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Full Length Research Paper

An Assessment of mean and inter-seasonal variation during growing season across Kano region, Nigeria using normalized difference vegetation index derived from SPOT satellite data

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Kano Region covers Kano and Jigawa states both located in a semi-arid area of Nigeria that is characterised by large inter-annual variability in precipitation and consequently its vegetation. The aim of this assessment is to highlight changes in the mean and inter-seasonal variation of these variables that affected the general landcover of this area using Remote Sensing and GIS techniques. Fifty four (54) dekadal Normalized Difference vegetation Index (NDVI) images at 1km resolution from SPOT-4 and 5 Satellite System covering the growing season years from 1999 to 2007 were utilised within a GIS environment. Both the mean and a co-efficient of variation (COV) images covering the time series were derived from the assessment. Purposive sampling technique was also used to correlate the 2007 imagery to landcover reality through groundtruthing. The generated COV imagery was classified into seven classes showing percentage changes across the study area. Areas that exhibit highest coefficient of variation were found to be located within Jigawa state with few of such areas in Kano state. Although these changes during the growing season are attributed to anthprogenic factors in this semi-arid area, they are to a certain degree also attributed to climatic affects, particularly the changes on land cover across these two states in Nigeria.

Keywords: Dekadal, NDVI, Inter-seasonal variability, Growing season, Coefficient of Variation.

INTRODUCTION

Vegetation is one of the major components of earth physical parameters. Its presence protects the earth from the impact of solar radiation influx and it's lost or reduction exposes the earth to denudational activities which consequently may affect local, regional or global climatic changes. In most semi arid regions the continuous depletion of vegetation cover increases the level of degradation and this poses more serious environmental problems (Abubakar, 1998). Man in the quest of food, water, shelter, fuel and other comforts affects his environment with such actions triggering other

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natural events. (Eniolorunda 2007). John and David (1999) were of the view that twenty-five years ago thousands of people became malnurished as a result of vegetation being dried-up in the Sahel region of Africa during an extended drought.

Vegetation in particular has long been under destruction through fuel wood extraction, runoff, population pressure and urban encroachment. Thus, because of this anthropogenic activity most parts of the northern fringes of Nigeria have either experienced or are still experiencing some level of degradation in landcover (Yelwa, 2004).

In order to have a sustainable environment particularly in this semi-arid area there should be a systematic monitoring of vegetation dynamics. Such monitoring should also involve both accessible and even the inaccessible terrains at frequent time intervals, and to achieve this therefore, satellite remotely sensed data can conveniently be utilised.

The states of Kano and Jigawa located in the semi-arid area of Nigeria are subjected to regular seasonal dryness and high inter-annual variability in precipitation (Olofin, 2008). These characteristics in addition to human activities have exposed the region to serious environmental degradation. Although there were other studies on specific areas across the country which indicated that certain land cover particularly forested areas in Nigeria have changed due to different land use activities, the report on the level of implementation of Agenda 21 of the United Nations Conference on Environment and Development (UNCED, 1997) has shown that there is still persistent decline of land cover, and in particular, vegetated areas across Nigeria due to population pressure, overgrazing of marginal lands and other forms of landuse (Yelwa, 2008). Periodic monitoring for ecological sustainability was therefore suggested. The study by the Forestry Monitoring and Evaluation Coordinating Unit (FERMECU, 1996) on the assessment of forest covers across Nigeria which resulted in the production of 1:150,000 scale forest and land use maps covering the whole country has shown areas across the country from 1978-1995 where changes have taken place due to different types of landuse in operation. Since then, very little work have been conducted in this regard specifically the Kano region which covers areas in Kano and Jigawa states, which is the focus of this assessment. Although Abubakar (1998) and Yelwa (2008) covered these states broadly, they did not study them exclusively.

In is against this background that this study is set out to highlight specific areas within the Kano region exhibiting changes in the mean and inter-seasonal variability during growing seasons using NDVI data derived from satellite remote sensing.

