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An assessment of forest degradation in Taraba Central Zone, Nigeria

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ABSTRACT

This study assesses forest degradation in the Taraba Central Senatorial District of Nigeria over a 30-year period, utilizing Normalized Difference Vegetation Index (NDVI) data to analyze changes in vegetation cover. The results reveal a significant decline in areas of dense vegetation, from 2,560.28 km^2 in 1993 to 1,972.29 km^2 in 2003. Similarly, areas of less dense vegetation decreased from 3,496.37 km^2 in 1993 to 3,312.98 km^2 in 2003. By 2013, both dense and less dense vegetation had completely disappeared from the study area. Concurrently, areas of sparse vegetation exhibited a progressive expansion, increasing from 4,264.16 km^2 in 1993 to 4,511.94 km^2 in 2003, 4,911.01 km^2 in 2013, and further to 6,322.44 km^2 by 2023. These findings underscore the extensive degradation of forest resources in Taraba Central Senatorial District, emphasizing the urgent need for sustainable forest management practices and effective policy interventions to mitigate further environmental deterioration.

Keywords: Degradation, Dense vegetation, Forest, NDVI and sustainable forest management.

1. INTRODUCTION

Forests are very essential for the survival of human's and animals on earth, providing numerous environmental and socio-economic benefits. The forests in this region are vital to Taraba State's ecological well-being because they sustain a diverse array of plants and animals and offer crucial ecosystem services like soil preservation, water management, and carbon sequestration. Additionally, these forests are vital for the socio-economic well-being of local communities, many of whom rely on forest resources for their livelihoods through activities such as farming, hunting, and gathering. In Nigeria, particularly in Taraba State, these benefits are particularly pronounced. The state boasts of rich and diverse forest ecosystems, playing a critical role in the ecological and economic well-being of the Taraba Central Senatorial District (TCSSD).

Taraba State, located in northeastern Nigeria, is home to a variety of habitats, including sizable forested regions that are essential to the ecological and socioeconomic stability of the area. The Taraba Central Senatorial District of the State, encompassing various Local Government Areas (LGAs) such as Bali, Gashaka, and Sardauna, is particularly significant due to its rich biodiversity and the presence of several protected areas, including the Gashaka-Gumti National Park. However, forest degradation remains a significant environmental concern, particularly in Nigeria where economic pressures often lead to unsustainable land-use practices. Concerns over the destruction of these important forest have grown in recent years. The destruction of forests and the extraction of fuelwood are examples of unsustainable activities that are placing immense pressure on forest resources.

These concerns are echoed in previous studies highlighting significant land-use and land-cover changes within central Taraba State, suggesting a pattern of deforestation. In Nigeria, forest degradation has accelerated due to factors such as agricultural expansion, logging, and infrastructural development. This degradation not only threatens the biodiversity and ecological integrity of the region but also exacerbates climate change impacts and undermines the sustainability of local economies. Despite the evident signs of forest degradation, there is a paucity of comprehensive and up-to-date data on the extent and drivers of this issue in the region. The lack of detailed, region-specific information hampers the ability of policymakers, conservationists, and local stakeholders to develop and implement effective strategies for forest conservation and sustainable management.

Thus, there is an urgent need to assess the current state of forest degradation in the Taraba Central Senatorial District, identify the primary factors contributing to this degradation, and propose evidence-based recommendations to mitigate its adverse effects. Understanding the extent and drivers of forest degradation in the Taraba Central Senatorial District is crucial for developing effective conservation strategies and sustainable management practices. This study aims to provide a thorough investigation into the state of forest degradation in the TCSSD. By analyzing the primary causes and drivers of deforestation, measuring the extent and severity of forest loss, and evaluating the resulting social, economic, and environmental consequences, this study will offer crucial insights for developing effective conservation strategies. The findings will be instrumental in promoting sustainable forest management practices and ensuring the continued health and productivity of these vital ecosystems for future generations.

Conceptual Framework

This study is anchored on the concept of environmental degradation. Environmental degradation refers to the deterioration of the environment through the depletion of resources, destruction of ecosystems, and extinction of wildlife (MEA, 2005). In the context of forest ecosystems, this involves the loss of forest cover, biodiversity, and ecosystem services due to both natural and anthropogenic factors. This study focuses on assessing forest degradation in the Taraba Central Senatorial District by examining changes in vegetation cover using NDVI data over a period of 30 years. The key concepts include forest degradation which is the reduction in the capacity of a forest to provide goods and services (FAO, 2011). The indicators of forest degradation are decline in dense and less dense vegetation, increase in sparsely vegetated areas (Lambin et al., 2003). The causes of forest degradation include logging, agricultural expansion, infrastructure development, and climate change (Geist and Lambin, 2002).

