

VEGETATION CHANGE ASSESSMENT IN THE NIGERIAN SAVANNAH USING THE MAXIMUM VALUE COMPOSITE, NORMALIZED DIFFERENCE VEGETATION INDEX AND SOCIAL SURVEY

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Abstract

This study was conducted to examine vegetation change assessment in Nigeria's savannah due to continued exploitation of natural resources to meet human needs. The study aimed at understanding and assessing the nature and rate of vegetation change in the savannah zone of Nigeria. The study covers Jigawa, Bauchi and Plateau in Sahel, Sudan and Guinea Savannah vegetation belts. Triangulation method was used since it involved the application and combination of two research methods on the same phenomenon. Remote sensing application and questionnaire methods were used. The remote sensing involved the use time series SPOT VEGT of 1998-2018, it was downloaded from <http://free.vgt.vito.be>. The data covers the years between 1999 and 2018 and consists of 10 day synthesis NDVI (S10) data. Maximum value composite technique was used to remove atmospheric moisture, cloud and simple haze in the imageries. The 10 days, monthly and later annual composites were generated in image calculator tool in IDRISI selva 17.0 software. Time series trend analysis was performed to determine the vegetation trends of the annual NDVI. The annual composites were imported into GIS environment to analyse spatial variations of NDVI in the study area. The composite of 2011 was noisy hence was not used in the analysis. The result indicated that NDVI is characterised by moderate spatio-temporal heterogeneity. The relatively high value of NDVI (above 0.4) is mainly distributed in Jos East, Riyom, Bokkos which are located south of the area while the low value (slightly below 0.3) is obtained in Gamawa Gurri and Ringim. Furthermore, significant positive trends in overall greenness were observed in the southern region while negative trends are also present in the north. A total of 300 copies of the questionnaire (100 per state) were purposively distributed to selected staff of the Ministry of Environments and other stakeholders in each of the states. Findings of the study shows that overall 19% of the respondents opined that changes occurred within 1-5 years, 21% opined 5-10 years while 52% opined that changes in vegetation has been occurring for over 10 years. Assessment of vegetation condition shows that vegetation composition and changes affects the sustainable development. This study recommended for studies on vegetation dynamics (in relation to climate and anthropogenic influences) with high resolution satellite data in order to remove the uncertainties associated with coarser resolution remote sensing based vegetation data.

Keywords: Vegetation, Conservation Savannah

Introduction

According to Ezealor (2001), protection of habitats and species has long been practiced by various cultures in Nigeria, through their preservation of groves and other distinctive habitats for religious, ceremonial and/or hunting purposes. Aminu-Kano and Marguba (2002) further reported that Nigeria's first modern Forest Reserve was created in 1889. By 1950, Forest Reserves covered

about 8 per cent of the country's land area, and gradually rose to 11 per cent by 1980. Thereafter, the inability to formulate policies to establish more reserves prevailed, leading to the current situation whereby even protected areas are being de-reserved. Researchers like Danjuma (2007) Haruna and Jiya (2011) reported that environmental changes that resulted from both natural and human factors have adversely affected the ecosystem in many ways. This trend was responsible for the loss of vital ecosystem services as well as species that helped in long-term environmental sustainability in the country. Several studies in the past like FORMECU (1998), Garba, (2008) indicated that Nigeria is undergoing unprecedented forest degradation as a result of climate change, due to over population and change in land use activities. Despite the value of biodiversity in different ways: source of food, raw materials, wide range of goods and services and genetic materials for agriculture, medicines and healthcare support, domestic and commercial products, aesthetics and cultural values, unfortunately, information on Nigeria's extremely diverse biological heritage is very limited. The strength of this study is its inclusion of primary stakeholders (local actors) as biodiversity has direct link with living standard of the people in the study area. This research is only limited to the spatial study of vegetation zones of Jigawa, in sahel, Bauchi in sudan and Plateau in guinea savanana with emphasis on only vegetation change assessment using remote sensing data and social survey. It covers a 10 year period. The data was sourced from time series Spot VEGT (2009 to 2019). Biodiversity is the variability among living organisms from all sources, including, inter alia, terrestrial, marine, and other aquatic ecosystems, and the ecological complexes of which they are part: this includes diversity within species, between species and of ecosystems (Convention on Biological Diversity, 1992). Research on vegetation has been conducted in Nigeria since 1940s with the pioneer works of Keay (1948) David (2008) and UNEP (2012). Whereas, remote sensing provides wide range of data since its inception in 1972 where aerial photography and satellite imagery are used in various environmental change studies in the country. The advantages of applying remote sensing methods are evident in the monitoring and management of vegetation resources. Satellite remote sensing data can be useful in delineating structural and functional characteristics of forest at a variety of geographical scales (Iverson *et al.*, 1989). Satellite remote sensing has long been considered an ideal technology for monitoring vegetation dynamics because it permits the analysis of large areas with a high temporal frequency (Peterson and Running, 1989). In Nigeria, the first national vegetation and land-use studies were carried out in 1976 and the study revealed that natural vegetation was altered by human activities such as grazing, cultivation, bush burning and logging over long period of time. In another study by FOMECU (1995) shows that drastic changes in the vegetation over those of 1976 (FGN, 2001). According to a report again by FORMECU (1998) variations in terms of vegetation are always found when large geographical areas with distinct features are studied. Salami (1999) used a combination of satellite data obtained from Landsat TM of 1991 and aerial photographs of 1963 and 1973 to assess vegetation dynamics on the fringes of the low land humid tropical forest of South-western Nigeria shows same trend. Study of this nature is needed as an update on the previous studies for policy formulation.

