IMPACT OF LAND USE AND CLIMATE CHANGE ON VEGETATION DYNAMICSOFDOMA FOREST RESERVE IN NASARAWA STATE, NIGERIA

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THESIS SUBMITTED TO THE POSTGRADUATE SCHOOL, FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA, NIGERIA IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF THE DEGREE OF MASTER OF TECHNOLOGY (MTECH) IN CLIMATE CHANGE AND ADAPTED LAND USE

SEPTEMBER, 2015

DECLARATION

I hereby declare that this thesis, titled: "Impact of Land Use and Climate Change on Vegetation Dynamics of Doma Forest Reserve in Nasarawa State, Nigeria" is a collection of my original research work and it has not been presented for any other qualification anywhere. Information from other sources (published or unpublished) have been duly acknowledged.

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CERTIFICATION

The thesis titled: Impact of Land Use and Climate Change on Vegetation Dynamics of Doma Forest Reserve in Nasarawa State, Nigeria, carried out by MOUSSA, Soulé (M Tech/SNAS/2013/4213) meets the regulations governing the award of the degree of Master of Technology of the Federal University of Technology, Minna and it is approved for its contribution to scientific knowledge and literary presentation.

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Prof. M. G. M. Kolo ……..

Dean, Postgraduate School Signature & Date

DEDICATION

This piece of work is dedicated to the Niger Republic and to whoever fights for forest protection in the world.

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“Glory to the Almighty ALLAH”

ABSTRACT

Nigeria' forests reserve are reducing due to human activities. Forest reserves in Nigeria are depleted as a result of cropland expansion, pastureland and logging activities. A lot of studies have showed that deforestation is serious environmental problem in Nigeria with forest loss occurring at a highest world 'rate of 3.3% per year. The aim of this study is investigate the impact of land use and climate change on Doma forest reserve dynamics by combining Remote Sensing, GIS techniques and field data measurement. Land satellite images for 1984, 1999 and 2015 were downloaded from GlOVIS. The field data were obtained from Doma forest inventory and questionnaire was used. The three years of satellites images were processed using ArcGIS 10, ENVI4.7 and IDRISI 17, for computerizing the maps of Normalized Vegetation Index (NDVI).Excel was used for statistical calculations. NDVI map comparison, NDVI differencing and descriptive statistic were used for the data analysis for Doma forest change detection. Floristic analysis was used to describe the woody flora of Doma forest reserve. Descriptive statistic was used to find out climate change perception of Doma forest reserve communities and their perception about the impact of climate change and land use affecting Doma forest dynamics. Doma forest reserve NDVI analysis revealed that high positive NDVI values of + 0.57 was recorded in 1999 while the lowest of -0.035 occurred in 1984 and followed by + 0.05 of 2015.But there was much reduction in Doma forest reserve greenness in 2015. As for Doma forest reserve woody flora description, the analysis showed that 36 woody species were recorded belonging to 16 botanical families and 36 genera within 10 plots but Fabaceae had the highest number of woody species (seven species) distributed in seven genera. All the recorded genera were monospecific. Questionnaire data analysis revealed that that 69 among 100 of the respondents were aware of climate change but only 31 respondents were not aware of climate change. Further, the analysis showed that 30% of the people perceived that climate change has impact on Doma forest reserve dynamics. Their feeling was that the impacts of climate change on Doma forest reserve dynamics were dryness of the forest and the long presence of Fulani men within the reserve due to the long delayed onset of rainfall. Nevertheless, 41% of Doma forest communities perceived that farming activities impacted more Doma forest dynamics followed by illegal logging and grazing. The study concluded there was substantial decrease in Doma forest reserve greenness form 1999 to 2015.Further, the study concluded that unsuitable land use practices such as the use of fire, cutting down the trees for land clearance, the collection for timber, the huts of Fulani men within the reserve were the land use of the depletion of Doma forest reserve.

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List of Abbreviations

BNRCC Building Nigeria's Response to Climate Change

FOSA Forestry Outlook Studies in Africa

FAO Food and Agriculture Organization of the United Nations

IPCC Intergovernmental Panel on Climate Change

GLOVISGlobal Visualization Viewer

LANDSATLand Satellite

LGA Local Government Area

LP DAACLand Processing Distributed Active Archive Centre

MEA Millennium Ecosystem Assessment

MODIS ModerateResolutionImaging Spectrometer

MDP Millennium Development Goals

NDVI Normalized Difference Vegetation Index

NIMET Nigeria Meteorological Agency

NTFP Non Timber Forest Product

SOFO State of World's Forests

SPSS Statistical Package for Social Sciences

UN-REDD United Nations Programme on Reducing Emissions from Deforestation and forest Degradation

UNDP UnitedNationsDevelopmentProgram

UNFF UnitedNations Forumon Forests

UNEP UnitedNations Environmental Programme

USAIDUnited States Agency for International Development

GIS:Geographic information System

GPSGlobal Positioning Systems

RSRemote Sensing

WASCAL West Africa Science Service Centre on Climate Change and Adapted Land Use

CHAPTER ONE

1.0 INTRODUCTION

1.1Backgroundto the Study

Africa is undergoing unprecedented forest degradation due tohuman activities and climatechange (Lambin, 1999; Stephenne&Lambin, 2001; Darkoh, 2003).During the past decades human population growth and the intensification of land use increasedthe pressure on forest ecosystems (Wilkie and Laporte, 2001).From some of the studies, land use is the driver of forest changes. Land use as the direct anthropogenic intervention in nature is considered as the major threat to global biodiversity in terrestrial ecosystems (Millennium Ecosystem Assessment, 2005; Feeley and Silman, 2009;Sabellek, 2010).Further, the expansion of agricultural areas causes a rapid conversion, fragmentation and destruction of native habitats and a severe risk of endangerment and extinction of species in the past, present and future (Rebelo and Siegfried, 1992; Ellis and Ramankutty, 2008).Forests in Nigeria are under pressure due to land use as a result of human population growth. Further, Nigeria loses more than 350,000-400,000 hectares per year (Food and Agriculture Organization, 2005) due to human activities. Furthermore, logging is one of the most common forest disturbances in Nigeria(Philip*etal.,* 2014).For instance, wood is a major source of energy in Nigeria (Forestry Outlook Studies in Africa, 2001). Moreover, grazing is a principal cause of tropical forest degradation (Food and Agriculture Organization of the United Nations, 2010).In general, with increasing population, expansion agriculture, unsustainable forest use and urbanization which are the major leading causes to deforestation in the tropical regions (Duveiller, Defourny, Desclée,

&Mayaux, 2008).

Deforestation is a major environmental problem in the world (Forestry Outlook Studies in Africa, 2012).For instance,deforestation is a serious environmental problem in Nigeria(Deforestation rate 3.3%) per year (FAO, 2005).Further, deforestation is one of the greatest environmental challenges in Nasarawa State of Nigeria (Alao, 2009).Furthermore, deforestation menaces tropical forests since it is the driver of biodiversity loss (Lung and Schaab, 2009). Deforestation causes land degradation and climate change.Further, deforestation is responsible for 20% of annual global greenhouse gas emissions (United Nations Programme on Reducing Emissions from Deforestation and forest Degradation, 2011). Moreover, millions of species are impacted by deforestation since it is a destructionof their natural environment (National Geographic, 2010).

Apart from the land use, climate change affects world's forest. Further, change in climatic factors can alter tree physiology (Ayres and Lombardero, 2000).Ecologically, climate change hinders the ecosystems interaction (Stireman*et al*., 2005).Moreover, the impact of climate change on tropical vegetation is of global and regional concern because of the typically high biodiversity and the potential feedback to the carbon, water, and nutrient cycles (Bazzaz, 1998).

Forests protection are of paramount importance to sustainable development (UNEP, 2001).Therefore, forestry study is of overwhelming importance to provide data for sustainable forest management (Lung and Schaab, 2009). The forests are also sink of

carbon. But deforestation is a great problem to achieve sustainable development.

Today, geospatial techniques play a crucial role in solving environmental problems. Remote sensing provides the information of the object without any physical contact to the object in the digital form(Agone and Bhamare, 2012) whilegeographic information system (GIS) is a computerizedinformation system with functions for collection, storage, processing, analysis and visualization of spatial data(Harrie, 2008).Geospatial technologies constitute apowerfultooltogloballystudyvegetation dynamics especially forest change detection in the world. GIS is useful in forestry (Eklundh, 2003).Geospatial technologies provide a powerful tool for the forest change detection for the sustainable forest management. Geospatial techniques help to get information about environment (Manoj, Patil, Snehal&Bhole, 2012).The geospatial technique is not the approach to be used to carry out this study. The study used also the field data measurement such as forest inventory and ethnobotanical survey.

1.2 Statement of the Problem

Deforestation is a widespread problem and the biggest menace to the forest is anthropogenic activities (Naemi and Anja, 2001).For example, deforestation is a major environmentalproblem inNigeria (Central IntelligenceAgency,2008).According to Federal Ministry of Environment Abuja (2006), the degradation of Nigeria forest resources is indisputable. For instance, Nigeria loses more than 350,000-400,000 hectares per year (FAO, 2005) due to human activities. According toForestry Outlook Studies in Africa (2001), cropland is increasing at an average 554,657 hectares per year while the forested

area is diminishing at a rate of 105,865 hectares per year in Nigeria. For example, 65 of 560 trees species are faced with extinction while a lot of others are at different stages of risk(Imehtand Adebobola,2001). Further, there is evidence that Nigeria forests are destroyed due to human activities such as farming activities, grazing and unsustainable water management (FOSA, 2001).Wood consumption is a major source of deforestation. Nigeria is largest wood producer with an annual harvest estimated in 1998, of more than 100 million cubic meters in Africa(FOSA, 2001).Further, wood is used as energy by 60% of Nigerians(Francis and Theophilus, 2011).Furthermore, Nigeria about 90% of the rural communities in the South and up to 98% in the North depend woodenergy (FOSA, 2001).

Moreover, Nigeria forests are destroyed each year by urban development(Imeht and Adebobola, 2001).Likewise,Akintoye,Bisong,Utang, Andrew(2013) and Mfon,(2003) confirmed the loss of biodiversity was due to mainly inappropriate human activities such as logging and constitutes the serious menace to forests conservation in Nigeria. In general,the key causes of tropical deforestation are logging and conversion to farming activities or grazing (Rowe, Sharma, & Browder, 1992). Especially in the West African forests approximately 50% of natural areas have already been converted to cultivated land (Poorter and Bongers, 2004). According to FAO (2005),human activities such as logging, agricultural expansion, and collection of fuel wood are major driving factors for deforestation in Nigeria. Theforests degradation in Nigeria is exacerbated by high levelpoverty in rural areas, and rapidly growing population with attendant higher demand for croplands, pasturelands and wood resources. The concept ‘forest reserve’ now is only a nomenclature and the term does not indicate that it contains trees in Nigeria and many of

the forest reserves have been highly destroyed due to human activities(FASO, 2001).Nevertheless, deforestation is not mainly driven by the conversion of forests to agricultural land. Climate change is alsoimpacting world'sforests. For instance,the increase of global averagetemperature more than 1.5 to 2.5 °C, will affect about 20 to 30 percent of plant and animal species and the species willat an increased risk of extinction (Intergovernmental Panel on Climate Change, 2007).

