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ANALYSIS OF DEFORESTATION IN THE FEDERAL CAPITAL TERRITORY, NIGERIA

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Abstract

A detailed analysis of deforestation in the Federal Capital Territory (FCT), Abuja, Nigeria was carried out with the aim of assessing the nature and extent of deforestation in the territory between 1987 and 2014 using satellite images of 1987 and 2014. The images were retrieved using Landsat TM at 1000m resolution and subjected to NDVI to ascertain the actual sizes of dense vegetation in the area. The FAO formula, $Q = (A_2 / A_1)^{1/(t_2 - t_1)} - 1$ was used to calculate the deforestation rate while Focus Group Discussion (FGD) and Key Informant Interview (KII) were adopted to retrieve qualitative data from women, key stakeholders and residents in some selected communities of the FCT. The results of the survey show a dense vegetation of 18.28% in 1987 and 12.69% in 2014 respectively giving a deforestation rate of 0.279% amounting to 374.023ha of dense vegetation loss. The findings also show that illegal logging, farming activities, developmental projects and poor regulation by the relevant authorities are some of the factors that contribute to deforestation. It therefore concluded that the activities of residents, government and poor regulation contribute to the high rate of deforestation and other forms of degradation of the forests. Recommendations were made based on the findings of the study.

Keywords: Deforestation, Vegetation, Federal Capital Territory, Nigeria

Word count: 209

1. Introduction

The Federal Capital Territory (FCT), Abuja is the administrative headquarter of Nigeria carved out of Niger and Kogi States in 1976. It had rich natural forest resources replete with various indigenous species of trees and animals as well as 18 gazetted forest reserves inherited from Niger, a State bounding the FCT on the west (Forestry Department, Federal Capital Development Authority (FCDA), 2013). These forest reserves gave the FCT a very conducive environment of 10% vegetation cover by 1976. Thirty-eight years later in 2014, the vegetative situation has changed due to environmental degradation. The vegetation cover from these reserves is now about 2%. These forest reserves and primary forests have been encroached upon giving way to infrastructural development and human settlements. Some of the economic trees and wildlife are already endangered (Forestry Department, FCDA, 2013). Out of the 10,914.85 hectares of forest reserve that existed in the FCT, only about 1000 hectares remain intact (*see*, Table 1).

Table 1: Present Forest Reserve Status in the FCT.



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1	Gwagwa	237.84	AMAC	colonized by farmers
2	Karmo	513.62	AMAC	Encroached
3	Karon Majigi	228.95	AMAC	Deforested
4	Garki	474.56	AMAC	Deforested
5	Idu	631.20	AMAC	Encroached
6	Kukwuaba	447.87	AMAC	Deforested
7	Galadimawa	697.32	AMAC	Deforested
8	Gaba Zuma	184.93	AMAC	Deforested
9	Chikwoi	27.27	AMAC	Deforested
10	Chihurma	136.09	AMAC	Deforested
11	Kusoru	104.74	AMAC	Deforested
12	Odu	4,322.99	AMAC	Deforested
13	Kuje	89.31	KUJE	Intact
14	Babban Kurmi	372.15	KUJE	Deforested
15	Tukoki	628.46	KUJE	Deforested
16	Shaba	60.91	KUJE	Deforested
17	Buga Hill	736.41	KUJE	Deforested
18	Kujekwa	1,020.03	KUJE	Deforested
TOTAL		10,914.85		

LGA – Local Government Area

Source: Forestry Department, FCDA, 2013.

Prominent among this form of environmental degradation is deforestation which has obvious environmental change and socio-economic impacts on human life. These impacts include loss of agricultural productivity, alteration of the carbon and water cycles. Deforestation also has detrimental effects on vector-borne diseases and leads to loss of biodiversity (Walsh, *et al*, 1993; Fearnside, 2005).

2. Research Problem

Nigeria is well endowed with forest resources, accounting for about 2.5% of the Gross Domestic Product (GDP). These resources provide employment and help maintain the health status of the residents (Olufemi and Ameh, 1999). A major challenge faced by the country is extensive deforestation which occurs at a rate of 3.3% per annum. Since 1990, the country has lost over 6 million hectares or 36% of its forest cover. The most diverse ecosystems (old growth forests) are disappearing at an alarming rate; between 1990 and 2005, 79% of these forests were lost. Since 2000, Nigeria has been losing an average of 11% of its primary forests each year. According to the Food and Agriculture Organization (2001), these losses have resulted in Nigeria having the greatest deforestation rate in the world. Out of the 10,914.85 hectares of forest reserve inherited by the FCT, only about 1,000 hectares currently exist and this excludes all of the primary forests where little or no protection is enforced. Deforestation is largely uncontrollable in the FCT due to the activities of the residents, chief of which is bush burning (Forestry Department of the FCDA, 2013).



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The cultural beliefs of the indigenes and residents of the FCT have a significant impact on deforestation rate in the area. In order to prepare land for cultivation and urban development, these people believe that vegetative clearance has to be done thoroughly without consideration to important role of vegetation in sustaining the ecosystem of the area. The vegetative clearance is often carried out faster by setting the forest on fire. Similarly, poachers and games chasers freely set the vegetation on fire in order to enable them have access to wild animals. Another belief which fosters deforestation in the FCT is the use of wood fuel. The residents are of the view that wood fuel offers a faster burn in cooking and add unique flavour to the food. Indiscriminate burning of vegetation exposes the soil to sunlight which leads to loss of soil nutrients, mosquito breeding and outbreaks of malaria. This study will examine the volume of wood fuel used by residents in cooking as an indicator of the number of trees felled.

The poverty level of the rural dwellers in the FCT also contributes to deforestation. Some rural dwellers engage in timber business which involves illegal lumbering, selling of timber as firewood and to developers who use them for construction purposes. Others convert this timber to charcoal and sell the product to caterers and smiths. The poverty level of these dwellers forces an early harvest of the forest resources with little time for the trees to mature while other plants are often cut down if they have no market value. These activities pose a serious risk to the environment and increases the incidence of diseases such as malaria on the human population. A number of social and health issues associated with deforestation is discussed in the study conducted by Pattanayak *et al*, 2006.

Another factor which causes deforestation is the lack of enforcement by the relevant authorities. In the FCT, there are no forest guards to monitor the forest reserves and the manner in which the residents exploit the forest resources. Policy-makers and regulators argue that for the law to be enforced, an alternative, especially for wood fuel, must be given to the dwellers to avoid unnecessary conflict between them and the government. The environmental implication of alternative source of wood fuel, like kerosene, cooking gas or electric stoves is a cleaner and better environment. Government, on its own, prefers to spend money managing the consequences of using wood fuel than to spend on prevention by providing alternatives like kerosene stoves, gas cookers and electric cookers. Beyond this, the constant increase in the price of these alternatives and the frequency of their availability is a source of major concern. Most of the residents concerned are not capable of acquiring these cooking equipment and even when they acquire them, they are not sure of the availability of the fuels to use. They, therefore, rely on the best alternative that is readily available and affordable which is the trees in the forests.

