Journal for Worldwide Holistic Sustainable Development
ONLINE ISSN: 2409 9384
PRINT ISSN: 2414 3286

2017 VOLUME 3 (ONLINE VERSION)

Recommended Citation: Uzonu, I, Dogo B. (2017) "Analysis of Deforestation and Malaria Prevalence in the Federal Capital Territory, Nigeria" JWHSD, 3, 10-34. Available at: http://wwhsdc.org/jwhsd/articles/.

ANALYSIS OF DEFORESTATION AND MALARIA PREVALENCE IN THE FEDERAL CAPITAL TERRITORY, NIGERIA

Uzonu Ikenna [1] and Bala Dogo[2]

1. Department of Geography, Faculty of Arts and Social Sciences, Nigerian Defence Academy, Kaduna.
2. Post Graduate Department, Kaduna State University, Kaduna.

*Corresponding author: ijkuzonu@gmail.com; +2348077621966

Abstract

Analysis of deforestation and malaria prevalence in the Federal Capital Territory was carried out with the aim of establishing whether or not a relationship exists between deforestation and malaria prevalence using satellite imageries and data from the National Malaria Elimination Programme for 1987, 1990, 1999, 2002, 2005, 2008, 2011 and 2014. The imageries were subjected to Normalised Difference Vegetation Index (NDVI) to calculate dense vegetation sizes for the years under study. Pearson's Product Moment Correlation was used to establish whether or not there exists a relationship between deforestation and malaria prevalence using the NDVI data and malaria prevalence rates as correlates. Results show that the reported cases of malaria rose from 160 in 1987 to 1,920 in 2014, while the prevalence rose from 3.5% to 4.1% for same years, thus a 30.58% decrease in dense vegetation coincided with a 17.14% increase in malaria prevalence. The correlation analysis showed that there is no significant relationship between deforestation and malaria prevalence. This may be due to some environmental and physical factors like the soil type and terrain. The study concluded therefore that the insignificant relationship between the two is as a result of population increase.

Keywords: Deforestation, malaria, NDVI, population.

1. Introduction

Nigeria is well endowed with forest resources accounting for about 2.5% of the GDP. These resources provide employment and help maintain the health status of the populace. A major challenge therefore being faced by the country now is that of deforestation (Olufemi and Ameh, 1999).

Deforestation is one of the most potent factors at work in emerging and re-emerging communicable diseases (Singer and De Castro, 2001). Wilson (1995) clarifies our understanding that the control of diseases would be inadequate without the ecological perspective on the life cycles of parasitic microorganisms and the associated infectious diseases. One of these diseases with new causes of infection is malaria and its presence may be as a result of attack by invasion on the host vectors natural habitat.

Environmental change is expected to affect profoundly the transmission of the parasites that cause malaria (Keiser et al, 2005). Keiser continued to claim that several environmental factors are known to affect the transmission of the parasites that cause malaria. One of such is deforestation, and is of particular concern because of its scale and ubiquity in tropical areas especially Nigeria. Amongst the anthropogenic drivers of environmental change is deforestation and it is possibly the most noticeable and most fingered cause of increase in malaria (Hay et al, 2004). Deforestation destroys natural boundaries that protect humans against exposure to certain diseases and it can also create new ecological niches favouring the multiplying of vectors (MacCormack, 1994). Vectors here refer to organisms that carry disease-causing micro-organisms from one host to the other.

This means therefore that deforestation possibly increases the survival rate of anopheles species that carry plasmodium— the causative organism for malaria— by exposing them to warmer temperatures that speed up larval metamorphosis. Some of the health issues influenced by the presence of forests include dietary health and nutrition security, infectious disease security, medical science and medicinal resources, social and psychological health (Keesing, 1997). This means therefore that the absence of forests can reduce health, nutrition and infectious disease security.

Around the world, vector populations in terrestrial system are on the decline as a result of significant human activities on forests leading to habitat destruction and relocation, over-utilization and pollution. This decrease in vector population is profoundly significant and represents a major public health threat to humans as they interact with their environment. This is because most of these vectors under threat try to adjust by migrating to a more favourable environment, and usually, closer to humans.

2. Review of Literature

The population growth in sub-Saharan Africa is unprecedentedly on the increase. This has led to an uncontrolled and unsustainable exploitation of natural resources, especially forest resources (Uneke, 2008). Uneke claimed that deforestation is a process that cannot be readily controlled for a variety of political and economic reasons, and that future consequences as a result of this process may be crucial with respect to malaria epidemics. He argued in this study that malaria started infecting humans in Africa when there became a shift from hunter-gatherers to farmers causing a dramatic change in environmental and behavioural practices. This is supported by Yasuoka and Levins, (2007), when they opined that deforestation and land transformation influence the malaria vector – anopheles, especially larval survivorship, adult survivorship, reproduction and vectorial capacity. This they claim is possible through changing environmental and microclimatic conditions such as sunlight, temperature, humidity, water condition, soil condition and vegetation.

Uneke (2008), showcased six points, basically:

1. Deforestation changes the ecology of disease vector and its options for hosts.
2. Deforestation can change local climate and thereby affect the spread of disease by reducing moisture and raising ground temperatures.
3. Deforestation is often the beginning of a variety of land use changes.
4. Deforestation is accompanied by migration that may enhance the spread of malaria.
5. Deforestation has so many putative climate impacts via the role of trees in the carbon cycle and regional weather patterns.
6. Ecosystem change such as deforestation can play a role in antimalaria resistance that has become a major concern for several plasmodium species.

Uneke therefore concluded that deforestation is an integral part of life of forest communities in rural sub-Saharan African countries and that malaria has a strong correlation with forest management.

Brant *et al*, (2012), also believe that land use changes modify temperature and relative humidity which in turn affect the survival density and distribution of mosquitoes. In this crucial study, Brant et al, in the hinterlands of Sabah, Malaysia, looked at the effects of land use practices on mosquito abundance, composition and biting times. Three sites were chosen for the study: old growth forest, logged forest and oil palm plantation. They employed human landing catches from 5pm to 11pm. Ninety-two collections were made in the three sites using red torch lights to seek out mosquitoes. The result showed that the biting time per night of logged forest doubled that of the old growth forest and oil palm plantation put together.

Disease emergence and persistence are inherently geographic phenomena (Melinda *et al*, 2010). Melinda *et al* used the principles of Disease Ecology and the Health Belief Model to examine perceptions of mosquito-borne disease and preventive action in the study area. The study identified that the emergence of vector-borne diseases represents a complex interplay among pathogens, hosts, and their environments. This they said is an inherently geographic concern. They used the Disease Ecology Framework because of its appropriateness for the study of disease emergence and persistence. This framework addresses the ways in which human populations, physical and built environments, and human behaviour interact either to prevent or produce disease (Hay, 2000). Manga *et al*, (1995), agree that this framework illustrates the potential for geography to unite the physical and social worlds. This study however focused particularly on the population characteristics and human behaviour of disease ecology, and dwelt very little on the role of deforestation.

One of the very first conclusive studies carried out shows the association between human biting and the degree of deforestation, by Vittor *et al*, (2006), claimed that the recent comeback of malaria in the Peruvian Amazon was caused by deforestation. This study showed that the risk of being bitten by the primary malaria-carrying mosquito is nearly 300 times higher in cleared areas than undisturbed areas. The study further revealed that clearing forests for cropland has created more breeding sites for Anopheles species which prefer to lay eggs in waters surrounded by short vegetation. This study became conclusive when it found out that increase in human population has no effect on Anopheles biting rates. This is because as human population is increasing, so also is the vector population, thus giving rise to a stable prevalence.

Also in the same line of study before the study by Vittor, *et al*, Pichainarong and Chaveepojnkamjorn, (2004), had established a strong correlation between forest destruction and the incidence of the mosquito Anopheles *darlingi* in the Amazon. They chose the Amazon because of the rapid increase in malaria incidence there in the early 1990s. In their very own words, “we saw a major upsurge in the incidence of the disease that coincided with an extensive push in human settlement. It was critical to ask why”.

Their study identified 56 sites along a recently constructed road in Peru. Lines were then established and nets used to sample for mosquito larvae in streams and ponds along each line. The fieldwork took about 12 months during which 5,524 water samples from 1,224 streams and ponds were taken and 24,000 mosquitoes identified. Of those that carry malaria, a greater number were found in more heavily deforested landscapes. They also found out that in 17% of ponds and streams where deforestation was heavy, malaria vector was found, in 10% of water bodies where deforestation was light and in 2% water surrounded by intact forest. They therefore concluded that the unintended consequence of deforestation in the Amazon, unfortunately, is the increase in abundance of the main malaria-carrying mosquito in the region.

