World Journal of Advanced Research and Reviews
eISSN: 2581-9615 CODEN (USA): WJARAI
Cross Ref DOI: 10.30574/wjarr
Journal homepage: https://wjarr.com/

(Review Article)

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Spatial variation of vegetation changes in Sokoto region from 2000 to 2018

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World Journal of Advanced Research and Reviews, 2022, 13(03), 329–336

Publication history: Received on 27 January 2022; revised on 15 March 2022; accepted on 17 March 2022

Article DOI: https://doi.org/10.30574/wjarr.2022.13.3.0116

Abstract

Previous researchers reported that vegetation is one of the natural resources that are constantly changing. These changes are mostly found in an area affected by human activities. Those researchers study vegetation using holistic approach without identifying the locations affected and species of plant that withstand the prevailing conditions. The aim of this research was to find out the locations where these changes are mostly affected. This was achieved using Coefficient of Variation analysis on MODIS-EVI dataset, supported by the field observation. The result shows that high CV areas are mostly around farmlands and around the nomadic routes, while low CV areas are around the floodplains of Rivers Sokoto and Rima. The identified plant species that can survive in the high CV areas are Gueira senegalensis (Sabara), Combretum micranthum (Geza) and Piliostigma thonningii (Kalgo). It was recommended that the dominant plant species in the area should be domesticated and used for afforestation programme in the region. Government should provide adequate grazing reserves and animal routes to avoid indiscriminate grazing activities in the area.

Keywords: Vegetation; Coefficient of Variation; Sokoto region; Plant species

1. Introduction

Vegetation Resources are those resources that are derived from the flora and are of immerse important to man, animals and plants, it is a key component of an ecosystem and as such, it regulates various biogeochemical cycles, example water, carbon, and nitrogen (6). Vegetation provides habitat to wildlife and ecosystem services such as food and fuel, timber, cash crops, pulp, fruits, robes, clothes and many game reserve (1). Vegetation converts solar energy into biomass and forms the base of food chains. Vegetation influences the energy balance at the earth's surface and in the atmospheric boundary layer, often mitigating extremes of local climate (14).

The earth is undergoing rapid environmental changes because of human actions. As urban expansion progresses, degradation of vegetation patches is anticipated. The trend of negative changes in vegetation shows the rapidity of urbanization (2; 13). Humans have greatly affected the environment by altering its natural composition through various pollutions, and this causes climate change. Human adapted the use of fire as a land clearing or management tool. Other human activities include: overgrazing, sourcing for fuel wood, urbanization, road construction, lumbering for timber and agriculture intensification (17). Vegetation destruction can cause immediate extinction of plant species that lived only in areas destroyed (5). Folorunso *et al.*,(9) discovered that household vulnerability to climate change in the three agro-climatic zones as measured by the Vulnerability Index (VI) was highest in the derived savannah (VI = -0.99), followed by the savannah (VI = 0.46), and lowest in the rain forest (VI = 0.53). This explained that vegetation of the Savannahs is more vulnerable to destruction by human than forests.