The Study Area

The study area covers Kano and Jigawa states in the semi-arid part of Nigeria. This area is located between 7° 45´ E and 10° 35´E and between 13° 02´N and 10° 30´N. The area is bordered to the north by Niger Republic, to the west by Katsina state, to the southeast by Plateau state, to the east by Bauchi state and to the south-west by Kaduna state (Figure 1).

According to Olofin, (2008) the climate of the region can be described as dry-and-wet type. Rainfall is seasonal starting from May and ends in October, a period in which Vegetation grows. Olofin and Tanko (2002) reported that, the region is characterised by low rainfall (850-870mm) and high rainfall of about 4200mm in a wet year. The region is also characterised by high evaporation in the hottest months.

The natural Vegetation of the region is the savannah type consisting of Sudan and Guinea savannah types, three varieties of which are identifiable from south to the north. In the southern fringe from Tudun Wada in the west and Birnin-kudu in the east southward, it is the dry guinea savannah while the Sahel thorn bush occupies the northernmost tips. The normal vegetation has always been the dry Guinea in the southern fringe and the Sudan in the larger part of the region (Olofin, 2008).

According to 2006 population census, Kano and Jigawa states had a population of 9,383,682 and 4,348, 649 respectively (NPC, 2006). Such high population figures are likely to be influenced by birth and death rate as well as migration. Accordingly, the rate of anthprogenic activities is a factor that triggers changes in the local climates thereby posing more environmental degradation to the region.

MATERIALS AND METHODS

One hundred and sixty two (162) dekadal Normalized Difference vegetation Index (NDVI) images at 1km resolution from SPOT-4 and 5 Satellite Systems covering the growing season years from 1999 to 2007 were extracted using VGTExtract (VGTExtract User's Guide, 2010) and imported into Idrisi Andes Geographical Information Systems (GIS) and Image processing software within a GIS environment.

All the data in the time-series were converted into ASCII format and imported in to EXCEL where they were re-composed into mean and a co-efficient of variation. Thus, for each of the 3 dekadal NDVI data for each month, they were re-composed into Mean Monthly Value Composites (MMVC) for each month of the growing season (May-Oct) and for each season of the time series.