Scientific literature makes it abundantly clear that the association of deforestation and malaria disease is not mere coincidence. In line with this, Pattanayak *et al*, (2006), described the malaria burden including its etiologic roots and social toll. It considered activities especially that of forest degradation by the local people who are poor to be responsible for the increasing malaria incidence. According to Wilson et al (1994), an ecological perspective on the life cycles of parasitic micro-organisms and their associated infectious disease is critical to understanding and controlling the disease. Wilson, (2001), pointed out that infectious diseases are part of a larger human ecology in which human social systems, economic activities, interactions with the environment, and lifestyles represent some of the key domains of interaction that affect infection and disease risk. Pattanayak *et al* concluded therefore that malaria and deforestation are central elements to the poverty cycle in the rural areas of many developing countries. Simply put, malaria causes deforestation. This is because malaria makes people poorer and poverty leads to deforestation under some conditions.

Sawyer, (1993), argued that high rate of malaria which leads to poverty, encourages men to work as day labourers (in logging and ranching), rather than establish family farms. This study made use of the "Decision-Analyses Framework" as the key framework. This framework identifies outcome of interest which includes health indicators, wealth and environmental quality. The variables used include: extent of forest cover and forest conditions.

Continued development in developing countries in the form of agriculture, road construction, logging amongst others, have resulted in an increasing level of deforestation (Gainey, 2014). Gainey continued that if a positive correlation between deforestation and malaria transmission is confirmed, then the negative implications for residents of deforested areas could be significant. Gainey claimed he started monitoring deforestation in the Amazon since 1988, and that it has been progressing at a steady rate, now accounting for almost 24% of the overall global greenhouse gas emissions and other health issues. To support this, Olsen *et al,* (2010) in their study concluded that a 4.3% increase in the percentage of deforestation from august 1997 – august 2000 was associated with a 48% increase in malaria incidence with the population steady within the area they studied.

Gainey showed that there are three main consequences of deforestation that help increase the chances of malaria transmission;

A. removal of competition,

B. removal of dead end host and,

C. creation of new suitable habitats.

Disturbing the forests compromises the ability of non-vector species to thrive. Therefore, removing a main competitor of anopheles *darlingi* from the ecosystem allows for their population to cover more grounds (Yasuoka *et al,* 2006b). Forests serve as habitat to many warm-blooded hosts of malaria; disturbing the forests therefore can result in the migration of such species away from human interference, thus removing a source of prey for mosquitoes, leaving them with no alternative than human beings in the neighbourhood. Removing the forests' canopy increases the sun quantity on water bodies available for the habitation by the vector carrying mosquitoes (Hahu *et al*, 2014).

Gainer concluded that malaria transmission is a widespread problem in the Amazon and Tropics in general and it is a public health issue that requires attention. He continued to say that the transformations of ecosystems in the interim between high-impact selective logging and ecosystem recovery may replicate the ecological transitions that support mosquito breeding that are generally associated with malaria.

Guerra *et al*, in (2006) carried out a study in South-East Asia. In doing this, they first defined forest according to Anon, (2001b), as land with a tree canopy cover of more than 10%, and an area of more than 0.5ha, including natural forests and forest populations, but excluding trees specifically established for agricultural purposes. Anon further subdivided natural forests into closed (>40% canopy cover) and open (>10 – 40% canopy cover).

Guerra *et al* used geographic Information System (GIS) and maps of forest cover to determine the areas of forest cover within the spatial limits of malaria transmission. As a result, they then derived the estimate "Population at Risk of Malaria" (PARM) in these areas. These methods gave credit to the research. These GIS platforms allowed for the study and quantification of spatial associations between forest cover and malaria patterns within human settlements. The maps used in the study were generated using existing information retrieved from health guidelines. However, the study excluded highlands altitudinal limits of malaria and areas with human population densities of less than one person/km^2. This is because the human vector contact in such areas would be so low to interrupt transmission.

The study identified areas of closed forest that are prone to malaria infection by overlaying the malaria distribution map on the Food and Agriculture Organisation (FAO) delimitations of closed forests. An equal area projection and GIS software (Arcview 3.2; ESRI, Redlands, CA), were used to evaluate the areas in km2 and the number of individuals living in such forests.

The result from this research showed that in South-East Asia and western pacific, high population densities in or near areas of malaria closed forests (these are closed forests within areas of malaria risk) expose large numbers of people to malaria parasites transmitted by highly efficient forest vectors. It is noteworthy that some vectors carry more plasmodium and also transmit same faster. It is known that the prevalence of such vectors has historically represented an issue for the control of malaria and challenged environmental management approaches, such as deforestation. (Mouchet and Brengues, 1990; Arbani, 1993).

They concluded that the relationship between forests and malaria transmission is important, and a deep understanding of it will guide strategies designed to reduce the burden of malaria in endemic forested areas.

3. Methodology

This study utilized data obtained from different establishments using such tools as questionnaire, Focus Group Discussion (FGD), Key Informant Interview (KII), satellite images and observation from the field. Some of these establishments include Health Centres, Department of Forestry of the Federal Capital Development Authority (FCDA), Abuja Geographic Information System (AGIS), National Malaria Elimination Programme (NMEP), United States Geological Survey (USGS, GLOVIS Viewer) and Google Earth. Primary sources include the gatekeepers and women in the selected communities.

The questionnaire helped obtain information on the socio-demographic characterization of respondents, health seeking behaviours and the malaria prevalence/incidence rates. The structured questionnaire was administered to Health Facilities. The Key Informant Interview (KII) was administered to 21 key players in each of the study communities chosen and this method helped get latent information from these players. Focus Group Discussions (FGD) were administered to women of childbearing age. This group was chosen because women in Nigeria are at the center of malaria issues. They take care of themselves, the children and the men when infected. FGDs were administered under encouraging atmosphere in all the areas selected and comprised of between five to ten women per group.

The National Population Commission (NPC) provided the population figures of Federal Capital Territory (FCT) and all the Area Councils that were selected for the study. As usual, a formula was given to be able to calculate future population figures and even previous ones since the population growth of the FCT is fixed at 9% per annum. The supplied data on population of Area Councils where the study took place helped with the calculation of malaria prevalence rates especially for the years before 2001 where the NMEP does not have adequate data.

All the maps that have to do with vegetation, the Normalised 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.

3.1.Sampling

This research covered the FCT, but 6 settlements (Kuje, Kukwaba, Galadimawa, Idu, Karmo and Buga) were selected to gather qualitative information.

Attention was also given to primary forests. As a result the satellite imageries provided information on the sizes of both primary forests and forest reserves. People that participated both in the KII and FGD were selected through a systematic exercise where the names of people from the 6 communities were listed alphabetically and names against even numbers were selected for the FGD. The three people that were interviewed through the KII for each community were chosen through a purposive sampling.

3.2.Methods of data analyses

In analysing the data, two relevant methods were employed: statistical and content analysis. Statistical analysis was employed to analyse the degree of relationship between deforestation and malaria prevalence using the Pearson correlation while content analysis was used to analyse all the qualitative data generated from the Key Informant Interview, the Focus Group Discussions and questionnaire.

The malaria prevalence level was correlated against the calculated periodic forest sizes respectively for the years under study. The help of softwares like Statistical Package for Social Sciences (SPSS), and Microsoft Excel were employed for plotting of graph and some other cartographic analyses. The imageries showing vegetation cover was taken after every three- year-interval; a gap however was noticed from 1991 to 1998 as a result of no data from the United States Geological Survey (USGS).

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ONLINE ISSN: 2409 9384
PRINT ISSN: 2414 3286
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The Pearson Product Moment Correlation was used to analyse the strength or degree of relationship between deforestation and malaria prevalence. The result here answered to the number 4 objective. The Pearson Correlation was calculated using the following formula:

$$r = \frac{n\sum xy - \sum x \sum y}{\sqrt{(n\sum x^2 - (\sum x)^2)(n\sum y^2 - (\sum y)^2)}}$$

Where r is Pearson Correlation, x = forest cover data, y = malaria prevalence data and y = the number of outcomes.