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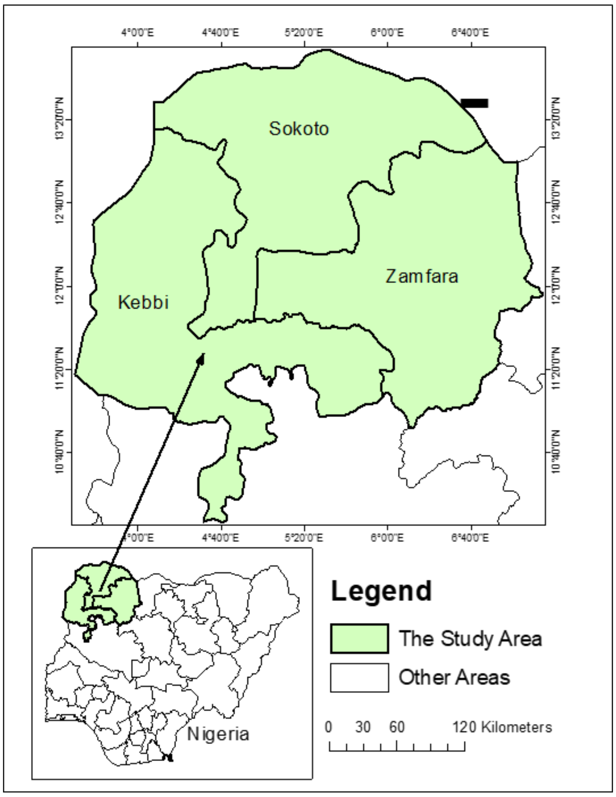
Microclimate conditions are often dependent on the physical setting of the physical environment (3). Vegetation covers a considerable portion of the earth and has an effect on weather and climate. Vegetation influences albedo of the earth and the amount of water vapor and carbon dioxide in the air. With vegetation covering about 20 per cent of our planet, it is no surprise that plants affect climate. Plants process, release and contribute to water vapor (transpiration) for cloud formation, and also absorb and emit energy used to drive weather. Plants produce their own micro-weather by controlling the temperature and humidity around its immediate environment through transpiration on their leaves. Most plants and forest soil have a very low albedo, (about 0.03 to 0.20) and absorb a large amount of energy (11). In a nut shell, decrease or completely absence of vegetation cover in an environment leads to desertification and subsequently devastating effect on large scale environment called *climate change* (12).

Experts believed that an estimated area of 75 million hectares of land in the North is threatened by desertification (16). This portends great danger to food security in Nigeria and in the ECOWAS sub-region. Many experts attributed desertification to anthropogenic activities especially felling of trees, intensive farming, urbanization, (see 2; 7; 15; 18; 20, 13). Even though, vegetation in the Sokoto region is decreasing, not all the plants were completely destroyed, some species of plants can be found on the worst locations. This research seeks to find out areas where worst vegetation degradation exists and which plant species survived in that area?

2. The Study Area

2.1. Location

The study area is centered on old Sokoto State comprises of Sokoto, Kebbi and Zamfara States, but the data images used included a rectangular area covering part of Katsina State in the East, part of Kaduna State in the Southeast, part of Niger State in the South, part of Republic of Benin in the West and part of Niger Republic in the North (subjectively, Sokoto Region). The area is geographically located between latitudes 10.0⁰ and 13.9⁰ North, and between longitudes 3.4⁰ and 7.3⁰ East, occupying about 230,000 km² (Fig 1).



Source: Adapted and modified from Tijani *et al.,* (2018)

Figure 1 The Study Area

2.2. Data Collection

The Vegetation data for this research used to measure vegetation greenness are from satellite observations obtained from Moderate-resolution Imaging Spectroradiometer (MODIS) sensor as Enhances Vegetation Index (EVI). The EVI data has a 250m spatial and 16 days temporal resolutions. Example, Badamasi (4) and Miriam *et al.,* (10) applied EVI to monitor vegetation changes with time-series analysis and achieved positive results. This research is May to October (inter-seasonal) covering a period of 19 years from 2000 to 2018. There are two images per month, and a total of 12 images per wet season, totaling 228 EVI images. This data was accessed free from Land Processes Distributed Active Archive Center (LP DAAC) from the United States Geological Survey (USGS) website on Earth Explorer tool (https://earthexplorer.usgs.gov) and downloaded in Hierarchical Data Format (HDF).

2.3. Data Processing

The data was imported, converted to Idrisi raster format from Hierarchical Data Format (HDF), reprojected to latitude-longitude from sinusoidal projection and windowed using GIS software (IDRISI v16.05, the Taiga Edition, by Clark Labs, Clark University). A composed 6 months average was created after windowing using IDRISI Image Calculator. This reduces the number of images to 19 (that is one image per season). All the geospatial analysis was conducted using IDRISI-Taiga, while Microsoft Office Excel (2003 and 2007 edition) was used to create graphs.

