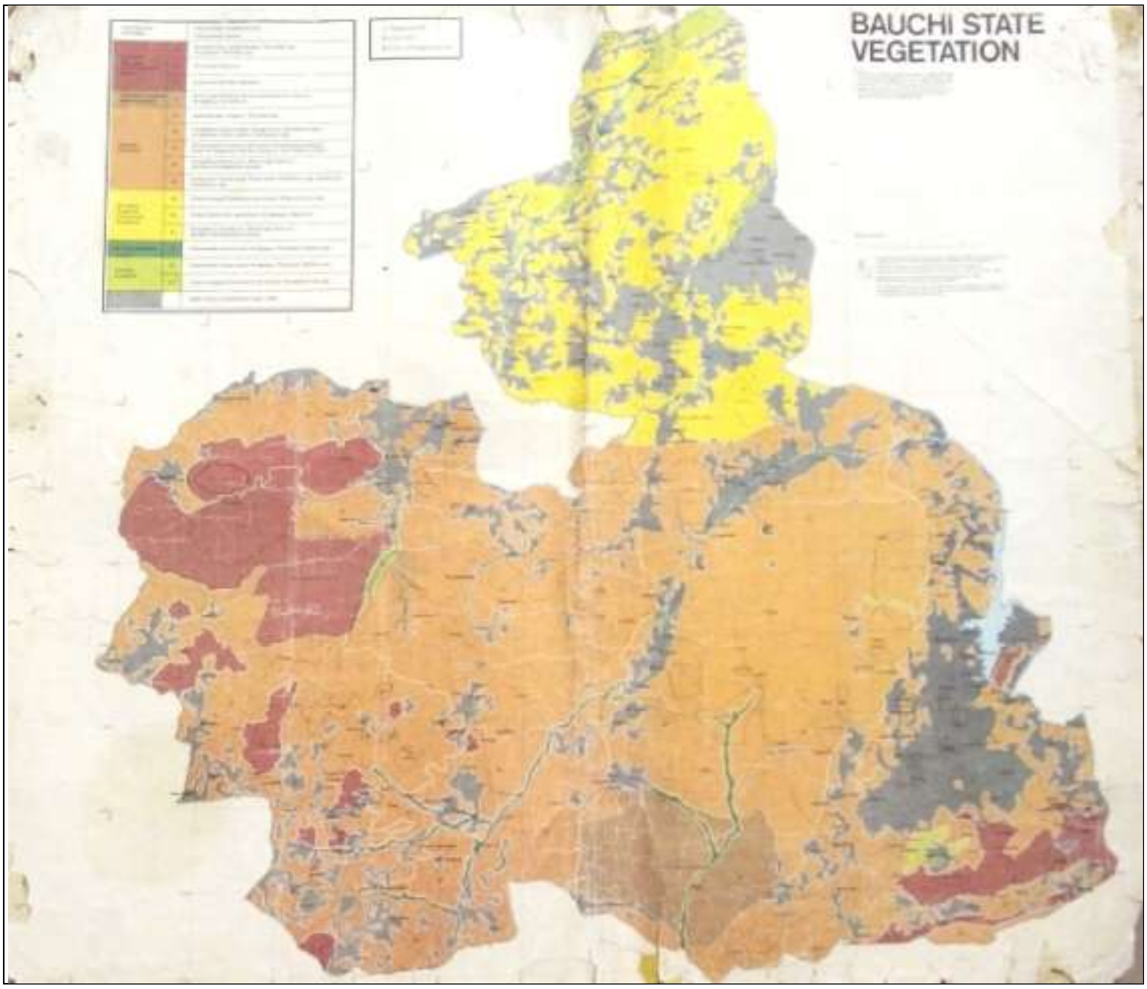
2006

Location	X	Y	Temp (°C)	Rain (mm)	NDVI Values
Azare	9.6625	10.1974	35.92	59.96	0.37
Alkaleri	10.652	12.335	32.88	88.44	0.17
Zaki	10.3125	10.4597	37.99	50.07	0.37
Toro	10.3125	11.7086	29.57	96.21	0.17
Ningi	9.6875	11.0841	35.51	86.65	0.17
Misau	9.6875	10.1474	35.92	60.55	0.28
Liman Ktg.	10.3125	11.3964	39.10	65.12	0.17
Lame Bura	10.625	11.0841	38.92	79.14	0.17
Gamawa	9.6874	10.4597	37.30	55.31	0.37
Darazau	9.375	10.4597	36.17	71.20	0.62
Bauchi	10.625	12.0206	31.64	9.93	0.17