4. Results and Presentations

Community livelihood activities in the FCT

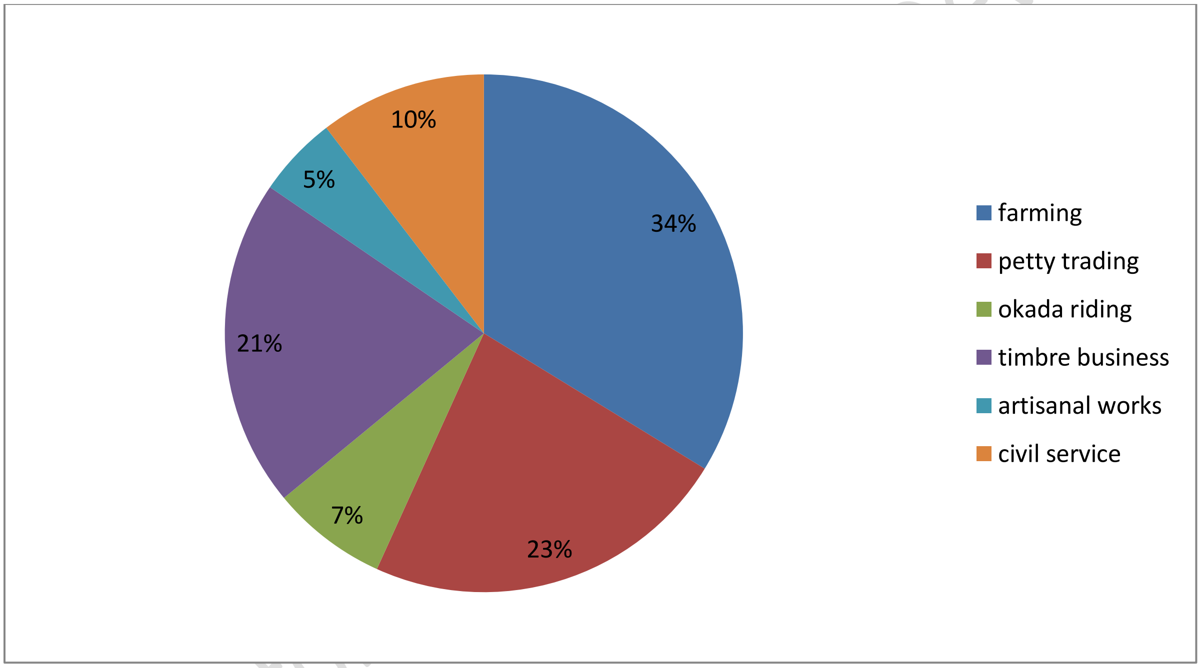

Figure 1: Livelihood activities.
Source: Fieldwork, 2015.

Two activities from Fig. 1 common to all the communities are farming and petty trading. Farming and timbre business are two activities that contribute to deforestation according to literature and these are what 55% of the residents engage in almost on a daily basis. Only the residents of Galadimawa are known not to engage in timbre and logging business since they believe forests house the community deities and help to regulate the temperature. The other communities that engage in the business of logging claim strongly they do so without the fear of regulatory authorities since they also partake in sharing the profit. This has given the loggers room to continue with the business of deforestation.

4.1.Agents of deforestation in the FCT

Agents of deforestation are those bodies or defined groups that engage in deforestation at a significant rate. Six major agents were identified to be operating within the FCT. These are the government, furniture makers, farmers, loggers, cattle rearers and the market association as in the case of Kuje. The worrisome thing here is that majority of the farmers do not just cut trees but set the desired area on fire thus burning the trees therein to their roots and totally destroying them. As a result, agents 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"*).

4.2.Health, spiritual, psychological and physical implication of deforestation on residents of the FCT

The health, spiritual, psychological and physical implication of deforestation on the residents cannot be overemphasized. The residents believe that there are implications, some without clear reasons, and some with. Some of the implications mentioned include increase in temperature. The residents of Galadimawa, Kukwaba, Kuje and Buga agree that the forests were regulating temperature by providing shades and serving as wind breaks, however since the forests have been tampered with, noticeable temperature increase has been noticed. Others believe that proliferation of ailments is on the increase based on the fact that the local herbs that were readily accessible from the forests are no more, thus making treatment more difficult and subjecting them to orthodox treatment which is costly.

The women of Idu, Buga and Galadimawa lamentably agree that deforestation sent some wild spirits that were trapped within the forests on rampage. These spirits therefore unleashed a lot of sicknesses on them which includes epilepsy, diarrhea and malaria fever. The Idu women said that reciting the Koran or offering sacrifices to the spirits gives temporal relief.

In Kuje, the women affirmed that a significant increase in the breeding rate of mosquitoes has been noticed since the market union invaded the forest to set up the daily market because of the degree of canopy that provides shade. This invasion created room for forest fragmentation causing enough sunlight to get to the ground. The market presence also generates refuse which accommodates and promotes mosquito egg production at the slightest concentration of moisture.

4.3.Relationship between deforestation and malaria infection in the FCT

Many of the residents of FCT do not really know if there exists any relationship between deforestation and malaria. Some of the respondents believe against known literature that deforestation reduces the rate of malaria infection as it brings about a total destruction of their natural habitat. Ironically, the women of Idu strongly believe that deforestation increases malaria infection. Their opinion was that the number of reported cases by people from neighbouring communities who live in deforested environments are more than theirs.

4.4.Reasons for increase in malaria infection in the FCT

Several reasons can be attributed to malaria infection increase according to scholarly studies. Some of the reasons identified in the FCT include clogged drains, increase in population, inconsistent rainfall (heavy and consistent rainfall flushes or even totally destroys the breeding chain of anopheles mosquitoes by flushing the eggs and larva), improper garbage disposal and generally unhygienic surroundings. Some of these reasons in addition to deforestation create enabling environments for anopheles breeding. A respondent attributed this increase to incomplete treatment or, in other words, drug abuse. Abusing malaria drugs causes the causative organism to be resistance to drugs thus prolonging the stay of plasmodium in the human system.

4.5.Methods of prevention against malaria in the FCT

The National Malaria Elimination Programme was established to stamp out malaria or reduce the infection to the barest minimum. Consequently, a lot of work on prevention in collaboration with some other agencies and organisations has been carried out. To this end, insecticide treated mosquito nets were distributed freely to all antenatal women and households. For so many that do not like using the nets, they shift their option to insecticide spray or mosquito coil.

The respondents from the six study sites agreed on different prevention methods, and common amongst all the methods is clean environment. They believe that keeping the environment clean and maintaining proper personal hygiene are prime and, by so doing, there won't be any comfortable breeding space for the mosquitoes and thus no need for any other preventive method. On ground however, they use nets but claim they do so only on cold nights because the nets generate heat except when there is power to make use of the fans. The Dakachi of Galadimawa (the Village Head) further asserted that people who are well off use insecticide spray and or repellents. However from field observation, window nets were seen on some windows. Most of them torn without any hope of changing or mending them soon. The danger of having a torn net is that it allows and traps mosquitoes inside the houses.

Winckler (2013) came out with best practices that will help prevent malaria infection. These include staying in well screened areas at night, use of insecticide treated mosquito nets, use of repellents, putting on of long sleeve shirts and long pants. Others are the use of antimalaria drugs and putting on air conditioners at night as mosquitoes dread very cool environments.

4.6.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 claim they cut down trees to pave way for farming as to encourage enough sunlight and aeration for maximum crop yield. The Idu Gatekeepers went ahead to share that they deforest to make available wood fuel and poles for rural electrification. In Kuje however, the women said they cut down trees to increase visibility thus curtailing armed robbery and rape incidences within and around the forest area and also to scare wild animals away into the primary forests surrounding them.

The produce from the forest is used for furniture making, electric poles, and herbs for treating ailments traditionally, timber for construction, carving of mortar and pestle, and for the construction of temporary houses. The bottom line in all of these is to generate income. Yengoh (2008) attributed deforestation to income sensitive causes. Consequently it is believed that whatever drives poverty also drives deforestation. This line of thought strongly holds that poor people depend on and use more environmental resources than the rich.

4.7.Methods of deforestation in the FCT

The gatekeepers of Galadimawa and Kukwaba said that the level deforestation that took place within their villages was done by the government using bulldozers and other heavy machines. To this effect therefore large expanse of vegetation was removed within a short period. Kuje residents said they 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 cheap. 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 bud and probably regrow. Other methods used by locals who cut one tree at a time for personal use include the use of machetes, axe and other cutting implements. Of all these methods, the use of machines often encourage deforesting beyond the expected limit or boundary.

Malaria prevalence rates in the FCT

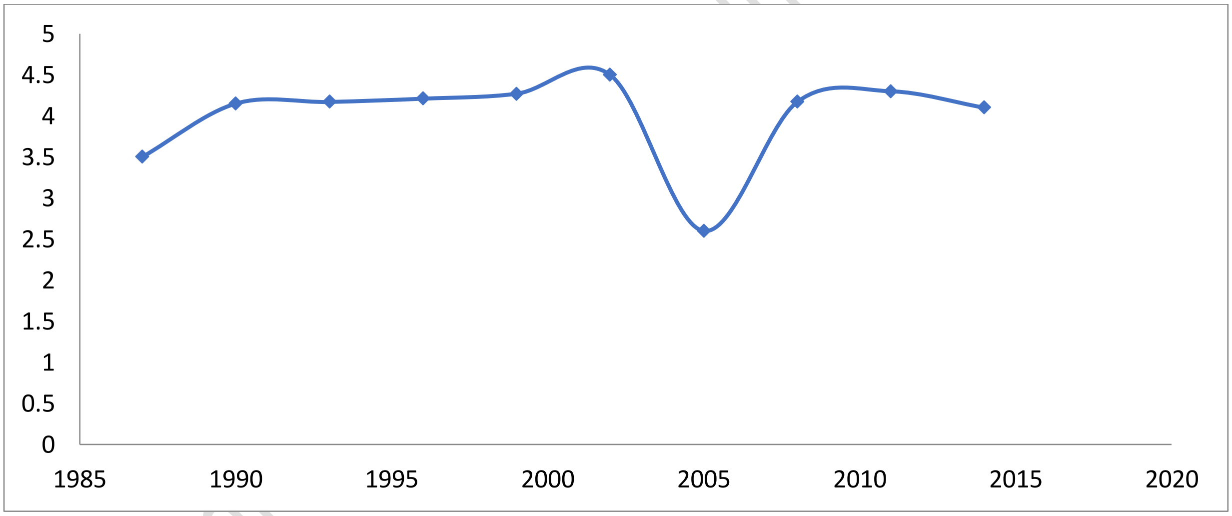

Fig 2: Malaria prevalence rates.
X axis = year and Y axis = rate.
Source: Fieldwork, 2015.