Further, warmer temperatures will increase the loss of water from evapotranspiration and will reduce the plant water use efficiency (Mortsch, 2006). Such conditions can affect the phenology and health of trees (Mortsch, 2006).Furthermore, the forests are under a variety of disturbances that are themselves strongly influenced by climate(FAO, 2008).Deforestation is one of the greatest environmental problems in Guinea Savannah of Nigeria. According to FOSA(2001), management of Nigeria forest reserves has been inadequate and forest management seems to have been replaced by the project syndrome. Further, FOSA, (2001), stated that a lot of forest reserves particularly in the Guinea Savannah are destroyed due to anthropogenic activities.Furthermore, many of trees are cut for fuel wood by residents in Guinea Savannah areas or cleared to make room for agriculture (Geomatics, 1998).For example, Nasarawa State of Nigeria located in Guinea Savannah, its forestry development faces a very bleak future (Alao, 2009).In general, Nigeria's forest are under great threat due to anthropogenic activities such as unsustainable agricultural practices, illegal logging, grazing, medicinal use, wood energy etc.

This threat brings a lot of environmental problems such as desertification, deforestation,

climate change and it also has great consequences on population well-beingin Nigeria. The consequences of deforestation are huge.For instance, between1990 and 2005, Nigeria lost a staggering 79% of its old-growth forests (Rainforests Mangabay, 2007).Further, deforestation in Nigeria has destroyed biodiversity of the forest ecosystem(Philip et *al*., 2014).Furthermore,when deforestation takes place, the region may not hold as much water which can lead to a much drier climate. (Wikipedia, 2008). Deforestation is one of the major causes of climate change. For instance, IPCC (2007) estimated 17 % of global greenhouse gas emissions comes per year from deforestation. Further, the water cycle is affected by deforestation (Philip *etal.*, 2014).Furthermore, encroachment is accelerated by deforestation(Philip e*t al.*, 2014) in Nigeria.

Likewise, deforestation is a hindrance for achieving the Millennium Development goals world and particularlyin Nigeria (Philip *et al.*, 2014). Today, land use, climate change and deforestation are cross cutting issues. However, sustainable management of forest has become imperative due to the socioeconomic and environmental role of theforest.Indeed,Nigeria has made a lot ofefforts to control deforestation thus, the creation of forest reserves. For instance, Doma reserve forest is one among them. There is need for more environmental studies are needed to get a better understand of environmental problem (Lung and Schaab, 2009).

1.3Initial Assumptions

Thegeneral assumptionisthat forestsreserve in Nigeriaareimpactedbylanduseandclimate

change. The present study investigatedthe land use practices and climatic changes that affect adversely vegetation dynamics.

1.4Significance of the study

Vegetation cover plays an important role in all aspect of human activities at different spatial and temporal scales (Flavio, Gianvito, Gian, & Dario, 2008 and Nwagbara, 2008).Guinea Savannah vegetation has great impact on the environment and socioeconomic activities of West African, especially in Nigeria where about 80% of Nigerians are forest resources dependent. Today forest protection has become an important part of the international climate agenda due to its role in global climate system and ecosystem services. For instance, remarkable attention has been given to the role of forests and forestry in poverty reduction strategies in recent years, as one aspect of the Millennium Development goals (2003). In general, forests and the forestry sector can contribute to poverty reduction by addressing subsistence and vulnerability, income generation, energy, as well as agricultural and rural development (Souleymane, 2008). In many countries, there is a dependence of people on forest resources (Bergeret&Ribot, 1990).Howeverthere is a reduction in Nigeria's vegetation cover due to human activities. For instance, forests are under threat in Nigeria due to human activities (United States Agency for International Development, 2008).Nigeria's Minister of Environment stated that deforestation is one of the greatest environmental problems in Nigeria.

Further, Laurentia(2014) said that forest protection is of great concern in Nigeria.Moreover,actions to combat deforestation andpromote restoration of

destroyedlands will contribute sustainable development(Climate Summit, 2014).Furthermore,Reducing Emissions from Deforestation and Forest Degradation (REDD) is giving opportunity to tropical forest countries through financial assistance to conserve their forests.In this regard, UN-REDD offers a great opportunity to Nigeria to reduce the issues of deforestation and to fight also the sources of deforestation by promoting socioeconomic activities in rural areas. In the current context of climate change, sustainable use of forests becomes a priority (OECD, 2009).In this regard, promoting a sustainable use ofGuinea Savannah vegetation, case of Doma forest of Nigeria is of paramount importance because of its role in carbon sequestration and in ecosystem based adaptation for the rural population. Infact, one tropical tree can sequester at least 22.6kg of carbon from the atmosphere each year (World Agroforestry Center, 2011).

This is why this study aims at investigating the impact of land use and climate change on Doma forest of Nasarawa for a sustainable forest management in Nasarawa State. Guinea Savannah vegetation of Nigeria makes this region an important climate protector and plays a key role in biodiversity conservation, therefore, a good natural resource to promote climate change adaption and mitigation for the rural population for a sustainable forest management.UN-REDD recognizes the forests as source of adaptation and mitigation of climate change because they constitute source of diversity of ecosystem services. The maintenance of Guinea Savannah forest, the case of Doma forest is of high importance for local environment. Themaintenanceofforests isanindispensableprecondition forthefunctionalityof ecosystems andtheprovision ofhumanswithimportant ecosystem services. Doma forest reserveand the services itoffers Nasarawa State society are

important to sustainable development.Therefore,vegetation changes in Nigeria is gradual and there is a dire need for monitoring to ensure a sustainable management through the use of the method which combines remote sensing/GIS and traditional method relies on manual field.

1.5Scope of the study

Doma forest reserve of Nasarawa State was the scope of study where the impact of land use and climate change on vegetation dynamics was the focus of the study. Doma forest reserve issituated inDoma local government of Nasarawa State ofNigeria. Doma forest reserve lies at a latitude 8˚16’55” N to latitude 8˚17’50’’N and a Longitude 8˚17’44” E to longitude 8˚18’49”E.It has an elevation of 151 meters above sea level.Doma forest reserve has 86,374.40 hectares. Legal status of Doma forest is gazetted and its degree of protection is not protected.

1.6 Limitations to the Study

The limitations to the study are related to financial issue to get the satellite images of high resolution in order to see clearly the presence of forest for better understanding of the impact of land use and climate change on vegetation dynamics. Climate data of Doma local government constitute a great limitation as Nasarawa State has scanty weather stations.

1.7Aim, Objectives and Research questions

The aim of this study was to investigate the impact of land use and climate change on Doma forest reserve dynamics in Nasarawa State of Nigeria between the period 1984-2014 by using Remote Sensing and GIS techniques.

1.7.1 Specific Objectives

The specific objectives of the study are to:

i. Assess the impact of land use practices on Doma reserve dynamics between the period from 1984-2015.
ii. Describe the systematic composition in terms of woody species of the Doma forest reserve in Nasarawa State of Nigeria.
iii. Find out the perception of climate change of Doma forest reserve communities.
iv. Find out the perception of impact of climate change and land use on Doma forest reserve dynamics and the key Doma forest products.

1.7.2 Research questions

i. What are the impacts of land use practices on Doma forest reserve dynamics?
ii. What is the systematic composition in the terms of woody species of the Doma forest reserve?
iii. What is the climate change perception of Doma forest reserve communities?
iv. What is the perception of Doma forest reserve communities of the impact of climate change and land use on Doma forest reserve dynamics? What type of Doma forest products the population is using?

1.8Study area

The study area is located between latitude 8˚16’915” N to latitude 8˚17’884’’N and Longitude 8˚17’135” E to longitude 8˚17’955”E in Doma local government of Nasarawa State of Nigeria. The study area covers 86,374.40 hectares of land with the elevation 151 meters above sea level. Legal status of Doma forest is gazetted and its degree of protection is not protected. Doma local government has an area of 2,714 km^2a population of 139,607 (NPC, 2006). Agriculture is the dominant occupation of the inhabitants of Doma local government. Doma local government has two distinct seasons. The wet spellis from about the beginning of May and ends in October. The periodseason is experienced between November and April. It is in the Guinea Savanna eco-vegetation. The mean annual rainfall of the area is 1550mm, while the mean annual temperature of 27°C.The study was conducted in Doma local government area of Nasarawa State where Doma forest reserve was the target population (Figure 1.1).

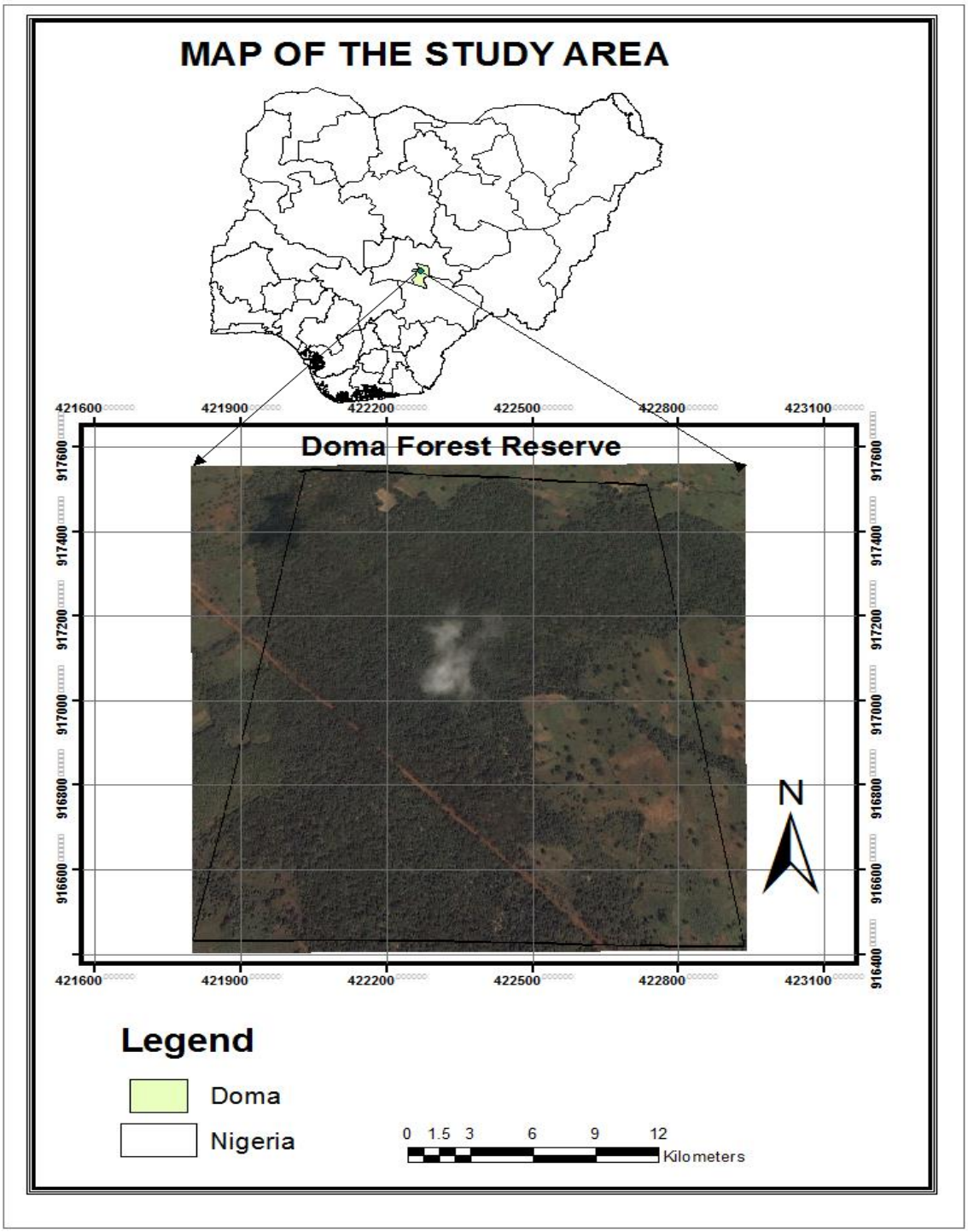

Figure 1.1Doma Forest Reserve(Source: Author' work, 2015)

