DIVERSITY AND GEO-SPATIAL DISTRIBUTION OF TREES AND SHRUBS IN GURARA FOREST, KADUNA STATE

BY

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BY

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A THESIS SUBMITTED TO THE SCHOOL OF POSTGRADUATE STUDIES, AHMADU BELLO UNIVERSITY, ZARIA IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF A MASTER OF SCIENCE DEGREE IN BOTANY.

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NOVEMBER, 2015

DECLARATION

I declare the work in this dissertation entitled "DIVERSITY AND GEO-SPATIAL DISTRIBUTION OF TREES AND SHRUBS IN GURARA FOREST KADUNA STATE, NIGERIA" has been carried out by me in the Department of Biological Sciences. 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.

Blessing Ovaiyoza ADAAJA ---------- ----------
-

Signature Date

CERTIFICATION

This dissertation entitled "DIVERSITY AND GEO-SPATIAL DISTRIBUTION OF TREES AND SHRUBS IN GURARA FOREST, KADUNA STATE, NIGERIA" by Blessing OvaiyozaAdaaja meets the regulations governing the award of the degree of M.Sc. in Botany of Ahmadu Bello University, and is approved for its contribution to knowledge and literary presentation.

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DEDICATION

This M.Sc. dissertation is dedicated to my beloved Mother (Mrs. Lucy Ife Adaaja) who taught me the way to greatness.

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I wish to acknowledge the almighty God for preserving my life and granting me the wisdom to carry out this research successfully.

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ABSTRACT

The study assessed the diversity oftree and shrub species and geo-spatial distribution of Gurara forest in Kaduna State. Primary data on the field was collected by employing the plot count techniques by randomly selecting five plots within the forest, measuring a 50 by 50 meters plot (0.5hectare) on the ground for each plot. Secondary data made use of LANDSAT images of the year 1991, 2000 and 2009 whichwere processed using Ilwiss 3.3a processing software. All the trees and shrubs species on the selected plots were enumerated. A total of 31 species were identifiedwith 3502 number of individual of trees and shrubs.*Senegalia senegal*species hadthe highest number of stand (1066) and a percentage composition of 30.44%.FamilyFabaceae,Rubiaceae, and Moraceae had multi-species of 10, 3 and 3 respectivelywhile some families had a single species within the family. Species diversity, evenness and similarities were determined between plots for the identified trees and shrubs species. Shannon -Wiener diversity values (H) for the five plots was recorded for trees and shrubs, for the tree species, Plot 5 had the highest diversity of 5.74 and Plot 4 with the least diversity of 0.95 for shrub species, we recorded 1.56 has the highest diversity and 0.65 as the least diversity respectively. For species abundance or evenness (E), the highest and least values for tree species were (2.12 and 0.62) and for shrub species (0.97 and 0.4) respectively, this implies that diversity and evenness were higher for trees as compared to the shrub species identified. Jaccard similarity indices indicated highest similarity of 80% among shrubs and 67% among trees. For the secondary data collection, the area was demarcated into shrub land, secondary forest, road networks, rock –outcrop, water bodies, farming and buildup areas.

Results from the satellite imagery reveals a negative change of -37.89km^2(- 4.21%) and -45.82km^2(-5.10%) for the secondary forest and shrub land of the area during the 18years period under observation with other land cover categories having positive gain. Result from the primary and secondary data collection reveals that the presence of dam construction and other anthropogenic activities are depleting the Gurara forest.

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ABBREVIATIONS AND SYMBOLS

CNVC – Canadian National Vegetation Classification

E – Evenness

GPS – Global Positioning System

GIS – Geographical Information system

H-Shannon Wiener Diversity index

RS – Remote Sensing

° C- Degree Celsius

Pt – Plot

FAO – Food and Agricultural Organization

NTFPS – Non timber forest products

USAID – United States Agency for International Development

LAND SAT TM- Land Satellite Image

USGS – United States Geological Survey

CHAPTER ONE

1.0 INTRODUCTION

1.1 Definition of Vegetation

Hopkins (1981) described vegetation as the sum total of plants covering an area.Vegetation is the most obvious physical representation of an ecosystem and the biodiversity of an area is intricately tied to its vegetation density (Higgins *et al*., 1994). The term vegetation is used in ecology to describe the overall characteristics of plant cover in an area by referring to dominant plant growth forms or structural characteristics such as forest vegetation and grassland vegetation (CNVC, 2012).

Vegetation integrates the combined influence of a variety of environmental factors such as climate, organisms present, topography and soil parent material (CNVC, 2012).The Canadian National Vegetation Classification (2012) recognizes the range of vegetation from natural to cultural. Natural vegetation is that which develops naturally with little to no influence or modification by humans. Such vegetation is characterized by native species. Semi-natural vegetation is generally included in the 'natural' landscape, as humans have influenced the natural vegetation in many areas while cultural vegetation is planted and or maintained by humans, often with considerable input of energy. The species involved are often not native to the areaand majorly in the category of crop plants.

1.2 Significance of Vegetation

Vegetation provides us with an array of products that play important roles in our general well-being and economic life. Forest covers approximately 30% of the Earth's land surface goods. They provide goods and services, including food, water, shelter, nutrient cycling and cultural and recreational value. Forests also store carbon, provide habitat for a wide range of species and help alleviate land degradation and desertification. Forests were estimated to provide approximately 6 billion people with food, medicines, fuel and other basic necessities(FAO, 2005; Millennium Ecosystem Assessment, 2005).

It is estimated that about 60% of the earth's land area was once covered by forests but due to the need of lands for agriculture, town houses, mining and logging, these forests were cut down. Today about 30% of the earth is still forested although deforestation still continues. Forests supply many economic products like wood from trees as lumber, plywood and fuel wood or charcoal (Malaka, 2011).

Timber is used in furniture making, building houses, ships and railway sleepers. Pulp and paper are made from the cellulose of trees. Processed wood products include cellophane, plastics, and synthetic fibers like rayon. Latex from trees such as the rubber tree goes into making tyres and a wide range of rubber goods.

Fruits, nuts and spices are gathered from forests. Many medicinal plants such as camphor, cinchona (from which the drug cocaine is extracted) also come from the forests. Cork from the thick bark of the cork oak is stripped for making bottling cork.Forests help to conserve soil by preventing rapid runoff of water after heavy rain and maximizing

flooding. Trees take in carbon dioxide and release oxygen into the air. This is of great benefit to mankind..Forests influence local and global climate. The forest is also vital as a watershed. Because of the thick humus layer, loose soil and soil retaining powers of the tree's long roots, forests are vitally important for preserving adequate water supplies.

The forest is the natural habitat of most animals and plays a very important role in the animal's life. Forest structure is both a product and a driver of ecosystem processes and biological diversity. If it changes due to natural or anthropogenic disturbances, there may be consequences for other forest components (Foster *et al*., 1997). Common forms of anthropogenic and human induced disturbances involve logging; grazing, collection of non-timber forest products (NTFPS) and conversion of forest land other forest use types (García-Montiel and Scatena, 1994).Tanko (2012) observed total de barking of trees for ethno-medicine as one of the major factor contributing to the decline of forests. Such disturbances might affect the availability of certain commodities on which the people depend for their livelihoods.

1.3Importance of Vegetation Analysis

Vegetations are of immense importance in soil stabilization and erosion control especially in mountainous and hilly regions. They also protect and conserve water supplies and prevent floods. Small groups of trees and even single trees have a similar role locally in preventing washouts and in holding stream banks, they contribute significantly to nutrient recycling, carbon dioxide absorption, and oxygen generation. Vegetation analysis is very important in order to estimate the vegetation of the area, through vegetation analysis; the given vegetation is classified for homogeneity of

Composition stature into different vegetation classes with studies on changes in plant diversity and chemical properties of soil (Verma *et al*., 2004).

Vegetation analysis is used in evaluation of vegetation response to management, estimation of carrying capacity,characteristics of cover and habitat components or long-term monitoring of the general trend of plant vigor or habitat condition (Higgins *et al.*, 1994). Change in composition, presence of new species.

1.4Vegetation Change and Spatial Distribution

During the past millennium, humans have taken an increasingly large role in the modification of the global environment. With increasing numbers of developing technologies, man has emerged as the major, most powerful, and universal instrument of environmental change in the biosphere today. Globally, land cover today is altered primarily by direct human use. Any conceptualization of global change must include the pervasive influence of human action on land surface conditions and processes (Yang, 2001). Boakye *et al.*,(2008), explain 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 *et al.*, 1999).

Proper forest monitoring and management can only be achievedby using remote sensing techniques and creating spatial representations such as maps to know the exact locations and extent of deforestation. This information has not being documented for the Gurara

forest. The Center of Biodiversity and Conservation (CBC) had in 1998 established the Remote Sensing and Geographic Information System (RS/GIS) facilities. Its technologies have helped identify potential survey sites, analyzed deforestation rates in focal study areas, incorporate spatial and non-spatial databases and create persuasive visual aids to enhance reports and proposals.

A remote sensing device records response, which is based on many characteristics of the land Surface, includes natural and artificial cover. An interpreter uses the element of tone, texture, pattern, shape, size, shadow, site and association to derive information about land cover. The generation of remotely sensed data/images by various types of sensor flown aboard different platforms at varying heights above the terrain and at different times of the day and the year does not lead to a simple classification system. It is often believed that no single classification could be used with all types of imagery and at all scales. To date, the most successful attempt in developing a general-purpose classification scheme compatible with remote sensing data has been by Anderson*et al.,* 1976 which are also referred to as USGS classification scheme.Other classification schemes available for use with remotely sensed data are basically modifications of the above classification scheme. Ever since the launch of the first remote sensing 1972(Land Sat-1) land use and cover studies were carried out on different scales for different users.

Gurara forest in Kaduna state is one of the forest that is been exploited daily for timber. The forest is rapidly degrading with little or no information on the type

ofdeforestationactivities taking place this includes the Gurara dam Rail lines, farming, markets and so on; this will make information retrieval for future use very difficult.

1.5Statement of Research Problems

Biological (flora and fauna) inventories of species diversity of Nigerian forest ecosystem are not keeping pace with forest destruction which is put at about 300,000 ha/annum (Soladoye and Ola-Adams, 1990).Lack of inventory on the vegetation analysis of the area will make information retrieval and future conservation strategies difficult. There is high pressure on the forest due to urbanization, timber and fuel wood extraction with no apparent conservation strategies put in place to reduce loss of resources.There is also lack of coordination and planning of the land use pattern of Gurara forest.

1.6 Justification of the Study

Gurara forest is a natural forest with sites of tourist attraction like the Gurara dam, and the associated mountains which have brought about various economical and anthropogenic activities leading to increased exploitation of the forest.Though data on Nigerian floral are available, they are inadequate and incomplete, there is a continuous depleting of Forest resources on daily basis, and hence there is need for regular inventories even in areas where such inventories had been documented. To be able to conserve and utilize any resource effectively, there is need for more inventories of such resources.Spatial growth of some species has been affected by deforestation and encroachment bringing about limitation in species and further extinction; study area will become inadequate for scientific research.There are no adequate information on the

vegetation status and the spatial analysis of the Gurara forest, with serious exploitation of timber and other human settlement increasing rapidly, proper inventory of the vegetation status should be made available for easy recovery of information for conservation and planning in the future. Flora inventory is of significance in this regard (Soladoye *et al.*, 2011).

1.7 Aim of the Study

This research is aimed at inventorizing the species of trees and shrubs and determiningspatial distribution in Gurara forest, Kaduna State.

1.8 Objectives of the Study

The specific objectives of the research are therefore to determine:

1. The diversity of tree and shrub species of the area.
2. The changes in the forestthat has taken place over time using satellite images.
3. The effect of the dam construction and other anthropogenic activities affecting the Gurara forest.

1.9 Research Hypotheses

1. There is no significant difference in the diversity of tree and shrub species of plots in theforest.
2. There is no significance impact on the floraof the area by the Gurara dam construction
3. There is no significance impact on the forest by theanthropogenicactivities going on in the forest

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1Natural Forest

A natural forest is characterized by elements such as a complex spatial structure, a composition and distribution of climax species, a wide range of ages in tree species and the presence of coarse woody debris. All of the following loosely defined terms, that is natural forest, old-growth forest, ancient forest, virgin forest and primary forest have been used interchangeably in literature (FAO, 1997). Natural forests have unique features that distinguished them from other forest types. A more natural forest is one that is only slightly modified, contains primarily native species and requires less human input to maintain system functions (Peck, 1998).

Semi-natural forests are defined as those forests, which have been modified by humans through use and management. A stand which is composed predominantly of native trees and shrub species which have not been planted. Also, a forest which has developed gradually or accidentally, as its location or site quality was not suited for intensive exploitation or production-oriented management (e.g. mountainous regions) (FAO, 1997).

2.2Protected Forest in Nigeria.

Dudley (2008) defined forest reserves as areas set aside by deliberate laws for the protection of certain fauna and flora or a combination thereof. This definition is in line with that of Drawing from these definitions; therefore, a forest reserve can be describedas

a legally protected natural area where human influence is totally minimized, functioning primarily for the preservation of genetic resources and for scientific research.

Before the 1960s about one third of the country land mass of 983,213km^2 was classified as forest (Oguntala, 1981). But that is not the case today as tragedies of untold proportions have been unfolding in the forestry sub-sector. FAO (1997) established that Nigeria has a land area of about 99.3 million ha, about 10% is estimated as forest land. This is small when compared with countries like Ghana 41%, Cameroon 43%, Liberia 48%, Senegal 39% and Sierra Leone 26%. Therefore it could be seen that, Nigeria's conservation is well below the FAO recommendation of at least 20 – 25% of any country's land area.

Nigeria has 445 forest estates distributed over the five main ecological zones namely: Freshwater/Mangrove, the Lowland Rainforest, the derived Savanna, the Guinea Savanna and the Sudan/Sahel zones. These reserved forests are made up of the following: 20,746km^2 of high forest, 3,208km^2 of derived Savanna and 72,089km^2 of Savanna (FME, 2006). Nigeria's forestry sector over the years has continued to witness government interventions. Yet the rates of deforestation continue unabated. However, in order to address the deplorable situation of the nation's forest, the Federal Government of Nigeria joined other nations of the world in ratifying the African conservation convention for the conservation of nature and natural resources.

Nigeria is also an active member of many forestry related international organizations like the International Tropical Timber Organization (I.T.T.O) and the International Network

on Bamboo and Rattan (INBAR). Nigeria also collaborates with a number of United Nations organization including, multilateral organizations. These organizations are: the Food and Agriculture Organization of the United Nations (FAO), the United Nations Development Program (UNDP), the World Bank (WB) and the African Development Bank (ADB) (Oyebo, 2005). The government also in 1989 announced receipt of World Bank loan for aforestation to stabilize wood products outputs, forest reserves and safeguard forest resource from indiscriminate exploitation, underutilization to meet the demand for poles, energy and food in a sustainable manner (CBN, 2001).In many countries, Nigeria inclusive, forest reserves are established primarily to safeguard species while providing for other compatible uses. These vast areas of land are designated forest reserves with the aim of capturing element of biodiversity that can be missing from harvested sites, provide recreation and tourism services, protect sites and objects of cultural, historical and archeological heritage and maintain environmental regulation (Ayodele and Falade 1990). The socio economic growth of any country depends significantly on theavailability of its natural resources, but this growth can only be sustained when these resources are used rationally in a sustainable manner.

