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Mapping the Impacts of Anthropogenic Activities on Vegetation in the Area Councils of FCT using Remote Sensing

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Abstract

Globally, amongst all the factors threatening the existence of landcover in the biosphere, agriculture and urbanization plays the most potent role aside from the natural factor of climate. The study examines the effect of human factors on vegetal cover and identifies the drivers of the changes within the area councils of the FCT over a period of three decades. The need to conserve limited natural resources is threaten by the effect of increased population and their continuous anthropogenic activities on this limited resource, thus the vegetation cover which represents an important natural resource for both humans and other species is lost due to reckless and unsustainable usage. Using geospatial techniques, the magnitude of human activities of development is assessed as it affects vegetation cover. The results of the analysis show a tremendous impact of anthropogenic activities as the landcover continue to deplete from 1987 – 2016. Human impacts were identified as the major driver of vegetal cover change in all area councils as it increases from 11510.89km2 to 85563.01km2 in AMAC, 765.55km2 to 82820.74km2 in Gwagwalada, 1621.73km2 to 54267km2 in Kwali, 1259.49km2 to 4985.56km2 in Abaji, 6621.80km2 to 34295.20km2 in Kuje and 15678.82km2 to 24925.94km2 in Bwari.

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The study recommends that continuous inventory of human impacts should be carried out to check mate the unsustainable management practices of human induced activities in the study area. It concludes that anthropogenic activities are on the rise thus measures should be taken to mitigate its effects to ensure better environmental sustainability.

Keywords: Anthropogenic Activities; Geospatial Techniques; Human Impacts; Remote Sensing; Vegetation.

1. Introduction

One of the most important factor critically affecting the present status of human activities globally is Agricultural practices. Other factors include, weed species in agricultural ecosystem. On a global scale, Agricultural practices plays a key role which depends on the various agrarian traditions and the general influence of geographical variation in landscapes [2]. Natural resources are as old as mankind and form the fundamental life line of all living organisms. They are materials and components that can be found within the environment and it includes sunlight, atmosphere, water, and land along with all vegetation and animal life that naturally subsists upon or within the environment [1]. It is feared that unless proper steps are taken to conserve them on time, mankind and other organisms will be facing a tremendous hardship in future. Hence, the need to conserve our natural resources by taking a proper inventory is necessary. Vegetative land cover according to Hansen and his colleagues [1] is an important variable in many earth system processes. Monitoring and evaluation of the types and extent of vegetation is important for resource management and issues regarding land cover change [4]. Forest cover today is altered primarily by direct human use and any conception of global change must include the pervasive influence of human action on land surface conditions and processes. As the human population increases and more people relocate to urban areas, anthropogenic factors are having a profound effect on the urban environment, thus redefining vegetation which has emerged new challenges and research opportunities. This has resulted in social burden in the urban cities as stated by Aladesanmi and his colleagues in 2017. The work assessed the extent, intensity, and direction of development in the territory and as it affects vegetal cover using geospatial techniques.

The Federal Capital Territory (FCT) is diverse and varied with respect to biophysical composition. FCT is characterized with savannah vegetation with 53% of grass land, 12.8% of woodland and 12.9% of shrub lands. Over time, man, and natural forces such as climate has affected the natural resources. FCT has, however, witnessed tremendous developments since inception. Most of these developments include massive infrastructural developments like roads, dams, residential and commercial layouts, schools, and hospitals as well as other physical developments.

There is dearth of comprehensive data to show the extent, intensity, and impact of the development process on the natural environment of the area since commencement of intensive developmental work in the territory from 1976. These activities tend to affect the natural resources of the area especially in depleting the natural vegetal cover. In the rural country-side, farming and other activities also tend to accelerate the rate of change in the FCT. These activities are mostly carried out without consideration to conservation measures and adherence to the original master plan especially in the rural areas of the FCT. These developmental activities are impacting negatively and affecting the effective resource utilization in the FCT. The aim of this research is to assess the extent and intensity of development as it affects vegetal cover and to indicate areas affected by human induced activities for necessary intervention measures in the FCT using geospatial techniques. The spatial scope of the research covers six area councils of the FCT while the temporal scope spans three decades (1987-2016).

2. Materials and Methods

2.1. Study Area

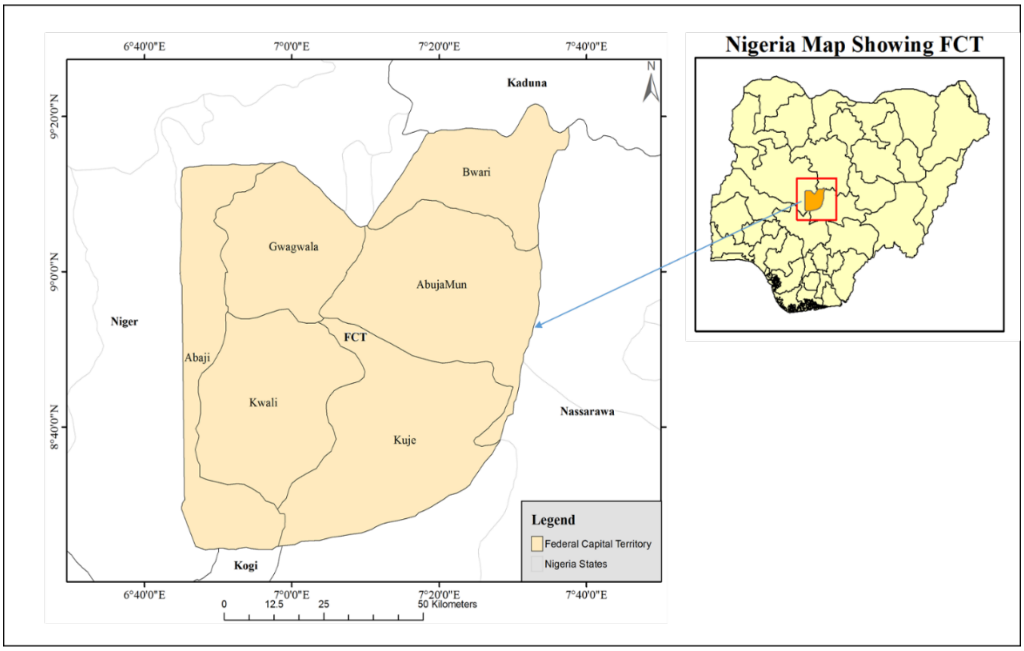

Figure 1: Study area map

Abuja is the capital city of Nigeria located within latitude 7° 25’ N and 9° 20’ North and longitude 5°45’ and 7° 39’ East respectively [5]. The Federal Capital Territory (FCT) has a land area of 8,000 square kilometers, dotted with hills, highlands, and other distinguished features. FCT is characterized as the savannah grassland of north and the middle belt with the richness of the tropical rain forests of the south.