The malaria prevalence rates of the FCT follow an oscillatory pattern. From 1987, an increase in prevalence is observed making its peak in 2002 with 4.5% prevalence, NMCP (2014). Thereafter a decline was initiated till 2005 and the pattern continues. This however is not true with the number of reported cases of malaria. The number of reported cases kept on increasing except in 2005 where there was a slight decrease. This increase is chiefly attributable to population increase of both man and anopheles mosquitoes. For the reported cases to be on the increase while the prevalence fluctuates means that the reported cases per 1000 persons across the years is also fluctuating. This therefore means that the increase in the reported cases does not mean necessarily an increase in prevalence.

Diagnosis of malaria in the FCT

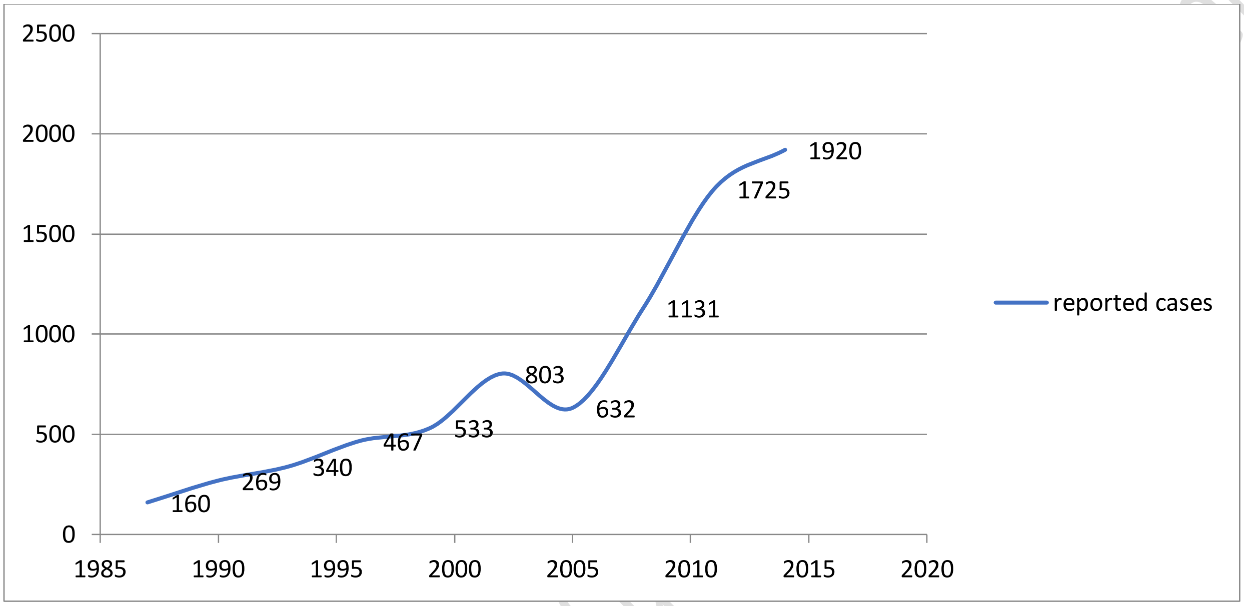

Fig 3: Weekly diagnosis of malaria infection.
Y axis = number of cases and X axis = years
Source: Medical Centres in the FCT, 2015.

The graph in the figure above is quite different from that in Fig 2. This further buttresses the fact that reported cases have no direct relationship with prevalence because of population increase. Four of the 6 communities (Idu, Karmo, Kuje, and Buga) have average diagnosed cases of 11 – 20/week. It has to be noted that these are the cases that were reported to the Health Facilities. As has been observed, some other schools of thought engage in drug abuse through self-medication by going to pharmacy shops and herbalists for treatment even without a routine test to ascertain the true sickness. Communities that have forests diagnose less malaria cases than deforested ones except for Buga probably because the natural vegetation which was deforested has been allowed to re-grow. Kukwaba and Galadimawa have the highest diagnosis of more than 30/ week. This is attributed to the total deforestation that occurred over time there, population increase and dirty environmental habits.

The sharp increase in reported cases from 632 in 2005 to 1920 in 2014 could be attributed to the population increase and secondly the total deforestation that occurred in major communities to pave way for housing estates intended to take care of the increasing population.

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ONLINE ISSN: 2409 9384
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4.8.Correlation of deforestation and malaria prevalence in the FCT

Table 1: Malaria prevalence and dense vegetation size.

[redacted]								
Forest size %	18.28	18.79	20.75	13.77	13.10	13.06	12.70	12.69
Malaria prevalence	3.5	4.15	4.27	4.5	2.6	4.17	4.3	4.1

Source: Fieldwork, 2015.

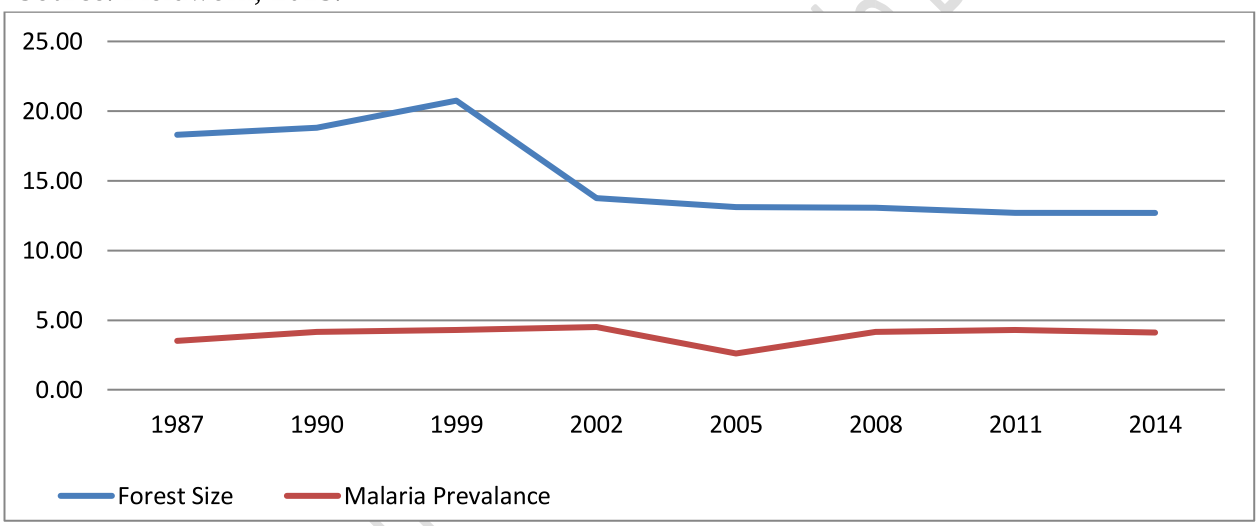

Fig 4: Malaria prevalence and area covered by dense vegetation.

Y axis = rate, X axis = years.

Source: Fieldwork, 2015.

From Fig 4, it is seemingly clear that there may not be a clear relationship between malaria prevalence and forest size in the FCT within the study period. This however will be put to statistical test using the Pearson Product Moment Correlation to x-ray the degree of relationship.

$$r = \frac{n\sum xy - \sum x \sum y}{\sqrt{(n\sum x^2 - (\sum x)^2)(n\sum y^2 - (\sum y)^2)}}$$

Where n = number of outcomes, x = area covered by forest, y = malaria prevalence.

Table 2: Correlation table.

Forest size (*x*)	**Malaria prevalence (*y*)**	***X***^{2}	***Y***^{2}	***xy***
18.28	3.5	334.16	12.25	63.98
18.79	4.15	353.06	17.22	77.98
20.75	4.27	430.56	18.23	88.6
13.77	4.5	189.61	20.25	61.97
13.1	2.6	171.61	6.76	34.06
13.06	4.17	170.56	17.39	54.46
12.7	4.3	161.29	18.49	54.61
12.69	4.1	161.04	16.81	487.69
123.14	**31.59**	**1971.89**	**127.4**	**487.69**

Source: NMCP, 2014 and USGS, 2015.