2.3 Unprotected Forest in Nigeria.

A careful study of the vegetation of Nigeria shows that true and protected forest is mainly found in the southern part of the country and it occupied 93,345 km^2 in 1993 that is 9.6 percent of the total land area of the country. This area increased to 11.4 percent in 1994 but dropped to 10 percent in 1995 (CBN, 2001).

Forests in Nigeria include closed canopy forest and open woodlands where some leaves and twigs of adjacent trees overlap. Forests in Nigeria encompass three vegetation types: the swamp forest, tropical rain forest and Secondary re-growth. The vegetation of the northern part of Nigeria where Gurara forest belonged is characterized by woodland savanna and is endowed with great varieties of plants including grasses, vines, forbs and trees, though Gurarafalls in savanna woodland, patches of forest – outlines prevail in the area. These forest outlines have been the major source of timber to the area for decades.

Free areas are forested areas that are not under strict management by the State Forest Departments. However, permission to exploit trees from free areas still has to be obtained from State forestry department. State forestry departments in Nigeria are the most important institutions in forest management because the constitution grants to them the sole right to manage the country's forest resources – not on behalf of the country – but rather, on behalf of their specific state.

The main drivers of deforestation in the country are agriculture, logging and mining. Studies in the southern regionhave cited rapid population growth, agricultural expansion (e.g. cocoa belt of southwest Nigeria), use of fuelwood and logging as major drivers of deforestation in the country. Many communities depend on traditional methods of farming and are facing land use constraints. Population growth stimulates agricultural expansion, thereby diminishing arable land and encouraging forest clearing.

Rising prices of petroleum products, especially cooking gas and kerosene, have encouraged both rural and urban households to rely on fuelby wood and charcoal as their

main sources of energy. This has led to further deforestation. While logging operations practice a selective system in allocated forested areas, clear felling is common in some forest reserves. The removal of timber in Nigeria is occurring at an uncontrolled rate, without strict adherence to laws or payment of appropriate fees and levies, contributing to increasing rates of forest loss (FAO, 2010).

2.4Floral Diversity in Nigeria

Nigeria is a diverse country with many different natural habitats, including Savannas, tropical forests, wetlands, lakes, rivers, and coastal areas (USAID, 2008).

Rainfall is heaviest along the coast and in the southeast, leading to the development of rain forest in this region (USAID, 2008). By contrast, the northern part of Nigeria receives much less rain and includes increasingly drier vegetation zones the further north one goes (USAID, 2008).

In many regions of the world, structural vegetation changes could be attributed to alterations in the vegetationcover storey, which in turn influences under storey densities, cover, frequencies and biomass (D'Amatoet *al.*, 2009). Such changes in forest structure may even lead to local extinctions of certain species where changes in the forest structure persist over long periods of time (Vellend *et al*., 2006). On the other hand, re-growth forests protected from anthropogenic disturbance can encourage species recovery by promoting understorey conditions suitable for ground vegetation (Parrotta *et al.*, 1997).

For close to half a century, there has been a renewal of the concern over the decline of biodiversity on our planet. The crisis of human environment has manifested in different

forms, at different intensities among different regions of the world and different classes of people in different countries and societies (Olorode, 2007).The diversity of plant life is an essential underpinning of most of our terrestrial ecosystems. Humans and most other animals are almost totally dependent on plants, directly or indirectly, as a source of energy (Yavari and Shahgolzari, 2010).

In order to know the composition and species diversity of Nigerian forest ecosystems, biological (flora and fauna) inventories are a 'sine qua non' (Soladoye *et al*., 2011). The preparation of these inventories is not keeping pace with forest destruction which is put at about 300,000 ha/year (Soladoye and Ola, 1990). It is very difficult to find primary forest in Nigeria as compared to what obtained about 80-90 years ago. However some remnants could be found in established reserves or protected areas of variable integrity (Soladoye *et al.*, 2011).

As the most populous country in Africa, Nigeria faces extreme pressures on biodiversity and tropical forests that are mounting (USAID, 2008). Wildlife, trees, and many other plants are overharvested and poached, and the natural environment faces increased degradation from expanding unsustainable agriculture, water pollution, air pollution, and a variety of other anthropogenic factors (USAID, 2008). Lack of information about the present status of most habitats and species, about the actual extent of protected areas and about other key data makes management difficult.

2.5 Socio-Economic Implication of Forest Degradation

Forest degradation involves a change process that negatively affects the characteristics of a forest such that the value and production of its goods and services decline. This change process is caused by disturbance (although not all disturbance causes degradation), which may vary in extent, severity, quality, origin and frequency. Disturbance may be natural (e.g. that caused by fire, storm or drought), human-induced (e.g. through harvesting, road construction, shifting cultivation, hunting or grazing) or a combination of the two. Human-induced disturbance maybe intentional (direct), such as that caused by logging or grazing, or it may be unintentional (indirect), such as that caused by the spread of an invasive alien species (FAO, 2012).The implications of forest degradation are:

- Deforestation and forest degradation are therefore accountable for about 20 percent of the annual worldwide CO_2 increase.

- The loss of forest has also reduced access to and supplies of non-timber food products for export by as much as 40-50 percent in the last five years. This implies that in due course, Nigeria will depend on importation of wood and wood products, plunging the country into imbalance trade depleting the nation's foreign reserve.

- The economic cost of fuel wood losses per year was estimated by the increase in the cost of fuel wood supply taking into account, the increase in the cost of collecting the wood and the transportation costs.
- Deforestation by bush burning is estimated to have been the cause of 20% of annual greenhouse gas emissions in the 1990s. (FAO, 2005).Deforestation emits greenhouse

gases for two main reasons: burning and decaying. Farmers use fire to get rid of non-valuable woody parts such as stumps and tree crowns, or even stems when their needs for wood are already fulfilled. In the short-term, the resulting ashes also act as a fertilizer for the deforested plot. Greenhouse gas emissions from biomass burning mainly consist of CO_2, but some methane (CH_4) and nitrous oxide (N_2O) is also emitted

2.6 Effect of Deforestation

Deforestation is a process of clearing virgin forests, or intentional destruction or removal of trees and other vegetation. It is to a large extent an anthropogenic intervention into the natural forest milieu to meet man's demands for food, shelter, raw materials, industrialization, livestock production, mining, and infrastructure. Trees are felled for several purposes but without replantingto replace the ones felled (Aina and Salau, 1992). It is the large scale removal of forests resulting to non forest areas for urbanization, agriculture and for someother reasons without corresponding reforestation of the area (Fiset,2012). According to FAO (2005b) deforestation is the conversion of forest to another land use or the long term-term reduction of tree canopy cover below the 10% threshold.

2.6.1 Global status of deforestation

The world's forests have continued to decline over time. From the initial 6 billion hectares (at the end of the great ice age), representing 45% of the total land area, it fell to 4 billion as at 2010, representing 31% of the land area(FAO, 2012). Specifically, the

FAO (2012) in its Forestry Resources Assessment Report (FRA) for 2010 documented that between year 2000 and 2010, there was a global loss of 130 million hectares (about 3.2% of the total forest area in 2000). But 78 million of this was to be recovered through reforestation, such that the net loss for the period was 1.3%. In the case of Africa as a continent which had a total forest area of 674 million hectares (representing 23% of its land area), an average net yearly loss of 4.07 million hectares (which is 0.56% rate of decline) was experienced between the year 1990 and 2000. However, for the years 2000 to 2010, the continent lost 3.4 million hectares, giving a cumulative net loss of 0.49%

In 2010, Nigeria had 9 million hectares of forest, 336,000 hectares of which were primary forest. Nigeria has one of the highest rates of deforestation in the world, having lost around 410,100 hectare per year over the period 2005 to 2012.(FAO,2012).

Forest predates man and they have evolved overmillions of years and have been profoundly shaped byswings and variations between climates and othernatural forces (Popoola, 2014). Climate conditionshave continued to influence the world's forests, whileanthropogenic factors have also played key roles inshaping what became of world's forest.Africa accounts for more than one-quarter of global wood fuel production. Nigeria produced 13% of Africa'sfuelwood in 2006 reports (FAO 2009). The most prominent of these is fuel wood, cut directly from trees and forests (FAO, 2009).

2.6.2 Deforestation: drivers and effects

The drivers (or causes) of deforestation can be direct or indirect. Scientists currently agree that the three most important of the several global direct drivers of deforestation are

agricultural expansion, infrastructure development, and wood extraction in that order. On the other hand, the indirect drivers refer to the interplay of economic, institutional, technological, and demographic and cultural forces exerting pressure on the direct drivers (European Commission, 2010). Although natural agents (like earthquakes, droughts, soil erosion) can engender deforestation, yet the drivers are largely anthropogenic phenomena. Some of the direct drivers of deforestation are as follows:

2.6.2.1 *Agricultural production practices*

This has been a primordial driver of deforestation. In primitive times, shifting cultivation was adopted as a means of farming to exploit nutrients of uncultivated areas. Increasing demand for food and fiber due to population growth has also necessitated clearing of forests for farming purposes. In Nigeria for instance, 80% of annual deforestation is accounted for by farming (Alaje *et al.*, 2012). Grazing practices also contribute to deforestation.

2.6.2.2 *Urbanization/infrastructure development*

The world's human population has grown to about 7 billion today, and this growth necessitates expansion of towns and cities and the provision of corollary infrastructure like schools, markets, hospitals, dams or water projects, roads, rail lines, and airports. These occupy space and in most cases bring with them further impetus for deforestation. Population and deforestation growth rates are correlated; both tend to vary among different regions of the world and increase during periods of economic development.

They both stabilize or fall after a society has attained a certain level of wealth (FAO, 2012).

2.6.2.3 *Fuelwood exploitation*

Fuel wood gatheringis often common in the tropical dry forests (Rowe *et al.,* 1992) where it is a major cause of deforestationand degradation. Trees are deliberately felled, left tobe dried and then cut and harvested as source ofenergy for various domestic and industrial uses. It is estimated that about 1.3 billion people do not have access to electricity, and 2.6 billion people globally rely on wood biomass for domestic cooking, most of who live in developing Asian countries and sub-Saharan Africa (IEA, 2013). In Nigeria, two-third of the population depends on fuel wood for domestic cooking (UN-REDD, 2012). This scenario aptly explains the increasing rate of forest depletion in the country.

2.6.2.4 *Industrialization*

Increase in population as well as urbanization came along with ijt, increased demand for raw materials largely (in the form of forest products), expansion of agriculture, and emergence of manufacturing plants which transformed these resources into finished products. This has been accompanied with reduction in the forest area (Alaje *et al.*, 2012).

2.6.2.5 *Timber exploitation/logging*

In Nigeria, timber resources which are raw materials in the furniture and construction industries, contribute substantially to national development. A lot of timber is also exported especially from the rain forests ecological zones. But the high rate of

indiscriminate and illegal logging has been a major cause of deforestation of primary forests. Jimoh (2001) asserted that, as much as 6,360 km^2 has been lost from forest reserves in Edo and Delta states due to logging. Timber exploitation has also led to species' loss and ecosystems degradation in many parts of the developing world, affecting traditional livelihoods, microbial ecology and causing other health-related problems (WHO, 2005).

2.6.2.6 *Forest fires*

These could be caused by natural forces or as a deliberate action by man as in the case of hunting for game or bush clearing for farming. Fire has profound effect upon all factors of the habitat. It often gets out of control and become not just very deleterious to the forest environment by destroying the soil cover, killing soil living organisms and destroying the soil structure, exposing it to soil erosion, but also other assets, human lives and livelihood (FAO, 2012; Hocker, 1979; Sangotoyinbo *et al.*, 2012).

2.6.2.7*Mining and oil exploration*

Mather(1991) and Sands (2005) said that mining is veryintensive and very destructive. If this occurs in theforest areas, it involves the removal of substantial number of trees both at the site of extraction and access roadleading to it. Mining worsen deforestation if wood is the source of fuel in mining operations. The exploration of minerals and oil, compete with forest and forest resources and the pendulum has always tiltedunfavorably against nature. The land degradation as a result of tin mining on the Jos Plateau evidenced by the mining ponds, and the oil spillage and fires in the Niger Delta region of Nigeria which

have wrought great damages to the size and quality of swamp forest are classical examples. These have resulted in land degradation, soil erosion, acid rain due to gas flaring, pollution, soil and water quality deterioration and the associated depletion of terrestrial and aquatic biodiversity.

2.7 Approaches to Combating Deforestation, Forest Degradation and Fragmentation.

Approaches to reduce deforestation are bestthrough the collaborative efforts among individuals, organizations, governments and non-governmental agencies. Combating deforestation can be effectiveand rapid through the method that embracesenvironmental enlightenment, avoided deforestationand continuous afforestation backed by adequate sustainable forestry policy and legislature. Some ofthe strategies of combating deforestation, forestdegradation and fragmentation include the following:

i. Environmental education and literacy

Understanding the context of environment andthe knowledge of how human interactions caninfluence the environment is a requirement for curtailingdeforestation and other environmental problems.Environmental education and literacy can help createa stewardship ethics, a sense of duty to care for andmanage wisely our natural environment and endowment and our productive resources for the longhaul (Cunningham and Cunningham, 2006).Environmental literacy of all stakeholders will help topreventing deforestation and reducing adverse effectsassociated with it as well as taking appropriate

actionwhen possible. Outcome of environmental educationshould enable every person to be environmentallysound in terms of natural context, social context.

ii. Encouragement agroforestry practice

Agroforestry is the production of trees and non-treecrops or animals on a piece of land at a particularperiod of time. The integration of growing cropsand/or animal with trees on the same piece of land willincrease forest areas and reduce the dependence onprimary forest. Also, trees in agroforestry system helpin soil management through holding the soil againsternson and improving soil fertility (Martin andSherman, 1992; Popoola, 2014).

iii. Increase of protected area

Since ancient times, forest areas have been set aside for cultural and religiouspurposes or pleasuring grounds for royalty(Cunningham and Cunningham, 2006) but in therecent, such areas have been encroached due tourbanization. The provision of protected areas isfundamental in any attempt to conserve biodiversity(Myers and Mittermeier, 2000; Nepstad *et al.,* 2006).

