SPATIO-TEMPORAL DISTRIBUTION OF VEGETATION IN SOME FOREST RESERVES OF KANO REGION, NIGERIA

BY

Ahmed, S.A.[1*], Ahmed, M.[2], Haruna, H.[1] and Aliko, A.A.[1]

[1]Department of Plant Biology, Bayero University Kano, Kano, Nigeria
[2]Department of Geography, Bayero University Kano, Kano, Nigeria
*Corresponding author: mahmad.geog@buk.edu.ng

ABSTRACT

Forest reserves in the Kano region of Nigeria are under threat from anthropogenic activities such as grazing, poor land use and hideout for criminal elements. These have caused a high degradation in the savannah vegetation, thus affecting the biodiversity and environmental settings of the areas. Therefore, there is a need to study the status of some forest reserves using remote sensing tools. The research aims to analyse the rate of degradation of some selected forest reserves within the Kano region. Landsat images were sourced from the Glovis website and converted to a Normalized Difference Vegetation Index (NDVI) using the GPS data from ground survey. Six study sites were selected using a purposive sampling method and the results were analysed in the GIS environment for the period 2009 to 2019. For the detection of forest changes, the results were analysed using descriptive statistics. The results indicated high positive NDVI values of +0.572 recorded in the year 2009, while the lowest of 0.18 occurred in the year 2019. The percentage changes detected in the forest reserve NDVI values over the decade were categorized as Farin Dutse F.R (55.75%) > Rurum F.R (52.88%) > Albasu F.R (51.52%) > Unguwar Jibrin F.R (47.06%) > Danshoshiya F.R (23.08%) > Falgore F.R (9.8%). The study concluded there was a decrease in the forest reserve greenness from the period of 2009 to 2019. These results also provide valuable information on the status of the forest reserves and could be applied in developing forest conservation policies for enhanced ecosystem services and livelihoods.

Key words: Degradation, Forest changes, Forest reserves, Normalized Difference Vegetation Index

INTRODUCTION

Forest reserve is an important component of ecosystems that safeguard from degradation by preserving soil biomass, soil moisture, soil structure, control climate, carbon storage, soil fixation, and support for various forms of life. It also serves as a habitat for other organisms that contribute to the proliferation and protect their niche within the ecosystem. The alteration of ecosystems due to anthropogenic factors has been affecting the environment and the effects have caused a lot of degradation due to the actions of erosion by wind and water (Adamu et al., 2014).

In the dry lands of Northern Nigeria, plant diversity is lost along the forests of savannah vegetation (Green et al., 2013), especially where it houses several forest reserves. Forest reserves are portions of state lands where commercial harvesting of wood products is excluded to capture elements of biodiversity (Mleziva and Wang, 2012). These forest reserves are important sources of natural products such as fruits, foods, and resources for medicine (Langat et al., 2016).

Additionally, natural and man-made threats as well as direct and indirect consequences of socio-economic development have contributed to the erosion of biodiversity at all levels in the country (Suleiman, 2014). The Food and Agricultural Organization's Global Forest Resources Assessment 2020 put the annual rate of net forest loss in 2010-2020 in Nigeria and other African countries at 3.9 million hectares- the largest amount in the world (FAO, 2020).

There is need to analyse the distribution and level of degradation of some forest reserves within selected time over space. However, several studies have been carried out using different approaches. The most common is the use of a vegetation indicator or the Normalized Difference Vegetation Index (NDVI), which is an index for describing the phenology, greenness, and productivity of vegetation. It is an index of green biomass (Sabellek, 2010). NDVI gives a measure of the volume and dynamism of vegetation on the surface area (Usman et al., 2012).

It was noted that remote sensing and GIS help in decision making, especially in the aspects of modelling and vegetation studies (Mishra and Agarwal, 2015). The integration of remote sensing and GIS contributes to making it a powerful tool to globally study vegetation dynamics, especially forest change detection in the world (Egide and Jacob, 2020). The Normalized Difference Vegetation Index (NDVI) has been considered to have a range of -1 to +1. meaning, the closer the value is to +1, the more the vegetation biomass, while the closer it is to -1, the less the vegetation biomass

The NDVI analysis of Doma forest greenness shows there was a substantial decrease from 1999 to 2015 which was degraded due to human activities such as agricultural activities, grazing, and illegal logging (Moussa, 2015). While several studies have been conducted in the area on vegetation, like trees composition, density and diversity (Badamasi, 2014; Ezeobi et al., 2015; Suleiman et al., 2017; Zakariya and Mohammed, 2018; Suleiman et al., 2018; Danjuma et al., 2021), dynamics and change detection (Badamasi and Yelwa, 2010; Usman et al., 2012; Suleiman, 2014; Idris et al., 2018), land use diversity changes (Yelwa, 2008; Ahmed et al., 2015). The majority of these studies concentrated on isolated forested areas that are gazetted. This shows the need to explore and combine the areas especially cutting across the North and Southern Guinea with areas that have rainfall challenges, so, as to look at it spatially. Therefore the main objective of this study is to analyse the rate of degradation in Rurum, Falgore, Danshoshiya, Albasu, Unguwar Jibrin and Farin Dutse forest reserves within the Kano region of Nigeria.