$\sum x = 123.14$, $\sum y = 31.59$, $\sum x^2 = 1971.89$, $\sum y^2 = 127.4$, $\sum xy = 487.69$, n = 8.

$$r = \frac{((8)(487.69)) - (123.14 - 31.59)}{\sqrt{((8)(1971.89) - (123.14)^2)((8)(127.4) - (31.59)^2)}}$$

$$= \frac{11.53}{\sqrt{13{,}010}}$$

$$= 0.10105$$

Applying t – test

$$t = r\sqrt{\frac{n-2}{1-r^2}}$$

$$= .01015 \times 2.4621$$

$$= 0.2488$$

Degree of freedom = N-2 = 6

6 @ 5% = 0.707 Thus a null result is accepted.

Deforestation in the FCT therefore has no significant relationship with malaria prevalence. This is against what we know from the literature, especially those focusing on the Amazons. This means probably that there are other factors that trigger this high prevalence thus creating a gap for future studies. Beyond the identified factors leading to malaria increase in the study area like clogged drains, population increase, inconsistent rainfall, poor waste management and dirty surroundings, a major reason could again be the nature of soil and the topography of the study area. Most of the soils found within the study area have capillary qualities and are able to absorb as much moisture as possible. The topography again is highly undulating and encourages runoffs as soon as the rains stop. This therefore does not encourage formation of puddles for *Anopheles* egg production. It is also possible that thickness of the vegetation in the FCT characterised by canopy covers may not be as thick as those found in the Amazon which probably led to the non-significant relationship.

According to Dejenie, Yohannes and Assmelash (2011), small water bodies such as ponds, hoof prints of cattle and irrigation channels host most of the mosquito larvae especially water with sandy bottom. The larvae occur in a wide range of habitats but most species prefer clean, unpolluted water. Larvae of *Anopheles* mosquitoes have been found in grassy ditches, the edges of streams and rivers, and small, temporary rain pools. Many species prefer habitats with vegetation. Others prefer habitats that have none. Some breed in open, sun-lit pools while others are found only in shaded breeding sites in forests. A few species breed in tree holes or the leaf axils of some plants.

5. Conclusion

Findings from this study show that occupations of residents in the study area like farming, logging and trading pose the greatest threat to devegetation. Of the six agents of devegetation identified, these occupations fit into the three slots of furniture making, farming and illegal logging. Illegal logging is the most direct danger to the FCT's remaining Forest Reserves. There is clear indication that illegal and corrupt forestry activities have a series of negative and habitually interlinked, environmental, economic and social impacts (Callister, 1999). Such activities almost certainly weaken attempts to sustainably manage forests, even though the current government lacks the sincerity and ability to secure FCT's remaining Forest Reserves. All these put together have contributed to the significant rate of deforestation within the Study Area.

Serious cultural undertones are also responsible for devegetation in the FCT. The residents agree that the two most important reasons of forests are to provide firewood and timber. This is further given a boost since the government cannot provide sufficient alternatives for firewood like kerosene and cooking gas. It was noted through observation that majority of the residents agree that charcoal is both available and affordable unlike kerosene that is available but not affordable, likewise cooking gas. Another that is both available and affordable is saw- dust from mills. Of the three that are available and affordable, charcoal and saw dust are pointers to the fact that serious devegetation takes place in the Study Area.

Owing to migration and general increase in population, the malaria prevalence has remained relatively stable. Malaria which tops the list of prevalent diseases in the study area is on the increase chiefly because of dirty environment and drug abuse (NMCP, 2014). Malaria whose prevalence remained at 4.1% amounting to 1920 reported cases in 2014 puts serious burden on the residents. Use of Insecticide Treated Nets, insecticide spray and consistent sanitation are some of the suggested ways to curb the infection.

Pearson Product Moment Correlation was used to analyse the significance in relationship between deforestation and malaria prevalence using the percentage sizes of both the dense forest and sparse vegetation for the selected eight years and the malaria prevalence for same years as correlates. The result clearly shows that there is no significant relationship between the two. This means that even though devegetation has a positive relationship with malaria increase, same is not true for its prevalence, because as the infection rate is increasing so also is the population. Therefore some other environmental and socio-cultural conditions must be fingered as being responsible for the trend in malaria prevalence in the Study Area.

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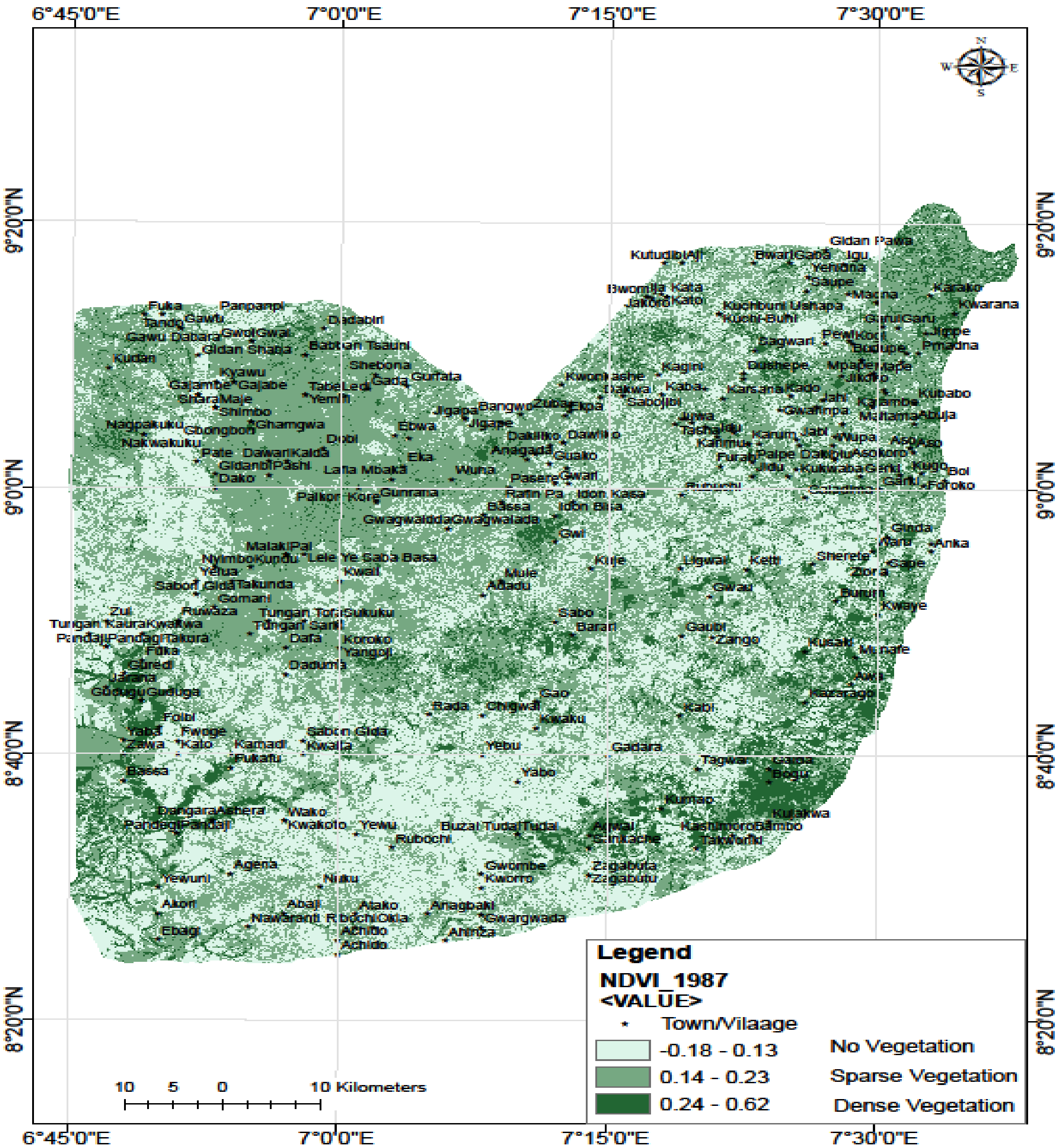
Appendix: NDVI maps for FCT.