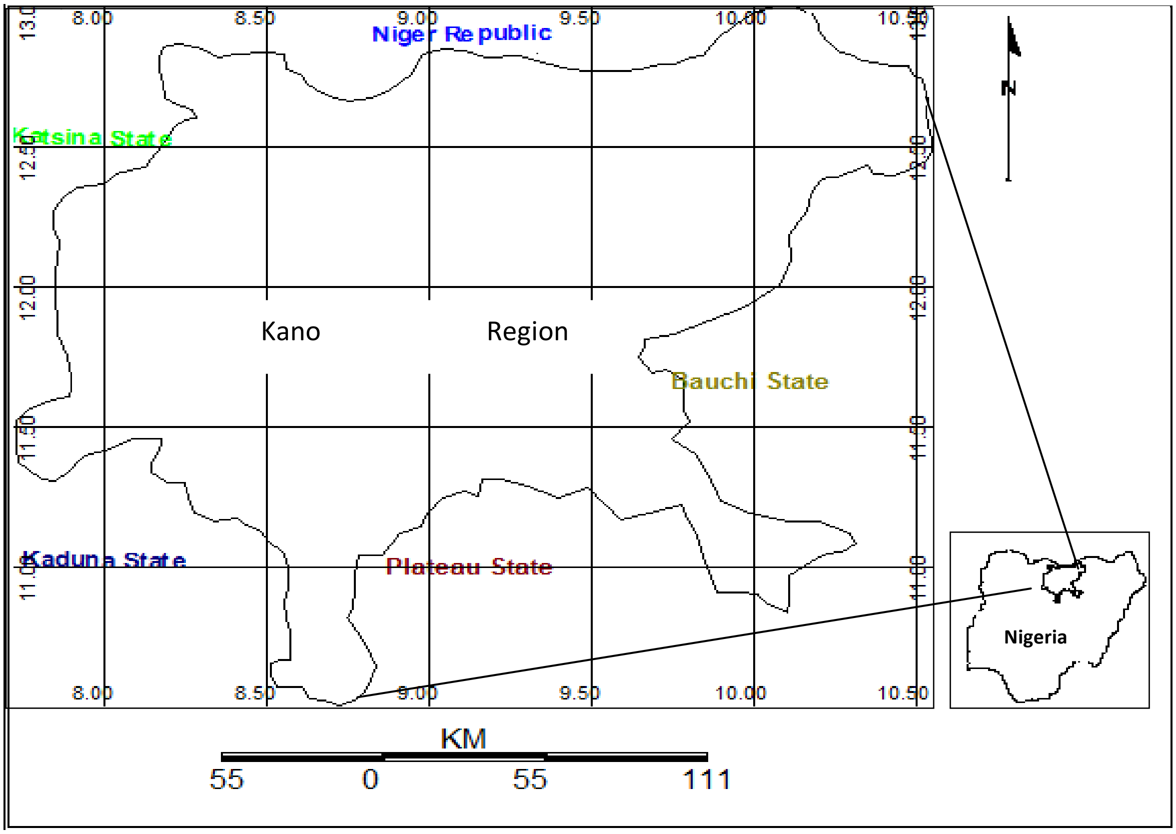

Figure 1. Map of the Kano Region covering Kano and Jigawa States

The re-composition procedure reduced the total dataset for the final analysis to 54 MMVCs. These were further re-converted and exported back to the Idrisi Andes software and the data was finally utilised in a GIS environment and analysed.

The Coefficient of Variation and Mean images were derived as:

$$cov = \frac{\sigma}{\mu} * 100$$

Where

COV = inter-seasonal coefficient of Variation

δ = Standard Deviation

and

μ = Mean

A photo layer was created and used during the ground truthing which were restricted to areas of high COVs and a Global Positioning System (GPS) was connected to a laptop with way points being recorded. Pictures of the different landcover/landuse types were taken so as to facilitate the classification process. Analyses of the changes were undertaken using the coefficient of variation images. At each sample point the vegetation type and current landcover were determined (See Table 1 and Figure 2). These sampled points represent the condition of the sample pixels.

RESULT AND DISCUSSION

Results of the analysis are presented in Table 1 and Figure 2. The overall mean growing season NDVI image on Figure 2(a) shows a pattern of disparity between the northern and southern part of this region. The mean image shows a typical growing season pattern covering the time-series representative both of Kano and Jigawa states. The southern part clearly shows a more intensive agricultural activity both in the dry and rainy seasons while the southern part show a low vegetation biomass based on the NDVI. Figure 2(b) shows the inter-seasonal coefficient of variation (COV) of the study area where more variation exist along the rivers. Although the study by Yelwa (2004) agrees with some of the results obtained here, however, the variation on this study are more

