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GEOSPATIAL TECHNIQUES TO IDENTIFY CONFLICT PRONE AREAS ALONG CATTLE ROUTES IN NORTH EASTERN NIGERIA

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ABSTRACT

This study employs geospatial techniques to identify conflict-prone areas along cattle routes in North-Eastern Nigeria. Key objectives include identifying grazing routes, analyzing vegetation changes using Land Use and Land Cover (LULC) data, establishing relationships between these changes and conflict zones, and mapping areas of high conflict potential. The methodology involves data collection from various sources, including government agencies and community organizations, to digitize historical grazing routes in ArcGIS. This process entailed loading historical maps and satellite imagery, georeferencing them, and then tracing the grazing routes to create accurate line shape files. For vegetation analysis, multispectral Land sat images from 1992, 2002, 2012, and 2022 were acquired and preprocessed using Google Earth Engine. LULC classification was performed based on spectral bands, resulting in maps of vegetation, built-up areas, water bodies, and bare surfaces. By comparing LULC changes over time, trends in vegetation loss and land cover shifts were assessed, providing insights into land degradation and human activities. The study finds a decline in vegetation cover from 80% in 1992 to 24.78% in 2022, indicative of extensive land degradation. Logistic regression analysis links grazing route density and vegetation loss to higher conflict rates. The mapping of overlapping grazing routes and local communities identifies areas with high conflict potential. This research underscores the necessity of integrated land use planning and conflict management strategies to mitigate risks and promote peaceful coexistence. It lays the groundwork for future policy interventions and sustainable development initiatives in North-Eastern Nigeria

Keywords: Geospatial, Conflict, Grazing routes, Land Degradation, LULC

Introduction

The North-Eastern region of Nigeria has been engulfed in a prolonged and multifaceted conflict, primarily characterized by escalating clashes between the Herders and sedentary farming communities. Traditionally, the Herders, a nomadic or semi-nomadic pastoralist group, have relied on transhumance, moving their cattle across vast landscapes in search of grazing lands and water sources. This mobile pastoral

livelihood has fostered economic exchange, cultural interactions, and ecological adaptation across diverse regions in Nigeria (Meagher, 2010).

However, with the increasing pressure on land due to population growth, sedentarization of communities, demographic shifts, and changes in climatic conditions, the harmony between herders and farmers has steadily eroded, leading to conflicts over resources. The conflicts have intensified over the years, resulting in widespread violence, loss of lives, destruction of property, and mass displacements (summers, 2012)

Numerous factors contribute to the escalating conflicts between Herders and local communities in North-Eastern Nigeria. One critical factor is the competition over access to land and water resources, which are essential for both pastoralists and sedentary farmers (Onuoha, 2008). The process of encroachment on traditional grazing routes by expanding farmlands and settlements has resulted in resource scarcity, degradation of pasturelands, and environmental degradation (Onwunyi & Anekwe, 2020). Moreover, long-standing socio-cultural and historical grievances add complexity to the conflicts, making them deeply rooted in ethnicity, identity, and land tenure systems (Komey, 2010). Despite the increasing scholarly interest in understanding the herder-farmer conflicts, significant gaps remain in the literature

North-Eastern Nigeria faces significant challenges due to the complex interplay between livestock herding and agricultural activities, leading to conflict over land and resources. The region's traditional grazing routes are under pressure from expanding human settlements and agricultural activities, which disrupts the free movement of cattle and increases the likelihood of clashes between pastoralists and farmers (Gebeyehu et al., 2021). These conflicts have serious consequences, including loss of lives and property, displacement of populations, and threats to food security and economic stability.

The need for sustainable land management practices and conflict resolution strategies is critical to address these challenges. However, there is a lack of comprehensive, data-driven studies that map the distribution and density of grazing routes in relation to conflict zones and changes in vegetation cover. By utilizing geospatial techniques, this study aims to fill this gap by identifying and analyzing the spatial patterns of conflict-prone areas along cattle routes in North-Eastern Nigeria

The aim of this research is to identify conflict prone areas along cattle routes in North-Eastern Nigeria using geospatial techniques. This will be achieved by identifying grazing routes and examine vegetation changes in the study area, and determine the relationship between vegetation change and grazing routes and also identify areas of high

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conflict potential by mapping . By using geospatial techniques, the study can contribute to evidence-based policy and decision-making processes, facilitate conflict prevention, and offer long-term solutions to the herder-farmer conflicts.

Collaborative efforts between academics, local communities, and policymakers are crucial to gather accurate data and develop sustainable conflict resolution strategies. By addressing the root causes of the conflicts and adopting a multidisciplinary approach, the research can contribute to regional stability, national security, and socio-economic development. The application of geospatial techniques to this specific context is essential, as it can provide valuable insights into the spatial patterns of grazing routes, land use changes, and conflict incidents, which were previously underexplored in the existing literature

The study was primarily relied on geospatial data, including Geographic Information System (GIS), remote sensing imagery, and spatial analysis, to analyze and visualize the spatial patterns of grazing routes, land use changes, and conflict incidents.