Increasing the protected forest area will assist tocombat deforestation as such area will be devoid ofhuman deleterious impacts.

iv. Development of Alternatives

Encouraging substitutes for all purposes whereforest products especially timber are utilized is necessary to reducethe rate of deforestation. Also combining of non-forest product with forest productsin manufacturing for example furniture will greatlyreduce the market and utilization of wood productsand consequently reduce deforestation.

v. Policy and enforcement

FAO (2010b) considered that half of the currenttropical deforestation could be stopped if thegovernments of deforesting countries were determinedto do so. There is need to develop new policystatements, legislative and regulatory measures andmodified existing ones to combat deforestation butthere is also the need for enforcement for effectiveness. Such laws, policies and legislationsshould be such that they encourage local people and institutional participation in forestry management andconservation along with safeguarding indigenouspeople's traditional rights and tenure with rightfulsharing of benefits. The following strategies could beemployed for effectiveness measure againstdeforestation: negotiation, warnings, cancelling workorders, notices of violation, fines, arrests and courtaction.

vi. Reforestation, afforestation and avoided deforestation

Increasing the area of forest plantation byreplanting tress to replace the deforested ones is vitalin managing deforestation (Williams, 2002). Thiscould be done by using vacant or unused lands andwaste lands for forest plantations and avoiding cuttingdown of trees in the already established forest will helpto combat deforestation and associated devastatingimpacts. Planting trees on roadside, along railwaytracts, on contours, avenues,

boundaries and othernon-forest areas will reduce pressure on the primaryand established forests and thereby reducedeforestation.

(Vii) Carbon market

Heal (1999) analyzes economic mechanisms through which goods and services provided bytropical forests and their biodiversity could be marketed. One discussed mechanism is thefinancial compensation for carbon sequestration services of forests under an internationalclimate agreement, potentially generating incomes high enough to radically change theincentives for forest conservation. Supported by the Coalition for Rainforest Nations, PapuaNew Guinea recently proposed to address reducing emissions from deforestation anddegradation (REDD) within the international climate regime (UNFCCC, 2005). Whereasunder the Kyoto Protocol only forestation and reforestation activities are eligible for creditingthe associated carbon abatement, the proposal suggested that developing countries mightcommit to reducing emissions from deforestation – in exchange for receiving tradable carbonabatement credits and participating in international post-Kyoto emissions trading.

2.8 Integrating Remote Sensing and Geographical Information System inForest Cover Change Detection

Remote Sensing is a process of acquiring information about the Earth's surface without actually being in contact with it. This is done by sensing and recording reflected or emitted energy and processing, analyzing and applying that information (Canada Centre for Remote Sensing, 2008).

Remote Sensing technique for forest cover change detection and monitoring has been used to assess the dissimilarities in forest cover over two or more time periods caused by environmental conditions and human actions. Remote Sensing and Geographical Information System (R&S & GIS) are practical tools in estimating and validating ecosystem changes arising from forest use and application of Remote Sensing and Geographical information System for Forest Cover Change Detection management interventions. Quantitative knowledge about Land use – Land use changeenables the economic comparison of different ecosystem services within and across different countries (Kreuter *et al*., 2001; Zhongmin *et al.,* 2003.) Another unique quality of Remote Sensing data is that it provides a means of quickly identifying and delineating various forest types, a task that would be difficult and time consuming using traditional ground surveys.

Data is available at various scales and resolutions to satisfy local or regional demands. Species identification can be performed with multispectral, hyperspectral, or air photo data interpretation.Normally, data about earth's features is acquired either from air (aerial photography) or from space (satellite imagery).

Aerial photographs are in analogue form while satellite images are basically in digital form. Remote sensing is based on the measurement of electromagnetic energy. The remote sensing sensor measures the energy that is reflected or backscattered by the earth's surface. The measured energy is converted and stored as a digital number (DN) value, which ranges from 0-255. Both imagery and the extracted information can be

incorporated into a GIS to further analyze as slopes, ownership boundaries, or roads. Satellite remote sensing is a widely used technique to produce land use-land changemaps and to study vegetation cover (Fung and Chan, 1994).

2.8 1Land use change

Natural scientists define land use change as human activities such as agriculture, forestry and building construction that alter land surface processes including biogeochemistry, hydrology and biodiversity. Land use change means (quantitative) changes in the area extent (increase or decrease) of a given type of land use respectively. It is important to note that even at this level, the detection and measurement of change depend on the spatial scale; the higher the spatial level of detail, the higher the changes in the area extent of land use which can be detected and recorded(Helen, 2005).

2.8.2 Land cover change

Land cover refers to the physical and biological cover over the surface of land, including water, vegetation, bare soil, and/or artificial structures (Ellis*et al*, 2009). Land-coverdenotes the surface cover over land, including vegetation, rock and human-modified surfaces such as buildings (Ellis *et al*., 2009). Land-cover is a characteristic of the land that can be observed physically, as by remote sensing. This is different from land-use, because a single land-cover type can be used in various ways by humans (Ellis *et al*., 2009).Land cover change isrelated to natural processes such as climatic variations, volcanic eruption, change channel or sea level etc. However, most of the land cover changes of the present dispensation are due to human actions such as Dam construction,

construction of settlement. Land cover change still is related to natural causes such as short or long term shifts, vegetation changes (floral disturbance),and geologic/tectonic events influenced by man-made changes to the natural environment particularly land clearing for cultivation, logging of plants for timber use in construction. Land cover change over can be neutral or negative and is often taken as an indicator of overall environmental disturbance (Ringrose*et al*., 1997).Adeniyi and Omojola (1999) in their land use and land cover change evaluation in Sokoto – Rima Basin of North – western Nigeria based on Archival Remote Sensing and GIS techniques, used aerial photographs, LANDSAT MSS, SPOT XS/Panchromatic image Transparency and Topographic map sheets to study changes in the two dams (Sokoto and Goronyo) between 1962 and 1986.in which their work revealed that land use /land cover of both areas was unchanged before the construction of the dam while settlement alone covered most part of the area. However, during the post dam era, land use/land cover classes changed but with settlement on earth, affecting the ability of the biosphere to sustain life.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Study Area

The study was conducted in Gurara forest, (Figure 1.1), Kachia Local Government Area of Kaduna State. Gurara forest is located between coordinates of Latitudes 09°46' and 09°41″ North of the Equator and at Longitudes 07°45′ and 07°48' East of the Greenwich Meridian using the Global Position System (GPS). It occurs at UTM Zone 32, covering an approximate surface area of 905 km^2. Kaduna belongs to the Guinea savanna vegetation belt with rainfall starting in April and ending in October in the southern part of the state. The annual rainfall shows marked decrease from 1,524mm in the south to 635mm in the north, while the mean annual temperature ranges between 19°C–32°C. Gurara dam is located near Katari, a town located at Kaduna South Nigeria.The dam is located at about 30Kms away from the Katari town.Katari was initially a local settlement at the perimeter of the forest but has now grown into a major city due to the dam construction. About fourteen village settlements with three districts, Awon, Ariko, Katari North are found within the road that cut across the forest to the dam. Some of the villages are; Gurara Dam, Dam Market, Doka, Asawe, Atara, Ungwan Tora, Ariko, Kintaro,Sabon Gari Kurmin Taba Kigwale, Gidan Alewa, Katambi and Katari.

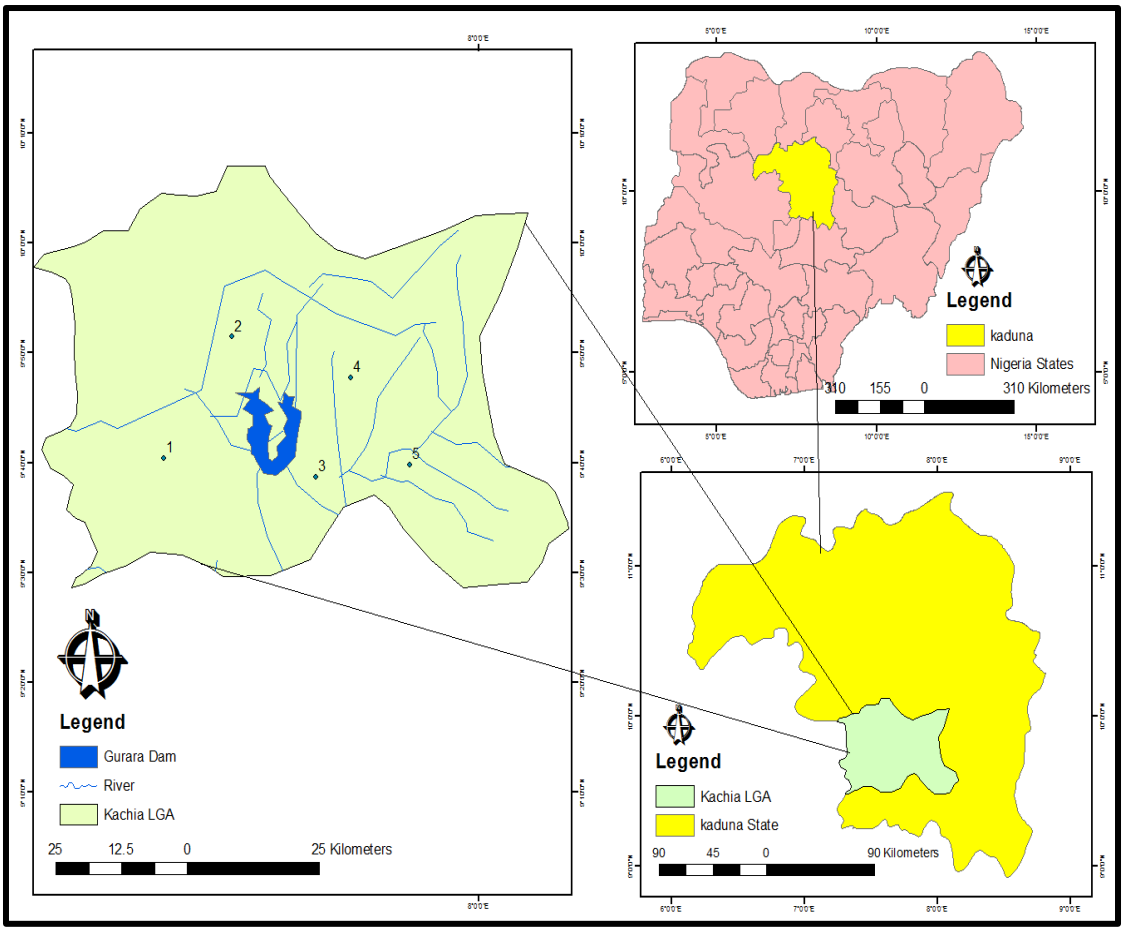


Figure 1: The Administrative Map of Kaduna State showing Kachia Local Government Area where the study area was located

Source: Modified from Kaduna State Administrative Map by Missamari .I, 2014

3.2 Floristic Survey and Measurement

3.2.1 Primary data collection

Two methods were employed in data collection.These were the Primary data and secondary sources of the data. For the Primary data collection, the plot count technique also known as the modified Whitaker's technique or $1/10^{th}$ of plot count technique a hectaretechniquewasused (Whittaker, 1975). According to the technique, representative plots of known sizes are mapped out using surveyors tape and twines used to demarcate the mapped out plots. The Location of the plots were noted using GPS.Ten (10) sites were established during a pilot survey taking note of their GPS locations, of these five sites were randomly selected for sampling and identifiedasplots 1, 2, 3, 4 and 5. During the survey, 0.5ha plots (i.e 50m×50m) were mapped out in each of the five sites sampling. The 0.5ha plot was measured using surveyor's tape. The mapped out plot was demarcated with twine to avoid sampling into the unmapped areas. The 0.5ha was further divided into 50 quadrats of 5m by 5m for easy counting. Thestudy concentrated on woody vegetation. All the trees and shrubs species that falls within the mapped out plot were identified, counted and recorded (Ellenberg and Muller-Dombois, 1974) The procedure was repeated for all the plots until all the five plots were sampled. In random sampling, there is no subjectivity as samples are chosen completely at random with each potential sampling unit having an equal chance of selection, completely independent of the selection of all other units(Husch *et al.*,1972).

Those plants which wecould not identify on the field were collected and preserve using the plant press and taken back to Department of Biological Sciences where proper identifications were done with the aid of herbarium specimen and identification keys by Hutchinson and Dalziel. (1954 -1972).

3.2.2 Secondary Data Collection

3.2.2.1 *Data sources and data collection for satellite imagery:*

The secondary data includes the use of spatial data such as topographical map, LAND SAT TM (1991) Imagery, LAND SAT TM (2001) Imagery and LAND SAT TM (2009) of the study area, obtained of path 189, Row 53 from the archives of national remote sensing centre Jos, Plateau state. These were used because they were readily available as at the time of the research.The data collected was mapped by ground trotting and ground survey methods. This involves moving along defined traverse and line transect while observing surface samples which were decided based on the heterogeneity of classes mapped from the field samples and this was aided by the use of a Global Positioning System (GPS) to locate the ground verification points on the satellite image for further incorporation of details. Other materials utilized in the study include; digital camera, meter tape, ranging poles etc. The GPS points were collected along trafficable roads intersections and edges of defined boundaries. Sixty percent of collected ground truth (training samples) was used in image classification.Topographical map is the map of the study area; this was generated using the GPS points of the area (Latitudinal and Longitudinal points) which served as reference point for acquiring the image and to retrieve on the image the position of the study area These were taken to Jos remote center

where the satellite images of the study area were generated. Based on the image processing analysis, the software generated the values for each land cover in each year.

3.3 Satellite Image Analysis

The data used in this research were for the years 1991, 2000 and 2009. These years were selected because informationwas more complete and comprehensive as compared to the other years were readily available. The study adopted imageries of different multi-temporal data acquired in the dry season with cloud free conditions as described by (Michael, 2013). An important advantage of LAND SAT imageries is the availability of older images to establish a baseline for determining medium-term rates of change. The entire satellite images were processed using Ilwis 3.3a processing software. Using this approach, seven broad land use classes (Built up area, Baresoil, Rock outcrop, Farmland, Secondary forest, Shrub land, River and Water body) were identified using the maximum likelihood algorithm in supervised classification procedure. Furthermore, the different land cover maps were produced.