2.4. Determining Spatiotemporal Relative Changes

The EVI data was subjected to the measurement of relative variability to determine the spread of seasonal changes across the study area using Coefficient of Variation (CV) (Equation 1). The CV equation was applied on IDRISI software using Image Calculator.

$$CV = \frac{\delta}{\mu} \times 100 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (1) \text{ (Everitt, 1998)}$$

Where:

- CV = Coefficient of Variation
- δ = Standard Deviation
- μ = Mean (average)

2.5. Fieldwork

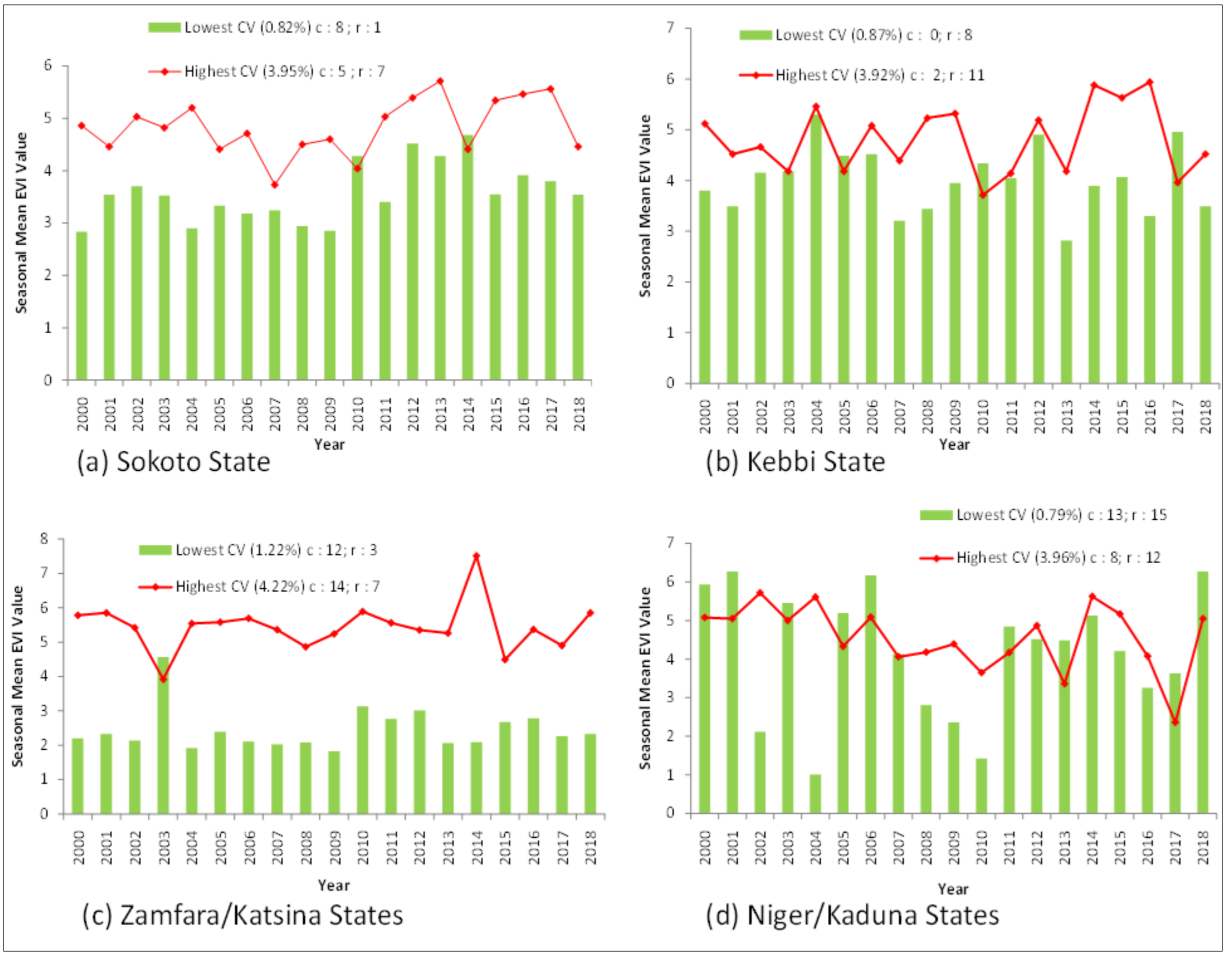
Ground information was collected through informal conversation and observation. Pictures of some locations with distinct characteristics and individual dominant species were snapped. This serves as ground truthing which helps in understanding the state of the vegetation, particularly on the locations where distinct characteristics exist.