2.2. Vegetation and Wildlife

The Federal Capital Territory falls within the Savannah zone vegetation of the West African sub-region, but patches of rain forest occur in the Gwagwa plains that form one of the surviving northern-most occurrences of the mature forest vegetation in Nigeria.

The vegetation of the FCT is divided into three Savannah types which are park or grassy that occupies about 53 percent of the total area. The Savannah woodland occupying 12.8% occurs mostly in the rugged and less accessible parts of the Gurara, Robo, Rubochi plains and the surrounding hills. The Shrub Savannah that occurs extensively in rough terrain close to hills and ridges in all parts of the FCT and covers about 12.9 % of the land area.

2.3. Settlements and Occupational Structure

The settlement pattern of the indigenous rural communities in the FCT is the nucleated type and scattered in the plains. A typical village is made up of hamlets, while a ward is made up of households, which are close to each other basically for security and defense purposes.

Historically, most settlements were on the hills until when the colonial government forced them to the plains in the second decade of the 20th century and the settlement pattern of the inhabitants was greatly influenced by shifting cultivation practice because crops such as guinea corn, maize, millet, yam, and coco-yam consume a lot of nitrogen, phosphorus, and other nutrients.

The indigenes of Abuja are chiefly subsistence farmers. The major food crops include yam, maize, guinea corn, beans, and millet. Fishing activities are also prominent among the Bassa people and villagers along rivers of Usuma, Jabi, and Gurara. Besides farming, wood and craft work was and is still a notable occupation of the people of the territory especially the Gbagyis. The Ganagana are renowned in iron works. By 1976, the main type of architectural style was the round Sudanese type common in the FCT. There were also a few rectangular "west coast" type and by the side of these residential huts were cone-shaped granaries

2.4. Data and Materials

Geospatial technique was used to carried out the impact of humanly induced activities in the six-area council of the FCT. The technique supports the development of better plan for resources, implementation of the plan for better management and possible modelling.

It presents the sequential processes involved in the acquisition of data, pre-processing, image processing and post processing analysis. However, the method employed in this study is broadly classified into pre-processing of the satellite imagery, field work/data collection, image processing and analysis

The primary data used were acquired from field work and an interactive session with the local inhabitants. Primary data collected included GPS point locations of features, such as vegetation, rock outcrops, water body, settlements bare lands, and other observations recorded on the field including photographs.

As for the secondary data, it was obtained from the National Space Research and Development Agency (NASRDA).

Other secondary data used include Global Land Cover Facility (GLCF), (TAMSAT.org), and FCDA. Additionally, satellite data such as NigeriaSat-X data, Landsat TM, ETM and L8 TIR/OLI, Spot-5, Modis (NDVI) and Tamsat Rainfall data were used at a spatial resolution of 22m, 30m, 2.5m, 1km and 4km respectively (see Table 1). Additionally, the materials used includes:

- Hard-wares: Personnel computers (PC), Global Position System (GPS), field sheets and digital camera
- Soft wares: ArcGIS 10.5, Ecognition 9.1, Libre office, Microsoft office and Idrisi Selva 17.0.

Table 1: Data and Material used

Data	Date of Acquisition	Data Resolution	Data Source
Landsat TM	1987	30m	GLCF
Landsat ETM+	2001	30m	GLCF
Landsat ETM+	2016	30m	GLCF
NigeriaSat-X	2014	22m	NASRDA
GPS	Oct-Nov 2016	450 Points	Field work

2.5. Pre-processing

Satellite imagery obtained from different sensors were co-registered into same reference system. The bands were stretched and filtered to improve the spectral visualization. Maps prepared from the images overlaid with settlements and road network shapefiles was used as field guide.

2.6. Field Work and Data Collection

A scheduled field-work was embarked upon by the staff of Natural Resources Management Division of the Strategic Space Applications Department which lasted for two weeks i.e. from the 24th of October to 7th of November 2016. Prior to this, a reconnaissance survey was carried out to examine the characteristics of vegetation and other features to facilitate the identification of training classes for image classification and the drivers of changes of the vegetation. In each of the six area councils, six major feature classes were identified namely: waterbody, vegetation, farmland, rock outcrop, settlement, and bare-land. To further differentiate the assigned features for classification a code was assigned to as shown in Table 2 below

Table 2: Features classes and assigned codes collected during the field work

Classes	Sub-classes	Class-code
Water body	River	WR
	Lake	WL
	Stream	WS
Vegetation	Natural forest	VNF
	Disturbed forest	VDF
	Forest regrowth	VFR
	Grassland	VG
	Shrub land	VS
Farmland		FL
Rock outcrop	Bare	RB
	Covered	RC
Settlements (Built-up)	Urban	Su
	Rural	SR
Bare land		BL

The field points collected were retrieved from GPS and transferred in digital format and converted to shape file in ArcGIS, the shape file was then overlaid on the Landsat images of the study area to guide in the selection of the training sites of each LULC classes before the classification process using ERDAS Imagine and E-cognition