Methodology

This research involved utilising both qualitative (through interview) and quantitative (remote sensing) methods to generate the needed information. This study employed the triangulation methods where remote sensing as well as the questionnaire were used to assess vegetation change in northern Nigeria. The remotely sensed data were collected from SPOT VEGT (2009 to 2019) at a spatial resolution of 1km since the Savanna zone of Nigeria is vast enough to be assessed with satellite products with such scale. Data were downloaded from the Belgian Research Institute VITO web at <http://free.vgt.vito.be>. The data set is free at 1km² resolution and

consists of 10-day synthesis NDVI (S10) data. These were to assess vegetation change for the period covered by the product. Time series trend analysis was performed to determine the trends of NDVI. This study utilize Maximum Value Composite (MVC). MVC technique is selected because it effectively eliminates: the undesirable in sequence of solar zenith angle and viewing angle, concentration of water vapour, aerosols and cloud-free conditions in time series imageries (Holben 1986. One advantage of MVC which this study utilized is that only the highest NDVI value in a predefined compositing period (typically: 10 days) is retained. MVC were aggregated to monthly data in image calculator tool in IDRISI selva 17.0. Observations with the highest NDVI values were selected and new image created (monthly maximum value composites). The processed annual composites were imported into ArcMap environment to produce maps depicted spatial variations of NDVI in the study area. The data of 2011 was noisy hence was not used in the analysis. The nature of savannah landscape from Jigawa down to Plateau shows different cultural activities which direct bearing with vegetation.

Questionnaire Administration

The data was obtained through the administration of questionnaire to respondents selected across all Directors of Forestry in the Ministry of Environment of the three states in northern Nigeria. Others include a representative of the Great Green Wall Agency of the three states in the region. The selection was done through purposive sampling technique to ensure that all relevant segments of the sample population were captured in the study. The study also employs the use of in-depth interview for stakeholders whose routine responsibility is germane to the case under investigation.

Primary data collected from the field survey were analysed using inferential statistics –Simple Frequency Analysis. This method was adopted due to its unambiguity and conciseness. The result is presented in figures to draw inferences on the phenomenon under investigation. Out of the total of 300 questionnaire administered only 241 were returned.

Results and Discussions

The NDVI in the study area was characterized by moderate spatial heterogeneity. Based on the understanding that NDVI range from -1 to +1, findings of this study showed that it is generally low in the area. As indicated in Table 1 relatively high value of NDVI (above 0.4) is mainly distributed in Jos East, Riyom, Bokkos which are located south of the study area while the low value (slightly below 0.3) is obtained in Gamawa, Gurri and Ringim. It was surprisingly low in Jos north owing largely to mining of Tin in several parts of the area. The high NDVI regions are covered by moderate vegetation cover and large shrubby grassland which contributed to the measure of green vegetation in the area. The areas with low NDVI value are virtually dry and located at the north of the study area. These areas consist of mainly dispersed and degraded vegetation which has suffered from seasonal drought and erratic pattern of rainfall. Most of these areas are corridors of fuel wood extraction and overgrazing in the country. Shedding of leaves by deciduous plants (mostly trees) and mortality of herbaceous species during drought periods may also influence low annual NDVI values in the study area as the area is prone to widespread climate related local extinctions. The local extinction of plant and animals is now a global phenomenon. Finding of this study on the influence of climate on vegetation in the area corroborates UNEP (2012) who reported that climatic factors such as rainfall and relative humidity have a dominant influence on vegetation growth and composition. This finding is also in line with several studies including FORMECU (1998), who reported that vegetation in sub-Saharan Africa and indeed Nigeria reflects a steep south to north decline in rainfall. The low NDVI areas may be affected by

limited moisture and anthropogenic activities (deforestation) which could lead to loss of plant biomass and mortality of herbaceous species and shrubs. Here, the NDVI values of the study villages were mapped in order to show good visual indicators of vegetation vigour of the area. The maps depicted discerning pattern with varying colours as green and light green for high values and the maps covers the period between 2009 and 2018 except 2011 as indicated in the methods section (See figures 1a-1j under Appendix).

Table 1 Annual NDVI Values 2009-2018 for the Study Areas

SN	Study Locations	Annual NDVI Values for the Study Locations								
		2009	2010	2012	2013	2014	2015	2016	2017	2018
1	Bauchi Alkaleri	0.45	0.43	0.37	0.42	0.48	0.48	0.48	0.47	0.44
2	Bauchi Gamawa	0.26	0.23	0.26	0.25	0.27	0.29	0.27	0.29	0.17
3	Bauchi Misau	0.28	0.30	0.26	0.26	0.28	0.32	0.27	0.28	0.17
4	Bauchi Ningi	0.41	0.42	0.39	0.45	0.44	0.47	0.45	0.45	0.43
	Total =12.64	1.4	1.38	1.28	1.38	1.47	1.56	1.47	1.49	1.21
	Average =71.20per cent	140.44								
6	Jigawa Babura	0.31	0.27	0.27	0.26	0.28	0.32	0.29	0.29	0.20
7	JigawaBirnin Kudu	0.30	0.30	0.28	0.33	0.34	0.35	0.32	0.34	0.19
8	JigawaDutse	0.29	0.30	0.28	0.32	0.30	0.32	0.32	0.31	0.20
9	JigawaGuri	0.27	0.23	0.26	0.24	0.29	0.26	0.26	0.29	0.21
10	JigawaKazaure	0.31	0.28	0.27	0.32	0.30	0.33	0.27	0.30	0.26
11	JigawaRingim	0.29	0.28	0.24	0.28	0.31	0.36	0.32	0.33	0.21
	Total =13.26	1.47	1.39	1.33	1.49	1.54	1.62	1.49	1.86	1.07
	Avarage= 67.87per cent	147.33								
12	Plateau Bokkos	0.45	0.46	0.44	0.52	0.50	0.52	0.52	0.51	0.55
13	Plateau Jos East	0.47	0.49	0.46	0.58	0.53	0.56	0.54	0.54	0.58
14	Plateau Jos North	0.27	0.23	0.23	0.27	0.25	0.25	0.24	0.27	0.30
15	Plateau Jos South	0.38	0.36	0.36	0.46	0.41	0.43	0.46	0.42	0.55
16	Plateau Ryom	0.47	0.48	0.43	0.56	0.52	0.55	0.58	0.48	0.51
	Total = 19.94	2.04	2.02	1.92	2.39	2.21	2.31	2.34	2.22	2.49
	Average =45.13	221.55								
Σ		0.35	0.34	0.32	0.37	0.37	0.39	0.38	0.38	0.34