1.8.1Climate

Rainfall is the key climate variable which controls vegetation distribution in the world particularly in Nigeria where vegetation type differs from the North to the South.Doma local government is in the Guinea Savanna eco-vegetation and theannual average ofrainfall is 1550mm and yearly average of temperatureis 27˚C.Vegetation study has is important to understand the climate variability and change (Woodward&Mckee, 1991 and PCCF, 2003), mostly in the context of increasing population growth, urban development and climate change, as well as the role of vegetation studies to understand the climate system response and ecological balance (Bakker ,Poschlod, Strykstra, Bekker, &Thompson, 1996 and Douville*et al.*, 2000).

1.8.2 Vegetation

Vegetation is assemblages of woody and herbaceous species and the ground cover they provide (Barbour& Billings, 1999). As far as biodiversity status is concerned the State has a total of 41 natural forest reserves, 20forest guards and 25 fish ponds (Alao, 2009).The vegetation types are forest reserve, cropland and gallery forest but from this study the forest species were dominated by Fabaceae. Doma forest reserve is one of natural forest reserve. But in 1988, there was artificial plantation within the forest.Woody vegetation such as Doma forest reserve is of great importance to the socioeconomic andenvironmental development of Doma forest reserve communities.However, farming activities, grazing and logging are the key land uses impacting Nasarawa State vegetation.

CHAPTER TWO

2.0 LITERATURE REVIEW

Deforestation is one of greatest environmental problems in Guinea Savannah of Nigeria. According to FAO (2005) Nigeria has highest de deforestation rate(55, 7%) in the world.According to Aliyu, Mala, &Abdullahi(2014) human activities, climate change coupled with rural poverty have led to increased deforestation in rural areas of Nigeria and deforestation is the principal causative factor of environmental changes in Nigeria. Deforestation in Guinea Savannah has negative implications on the socioeconomic environment of this locality.The key drivers' factors of deforestation in the world are unsustainable land use practices and climatic changes.

According to FAO, Forest Resource Assessment (2005) 13 million hectares of the forests are lost in the world each year as a result of human activities. Alao,(2009) stated that forestry development in Nasarawa State faces a very bleak future. In the same view, Francis*et al.*(2011) found out that there is deficit of wood in north and middle belt of Nigeria. This confirms that deforestation is a real environmental problem in Guinea Savannah. Moreover, forests are also affected by climate change (IPCC, 2005). According to the Millennium Ecosystem Assessment, (2005) climate change will be become by the end of the century the dominant driver for the loss of biodiversity. This study was aimed at investigating the impact of human activities and climate change on Doma forest dynamics by using geospatial techniques for a sustainable forest management in Guinea Savannah of Nigeria.

2.1Concepts review

2.1.1Landuse, vegetation dynamics and forest reserve

Landuserefers tothepurpose forwhichhumans exploitthe Earth's surface andimmediatesubsurface (RamankuttyandFoley, 1998). For instance, forest may be exploited for wood production (the land use). Vegetation dynamics is defined as temporalbehavior of the vegetation performance(Roerink, Menenti, Soepboer& Su, 2003).A reserve is aprotected area for future use or a special purpose. But sadly many of Nigerian' protected areas lack real protection (USAID, 2008). Today the world reserve forests are under threat, especially tropical forests due to human activities. This menace is more accentuated in countries with high population rate, which has as direct consequences the increasing need for forest resources leading to the depletion of forest resources and environmental changes such as deforestation and desertification. For example,according toFAO(1998), there is an urgent need for agricultural land to increase the difficulty of preserving protected areas.

For instance, there is strong evidence that land use affects vegetation dynamics as it describes the alteration of an existing natural ecosystem by anthropogenic activities. For example, Jane *etal.*(2009) found out that farming is commonly practiced within the reserve which is situated in the lowland rainforest zonein Ehorforest reserve of Edo State in Nigeria. Land use is the destruction, conversion, and fragmentation of an existing system, represents the key driver leading to a considerable loss of biodiversity (Duraiappah, 2005).

2.1.2 Climate change and vegetation dynamics

Climate change is defined as any change in climate over time, whether due to natural variability or because of human activity (IPCC, 2001).Climate change has huge impact on vegetation dynamics, but the impact varies from the type of vegetation for every zone. For instance, according to the IPCC(2007) fourth assessment report, the resilience of many ecosystems will beexceeded within this century by the combination of climate,) and anthropogenic activities. About 20 to 30% of biodiversity assessed will be extinct if the temperature exceed 1.5 to 2.5 ° C (IPCC, 2007). With the increases in temperature there will be major changes in ecosystem function (Sié, 2010). Climate has huge impact on forest dynamics. Rainfall is the most important ecological driver for forest behavior.

2.1.3 Normalized difference vegetation index (NDVI)

Normalized Difference Vegetation Index (NDVI) is an index of describing the phenology, greenness, productivity of vegetation. It is an index of green biomass (Sabellek, 2010).There are several methods for vegetation change detection but NDVI is widely used and suitable for monitoring forest change. NDVI is a good indicator of showing the greenness for vegetation and has been widely used by researchers to estimate green biomass (Prince, 1991). For instance, Manoj*et al*. (2012) used NDVI approach and land use/land cover (LULC) to study vegetation change. The study revealed that NDVI is the suitable approach to detect vegetation change.

Similarly, the NDVI is one of the most suitable indexes to detect a green area (Agone and Bhamare, 2012). Furthermore, NDVI gives a measure of the volume and vigor of

vegetation at the surface area (Usman, Yelwa, Gulumbe&Danbaba, 2013).The Normalized Difference Vegetation Index (NDVI) is the most used indicator of terrestrial vegetation productivity (Pei-Ling and Nathaniel, 2013).The values of NDVI range from 1 to-1. 0 value is representing the area without or no vegetation.

2.2Empirical Review

Several studies have been done by geospatial techniques to detect forest change. For instance, Pavan, Meenu, Pandey,Arnab&Nathawat (2010) used remote sensing and geographic information system(GIS) to monitor deforestation and forest degradation using remote in Jharkhand (India).The study used NDVI time series to monitor deforestation and forest degradation. Further,Agone&Bhamare (2012)used NDVI to detect vegetation change in Tittur basin. The study comparedthe map of NDVI of 1989 and 2010 for vegetation change. The study found out that NDVI values vary from vegetation cover type and bare land has zero value. Nathalie*et al.*(2005) used NDVI to investigate ecological responses to environmental change. Furthermore,Stefanie, Assaf& Compton(2005) studiedvegetation dynamicsintheAfrican Sahel by using NDVI approach. Yang, Yang, & Merchant (1997); Wang,Rich&Price (2001) and Mahmoud, Bahram&Gieske(2001) studied vegetation change through the use of NDVI method.Guang*et al.*(2014) assessed vegetation dynamics in China by using NDVI.The NVDI analysis concluded that human activities affected vegetation dynamics insomeregions in China. In a similar study José, Barnard, & Catherine (2009) used NDVI to assess vegetation cover change in Sahel. Moreover,Abdussalam (2008)used NDVI) to assess vegetation degradationin Libya.

Further,Niels, Yi,Albert, Richard, & Tim (2013) used remote sensing and GIS to assess vegetation dynamics indrylandvegetation dynamics. In addition, Xia, Cerian, Jane& Peter(2013) used NDVI to assess vegetation change SouthernAfrica over the period 1950–2008.Furthermore, Pei-Ling and Nathaniel(2013) used NDVI to assessthe impact of climateand land useimpacts onvegetationincentralUnited States.Even within Nigeria, remotesensing and GIStechniques have been used for forest change detection. For instance,Alhassan, Aishatu, Abdullahi&Rukkaya (2014) used NDVI approachto estimateamountofforestdegradationand carbon sequestrationforEffanforestreservein Kwara State. The study used NDVI map for Effan forest reserve change detection.Further,Felix & Adebayo(2013) studied vegetation change by using remote sensing and GIS in theSouth-Eastern Nigeria.

The present study used two approaches: remote sensing/GIS techniques and field measurement approach (Doma forest inventory and questionnaire).Forest inventory plays a great role in knowing the type of forest species as land use is all about resource oriented. For instance, the forest rich in of high timber qualities, logging activities may be intensive within such forest. Several studies have been done by using forest inventory in order to describe the floristic composition of the forest ecosystems. For, instance Oke&Jamala (2013)used inventory approach to determine the woody flora in Adamawa State of Nigeria. They used floristic analysis for the data analysis.Further,Rabi'u&Adamu (2013) collected woody flora inDutsin-Ma area Katsina State by using inventory.Howerver, Mustapha carried outethnomedicinal studies of medicinal plants with antifungal activities in

Keffilocal government, Nasarawa state, Nigeria.He used ethnobotanical survey for data collection.

Several studies have been done by using questionnaire to find out the perception of the population about climate change and its impacts related to several sectors. For instance, Aphunu&Nwabeze (2012) used questionnaire to find out the perception of climate change impact on fish production in Delta State, Nigeria. Further,Falaki, Akangbe&Ayinde (2013) studied theanalysis of Climate change and rural farmers' perception in North Central Nigeria.The instrument used for data collection was a structured questionnaire. Methodological experiences benefited from the reviewed in reviewed literature have been applied to develop our own methodology found in the next chapter (Chapter3).Most of the studies reviewed used remote sensing and GIS to assess forest change detection, hence there is scanty of studies done about the impact ofhuman activities and climate change on forest dynamics in Nasarawa State using the remote sensing /GIS and field measurement. This study inventoried the Doma forest woody flora and to find out the Doma forest reserve communities perception about impact of climate change on Doma forest reserve dynamics. This study was to fill this gap mostly as the first intervention in Doma forest reserve in Nasarawa State of Nigeria.