Yet another factor contributing to deforestation is indiscriminate logging for timber and wood fuel. Since rural dwellers living close to the forests are highly dependent on wood fuel for their cooking, this puts an inordinate pressure on the forest resources. This ugly trend is worsened by the fact that alternative fuels such as kerosene, coal or cooking gas are either not available or affordable to the residents. The problem of deforestation is further exacerbated through the use of bulldozers for clearing estate sites and road construction leading to the clearance of large portions of forest in few hours thereby resulting in more damage and extraction higher than those approved by regulators. It is noteworthy that within the surrounding settlements, local residents are dependent on bush meat as part of their local staple food supply. Bush meat availability has decreased in many parts of Nigeria with the construction of roads and other infrastructures. Increased access to wildlife habitat places more pressure on forest



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from both hunters and poachers. There is a growing concern among health experts, geographers, social scientists and demographers that the quest for bush meat may be linked to forest degradation. This study, therefore, critically analyse the rate of deforestation in the FCT and cultural reasons behind it.

3. Review of Literature

Deforestation, according to World Wide Fund (WWF) for Nature (WWF, 2010), is the conversion of forested areas to non-forest land for agriculture, pasture, urban use, logged area, or wasteland. The WWF maintains that deforestation can also be seen as the removal of forests leading to several imbalances ecologically and environmentally which result in decline in habitat and biodiversity. According to Natural Resources Canada (2016), deforestation is an important issue since shrinking forest cover reduces biodiversity, affects soil and water quality, impacts wildlife habitat and influences climate change. The Canadian Government carefully monitors and regularly publishes reports on deforestation and their scientists combine satellite and aerial images with information about regional development, forest ecosystems, natural processes and local conditions to help monitor and manage the health of Canadian forests. At 0.02% of its forested area, deforestation in Canada is among the world's lowest, yet many myths exist about the state of their forests. The reality is that Canada is a world leader in sustainable forest management. Canadian forests are healthy, productive and thriving.

Deforestation comes in many forms, including mining, urbanization, fires, clear-cutting for agriculture, ranching and development, unsustainable logging for timber, and degradation due to climate change (FAO, 2007). Loss of forest cover impacts people's livelihood and threatens a wide range of plant and animal species. Some 46-58 thousand square miles of forest are lost each year and this is equivalent to 36 football fields every minute. Deforestation is a particular concern in tropical rainforests because these forests are homes to much of the world's biodiversity. For example, in the Amazon and parts of Indonesia, around 17% of their forests has been lost in the last 50 years mostly due to forest conversion for cattle ranching (WWF, 2010). Deforestation in the Sub-Saharan Africa which includes Nigeria is particularly rampant near more populated areas, roads and rivers. Even in remote areas, forests have been encroached upon. In the World Wide Fund for Nature Report (2010), forests cover 31% of the land area on our planet. They produce vital oxygen and provide homes for people and wildlife. Many of the world's most threatened and endangered animals live in forests and 1.6 billion people rely on the benefits offered by the forest which include food, fresh water, clothing, traditional medicine and shelter.

Studies carried out by Nobre, Sellers and Shukla (1991), Laurance (1998) and the WWF (2010) pointed out that forests play a critical role in mitigating climate change because they act as a carbon sink which soaks up carbon dioxide that would otherwise be free in the atmosphere and contribute to ongoing changes in climate patterns. Deforestation undermines this important carbon sink function. It is estimated that 15% of all greenhouse gas emissions are the result of deforestation (Riitters *et al*, 2000). Riitters *et al* (2000) further stressed that forests are more than just a collection of trees, they are integrated ecosystems and home to some of the most diverse life on Earth. They also serve as major players in the carbon and water cycles that make life possible. When forests are lost or degraded, their destruction sets off a series of changes that affect life both locally and globally.

3.1. Causes of deforestation



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Joshi and Singh (2002), in their study, attributed the main cause of deforestation to the rapidly growing population. They further contended that more people increasingly depend on forest land for other uses thus forests are being cleared to create land for a multitude of human activities. Joshi and Singh (2002) used a questionnaire to collect their data which was then subjected to content analysis. The analysis showcased a five-point-causes of deforestation which include increased agricultural land use demand, urbanization, improved transport networks, industrial development and fire. Some of the causes of deforestation are critically examined below.

Conversion for agricultural purposes - As the human population increases, there is an obvious need for more food and other necessities of life. In addition, agricultural products such as soy and palm oil are used in an ever-increasing list of products ranging from animal feed to lipstick and biofuels. The rising demand for these products has created incentives to convert forests to farmlands and pasture lands. Agriculture is estimated to be the direct driver for around 80% of deforestation worldwide (Wageningen University and Research Center, 2012). Jordan (2015) also pointed that in the next 40 years, agricultural land will expand by more than an area larger than India and about a third the size of the United States. Therefore, conversion of forest for agricultural purposes is most destructive especially when it occurs in a fragmentary pattern rather than in a consolidated patch. Similarly, in Nigeria, large scale agricultural practices which requires large land capital has also consumed a large portion of forested areas (Ogunwale, 2015). Ogunwale (2015) further asserts that mechanized farming in the middle belt was practiced by indigenous farmers but the system of shifting cultivation is still employed to improve crop yield. This requires shifting from existing farm sites to virgin and uncultivated lands thereby clearing existing natural forests. Even if the best natural forest management systems available could be implemented in Nigeria, the forest reserves would not be able to meet the country's timber needs of 19 million m³ cu in the year 2000. Yields of the natural high forests are about 10-25 percent of the short time yields from plantations. Therefore, the trend is the clearance of primary forest for plantation development which involves removal of both indigenous and exotic timber species often to the detriment of the country's natural forests. Once a forest is lost to agricultural practices, it is usually gone forever along with many of the plants and animals that once lived there.

Fire- Deforestation can happen quickly when fire sweeps through the landscape or the forest is clearly cut to make way for industrial development such as oil palm production. The latter is of particular concern in Indonesia and Malaysia which produce a combined total of more than 50 million metric tons of palm oil per year. Deforestation can also happen gradually as a result of ongoing forest degradation as temperatures rise due to climate change caused by human activities. Fire constitutes a natural and beneficial element of many forest landscapes but they are problematic when they occur in the wrong place, at the wrong frequency and with the wrong severity. While deforestation appears to be on the decline in some countries, it remains disturbingly high in others including Nigeria and this poses a grave danger to our world's most valuable forests.