3. Results and discussion

Fig 2 shows maximum and minimum CV values for EVI of some locations in the study area from 2000 to 2018. It indicated that Zamfara/Katsina region is the only area with less fluctuation, while other regions which include Sokoto; Kebbi; and Niger/Kaduna were experiencing more fluctuations on both minimum and maximum CV values. In a nutshell, vegetation in the study area over the study period is experiencing changes without definite pattern. It is observed that there is no uniformity among the seasonal distribution of EVI values. Only Zamfara/Katsina States have somewhat uniform distribution, while other locations (Sokoto, Kebbi, and Niger/Kaduna States) for both maximum and minimum CV values (Fig 2). This shows that vegetation in Zamfara/Katsina is experiencing relatively little changes compared to other parts of the region on which samples were selected.

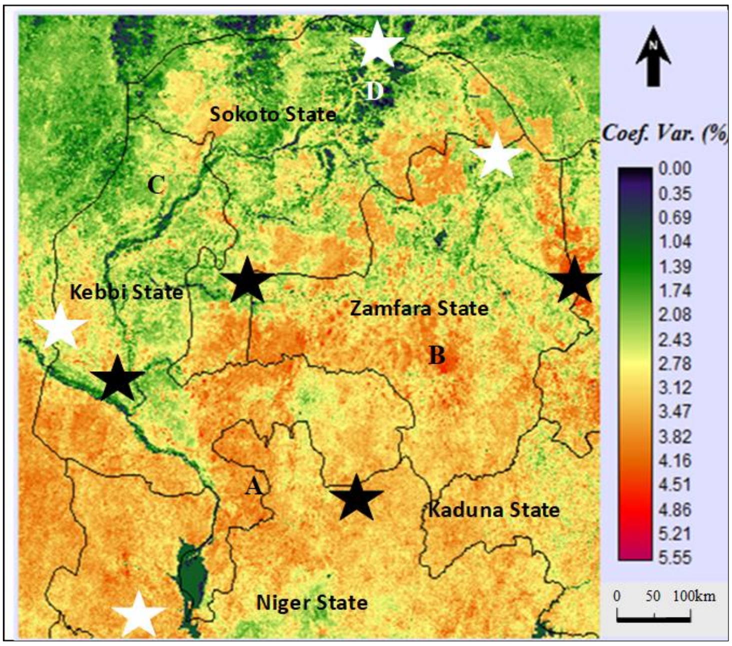
3.1. Fieldwork

With the use of hand-held Global Positioning System (GPS) devise and Google Earth, areas marked A, B, C and D (Fig 3) were identified for ground truthing where each location was photographed as presented in Figure 4. Area marked *A* is located between Kembu village in Kebbi State and Tungan Fona in Niger State (Guinea Savanna). Area marked *B* is located around the nomadic route which bye-pass Anka settlement in Zamfara State (a transition between Guinea and Sudan Savanna). Area marked *C* is located within the floodplain of River Rima to the East of Kwakware village in Kebbi State. Area marked *D* is located along the tributary of River Rima between Gada and Cadawa settlements in Sokoto State (Sudan Savanna).



Source: Author's analysis, (2019)

Figure 2 Univariate Statistics for CV-EVI for Selected Locations



The black and white stars on Fig 3 indicated pixels with the highest and lowest CV values respectively in relation to their surroundings. On same image, areas marked with A, B, C and D are locations with CV as very high (>3%), moderate (2-3%), low (1-2%) and very low (<1%) respectively.

Source: Author's analysis, (2019)

Figure 3 Spatial Coefficient of Variation for EVI

The locations with distinct characteristics were photographed which assist for the visual understanding of the vegetation characteristics of those areas (Figure 4). Figure 4 (a) is an open land where Maize and Guinea-corn were cultivated. The area has high CV (4.34%) because the farmers on that land are practicing shifting cultivation. This causes changes in vegetation between years of cultivation and years on which the land is left for natural vegetation to redevelop. Figure 4 (b) is found to be around the nomadic route in Zamfara State (CV = 3.45%). Due to the frequent movement of nomads with their animals, they destroy natural vegetation through over grazing and hoof action. These lead to variation in vegetation between the periods when the animals were present and when they are away.