CHAPTER THREE

3.0 MATERIALS AND METHODS

Unsustainable land use and climate change represent some of the most alarming long term threats to the world's forests especially in Africa.To overcome forest degradation, there is need to carry out a research so that the sustainable forest managementwill be promoted as forest conservation is of greatimportance.The present studyanalyzed the impact of land use and climate change on Doma forest reserve of Nasarawa State.The study used two approaches for data collection, namely remote sensing approach and field data measurement such as forest inventory and ethnobotanical survey. The present researchusedLandsat images downloaded from GLOVIS,floristic data (woody species) and the data from the interview of the population of interest in the study such as ethnobotanical data were collected from relevant sources and used to achieve the aim of this of this work which wasto assess the impact of human activities and climate change on Doma forest reserve dynamics in Nasarawa State. The research method adopted in this study followed two major steps: fieldwork (fielddata collection) and lab work(remote sensing and GIS analysis). The following software wereused forpreprocessing and GISanalysis;SPSS 20, ArcGIS10,IDRISI17and Microsoft Excel.

3.1Study population

The study population is the Doma forest reserve of Nasarawa State. Doma forest reserve issituated inYelwa village of Doma local government area of Nasarawa State ofNigeria. Doma forest reserve lies at a latitude 8˚16’55” N to latitude 8˚17’50’’ N and Longitude 8˚17’44” E to longitude 8˚18’49”E. Doma forest reserve covers 86,374.40hectares of land. Legal status of Doma forest is gazetted and its degree of protection is not guaranteed. Doma forest reserve was the scope of the study and the study was more focused on the impact of human activities and climate change on Doma forest reserve dynamics in order to investigate vegetation change by using remote sensing and GIS techniques.

3.2Instrumentation for data collection and analysis

Several materials were used to collect the data and for data analysis. The following equipments were used:GPS, Digital camera, 100 meters measuring tape, slip of inventory, questionnaires, pencil, andpen. The following softwares were used:

i. IdrisiSelva version 17 for computerizing NDVI.
ii. ArcMap version10 for images extraction, mapping of study area and NDVI mapping.
iii. Envi version 4.7 for the conversion of the images (vector) to raster.
iv. Excel for the calculations of percentage and for the graphs.

3.3Data collection for objective one

Objective one was to assess the impact of land use practices on Doma forest reserve dynamics betweenthe periodsof 1984-2015. To explore objectiveone, thisstudy used

theLandsat imageries for 1984, 1994and 2015 to detect Doma forest reservechanges. For thisobjective which aims at investigating the effect of land use practices on Domaforest reservedynamics, the Normalized Difference Vegetation Index (NDVI) is usedas method for detecting the impact of land use on the reserve. For instance, Sahebjalal and Dashtekian(2013) stated that the created NDVI images could be used to identify the pattern of changes that had occurred between two different dates. The Doma forest reserve (NDVI map) maps were established for 1984, 1999, and 2015.The images were downloaded from GLOVISwebsite and the available Landsat images for the study area were used.

3.4NDVI analysis

Normalized Difference Vegetation Index (NDVI) has been used by a lot of studies to detect vegetation change (Townshend &Justice1986,Malo& Nicholson 1990,Davenport &Nicholson1993, Agone&Bhamare, 2012 and Alhassan, Aishatu, Abdullahi&Rukkaya, 2014).NDVI is a measure of vegetation vigor, which provides an effective measure of photosynthetically active biomass, and it is calculated as follows:

$$\mathbf{NDVI}=\frac{NIR-R}{NIR+R}=\frac{band4-band3}{band4+band3} \qquad (3.1)$$

Where NIR and Rare spectral reflectance values in the near infrad-red and visible red band passes respectively. After determining the three NDVI maps for the three years, the mapped NDVI change analysis and NDVI differencing between 1999 and 2015 was done by comparing the three NDVI maps for determining the spatio-temporal changes of Doma forest reserve were detected by calculating the NDVI value and percentage change per year.

3.5Data collection for objective two

Objective two was to describe the systematic composition in terms of woody species of the Doma forest reserve in Nasarawa State of Nigeria. To describe the systematic composition of Doma forest, the study required forest data. Doma forest inventory was used to collect such data. Forest inventory plays an important role in systematic collection of data and forest information for assessment or analysis.Woody vegetation inventory was used to determine woody flora of Doma forest. The woody species were inventoried along transect (transect approach) from the periphery of forest to its Centre. Within each plot of 30mx30m, the trees species were counted the number of woody species, botanical families, and genius were determined. Number of species (floristic diversity), botanical families are ecosystem vital attributes. The field inventory concentrated on indicator species. Systematic composition is a good parameter to determine the type of species because the type of specie is a driver factor of forest uses. The unknown Doma forest reserve woody species were pictured and sent toMarco Schimidt, EmelineAssede and Ali Bechir for West African Plants for identification.

3.6Floristic data analysis

Floristic analysis was used to describe the systematic composition in terms of woody species of the Doma forest reserve in Nasarawa State of Nigeria. Number of species and botanical families were calculated. The figure was done showing the percentage per each botanical family.

3.7Data collection for objective three

Objective three was to find out the perception of climate change of Doma forest communities. Questionnaire was used to find out the perception of climate change of Doma forest reserve communities.The questionnaire was translated into the local languages by interviewers especially for the respondents that could neither read nor write.

3.8Questionnaire data analysis

A descriptive statistical analysis was used to analyze the data obtained from the questionnaire. Percentages were used to show the level of awareness of Doma population about climate change. Figures such as charts were used for statistical analysis to examine the key forest uses that affect Doma forest dynamic. Results emanating from the field work and analyses obtained were presented in the next chapter (Chapter 4).

3.9Data collection for objective four

Objective four was to find out the perception of climate change of Doma forest communities about the impact of land use and climate change on Doma forest reserve dynamics.Questionnaire and focus group discussion were used.

3.10 Questionnaire data analysis

A descriptive statistic was used to analyze the questionnaire data collected from the field. Percentages were used to get the level of perception the impact of land use and climate change on Doma forest reserve dynamics.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSIONS

This chapter presents the result of the study, explanation of the figures, tables and charts of the achieved objectives. The major results of the research are: Impact of land use on Doma forest reserve dynamics, Systematic composition of Doma forest reserve, the perception of climate change of Doma forest communities and the perception of Doma forest reserve communities about the impact of land use and climate change on Doma forest dynamics and the type of Doma forest products used by the communities.

4.1Impact of land use on Doma forest reserve

The first objective of this study was to assess the impact of land use on Doma forest reserve dynamics from 1984 to 2015 by using NDVI approach.This was intended to determine the human activities that threaten Doma forest reserve dynamics. The NDVI map of 1984, 1999 and 2015 were done.

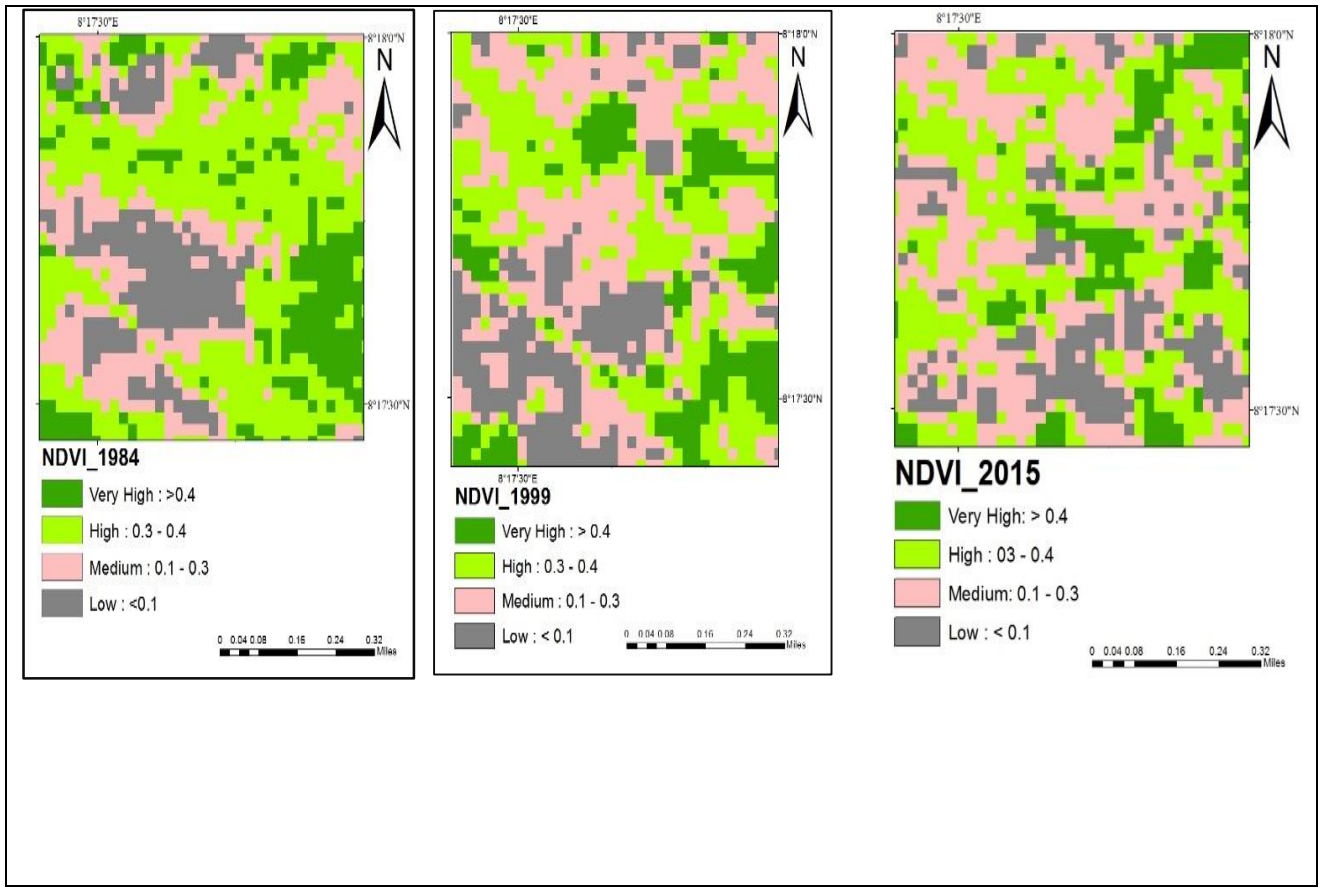

Figure 4.1 NDVI map of Doma forest reserve for 1984, 1999 and 2015

In the present study, the values of NDVI were categorized as low density < 0.1 , medium density from 0.1 to 0.3, high density from 0.3 to 0.4 and very high density >0.4.Figure4.1 shows the Normalized Vegetation Index(NDVI) of Doma forest reserve for the year 1984,1999 and 2015. The NDVI values for 1984 range from -0.035 to 0.52. In 1984, 0.52

was the very high value of the NDVI which indicates a high biomass .In 1984,the high NDVI value was 0.33 and the medium value was 0.15.The figure 4.1 shows Doma forest reserve reflectance for the year 1999 which has the highest NDVI values in all classes. The values range from 05(Low value) to 0.57(Very high value).But in 1999, the high NDVI value was 0.40 and the medium was 0.22.