3.4 Land Use Classification Scheme Description

The land use information for the study was based on field observation by researchers withfocus on the seven major land cover classes, which were the classification scheme adopted for the purpose of the research:

i.Built up: These were man-made areas covered with buildings and other artificial structures with intensive human developmental in-print. In this category the built-up are composed of areas with most of the land covered with structures such as villages,

commercial, strip development along highways, and an institutional complex. On the images they are represented by a regular and clustered pattern.

ii.Farmland: These were arable farmland and food crop of scattered cultivation areas used for growing agricultural crops and are apparently cultivated during the growing season. The area is dominated by growing cropping fields of legumes, root and tubers, grains, seeds and nuts. These have variegated appearance with definite geometrical shape clustering around settlements.

iii.Secondary Forest: These were areas covered by tree cover mosaics of different species distinguished by their height, with presence of little or no human activities. It refers to areas dominated with scattered bushes of woody plants or a light forest with trees. These were represented by its deep red colour on the satellite imagery.

iv.Rock Outcrops**:** These were uncultivated lands and areas dominated by inserlbergs and bare rock outcrops. These are depicted by very light tone with occasional white color and are represented by their irregular pattern.

v.Shrubland: These areas are covered with shrubs, thickets and grasses with little or no trees. These are depicted by an ash and light red color.

vi. River& Water body: These were open water bodies and/or areas covered mainly with water: dams, rivers and streams. These are depicted by a bluish to blackcolor recognized by clustering.

vii.Road Network**:** These include the road network in the study area. These were represented by whitish and black paved surface and have linear and curved patterns.

3.5 Analysis of Data

3.5.1 Estimating species richness and frequency of occurrence per 0.5 hectares

Data collected was summarized into tabular form to give species check list. Species Identification, botanical names and family was done; frequency of occurrence of each species in a plot was counted and tabulated to get the total of individual species that can be found in the five plots.

3.5.2Determination of percentage composition

Percentage composition wasderived by dividing the number of individual of a species by total number of individual of all species and multiplied by hundred.

Percentage Composition = $n/N \times 100$

n = number of individual of a species.

N = total number of individual of all species

3.5.3 Determination of Plant Species Diversity and Evenness

(i) Species Diversity

Plant species diversity was computed using Shannon - Wiener diversity indices of each plot Species Diversity was calculated by using:

$H = - \sum pi \times lnpi$

$Pi = ni/N$

ni = Number of individuals of the species

N = Total number of individuals in the plot

(ii)Species Evenness

Species evenness in the community was obtained using Shannon's equitability index (E_H):

$E_H = H/H_{max}$;

Where $H = \sum Pi \times lnpi$

Hmax = lnS: where S = Species richness

3.5.4 Determination of species similarity between plots.

The similarity between the five plots was estimated using the Jaccard similarity index

Jaccard index = $C_j = j/a+b-j$

Where:

j = the number of common species found in both plots

a = number of species unique in plot 1

b = number of species unique in plot 2

C_j approaches 1.0 when species composition are identical between sites and 0.0 when two sites have no species in common (Magurran, 1988).

3.5.5 Geo-spatial analysis:

This process helped to show the extent of temporal and spatial change in land use pattern. Geo-spatial techniques utilized are used to explain variation in change patterns occurring in the study area .Two change detection methods were used in the study.These are:

3.5.5.1*Area analysis*:

This analysis highlights the trend and rate of the land cover change

I. Percentage Change was calculated using the equation:

$$Percentage\ Change = \frac{OC}{ASC} \times 100$$

Where *OC* is the observed change; and *ASC* is the absolute sum of change.

II. Annual Rate of Change was calculated using the equation:

$$Annual\ Rate\ of\ Change = \frac{OC}{(Y2-Y1)}$$

Where OC is the observed change; *Y 1* is the starting year; and *Y 2* is the ending year.

3.5.6 Overlay analysis

The Overlay analysis involves the actual topological overlay of different data layers. This overlay, or spatial join, integrates data on built up, bare soil, farmland, secondary forest, shrub land, roads water body and river to produce a land cover map.

CHAPTER FOUR

4.0 RESULTS

4.1Structure and Physiognomy of the Gurara Forest.

The Gurara forest is a secondary forest with presence of woody trees, shrubs grasses, herbs and climbers. A total of 31 species were identified and recorded in Table 1. The 31 plant species belonged to 15 families with Fabaceaehaving more species (10), followed by Rubiaceae, Combretaceae and Moraceaewhich had 3 species each, others have 1 or 2 species in the family. The 31 plants species identified in the five demarcated plots had a total number of3502 stands of individual of which Trees were 2860 and shrubs were 64.

In plot 1, 18 plants species were identified out of which we have *Isoberliniadoka* with the highest frequency of occurrence or stand of 144, this was followed by *Lanneamicrocarpa* which occur 16 times,*Crosspteryxfebrifugia* hada total of 13 frequency, *Detariummicrocarpum* 10 individual and *Terminalia avicennioides* occurred 9 times. *Prosopsis africana*, *Terminalia mollis* and *Nauclealatifolia* both occurred once.

In plot 2, *Senegalia senegal* had the highest frequency of occurrence of 250 stands.This was followed by *Isoberlinia doka* which occurred 246 times, .*Afrormosia laxifolia* had 79 stands. The least occurred species are *Ficus glumosa*and*Khaya senegalensis* with one individual each.

In plot 3, *Senegalia senegal*has the highest frequency of 800 stands of individual and *Pilliostigmathonningii* which occurred 229 times,while the least occurring species were*Anogeissus leiocarpus*and *Ceiba pentandra* with 1 representative each.

Table 1: Frequency of occurrence of tree and shrub species in Gurara Forest, Kaduna State

				Frequency of Occurrence						
S/N	Species	Family	GH	Plot1	Plot2	Plot 3	Plot4	Plot 5	Total Frequency	Percentage (%)
1	*Afrormosia laxiflora (Benth)*	Fabaceae (P)	T	0	79	14	9	17	119	3.4
2	*Albizia lebbeck (*L.*)(Benth)*	Fabaceae (M)	T	0	0	30	0	0	30	0.86
3	*Annona senegalensis(*Pers.*)*	Annonaceae	S	8	25	67	20	35	155	4.43
4	*Anogeissus leiocarpus*(D.C) Guill & Perr.	Combretaceae	T	0	0	1	0	0	1	0.03
5	*Bombax buonopozense*(P. Beauv)	Malvaceae	T	0	0	0	1	2	3	0.09
6	*Borassus aethiopum (Mart)*	Arecaceae	S	0	0	0	4	4	8	0.28
7	*Ceiba pentandra* (L.)Gaertn.	Malvaceae	T	0	0	1	0	0	1	0.03
8	*Crossopteryx febrifugia (*G.Don) Benth	Rubiaceae	T	13	0	35	0	12	60	1.71
10	*Daniella oliveiria* (Benn.)	Fabaceae(C)	T	0	3	4	8	5	20	0.57
11	*Detarium microcarpum*(P.Beav.)	Fabaceae (C)	T	10	22	3	18	21	74	2.11
12	*Diospyros mespiliformis* (Hochst)	Ebenaceae	T	0	0	6	0	0	6	0.17
13	*Entanda africana* (Guill&Perr.)	Fabaceae	T	0	2	0	2	6	10	0.29
14	*Ficus exasperata* (Beaur.)	Moraceae	S	0	0	2	0	0	2	0.06
15	*Ficus glumosa* (Delile)	Moraceae	T	4	1	0	0	0	5	0.14
16	*Ficus sycomorus* (P. Beaur)	Moraceae	S	0	0	4	1	0	5	0.14
17	*Gardenia aquala*(Delile)kk	Rubiaceae	T	12	6	72	13	46	149	4.25
18	*Isoberlinia doka* (Craib& Stapf)	Fabaceae (C)	T	144	246	0	387	107	884	24.1

19	*Khaya senegalensis(*Desr, A Juss)	Meliaceae	T	0	1	0	0	0	1	0.03
20	*Lannea microcarpa*(A.Rich)	Anacardiaceae	T	16	0	3	3	27	49	1.4
21	*Monotes kerstingii* (Gilg)	Dipterocarpaceae	S	4	3	8	79	4	98	2.8
22	*Nauclea latifolia* (Smith)	Rubiaceae	S	1	2	18	0	19	40	1.14
23	*Parkia biglobosa*(Jacq)	Fabaceae	T	2	0	19	2	2	25	0.71
24	*Piliostigma thonningii* (Schum)	Fabaceae (C)	S	3	28	229	15	54	329	9.39
25	*Prosopsis africana* (Guill & Perr.)	Fabaceae (M)	T	1	3	9	11	14	38	1.09
26	*Senegalia senegal(*Linn)	Fabaceae (M)	T	0	250	800	16	0	1066	30.44
27	*Terminalia avicennioides (Guill&Perr)*	Combretaceae	T	9	11	101	2	14	137	3.91
28	*Terminalia mollis* (M.A Lawson)	Combretaceae	T	1	0	23	0	0	24	0.69
29	*Uapaca togoensis*(Pax)	Euphorbiaceae	T	6	32	0	13	21	72	2.1
30	*Vitex doniana(Sweet)*	Verbenaceae	T	2	11	6	1	4	24	0.69
31	*Vitteleria Paradoxa (Gaertn.*f) Hepper	Sapotaceace	T	6	5	37	0	14	62	1.77
	CROSS TOTAL			**247**	**730**	**1492**	**605**	**428**	**3502**	**100**

Key to Identification: GH (Growth habit).

The result of plot 4showed *Isoberlinia doka* having the highest frequency of occurrence with a total number of 387stands; this was followed by *Monotes kerstingii* (79). *Ficus sycomorus, Bombax buonopozene* and *Vitex doniana* with 1 occurrence each were the least. In plot 5, a total of twenty (20) species were identified with a total of 428 stands. *Isoberlinia doka* represent the highest population of plant species enumerated with the total population of 107,this was followed by *Piliostigma thonningii* which has a total of 35 stands. The least occurred species were *Bombax buonopozene* and *Parkia biglobosa* occurred 2 times each in this plot.

Comparing the flora distribution in the study area (five selected plots), *Montoes kerstingii, Vitex donianna , Piliostigma thonningii , Annona senegalensis, Termilnalia avecinoides* and *Gardenia aquala*occurred in all the plots. Species suchas*Isoberlinia doka ,Vitteleria paradoxa, Nauclea latifolia and Daniella olivera*were not common in all the plots though with high frequencies of occurrence (Table 1). The Percentage Composition of each species were estimated, *Senegalia senegal* had the highest percentage of 30.44%;followed by *Isoberlinia doka* with 24.1% while*Khaya senegalensis, Anogeissus leiocarpus* and *Ceiba pentandra* had the least percentage of 0.03% each across the plots.

4.1.1Tree Species Richness and Abundance

All Tree species found in the sampling site were recorded according to the plots as shown in table 2.The value of Shannon-Wiener diversity index (H) usually found to fall between 1.5 and 3.5 and only rarely surpasses 4.5 (Magurran, 1988).

Table 2: Tree species diversity and evenness in the sample plots.

S/N	Species	Family	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5
1	*Afrormosia laxiflora*	Fabaceae	0	79	14	9	17
2	*Albizia lebbeck*	Fabaceae	0	0	30	0	0
3	*Anogeissus leiocarpus*	Fabaceae	0	0	1	0	0
4	*Bombax buonopozense*	Bombacaceae	0	0	0	1	2
5	*Ceiba pentandra*	Malvaceae	0	0	1	0	0
6	*Crossopteryx febrifugia*	Rubiaceae	13	0	35	0	12
7	*Daniella oliveiria*	Fabaceae	0	3	4	8	5
8	*Deutarium microcarpum*	Fabaceae	10	22	3	18	21
9	*Diospyros mespiliformis*	Ebenaceae	0	0	6	0	0
10	*Entanda africana*	Fabaceae	0	2	0	2	6
11	*Ficus glumosa*	Moraceae	4	1	0	0	0
12	*Gardenia aquala*	Rubiaceae	12	6	72	13	46
13	*Isoberlinia doka*	Fabaceae	144	246	0	387	107
14	*Khaya senegalensis*	Meliaceae	0	1	0	0	0
15	*Lannea microcarpa*	Anacardiaceae	16	0	3	3	27
16	*Parkia biglobosa*	Fabaceae	2	0	19	2	2
17	*Prosopis africana*	Fabaceae	1	3	9	11	14
18	*Senegalia senegal*	Fabaceae	0	250	800	16	0
19	*Terminalia avicennioides*	Combretaceae	9	11	101	2	14
20	*Terminalia mollis*	Combretaceae	1	0	23	0	0
21	*Uapaca togoensis*	Euphorbiaceae	6	32	0	13	21
22	*Vitex doniana*	Verbenaceae	2	11	6	1	4
23	*Vitteleria paradoxa*	Sapotaceace	6	5	37	0	14
	Shannon-wiener diversity index (H)		**2.42**	**1.64**	**3.55**	**0.95**	**5.74**
	Evenness (E)		**0.94**	**0.62**	**1.25**	**0.36**	**2.12**

Evenness (E) is constrained between 0 and 1.0 with 1.0 representing a situation in which all species are equally abundant. The plot with the highest diversity was plot 5 with diversity (H) = 5.74 and species evenness (E) = 2.12. This was followed by plot 3, H = 3.55 and E = 1. 25. The plot with the least diversity is plot 4 with H = 0.95and evenness of 0.36

4.1.2Shrub Species Richness and Abundance

Shrub species found in the site were recorded according to plots. Table 3 showed the total number of shrubs present and their frequency of occurrence. Shannon- wiener diversity and evenness was also shown. Plot 1 had the highest diversity of H = 1.56 with low evenness (E) = 0.97, this was followed by plot 3 with diversity H = 1.2 and evenness (E) = 0.64. The plot with the least diversity is Plot 5 with H = 0.65 with evenness (E) of 0.4.

4.1.3Similarity Index between Tree Species in the Sample Area

Result from table 4 showed species similarities between plots (Identical species). The following values from Plot 1and 5 had the highest similarity of 0.65 (65%) among all the 5 sites compared. Plot 2 and 5 with 61%similarities index, Plot 2 and 3 and plot 2and 4 had values 41% and 47% respectively. The least similarities among tree species was recorded for Plot 3and 5 with a value of 34%.

4.1.4Similarity Index between Shrub Species in the Sample Area

Similarities index to show identical species between plots. The following values Plot 1and 2 and 2 and 5 had the highest values of 80% similarities each. Similarities between Plot 12and 5, Plot 2 and 3and Plot 4 and 5 had equal values of 67% each. The least similarity

value of 0.43 (43%) for shrub species in the study area was recorded for plots 1and 4indicating a very low similarity between plots.