THE STUDY AREA

The study area is within Kano and Jigawa states, popularly known as the Kano Region, The Kano region is located between Latitudes 10° 35' 46" N to 12° 58' 49" N and Longitudes 7° 42' 22" E to 10° 36' 59" E (Figure 1). It is bordered by the Niger Republic in the north, Bauchi/Yobe state in the east, Bauchi/Kaduna State in the south, and Kaduna/Katsina state in the west. The climate of Kano region is of the tropical wet and dry types. It is coded as 'Aw' by Koppen in which distinctive wet and dry seasons are caused by the oscillation of the ITCZ (Inter-tropical convergence zone) or the ITD from south to north to bring the rainy season and from north to south to bring the dry season. The ITCZ separates humid tropical maritime (mT) air masses originating from the Atlantic Ocean and desert tropical continental (cT) air masses.

Average annual rainfall varies from 500mm in the north-eastern part to 1000mm in the southern sub-area, but it is erratic in many parts. Unpredictability and unreliability characterize the pattern of rainfall in the area (Mortimore, 2001). The vegetation type is the West African type having wooded savannah in the south and scrub vegetation in the north, which follows the pattern of rainfall distribution. Kano and Jigawa states fall within the Sudan Savanna zone of

Nigeria, distinguished by large expanses of grassland with widely spaced trees of varying heights and diversity (Zakariya and Mohammed, 2018).

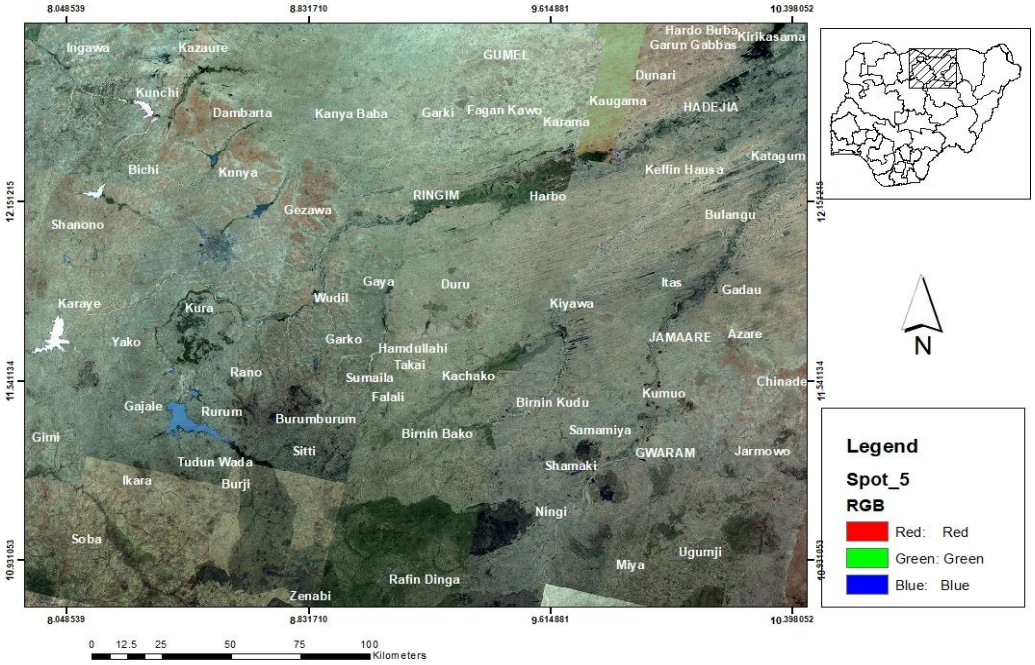


Figure 1: Kano Region (Study Area)

MATERIALS AND METHODS

A reconnaissance survey was carried out across the forest reserves in order to obtain an impression of the site conditions, after which a purposive systematic sampling method was used to generate data using Global Position Systems (GPS Garmin 74 model) (Figure 2). ArcGIS was used based on the distribution of the sampling location and mapping of the vegetation distribution.