4.1.1 Vegetation index map of Doma forest reserve for 1984

Figure 4.2 shows the vegetation reflectance of Doma Forest Reserve for the year 1984 which has NDVI Values which range from -0.035 to 0.52 indicating a high biomass.As at this time,Doma forest resere was natural plantation only signifying that the Doma forest reserve was still intact.Howerer, figure 4.2 shows the vegetation reflectance of Doma forest reserve for the year 1984 is negative value(-0.035) which indicates a decrease in the greeness of Doma forest resere.This affirms that there was Doma forest degradation which re-affirms the result found by several authors thatNigeria forest area has been on the decrease.For instance,Njoku (2008) revealed an apparent negative trend of vegetation vigour in the south eastern Nigeria with NDVI deficit of -0.5 to -0.7 between 1970 and 1980s and a concomitant loss of 78% (166,338m^2) vegetation covers. Furthermore,Egwumah, Ogunrinde & sanusi(2009) stated that Nigeria forest areas have diminished from about 60 million hectares in 1890 to the current value of about 9.6million hectares.Morever, the lowermostNDVI valuefor Doma forest reservein1984is-0.035.Thisvalueisclosetothe lowest figureof -1 NDVI for novegetation. The lowervalueof -0.035indicatesmuch less vegetative features within Doma forest reserve in 1984.

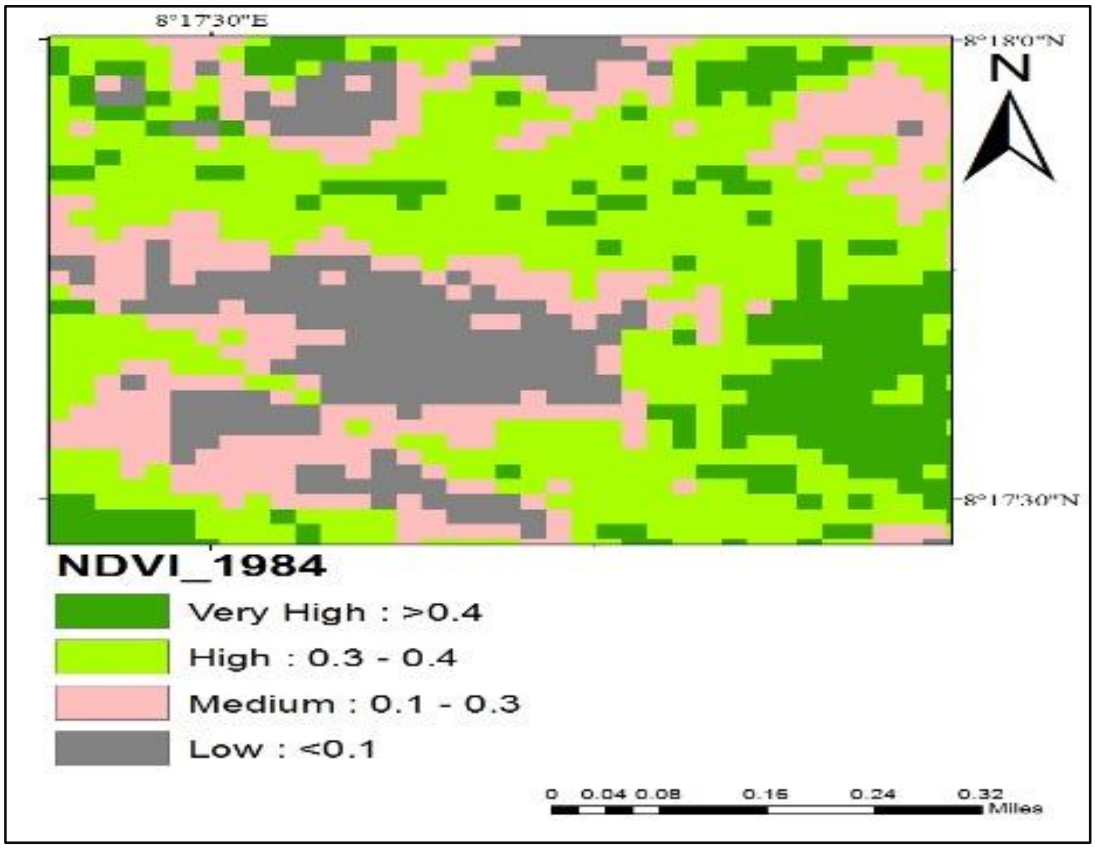

Figure 4.2NDVI values of Doma forest reserve for 1984

4.1.2 Vegetation index map of Doma forest reserve for 1999

Figure 4.3 shows the vegetation reflectance of Doma Forest Reserve for the year 1999 which has NDVI values which range from 0.05 to 0.57. The very highNDVIvalue forDoma Forest Reserve in 1999is0.57 andindicatescomparativedensevegetation. This value confirms that there is an increase of Doma forest amount of greenness in 1999. However, in 1988, there was an artificial plantation within Doma Forest Reserve.

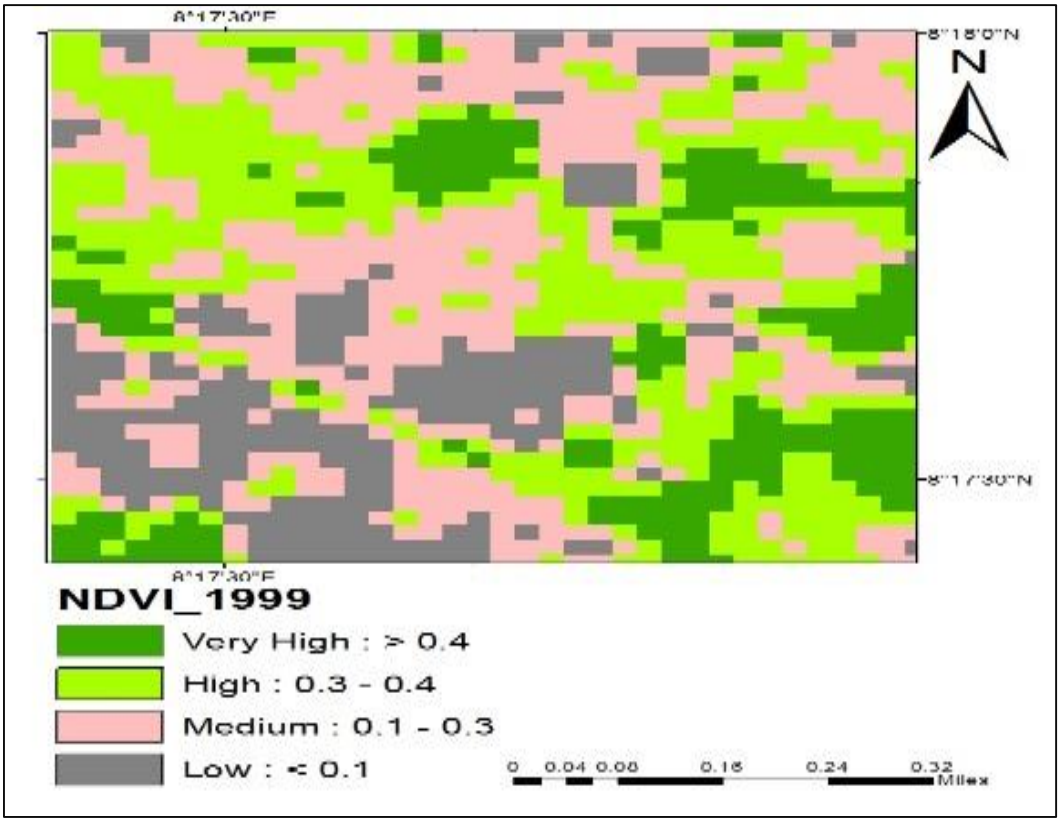

Figure 4.3 NDVI values of Doma forest reserve for 1999

4.1.3 Vegetation index map of Doma forest reserve for 2015

Figure 4.4 shows the vegetation reflectance of Doma Forest Reserve for the year 2015 which has NDVI values which range from 0.005 to 0.048. The very highNDVIvalue forDoma Forest Reserve in 2015is0.048 andindicatescomparativedensevegetation.

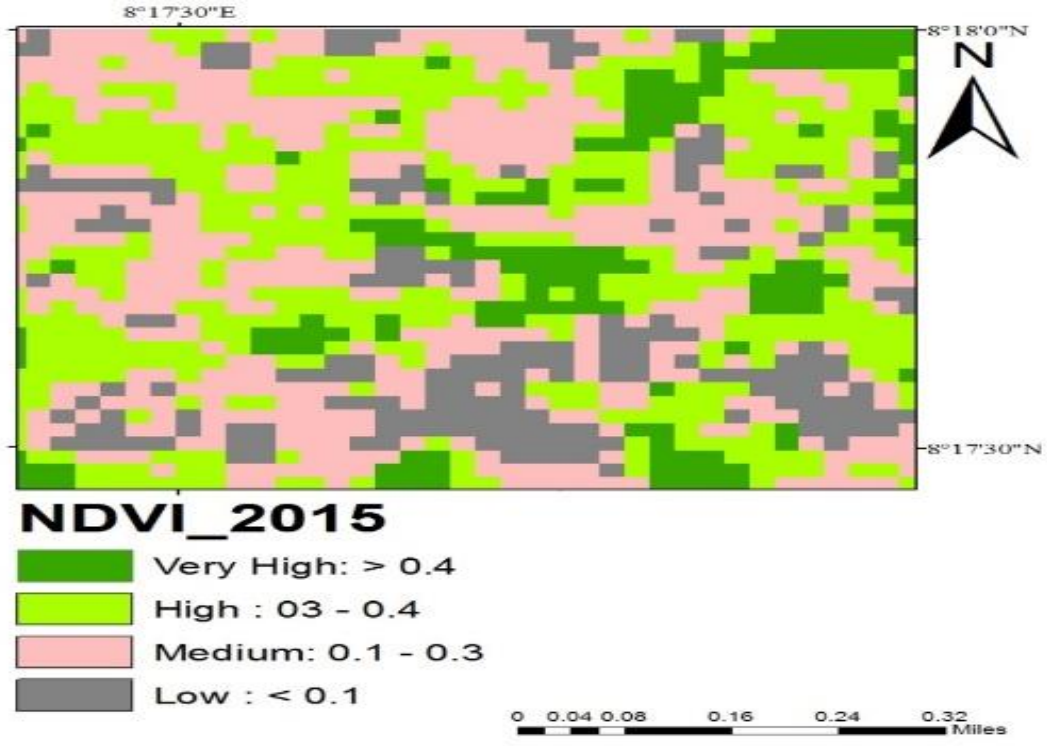

Figure 4.4NDVI values of Doma forest reserve for 2015

4.1.4 Doma forestchangedetection during1984 1999and 2015

Figure 4.5 shows the different NDVI changes of Doma forest reserve during the period of 1984, 1999 and 2015.The changes occurred in all classes but important changes have occurred in all classes in 2015. The category of very high NDVI density hasincreased from 0.52 in 1984 to 0.57 in 1999.In contrast, the category of very high NDVI density has drastically decreased from 0.57 in 1999 to 0.048 in 2015.The category of high NDVI density has also increased from 0.33 in 1984 to 0.40 in 1999 but it has decreased (0.034) a lot in 2015.The category of medium value of NDVI has increased from 0.15 in 1984 to 0.40 in 1999 but the medium NDVI value has also drastically decreased in 2015 to 0.019.The category of low NDVI value has increased from -0.035 in 1984 to 0.05 in 1999 and 0.005 in 2015.The low category is the only class of NDVI value that has increased in 1984 ,1999 and 2015.From figure 4.5, the most important reduction of Doma forest greenness occurred in 2015 in all classes except the low class which increased from the negative value(1984) to the positive value.