Source: 2019 Fieldwork

Results from Administration of Questionnaire

Information from administration of questionnaire to respondents on whether there is decrease in available trees, shrubs and grasses in the study area reveals that 86% agreed with the assertion that there were decrease in vegetation, while about 14% were of the opinion that there was noticeable increase in vegetation cover. (Fig. 2 below)

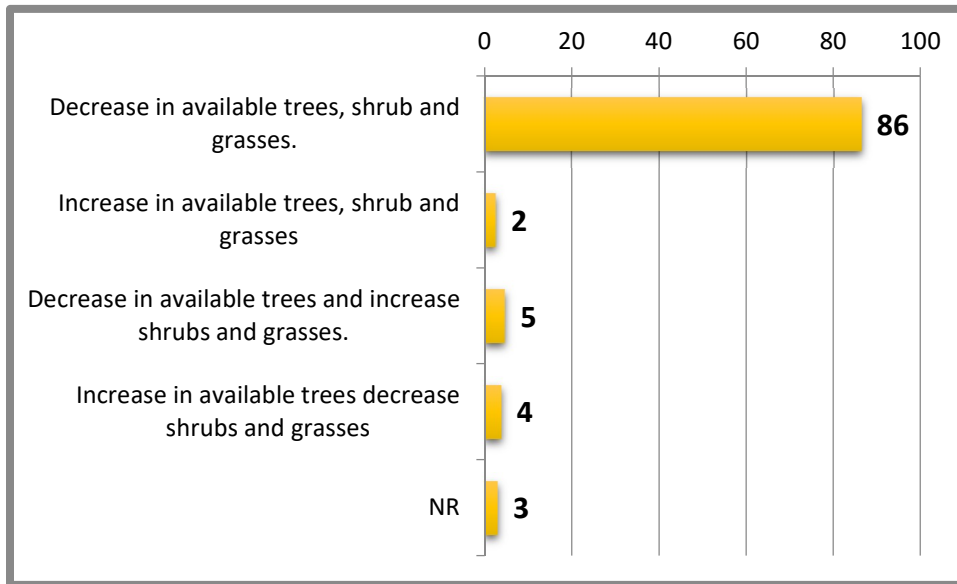


Figure 2: Status of Vegetation

On the time during which noticeable changes were observed the respondents constituting 19 percent opined that the changes occurred within 1-5 years, while 21 percent and 52 percent were of the opinion that changes in vegetation has been occurring for 5-10 years and 10-15 years respectively. It can be deduced that significant changes has been occurring for a long period.

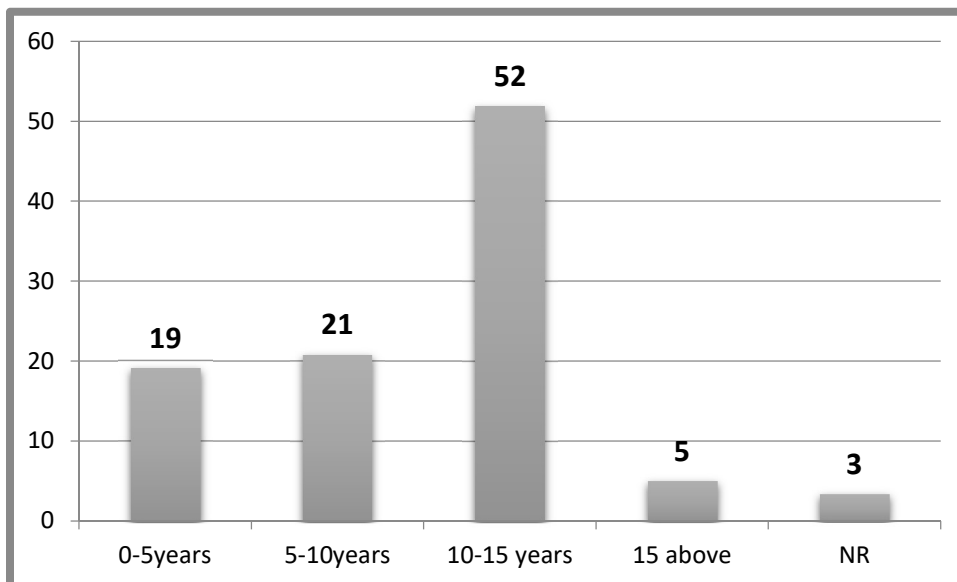


Figure 3: Duration of Changes in Vegetation

Conclusion

Evidence based on field studies have confirmed that natural processes of regeneration are not able to cope with the over-exploitation in high magnitude associated with rapid population growth. From this study it is clear that there is progressive decrease in the vegetation cover as result of human activities in the study area. As towns are becoming larger, new villages are being established; farms and wood cutting activities are extending further and further vegetation reserves. New roads and tracks enable farming, and wood cutting to occur in previously undisturbed natural vegetation. To curtail the menace of vegetation loss due to man's activities, the study recommends as follows:

- i. There is a need for further studies on vegetation dynamics (in relation to climate and anthropogenic influences) with high resolution satellite data in order to remove the uncertainties associated with coarser resolution of remote sensing based vegetation data.
- ii. In addition, relevant stakeholders should be involved to create awareness on dangers of deforestation and the need to conserve the vegetal resource for environmental sustainability particularly in the era of global climatic change.