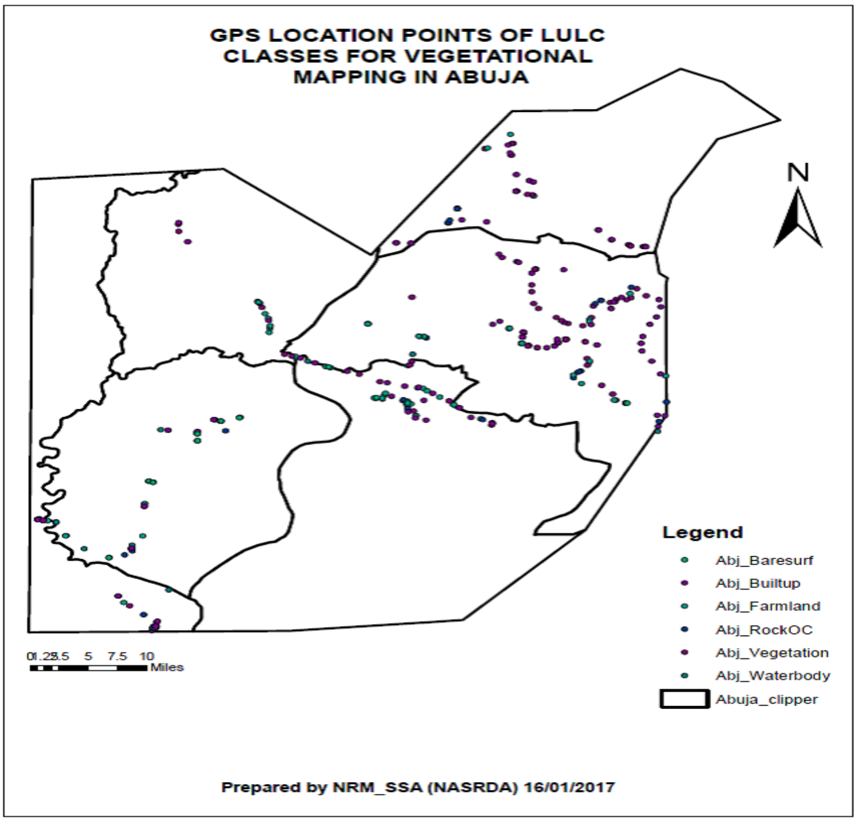

Figure 2: GPS location of the obtained features classes

2.7. Image Processing and Analysis

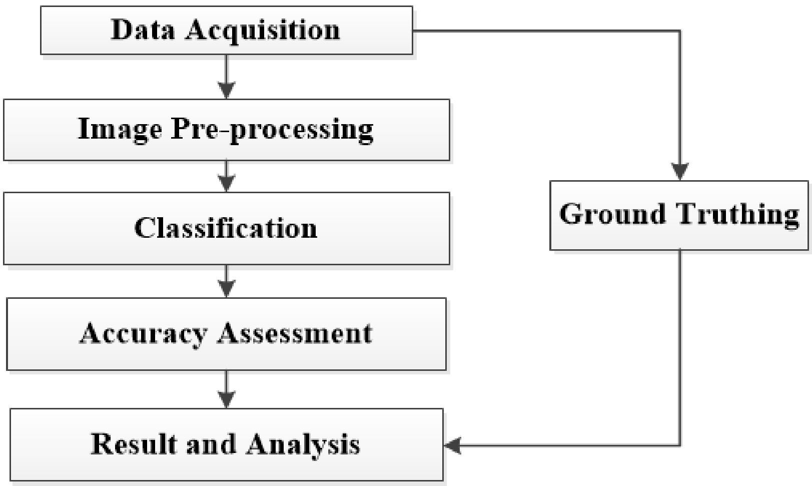

Figure 3: Flowchart diagram illustrating methodology

Supervised classification using nearest neighbor algorithm was carried out to match the spectral classes in the data to the information of classes of interest in Ecognition environment. The supervised nearest neighbor algorithm is the most widely and reliable specialized classification algorithm which is based on probability. Objects are created through multi resolution segmentation which is the process of grouping contiguous pixels as polygon (i.e., spectral similarity) based on information from one or more input layers. Accuracy of the classified images were determined in Erdas Imagine using the training classes obtained in the field. The accuracy was obtained in percentages using error matrix which compares the training samples obtained in the field and the samples used in the supervised classification.

3. Results and Discussion

3.1. Human Impact Hotspot Maps on Vegetation in the Six Area Councils

Based on the result of the analysis, human impacts were identified as a major driver of vegetal change in the study area. Human Impacts in this research means increase in built up due to an unprecedented population growth in the FCT and increase in the bare land which is associated to human induced activities such as bush burning and clearing vegetation for agriculture or settlement and exposing of rock outcrop for quarry activities etc. Thus, human impacts in the context of this research refers to the proportion of built up and bare surface. The human impacts were determined per local area councils in the FCT for the period of study as seen in the maps below. Although natural factors such as changes in the climate (amount precipitation) received over the period of study has as well been identified as a causative driver of vegetal change in the study area.

3.2. Human Impacts hotspot map on Vegetation in AMAC

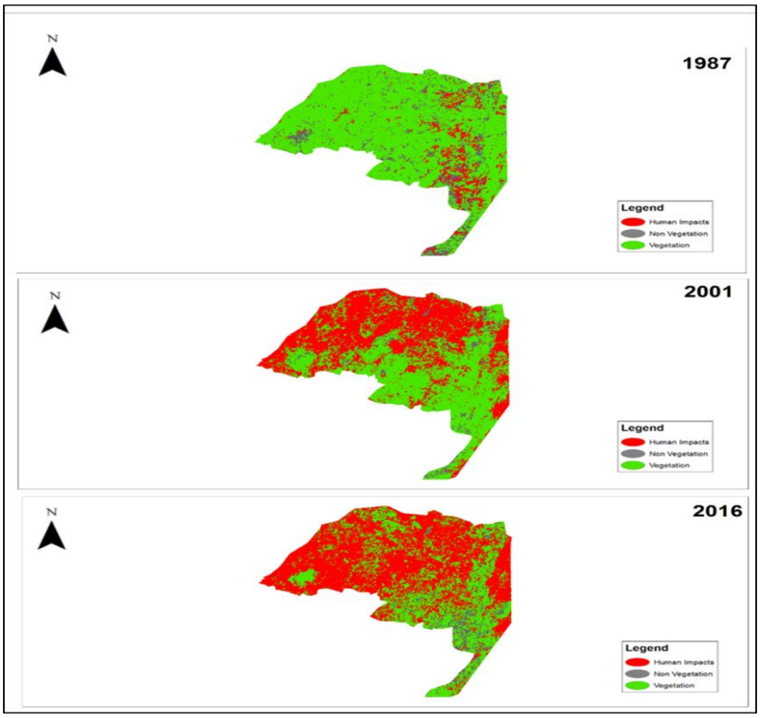

Figure 3: Human impacts on vegetation in Gwagwalada for the period of study

Table 3. below shows the human impacts, non- vegetation, and vegetation features in AMAC measured in terms of increase in built up and bare surface due to anthropogenic activities. In 1987, human impacts increase from

111510.84 km2 (7.95%) in 1987 to about 67219.84 km2 (46.45%) in 2001 and 85563.01 km2 (59.13%) in 2016. Non-Vegetation records a decrease from 15782.19 km2 (10.91%) in 1987 to 5214.469 km2 (3.60%) and 6717.214 km2 (4.64%) in 2001 and 2016 respectively. Vegetation has recorded an unprecedented decrease over the period study from 117410.3 km2 in 1987 to 72268.98 km2 (49.94%) in 2001 and 52423.07 km2 (36.23%) in 2016.