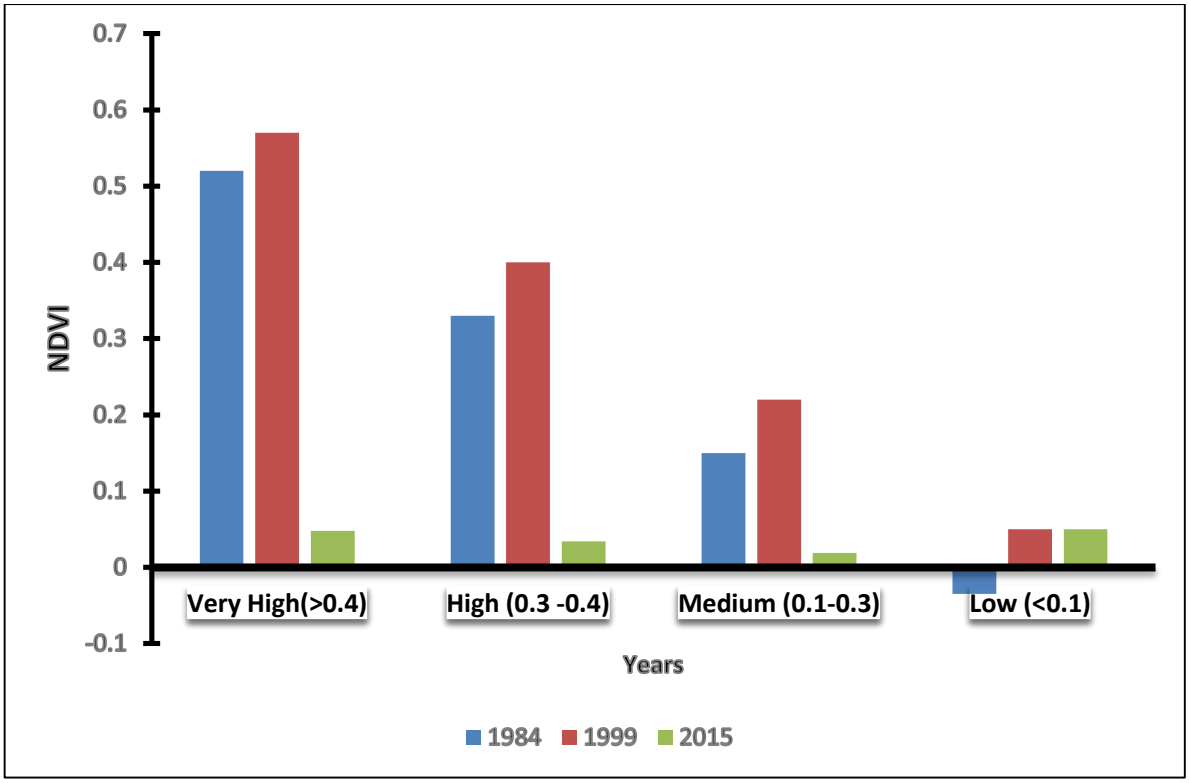

Figure 4.5Changes of NDVI density categories during the period of 1984 1999 to 2015(%)

Figure 4.6 shows the NDVI differencing between 1999 and 2015 for Doma forest reserve. It shows that Doma forest reserve decreased immensely in biomass from 1999 to 2015(16 years).For instance, the category of low NDVI in 1999 has reduced from 54.33% in 2015 while high density has reduced from 36.56% in 2015.Howerver, in 1984 the low class was negative but from figure 4.6 the low class increased from 1984 to 1999. Moreover, from figure 4.5 there was decrease of biomass of low class value from 1999to 2015. In 1984, Doma forest reserve was intact but in 1999, the vegetation reflectance of Doma forest has increased in all classes. This confirms the impact of 1988 artificial plantation within Doma forest reserve. This result was similar to whatAllasane (2014) found in Effan Forest Reserve in Kwara State of Nigeria. The study revealed that NDVI value of Effan Forest

Reserve indicated a high biomass in 2000 but the NDVI value of Effan Forest Reserve in 2006 indicated a decrease in the biomass. This confirms that Nigeria's forest reserves were under pressure due to human activities. This reveals that for 16 years so many trees were harvested in Doma forest reserve due to unsustainable land use practices. For example, the Doma forest community cropped the forest reserve under contract with the Nasarawa State Ministry of Environment and Natural Resources. The contract is called Taungya farming practice. One of the greatest unsustainable taungya farming practice was the use of fire for land clearance as shown in plate 4.1. In short, from the NDVI values from 1999 to 2015, Doma forest reserve has stressful behavior but from 1984 to 1999 Doma forest was healthy. The outcome of this study has shown that the degradation of Doma forest reserve is indisputable. This outcome is the view of several research findings that Nigeria's forest reserves are under pressure and are reducing due to human activities for a long time. For instance,about 11million hectares of forest are cleared for other uses annually in developing countries according Adeofun(1991).Furthermore according to FAO(2001), Nigeria's forest cover in 2000 was estimated at 13.5 million hectares compared to 17.5 million hectares in 1990.

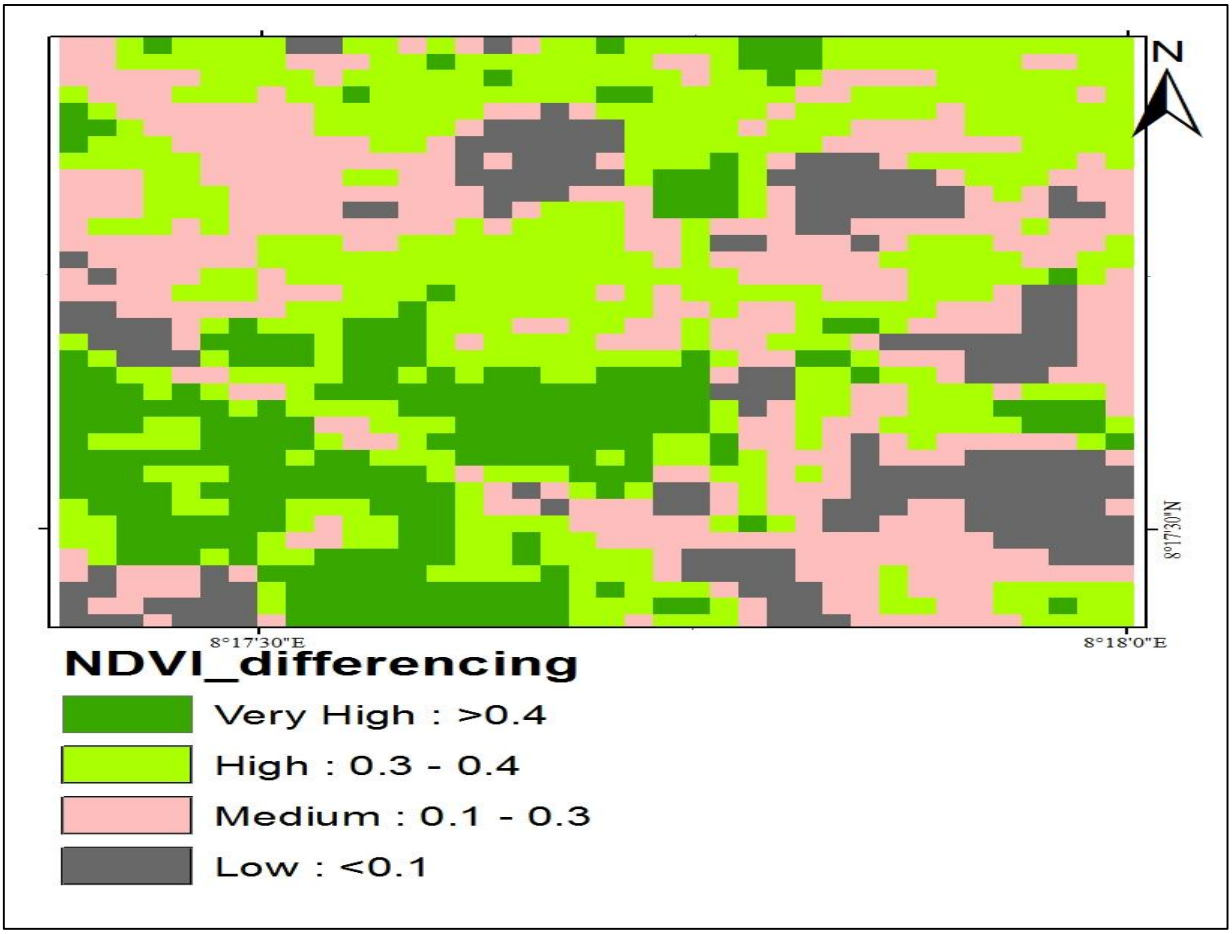

Figure4.6 NDVI differencing (2015 NDVI- 1999NDVI)

PlateI.showing the use of fire for land clearance within Doma forest reserve

4.2Systematic composition of Doma forest reserve

Results of systematic composition of Doma forest reserve is presented in Figure 4.7.The result revealed 36 woody species belonging to 16 botanical families and 36genera within 10 plots. Fabaceae had the highest number of woody species (seven species) distributed in seven genera.But the genera found were monospecific (One woody plant by genius).Figure 4.7 shows that the botanical family, Fabaceae was most species diverse (19.4 %) (High floristic diversity)followed byMimosaceae (11.1%). Anacardiaceae, Caesalpiniaceae and Rubiaceae were represented by8.3 %,(3 woody species each family). Arecaceae, Lamiaceae and Myrtaceae were represented by 5.6 %(2 woody species each family). The species like *Tectona grandis, Gmelina arborea* were artificial plantation of 1988 within the Doma forest reserve. Another exotic species were found within Doma forest reserve but at the periphery of it such as *Mangifera indica* and *Eucalyptuscamaldulensis.*This result was similar to several studies done in Nigeria. For instance, Oke&Jamala (2013) found out in derived savanna ecosystem of Adamawa State that Fabaceae was the richest botanical families in terms of woody flora. But, their research got more Fabaceae species (10 species) than 7 species for this study. Further, this result was also similar to the result found by Nodza, Onuminya&Ogundipe (2014) in Akoka campus of the University of Lagos. But within Akoka campus, they found 13 species of Fabaceae which is higher than Doma forest Fabaceae found during this inventory. Nevertheless,this result was different from the result found by Sani, Aliero&Ahmed(2014) in Magama Local Government area, Niger State of Nigeria. In their result,Mimosaceae had the highest speciescomposition with nine species from five genera. However, Fabaceae, Mimosaceae, and Caesalpiniaceae are legume species belonging to order of leguminosae.