Table 3: Shrub species diversity and evenness in the sample

S/N	Name	Family	Pt 1	Pt 2	Pt 3	Pt 4	Pt 5
1	*Annona senegalensis*	Annonaceae	8	25	67	20	35
2	*Borrassus aethiopum*	Arecaceae	0	0	0	4	4
3	*Ficus exasperate*	Moraceae	0	0	2	0	0
4	*Ficus sycomorus*	Moraceae	0	0	4	1	0
5	*Monotes kerstingii*	Dipterocarpaceae	4	3	8	79	4
6	*Nauclea latifolia*	Rubiacea	1	2	18	0	19
7	*Piliostimga thonningii*	Fabaceae	3	28	229	15	54
8	*Sercuridaca longipedunculata*	Polygalaceae	5	0	0	0	0
	Shannon- Wiener index (H)		**1.56**	**0.97**	**1.2**	**1**	**0.65**
	Evenness (E)		**0.97**	**0.7**	**0.64**	**0.62**	**0.4**

Table 4: Jaccard similarity index showing species association between plots

Plots Association	Trees(%)	Shrubs (%)
Plots 1 and 2	50	80
Plots 1 and 3	50	57
Plots 1 and 4	50	43
Plots 1 and 5	65	67
Plots 2 and 3	41	67
Plots 2 and 4	47	50
Plots 2 and 5	61	80
Plots 3and 4	36	57
Plots 3 and 5	34	57
Plots 4 and 5	45	67

4.2 Land Cover Distributions (Identifying and Mapping)

Figure 2, 3and 4 are satellite images for the period 1991, 2000 and 2009 respectively.The results for the static distribution of land cover presented and for land cover and land cover changes for the study area is presented in Table 5 and Figure 5, the results are essentially presented by maps, statistical tables and graphs. Looking at build up and road cover from table 5, the land covered by built up was 0.72km^2 in 1991, increased to 1.36km^2 in year 2000 and 4.85km^2 in 2009. There was no bare soil in 1991 but at 2000 1.35Km^2 of the area became bare. This figure further increased to 6.35km^2 in 2009. There was also progressive increased in the area taken by farm lands from 0.12km^2 1991, 0.14km^2 in 2000 and 0.28km^2 in 2009. Exposed rock out crops was 21.51km^2 in 1991 but shared a slight drop to 20.53km^2 in 2000 and then increased to 37.61km^2 in 2009.

Secondary forest increased from 704.51km^2 in 1991 to 724.65km$_2$. However these were a drastic decline to 686.76km^2 in 2009.Shrub land showed a progressive declinefrom 1991 to 2009 with Land cover of 177.56km^2 156.73km^2 and 110.91km^2 respectively. On the other hand, water bodies increases from 0.17km2 in 1991 to 58.89km^2 2009.Detailof the land cover distribution is shown in (Table 5 and Figure 5).

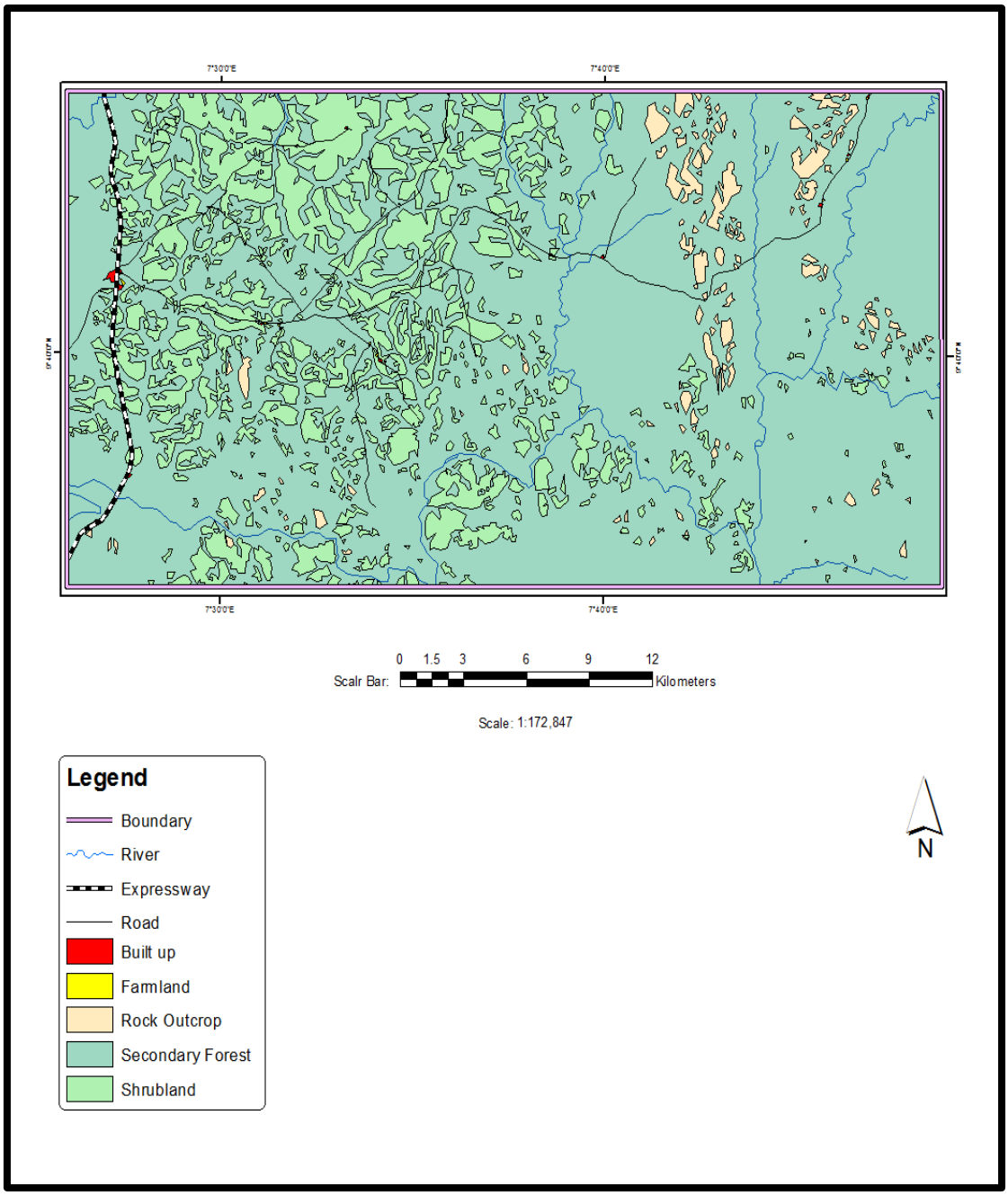


Figure 2: Satellite Imagery of Land Cover Categories of 1991
Source: National RemoteSensing Center Jos, Plateau State.

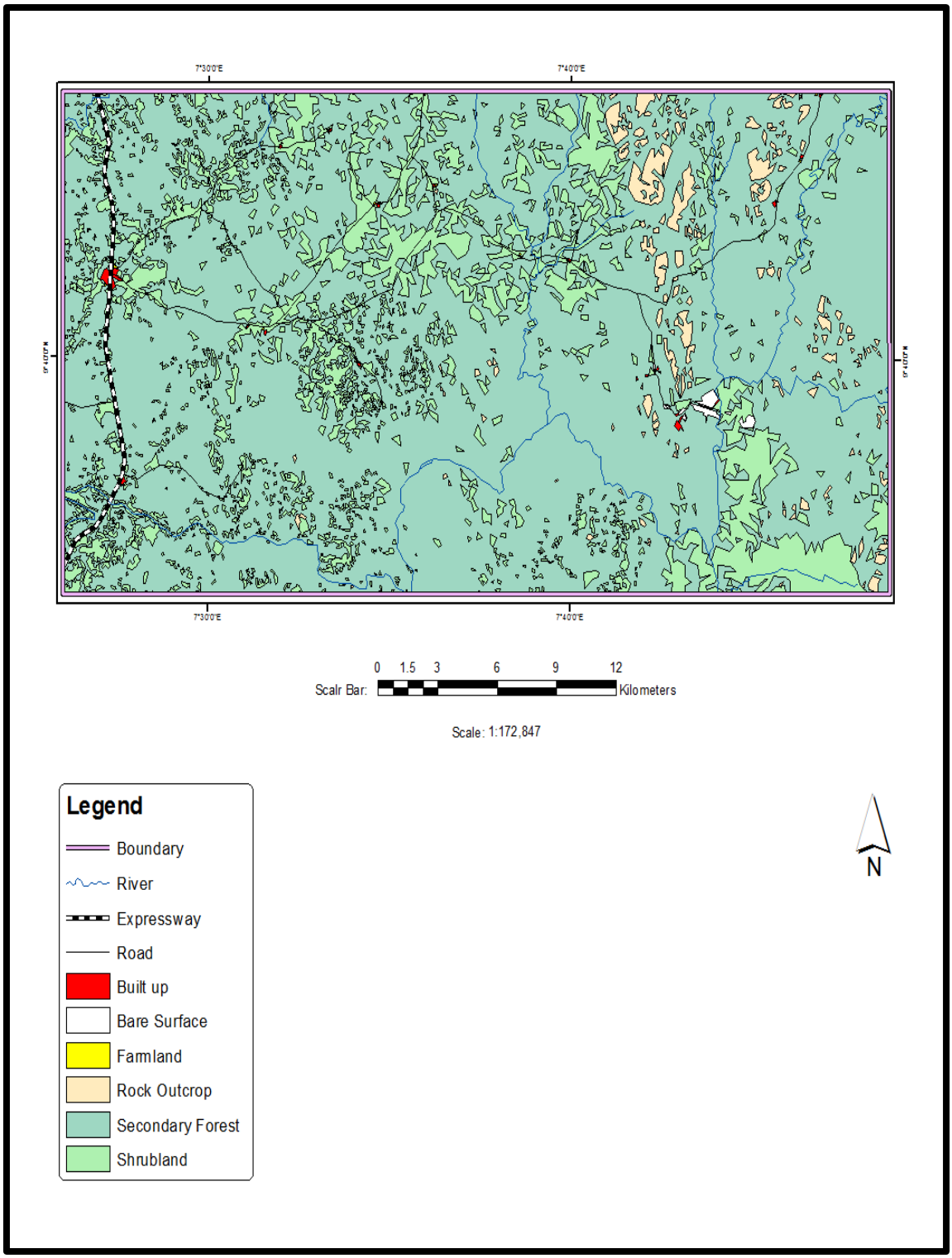


Figure 3: Satellite Imagery of Land Cover Categories of 2000
Source: National Remote Sensing CenterJos, Plateau State.

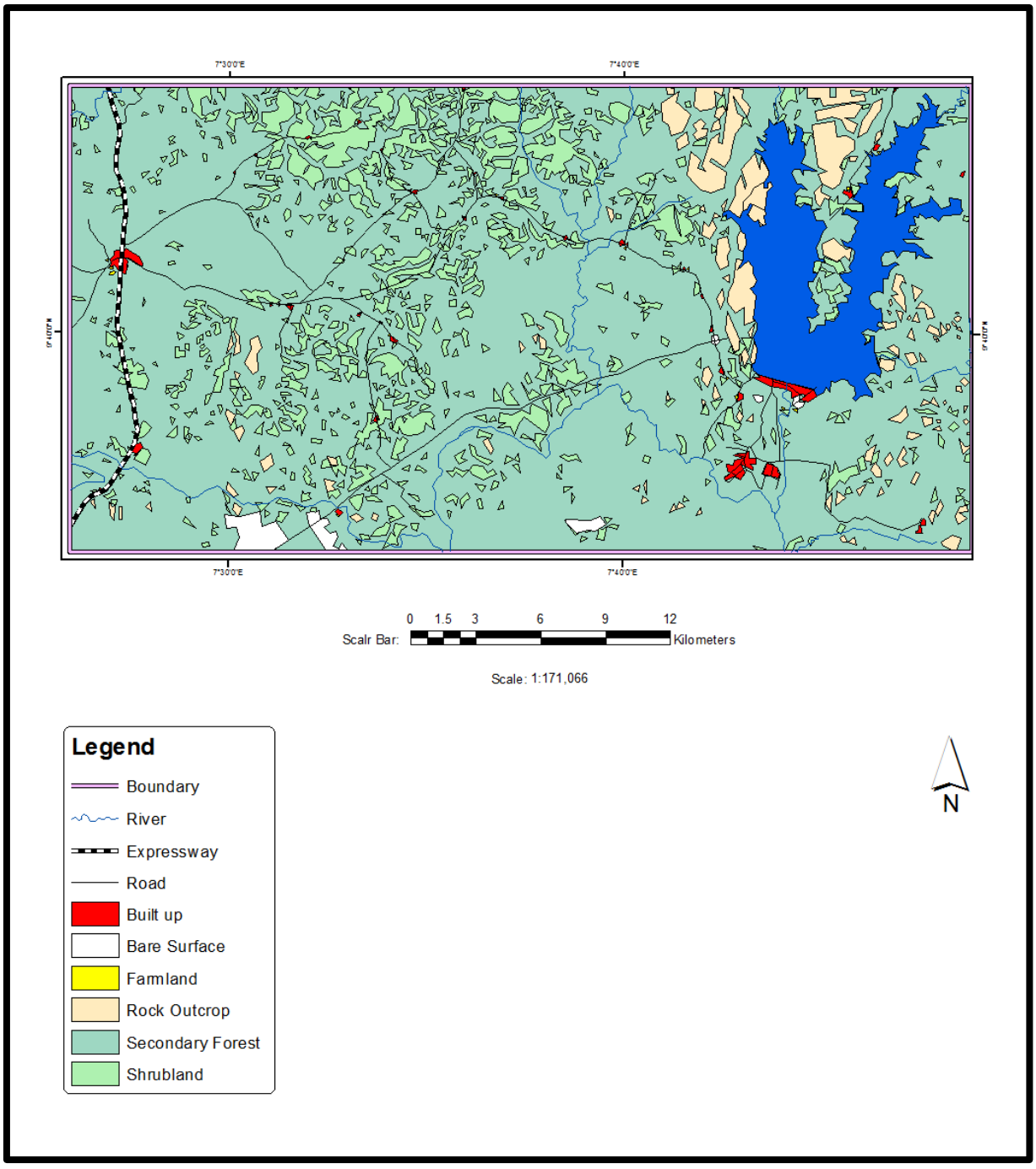


Figure 4: Satellite Imagery of Land Cover Categories of 2009
Source: National Remote Sensing Center Jos, Plateau State.

Table 5: Spatial Extent of Land Cover 1991, 2000, 2009.