Table 4: Human impacts in AMAC (1987, 2001, 2016)

Classes	1987 Area(km^2)	Area (%)	2001 Area(km^2)	Area (%)	2016 Area(km^2)	Area (%)
Human Impacts	11,510.84	7.95	67,219.84	46.45	85,563.01	59.13
Non-Vegetation	15,782.19	10.91	5,214.47	3.60	6,717.21	4.64
Vegetation	117,410.3	81.14	72,268.98	49.94	5,2423.07	36.23
Total	144,703.33	100.00	144,703.29	100.00	14,4703.29	100.00

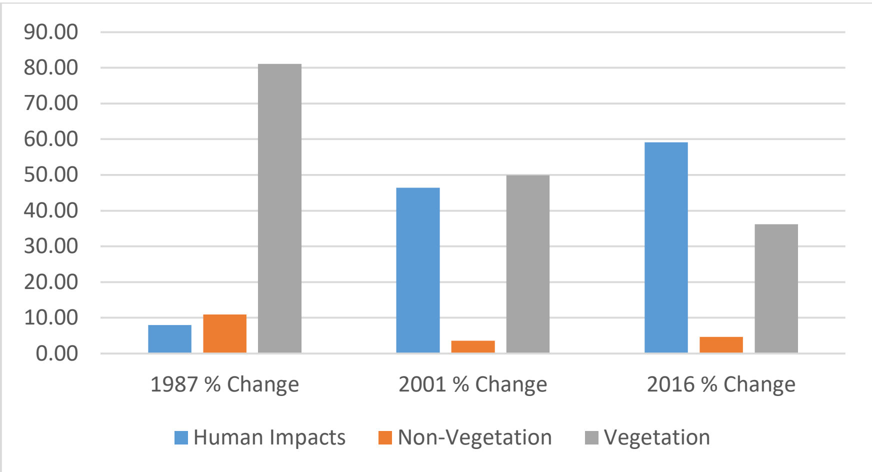

Figure 4: Percentage change in AMAC for Human impacts

3.3. Human Impacts hotspot map on vegetation in Gwagwalada

The values in Table 4 below were computed from the map in figure 6, it gives the trend of human impacts, non-vegetation, and vegetation features in the FCT.

In 1987, human impacts increase from 764.55 km2 (0.79%) in 1987 to about 34720.31 km2 (35.73 %) in 2001 and 82820.74 km2 (85.23) in 2016. Non-vegetation reduces drastically from 5060.88 km2 (5.21) in 1987 to 4234.14 km2 (4.36%) and 28.26 km2 (0.03 %) in 2001 and 2016 respectively. Vegetation has recorded an unprecedented decrease over the period study from 91353.01 km2 (94.01%) in 1987 to 58223.99 km2 (59.91 %) in 2001 and 14329.45 km2 (14.75 %) in 2016.

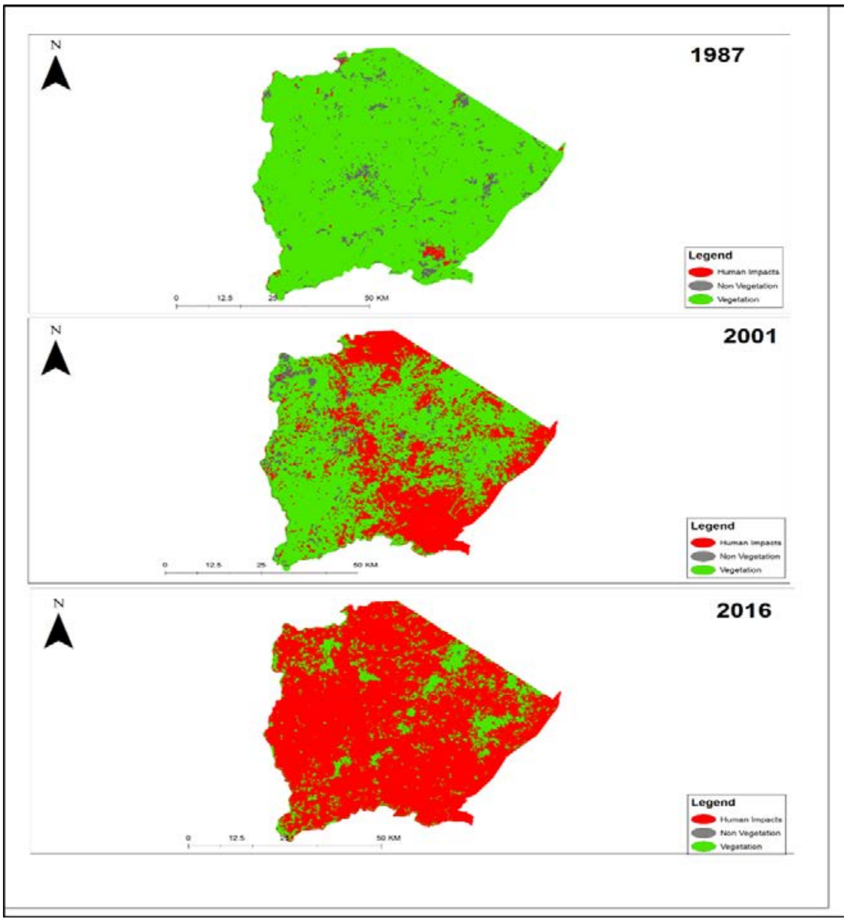

Figure 5: Proportion of vegetation, non-vegetation, and human impacts in Gwagwalada local area council