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Fig 1a 2009 sampled locations

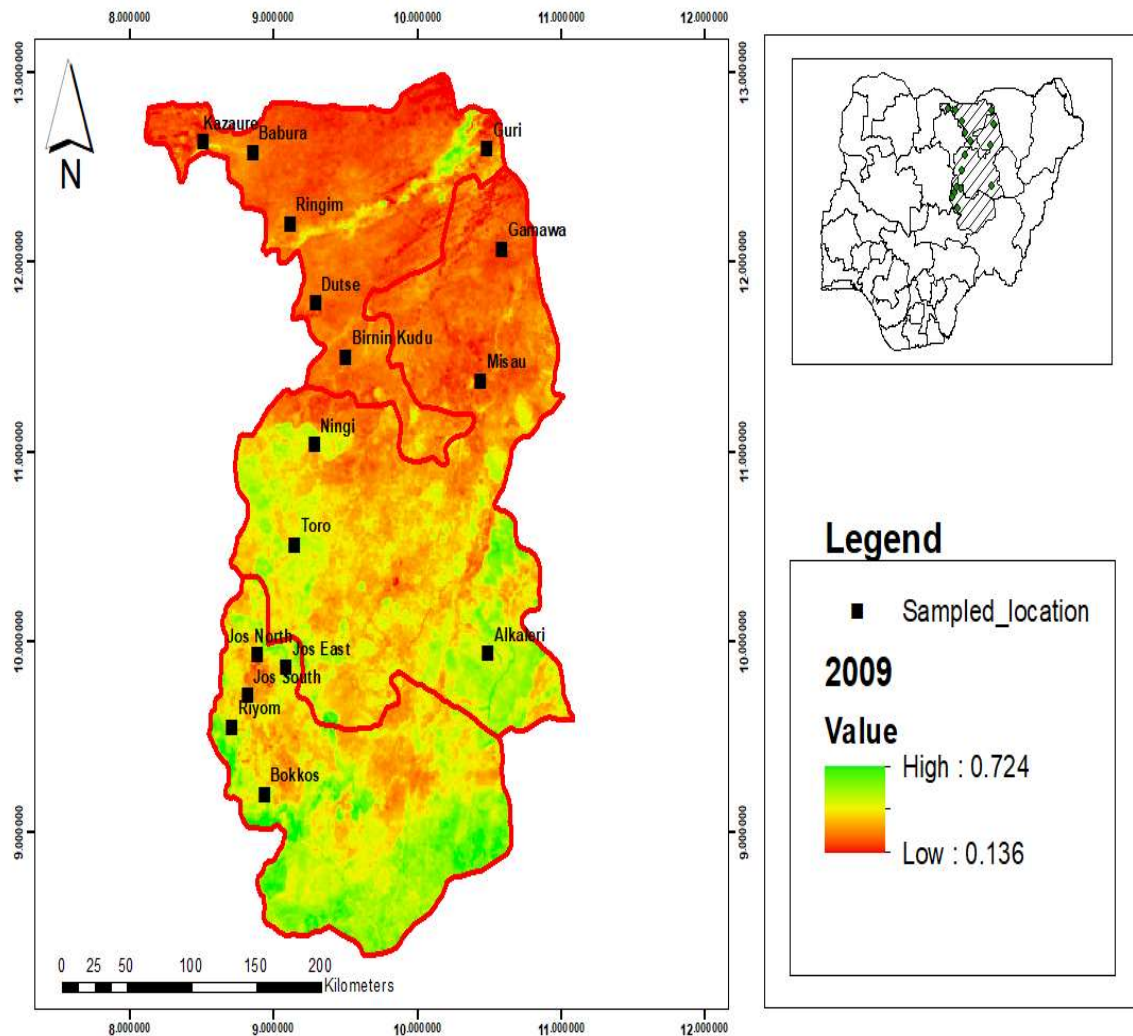


