Spatio-Temporal Vegetation Cover Change as an Analytic Technique for Appraising Desertification in Katsina State, Nigeria

Bishir Gambo Saulawa
Department of Environmental Science, University of Botswana, Gaborone

DOI: 10.29322/IJSRP.8.11.2018.p8313
http://dx.doi.org/10.29322/IJSRP.8.11.2018.p8313

ABSTRACT: In order to establish one of the physical manifestation of desertification the study set out to quantify the vegetation cover change in Katsina State from 1984 to 2014. The remotely sensed technology combined with GIS used the Normalized Difference Vegetation Index (NDVI) to analyze the vegetation cover change. Landsat data comprising monthly images for the wet season (May, June, July, August and September) were generated from the United State Geological Survey (USGS) dataset. The images were extracted from the Path/Row WRS 2 188/051, WRS 2 189/051 and WRS 2 189/052. The NDVI data was processed with the ENVI Software and cropped with the Global Mapper. The result showed a significant decline of vegetation cover on the Path/Row 188/051 and 189/052 which covers the Sudan Savannah and the Sahel Savannah of the study area.

Keywords: Desertification, Remote Sensing, Normalized Difference Vegetation Index (NDVI), ENVI Software

INTRODUCTION

One of the overwhelming environmental challenges in Katsina State is desertification. However, very few studies have been done to explain its manifestation. These few studies focused on a generalization of the desertification, manifestation, impact, and control across the country e.g. [1, 2, 3, 4, 5]. Thus, local or site-specific cases are not well understood. In most of these studies, the focus has been mainly on indicators such as sand mobilization and decline in forest reserves. Little has been done to report the manifestation of desertification comprehensively regarding vegetation cover decline in time and space in the study area.

According to [6,7,8] the more visible manifestations of desertification include an overall reduction in species diversity and plant biomass in dryland ecosystems. In absolute terms vegetation degradation or decline. As such, comparative vegetation cover change over time is central to finding out the appearance of desertification and the effectiveness of the control measures in the study area [9].

Thus, in monitoring degradation and desertification, indicator based approaches are often used from the global to the local scale [10]. The vegetation index (NDVI) is an index of green vegetation richness based on reflected visible near infra-red light intensity and wavelength measurement [11].

Monitoring of these changes is ideally accomplished from multi-temporal remotely sensed data [12]. Aerial photographs and multi-temporal Landsat data are used to study land use transformation [12, 13, 14, 15]. The result from multi-temporal remotely sensed images are usually compared with each other to detect the change area and to assess the severity of desertification. The established relationship between land covers spatially and temporally will reveal the state and tendency of the phenomenon.

NDVI was used as a proxy for vegetation cover by many researchers such as[16] in their study on monitoring desertification in Southern Tunisia and [17] in a study of trends in NDVI time series and their relation to rangeland in Senegal. Additionally, [18] used

NDVI in remote sensing and change detection in rangeland; [19] in their work on monitoring desertification in Central Asia and Western China using long-term NOAA-AVHRR NDVI time-series data. The NDVI was also used by [11] in their work on regional desertification; [20] in West Africa on desertification, drought and surface vegetation; [21] in their work in Morocco. This study used NDVI as a proxy for vegetation cover change.

MATERIALS AND METHODS

The data for changes in vegetation was determined using remotely sensed NDVI data to assess manifestations of desertification and effectiveness of control measures. Since the early 1980s, remote sensing has played a significant role in the acquisition of spacio-temporal data [22]. The fluctuation in vegetation cover can be monitored by the use of NOAA's Advanced Very High-Resolution Radiometer (AVHRR).. Landsat data comprising monthly images of NDVI for wet season (May, June, July, August and September) were generated for the years 1984 and 2014 of the study area from the United States Geological Survey (USGS) dataset. It is a reliable dataset which has produced 1km advanced very high-resolution radiometer (AVHRR) satellite datasets. The dataset is comprised of a time series of weekly, bi-weekly vegetation condition or greenness composite based on the NDVI. The dataset consists of a global collection of ortho-rectified cloud-free Landsat images from 1999 to date. The choice of the years 1984 and 2014 is predicated on the need to handle and analyse the data with a certain degree of accuracy.