APPENDIX 1



Source: United States Geological Survey, 2015

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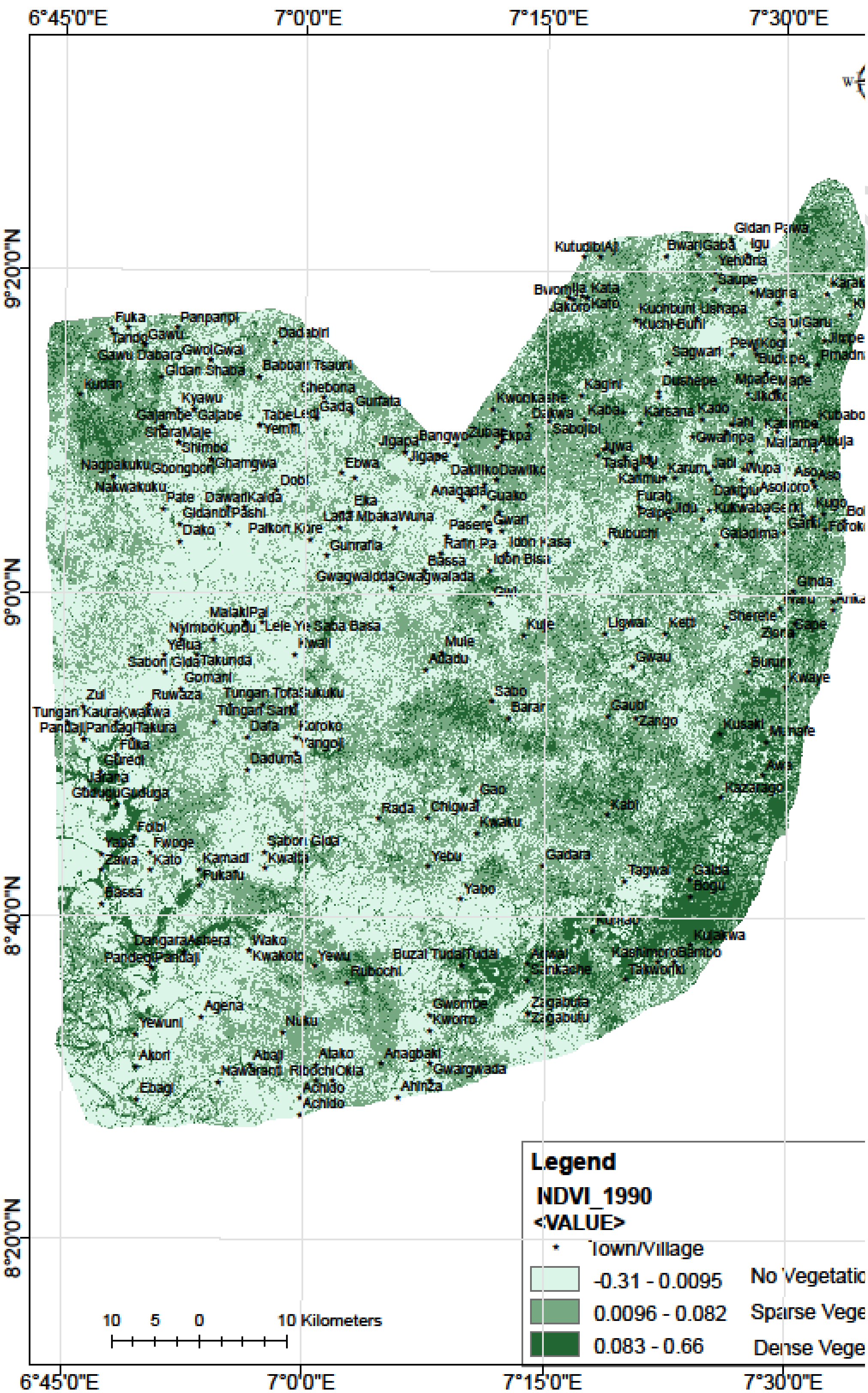
APPENDIX 2



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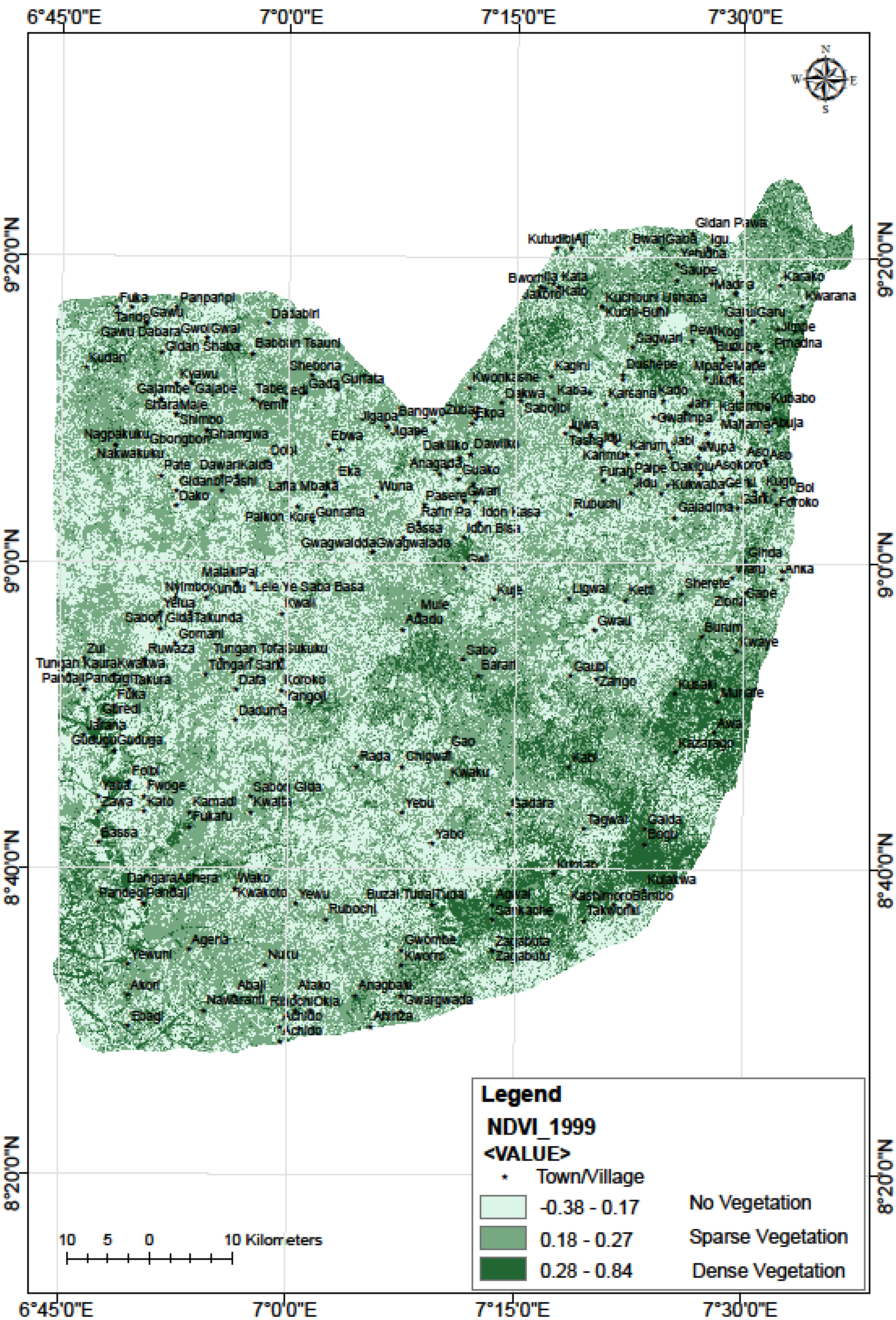
APPENDIX 3