Figure 4 (c) and (d) are places with low variation in vegetation (CVs = 1.94% and 0.82% respectively). They are found around the floodplains of River Rima at Kwakware village in Kebbi State and at Chadawa village in Sokoto State respectively. The CV is low in those locations because of the availability of soil moisture even during drought events which stabilizes plant growth throughout the season without much interference. The Statistical Consulting Group (2019) stated that the higher the coefficient of variation of values, the greater the level of dispersion around the mean, which is expressed as a percentage. It allows for comparison between distributions of values. When the estimated values were presented, the CV relates the standard deviation of the estimate to the value of this estimate. The lower the value of the coefficient of variation, the more precise the estimate is. Therefore, the rainfall-vegetation prediction model in this research will be precise on the areas with low CV values compared to areas with otherwise.

During an interview with the farmers, areas marked *A* and *B* on Figure 4 were experiencing decrease in the number of plants particularly lower plants (grasses) in those areas, which they related it to overgrazing. Those areas were transition zone between Guinea and Sudan Savannah. Areas marked *C* and *D* were said to have somewhat stable green vegetation. The areas were characterized by Sudan Savannah.

Figure 4 (a), (b), (c) and (d) have their geographical coordinates as (Lat. 10.80; Lon. 5.10), (Lat. 12.10; Lon. 5.80), (Lat. 12.90; Lon. 4.30) and (Lat. 13.70; Lon. 5.60) respectively. Source: Photo by Author, (2019)

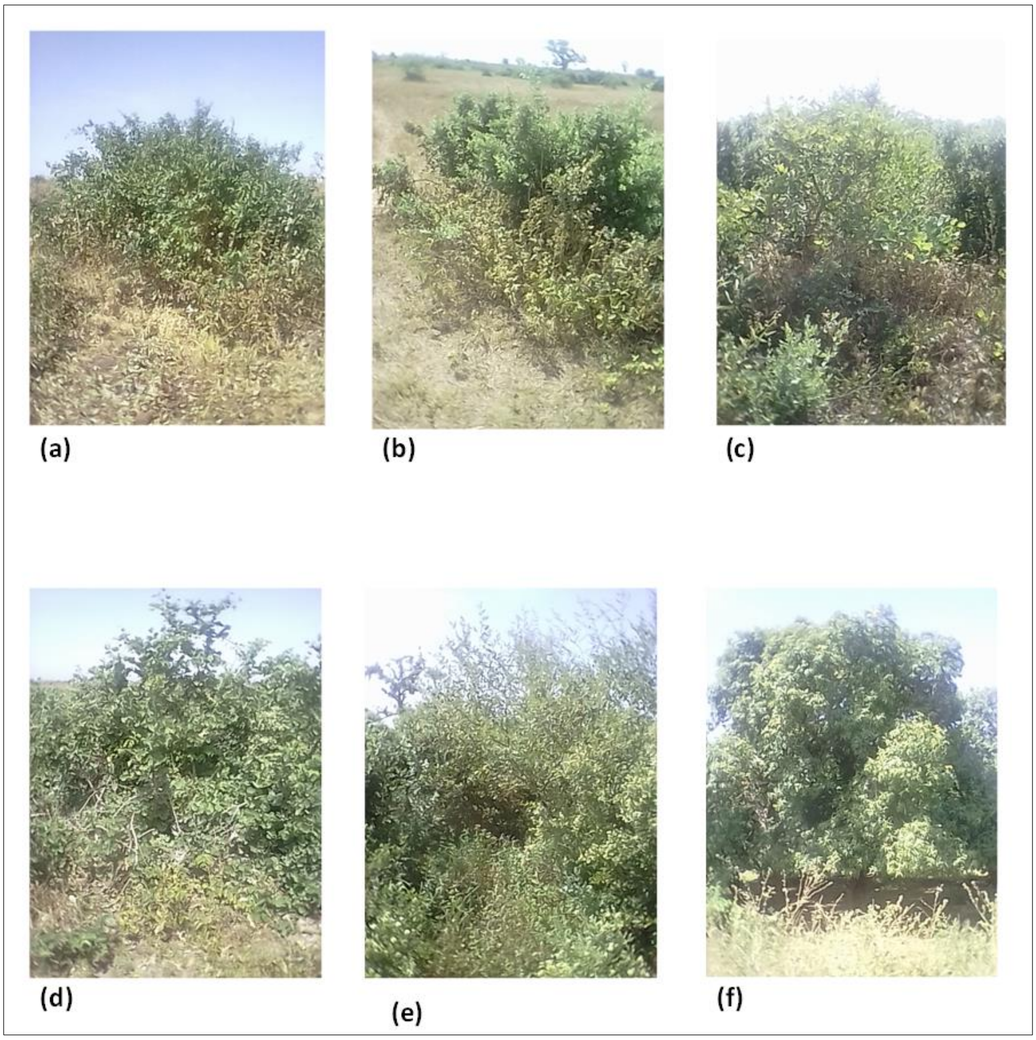
Figure 4 Vegetation Characteristics on some Strategic Locations (August, 2019)