Table 1. Sampled sites showing areas with high COV

Sampled Sites		Longitudes/ Latitudes	Land use	Nature of site and description	Type of Invasion	COV (%)
A	Saleri (a)	10 20 36/ 12 46 38	Rainfed and irrigation Farming/Grazing	Rice, cassava, ginger bread palm, Typha grass, millet, and Mango trees.	*Typha* sp plant	11.05%
B	Saleri (b)	10 22 30/ 12 48 00	Rainfed and irrigation Farming/Grazing	Rice, cassava, ginger bread palm, Typha grass, millet, and Mango trees.	*Typha* sp plant	12.07%
C	Balinsheri (a)	10 18 42/ 12 39 21	Rainfed and irrigation Farming/Grazing	Rice, cassava, Typha grass, ginger bread, millet and Mango trees.	*Typha* sp plant	10.89%
D	Balinsheri (b)	10 21 42/ 12 45 03	Rainfed and irrigation Farming/Grazing	Rice, cassava, Typha grass, ginger bread, millet and Mango trees.	*Typha* sp plant	12.63%
E	Makintari (a)	10 12 40/ 12 33 20	Rainfed and irrigation Farming/Grasing	Rice, cassava, Typha grass, ginger bread, millet and Mango trees.	*Typha* sp plant	12.23%
F	Makintari (b)	10 13 03/ 12 33 47	Farmig/Grasing	Rice, cassava, Typha grass, ginger bread, millet and Mango trees.	*Typha* sp plant	10.08%
G	Kadawa	8 29 43/ 11 40 27	Rainfed and irrigation Farmig	Maize and rice	*Typha* sp plant	12.79%
H	Duddurun Gaya	11 36 43/ 8 43 13	Grazing	Wild Bauhania, Jujube, “farar kaya” Cessia and ‘Geron	Grass	11.89%