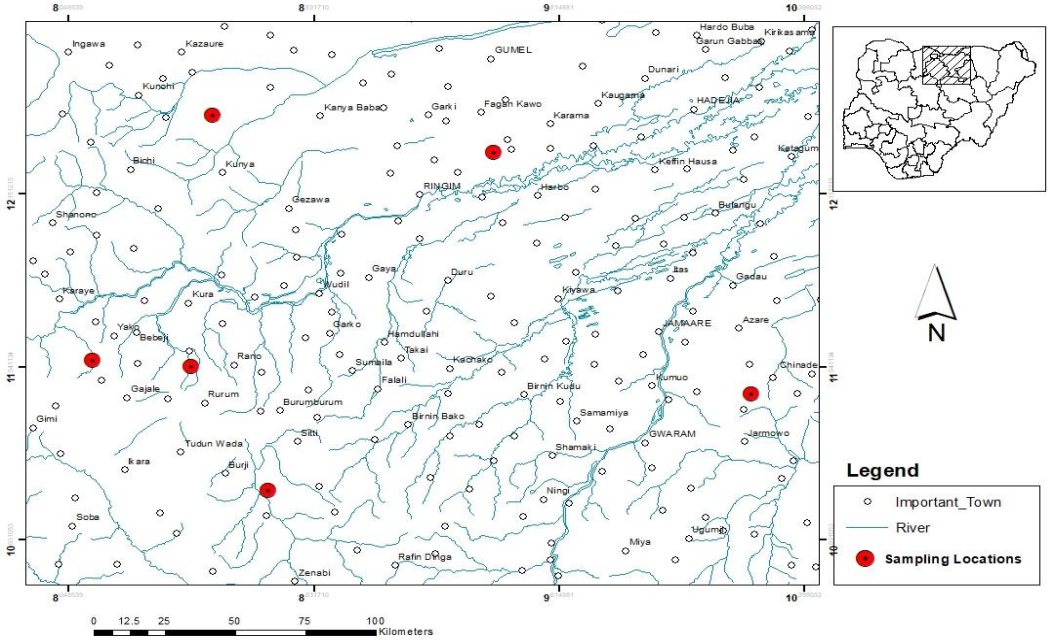


Figure 2: Kano Region and Sampling Locations

The forest reserve dynamics within a decade were detected for changes using the Normalized Difference Vegetation Index (NDVI) from ten Landsat imageries between the years 2009 to 2019 (Table 1). The images were downloaded from the GLOVIS website and were processed geometrically and radiometric corrected in the Arc GIS software for the purpose of this study.

Table 1: The Description of Landsat8_OLI Bands

Band name	Bandwidth (μm)	Resolution (m)	Date
Band 2 Blue	0.45-0.52	30	2009-2019
Band 3 Green	0.53-0.60	30	2009-2019
Band 4 Red	0.63-0.68	30	2009-2019
Band 5 NIR	0.85-0.89	30	2009-2019
Band 6 SWIR1	1.56-1.66	30	2009-2019
Band 7 SWIR2	2.10-2.30	30	2009-2019

Data analysis

The data collected from Google Earth images and ground surveys using hand held Global Positioning System (GPS) (Garmin 64s model) from the study sites was entered into the GIS environment and the mapping was done to identify the clear distinction between the vegetation over the years. NDVI was calculated as adopted by Aladesanmi et al. (2017).

$$NDVI = \frac{NIR - V\,IS}{NIR + VIS} \quad \ldots\ldots 1$$

NDVI is Normalized Differential Vegetation Index, NIR is near-infrared, and VIS is visible red reflectance. The value of the pixels varies between −1 and +1; the higher the value of NDVI, the richer and healthier the vegetation covers of such an environment.

RESULTS AND DISCUSSIONS

Changes within the Selected Forest Reserves

The linear regression analysis of the study sites shows a negative correlation between the NDVI and the biomass over the decade for all the study sites. However, Rurum, Farin Dutse, and Albasu forest reserves with -0.407, -0.564, and -0.519 respectively indicated highly affected sites. While Falgore, Danshoshiya, Unguwar Jibrin forest reserves with lower negative correlation values with -0.002, -0.238 and -0.226 respectively indicating a less aected sites. This could be as a result of seasonality, health status, anthropological factors and climate changes leading to high reduction in the size of the forest reserves (Idris et al., 2018).

Figures 3A, 3B, and 3F, representing the rate of distribution of forest reserves in Rurum, Farin Dutse, and Albasu which has been explained by NDVI with $R^2 = 0.32$, $R^2 = 0.27$, and $R^2 = 0.17$ respectively. While Figure 3C, 3D, and 3E representing Falgore, Danshoshiya, and Unguwar Jibrin forest reserves with a very weaker explanation of the NDVI with $R^2 = 4E\text{-}06$, R^2 0.06, and $R^2 = 0.05$, respectively.