Fig 1b 2009 sampled locations

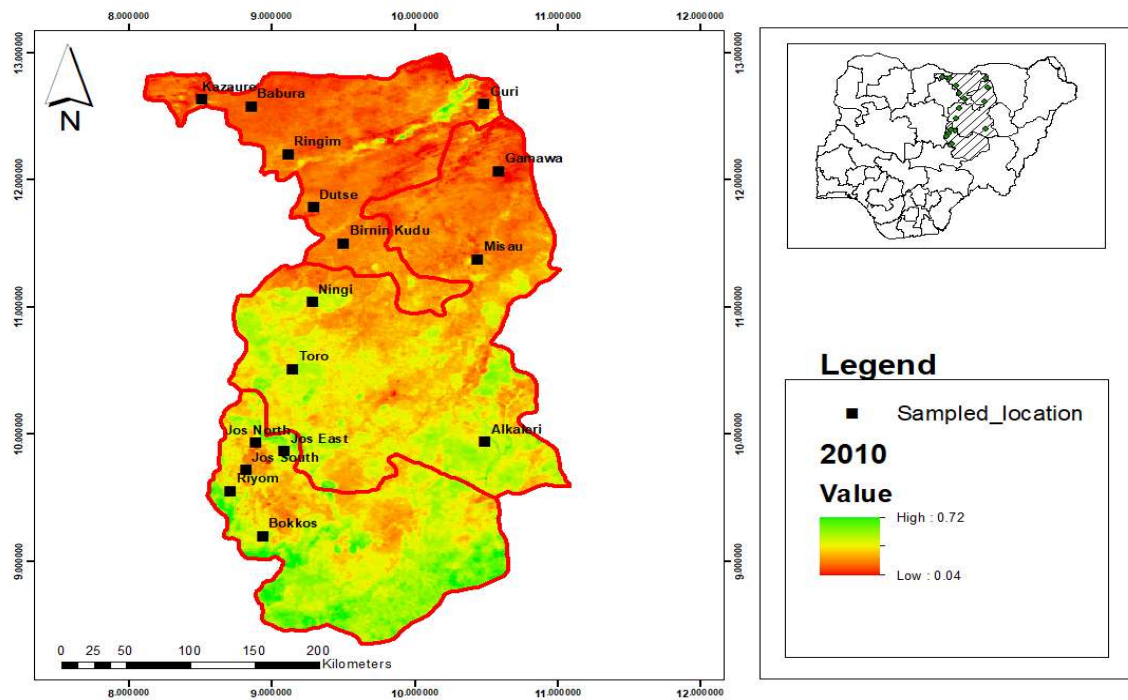
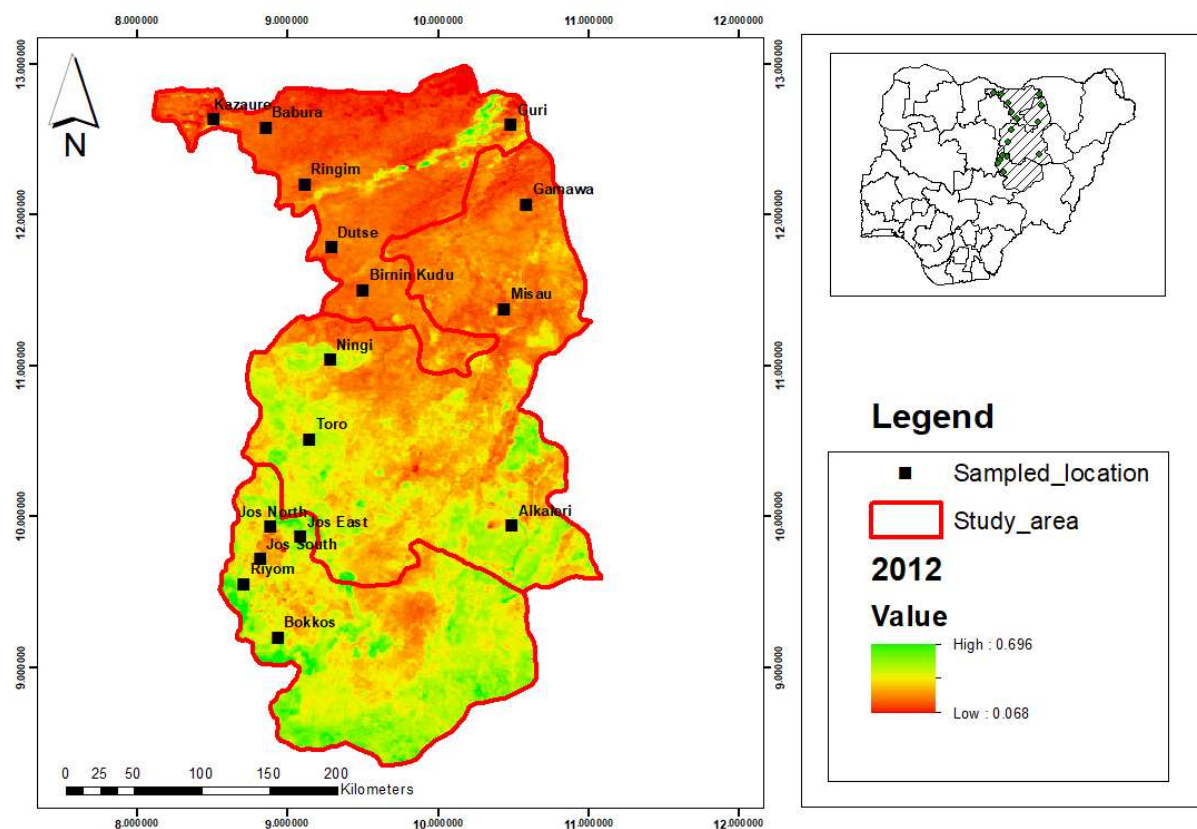