The Normalized Difference Vegetation Index (NDVI) which is a satellite-derived index that measures vegetation health and density Rouse et al., (1974) is most often used to quantify changes in vegetation cover over time (Tucker, 1979). High NDVI values indicate dense vegetation, while low NDVI values indicate sparse vegetation or degraded land (Pettorelli et al., 2005). The environmental impact of forest degradation includes biodiversity loss (decreased habitat for flora and fauna) Wilson and Peter, (1988), decline in ecosystem services (reduction in carbon sequestration, water regulation, and soil fertility) Costanza et al., (1997), impact on community livelihoods) (for communities dependent on forest resources) (Chomitz et al., 2007). By grounding the study in the concept of environmental degradation, this conceptual framework provides a structured approach to understanding and addressing forest degradation in the Taraba Central Senatorial District, Nigeria. This is conceptualized in Figure 1:

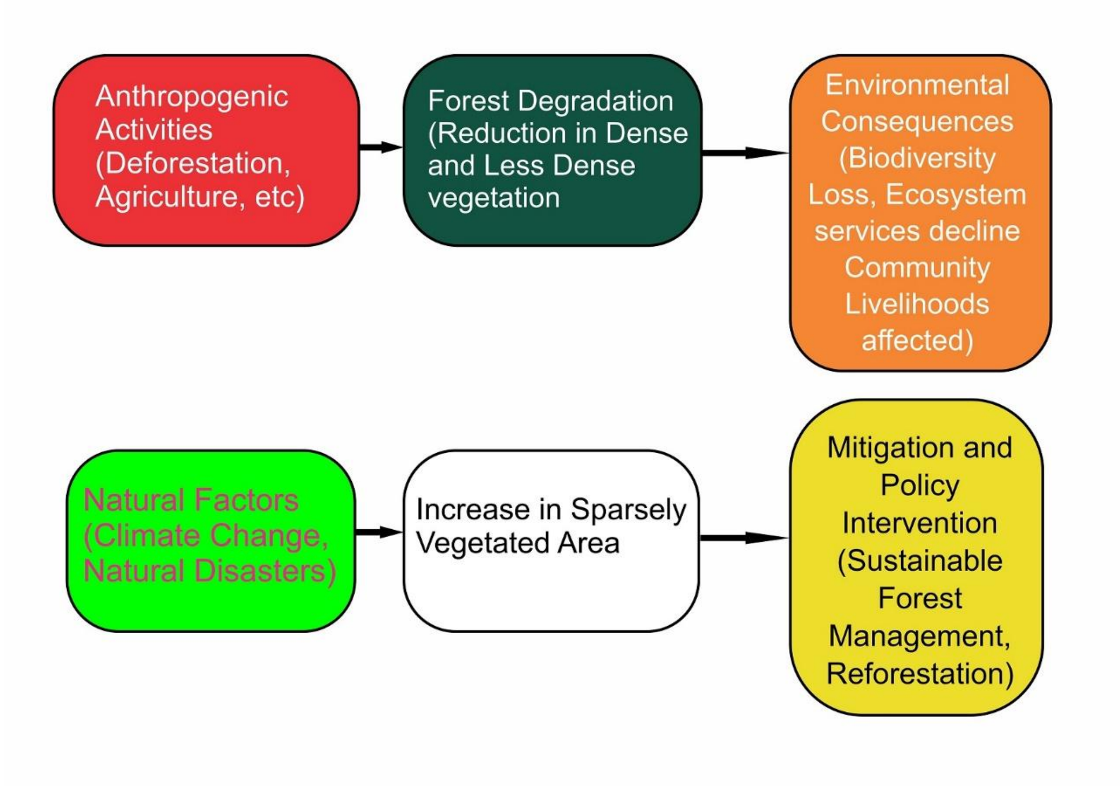

Figure 1 Conceptualized Framework of Forest Degradation

2. METHODOLOGY

This study used the Normalized Difference Vegetation Index (NDVI) which is a satellite-derived measurement that estimates the greenness of vegetation. Healthy, dense forests with abundant foliage will have a higher NDVI value compared to degraded forests with less vegetation cover. NDVI is a widely used remote sensing tool that is used to provide valuable insights in studies assessing forest degradation. The NDVI is a measure of vegetation health derived from satellite imagery. By analyzing NDVI data over the period 1993 to 2023, the study track changes in forest health in the study area.

Effort was made to select cloud-free data sets and to obtain data that are near the same date and season in order to reduce seasonal difference effects on the images for normalized difference vegetation index analysis. The selected images were acquired in January which is dry season in the study area to maintain consistency in date and clarity of images used. These images were downloaded from the United State Geological Survey (www.earthexplorer.usgs.gov). Table 1 gave detail information about the satellite images that were used in the study. The study used ArcGIS version 10.7.1 to process the image.

Table 1 Description of remote sensing data

Platform (sensor)	Row/ Column	Data Acquired	Spatial resolution	Description	Data source
LANDSAT_5_TM	188/55	06/01/1993	30 meters	7 bands multispectral image acquire by TM	www.earthexplorer.usgs.gov
LANDSAT_7_ETM	189/55	10/01/2003	30 meters	9 bands multispectral image acquire by ETM	www.earthexplorer.usgs.gov
LANDSAT_8	189/55	15/01/2013	30 meters	11 band multispectral image acquire by OLI and TIRS	www.earthexplorer.usgs.gov
LANDSAT_8	189/55	09/01/2023	30 meters	11 band multispectral image acquire by OLI and TIRS	www.earthexplorer.usgs.gov

Image pre-processing

The study area was clipped out from the stacked images (1993, 2003, 2013 and 2023) because of the following reasons;

The study area covered small area on the images

It saved processing time and reduced storage space

It was easier to carry out geometric correction on a small image

Analysis of Normalized Difference Vegetation Index (NDVI)