Table 4

	1987		1987		1987	
Classes	Area(km^2)	Area (%)	Area(km^2)	Area (%)	Area(km^2)	Area (%)
Human Impacts	764.55	0.79	34720.31	35.73	82820.74	85.23
Non-Vegetation	5060.88	5.21	4234.14	4.36	28.26	0.03
Vegetation	91353.01	94.01	58223.99	59.91	14329.45	14.75
Total	97178.44	100.00	97178.44	100.00	97178.44	100.00

3.4. Human Impacts hotspot map on vegetation in Kwali Area Councils

Table 5 below shows the human impacts, non- vegetation, and vegetation features in the Kwali as shown in figure 8, In 1987, human impacts increases from 1621.73 km2 (1.31%) in 1987 to about 18207.19 (14.67%) in

2001 and 54267.5 km2 (43.72%) in 2016. Non-vegetation reduces drastically from 13488.53 km2 (10.87%) in 1987 to 5926.29 km2 (4.77%) and 4566.83 km2 (3.68%) in 2001 and 2016 respectively. Vegetation has recorded an unprecedented decrease over the period study from 109004.4 km2 (87.83%) in 1987 to 99981.21 km2 (80.56%) in 2001 and 65280.37 km2 (52.60 %) in 2016.

Presently urbanization and industrialization is moving toward kwali area councils during period where there a lot of demolition of illegal structure around AMAC witness increase in human migration to the satellite town.

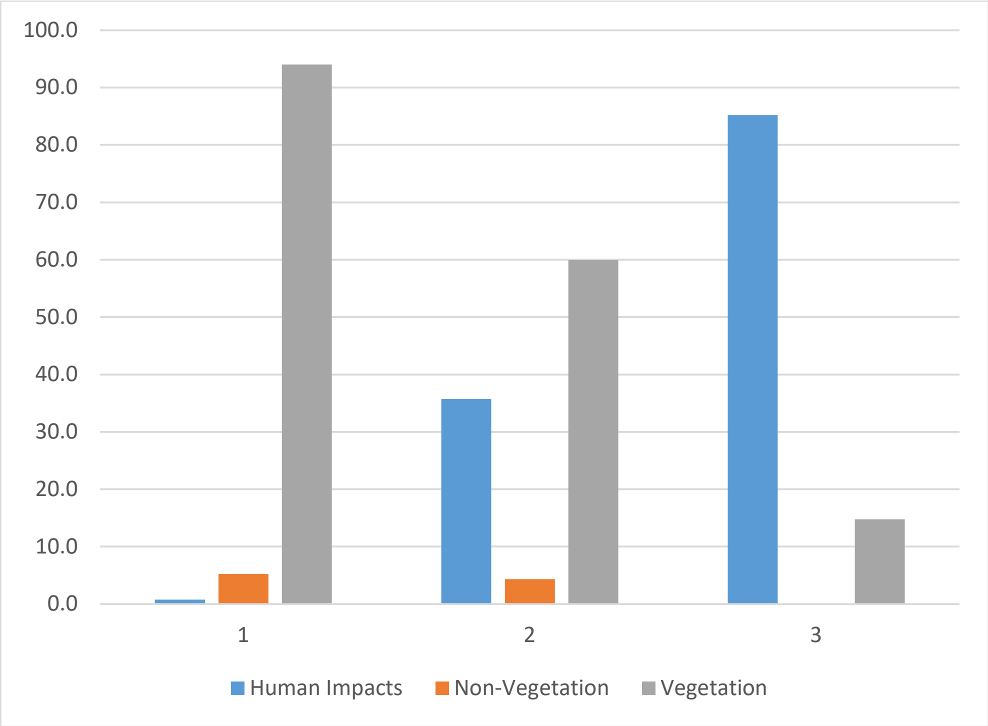

Figure 7: Percentage in Gwagwalada for Human impacts (1987, 2001 & 2016)

Table 5: Human impacts on vegetation in Kwali area council

	1987		2001		2016	
Classes	Area(km^2)	Area (%)	Area(km^2)	Area (%)	Area(km^2)	Area (%)
Human Impacts	1,621.73	1.31	18,207.19	14.67	54,267.50	43.72
Non-Vegetation	13,488.53	10.87	5,926.29	4.77	4,566.83	3.68
Vegetation	109,004.40	87.83	99,981.21	80.56	65,280.37	52.60
Total	124,114.66	100.00	124,114.69	100.00	124,114.67	100.00

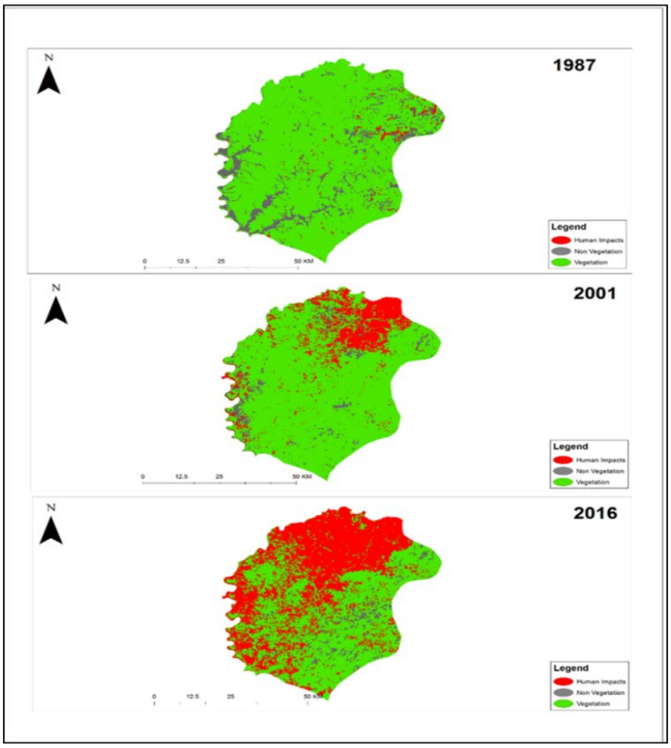

Figure 8: Proportion of vegetation, non-vegetation, and the human impacts in Kwali local area council