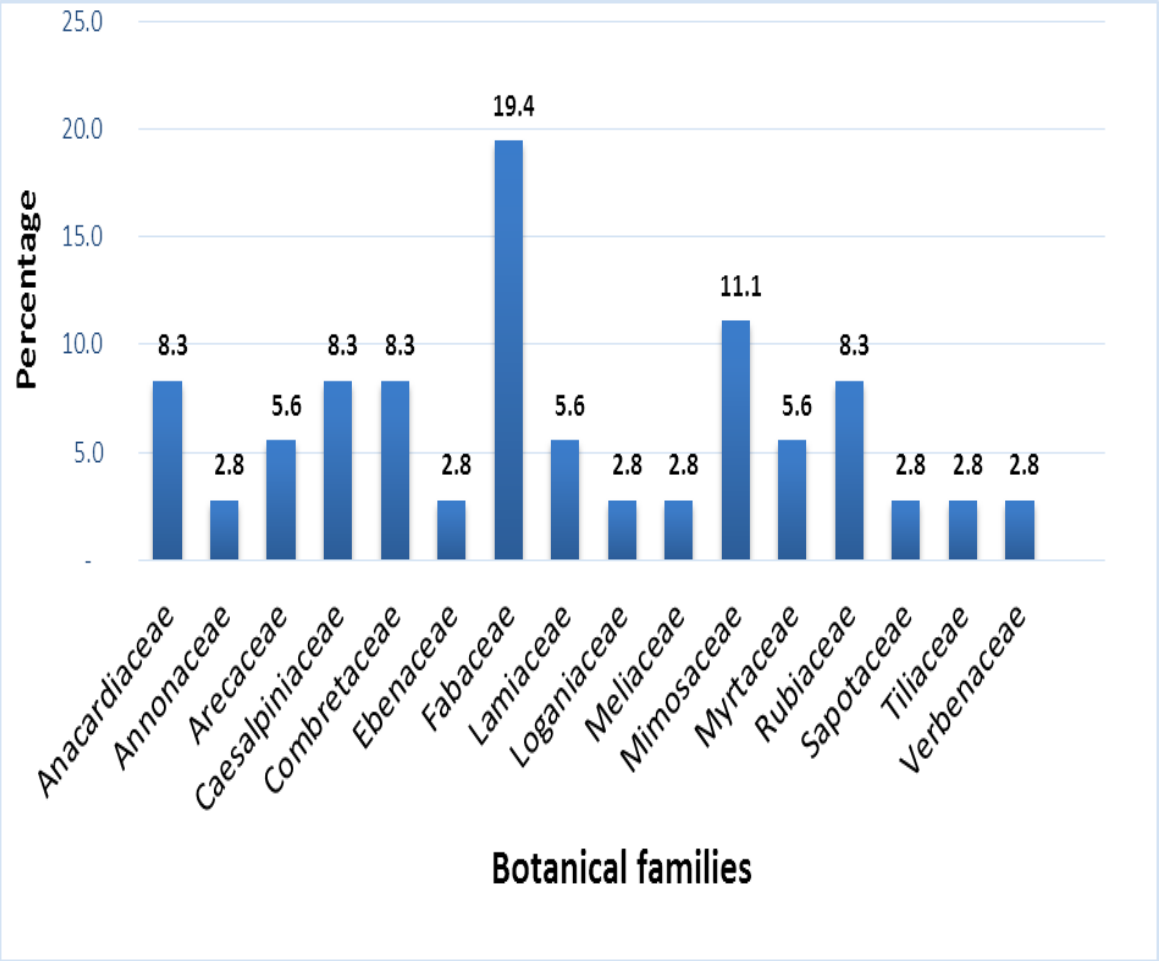

Figure 4.7Distribution of Species by Botanical Families

4.3 Climate change perception of Doma forest reserve communities

Figure 4.8 shows the climate change perception of Doma forest reservecommunities. The results of the survey on Doma forest reserve community' perception of climate change (Figure 4.8) indicated that 69% of the respondents were aware of climate change. The respondents perceived climate change as an augmentation in air temperature, decrease in rainfall and the delayed onset of rainfall. The figure 4.8 further shows that (31%) of Doma forest the communities was not aware of climate change. The percentage of climate change perception found by this study was greater than the percentage revealed by several studies. For instance, Ozor, Umanakwe, Ani&Nnadi (2015) found that 40.6% of rural farmers perceived climate change in Imo State of Nigeria. However,Bidoli,Isa,Shehu, Kezi,&Abdullahi (2012) found that about 98%of nomads understood whatwasmeantbyclimatechange inJigawaState of Nigeria.

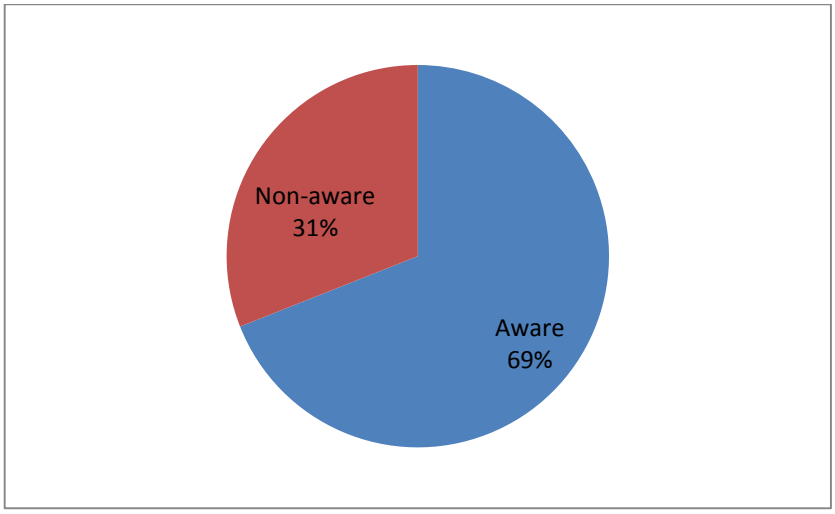

Figure 4.8 Doma forest reserve community perception of climate change

4.4.1 Perception of impact of climate change on Doma forest reserve dynamics

Figure 4.9 indicates that 30% of the people perceived that climate change has impact on Doma forest reserve. Information from the respondents revealed that the dryness of Doma forest was due to the long delayed onset of rainfall and the long presence of Fulani men due to the lack of grasses and due also to the long delayed onset of rainfall. Their feeling is that the impacts of climate change on Doma forest reserve were dryness of the forest and the long presence of Fulani men due to the long delayed onset of rainfall. However, majority of respondents did not perceive any impact of climate change on Doma forest reserve dynamics.

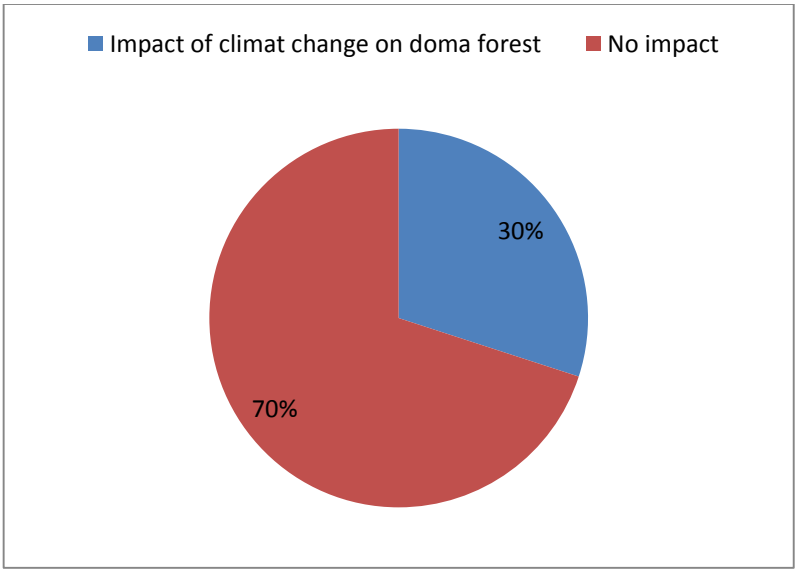

Figure 4.9Doma Forest people' perception about the impact of climate change on the Doma forest reserve dynamics

4.4.2 Perception of impact of land use on Doma forest reserve dynamics.

Figure4.10 shows the Doma forest community perception of land use activities impacting Doma forest dynamics. Figure 4.10 further shows that a significant proportion (41%) of Doma forest community perceived that farming activities impacted more the Doma forest reserve dynamics . 33.47 % of respondents agreed that illegal grazing activities impacted on Doma forest reserve dynamics. This result was similar to several research outcomes(Alao, 2009,Sabellek, 2010 and Noriko *et al.,* 2012)agreeing that agricultural and grazingactivities were the key drivers of forest loss. For instance,Emeka,Eboh&Nweze (2015) found that agriculture is one of the greatest causes of degradation in Enugu State, Nigeria. Agriculture is the main cause of deforestation in African countries according to Persson (1987). Added to this is deforestation caused by pasture and by harvesting wood for fuel or industrial uses as stated by Adams (2012), but 42.27 % of Doma forest farmers perceived illegal logging activities and about 0.84% perceived illegal hunting as affecting Doma forest reserve fishing activities impacted less (0.42%) on Doma forest reserve dynamics.

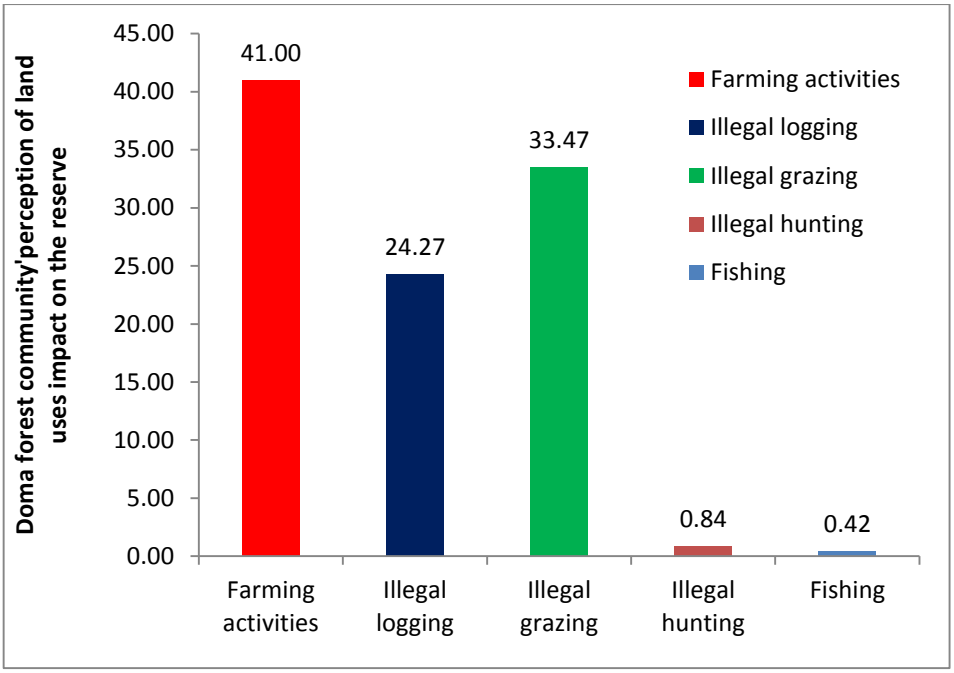

Figure 4.10Doma Forest community' perception of the land use impact on the Doma forest reserve dynamics

4.4.3 Doma forest reserve products used by its community

Figure 4.11 shows that 75% of respondents collected firewood and timber from Doma forest reserve while 12% of respondents did not use any forest product from Doma forest reserve. 8% collected the leaves from Doma forest reserve, 3% collected roots while 2% collected fruits from Doma forest reserve. This result confirms that wood and timber collection were likely the causes of Doma forest depletion. The woody plants of Doma forest reserve such as *Detarium microcarpum, Anacardium occidentale, Annona senegalensis, Dialium guineense and Tamarindus indica, Diospyros mespiliformis and Vitex doniana*provide fruits for food for Yelwa village.