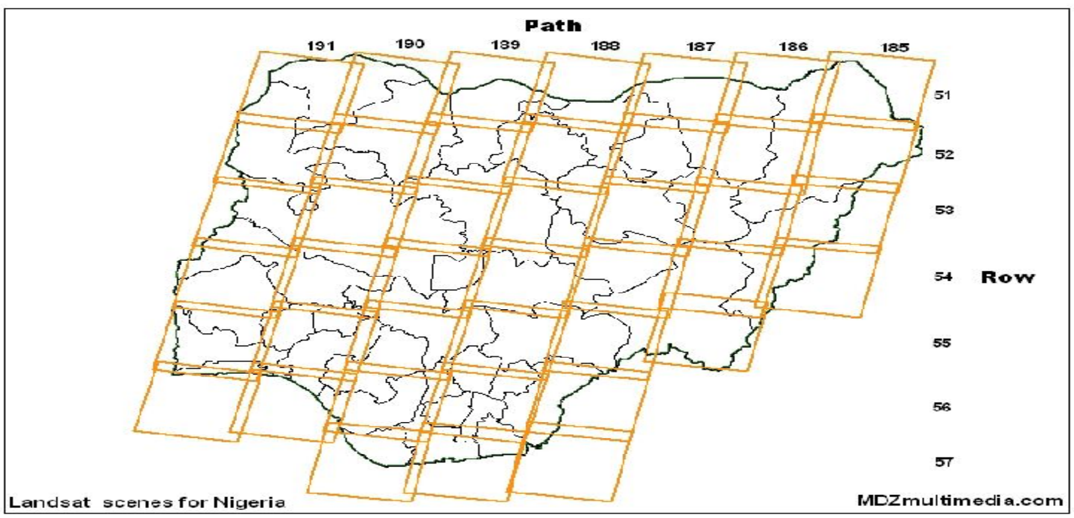

Figure 1 Land sat Scenes of Nigeria

As a result, images accessed from the 1984 and 2014 were used which allowed the study to fulfil the objective of defining the vegetation change over the envisaged thirty years'. The Julian date in Table 1 and the Path/ Row/Images in Table 2 validate the accuracy of the data used for the examination.

Table 1 Julian Dates

YEAR	May	June	July	August	September
Normal Year	121 – 151	152 – 181	182 - 212	213 - 243	244 – 273
Leap Year	122 – 152	153 – 182	183 - 213	214 - 244	245 – 274

Source: http://landweb.nascom.nasa.gov/browse/calendar.html

The data were collected from the following Path/ Row for the images of 1984 and 2014 as tabulated in Table 2 below:

Table 2 Path/Row/Images-1984 and 2014

Path/Row	Images (1984)	Images (2014)
WRS2 188/051	LT51880511984252XXX04	LE71880512014134ASN00 LE71880512014262ASN00
WRS2 189/051	LM51890511984179AAA03 LT51890511984179XXX04	LE71890512014269ASN00 LE71890512014141SG101 LE71890512014157ASN00
WRS2 189/052	LT51890521984179XXX03	LE71890522014141SG100 LE71890522014269ASN00

RESULT/ANALYSIS

Visualization and analysis of available data were carried out using image processing and analysis tools integrated with GIS. The Image processing of NDVI data obtained from USGS dataset was carried out with ENVI software, best suited to process satellite images and further cropping of the images in the Global Mapper. The study was predicated on changes in vegetation cover over a 30-year period from 1984-2014 to handle and analyze the data with some degree of accuracy. The path/rows in the study area are 188/051, 189/051 and 189/052 by WRS 2 standard. The available scene/images for 1984 and 2014 were accessed and analyzed consistent with the objective of the study to detect vegetation cover change over time in the study area

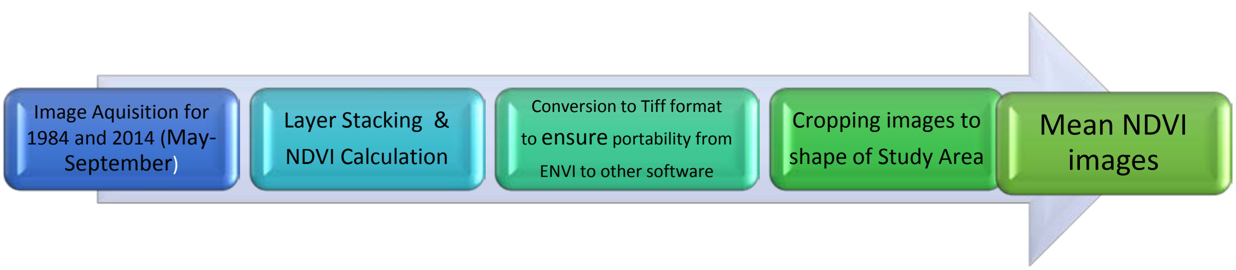

Figure 2 Flow Chart of the raw data processing in the ENVI software

Source: Field Survey (2015)

The images were extracted from the study area (5 images, each for1984 and 2014). The layer stacking tool was then applied to import all the five images per year into one output as shown in Figure 2 above. The Landsat data was independently classified based on NDVI values ranging from -1 to + 1 using a Global Mapper. The water and cloud reflect more in the visible band than they do in the near infrared band; therefore, they have negative NDVI values, whereas bare soils and rock have an NDVI value around zero. Healthy green vegetation, on the other hand, has a stronger infra-red reflectance thereby providing NDVI values close to +1 [23, 24].