Sokoto Region is situated within two Sub-savannah vegetation belts (Guinea and Sudan). Yelwa (19) view the region as the transition zone between the two Savannah belts. The location of the study area subjects it to be homogeneous in terms of vegetation characteristics. Therefore, the species of plants found in one place can also be found in other places within the region. Though, some dominant plant species were identified within the two categories of CV (very low and very high) as extracted from Fig 3. The dominant plant species were identified as presented in Table 1.

Table 1 Dominant Plant species on some strategic locations

Caption from Plates 4.2	Scientific Name	Hausa name	Common Name
(a)	*Gueira senegalensis*	Sabara	Gueira
(b)	*Combretum micranthum*	Geza	Combretum
(c)	*Piliostigma thonningii*	Kalgo	Camel's foot
(d)	*Calatropis procera*	Tumfafiya	Giant swallow wort
(e)	*Ziziphus abyssinica*	Magarya	Jujub tree
(f)	*Mangifera indica*	Mangwaro	Mango

Source: Author's Fieldwork (2019)



Source: Photo by Author, (2019)

Figure 5 Dominant Plant Species on Strategic Locations

Figure 5 contained pictures of individual plant species identified to be dominant on the strategic locations that were visited during field observation. Figure 5 (a), (b), and (c) are locations around very high CV areas (Lat. 10.80; Lon. 5.10), while Figure 5 (d), (e) and (f) are locations around very low CV areas (Lat. 13.7^0; Lon. 5.6^0). It is observed that these plant species were naturally existing vegetation. Even with the human actions and harsh climatic conditions, these plants have the ability to withstand the prevailing conditions. All the identified plants, excluding Mango, have small sized coated leaves that served as adaptation mechanism. Their multiple trunks make the plants grow wider than their height.

4. Conclusion and Recommendation

It was observed that dominant plant species in some strategic locations naturally existed. Even with the human actions and harsh climatic conditions, these plants have the ability to withstand the prevailing conditions. All the identified plants, excluding Mango, have small sized coated leaves that served as adaptation mechanism. Their multiple trunks make the plants grow wider than their height. Their wider diameter protects the soil from intense solar heating and a habitat for small wild animals like reptiles.

The Coefficient of Variation analysis shows that high CV values are found around farmlands and nomadic routs, while low CV values are more dominant on floodplains. The prevailing climatic condition of a location determines its vegetation characteristics. Similarly, grazing activities by herdsmen causes vegetation degradation, particularly grasses and shrubs. The dominant plant species mainly on high CV areas are *Gueira senegalensis* (Sabara), *Combretum micranthum* (Geza) and *Pili stigma thonningii* (Kalgo). It was recommended that these identified species of plant should be domesticated and used for afforestation programme in the region. Government should provide adequate grazing reserves and animal routes to avoid indiscriminate grazing activities in the area.

Compliance with ethical standards

Acknowledgments

Great thanks to NASA/Goddard Space Flight Center's team for providing Enhanced Vegetation Index (EVI) data (MOD13Q1v6) as archived at the Land Processes Distributed Active Archive Center (LP DAAC) managed by the NASA Earth Science Data and Information System (ESDIS) project for using their product for this research.

Disclosure of conflict of interest

Authors have declared that no competing interest exist.

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