Land cover Cat.	1991 Area(km^2)	%	2000 Area (km^2)	%	2009 Area(km^2)	%
Built up & Roads	0.72	0.08	1.36	0.15	4.85	0.54
Bare Soil	0	0	1.35	0.15	6.35	0.71
Farmland	0.12	0.02	0.14	0.02	0.28	0.03
Rock Outcrop	21.51	2.38	20.53	2.27	37.61	4.16
Secondary forest	704.51	77.8	724.65	80.08	686.76	75.83
Shrubland	177.56	19.2	156.73	17.31	110.91	12.22
River & Water body	0.17	0.02	0.17	0.02	58.89	6.51

Cat. = *Categories*

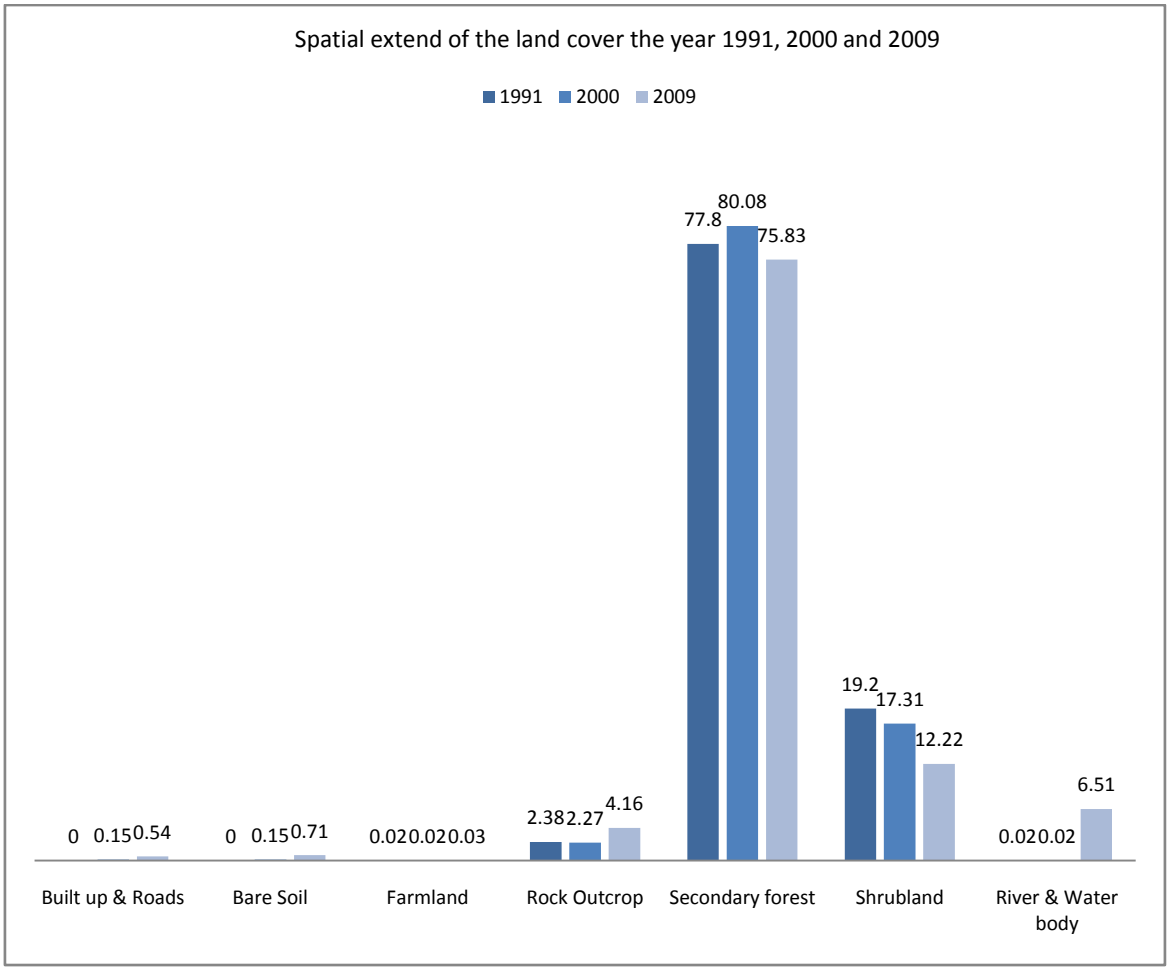


Figure 5: Proportion of land cover for 1991, 2000 and 2009.

4.2.1 Static land covers distribution for the year 1991

The static land use distribution of the study area as derived from the maps is presented in Table 6 and Figure 2 for each study year. The analysis of 1991 reveal's that farmland constituted the lowest proportion of the land use form in the study area and this seems to be practiced minimally occupying only 0.12 km^2 representing 0.01% of the study area and most farmlands areas were of less intensive use and were located close to settlements. These were usually cultivated during the growing season and were dominated by growing cropping fields of legumes, root and tubers, grains, seeds and nuts. This corroborates the fact that the study area is a rural area experiencing a traditional setting where farmland forms the basis for living. The development of built up, road network, and infrastructure was moderate and it constituted 0.72 km^2, which represents 0.08 % of the total land cover class. Thus, these are exhibited as farm settlements and villages concentrated as points which are irregularly spaced in a linear pattern occurring within short distances.Again, this may not be unconnected to the fact that the 1991 image was intentionally used to serve as a base year image to subsequent ones in other to observe earlier situations on ground before the construction and development of the Gurara reservoir. A notable feature of this period was the absence of any dam and bare soil surfaces since there hasn't been any reasonable encroachment and the existing land cover pattern at the time was relatively stable while experiencing no meaningful change. Also, secondary forest and shrub land occupied the largest proportion with 704.51 km^2 and 177.56 km^2 of the total categories representing 77.88 % and 19.62% respectively. Rock outcrop constituted 21.51 km^2 representing 2.38% respectively. Rivers covered 0.17 km^2representing 0.02% respectively while the water body

(dam) was virtually absent as this was the pre-dam period, as Gurara dam was yet to be constructed as at 1991. Altogether, during this period there was less pressure on the land use categories due to little need for expansion and low population density. The study area at the time had a low spatial aggregation.

4.2.2Static land cover distributions for the year 2000

In the year 2000, secondary forest and shrub land had expanded. Hence, it can be seen (Table 6 and Figure 2) that secondary forest have increased significantly and are the major land cover class covering 724.65 km^2 representing 80.08 % , shrub land is observed to have decreased from 19.62 % to 17.31 % in 2000 indicating a reduction in shrub land. The reduction is an indication of settlement expansion and increasing anthropogenic activities taking place. Farmland constituted the lowest proportion of the study are and this seems to have increased slightly from 0.12 km^2 to 0.14 km^2 representing 0.02 % from the initial 0.01%. The visibility of Rock outcrop have increased significantly occupying 20.53 km^2 representing 2.27%. Similarly, built up/road infrastructure have increased to 1.36 km^2 representing respectively.

Thus, noticeable expansions in built up area have gradually started taking place at the chosen site for the dam north east of the study area. During the period the direction of built up was gradually expanding forming a cluster and regular pattern of development that were linearly connected compared with the earlier period. The period (2000) met the beginning of the change in land cover. This was marked with the beginning of the dam construction and development. A notable feature in this period was the appearance of bare soil surfaces

which constitutes 1.35 km^2 representing 0.15 %. These were virgin lands encroached upon at the beginning of the dam construction which wasapparent to the north east of the Federal capital Territory (FCT). The rivers occupying 0.17 m^2 represented 0.02% which is recognized by their linear/irregular patterns. Altogether, this period indicates the beginning of pressure on land resources. The study area at the time had a low spatial aggregation with more settlement development.

4. 2. 3 Static land cover distributions 2009

In 2009 a careful observation (Table 6 and Figure 2) indicates that secondary forest and shrub land have the highest proportion in land cover categories covering 686.76 km^2 and 110.91 km^2 representing 75.83 % and 12.22 % respectively. Notwithstanding, the land and secondary forest land and shrub land areas recorded decrease from 80.08 % to 75.83% and 17.31 % to 12.22 % in 2009. Rock outcrop visibilities have increased from 2.27 % to 4.16% in 2009 covering an area of 37.61 km^2. Bare soil which are exposed surfaces constitutes 6.35 km^2 representing 0.71 %. Built up and road infrastructures have significantly increased from 0.15 % to 0.54 % in 2009 covering about 4.85 km^2.This indicates that built up and road infrastructure recorded significant gains .This period coincided with establishment of the Gurara dam in the study area occasioned by more expansion in built up and road infrastructure. Farm lands have continued to increase from 0.02 % to 0.03 % in 2009 covering about 0.28 km^2respectively and it is still practiced moderately. Consequently, the period was informed with the post dam development which had greatly increased. The study area at the time had a high spatial aggregation with a geographic characteristic of a linear and clustered pattern of settlements development.

4.2.4 Effect of spatial trend in land cover change

Table 6 represent the details of changes in land cover class, the comparisons for the trend for both the pre-dam and post dam periods(1991-2000) and (2000-2009)while Figure 6 showed the graphical representation for change in land cover for the eighteen (18) year period under investigation.

Table 6: Spatial Extent of Land Cover change for the Pre-dam and Post-dam periods.

Land cover Categories	**Change and (km^2) (%) Annual Rate of Change**	
	1991-2000	2000-2009
Built up & Roads	0.64 (0.08%)	3.49 (0.39%)
Bare Soil	1.35 (0.15%	5 (0.56%)
Farmland	0.02 (0.01)	0.14 (0.02%)
Rock outcrop	0.98(0.11%)	17.08 (1.90%)
Secondary forest	20.14(2.24)	-37.89(-4.21%)
Shrub land	-20.83(2.32)	-45.82 (-5.10%
River & Water body	0 (0.00%)	58.72 (6.53%)

Note: The positive sign means gain and the negative sign indicates loss in area extent.

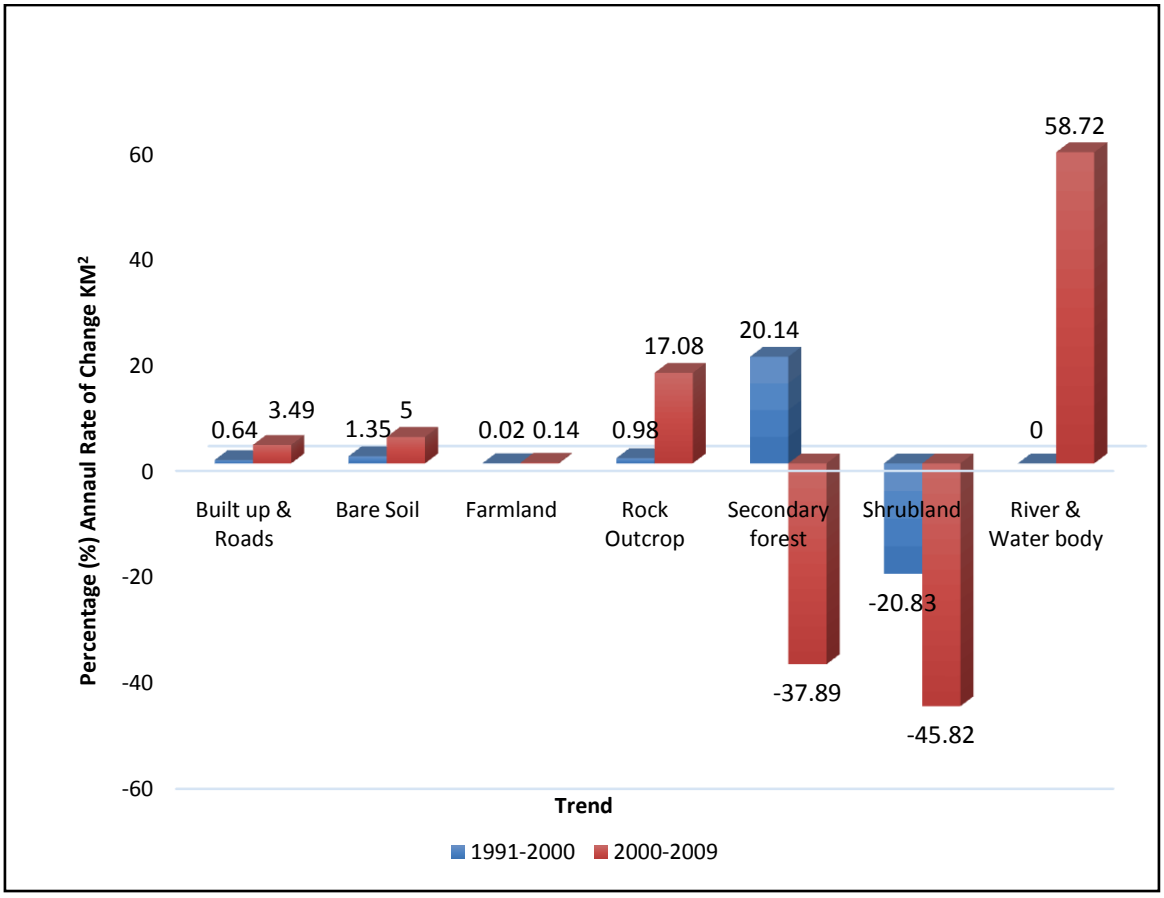


Figure 6 : Trend in Land Cover Change for year 1991 to 2009

CHAPTER FIVE

5.0 DISCUSSION

5.1 Checklist and Plant Species Composition of the Study Site

Plant species composition of 31 species belonging to 15families islow when compared to other research works done at the guinea savanna. Tanko *et al.*,(2013) reported 63 woody species associated with inserlbergs surroundings at Dumbi, Zaria in the northern guinea savanna. The low species richness is probably due to the fact that the site was a forest conservation area and this had given the plants allowance to grow to forest status which is always characterized by fewer numbers of species.This claim can be supported by the fact that the timber lumbering can only take place in forested areas and this was observed at the study site.Results from the species checklist in Table 1 shows that some species occurred in all the plots while some were predominant and absent in others. These variations on species distribution between the plots could be attributed to either environmental conditions or methods of pollination or dispersal in the various plots.

Austin *et al.*,(1996), in their research works on the patterns of tree species richness in relation to environment in South-eastern new South Walesopined that, high species occurrence in some areas is attributable to habitat adaptation and favorable environmental conditions which encourage pollination, dispersal and environmental establishment of species.Edaphic Parameter (soil nutrient) played a major role in species richness in an ecosystem. Anthropogenic activities may be a major factor attributed to the low occurrence of species in some area, This finding is in line with a research survey carried by USAID(2008) on *Nigeria Biodiversity and Tropical Forestry Assessment*in which they attributed

the low occurrence of species to anthropogenic activities such as logging , bush burning and diseases.Higher number of species in the family Fabaceae (C) is due to the fact the study area falls in a zone dominated by the members of this family. *Isoberlinia doka* to which the name doka town is derived is a member of this family. Deka *et al*.,(2012), attributed the success of the Fabaceae(C) to their fast germination ability, associated with symbiotic properties which enabled species to easily establish within habitat types.The multi-genera plant community has been reported in many tropical forests, while co-existence of co-generic species in forests indicate differences in flowering phenologies, pollination and dispersal agents of the species (Aiba, 1999; Valencia *et al*., 1994). Vegetation assessment of trees and shrubs indicates that legumes were prominent species recorded in the study area. Moraceae, Meliaceae and Fabaceae (P) also have the ability to produce numerous seeds and seedling whicheventually establish at the site. The reasons for the low number of species observed in some families could also be attributed to diseases and browsing by herbivores which resulted in poor growth and establishment of the species. Tanko *etal.,*(2013) observed species of *Anogeisus leiocarpus* and *Piliostigma thonningii* to remain stunted while some species died out as a result of over-grazing. This activities were equally observed at the study site.Seeds of some species need treatment to break dormancy before germination.This might have affected the germination and growth of those species there by giving opportunity to the other species to predominate. Also competition could be a possible factor. The species with low competitive ability will be faced out.