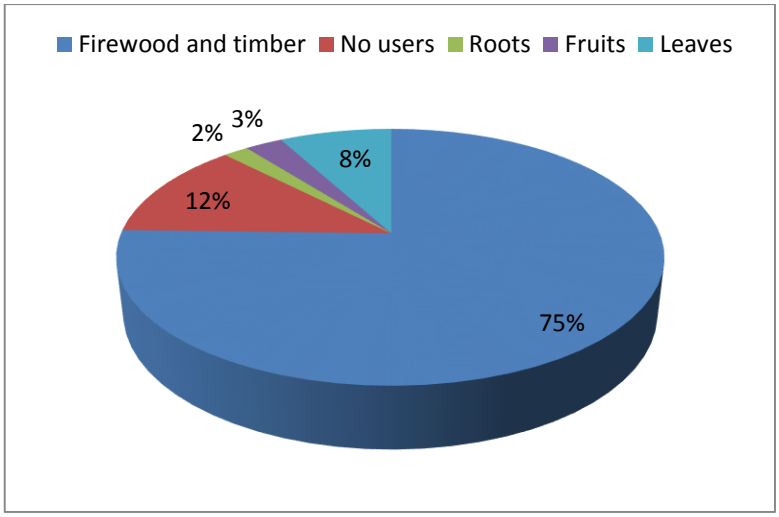

Figure 4.11Doma forest reserve products used by the communities

CHAPTER FIVE

5.0CONCLUSIONS AND RECOMMENDATIONS

This chapter presents a summary of the major findings of the research. It also outlines a number of suggestions on how to achieve a sustainable management of Doma forest reserve.The purpose of this study was to investigate the impact of land use and climate change on Doma forest reserve dynamics in Nasarawa State of Nigeria between the period 1984-2015 by using Remote Sensing and GIS techniques.

5.1Conclusions

From this research it was concluded there was substantial decrease in Doma forest greenness from 1999 to 2015. Further, NDVI analysis shows that Doma forest reserve dynamics is reducing in terms of the greenness. The study revealed that Doma forest reserve was degraded due to human activities such as agricultural activities, grazing, and illegal logging. Floristic analysis shows that Doma forest reserve woody flora has 36 woody species belonging to 16 botanical families and 36 genera within 10 plots but Fabaceae had the highest number of woody species (seven species) distributed in seven genera.Furthermore, questionnaire shows that 69% of the respondents perceived climate change but only 31% were not aware of climate change. However, 30% of people perceived that climate change impacts on Doma forest dynamics. Their perception is that the impact of climate change on Doma forest dynamics were dryness of the reserve and the long presence of Fulani men due to the long delayed onset of rainfall. Moreover, Doma forest communities perceived that farming activities impacted more on Doma forest reserve

dynamics followed by grazing activities and logging.The study found out that forest Doma forest reserve of Nasarawa State is under pressure from expansion of agricultural crop cultivation, installation of Fulani houses within the forest and evidence of these pressures is the growing degradation of both community and state forest within the country especially in the study area, Nasarawa State. The study also concluded that land use is the key driving factor of Doma forest degradation.

5.3Recommendations

The research recommends sustainable use of Doma forest reserve as forest degradation and deforestation are threats to sustainable environmental development. Based on the general services made by Doma forest reserve in Yelwa and the small villages surrounding the forest reserve the study formulates some recommendation thus;

i. There is the need to avoid the use of fire for land clearance during taungya farming practices within Doma forest reserve.

ii. There is need for adequate and effective protection of Doma forest reserve so that the illegal human activities should be restricted.

iii. There is for plantation in Doma forest reserve mostly, within the degraded part so that it will be restored.

iv. Forestry management in Doma forest reserve should be developed and streamlined.

v. Adequate manpower in quality and quantity should be engaged especially those needed to police the Doma forest reserve in Nasarawa State so that Doma forest reserve will be protected from illegal land uses.

vi. There is the need for transfer of Environmental education within Doma forest reserve communities in order to achieve sustainable forest management of Doma forest reserve.

vii. There is the need to avoid the use of fire during land clearance and avoid cutting the woody species as Doma is rich in legume species because these can be used as green fertilizers.

viii. Further study should be done in order to determine additional key factors of Doma forest reserve dynamics.

ix. Further study of land use- climate-vegetation interactions in Doma forest reserve should use climate variables and phenology which are likely to impact such interaction.

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APPENDICES

APPENDIX A: Questionnaire Administered

FEDERAL UNIVERSITY OF TECHNONOLOY MINNA

DEPARTMENT OF WASCAL

Questionnaire on the Doma forest community

This questionnaire is for field work for M Tech thesis for Moussa Soule supervised by: Prof G.N. Nsofor. Please supply us these information that will be treated with utmost confidentially

A. Interviewee

1. Full name of the Interviewee: ……

2. Age of the Interviewee: ……

3. Occupation of the Interviewee: ……

4. Educational level of the Interviewee: ……

B. **Awarenessof climate change**

1. Have you heard about climate change? Yes/No

2. If yes. What are your sources? .....
3. Is climate change having impact on Doma forest dynamics? Yes/No

4. If yes. What kinds of impact is it having? You can list them.....

5. a. Does natural fire occur in Doma forest reserve?

Yes/No.....

b. If so, how often do these fires occur, for instance how many times in a year?

c. Which season of the year does this occur? Rainy season/Dry season

d. Do these fires also occur as a result of human actions Yes/No

C. Doma reserve forest uses

1. Do you use forest reserve product?
   Yes/No.....

2. If yes. What type of product do you use?
.....

D. Population perception about the Impact of Land use on Doma forest reserve

1. Do you think Doma forest is reducing in size (area)?
Yes/No.....

2. If yes. What are the causes of reduction? .....

3. What are the Doma population' activities that impact Doma forest reserve?
.....

4. Do you think the surrounding agricultural lands of Doma forest constitute a threat to the forest?
Yes/No……

5. If yes. How can you we preserve Doma forest reserve? ….....

6. Do you think the Doma herdsmen exploit the forest?
Yes/No……

7. If yes. In what ways are they exploiting the forest reserve?
……

8. Do the wood sellers exploit Doma forest reserve?
Yes/No……

9. Do the hunters exploit Doma forest
reserve?.Yes/No.....

10. If yes. In what ways are wood sellers and hunters exploiting the forest reserve?
……

11. Do you use wood as source of energy?
Yes/No……

12. If yes. Where do you get the wood energy?
……

13. Where do you get your timber?
.....

14. What do think can be done to protect Doma forest reserve from the impact of land use and climate change ?.....

APPENDIX B: Slip of woody Species Inventory

№ Slip : …….

Date……

№ Plot: ……..

GPS coordinates: Latitude: ……. Longitude: ……

Number	Local name of woody species	Scientific name	State of specie
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			
17			
18			
19			

APPENDIX C: List of Doma Forest Reserve woody species

Species	Botanical Families	Hausa Names
Lannea acida A. Rich.	**Anacardiaceae**	Faru
Mangifera indica L.	**Anacardiaceae**	Mangoro
*Anacardium occidentale*L.	**Anacardiaceae**	Cashew (English)
Annona senegalensis Pers.	**Annonaceae**	GwandanDaji
*Elaeis guineensis*Jacq.	**Arecaceae**	Kwara
*Borassus aethiopum*Mart.	**Arecaceae**	Giginya
*Piliostigma reticulatum(*DC) Hochst.	**Caesalpiniaceae**	Kalgo
*cassia singueana*Del.	**Caesalpiniaceae**	Runhu
*Detarium microcarpum*Guill&Perr.	**Caesalpiniaceae**	Taura
*Combretum molle*R. Br. ex G. Don.	**Combretaceae**	Wuyandamo
Anogeissus leiocarpus (DC) Guill&Perr.	**Combretaceae**	Marke
*Terminalia avicenniodes*Guill.&Perr.	**Combretaceae**	Baushe
*Diospyros mespiliformis*Hotcht ex A. DC	**Ebenaceae**	Kanya
Afzelia africana Sm. ex Pers.	**Fabaceae**	Kawo
*Isoberlinia doka*Craib&Stapt.	**Fabaceae**	Doka
*Pterocarpus erinaceus*Poir.	**Fabaceae**	Madobiya
Tamarindus indica L.	**Fabaceae**	Tsamiya
*Albizia zygia*Macbride.	**Fabaceae**	Madobiyarafi
*Dialium guineense*Willd.	**Fabaceae**	TsamiaBiri
*Daniella oliveri*Hutch &Dalziel.	**Fabaceae**	Maje
Tectona grandisL.f.	**Lamiaceae**	Teak(English)
*Gmelina arborea*Roxb. ex Sm.	**Lamiaceae**	Malina
*Strychnos spinosa*Lam.	**Loganiaceae**	Kokiya
Khaya senegalensis (Desr) A. Juss.	**Meliaceae**	. Madaci
Parkiabiglobosa (Jacq.) R. Br. ex G.Don.	**Mimosaceae**	Dorowa
Prosopis africana (Guill&Perr)	**Mimosaceae**	Kiriya
Acacia siebieriana DC.	**Mimosaceae**	Farar Kaya
*Entada africana*Guill&Perr.	**Mimosaceae**	Tawatsa
Eucalyptus camaldulensis	**Myrtaceae**	Turare
Syzygium guineense	**Myrtaceae**	Malmo
Crossopteryx febrifuga (Afzel. ex	**Rubiaceae**	Kashi Awaki

G.Don) Benth		
*Sarcocephalus latifolius*Sm.	**Rubiaceae**	Tafashiakurm/TuwonBiri
Gardenia erubescens Stapf&Hutch.	**Rubiaceae**	Gaude
*Vitellaria paradoxa*Happer	**Sapotaceae**	Kade
*Grewia bicolor*Juss.	**Tiliaceae**	Dargaza
*Vitex doniana*Sweet	**Verbenaceae**	Dunya

Source: fieldwork 2015

APPENDIX D: Questionnaire administration during the field work

APPENDIX E: Showing the farming activities within Doma forest reserve

APPENDIX F: Showing grazing activities within Doma Forest Reserve

AppendixG: Showing logging activities within Doma Forest Reserve

AppendixH: Showing Fulani men houses within Doma forest reserve