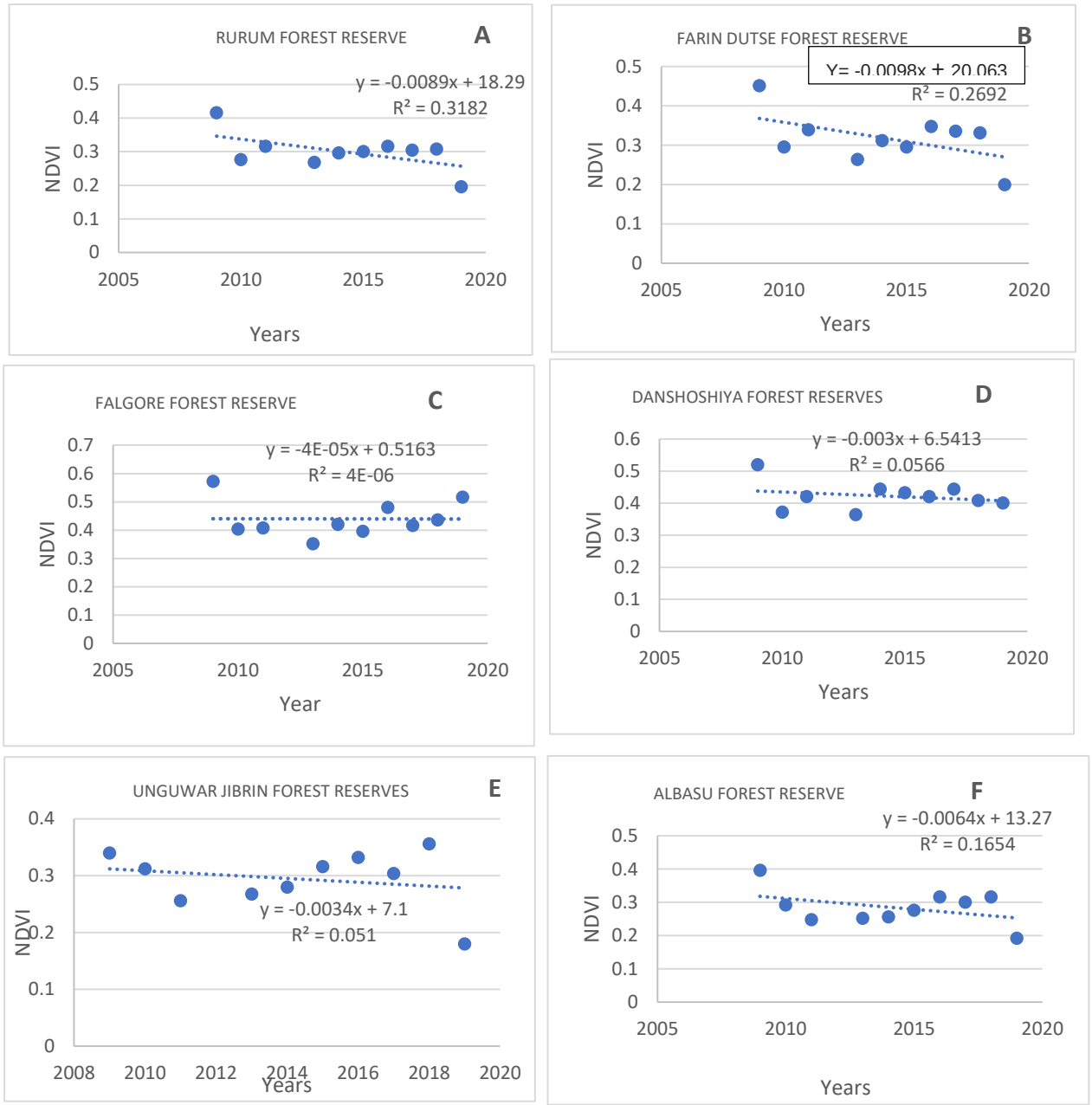


Figure 3: Forest Changes within the Selected Areas

Spatio-Temporal Distribution of Vegetation Using NDVI

In the present study, the highest percentage changes detected in the forest reserve NDVI values over the decade were categorized as; Farin Dutse (55.75%), Rurum (52.88%), Albasu (51.52%), Unguwar Jibrin (47.06%), Danshoshiya (23.08%), and Falgore (9.8%).

Figure 4 shows the Normalized Difference Vegetation Index (NDVI) of the forest reserve for the years 2009 and 2019 representing the previous and recent status. The NDVI values for 2009 range from 0.34 to 0.572. In 2009, 0.572 was the highest value of the NDVI, which indicates high biomass found in the Falgore game reserve. This was a result of protection measures by the government in the reserve (Idris et al., 2018). In 2019, the highest NDVI value was 0.516, showing a 9.7% decrease in the biomass of the Falgore game reserve, while the lowest NDVI in the year 2009 was in Unguwar Jibrin forest reserve with a value of 0.34. Similarly, it had the lowest NDVI value of 0.18 in the year 2019.

In Figure 4, Falgore game reserve had the least changes in vegetation (9.7%), which could be attributed to forest succession on bared land as well as natural regeneration of trees on sites where trees were cleared for fuelwood and grazing in the reserve (Suleiman et al., 2017), in contrast to Idris et al. (2018), who reported Danshoshiya forest reserve as the least disturbed. The study reported 35.45%, 0.6%, and 8.52% changes in Rurum, Danshoshiya, and Falgore forest reserves from 1966-2015, respectively. This research has shown a greater increase in the disturbance occurring in Danshoshiya forest reserve than in Falgore game reserve within the 2009-2019 periods. According to Yelwa (2008), the Falgore Game Reserve serves as a safety net to nearby communities by offering alternative income sources and food for households during the off-farming season.