The reasons for the poor establishment of members of some plant families which showed lowest species may be attributed to competition for nutrients, limited light by canopy trees

and destruction of undergrowth during tree snag and logged on the forest floor. Egbe *et al.*, (2012) mentioned similar reports in a disturbed and natural regeneration forest in Korup National Park Cameroon.

Coley and Barone (1996) also recorded anthropogenic activities affecting growth and distribution of species. *Senegaliasenegal* which was formerly named as *Acacia senegalensis* had the highest number of individuals belonging to the family Fabaceae(M).Tanko(2012)inDumbi, Zaria, the northern part of Nigeria observed that the members of the family were avoided by wood gatherers due to thorny and hard nature of the wood, hence their abundance.The low number of species could further be attributed to anthropogenic activities which affected species growth and production. Similar findings have been reported by Sumina (1994) on plant communities on anthropogenically disturbed sites in Chukotka Peninsula.It could be deduced from this result that some of these species have been seriously endangered due to some anthropogenic activities such as farming, building Road and Rail construction, felling fuel wood, harvesting, collection of herbs which was also confirmed by Malaka,2011 and Tanko *et al*, 2013. The harvesting of plants parts for medicine was also obvious at the sites. Comparing the plots, Plot 5 had the highest Shannon-wiener diversity value (5.74) while Plot 4 had the least 0.95,it could be anthropogenic activities occupied by rock outcrops, bareland or water bodies i.e for plot 5 may be due to high protection and terrain to access the vegetation thickets, lack of access road for wood lumbering and wood logging might have led to the high diversity recorded.

The implication of this is that if judicious uses are not put in place for proper management, there is tendency that the future generation will be denied of their own opportunity and

advantage of these resources as a result of all the anthropogenic activities farming, dam, road and building constructions increasing in Gurara forest.

5.2 Similarities of Tree Cover among the plots.

Result from table 2 on Shannon diversity among trees shows that even among tree species in different sites in the forest some species have been disturbed by agriculture, logging and deforestation for plot 4 with the least diversity and evenness. Tree species in plot 5 and plot 3 are still highly diverse which indicates species richness in the area. Change due to anthropogenic activities has not affected all the area. Species diversity is one of the most important indices to evaluate an ecosystem. A rich ecosystem with high diversity has a large value H while an ecosystem with low H value would have a low species diversity (Sobuj and Rahman; 2011 Deka *et al*., 2012). Distribution of trees in the study area is quite even for plot 5 and 3 but very low for plot 2 with 36% value.Similaritiesbetween the plots indicated the presence of high identical species among the trees in the two of the studied sites from table 4 with values (65% and 61%). The least similarities among tree species was recorded between Plot 3and 5 with a value of 34%When similarities in tree cover between any two plots is less than 50%, this indicated that the plots had not too many tree species in common.

5.3 Shrub Cover of the Forest

The highest diversity of shrubs obtained was from plot 1 with H value of 1.56, and evenness(E) = 0.402,abundance which shows that the shrub species are relatively diverse while evenness or species abundance is very low. High diversity index of shrubs in Plot 1

may be due to wood lumbering where tree species probably removed for timber, giving way to shrub species to dominate the plot. To support this claims, a shift in the Zaria Isoberlinia woodland to combretaceous woodland was observed by Tiseer and Smith (2004). A shift in *Isoberlinia* woodland of the Zaria area to *Albizia lebbeck* was also observed by Tanko *et al*.,(2010).Tanko *et al*., (2013) in a similar study on Inserlbergs in Zaria reported a shift from the forest out layered guierawhich is a Sudan –Sahelian species. Association among shrub species between plots recorded 80% percentage association as the highest which indicated the presence of identical species.These results therefore indicated that association is higher between shrubs species identified in the study area as compared to tree species.Magarrun, 1988, states that when C_j approaches 1.0 species composition are identical between two sites and at 0.0when two sites have no common species**.** High percentage of associationbetween plots in the shrub stratum could be attributed to the mode of dispersal of the species, sub familyCaesalpinaceae which was dominant at the site produced large number of seeds which are dispersed by explosive mechanism making it possible for seeds to cross from one plot to another.Tanko *et al*.,(2013), had a similar observations at dumbiinserlbergs and they attributed it to close proximate of the plots and modes of dispersal.

5.4 The Dam Period

5.4.1 The pre dam period (1991-2000)

This period gave a clear cut change to the start of Dam construction in the study area. Thus, construction activities broke ground in the late 1990s, due to economic gains and political stability. During the period (1991-2000) most of the land cover were relatively stable with

secondary forest experiencing the most positive change (gain) followed by bare soil, rock outcrop use, built up and road network, farmland, river with only shrub land experiencing decrease. Conversely, shrub land experienced a negative change (loss) and accounted for -20.83(-2.32 %).

Themajor impacts of the dam/reservoir construction from the study site include:

Several small villages mapped along the reservoir were no longer functional as they were being submerged. These were relocated away from the dam site to areas apart. Similarly, the reductions in shrub land shows that built up and road expansion have continued to encroach as a result of anthropogenic activities taking place at the expense of vegetal cover loss. This means that the rate of encroachment in shrub land have increased in their spatial extent for the years 1991- 2000. The positive changes observed in built-up areas and roads indicating that encroachment into the site for build-up started even before the construction of the dam. This is not unconnected with global population explosion and search for livelihood. The build-up areas have a link with the roads constructions since the settlers will have access roads to their homes and also transport their goods to the market. Positive change in bare soil is an indication that deforestation and other human related activities that could expose soil to erosion were already on going at the site before the dam construction.This may show that farming may not be a major threat to the site before the construction of the dam. The settlers were probably engaged in other activities like woodlogging, fishing and grazing with the farming being a secondaryactivities. Rock outcrop showed a positive increased probably because the ongoing anthropogenic activities further exposed them making them more visible than they were when the site was densely

forested. Secondary forest shared a significant positive increase. Though there where encroachment in far patches of the study area, the lack of protection is very high with high restriction in lumbering activities. This gave opportunity to some of the forest to boost. Shrubland showed a negative change indicating a decrease. This is expected because the area is the major source of fuel wood that serves Kaduna metropolis. With the opening of the road it made it easier for the wood gatherers to transport the wood to the Markets,this probably lead to the decreased in shrub stratum during the period.

5.4.2 The post dam period (2000-2009)

The period 2000-2009 was met with the establishment of the Gurara dam.During this period most of the land cover experienced significant changes with river and water body (Gurara dam)experiencing the most positive change (gain) followed by rock outcrop use, bare soil, built up and road network, farmland. Consequently, secondary forest land shrub land are observed to have decreased and have experienced a negative change (loss) and accounted for-37.89 km^2 (- 4.21%) and -45.82km^2 (-5.21%), respectively.

A notable feature in this period was the construction of the Gurara dam. The increase in built up and road network occasioned with the completion of the dam accelerated to its peak and it thus came with increase in physical developments and the provision of basic services and amenities. Most expansion was apparent to the north east, north west, south and in other parts of the study area. The increasing shares in the built up areas have intensified and have accelerated urban encroachment into the natural vegetation, hence

leading to increase in changes observed .These activities have negative impactson the shrub stratum as already stated above, therefore the negative change observed.

The major impact of the dam and reservoir construction in the post dam study site includes: The period was not unconnected with the relocation of most displaced villages on/close to the dam site. These villages were resettled in new locations and later formed settlements in areas apart. Besides the above, the impoundment has displaced a vast majority of farmland, secondary forest and shrub land.

Similarly, the reduction in secondary forest and shrub land indicates that built up and road expansion have continue to encroach as a result of anthropogenic activities taking place due to rapid expansion occurring at the expense of vegetal cover loss. This means that the rate of encroachment in secondary forest and shrub land have decreased in their spatial extent and has reduced for the years 2001- 2009.

Therefore, the period presents secondary forest and shrub land with a decline compared with the previous period. This therefore, demonstrates that expansion activities have placed more pressure on the bio-diversity of the study area.

The result of the Pre/Post dam period is in line with the work of Adeniyi and Omojola, (1999) in their land use land cover change evaluation in Sokoto – Rima Basin of North – western Nigeria in which their work revealed that land use /land cover of both areas was unchanged before the construction of the dam while settlement alone covered most part of the area. However, during the post dam era, land use/land cover classes changed but with

settlement on earth, affecting the ability of the biosphere to sustain life. Human have become ever more adapt at appropriating and altering the earth's resources for their needs. Intensification and diversification of land use and advances in technology have led to rapid changes in biogeochemical cycles, hydrological processes and landscape cycles, hydrological processes and landscape dynamics. Creation of the Kanji dam was reported to have displaced over 35,000 acres of land 44,000 people displaced.

Vegetation degradation/depletion arising from agricultural extension, increased demand for fuel wood, vegetal clearance at exposing bare soil surfaces were encroached upon for construction activities. This findings support the work ofBoakye *et al*., (2008), which explain that vegetation changes are often the result of anthropogenic pressure (e.g. population growth) and natural factors such as variability in climate.

A significant change in rock outcrop was its continuous incline for use caused by engineering activities; emerging quarries enclosed for construction under the pressure of rapid construction. This was occasioned by increase in population and physical developments.

CHAPTER SIX

6.0 SUMMARY,CONCLUSIONS AND RECOMMENDATIONS

6.1 Summary

The objectives of this research were to identify the tree and shrub species of the area, their frequency of occurrence, family composition, diversity and the spatial distribution of the forest. From the primary data collected on the field and computed, our result showed that there were more tree species in the study area when compared to the shrub species. Species evenness for Shrubs species had generally low values all through the plots. Tree species with higher values were recorded in about three of the plots. For species similarities, shrubspecies were more identical among the plots when compared to trees within the plots. Secondary data was collected from LAND SAT image of 1991, 2000 and 2009 (a total of 18 years) this revealed a change in the land use-land cover area of the forest. The forest was demarcated into shrub land, secondary forest rock-outcrop/road network, River, Dam/reservoir and bare soil. Significant change was noted on the secondary forest cover and shrub land cover areas during the post dam period (2001- 2009). Result from pre- dam period (1991- 2001) showed no significant change, these result therefore indicated that the forest was negatively affected by the dam construction and other human activities arising in Gurara forest as a result of the construction of the dam.

6.2 Conclusions

There is a significant difference in species composition and diversity of the forest as Shannon-Wiener diversity (H) was very high with a value of 5.74 for tree species with evenness recorded as 2.12, while for shrub species, the highest diversity was recorded as

1.56 and evenness 0.4. For species similarities, more identical species were found among the shrub as compared to the tree species.

The changes in vegetation over time have negative significant effect of-37.89 km^2(- 4.21%) and -45.82km^2 (-5.10%) on the flora of the area for secondary forest land and shrub land respectively, these were observed to have decreased and have experienced a negative change (loss) over the eighteen years period.

The Gurara dam construction and other anthropogenic activities have significance effects on the flora of the area with the construction of the Gurara dam(pre-dam period),water body, build up area and road construction experienced a positive gain of 58.72km^2 (6.53%) and 3.49km^2(0.39%) respectively.

The change in the forest vegetation and the low species occurrence was confirmed by our result to be caused by anthropogenic activities and encroachment activities and a need for development and urbanization in the area.The implication of these is that in the next eighteen years, most of the tree and shrub species of the Gurara forest will go into extinction and future generation will not only be deprived of their own opportunity of benefiting from these resources but also be affected by the effect of deforestation, global warming and environmental depletion onboth localand global environment.

6.3 Recommendations

Deforestation and other human activities on the forest is not an unstoppable or irreversible process. Increased and concerted efforts in forest plantation ‘rebirth’ and rejuvenation will bring to use the type of forest reserve we envisaged. In order to reduce the effects of

deforestation in Gurara forest in Kaduna state, the study has the followings as its recommendations:

- Government by way of policy should be strict in preserving forest reserves from illegal encroachers.
- The promotion of alternative energy source for fuel wood in order to reduce the pressure on the forest.
- Development and promotion of trade in non-timber forest product to reduce the pressure on timber resources and to enhance rural livelihood.
- The available vegetation area and the farmland must be properly utilized to encourage sustainable management between the rural dwellers and the government.
- Regular training and seminars should be organized by forestry officers to the rural communities on the practice of agro-forestry to promote regeneration of tree species in the area and a sustainable utilization of forest resources.
- The technology of remote sensing and GIS should be employed in major studies, concerning national issue such as deforestation, desertification etc.
- Establishment of tree logs within the state, to allow people access to wood for more efficient use.
- Carbon economy as a way of generating income can be introduced by government and international agencies; this will encourage people to protect the forest, carbon economy generates more income than any other forest encroachment activities.

- Finally, further studies should be carried out to assess theimpact of these flora changes on the fauna population and distribution.