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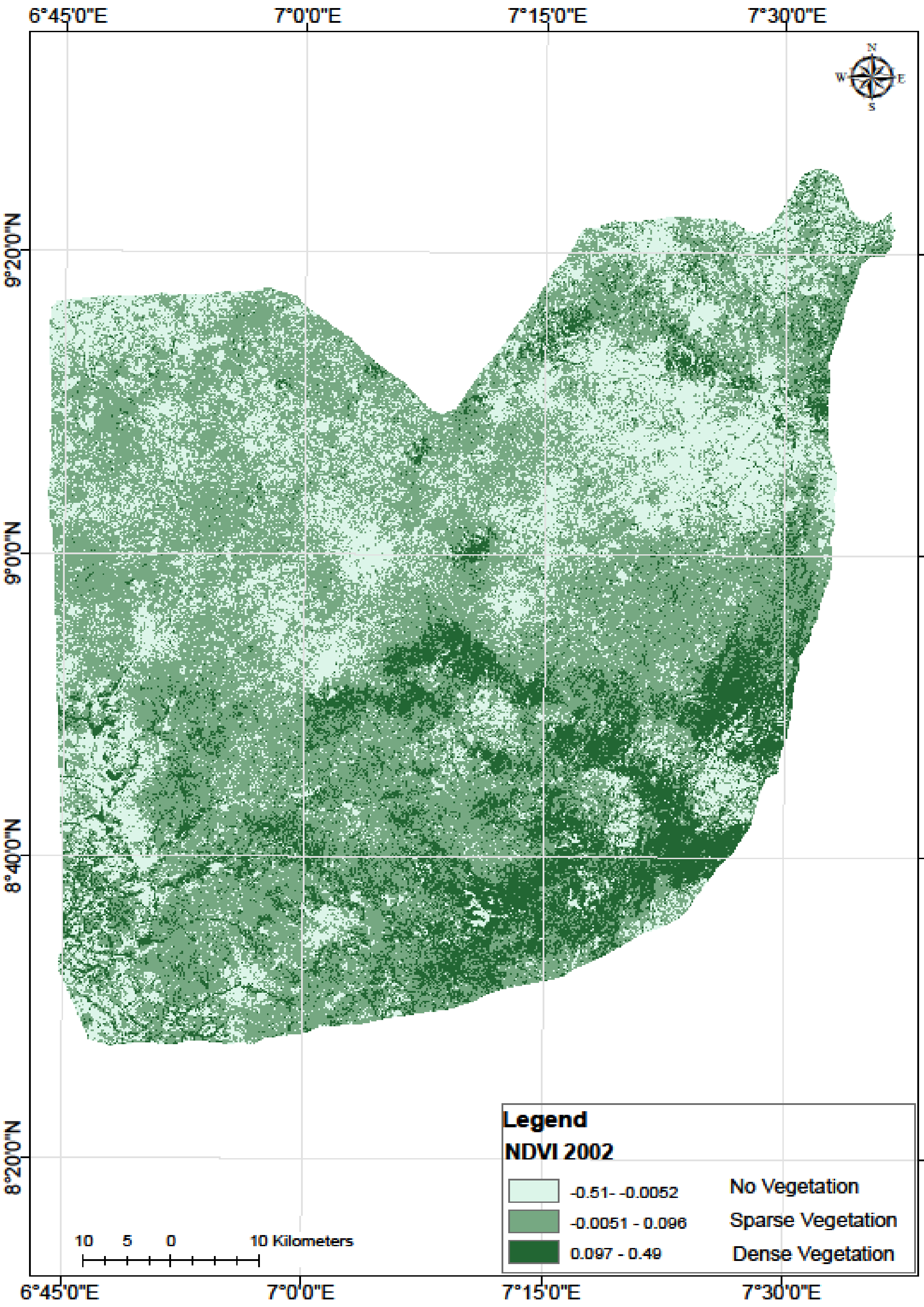

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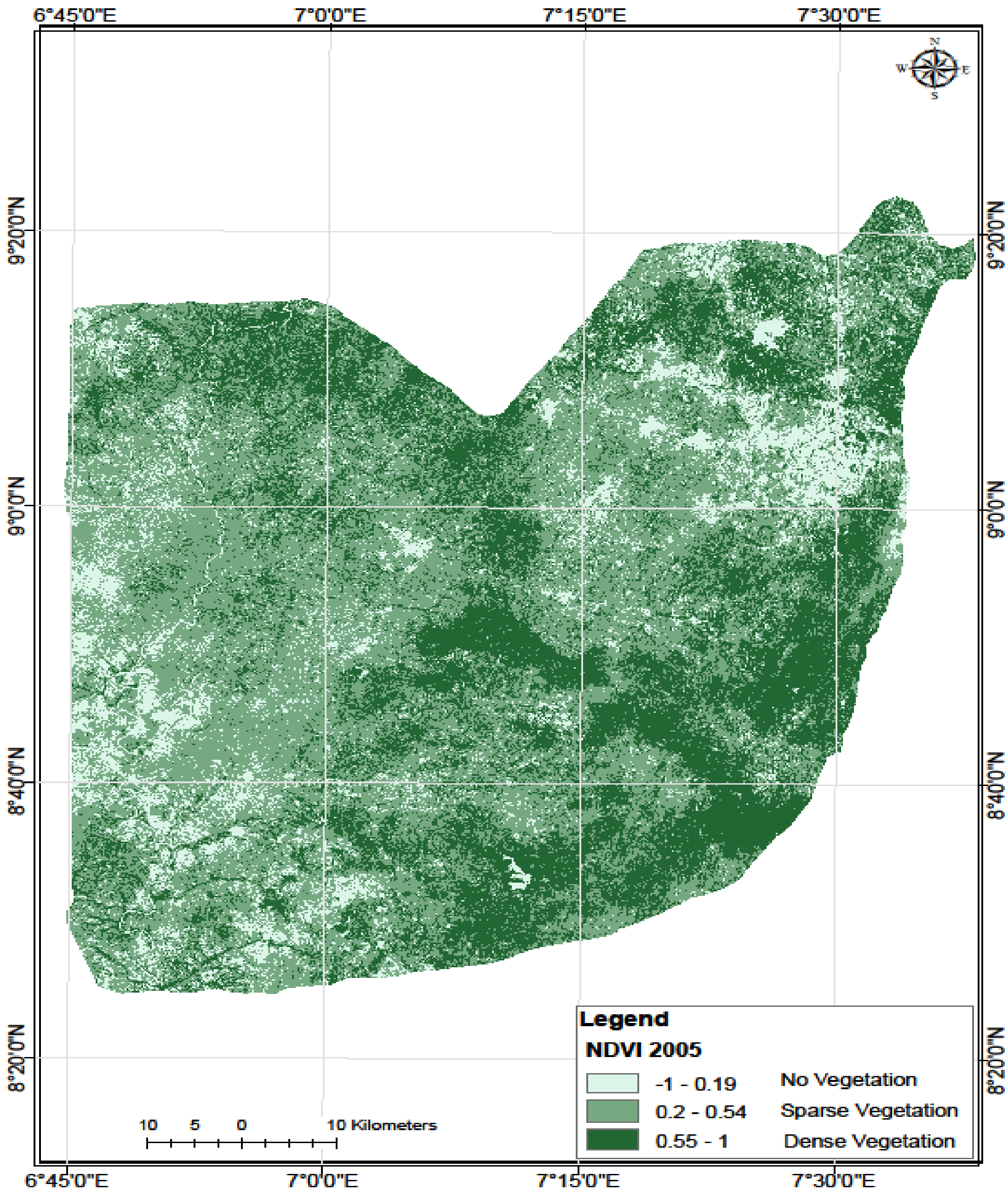
APPENDIX 5



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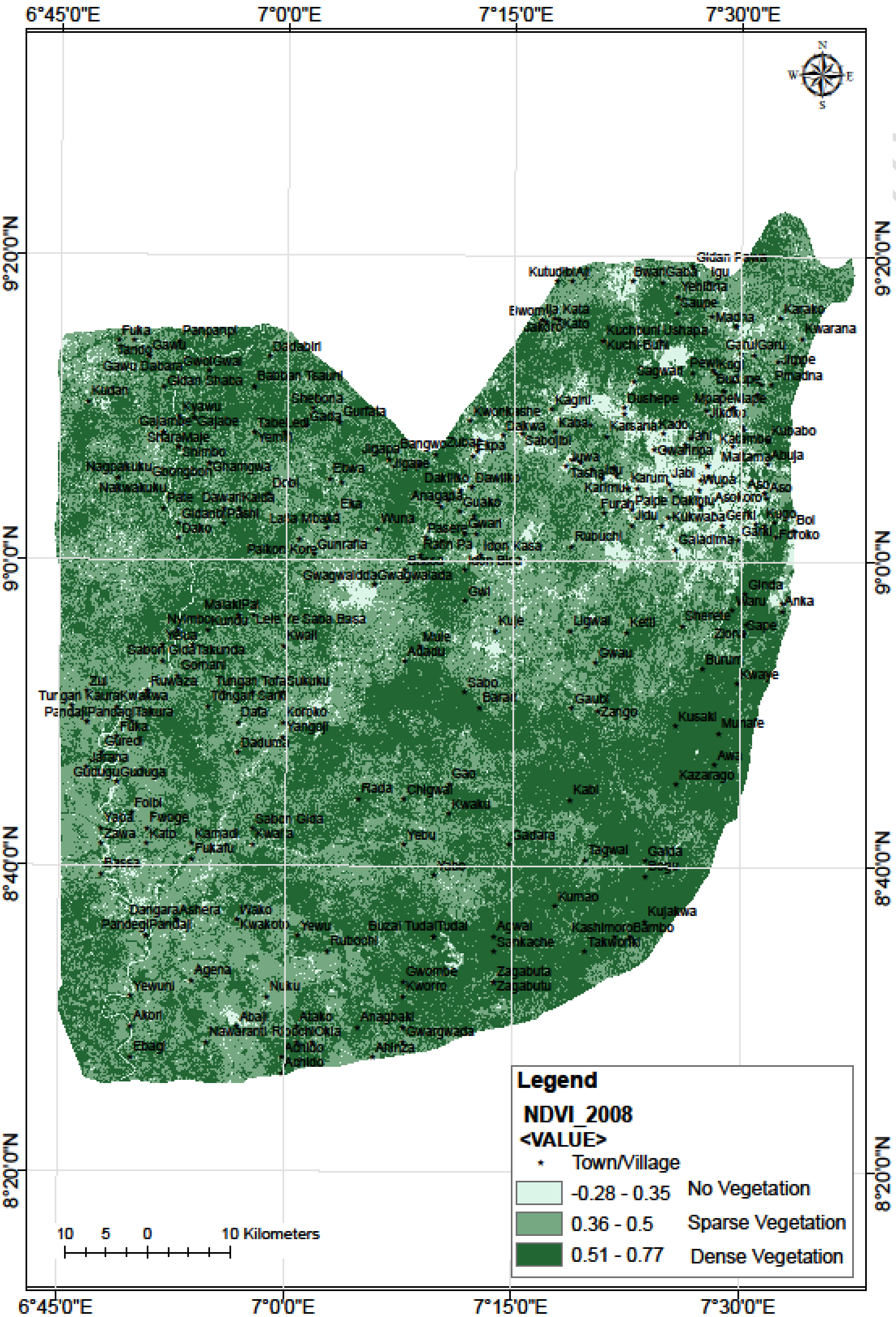