NDVI is used to quantify vegetation greenness and is useful in understanding vegetation density and assessing changes in plant health. NDVI is calculated as a ratio between the red(R) and near infrared (NIR) values as follows;

$$\text{NDVI} = \frac{NIR - R}{\text{NIR} + \text{R}}$$

Where by NIR is near infrared and R is Red

In LANDSAT 4 – 7

$$\text{NDVI} = \frac{Band4 - Band3}{\text{Band4} + \text{Band3}}$$

While in LANDSAT 8 – 9

$$\text{NDVI} = \frac{Band5 - Band4}{\text{Band5} + \text{Band4}}$$

USGS LANDSAT Mission, 2021

According to USGS LANDSAT Mission 2021 LANDSAT 4,5,6 and 7 have the Red and Infrared bands at band number 3 and 4 respectively. While LANDSAT 8 and 8 has their Red and Infrared at band number 4 and 5. In this case, band 3 was subtracted from band 4 and divided by the sum of band 3 and 4 to get NDVI at 1993 and 2003 since the images are in LANDSAT 4 and 7, while band 4 was subtracted from band 5 and the result was divided by sum of band 4 and 5 in LANDSAT 8. This was achieved using raster calculator in ArcGIS 10.7.1 software

The NDVI results obtained at 1993, 2003, 2013 and 2023 was reclassified using reclassify tool in ArcGIS 10.7.1 software with the following classification ranges;

Dense vegetation 0.6 to 1.0

Less dense vegetation 0.3 to 0.6

Sparse vegetation 0.1 to 0.3

Bare land -0.1 to 0.1

Water bodies -1 to 0

NDVI with maximum value up to 0.9+ as in the case of 1993 and 2003 were classify as dense vegetation, less dense vegetation, sparse vegetation, bare land and water body. NDVI with value below 0.3 were classify as sparse vegetation, bare land and water because the vegetation at those periods is not up to densely and less dense status. Finally, the area of all the classes in the NDVI were computed using field calculator tool in attribute of ArcGIS 10.7.1. The area was calculated using as follows;

Area(msq) = number of pixels in a class x spatial resolution of the image

Whereby the spatial resolution is 30 by 30 meters

$$\text{Area(kmsq)} = \frac{\text{Pixel}_{\text{number}}\text{x } 30\text{x}30}{1{,}000{,}000}$$

Finally, the maps were exported in JPEG format file extension.

The resulting NDVI values range from -1 to +1, where higher values (closer to +1) indicate healthier and denser vegetation, and lower values (closer to -1) indicate non-vegetated surfaces like water, barren land, or degraded vegetation.

The NDVI in this study was used to map and visualize areas of forest degradation in the study area. This degradation could be due to factors like logging, uncontrolled fires, or conversion of forest land for agriculture. By mapping these areas of decreasing NDVI, the study tried to identify the extent and severity of forest degradation in the study area. Rural communities living near forests often depend on them for various resources like timber, firewood, non-timber forest products (fruits, nuts, medicinal plants), and grazing land. Forest degradation reduces the availability and quality of these resources. This spatial information is crucial for identifying specific part of the study area where the forest health is declining and correlating these areas with socio-economic data of rural households.

By mapping NDVI data alongside socio-economic data, the study can identify correlations between forest health and rural livelihood activities. For example, areas with significant NDVI decline might correlate with regions where households rely heavily on forest resources for income or subsistence. The Changes in NDVI was used to assess the impact of forest degradation on various aspects of rural livelihoods, such as availability of forest products (e.g., firewood, medicinal plants), agricultural productivity (affected by changes in microclimate due to forest cover loss), and overall environmental health (e.g., soil erosion, water availability). The NDVI method was chosen so that it can help evaluate the effectiveness of conservation or reforestation interventions. By comparing NDVI values before and after such interventions, the study can assess whether the actions taken have led to improvements in forest health and thus positively impacted rural livelihoods.

The insights gained from NDVI analysis can inform policymakers about the regions most affected by forest degradation and the households most vulnerable to these changes. This information can guide the development of targeted policies and programs aimed at sustainable forest management and rural development. By utilizing NDVI in this study, the impact of forest degradation on rural household livelihoods gained robust, spatially-explicit insights that are critical for both understanding the problem and informing effective solutions. A hypothesis was employed to direct the focus of the study as follows;

Ho: There is no significant difference in the vegetation cover changes in the study area within the period under study (1993 to 2023). The ANOVA analysis was used to confirm the hypothesis. To determine whether the variations in the vegetation pattern between the years under study were statistically different, a two-way ANOVA (F-Ratio) was employed. The alpha value of 0.05, or the 95% confidence level, was utilized to determine whether to accept or reject the hypothesis.

3. RESULT OF THE FINDINGS

The study area located in Taraba central displays a mosaic of different landcover types which include dense vegetation, less dense vegetation, sparse vegetation, bare land /settlements /farmlands and water body /rocks. Table 2 represents the land cover classes for each year of 1993, 2003, 2013 and 2023, all of which have undergone changes over the years. (Figures 2, 3, 4 and 5) show the spatial distribution of the land cover types of the study area.