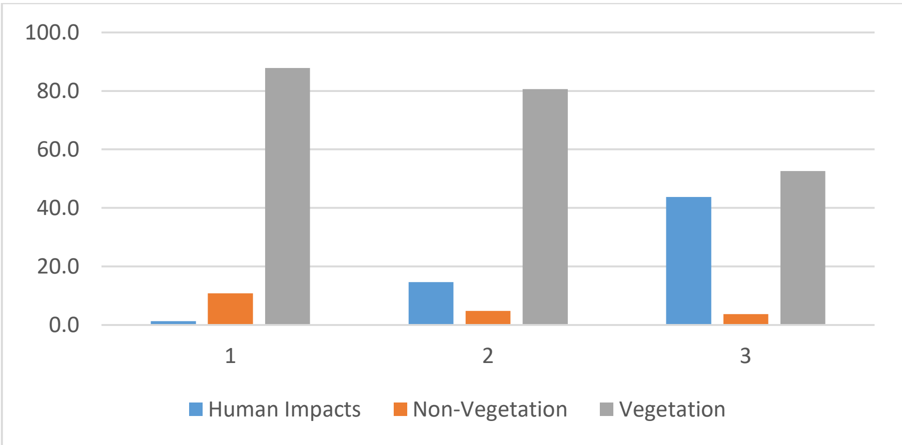

Figure 9: Percentage change in Kwali for Human impacts (1987, 2001 & 2016)

3.5. Human Impacts hotspot map on vegetation in Abaji Area Councils

Figure 10 depict the trends of human impact in the hot spot maps and furthermore Table 6 below shows the human impacts, non- vegetation, and vegetation features in the Abaji. In 1987, human impacts increase from 1259.49 km2 (1.48%) in 1987 to about 10988.25 km2 (12.94%) in 2001 and 49857.56 km2 (58.71%) in 2016. Non-Vegetation reduces drastically from 8087.84 Km2 (9.52%) in 1987 to 10292.35 km2 (12.12 %) and 1232.94 km2 (1.45 %) in 2001 and 2016 respectively. Vegetation has recorded an unprecedented decrease over the period study from 75575.8 km2 (88.99%) in 1987 to 63642.53 km2 (74.94%) in 2001 and 33832.63 km2 (39.84%) in 2016.

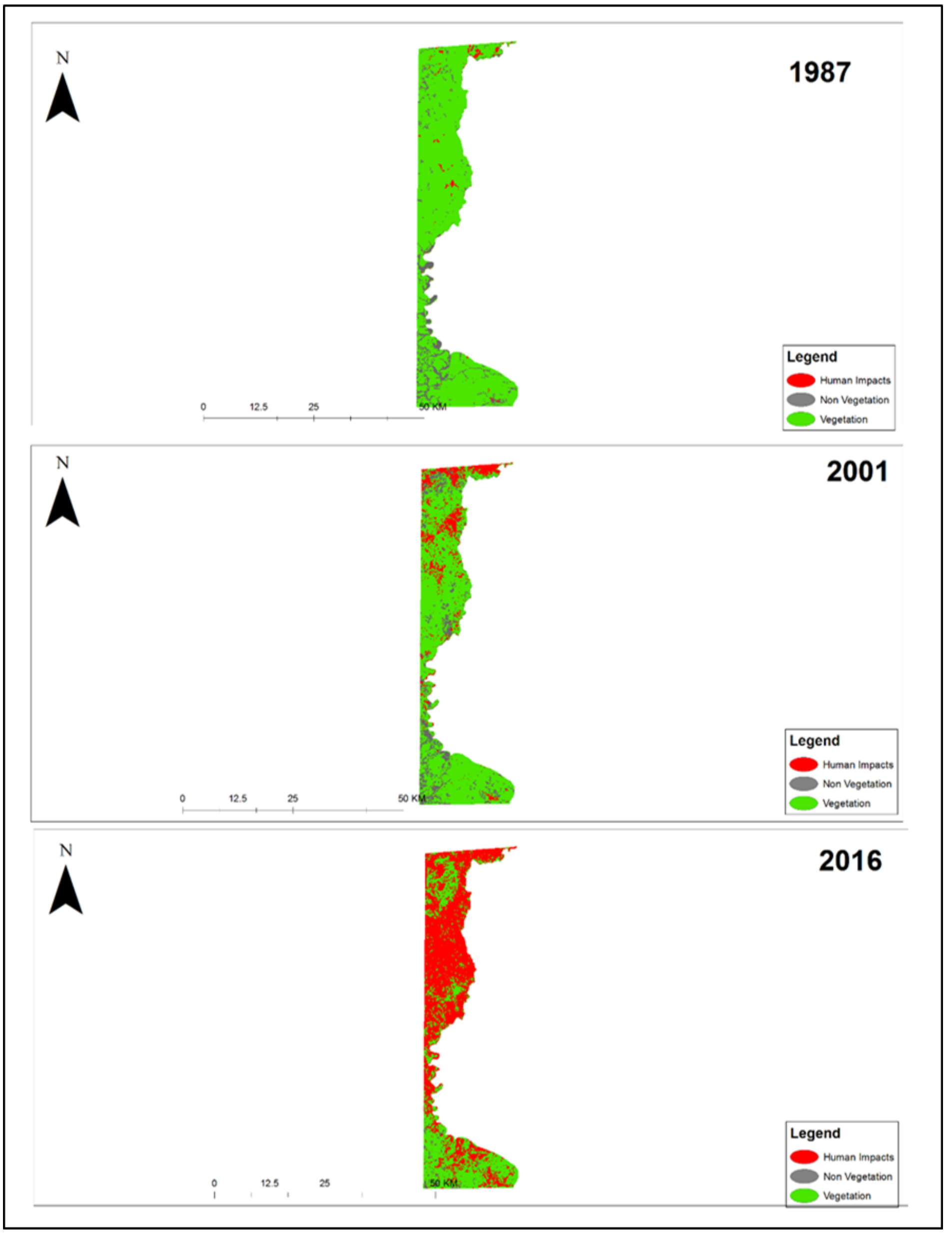

Figure 6: Proportion of vegetation, non-vegetation, and the human impacts in Abaji local area councils

Table 6: Human impacts on vegetation in Abaji area council

	1987		2001		2016	
Classes	km^2	%	km^2	%	km^2	%
Human Impacts	1,259.49	1.48	10,988.25	12.94	49,857.56	58.71
Non-Vegetation	8,087.84	9.52	10,292.35	12.12	1,232.94	1.45
Vegetation	75,575.80	88.99	63,642.53	74.94	33,832.63	39.84
Total	84,923.13	100.00	84,923.13	100.00	84,923.13	100.00