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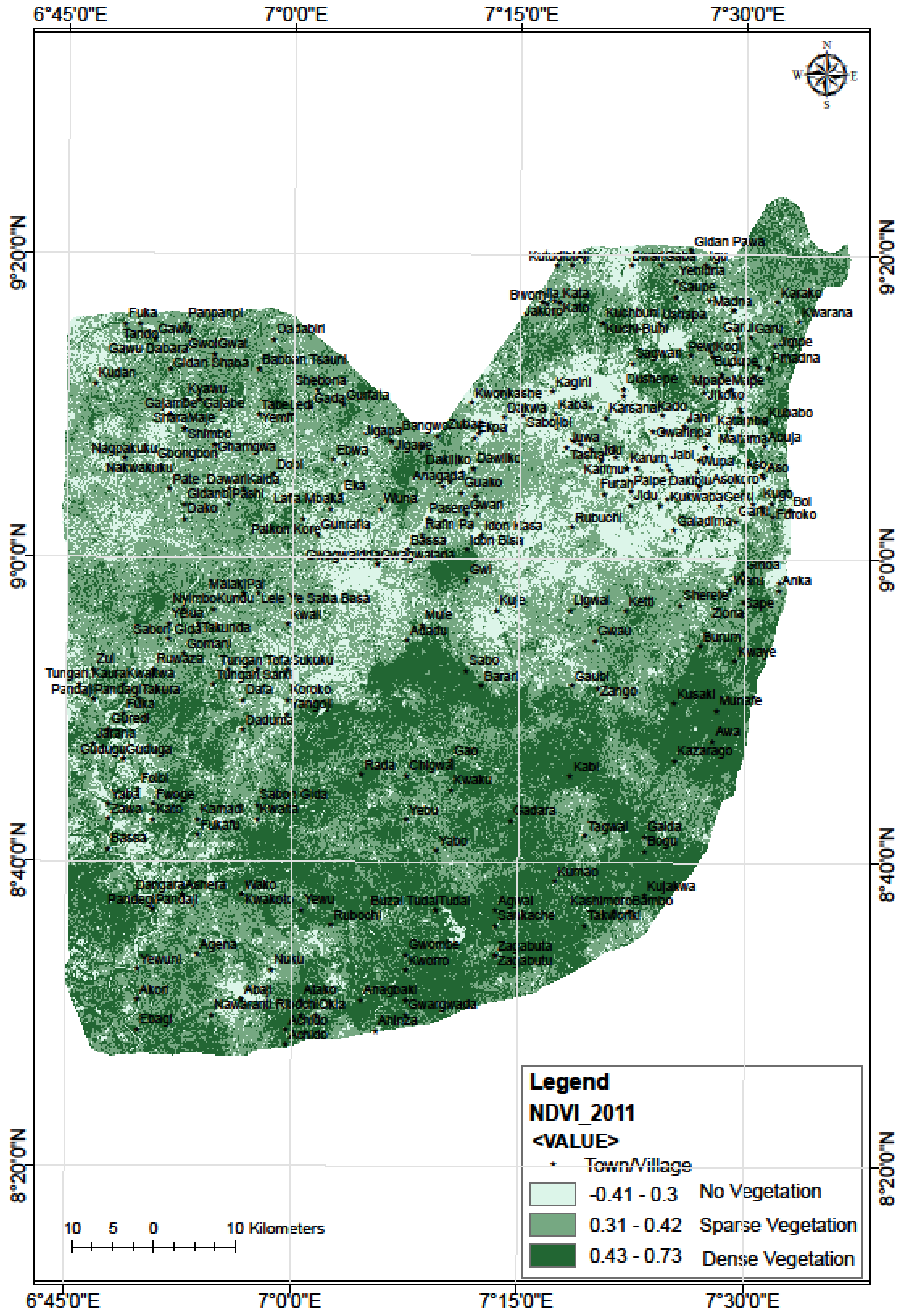

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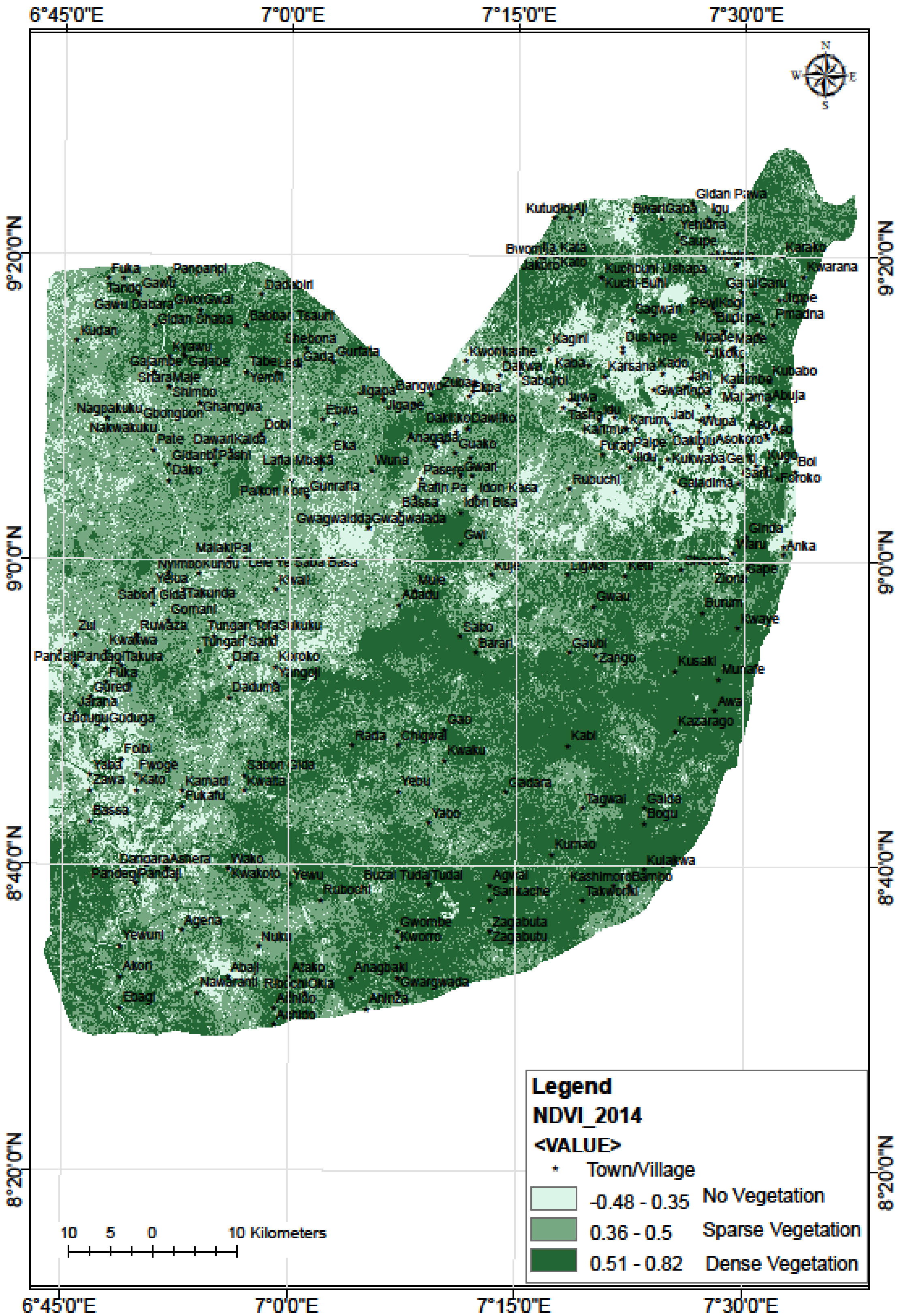
APPENDIX 8



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