Table 2 Land Cover Change in the Study Area

Type of surface	**1993**		**2003**		**2013**		**2023**		**Rate of Change**		
	Area (km2)	**Area (%)**	**Area (km2)**	**Area (%)**	**Area (km2)**	**Area (%)**	**Area (km2)**	**Area (%)**	**1993/2003 (km2)**	**2003/2013 (km2)**	**2013/2023 (km2)**
Water body/rocks	3183.052	17.50	3327.141	18.3	4413.828	24.27	4104.125	22.57	14.41	108.67	- 30.97
Bare land/Settlements/ Farmlands	4679.745	25.74	5059.24	27.82	8858.759	48.72	7757.038	42.66	37.95	379.95	- 110.17
Sparsely vegetation	4264.155	23.45	4511.941	24.81	4911.012	27.01	6322.435	34.77	24.78	39.91	141.14
Less dense vegetation	3496.367	19.23	3312.983	18.22	-	-	-	-	-18.34	-	-
Dense vegetation	2560.28	14.08	1972.294	10.85	-	-	-	-	-58.80	-	-
Total	18,183.599	100	18,183.599	100	18,183.599	100	18,183.598	100	-		

Source: Result of NDVI Analysis, 2024.

Table 2 shows the entire study area covering 18,183.599 km^2. In 1993, areas of dense vegetation constituted the least land cover occupying 2,560.28 (14.08%) and less dense vegetation and sparse vegetation occupied 3,496.37 km^2 (19.23%) and 4,264km^2 (23.45%) respectively of the study area (Figure 2). Bare land/settlements/farmlands occupied the largest area of 4,679.75km^2 (25.74%), and water body/rocks occupied 3,183.05km^2 (17.50%) of the study area (Figure 2).

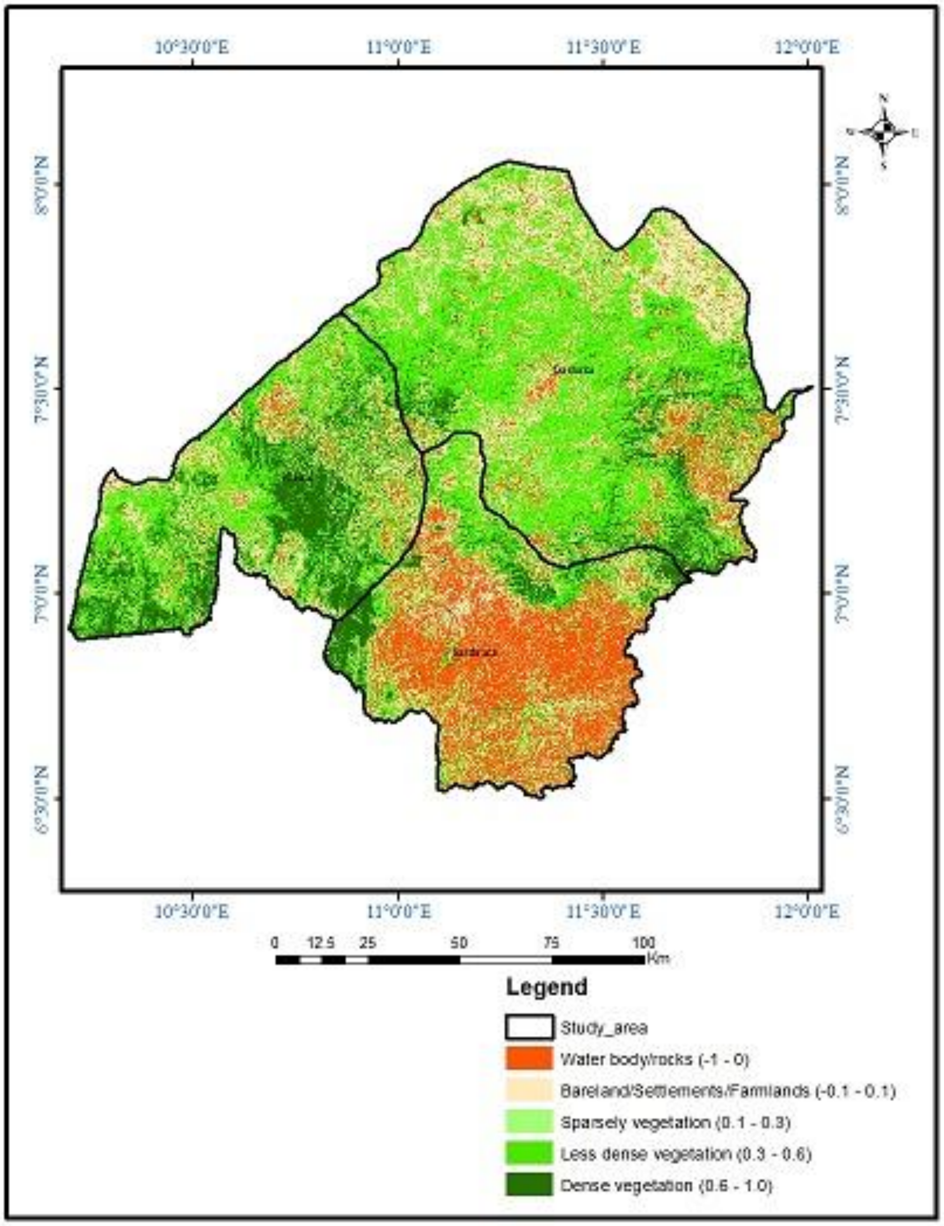

Figure 2 Map of Land Cover of the study area in 1993

However, in 2003, areas of dense vegetation decreased quite rapidly, decreasing to 1972.29km2 (10.85%) of the study area. Areas of less dense vegetation also decreases from 3,496.37km2 (19.23%) to 3,312.9 km2 (18.22%) of the study area. Areas of sparsely vegetation on the other hand increases from 4,264.16 km2 (23.45%) to 4,511.94 km2 (24.81%) of the study area (Figure 3). Bare land/settlements/farmlands areas expanded rapidly from 4,679.75 km2 (25.74%) to 5,059.24km2 (27.82%) of the study area. Water body/rocks increased from 3,183.05km2 (17.50%) to 3,327.14 km2 (18.3%) of the study area (Figure 3).