Illegal logging – Palmer (2000), considered the underlying causes of recent high rates of deforestation in Indonesia. He did this using the Materials Balance Method.

$$H_L.A_L = Q_L \dots\dots\dots(1)$$

$$H_T.A_T = Q_T \dots\dots\dots(2)$$



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Hence illegal logging $Q_i = Q_T - Q_L$ (3)

H= harvest quantity, i= illegal, A= area (hectares), T= actual (total), Q= output (m³), L= legal
From the analysis, Palmer discovered that in Indonesia, the fundamental causes of illegal logging are market and government failures often arising as a result of corruption.

Illegal logging generally occurs around the world while, in some places, illegal logging is more common than the legal variety. Illegal logging depresses the price of timber worldwide, disadvantaging law-abiding companies, and depriving governments of revenues normally generated from duties and taxes (Olufemi and Ameh, 1999). Poor communities near forests are often vulnerable when outsiders try to gain control over the timber nearby which can lead to repression and human rights violations.

Fuelwood harvesting - Wood is still a popular fuel choice for cooking and heating around the world and about half of the illegal removal of timber from forests is thought to be for use as fuel wood. The International Union of Forest Research Organisations (2015) itemized reasons why deforestation is on the increase. Some of these reasons include; unsustainable timber extractions including excessive cuttings and poor harvest operations, expansion of agricultural lands and unsustainable agricultural practices, climate change, non-involvement of local communities in land management decisions, exploitation due to weak rule of law and deficient monitoring by enforcement agents and poverty.

3.2. Agents of deforestation

Agents of deforestation are different from the causes. The agents of deforestation refer to those individuals, government agencies, corporations or development projects that clear the forests as opposed to the motivational forces (FAO, 2007). Table 2 shows some of the agents of deforestation and their links.

Table 2: Agents of deforestation

1	Slash and burn farmers	clear forest to grow subsistence and cash crops
2	Commercial farmers	clear the forest to plant commercial cash crops, sometimes displace slash and burn farmers who then move to the forest
3	Cattle ranchers	clear the forest to plant pasture, sometimes displace slash-and-burn farmers who then move to the forest
4	Livestock herders	intensification of herding activities can lead to deforestation
5	Loggers	remove commercial timber, logging roads provide access to other land users
6	Commercial tree planters	clear mostly forest fallow or previously logged forests to establish plantations and to supply fibre to the pulp and paper industry
7	Firewood collectors	intensification of firewood collection can lead to deforestation



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8	Mining and petroleum industrialists	roads and seismic lines provide access to other land users, localised deforestation related to their operations
9	Land settlement planners	relocation of people into forested areas as well as settlement projects displacing local people who then move to the forest
10	Infrastructure developers	new access to other land users from road and highway construction through forested areas, flooding by hydroelectric dams

Source: Forestry Department, FAO (2007).

In Africa and Nigeria in particular, five main agents of deforestation have been identified. These are slash and burn farmers, commercial farmers, loggers, livestock herders and civil and refugee disturbances (Uneke, 2008).

3.3. Deforestation rate

Tropical forests (including forests in the FCT), which are estimated to contain over half of the global biodiversity, are being destroyed at a significant rate (Laurance *et. al*, 2001). Deforestation in the tropics has been going on for several years but the main damage has occurred during this century since the spread of broad-scale industrialization and plantation agriculture especially in Brazil, and since the rapid population growth in Madagascar (Wilson, 1987). Understanding the dynamics of forest loss is crucial to the effective management and conservation of biodiversity and improving the health status of residents. However, the indices needed to estimate deforestation are often flawed (Dirzo and Garcia, 1992; Fearnside, 1993). In recent years, forest loss is basically measured using satellite imagery and spatial analyses. This study also calculated the rate of deforestation by comparing the areas with dense forest cover in the FCT for 1987 and 2014 and subjecting the data to the FAO model.

4. Methodology

Table 3. Methodology Table.

To assess the nature and extent of deforestation in the FCT.	Satellite images of FCT for 1987 and 2014. Using Landsat Thematic Mapper (TM) at a 1000m resolution.	Abuja Geographic Information System, National Air Space Research and Development	Geographic Information System	The 1987 and 2014 forest sizes for FCT were subjected to the FAO formula $Q = (A_2 / A_1)^{1/(t_2 - t_1)} - 1$ Where Q = rate of deforestation, A ₂ and A ₁ are forest sizes for 2014 and 1987 respectively.
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Agency
and
USGS.

This study utilized data on socio-demographic characteristics of respondents (age, sex, *et. cetera*). Other data types include ownership of forests, areas covered by forests, nature of forests, vegetative distribution, number of trees cut per annum, average monthly income, agents of deforestation, alternatives to wood fuel, their availability and affordability, Normalized Difference Vegetation Index, opportunity cost of deforestation, methods of deforestation, satellite images of areas covered by forests and importance of forests. This study utilized data obtained from different establishments using research instruments such as the questionnaire, Focus Group Discussion (FGD), Key Informant Interview (KII), satellite images and observation from the field. Some of these establishments include the Department of Forestry of the Federal Capital Development Authority (FCDA), Abuja Geographic Information System (AGIS), United States Geological Survey (USGS, GLOVIS Viewer) and Google Earth. Primary sources include the Gatekeepers and women in the selected communities. Others came from literature and from GIS reports.

In order to obtain data on deforestation, the list of forest reserves in the FCT was obtained from the Forestry Department of the FCDA (Table 1) and has been listed according to Area Councils. Two Area Councils accommodate these forest reserves namely AMAC and Kuje Area Councils. AMAC initially accommodated 12 reserves out of which two are remaining at Idu and Karmo, while Kuje accommodated 6 out of which one is still intact. All of the vegetation maps, including the Normalized Difference Vegetation Index (NDVI) at a low resolution and the Google Earth Maps at a high resolution, were sourced from the Abuja Geographic Information System (AGIS), the Forestry Department of the Federal Capital Development Authority (FCDA), United States Geological Survey (USGS, GLOVIS Viewer) and Google Earth. This research anchored on the FCT but sampled six (6) settlements (Kuje, Kukwaba, Galadimawa, Idu, Karmo and Buga) to obtain qualitative information. Out of these six communities, three still have gazetted forest reserves (*see*, Table 1) and served as the control sites while in the other three, full deforestation has taken place and they served as treatment sites.