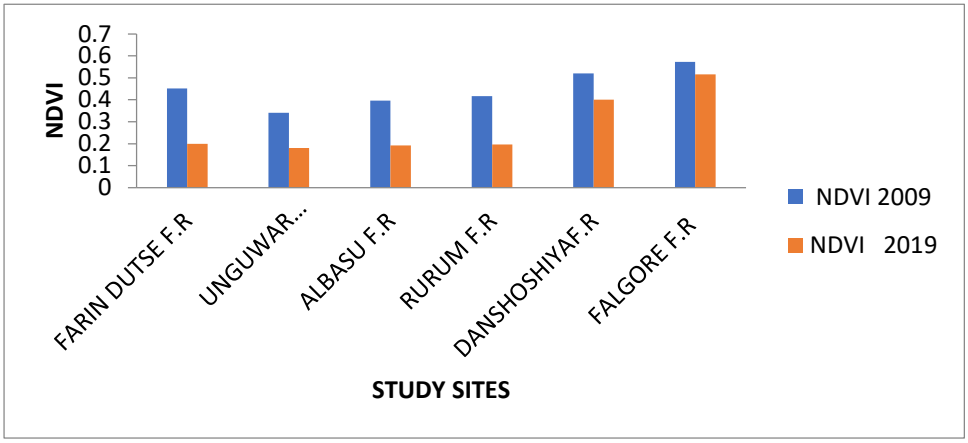


Fig 4: NDVI across the Sampled Location for 2009 and 2019

Fig 4 shows the differences from 2009-2019 in the study sites, the changes in the forest reserve greenness in figures 2A-F is a result of uncontrolled collection of non-timber forest products (NTFPs), climate variability, and natural and human-induced forest fires as observed in many parts of Africa (Kessy et al., 2016). Lack of security as a cause was also reported by Green Grass (2006). Badamasi and Yelwa (2010) reported that the Falgore reserve has been encroached on, while Ahmed (2006) concluded that all forest reserves in Kano state are under threat. Suleiman et al. (2017) also reported that protection strategies employed in Falgore Game Reserve were not effective as deforestation is still evident in the reserve.

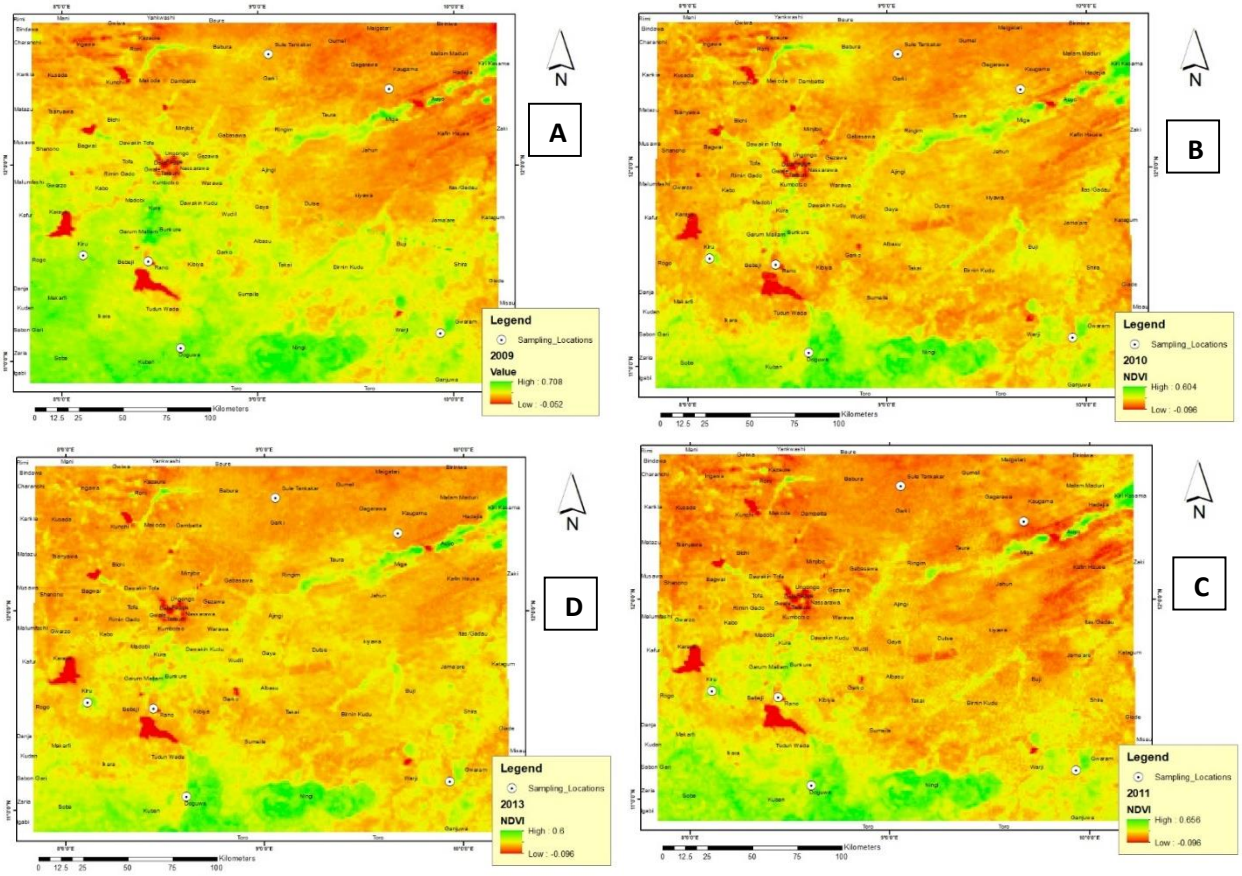
Idris et al. (2018) research findings using GIS also reported the Rurum forest reserve as one of the most affected due to farming activities, hunting, grazing, and high demand for fuel wood. This study found out there is a high degree of exploitation in all the reserves in Kano and Jigawa states (Kano Region), which is similar to the results of NDVI analysis by Moussa (2015), which shows that Doma forest reserve dynamics in Nasarawa state are reducing in terms of their greenness. The study concluded that the reserve is degraded due to human activities such as agricultural activities, grazing, and illegal logging.