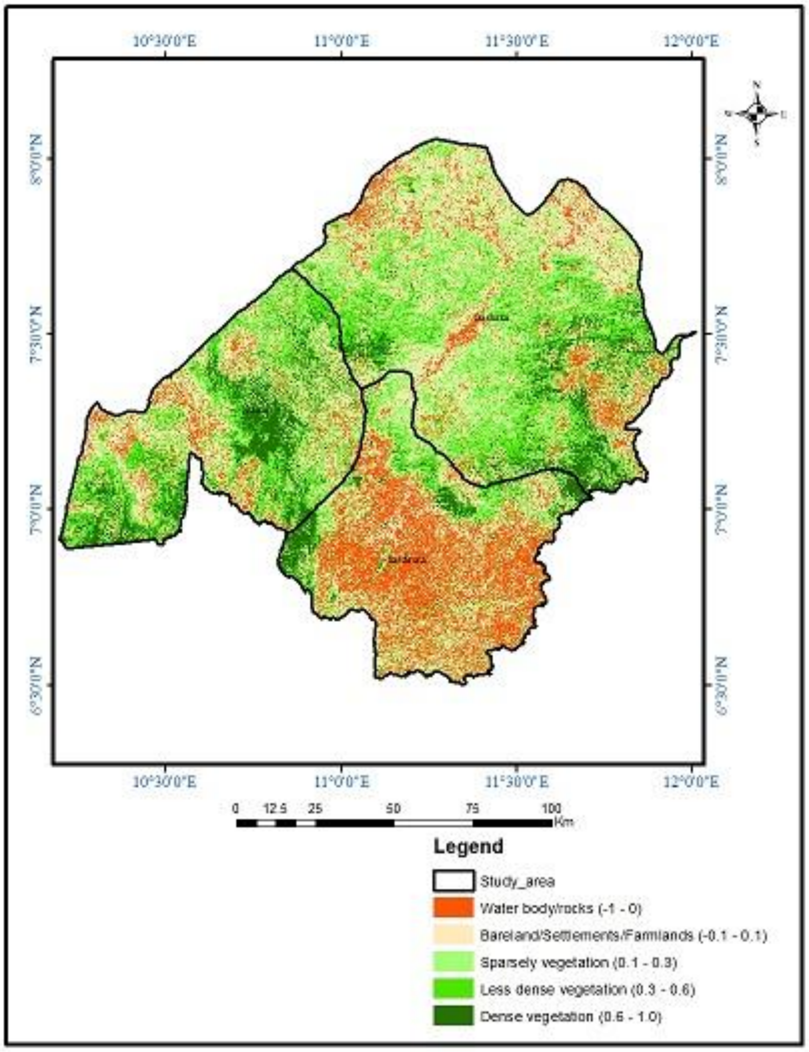

Figure 3 Map of Land Cover of the study area in 2003

In 2013, areas of dense vegetation and less dense vegetation has disappeared completely in the study area with maximum NDVI value of 0.207221 and minimum NDVI value of -0.564227. Bare land /settlements/ farmlands recorded the largest increase from 5,059.24km2 (27.82%) in 2003 to 8,858.76km2 (48.72%) in 2013 of the study area (Figure 4). This was followed by water body/rocks which increased from 3,327.14km2 (18.3%) in 2003 to 4,413.83km2 (24.27%) in 2013 of the study area. The area of sparsely vegetation also increased from 4,511.94km2 (24.81%) in 2003 to 4,911.01km2 (27.01%) of the study area (Figure 4).

In 2023, the areas of bare land /settlements/ farmlands decreased from 8,858 (48.72%) in 2013 to 7,757.038 (42.66%) in 2023. Also, in 2023, the areas of water body/rocks decreased from 4,413 (24.27%) in 2013 to 4,104.13 (22.57%) in 2023. On the other hand, areas of sparsely vegetation increased from 4,911.012km2 (27.01%) in 2013 to 6,322.435km2 (34.77%) of the study area (Figure 5). There was no dense vegetation and less dense vegetation as the maximum NDVI value was 0.195625 and minimum NDVI value was -0.511954.

The Annual Change Rate

The rates of land cover changes from 1993 to 2023 (Table 2) revealed that rates of land cover changes for the different classes over the periods were of different magnitude. The dense vegetation and less dense vegetation classes have shown decrease (-58.80 and -18.34) from 1993 to 2003, after which there was none again in the study area, while sparsely vegetation had increased area coverage (23.45, 24.81, 27.01 and 34.77) from 1993 to 2003, 2003 to 2013 and 2013 to 2023 respectively. The annual rate of change of the remaining land cover classes fluctuated between the study periods.