2014

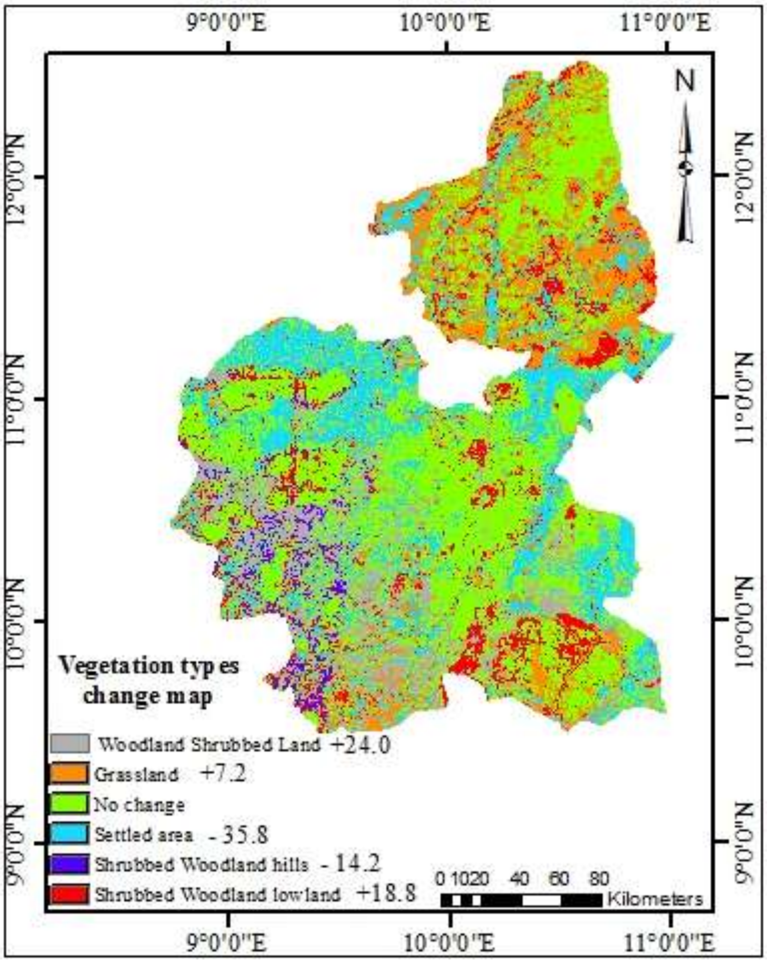
Location	X	Y	Temp (^oC)	Rain (mm)	NDVI Values
Azare	9.6625	10.1974	36.2	57.61	0.48
Alkaleri	10.652	12.335	34.82	92.12	0.17
Zaki	10.3125	10.4597	39.13	47.05	0.295
Toro	10.3125	11.7086	30.12	96.47	0.17
Ningi	9.6875	11.0841	36.43	79.81	0.17
Misau	9.6875	10.1474	36.9	58.01	0.39
Liman Ktg.	10.3125	11.3964	39.16	68.14	0.17
Lame Bura	10.625	11.0841	38.25	82.61	0.17
Gamawa	9.6874	10.4597	39.26	45.42	0.48
Darazau	9.375	10.4597	38.26	59.26	0.53
Bauchi	10.625	12.0206	34.34	83.51	0.17

APPENDIX 3



Vegetation Map of Bauchi State
Source: Department of Forestry, Ministry of Animal and Forest Resources, Federal Government of Nigeria, NIRAD Project Report (1978)

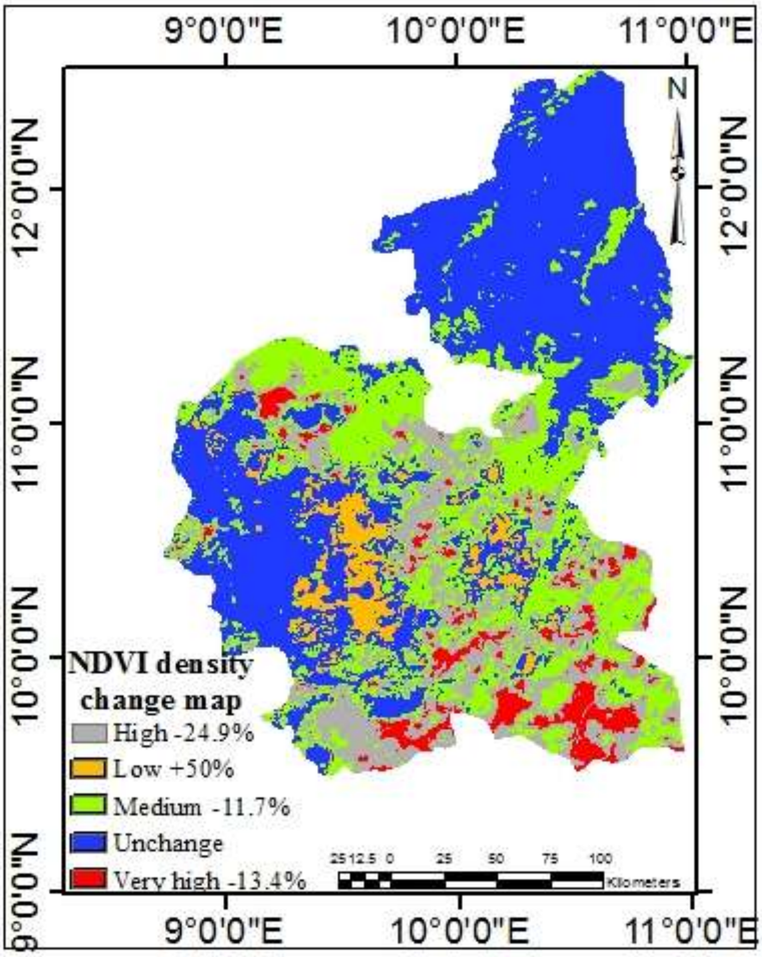
APPENDIX 4



Land cover change map (1976 to 2015)

Source: Author's Analysis, 2017

APPENDIX 5



NDVI density change 1998 and 2014

Source: Author's Analysis, 2017