The study area's vegetation is typically semi-arid savannah, with annual and perennial grasses, other herbaceous plants, shrubs, and small trees (Abdulhakim et al., 2017). The Sudan Savannah is sandwiched between the Sahel Savannah in the north and the Guinea Savannah in the south (Danjuma et al., 2021). The rainy season lasts from May to September with an average rainfall of between 600 and 1000 mm, while high temperatures are normally recorded between the months of April and September. The southern part of the state has a higher rainfall percentage than the northern part (Murtala et al., 2015; Oyebanji et al., 2017).

Generally, the observed decrease in the NDVI values in Jigawa and Kano states could be due to the settlement of the Fulani cattle herders in the reserve, the community felling trees to feed

their livestock and construct houses, and the community's over-reliance on forest resources to meet their economic and food needs, especially at times of scarcity occasioned by droughts (Suleiman et al. 2017). The spatial distribution of vegetation across the area indicated that the highest NDVI value of 0.708 in 2009 (Figure 5A) dominates the forested areas, especially those in the southern part like Falgore game reserves in the south-western part of the area and the central to the northernmost part of the area, distributed along the floodplain of Hadejia Jama'are area, which is moist and cuts across the Baturiya Forest reserve, and that makes the greenness more apparent from the satellite image. However, in the northern part, due to low rainfall and low moisture availability, the area tends to remain dry unless in some pockets of strategic locations with low moisture that remain green. Even though the water bodies retained energy, that is why it has a negative value of -0.065, but the northern part is dominated by zero indexes distributed with grasses and bare soil.

Similarly, in 2010, Figure 5B shows the range of NDVI from 0.604 to -0.016. In 2011, a little increase of 0.656 to -0.096 (Figure 5C). In 2013, with 0.600 to -0.096 (Figure 5D). Similar indexes were shown in 2014 and 2015, from 0.644 to -0.096 (Figures 5E and 5F). There was a slight offshoot of the index in 2016 with 0.672 to -0.096 (Figure 5G) and a slight drop in 2017 with 0.656 to -0.096 (Figure 5H). In 2018, Figure 4I showed an index of 0.684 to-0.096 and in 2019 (Figure 5J) indicated a range of 0.720 to-0.012, which shows an increase in the vegetation around the southern part and a decrease in the northern part due to low rainfall and low water holding capacity.