Fig 1c 2012 sampled location



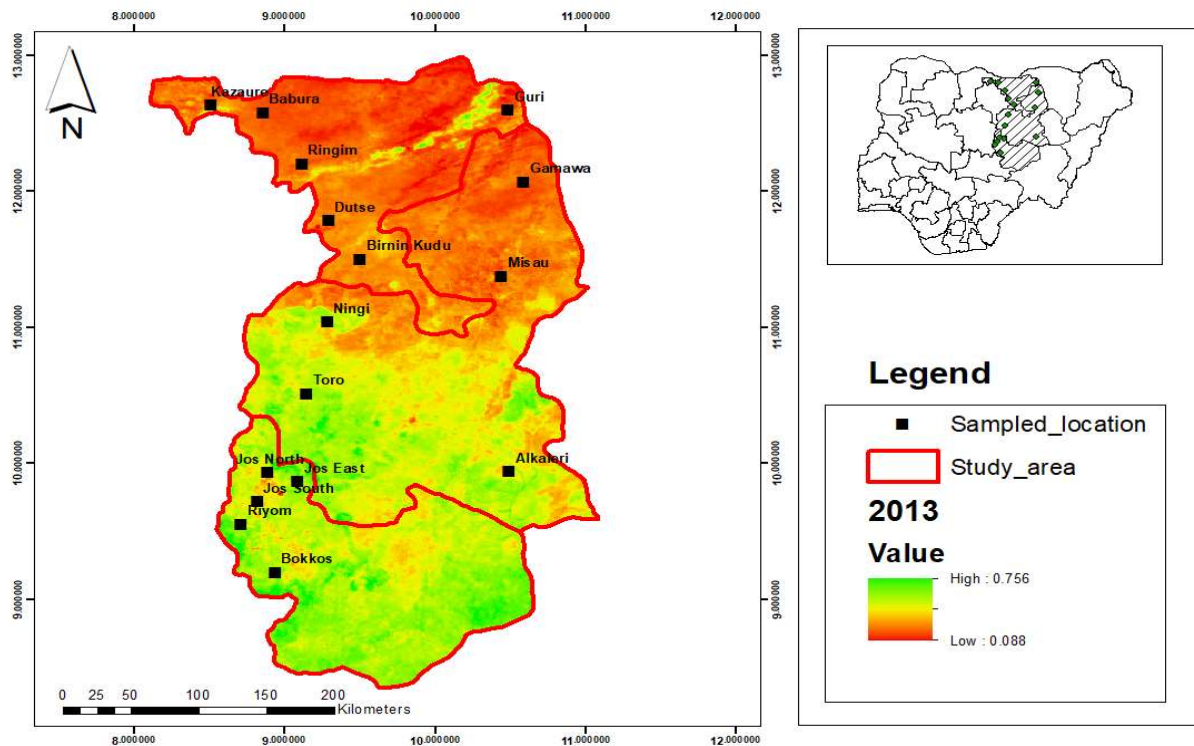


Fig 1d 2014 sampled locations

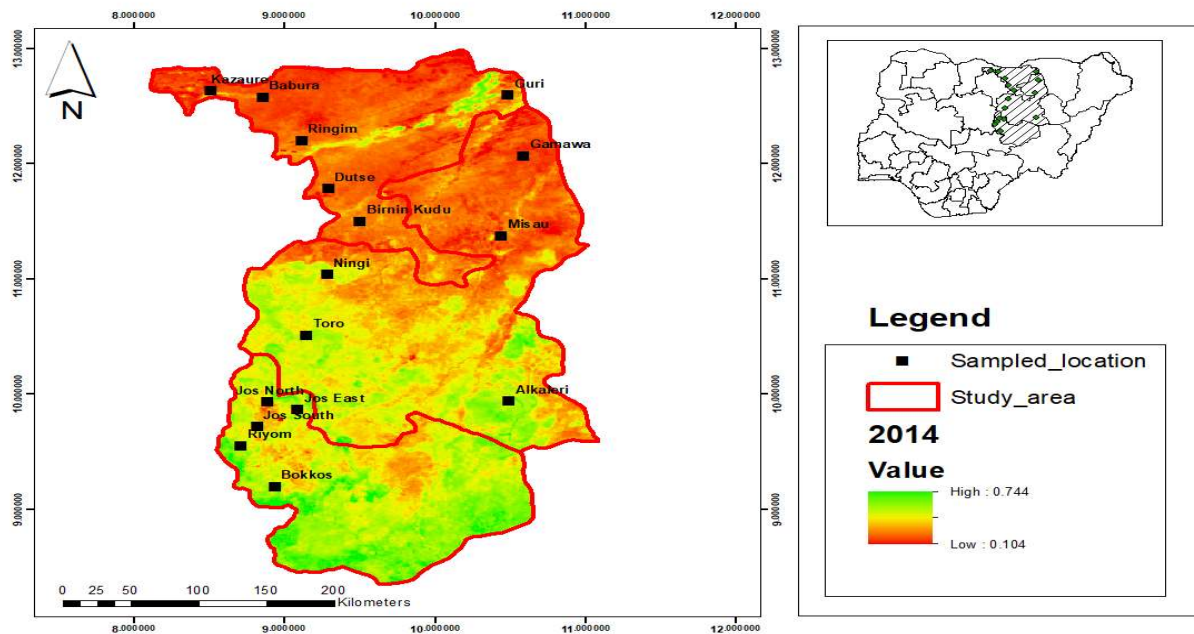


Fig 1e 2015 sampled locations