The computed NDVI values are consistent with the general savannah ecology of dense to a sparse vegetation pattern from the south to northern part of the study area. Figures 3 and 4 show the mean NDVI images for the years 1984 and 2014. The NDVI values for 1984 range between -1 to +1 for the study area across the agro-ecological zones. However, the values for 2014 showed significant variation, especially in the northern parts of the study area on Path/Row 189/051 where NDVI values range between -0.400 and +0.480 and on path/row 188/051 with values of -.0500 to -0.520 as elaborated in Table 3. Without a doubt, the period 2014 reveals an increase in the bare lands as well as reduced vegetation cover in the Northern parts of the study area, which represents the Sahel and Sudan Savannah. The study conducted in Mau complex, Kenya by [25] equally showed that similar changes in vegetation cover had occurred and resulted in the forest cover reduction between 1973 to the year 2010. Further, the findings reflected an assessment of the effect of desertification in Yobe State, Nigeria by [26], which revealed a similar pattern of tremendous increase in the bare surface between 1986 and 2009. The findings further trail the line of argument of [27] in a similar case in Burkina Faso, which posited that the loss of recovery potential of the bare soils in spite of increased rainfall shows the irreversibility, and thus the human factor in the observed land degradation.

Table 3 Calculated NDVI Values for 1984 and 2014

Path/Row	1984	2014
188/051	-1 - +1	-0.500 – +0.520
189/051	-1 - +1	-0.400 - +0.480
189/052	-1 - +1	-1 - +1

Source: Field Survey (2015)

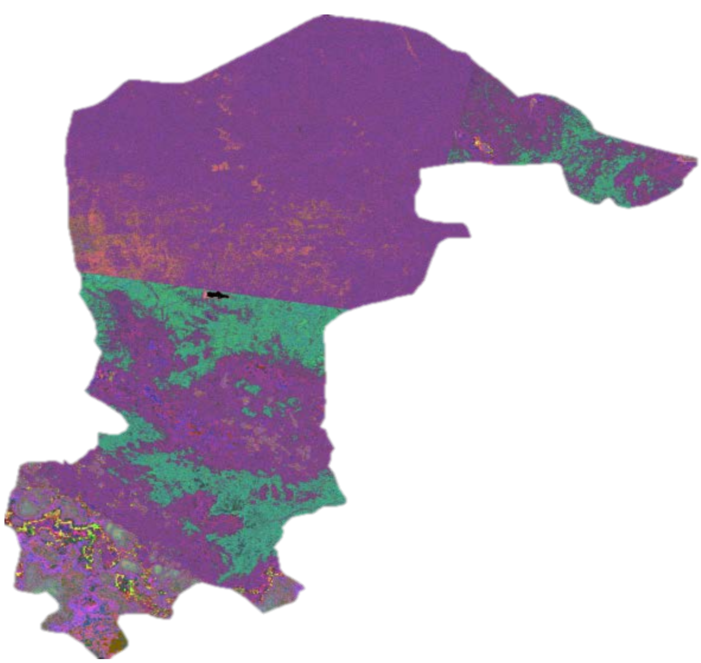

Figure 3 Mean NDVI Katsina _1984(Red)

Source: Field Survey (2015)

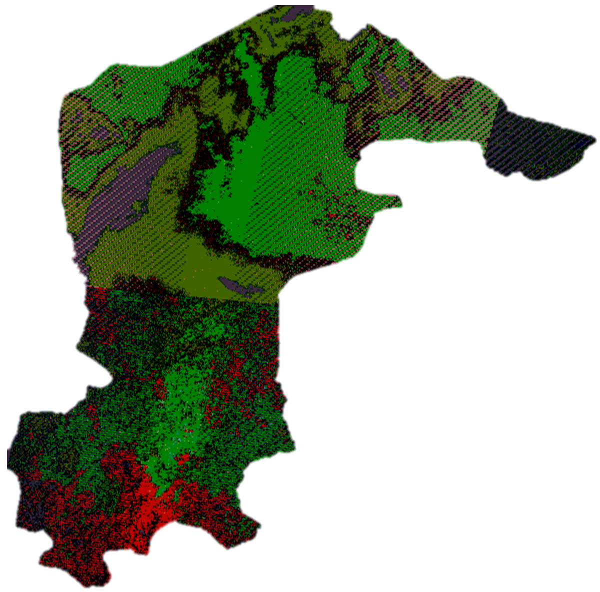

Figure 4 Mean NDVI KT_2014 (Enhanced)

Source: Field Survey (2015)

CONCLUSION

It could be deduced that the apparent vegetation cover decline from 1984-2014 in the study area have an effect on life supporting abilities of the ecosystem, human health and on the economic and social performance of the farming families. In simplistic terms there had been a 52%-60% decline of vegetation cover in the path/ row 189/051 and 48%- 50% in the path/row 188/051 of the study area, which represented the Northern part of the State covering a part of the Sudan Savannah and the totality of the Sahel Savannah zone. It is as a result of the decline in vegetation cover that some of the livelihood undertakings and strategies are affected in the study area. The vegetation cover plays an important role in soil retention. The land of the study area is exposed to wind and water erosion as a result of the vegetation cover decline and thus, could not provide the required provisioning, regulating and supporting services for the enhancement of the livelihoods of the farming families. Where such conditions of degradation occur whether in arid, semi-arid and/or dry sub-humid regions as result of climatic variations or human influence, desertification become fully well-defined.

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