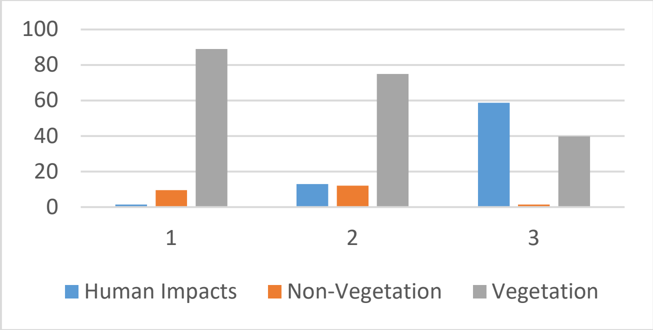

Figure 7: Percentage change in Abaji for Human impacts (1987, 2001 & 2016)

3.6. Human Impacts hotspot map on Vegetation in Kuje Area Councils

Table 7 below shows the human impacts, non- vegetation, and vegetation features in the Kuje as clearly seen in the maps in figure 12. In 1987, human impacts increase from 6621.8 km2 (3.8 %) in 1987 to about 13407.0 km2 (7.6 %) in 2001 and 34295.2 km2 (19.5%) in 2016. Non-Vegetation reduces drastically from 29965.0 km2 (17%) in 1987 to 15807.7 km2 (9%) and 17462.5 km2 (9.9%) in 2001 and 2016 respectively. Vegetation has recorded an increase between 1987 and 2001 and decrease from 2001 to 2016. It increases from 139245.4 km2 (79.2%) in 1987 to 146617.5 km2 (83.4%) in 2001 and 124[]074.6 km2 (70.6 %) in 2016. The major factor that lead to an increase in migration of people to the satellite towns especially those closer to the AMAC such as Kuje, was because of the push and pull factors due to government policy of reverting to Abuja Master Plan that lead to demolition of illegal structure in AMAC between 2003 to 2007.

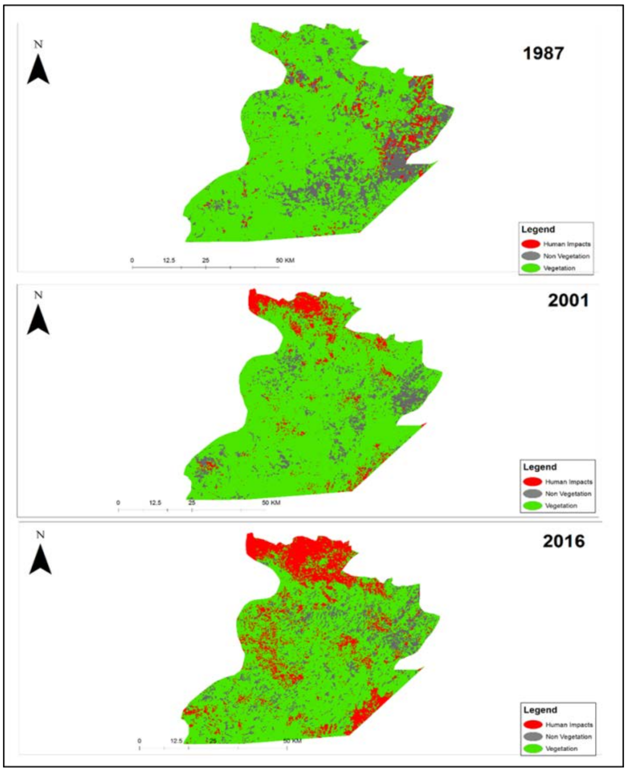

Figure 8: Proportion of vegetation, non-vegetation, and human impact in Kuje local area council

Table 7: Human impacts on vegetation in Kuje area council

Classes	1987 Area (Km^2)	1987 Area (%)	2001 Area (Km^2)	2001 Area (%)	2016 Area (Km^2)	2016 Area (%)
Human Impacts	6,621.80	3.80	13,407.00	7.60	34,295.20	19.50
Non-Vegetation	29,965.00	17.00	15,807.70	9.00	17,462.50	9.90
Vegetation	139,245.40	79.20	146,617.50	83.40	124,074.60	70.60
Total	175,832.30	100.00	175,832.30	100.00	175,832.30	100.00

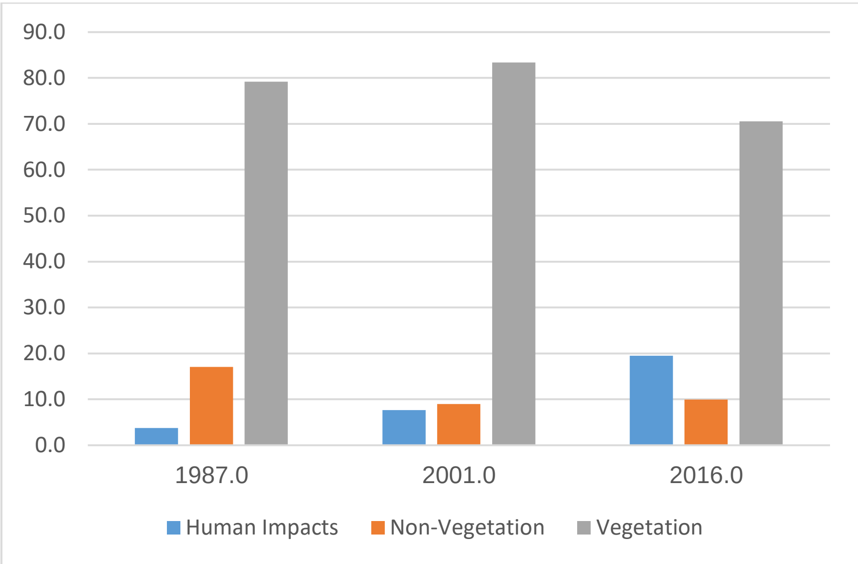

Figure 13: Percentage change in Kuje for Human impact (1987,2001 & 2016)

3.7. Human Impacts hotspot map in Bwari Area Councils

Figure 14 and Table 8 below shows the proportion of vegetation, non-vegetation and the human impact in Bwari local area councils measured in terms of increase in built up and bare surface due to anthropogenic activities. Human impacts increase from 16% (15,678.82 km2) in 1987 to 24.18% (22944.18 km2) and to 26.27% (24925.94 km2) in 2016. Non-Vegetation showed a decrease from 19.91% (18887.88 km2) in 1987 to 12.38% (11742.67 km2) in 2001 but increases to 19.58% (18574.24 km2) in 2016. Vegetation records a slight decrease from 63.56% (60303.43 km2) in 1987 to 63.44% (60183.29 km2) in 2001 and a drastic decrease to 54.15% (51369.96 km2) in 2016.