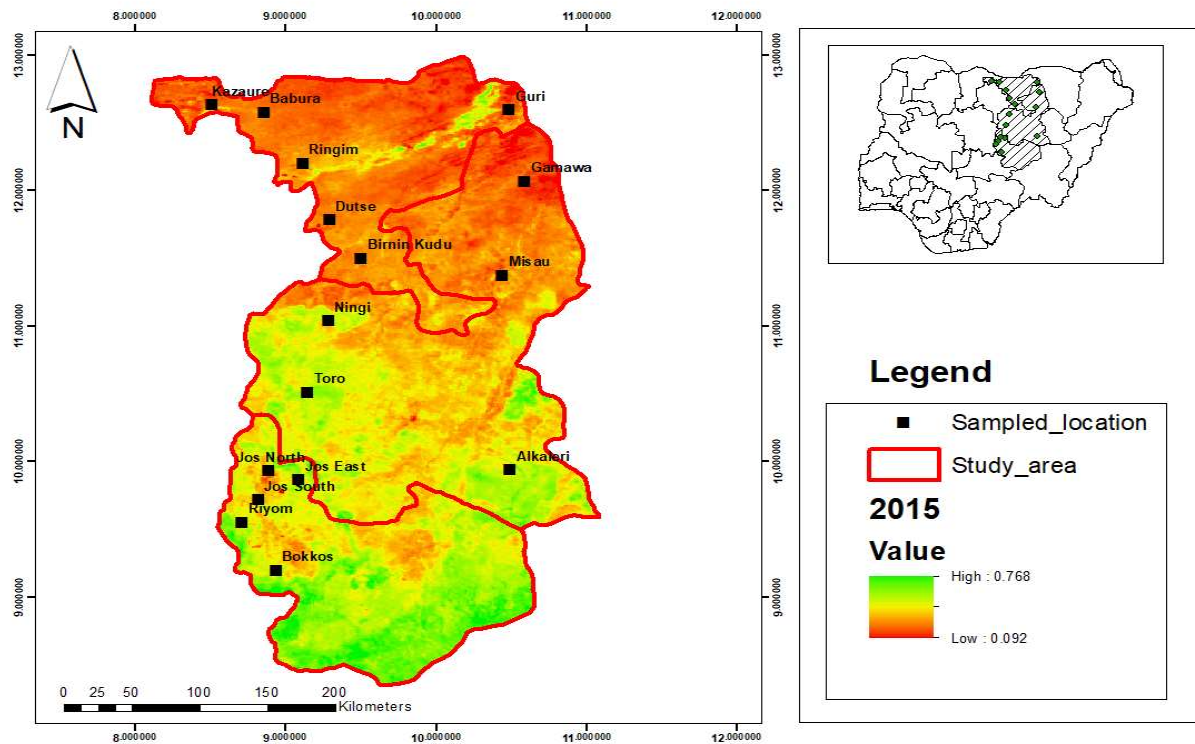


Fig 1f 2016 sampled locations

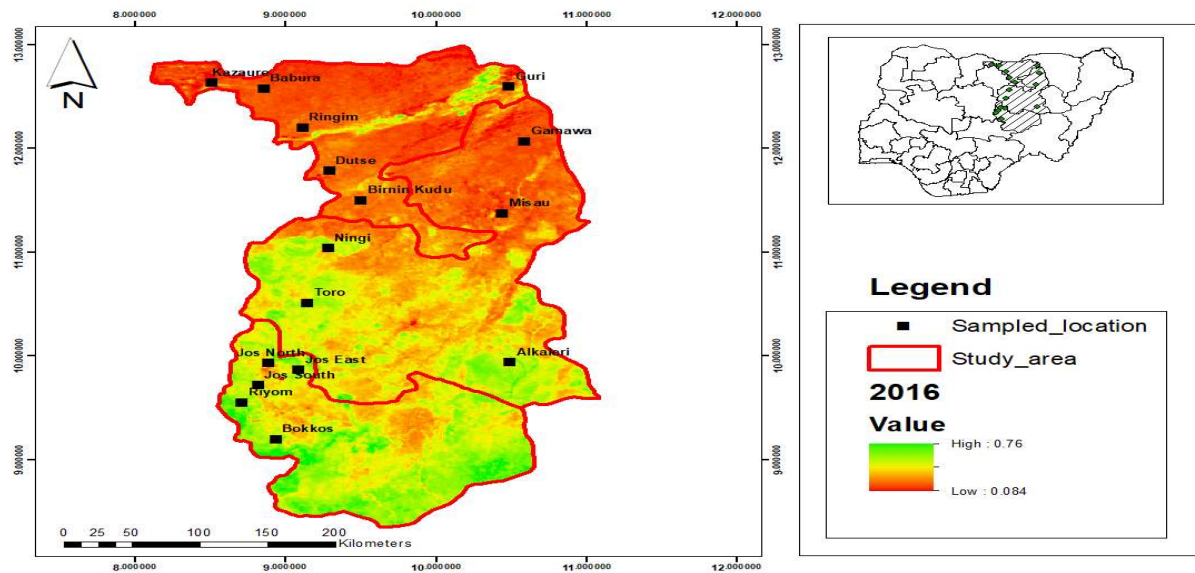


Fig 1g 2017 sampled locations

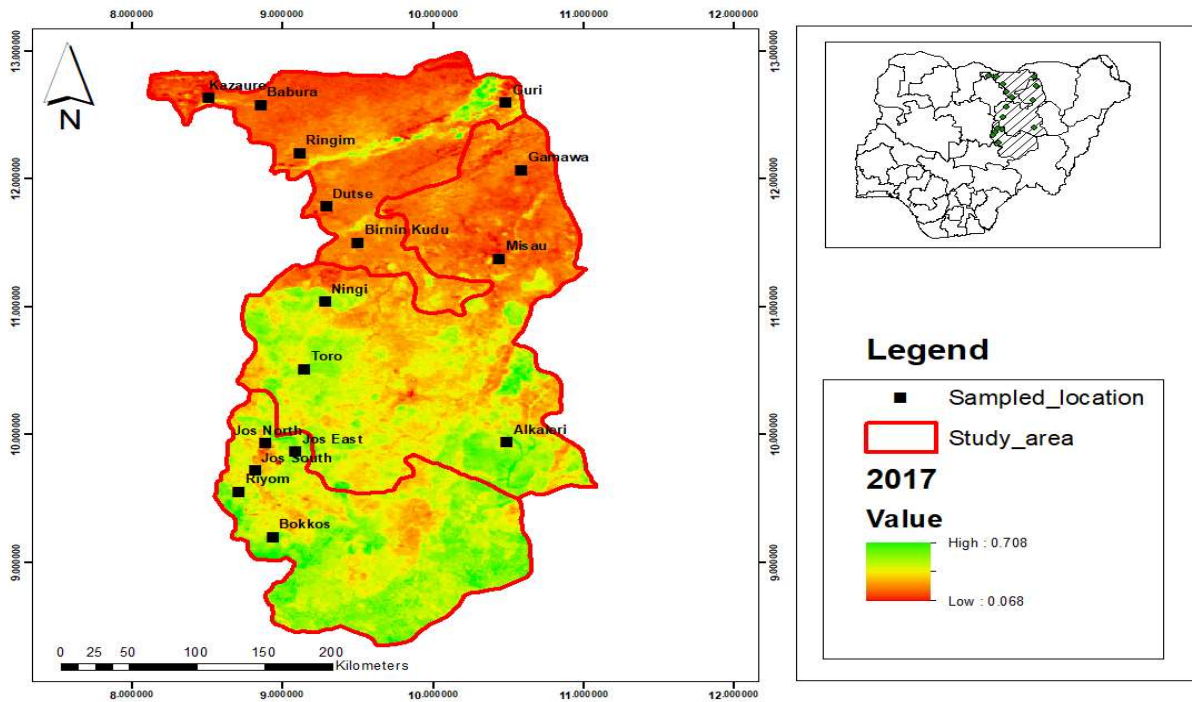


Fig 1h 2018 sampled locations