Source: Ground Truthing, 2010

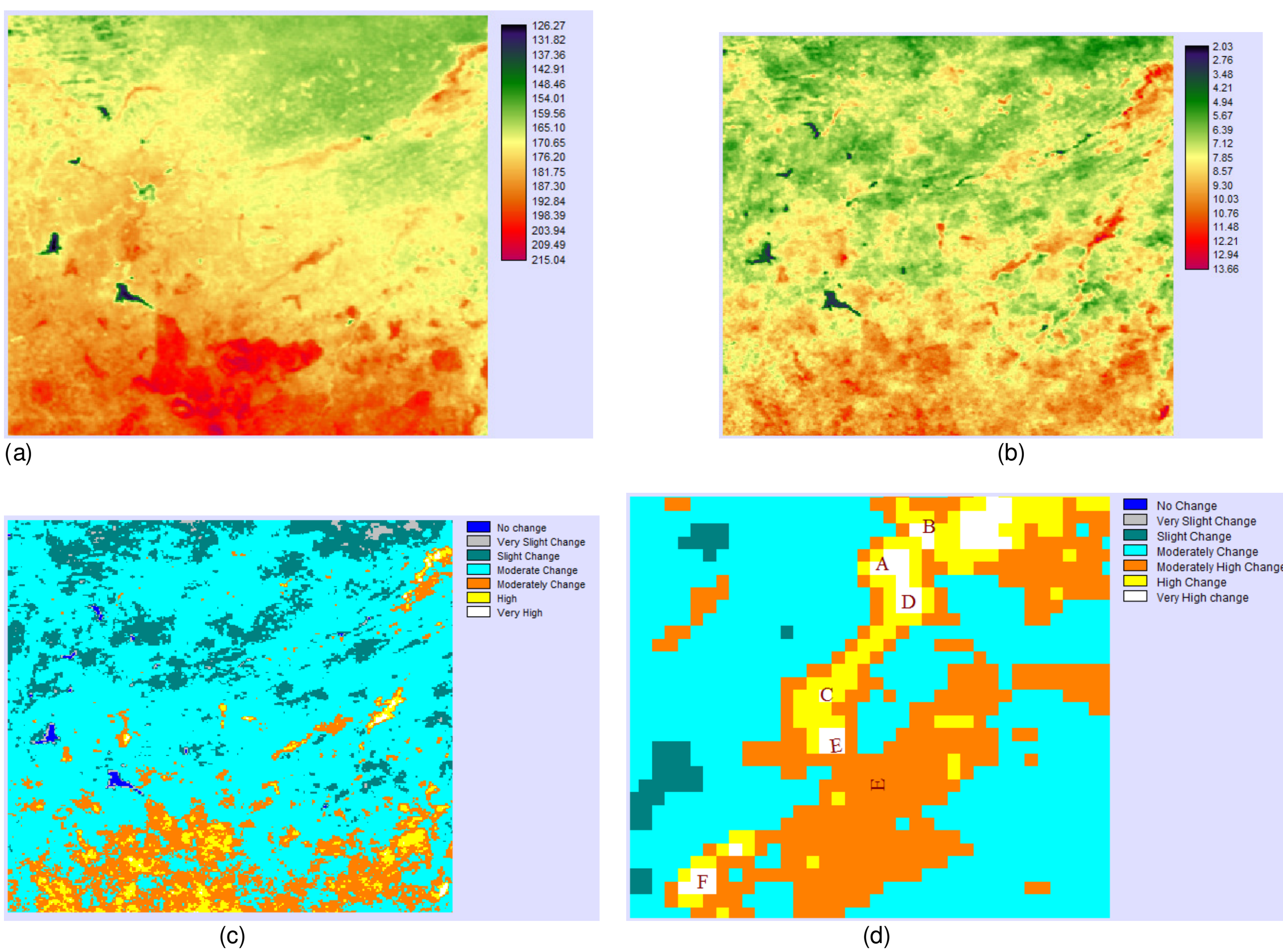

Figure 2. Mean NDVI and change images covering the study area. (a) shows the Mean Annual Imagery of the study area (b) shows zoomed areas of high Coefficient of Variation during the growing seasons of the time-series (1999-2007) within the Study area while (d) shows the classified change image from the Coefficient of Variation Image showing areas from no- change to areas of high coefficient of variation within the study area.

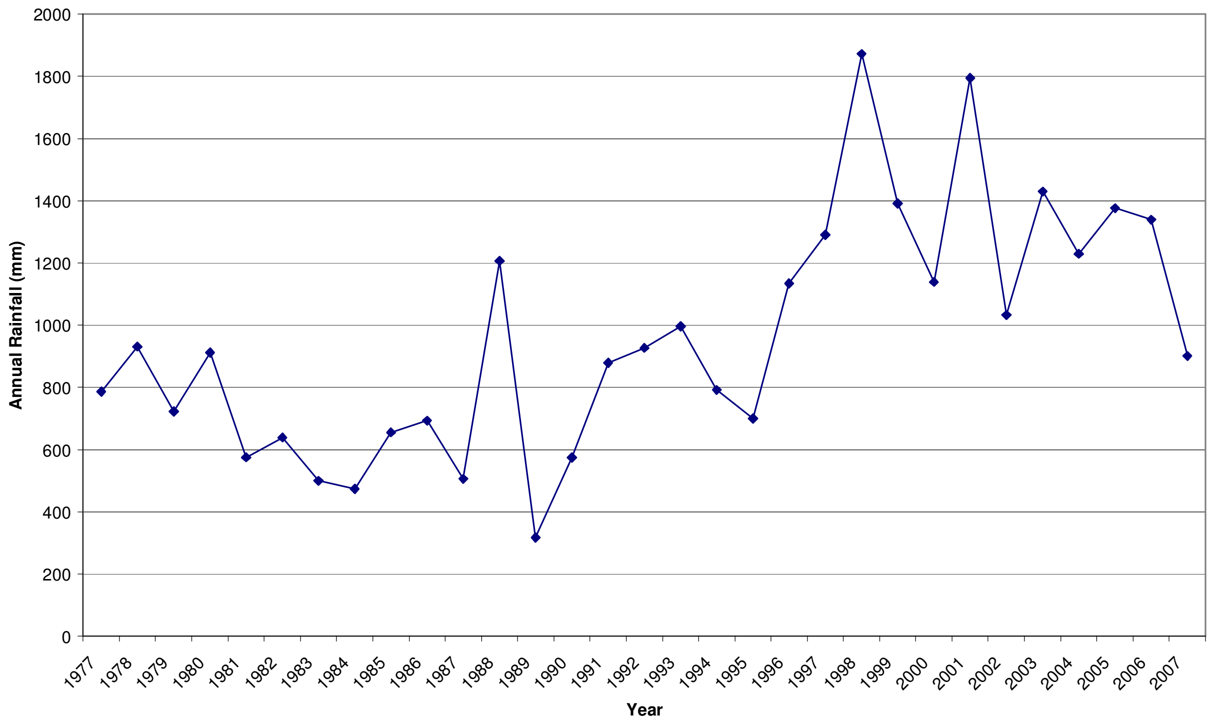

Figure 3. Long term trend of Rainfall across the Study Area (Source: Nigerian Meteorological Agency)