The choice of these six communities is based on the fact that only three gazetted forest reserves out of eighteen, *ab-initio*, still exist in the Federal Capital Territory. These are the two sites in Idu and Karmo respectively and the site in Kuje which served as control sites while two other sites in AMAC, Galadimawa and Kukwaba, and Buga Hill in Kuje have also been selected using a systematic sampling technique hence, they served as treatment sites. The deforested areas in AMAC were listed alphabetically and every fourth community was chosen thus having Galadimawa and Kukwaba selected. In Kuje Area



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Council, Buga Hill was selected. Attention was also given to primary forests. As a result, the satellite images provided information on the sizes of both primary forests and forest reserves. The people that participated both in the KII and FGD were selected through a stratified systematic exercise where the names of qualified people were listed alphabetically and those against even numbers were selected. Three people were purposively chosen from each of the communities for interview using KII. These people were proven to be residents by the qualified gate keepers.

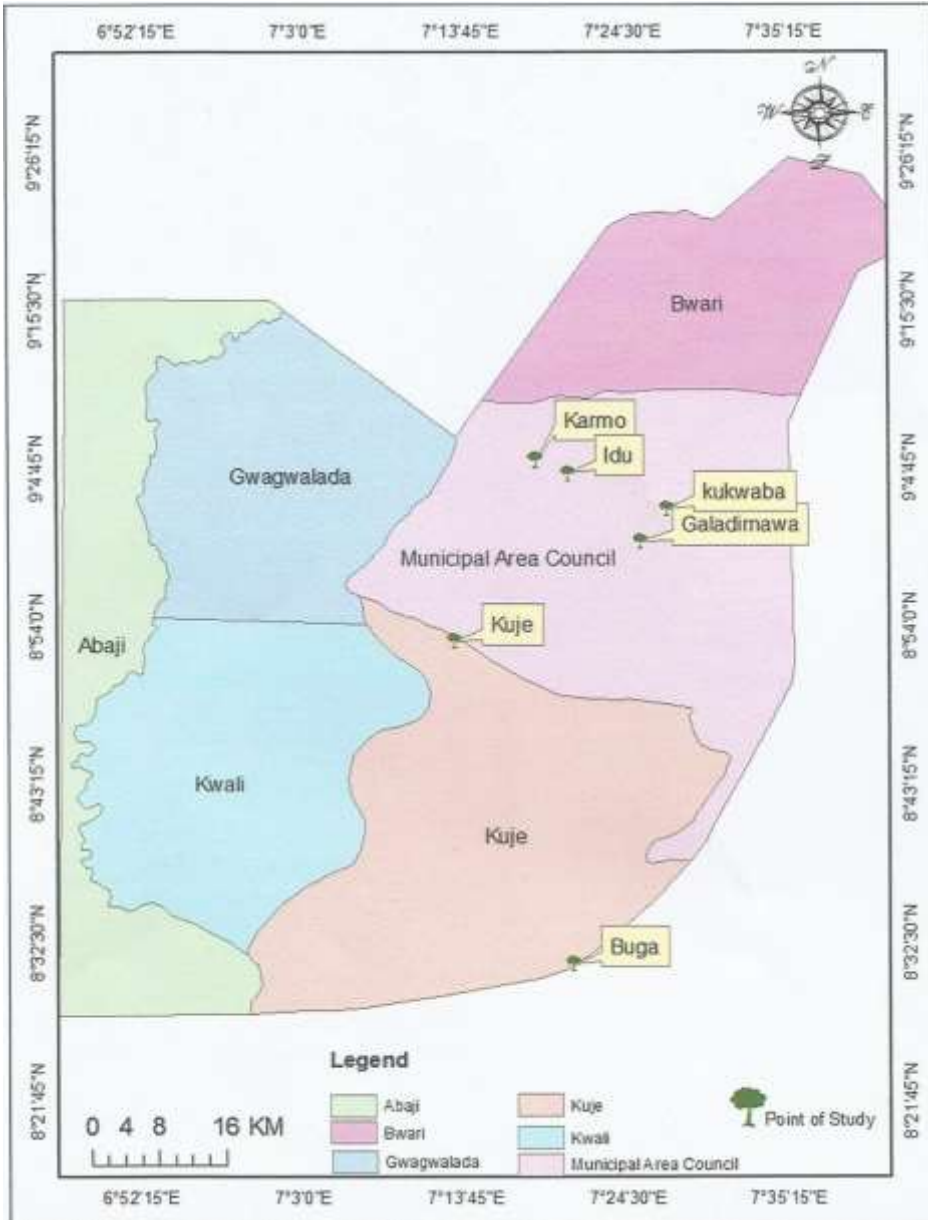


Fig 1. The FCT showing the Area Councils and Communities of study.



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In analyzing the data, two relevant methods were employed; statistical and content analysis. Statistical analysis was employed to analyze deforestation rate in the FCT using the FAO formula. Content analysis was used to analyze all the qualitative data generated from the Key Informant Interview, the Focus Group Discussions and questionnaire. Information include data related to environmental perception, abiding by enforcement policies, and choice of wood fuel for cooking while the FAO formula was applied to calculate deforestation rate.

$$Q = (A_2 / A_1)^{1/(t_2 - t_1)} - 1$$

Where A_2 and A_1 are forest cover at time t_2 (2014) and t_1 (1987) respectively and Q is the rate.

This gave the necessary data for the forests and helped to calculate the rate at which these forests are lost.

The cumulative extent of deforestation [$f(t)$] is simply the cumulative fraction of an area classified as deforested up to a given year.

The deforestation rate, k , is $f_2 - f_1 / t_2 - t_1$

Where f_1 is the cumulative fraction of an area deforested by time 1, and t_1 is the year at time 1. Same goes for f_2 and t_2 . In practice, t_1 and t_2 are often chosen based on the available satellite imageries showing appreciable change. Consistent definition of the rate of deforestation requires unambiguous and preferably automated identification of the beginning and end of clearing (Biggs *et al*, 2008).

The above model is similar to the FAO model that this study has adopted over any other. According to FAO (1995), deforestation rate Q , can be calculated using the formula;

$$Q = (A_2 / A_1)^{1/(t_2 - t_1)} - 1$$

Where A_2 and A_1 are areas covered by forests at time t_2 and t_1 respectively.

According to Fearnside (1993), and Liu *et al* (1993), annual rate of deforestation R is given thus $R = A_1 - A_2 / t_2 - t_1$. This gives basic information since it is the average at which the forest is being cut and expressed in unit area per year.