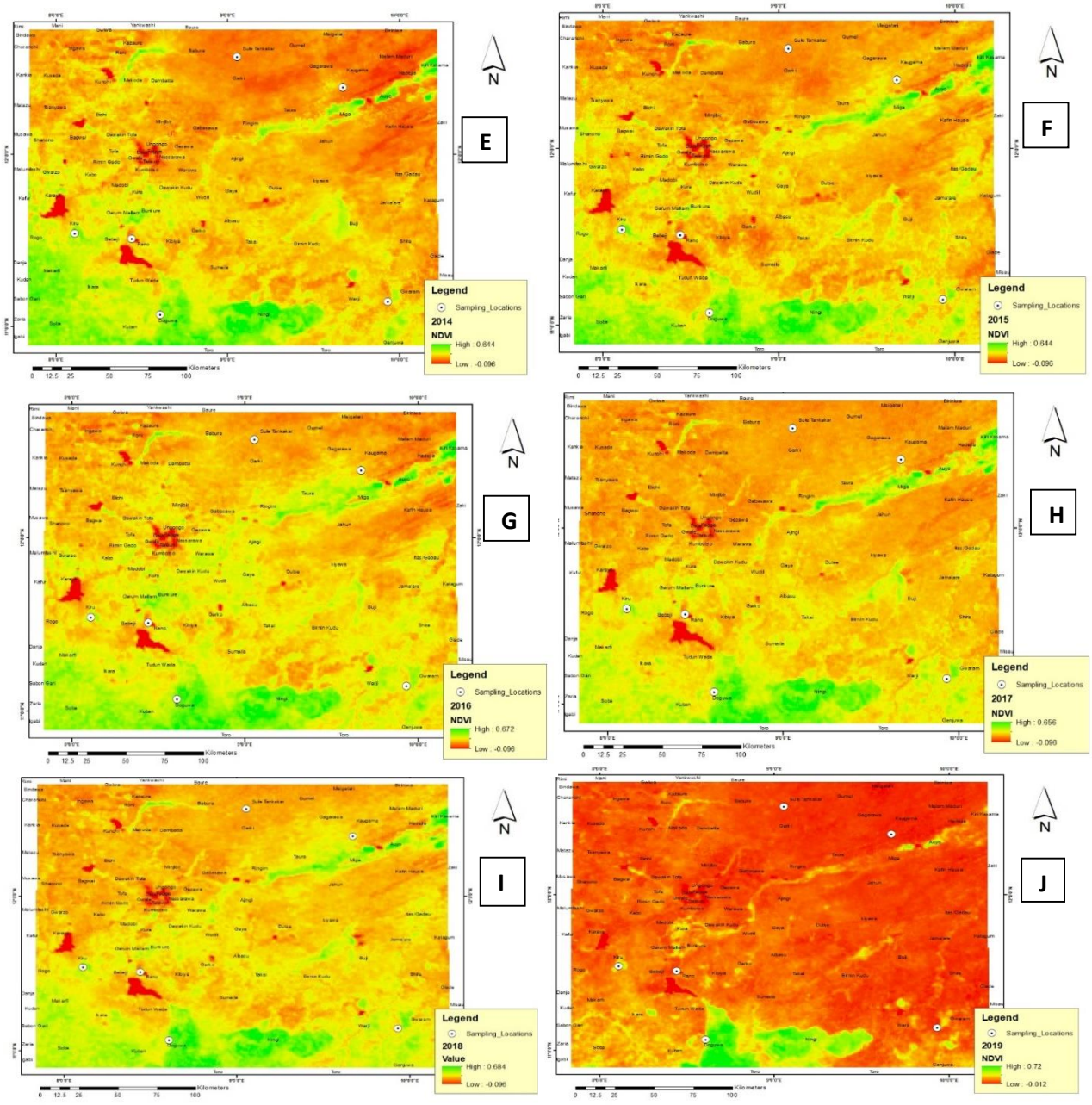


Figure 5: Spatio-temporal Distribution of Vegetation using NDVI Between 2009 to 2019

CONCLUSION

The study concludes that there is a decrease in the vegetation biomass of the forest reserve areas in the Kano region particularly Kano and Jigawa states, with Rurum, Albasu, and Farin Dutse forest reserves being mostly affected. This was indicated by the satellite images showing an increase in anthropological disturbance carried out in the forest reserves, and this will lead to loss of biodiversity, desert encroachment, lowering soil quality and eventually climate change as the greenness continues to diminish. The study recommends ground data collection in all forest reserves to document the remnant vegetation for future use in reforestation, afforestation, and maintenance. The poverty level in the country has directly increased the damage done within the forest reserves, and the best way to reduce the impact is through sensitization and awareness campaigns to the communities around the reserves on the benefits

and effects of forest extinction. Natural regeneration should also be encouraged to improve the spatial vegetation coverage to protect the greenness of the vegetation and support the survival of the fauna within it.

REFERENCES

Abdulhakim, I. K., Kabiru, I.I., Muhammad, N. D. (2017) Assessment of Woody Vegetation Diversity in Babura Area Northwestern Nigeria. *Dutse Journal of Pure and Applied Sciences*, 3(2), 82-89.

Adamu, G. K., Maharazu A. Y., Ahmed, M. (2014). Soil Degradation in Drylands. *Academic Research International*, 5 (1), 78.

Ahmed, K. (2006). The Physical Environment of Kano State, www.kanostate.net/physicalenvironment.html. (*Accessed 08/08/2013*)

Ahmed, M., Abdulhamid, A., Kende S. A. (2015). Land Use and Biodiversity Changes in the Watershed of Karaduwa Drylands: insight in around the Zobe Dam Katsina state, Nigeria. *Journal of Dryland Agriculture,* 1(1), 101-118.

Aladesanmi, D. A., Onyekwelu, J. C., Matthew, B. O. (2017). Tree Species Richness, Diversity and Vegetation Index for Federal Capital Territory, Abuja, Nigeria. *International Journal of Forestry Research,* (1), 1-12.

Badamasi, M. M., (2014). Vegetation and Forestry. In Tanko, A.I. and S.B. Momale (Eds.) *Kano Environment, Society and Development*. London and Abuja, Adonis and Abbey Publishers. pp. 43-64.

Badamasi, M.M., Yelwa, S.A. (2010). Change Detection and Classification of Land Cover at Falgore Game Reserve: A Preliminary Assessment. *Biological and Environmental Sciences Journal for the Tropics*, 7 (1), 75-83.

Danjuma, M. N., Ahmed, M., Zakariya, M. (2021). Effects of *Faidherbia albida* Del. A. Chev. on Soil Properties in Agroforestry Parkland Ecosystem in Garki Village, Katsina State, Nigeria. *Renewable Journal,* (1), 44-52.