localised around the Hadejia-Jama'are wetlands as well as around the dam sites. This image shows how the inter-seasonal variation of NDVI vegetation biomass corresponds to land cover reality based on the ground truthing. Thus, the COV image infers the existence of a signal of rapid, dynamic land degradation.

Sampled sites of groundtruthed information were presented in Table 1 showing areas of high COV and typical vegetation and landuse as the time of ground truthing in 2010. As the last class on the classified COV image indicated, areas that underwent high changes throughout the growing seasons were indicated. By implication, the degradation is much and, are localised around the Hadejia wetland of Jigawa State with the exception of Kadawa and Duddurun-gaya areas falling in Kano State.

Most of the areas covered with water based on the NDVI imageries between 1999 to 2005 are now somewhat degraded as many areas have dried-up. The main landuse activities around these areas are cultivation of millet, cassava, and rice, which are overtaken with grasses in areas where there are no cultivation during the dry season. The dominant woody trees found comprised of date palm, neem and mango scattered at the edge of some water areas. With regards to land cover within Kano state generally, places that exhibited high COV are located around Kadawa and Duddurun Gaya. In Kadawa area for example, the "kachala" *Typhacea* plant can be seen in some places although not too prominent in Kano state compared to areas visited in Jigawa State. However, the variation in Duddurun Gaya can be attributed to the high level of grazing by animals in the area.

In all the sampled areas visited during the ground truthing, both rainfed and irrigation cropping system were being practiced but in the whole study area most water bodies were pervaded with the *Typha* sp plants and the content of water was seen to be reducing due to the presence of this plant except in Dundurun-Gaya. Although the study conducted by Tucker *et al;* (1991) covering the arid areas of the African continent are of the view that some of the features that exhibited high COV in such region are likely to have changed as a result of variation in rainfall amount (Figure 3), this study however, pointed to the fact that anthropogenic factors are likely to have more impacts on the landcover than climatic variables although a more detailed study is required to confirm this.

Furthermore, based on interviews conducted with farmers within the study area, most of them were of the view that the emergence of the *Typha* sp plant, (though beneficial to a certain degree because at a certain stage its appearance within the area shrinks the water thereby providing them with more available land on which they grow more food crops) have drastically changed the appearance of the general land cover in these areas.

Certainly, food production around the area exceeded what was obtainable many years ago when there was no invasion of the *Typha* sp plant and consequent reduction in the volume of water. Accordingly, in the past 10 years a farmer around the area was harvesting about 80 sacks (each sack is equivalent to 50kg) of farm produce at the end of each growing season, but this has now increased to 100 sacks or more.

CONCLUSION

Although this assessment is broad in nature covering a large area, it only highlighted the changes in land cover taking place in some specific locations based on the mean and inter-seasonal variations of growing seasons NDVI. However, results have shown that there are clear evidences of changes in landuse/landcover particularly within the wetland and irrigated areas around the dam sites. Though the results indicated that the COV-NDVI values are small in some areas, but because of the nature of the region being located in a semi-arid area, they can be sensitive to very small inter-annual variations in surface reflectance, atmosphere, sensor calibration and image registration (Huete and Tucker, 1991) even though the data used in this study has undergone all necessary calibrations and corrections. In general though, the study has shown that the use of Remote sensing data analysed within a GIS environment for the assessment of seasonal variation within a growing season in this semi-arid area if periodically carried out in conjunction with climatic variables using robust modelling techniques would go a long way in assisting stakeholders and policy makers locally and regionally during this era of climatic change debate.

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