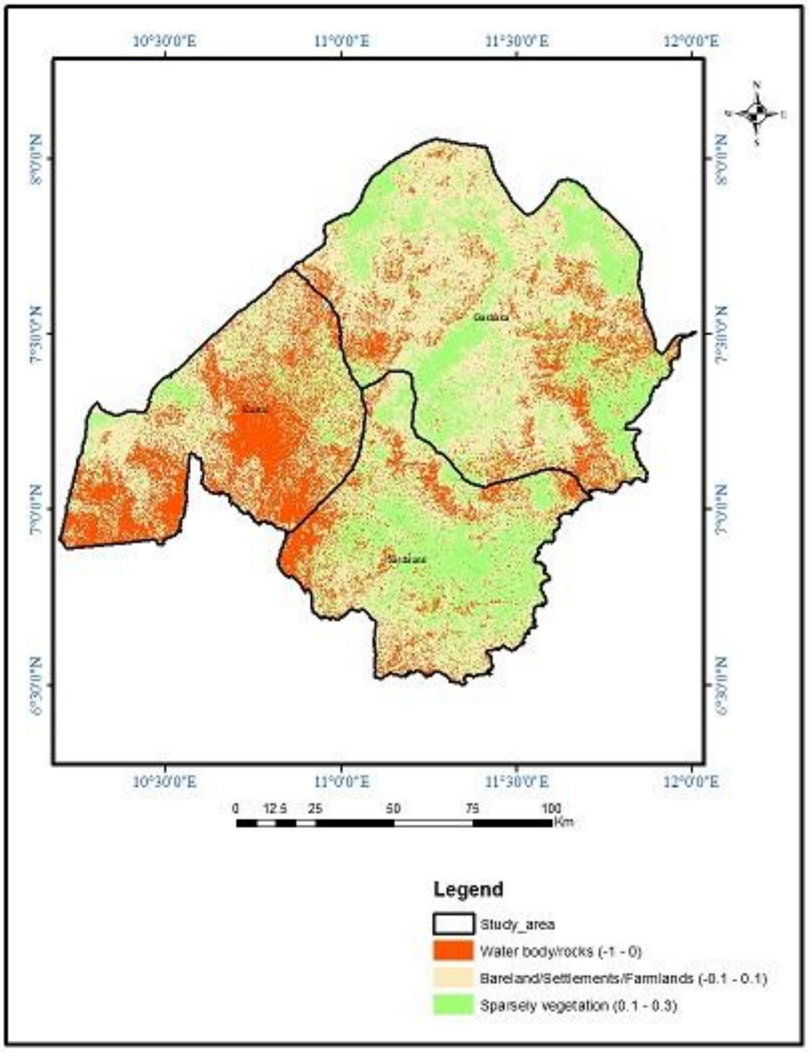

Figure 4 Map of Land Cover of the study area in 2013

Vegetation Cover Changes between 1993 and 2023

To identified vegetation cover changes in central Taraba, the study area was subjected to analysis of variance (ANOVA) at 0.05 level of significance to statistically confirm the significant difference in the magnitude (value) of the vegetation cover between 1999, 2003, 2013 and 2023. Table 3 shows the detail

Table 3 Analysis of variance for level of significance for land cover classes

Source of variation	Sum of Square	Degree of Freedom	Mean of Square	F-ratio calculated (Fcal)	F- critical (Ftab)
Between class years	25042881.81	3	8347627.270	11.023	0.001
Within class years	27263702.287	12	2271975.191	-	-
Total	3096.74	15	-	-	-

Source: Study analysis, 2024.