Egide, N., Jacob, O. (2020). Remote Sensing and GIS Integration. In Fath, B.D., Jørgensen, S.E., & Cole, M. (Eds.) *Managing Human and Social Systems* (2nd ed.) CRC Press.pp.139-143. https://doi.org/10.1201/9781003053514

Ezeobi, J. U., Yakubu, I. B., Ahmed, M. (2015). Tree Compositions in Selected Farms in parts of Kano State, Nigeria. *International Journal of Agriculture, Forestry and Fisheries*. 3(1), 17-24.

FAO (2020).Global Forest Resource Assessment 2020: Main report, Rome. Impact of COVID-19 on Agriculture, Food Systems and Rural Livelihoods in Eastern Africa.http://www.fao.org/3/cb0552en/CB0552EN.pdF

Green, J.M., Larrosa, C., Burgess, N.D., Balmford, A., Johnston, A., Mbilinyi, B.P., Platts, P.J., Coad, L. (2013). Deforestation in an African Biodiversity Hotspot: Extent, Variation and the Effectiveness of Protected Areas. *Biological Conservation,* 164: 62-72.

Greengrass, E.J. (2006). A survey of Chimpanzees in South-west Nigeria. NCF-WCS Biodiversity.

Idris, H.A., Ahmed, M., Mohammed, U.K., Nuhu, Z. (2018). An Examination of Changes in Some Forest Reserves of Kano State, Nigeria. *FUDMA Journal of Sciences (FJS),* 2(4), 221-230.

Kessy, J.F., Nsokko, E., Kaswamila, A., Kimaro, F. (2016). Analysis of Drivers and Agents of Deforestation and Forest Degradation in Masito Forests, Kigoma, Tanzania. *International Journal of Asian Social Science,* 6: 93–10.

Langat, D. K., Maranga, E. K. Aboud, A. A., Cheboiwo, J. K. (2016). Role of Forest Resources to Local Livelihoods: The Case of East Mau Forest Ecosystem, Kenya. *International Journal of Forestry Research,* pp.10. https://doi.org/10.1155/2016/4537354

Mishra, R.K., Agarwal, R. (2015). Application of Information Technology and GIS in Agroforestry. *Tropical Plant Research,* 2(3), 215-223.

Mleziva, M.M., Wang, J.H. (2012). 'Paper' in Polymer Science: *A Comprehensive Reference*, (Neenah, WI, United States: Elsevier), 397-410.

Murtala U. Mohammed, A. Abdulhamid, Badamasi M. M., Ahmed, M. (2015). Rainfall Dynamics and Climate Change in Kano, Nigeria. *Journal of Scientific Research & Reports,* 7(5), 386-395.

Mortimore, M. (2001). A Profile of Rainfall Change and Variability in the Kano – Maradi Region, 1960 – 2000. Drylands Research Working Paper 25, Dry land Research, Crewkerne, UK.

Moussa, soulé (2015). *Impact of Land Use and Climate Change on Vegetation Dynamics of Doma forest reserve in Nasarawa state, Nigeria.* MSc. Thesis submitted to Federal University of Technology, Minna, Nigeria.

Oyebanji, S. B., Adeyemi, O. O., Agboola, Bolarinwa K. (2017). Taxonomy, Ethnobotany and Vegetation Analysis of Biodiversity in Dutse Local Government, Jigawa State, Nigeria. *FUW Trends in Science & Technology Journal,* 2(2), 679-683.

Sabellek, K. (2010). *Impact of Land Use and Climate Change on Plant Diversity Patterns in Africa*. Doctoral thesis. The University of Bonn.pp.1-135.

Suleiman, I.L. (2014). Forests and Forest reserves as Security Threats in Northern Nigeria, *European Scientific Journal,* 10(35), 120-142.

Suleiman, M.S., Wasonga, O.V., Mbau, J.S., Elhadi, Y.A. (2017). Spatial and Temporal Analysis of Forest Cover Change in Falgore Game Reserve in Kano, Nigeria, *Ecological Processes,* 6:11.

Suleiman, R. M., Sawyerr, H. O., Adio, A., Salako, G. (2018). Spatial Variation in Diversity of Woody Vegetation Species within Kwara State University Malete Campus, Kwara, Nigeria. *International Journal of Biodiversity Conservation*, 10(10), 419-431.

Usman, U., Yelwa, A. S., Gulumbe, U. S. (2012). Assessment of Vegetation Cover Changes across Northern Nigeria. *Journal of Agriculture and Environmental Sciences* 1(1), 01-18.

Yelwa, S.A. (2008). Broad Scale Vegetation Change Assessment across Nigeria from Coarse Spatial and High Temporal Resolution, A VHRR Data. Cuvillier Verlag,Gottingen, pp. 35.

Zakariya, K.M., Mohammed, S. (2018). Vegetation Density and Diversity in the Dryland of Northwestern Nigeria, *Dutse Journal of Pure and Applied Sciences* (*DUJOPAS)*, 4(1), 195-208.