Fischer (1994) and Zhang *et al* (2003) both agree on a logistic function model. This model is best adapted to describe deforestation time series. $F(t) = F_s / (1 + Ae^{-Bt})$ where $F(t)$ is the cumulative fraction of forest cleared by time t , F_s is the stable deforestation extent, while e is the base of the natural logarithm, A and B are fitted parameters. The challenge with this model is that it assumes that the cleared areas remain in pasture or secondary forest status. Another school of thought applies this formula;

$$DF = \frac{nr\text{Deforested pixels}}{nr\text{Forested pixels} (t_2 - t_1)}$$

where DF = deforestation rate between t_1 and t_2 (year),

t_1 = start time of deforestation rate calculation (year),

t_2 = end time of deforestation rate calculation (year),

$nr\text{DeforestedPixels}$ = total number of pixels that changed from forest in year t_1 to non-forest in year t_2 and for which t_2 is the first image that does not have missing data in-between t_1 and t_2 ,

$nr\text{Forested Pixels}$ = total number of forest pixels in image at t_1 for which t_2 is the first image that does not have missing data since t_1 .

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This model requires further training to be able to apply it. Therefore, its cumbersome nature has disqualified it from being used in the course of this study.

5. Results

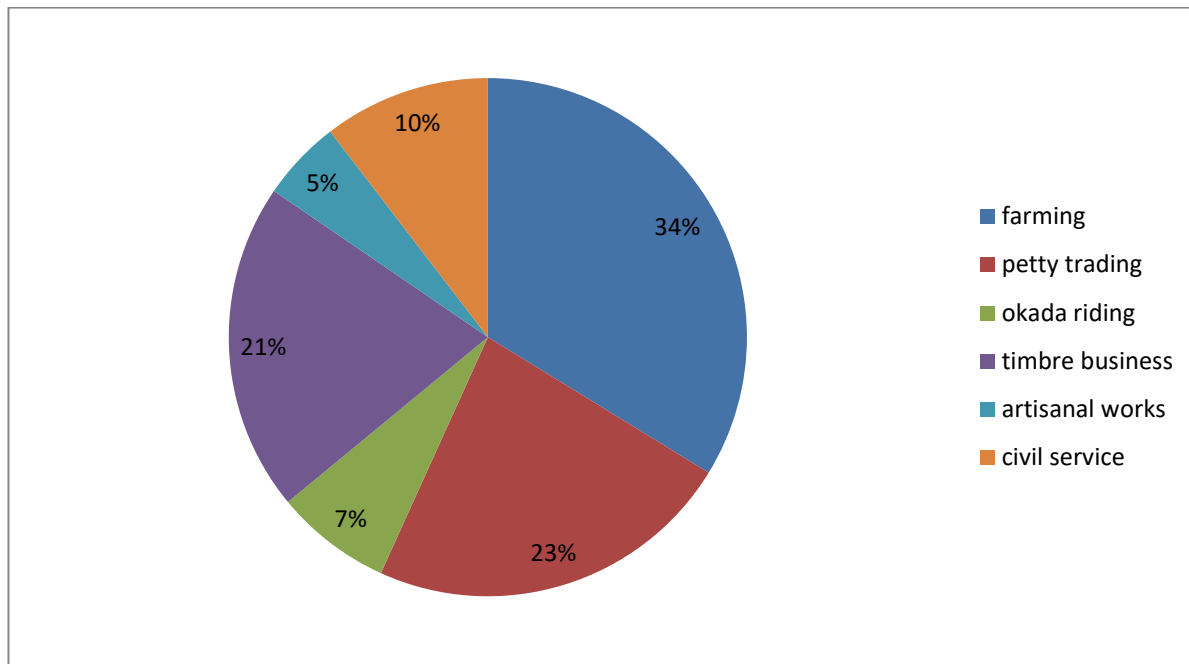


Fig 2: Livelihood activities within the FCT.
Source: Fieldwork, 2015.

From figure 2, it could be inferred that farming (34%) and petty trading (23%) are two activities that are common in the selected communities of the FCT. Farming and timber business are two activities that contribute to deforestation with more than half of the total population of the local residents (55%) engaging in these activities almost on a daily basis. Only the residents of Galadimawa are known not to engage in timber and logging business. They attributed this to the belief that forest provides housing for the community deities and help to regulate the environment. Other communities that engage in the business of logging expressed that they do so without the fear of regulatory authorities since they also partake in sharing the profit. This gives the loggers undue boldness to continue their business which fosters deforestation.

5.1. Agents of deforestation in the FCT

As already stated, agents of deforestation refer to those organisations or defined groups that engage in the act of cutting down trees at a significant rate or level. Six major agents that were identified to be operating within the six communities include the government, furniture makers, farmers, loggers, cattle-rearers and the market association as in the case of Kuje. The main concern



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here is that most of the farmers do not just cut down the trees, they also burn them thereby causing the trees to die to their roots and totally destroying them. As a result, agents of deforestation like furniture makers and loggers try to reach the trees first before the farmers and this creates an unhealthy competition. Yengoh (2008) supports this by saying that deforestation by agents is caused by competition amongst them (*“if I do not cut these trees first for my benefit, another person will for his and so I must cut as many as I can before it is completely cut by others”*). This implies that the trees are cut down without any opportunity to regrow. The furniture makers whose major merchandise are caskets and couches wait impatiently for some of these trees to mature before cutting them down without any plans of replanting. A woman in Kuje claims that the Furniture Makers Association connive with some staff of the FCDA and pay some illegal taxes to them in order to allow them continue the perpetration of this terrible act.

5.2. Substitutes to wood fuel, their availability and affordability in the FCT

Figure 3 reveals five major substitutes to wood fuel from the study. These include charcoal, kerosene, cooking gas, saw dust and electric stove. Both the gatekeepers and the women from the study communities agree that these five alternatives are available at every nook and cranny of their environment. Among these alternatives, only saw dust and charcoal are affordable and readily available since sawyers and carpenters give it away for almost free so as to create space within their shops for operation. The availability of sawdust and charcoal means that a lot of trees are being cut and seasoned almost on a weekly basis. Women in Galadimawa and Kukwaba agreed that their best option is the use of electric or kerosene stoves since they do not have forests again for wood due to massive deforestation by government to pave way for developmental projects.