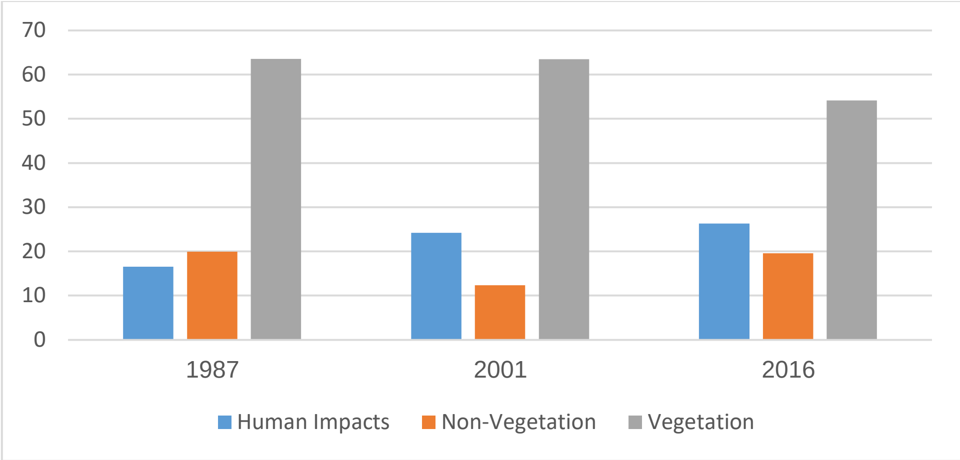

Figure 9: Percentage change in Bwari for Human impacts

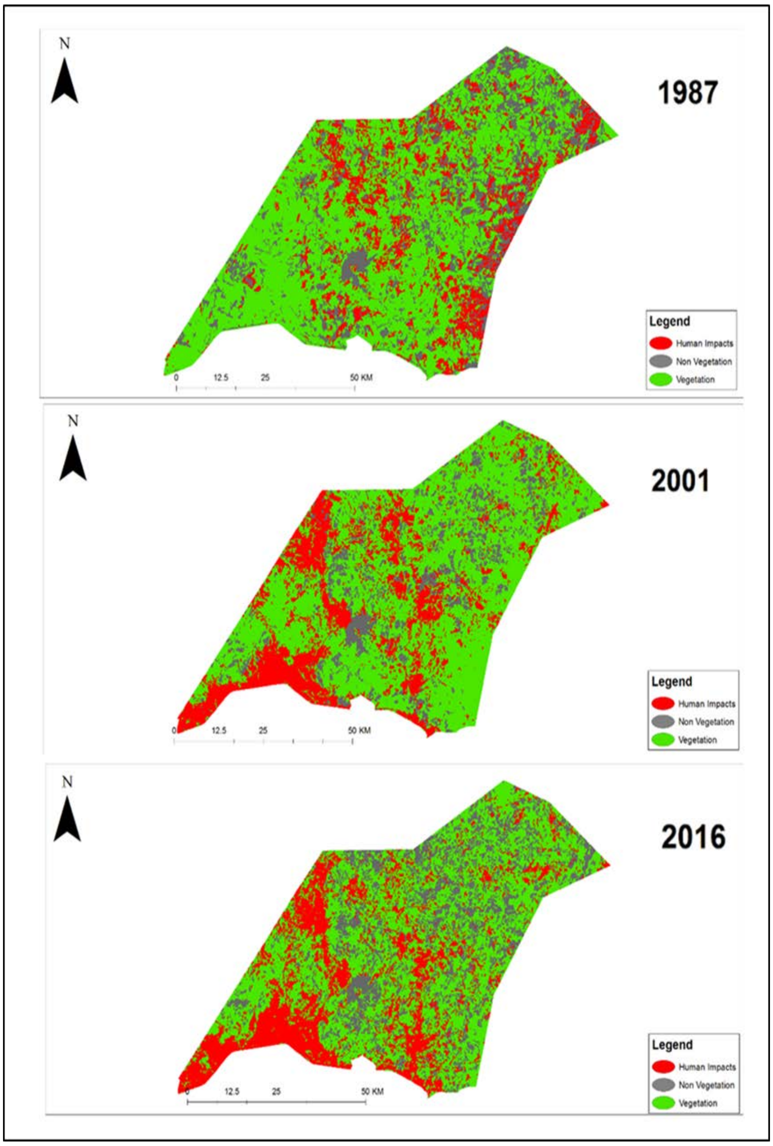

Figure 10: Proportion of vegetation, non-vegetation, and human impacts in Bwari local area councils

Table 8: Human impacts in Bwari area council

	1987		2001			2016
Classes	Area(km^2)	Area(%)	Area (km^2)	Area (%)	Area(km^2)	Area (%)
Human Impacts	15678.82	16.53	22944.18	24.18	24925.94	26.27
Non-Vegetation	18887.88	19.91	11742.67	12.38	18574.24	19.58
Vegetation	60303.43	63.56	60183.29	63.44	51369.96	54.15
Total	94870.14	100.00	94870.14	100.00	94870.14	100.00

4. Conclusion

In this study, the impact of anthropogenic activities on vegetation was examined, three landuse landcover classes namely: vegetation, non-vegetation and human impacts were classified from the satellite images of 1987, 2001 and 2016 for the six area councils of FCT. It was observed that the land areas of vegetation have decreased tremendously with increase of human impact factors as presented in the results which shows that the human impacts increase from 7.95% - 59.13% in AMAC, 0.79% - 85% in Gwagwalada, 1.31% - 43.72% in Kwali, 1.48% - 58.71% in Abaji, 3.80% - 19.50% in Kuje, and 16.53% - 26.27% in Bwari. This rapid change was experienced could attributed to population expansion due to rapid urbanization, and uncontrolled farming/ grazing activities within this six area councils of FCT.

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