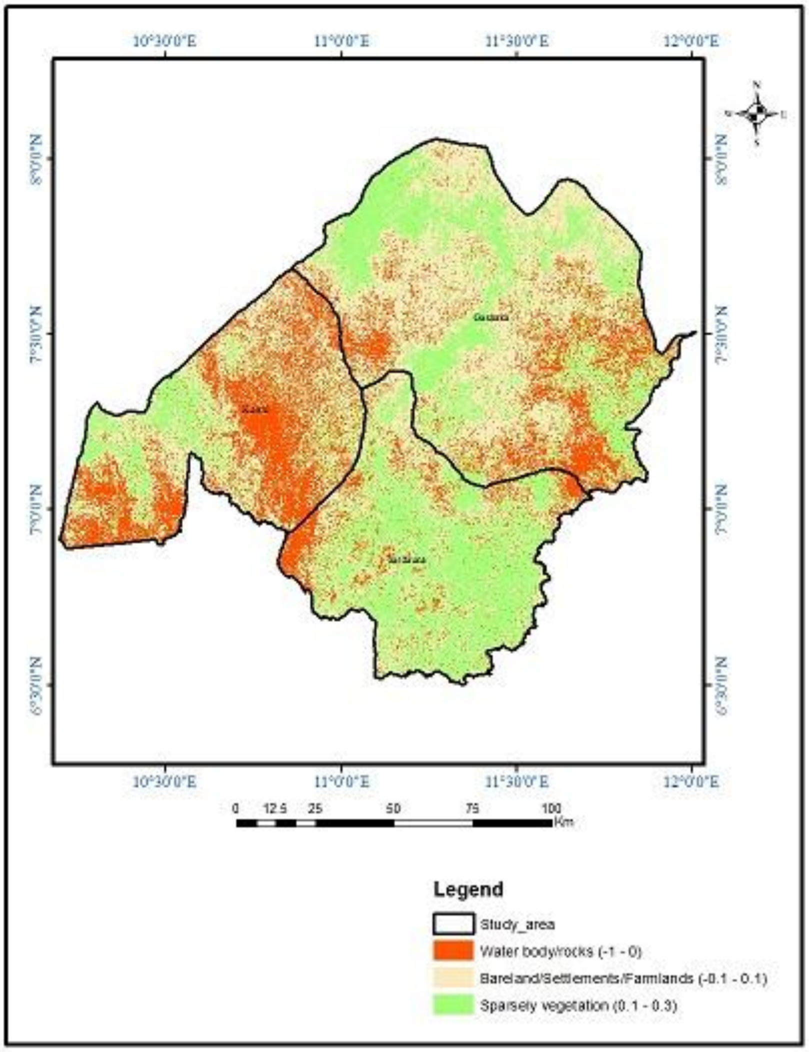

Figure 5 Map of Land Cover of the study area in 2023

Table 3 shows the result of the analysis of variance and Fcal is 11.023 while Ftab is 0.001 at 95% (0.05%) level of confidence and 15 degrees of freedom. Since Fcal is greater than Ftab (11.023 > 0.001), we reject the null hypothesis (Ho) and accept the alternative hypothesis meaning that there is a statistically significant difference in the vegetation cover changes in the study area between the years under study.

Drivers of Forest Degradation in Taraba Central Senatorial District, Nigeria

The findings of this study, indicating a progressive decline in dense and less dense vegetation cover between 1993 and 2003, culminating in the complete disappearance of these vegetation types by 2013, underscore a critical environmental challenge in Taraba Central Senatorial District. Several interconnected factors likely contributed to this rapid and severe forest degradation.

Potential Drivers of Forest Degradation

Agricultural Expansion

The primary driver of forest degradation in the region is the increasing conversion of forest land into agricultural fields. As the local population grows, so does the demand for agricultural land to ensure food security, leading to widespread deforestation. The conversion of forestland to agricultural use is a primary driver of deforestation and degradation globally, and it is likely a significant factor in Taraba Central. Population growth and increasing food demands can intensify agricultural practices, leading to encroachment into forest areas (FAO, 2020a).

Fuelwood and Charcoal Production

In most of the rural areas of the Taraba Central Senatorial District, wood remains a crucial source of energy for cooking and heating. The over-reliance on fuelwood has led to extensive deforestation as trees are cut down faster than they can naturally regenerate. The reliance on wood for cooking and heating, particularly in rural areas, is a common practice that contributes to deforestation. The production of charcoal for commercial purposes can also exert significant pressure on forest resources. This is has been made worst by the non-availability of kerosene and high cost of cooking gas which is only found in urban areas.

Fires

Both human-induced and natural fires can cause substantial damage to forest ecosystems. Climate change, with its potential to increase the frequency and intensity of droughts, may exacerbate fire risks (Plate 1).

Plate 1 Use of bush fire in clearing farmland

Population Growth and Settlement

The increasing population in the district exerts additional pressure on forest resources. The population of the district has grown from 735,288 in 1999 to 1,479,911 in 2023 (NPC Estimates and 2006 Census). This growing demand for land, wood, and other forest products often results in unsustainable exploitation practices, accelerating forest degradation. Increasing population density can lead to higher demands for land, including forestland, for housing, infrastructure, and agricultural purposes.

Overgrazing

Livestock grazing in and around forested areas leads to vegetation depletion and soil compaction. Overgrazing hinders the natural regeneration of forests and contributes to soil erosion, further degrading the land (Plates 2a & b).

Plate 2a & b Grazing of animals at Gashaka Gumti National Park

Illegal Logging

Logging and Timber Extraction: Both legal and illegal logging activities have significantly reduced forest cover. The high economic value of timber has incentivized excessive and unsustainable logging practices, severely impacting dense forest areas (Plate 3a & b). This is exacerbated by the use of motorized chain saw in felling of big trees. Unsustainable and illegal logging practices can rapidly deplete forest resources (Plate 4a & b). Weak governance and law enforcement can exacerbate this problem (FAO, 2020a).

Plate 3a & b Timber production on the Mambilla Plateau

Plate 4a &b Illegal timber extraction at Gashaka Gumti National Park

Mining activities

Mining activities both by illegal miners and small-scale miners has resulted in forest degradation in the study area. These activities are now carried out with heavy duty equipment such as bull dozers and excavators (Plate 5a & b). Unfortunately, there are many degraded mines within the Gashaka Gumti National Park which is a forest reserved area (Plate 6a & b).

Plate 5a Mechanized mining at Bokati, Gashaka LGA

Plate 5b Degraded mining land at Nguroje, Sardauna LGA

Plates 6a & b Degraded mines at Gashaka Gumti National Park

Governance and Policy

Inadequate Forest management policies, weak law enforcement, and lack of awareness about the importance of forest conservation can contribute to deforestation (FAO, 2020b). The presence of forest degrading activities within the Gashaka Gumti National Park is a clear indication of weak law enforcement of conservation laws. This is not peculiar to the study area alone but Nigeria as a whole.

Infrastructure Development

The expansion of roads, settlements, and other infrastructure projects necessitates the clearing of forested land. This development not only fragments forests but also disrupts local ecosystems and biodiversity.

Climate Change

Shifts in climate patterns, such as increased temperatures and altered rainfall, have stressed forest ecosystems. These climatic changes exacerbate other stressors, making forests more susceptible to degradation and reducing their ability to recover.