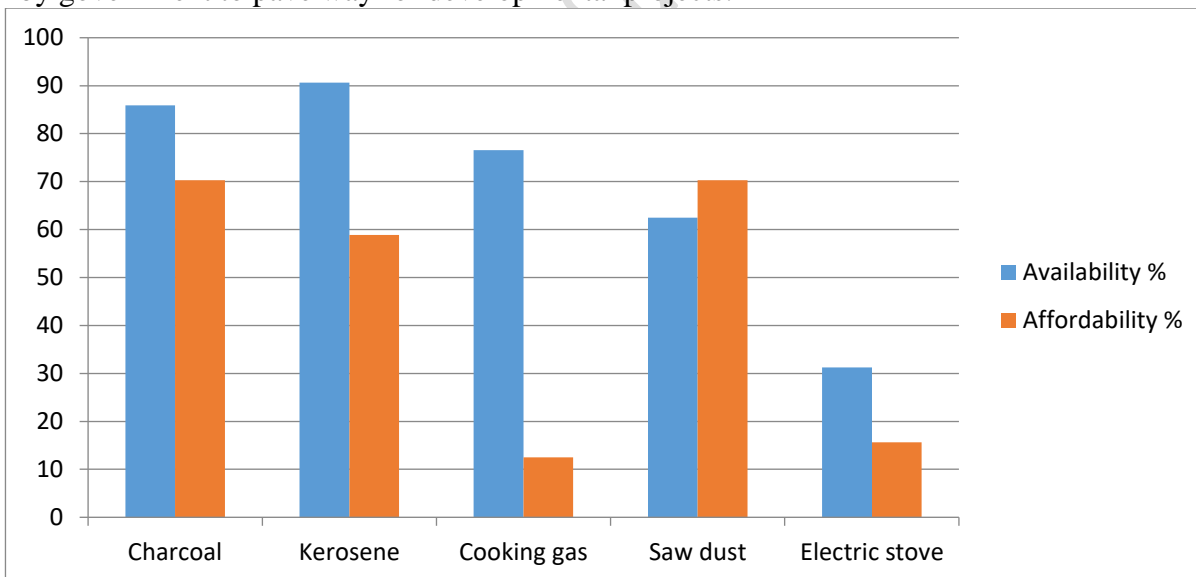


Fig 3: Alternatives to wood fuel, their availability and affordability.
Source: Fieldwork, 2015.



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5.3. Deforestation rate of the FCT

In order to calculate the deforestation rate of the FCT between 1987 and 2014 using the FAO formula, the areas covered by dense vegetation for the two years were calculated using the Normalized Difference Vegetative Index (NDVI). Dense vegetation here is used to substitute for forest cover while sparse vegetation refers to shrubs and trees that are not clustered. The NDVI showed the sizes in hectares of the areas with bare land, sparse vegetation and dense vegetation which was presented by percentage. A non-uniform interval is experienced between 1990 and 1999 because of lack of data. Table 4 presents the NDVI distribution of eight of the years under study.

Table 4: NDVI for FCT.

Year	Bare land		Sparse vegetation		Dense vegetation	
	Hectares	%	Hectares	%	Hectares	%
1987	4477.59	0.61	594821.59	81.11	134058.42	18.28
1990	1688.40	0.23	593861.65	80.97	137807.55	18.79
1999	1810.71	0.25	579365.80	79.00	152181.09	20.75
2002	8001.99	1.09	624345.28	85.14	101010.33	13.77
2005	52247.21	7.12	585020.06	79.77	96090.33	13.10
2008	54253.04	7.40	583270.84	79.53	95833.72	13.06
2011	58053.06	7.92	582132.00	79.38	93172.19	12.70
2014	59141.84	8.06	579414.51	79.00	93081.25	12.69

Source: Fieldwork, 2015.

It is evident from Table 4 that while the area without vegetation is on the increase, the area with dense vegetation has a downward gradient, therefore showing an inverse relationship. It was also established that a sharp decline in dense vegetation cover occurred almost at the same period (around 1999) with the sharp increase in the area without vegetation. This is attributed to the huge developmental projects (construction of estates, roads and university) that took place during that period.

The forest cover for 1987 and 2014 was estimated at 134,058.42ha and 93,081.25ha respectively. Applying the FAO formula:

$$Q = (A_2 / A_1)^{1/(t_2 - t_1)} - 1$$

Q = deforestation rate, A₂ and A₁ represent dense vegetation cover for years 2014 and 1987 respectively, while t₂ and t₁ represent years 2014 and 1987.

Where A₂ = 93081.25, A₁ = 134058.42, t₂ = 1987 and t₁ = 2014.

$$Q = \frac{93081.25}{134058.42} = 0.6943$$

$$Q = (0.6943)^{1/(2014 - 1987)} - 1$$

$$Q = 0.7204 - 1$$

$$Q = 0.279.$$

- Thus the rate of deforestation for the years under study is 0.279%.

Abuja covers 7333.576km² which is equivalent to 733357.6ha. In 1987, the dense vegetation cover was 134058ha, the implication of this based on the deforestation rate as calculated above is that the FCT has lost within the study period a total 374.023ha of its dense vegetation cover. This implies



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that on the average 13.85ha of dense vegetation is lost each year. There are strong health and environmental consequences associated with this loss and this is evident in the potential loss of biodiversity, increase in surface temperature, disruption of biochemical cycling and increase in soil erosion. The resultant effects of this include food insecurity, emissions that contribute to climate change, loss of medicinal trees, increase in the occurrence of diseases such as malaria and loss of original habitat.

5.4. Reasons for deforesting and forest produce use in the FCT

Several reasons were given for cutting down the trees by the residents of the FCT. The women of Galadimawa and Idu communities stated that they cut down trees to pave way for enough sunlight and aeration so as to ensure maximum crop yield from their farming activities. In the same vein, the Idu gatekeepers indicated they clear the forest to obtain available wood fuel and poles for rural electrification. However, In Kuje, the women indicated that they cut down trees to increase visibility thus curtailing armed robbery and rape incidences within and around the forest area. Moreover, removing forest cover also scares wild animals away into the primary forests surrounding them.

The produce from the forest is traditionally used for furniture making, electric poles, herbs for treating ailments, timber for construction, carving of mortar and pestle and for the construction of temporary houses. The bottom line is to generate income and this was corroborated by Yengoh (2008) who attributed deforestation to income sensitive causes. Consequently, it is believed that whatever drives poverty is capable of driving deforestation.

5.5. Opportunity cost of deforestation in the FCT

The opportunity cost of anything is the value of the best option foregone. The best forgone alternative to cutting down these trees and building houses on the forest land, as in the case with Galadimawa and Kukwaba, is to convert the forests into a regulated forest park or even zoo. The forgone values thus are recreational environments, employment opportunities, good health, regulated temperature and availability of animals for consumption. A gatekeeper in Kukwaba noted that there used to be a stream in the heart of the forest that disappeared following deforestation by the government and other agents. He further expressed that the stream had the powers to heal and restore spiritual status and that those ailments suffered by the residents which now prompt them to visit hospitals could have actually been cured simply by drinking from the stream. This borders on ethical and moral values associated with nature.

According to the gatekeeper in Kuje, global warming is also one of the implications of deforestation and so the opportunity cost could be more favourable environment. He claimed that the rate at which trees are disappearing (both natural and government reserves) probably has contributed to the increased temperature being experienced now.