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APPENDICES

Appendix 1: Composition of Tree Species Diversity and Evenness

S/NO	NAME	FAMILY	DVD1	DVD 2	DVD 3	DVD 4	DVD 5
1	*Afrormosia laxiflora*	Fabaceae	0	-0.25	-0.1	-0.07	-0.16
2	*Albizia lebbeck*	Fabaceae	0	0	-0.8	0	0
3	*Anogeissus leiocarpus*	Combretacea	0	0	0	0	0
4	*Bombax buonopozense*	Bombacaceae	0	0	0	-0.013	-0.03
5	*Ceiba pentandra*	Malvaceae	0	0	0	0	0
6	*Crossopteryx febrifugia*	Rubiaceae	-0.17	0	0.11	0	-0.12
7	*Daniella oliveiria*	Fabaceae	0	-0.01	0	-0.07	-0.07
8	*Detarium microcarpum*	Fabaceae	-0.13	-0.15	-1.5	-0.12	-0.18
9	*Diospyros mespiliformis*	Ebenaceae	0	0	-2.7	0	0
10	*Entanda africana*	Fabaceae	0	-0.02	0	-0.02	-0.08
11	*Ficus glumosa*	Moraceae	-0.08	-0.01	0	0	0
12	*Gardenia aquala*	Rubiaceae	-0.15	-0.04	0.11	-0.1	-0.28
13	*Isoberlinia doka*	Fabaceae	-0.29	-0.31		-0.18	-3.67
14	*Khaya senegalensis*	Meliaceae	0	-0.1	0	0	0
15	*Lannea microcarpa*	Anacardiaceae	-0.19	0	0.1	-0.03	-0.21
16	*Parkia biglobosa*	Fabaceae	-0.04	0	0.07	-0.02	-0.03
17	*Prosopsis africana*	Fabaceae	-0.02	-0.24	0.04	-0.08	-0.14
18	*Senegalia senegal*	Fabaceae	0	-0.02	-0.3	-0.11	0
19	*Terminalia avicennioides*	Combretaceae	-0.13	-0.02	0.21	-0.02	-0.14
20	*Terminalia mollis*	Combretaceae	-0.02	0	0.08	0	0
21	*Uapaca togoensis*	Euphorbiaceae	-0.11	-0.37	0	-0.09	-0.18
22	*Vitex doniana*	Verbenaceae	-0.04	-0.07	0.03	-0.01	-0.56
23	*Vittelaria paradoa*	Sapotaceace	-1.05	-0.04	1.1	0	-0.4
	Shannon-Wiener Diversity Index (H)		2.415	1.641	3.55	0.954	5.735
	Evenness, E		0.943	0.622	1.25	0.361	2.118

Evenness (J) = H/Hmax

Where H =$\sum$ Pi*lnpi and Hmax = lnS

Appendix II: Composition of Shrub Species Diversity and Evenness

S/N	Name	Family	DVD 1	DVD 2	DVD 3	DVD 4	DVD 5
1	*Annona senegalensis*	Annonaceae	-0.37	-0.36	-0.32	-0.3	-0.362
2	*Borrasus aethopium*	Arecaceae	0	0	0	-0.11	-0.11
3	*Ficus exasperate*	Moraceae	0	0	0	-0.3	0
4	*Ficus sycomorus*	Moraceae	0	0	-0.05	-0.04	0
5	*Monotes kerstingii*	Dipterocarpaceae	-0.32	-0.15	-0.08	-0.28	-0.11
6	*Nauclea latifolia*	Rubiacea	-0.16	-0.11	-0.15	0	0.29
7	*Piliostigma thonningii*	Fabaceae	-0.37	-0.35	25	-0.27	-0.355
8	*Sercuridaca longipedunculata*	Polygalaceae	-0.34	0	0	0	
			1.56	0.97	1.15	1	0.647
	Shannon-Wiener Diversity Index(H)						
	Evenness (E)		0.969	0.698	0.642	0.622	0.402

Appendix III: Shannon-Wiener diversity for tree species in Plot1

S/N	Species	Family	PLOT 1	Pi	lnPi	Pi×lnPi	%
1	*Crossopteryx febrifugia*	Rubiaceae	13	0.06	-2.81	-0.17	5.75
2	*Detarium microcarpum*	Fabaceae	10	0.04	-3.22	-0.129	4.42
3	*Ficus glumosa*	Moraceae	4	0.02	-3.91	-0.078	1.77
4	*Gardenia aquala*	Rubiaceae	12	0.05	-3.99	-0.15	5.31
5	*Isoberlinia doka*	Fabaceae	144	0.64	-0.45	-0.29	63.7
6	*Lannea microcarpa*	Anacardiaceae	16	0.007	-2.66	-0.186	7.08
7	*Parkia biglobosa*	Fabaceae	2	0.009	-4.71	-0.042	0.88
8	*Prosopsis africana*	Fabaceae	1	0.004	-5.52	-0.022	0.44
9	*Terminalia avicennioides*	Combretaceae	9	0.04	-3.22	-0.129	3.98
10	*Terminalia mollis*	Combretaceae	1	0.004	-5.52	-0.022	0.44
11	*Uapaca togoensis*	Euphorbiaceae	6	0.03	-3.51	-0.105	2.65
12	*Vitex doniana*	Verbenaceae	2	0.009	-4.71	-0.042	0.88
13	*Vittelaria paradoxa*	Sapotaceace	6	0.03	-3.51	-1.05	2.65
	Shannon- Wiener diversity (H)		**226**	**0.943**	**-47.74**	**2.415**	

Appendix IV: Shannon-Wiener diversity for teee species in plot 2

S/N	Species	Family	Pi	Lnpi	Pi*lnpi	%
1	*Afrormosia laxiflora*	Fabaceae	0.1176	-2.14	-0.252	11.76
2	*Daniella oliveiria*	Fabaceae	0.0045	-5.4	-0.0097	0.45
3	*Detarium microcarpum*	Fabaceae	0.033	-3.41	-0.146	3.27
4	*Entanda africana*	Fabaceae	0.003	-5.81	-0.017	0.3
5	*Ficus glumosa*	Moraceae	0.0012	-6.21	-0.012	0.15
6	*Gardenia aquala*	Rubiaceae	0.009	-4.71	-0.042	0.89
7	*Isoberlinia doka*	Fabaceae	0.366	-1.01	-0.307	36.6
8	*Khaya senegalensis*	Meliaceae	0.00149	-6.51	-0.097	0.15
9	*Prosopis africana*	Fabaceae	0.0045	-5.4	-0.243	0.45
10	*Senegalia senegalensis*	Fabaceae	0.372	-0.99	-0.024	37.2
11	*Terminalia avicennioides*	Combretaceae	0.016	-4.14	-0.02	1.64
12	*Uapaca togoensis*	Euphorbiaceae	0.048	-3.04	-0.37	4.76
13	*Vitex doniana*	Verbenaceae	0.016	-4.14	-0.066	1.64
14	*Vittelaria paradosa*	Sapotaceace	0.007	-4.96	-0.035	0.74
	Shannon-Wiener Diversity (H)		672	0.999	-4.133	1.641

Appendix V: Shannon – Wiener diversity of Tree Species in Plot 3

S/N	NAME	Family	Pi	lnPi	Pi*lnpi	%
1	*Afrormosia laxiflora*	Fabaceae	0.0185	-3.99	-0.073	1.85
2	*Bombax buonopozense*	Bombacaceae	0.0021	-6.17	-0.013	0.21
3	*Daniella oliveiria*	Fabaceae	0.0164	-4.11	-0.067	1.65
4	*Detarium microcarpum*	Fabaceae	0.0061	-3.3	-0.122	3.7
5	*Entanda africana*	Fabaceae	0.00411	-5.49	-0.023	0.41
6	*Gardenia aquala*	Rubiaceae	0.027	-3.61	-0.097	2.67
7	*Isoberlinia doka*	Fabaceae	0.8	-0.22	-0.176	76.3
8	*Lannea microcarpium*	Anacardiaceae	0.0061	-5.11	-0.0311	0.62
9	*Parkia biglobosa*	Fabaceae	0.0041	-5.5	-0.023	0.41
10	*Prosopis africana*	Fabaceae	0.022	-3.82	-0.084	2.26
11	*Senegalia senegal*	Fabaceae	0.033	-3.41	-0.113	3.29
12	*Terminalia avicennioides*	Combretaceae	0.004	-5.52	-0.022	0.4
13	*Uapaca togoensis*	Euphorbiaceae	0.027	-3.61	-0.097	2.67
14	*Vitex doniana*	Verbenaceae	0.022	-6.21	-0.0124	0.21
Shannon-Wiener Diversity(H)			0.992	-60.07	0.954	

Appendix VI: Shannon-Wiener diversity for tree species in plot 4

S/N	NAME	Family	Pi	lnPi	Pi*lnpi	%
1	*Afrormosia laxiflora*	Fabaceae	0.0185	-3.99	-0.073	1.85
2	*Bombax buonopozense*	Bombacaceae	0.0021	-6.17	-0.013	0.21
3	*Daniella oliveiria*	Fabaceae	0.0164	-4.11	-0.067	1.65
4	*Detarium microcarpum*	Fabaceae	0.0061	-3.3	-0.122	3.7
5	*Entanda africana*	Fabaceae	0.00411	-5.49	-0.023	0.41
6	*Gardenia aquala*	Rubiaceae	0.027	-3.61	-0.097	2.67
7	*Isoberlinia doka*	Fabaceae	0.8	-0.22	-0.176	76.3
8	*Lannea microcarpa*	Anacardiaceae	0.0061	-5.11	-0.0311	0.62
9	*Parkia biglobosa*	Fabaceae	0.0041	-5.5	-0.023	0.41
10	*Prosopis africana*	Fabaceae	0.022	-3.82	-0.084	2.26
11	*Senegalia senegal*	Fabaceae	0.033	-3.41	-0.113	3.29
12	*Terminalia avicennioides*	Combretaceae	0.004	-5.52	-0.022	0.4
13	*Uapaca togoensis*	Euphorbiaceae	0.027	-3.61	-0.097	2.67
14	*Vitex doniana*	Verbenaceae	0.022	-6.21	-0.0124	0.21
Shannon-Wiener Diversity (H)			0.992	-60.07	0.954	

Appendix VII:Shannon - Wiener diversity of shrub species in plot 5

S/N	Species	Family	GH	PLOT5	Pi	lnpi	Pi*lnPi	%
1	*Afromosia laxiflora*	Fabaceae	T	17	0.054	-2.92	3.016	5.45
2	*Bombax buonopozense*	Bombacaceae	T	2	0.006	-5.11	-0.031	0.64
3	*Crossopteryx febrifugia*	Rubiaceae	T	12	0.038	-3.3	-0.12	3.85
4	*Daniella oliveiria*	Fabaceae	T	5	0.016	-4.135	0.066	1.6
5	*Detarium microcarpum*	Fabaceae	T	21	0.067	-2.703	-0.181	6.73
6	*Entanda africana*	Fabaceae	T	6	0.019	-3.96	-0.075	1.92
7	*Gardenia aquala*	Rubiaceae	T	46	0.147	-1.92	-0.282	14.7
8	*Isoberlinia doka*	Fabaceae	T	107	0.343	-10.7	-3.67	34.3
9	*Lannea microcarpa*	Anacardiaceae	T	27	0.0865	-2.45	-0.212	8.65
10	*Parkia biglobosa*	Fabaceae	T	2	0.006	-5.12	0.031	0.64
11	*Prosopis africana*	Fabaceae	T	14	0.045	-3.10	-0.14	4.48
12	*Terminalia avicennioides*	Combretaceae	T	14	0.045	-3.10	-0.14	4.48
13	*Uacapa togoensis*	Euphorbiaceae	T	21	0.067	-2.70	-0.181	6.73
14	*Vitex doniana*	Verbenaceae	T	4	0.0128	-4.36	-0.558	1.28
15	*Vittelaria paradoxa*	Sapotaceace	T	14	0.045	-3.10	-0.4	4.48
	Shannon – Wiener diversity (H)			312	0.997	58.64	5.735	

Appendix VIII**:** Shannon - Wiener diversity of Shrub species in plot 1

S/N	Name	Family	PLOT 1	Pi	lnPi	Pi*lnpi	%
1	*Annona senegalensis*	Annonaceae	8	0.38	-0.97	-0.37	38.1
2	*Monotes kerstingii*	Dipterocarpaceae	4	0.19	-1.66	-0.32	19.1
3	*Nauclea latifolia*	Rubiaceae	1	0.05	-3.1	-0.16	4.8
4	*Piliostimga thonningii*	Fabaceae	3	0.14	-1.97	-0.37	14.3
5	*Sercuridaca longipedunculata*	Polygalaceae	5	0.24	-1.43	-0.34	23.8
	Shannon- Wiener diversiy (H)		21	1	-9.13	1.56	

Appendix IX**:** Shannon - Wiener diversity of Shrub species in plot 2

S/N	Name	Family	GH	PLOT 2	Pi	lnPi	Pi*lnpi	%
1	*Annona senegalensis*	Annonaceae	S	25	0.43	-0.84	-0.36	43.1
2	*Monotes kerstingii*	Dipterocarpaceae	S	3	0.05	-2.99	-0.15	5.2
3	*Nauclea latifolia*	Rubiacea	S	2	0.03	-3.5	-0.11	3.45
4	*Piliostimga thonningii*	Fabaceae	S	28	0.48	-0.73	-0.35	48.3
	Shannon - Wiener diversity			58	0.99	-8.06	0.97	

Appendix X**:** Shannon - Wienerdiversity of Shrub species in plot 3

S/N	Species	Family	GH	PLOT 3	Pi	lnPi	Pi*lnpi	Percentage (%)
1	*Annona senegalensis*	Annonaceae	S S	67	0.2	-1.61	-0.32	20.4
2	*Piliostimga thonningii*	Fabaceae		229	0.7	-0.306	-0.25	69.8
3	*Monotes kerstingii*	Dipterocarpaceae	S	8	0.02	-3.91	-0.08	2.44
4	*Nauclea latifolia*	Rubiacea	S	18	0.05	-3	-0.15	5.49
5	*Ficus exasperate*	Moraceae	S	2	0.61	-0.49	-0.3	0.61
6	*Ficus sycomorus*	Moraceae	S	4	0.01	-0.05	-0.05	1.22
	Shannon- Wiener diversity (H)			328	1.59	-9.366	1.15	

Appendix XI**:** Shannon - Wienerdiversity of Shrub species in plot 4

S/N	Species	Family	GH	PLOT 4	Pi	lnPi	Pi*lnpi	Percentage (%)
1	*Annona senegalensis*	Annonaceae	S	20	0.17	-1.77	-0.3	16.8
2	*Borassium aethiopium*	Arecaceae	S	4	0.03	-3.51	-0.11	3.36
3	*Ficus sycomorus*	Moraceae	S	1	0.008	-4.83	-0.04	0.84
4	*Monotes kerstingii*	Dipterocarpaceae	S	79	0.66	-0.42	-0.28	66.4
5	*Piliostimga thonningii*	Fabaceae	S	15	0.13	-2.04	-0.27	12.6
	Shannon- Wiener diversity (H)			119	0.998	-12.57	1	

Appendix XII **:**Shannon - wiener diversity of Shrub species in plot 5

S/N	Species	Family	PLOT 5	Pi	lnPi	PI*lnPi	Percentage (%)
1	*Annona senegalensis*	Annonaceae	35	0.302	-1.2	-0.362	30.2
2	*Piliostimga thonningii*	Fabaceae	54	0.47	-0.76	-0.355	46.6
3	*Monotes kerstingii*	Dipterocarpaceae	4	0.03	-3.5	-0.11	3.5
4	*Nauclea latifolia*	Rubiacea	19	0.16	-1.83	0.29	16.4
5	*Ballanite aegygptica*	Arecaceae	4	0.03	-3.5	-0.11	3.5
	Shannon- Wiener diversity (H)			0.992	-10.8	0.647	

Appendix XIII: Global position coordinates of the Gurara forest study area

Global Positioning System Coordinates of the Gurara Forest

Plot	Site	Latitude	Longitude
1	Ariko	09°46□ and 09°25□ 56□ □ N	07 47□ and 0750□ E
2	Doka	09 47□ and0942□ N	0744□ and 0746□ E
3	Awon	09 42□ 852□ □ and 0939□ 635□ □ N	0742□ 393□ □ ,07 39□ 745□ □ E
4	Asawe	09 49□ and 0944□ N	0752' and 0753E
5	Gurara dam	0.9 46□ 32□ □ and 0934□ 36□ □ N	0748□ 43" N and 0748□ 47□ □ E



Plate 1: Build up area in Gurara forest.



Plate 2: Farm land area in Gurara Forest



Plate 3: Secondary forest in Gurara Forest.



Plate 4: Rock outcrop in Gurara Forest



Plate 5: Shrubland in Gurara Forest



Plate 6: Gurara dam in Gurara Forest



Plate 7: Gurara dam lake in Gurara Forest


Plate 8: Road network in Gurara Forest