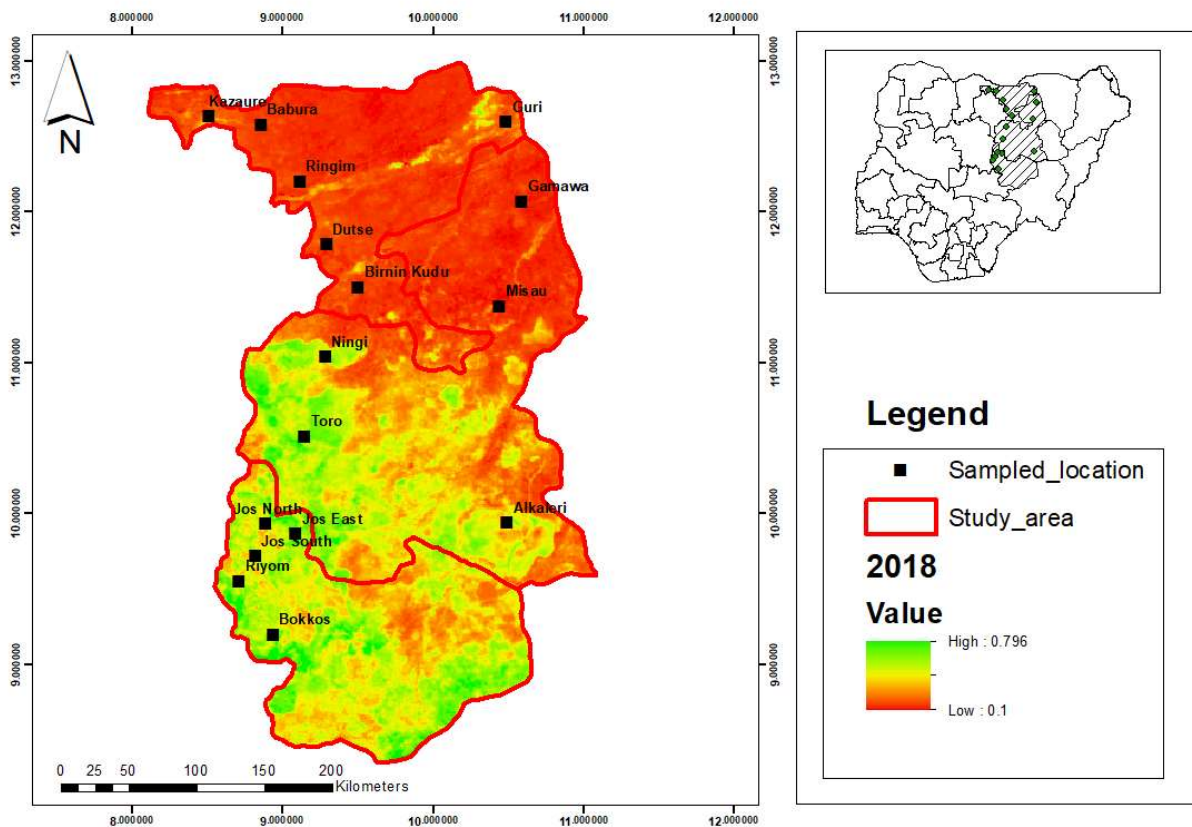


Fig 1i 2009 sampled locations

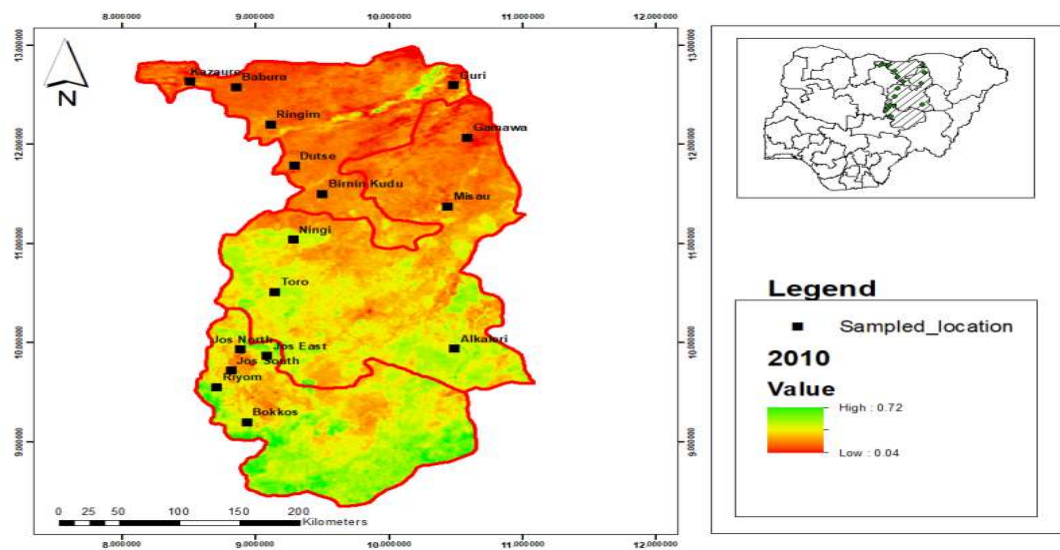
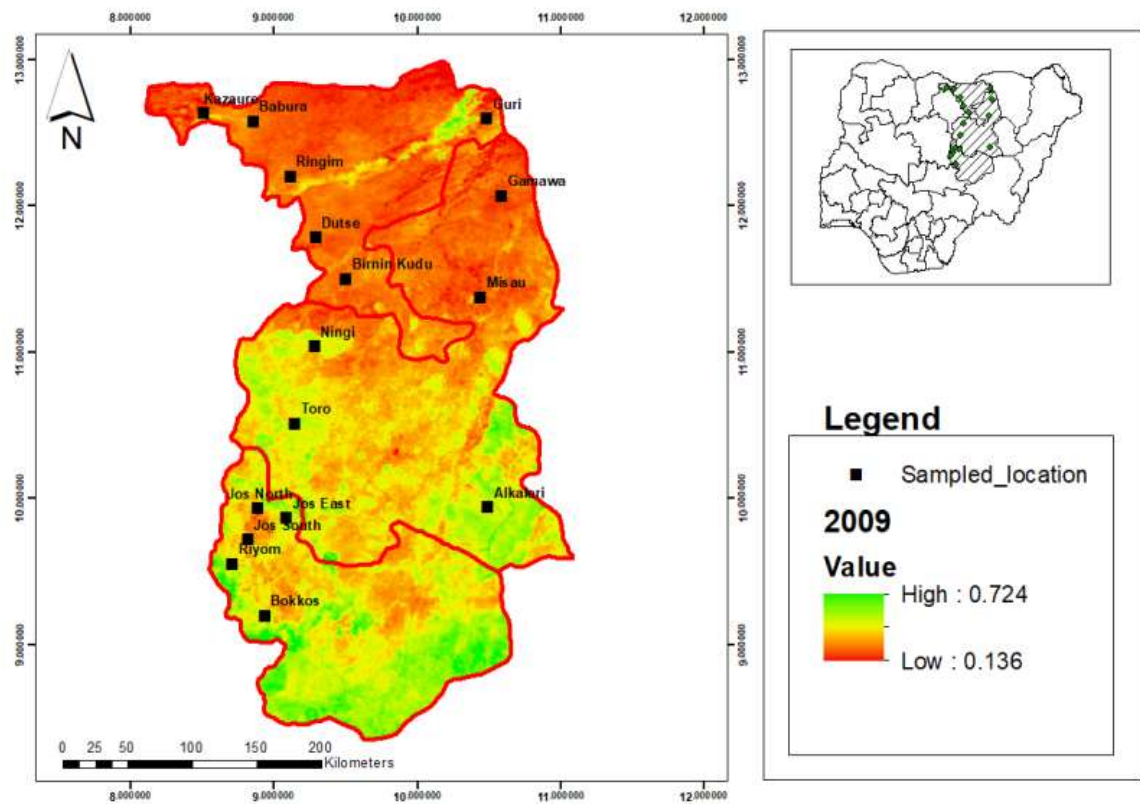


Fig 1j 2010 sampled locations