5.6. Methods of deforestation in the FCT

Several methods of deforestation are prevalent in the FCT. The gatekeepers of Galadimawa and Kukwaba reported that deforestation within their villages was massively done by the government using bulldozers and other heavy machines. The residents of Kuje use electric-driven sawing machine to save time. Idu and Karmo residents prefer burning the plants to their roots claiming it is most effective and



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cheap means of deforestation. Bush burning is really one method that cannot be controlled and destroys trees and plantations in large numbers. When trees are burnt to their roots, it does not offer them the opportunity to regenerate and probably regrow. Other methods adopted by the locals who cut one tree at a time for personal use include the use of machetes, axes and other cutting implements.

5.7. Suggested ways to preserve forests by FCT residents

Chief among the suggestions for forest preservation is the enforcement of existing policies on preservation. The Dakachi of Idu blamed the lack of enforcement on the level of corruption by FCDA staff. He claimed that the furniture makers are a powerful group that will go to any length to get what they want. Therefore, the enforcement agents would prefer to take money from them than face turbulent times even in the office. The women of Kuje strongly believe that the only way to do this will be for the government to fence the remaining forest reserve area completely. This will make it criminal for any unauthorised person found doing anything within the forest. This is in consonance with the view of Laurance (1999) who opined that deforestation occurs when institutions are too weak to control it or create an enabling environment for it. He classified this type of cause as “Institutional Sensitive Cause” involving all weak national and international governance as the root cause of deforestation.

The men of Kuje felt that an outright ban on bush burning by punishing culprits will go a long way in preserving the forests. Again, government support and enforcement of regulations is needed to ensure that wood fuel alternatives are readily available and that areas are properly monitored. The women of Galadimawa expressed that they witnessed the strict measures adopted by the forest guards of old in performing their duties and therefore recommended that bringing back armed guards to manage the forests will be the best way to preserve the forests and their resources. Two gatekeepers from Idu and Galadimawa respectively argued that the problem does not lie in deforestation but in the government not enforcing afforestation. Therefore, reforestation programmes will go a long way towards preserving the forests and benefitting the residents of the communities.

Importance of forests to FCT residents.

Table 5. Importance of forests.

Use	No. of respondents	Total no. of respondents	Percentage
Firewood	128	128	100
Timber	128	128	100
Wind breaks	62	128	48.4
Hunting	98	128	76.6
Treatment herbs	86	128	67.2
Fruits	101	128	78.9
Home for shrines	54	128	42.2
Space for business	82	128	64.1
Home for wilds	98	128	76.6
Controls erosion	96	128	75

Source: Fieldwork, 2015.



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Mclendon (2014) in her article titled “21 Reasons why Forests are Important” provided some reasons why forests around humans are important. Some of these reasons include serving as home for over 80% of known animal species, producing enough oxygen for human respiration, temperature regulation as well as reducing flooding and erosion. Others include serving as windbreakers, providing raw materials for medicinal research and refilling aquifers. Against the best practices for forest conservation, residents of the FCT generally believe that a major importance is the provision of wood fuel and timber. Other importance includes serving as a source for medicinal herbs and housing their shrines thus ensuring durable peace and tranquillity to the communities.

6. Summary and Recommendations

This study has done a detailed analysis on the extent of deforestation in the FCT within the study period and the results have shown a very significant rate of deforestation. Only three forest reserves out of eighteen survived deforestation to some extent. The dense vegetation size was reduced from 18.28% in 1987 to 12.69% in 2014. The rate of deforestation using the FAO formula turned out to be 0.279% thus leading to the loss of 374.023ha. This represents a loss of 13.83ha *per annum*. This degree of deforestation has a strong health, developmental and environmental implications on the environment and people living there. The nature of the three Forest Reserves showed that some form of degradation has taken place especially in the case of Kuje Forest which has been taken over by the local market. The implication of this degree of disturbance is that some living organisms would have been lost or displaced from their natural habitats.

Serious cultural undertones are also responsible for deforestation in the FCT. The residents agreed that the two most important causes of deforestation are the need to provide firewood and timber. This is worsened by government policy which does not ensure sufficient provision of alternatives especially for firewood. A vast majority of the respondents (85%) agreed that charcoal is available while some of them (70%) agreed that it is affordable. Virtually all the respondents (90%) submitted that kerosene is available, more than half of the respondents (58%) argue its affordability, while the remaining respondents noted that cooking gas is available but not affordable. Another product that is both available and affordable is saw dust from mills. Out of the three alternatives that are available and affordable, charcoal and saw dust are pointers to the fact that serious deforestation takes place in the FCT.

Sequel to the presentations of results and discussions of findings, many measures can be put in place to properly manage the forests in the FCT, Nigeria. These will, unarguably, lead to a better environment which will become more sustainable and promote the health status of the residents. The following recommendations are hereby made.

1. Efforts should be geared towards the provision of alternative sources of cooking fuel that are both affordable and environmentally sustainable to the local residents.
2. Government should consider the use of forest guards equipped with different best practices' monitoring tools. These guards should be committed and passionate with respect to forest management and should be rid of corrupt tendencies since corruption is considered to be the chief reason why illegal logging and bush burning are tolerated.



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3. Developmental projects should consider forest areas in their design and where it overrides public interest and part of the forest must go; reforestation and/or afforestation programmes should be established to make up for forest depletions.
4. The authorities of the FCT, ministry of environment and other relevant agencies should make concerted efforts to formulate an appropriate preservation policy for the forests of the FCT and ensure its proper implementation.