4. DISCUSSION OF FINDINGS

The study on the assessment of forest degradation in the Taraba Central Senatorial District, Nigeria, highlights significant changes in vegetation cover over a period spanning from 1993 to 2023. Using Normalized Difference Vegetation Index (NDVI) data, the findings reveal a compelling evidence of forest degradation within the Taraba Central Senatorial District between 1993 and 2023. The NDVI results show a marked decrease in areas of dense vegetation. Specifically, the area covered by dense vegetation declined from 2,560.28 km² in 1993 to 1,972.29 km² in 2003 and by 2013 there were no dense vegetation in the area. This represents a significant reduction of approximately 23%. The decline in dense vegetation can be attributed to several factors, including deforestation for agricultural expansion, logging activities, and other forms of land use change.

The reduction in dense vegetation areas is alarming as it indicates a loss of crucial forest resources and biodiversity, which are vital for maintaining ecological balance and supporting local livelihoods. Similarly, areas of less dense vegetation also experienced a decline, from 3,496.37 km² in 1993 to 3,312.98 km² in 2003 and by 2013 there were no areas of less dense vegetation in the study area. This reduction of approximately 5% suggests a gradual transition from less dense to sparsely vegetated or non-vegetated land. The decline in less dense vegetation can be associated with similar pressures affecting dense vegetation, such as agricultural encroachment, overgrazing, and unsustainable land management practices. The loss of less dense vegetation further exacerbates environmental degradation and diminishes the resilience of the ecosystem to withstand climatic variations and anthropogenic pressures.

Increase in Sparsely Vegetated Areas

Contrasting the decline in dense and less dense vegetation, the study reports progressive increase in sparsely vegetated areas from 4,264.16 km^2 in 1993 to 4,511.94 km^2 in 2003, 4,911.01km2 in 2013 and 6,322.44km2 in 2023. This expansion of sparsely vegetated land is indicative of ongoing forest degradation and land cover change, likely driven by unsustainable land use practices and the over-exploitation of forest resources. The increase in sparsely vegetated areas is a critical indicator of environmental degradation, leading to reduced carbon sequestration capacity, altered hydrological cycles, and increased vulnerability to soil erosion and desertification.

Implications for Conservation and Management

The findings of this study underscore the urgent need for effective conservation and sustainable land management strategies in the Taraba Central Senatorial District. The continuous decline in dense and less dense vegetation, coupled with the rise in sparsely vegetated areas, highlights the fragility of the region's forest ecosystems. To mitigate further degradation, it is imperative to implement policies that promote reforestation, afforestation, and sustainable agricultural practices. Additionally, enhancing community awareness and involvement in conservation efforts is crucial for ensuring the long-term sustainability of forest resources.

5. CONCLUSION

The NDVI-based assessment of forest degradation in the Taraba Central Senatorial District reveals a troubling trend of decreasing dense and less dense vegetation, alongside an increase in sparsely vegetated areas. These changes reflect significant environmental degradation and pose a threat to the ecological and socio-economic stability of the region. Addressing these challenges requires a concerted effort from policymakers, local communities, and environmental organizations to promote sustainable land use and conservation practices.

Recommendations

Based on the findings of the study, the following recommendations were suggested;

Implementation of Sustainable Forest Management Practices: The government should develop and enforce policies that promote sustainable forest management to curb deforestation and degradation. Government should also encourage community-based forest management (CBFM) where local communities are involved in decision-making and benefit-sharing.

Reforestation and Afforestation Programs: The government should initiate large-scale reforestation and afforestation projects to restore degraded lands. Native tree species should be utilized for reforestation to ensure ecological compatibility and resilience.

Strengthening Forest Monitoring and Enforcement: The government should enhance forest monitoring through the use of remote sensing technologies and periodic field assessments. The government should also strengthen enforcement of forest protection laws to prevent illegal logging and land encroachment.

Promotion of Agroforestry: The government should encourage agroforestry practices that integrate trees into agricultural landscapes, providing economic benefits while restoring vegetation cover. They should also provide training and incentives for farmers to adopt agroforestry systems.

Community Engagement and Education: Raise awareness among local communities about the importance of forest conservation and sustainable practices. Implement educational programs that focus on the environmental and economic benefits of healthy forests.

Alternative Livelihood Programs: Develop alternative livelihood programs to reduce dependence on forest resources, such as promoting eco-tourism, sustainable agriculture, and non-timber forest products (NTFPs). Provide microfinance and support for small-scale enterprises that do not rely on deforestation.

Restoration of Riparian Zones: Prioritize the restoration of riparian zones to protect water quality and provide critical habitats for wildlife. Implement buffer zone policies along rivers and streams to prevent further degradation. The government should establish a comprehensive database to track changes in forest cover and biodiversity over time.

Policy Integration and Collaboration: Integrate Forest conservation policies with other sectoral policies, such as agriculture, water resources, and land use planning. Foster collaboration between government agencies, NGOs, private sector, and international organizations for a coordinated approach to forest management.

Climate Change Mitigation and Adaptation: Implement climate-smart practices to enhance the resilience of forests to climate change. Promote the role of forests in carbon sequestration and as a critical component of climate change mitigation strategies.

Informed constant

Not applicable

Ethical approval

Not applicable.

Conflicts of interests

The authors declare that there are no conflicts of interests.

Funding

The study has not received any external funding.

Data and materials availability

All data associated with this study are present in the paper.

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