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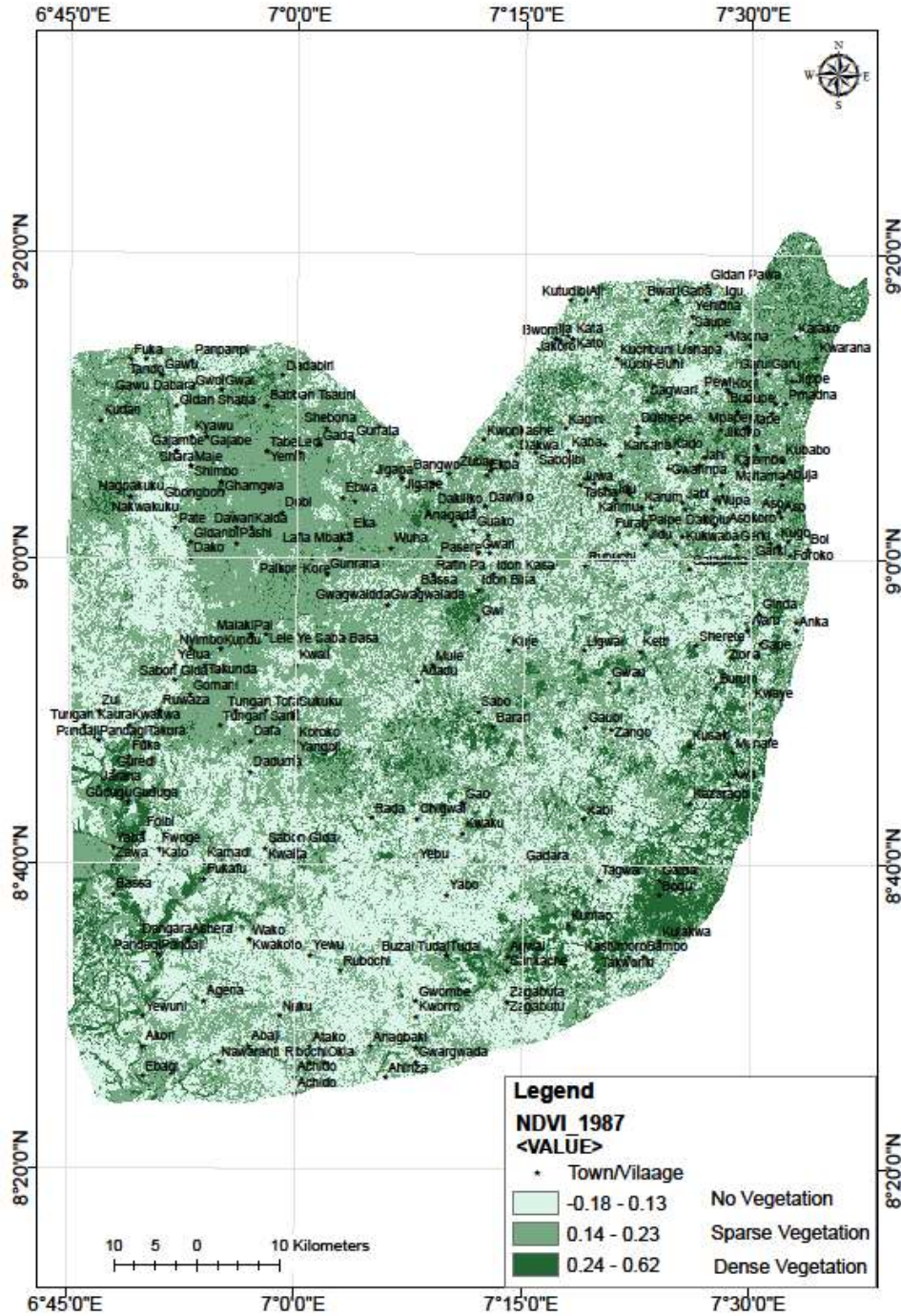
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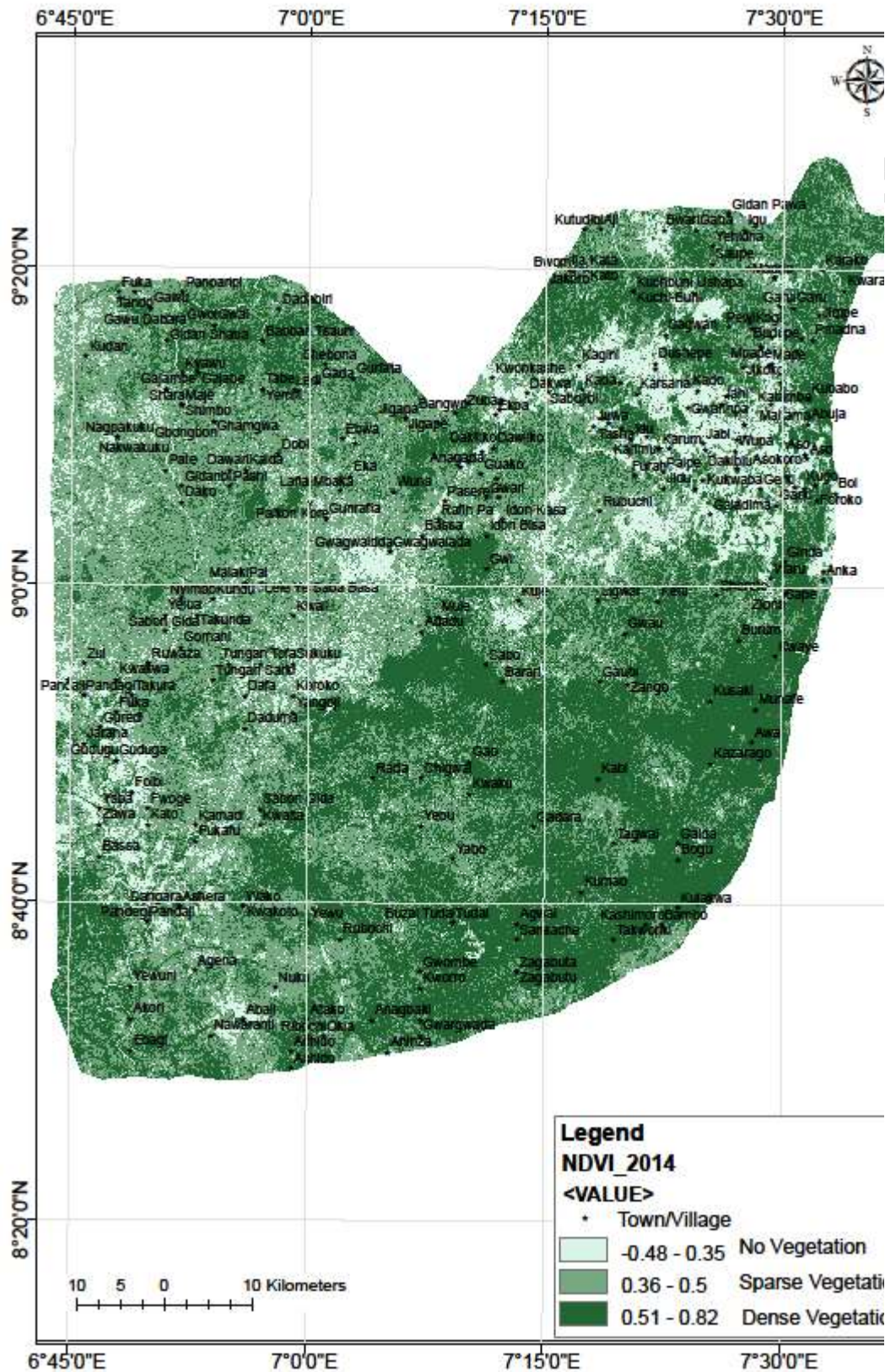
APPENDIX 1. 1987 NDVI Map for the FCT.





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APPENDIX 9. NDVI Map of the FCT for 2014.





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General comments: *(as attachment)*

1. There is a need for the author to correct some typographical errors in the labels of the figure 2. It should read timber business not timbre business

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