1. Materials and Methods

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2.1 Study Area

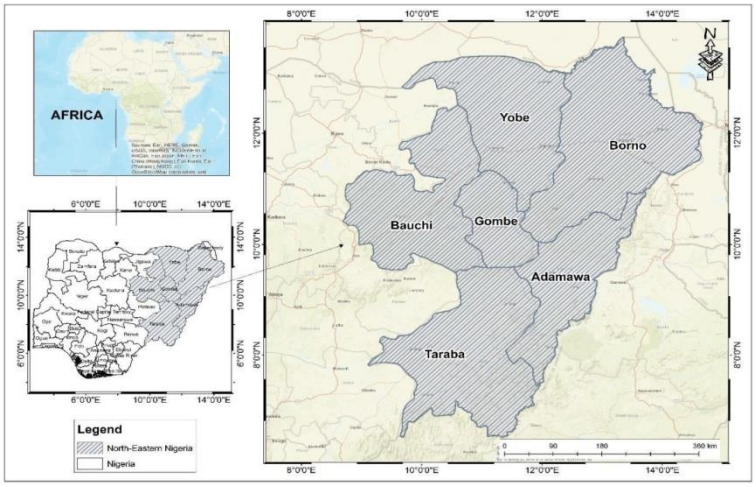


Figure 1: Study Area Map

The study area for this research is the North-Eastern region of Nigeria, a geopolitical zone in Nigeria, comprising six states: Adamawa, Bauchi, Borno, Gombe, Taraba, and Yobe as shown in Figure 1. Northeast Nigeria is located approximately between latitude 7°N and 13°N and longitude 7°E and 15° respectively.

Geographically, Northeast Nigeria is situated in the Sudano-Sahelian ecological

zone, marked by a transition between the Sahara Desert to the north and the more humid savannahs to the south. This positioning influences the region's climate, which is typically semi-arid, with distinct wet and dry seasons. The Chad Basin, located in the northern part of the region, is a significant geographical feature, serving as a vital water source for both human and animal populations

Drawing on conflict studies, the theoretical framework employed in this research integrates insights from prominent scholars such as Diehl (2009) whose work emphasizes the intricate and multifaceted nature of conflicts. These scholars highlight that conflicts are not isolated events but complex phenomena influenced by various social, economic, and political factors that necessitate a nuanced and interdisciplinary approach to analysis.

Geospatial analysis, a critical component of this research, harnesses the capabilities of Geographic Information System (GIS), Remote Sensing, and Global Positioning System (GPS) technologies to unravel the complexities of conflicts along cattle routes. The theoretical foundations of geospatial analysis, as articulated by Long & Robertson (2018), underscore the significance of spatial data in understanding geographical patterns and relationships. These scholars emphasize that geospatial analysis serves as a powerful tool for extracting meaningful insights from spatial data, facilitating a more informed exploration of the landscape

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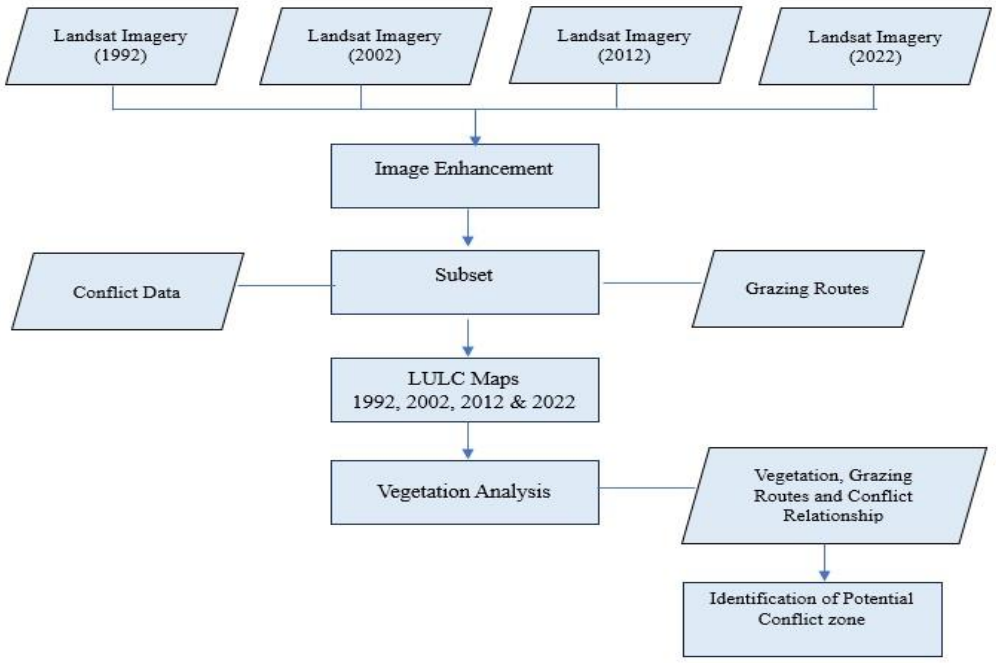


Figure 2: Methodological Flowchart

Research Method

a. Data Collection and Preparation

The methodology involved in this study encompassed the collection of historical data, maps, reports, and documentation pertaining to grazing routes. Various sources were tapped into, including government agencies, local authorities, and community organizations. A concerted effort was made to guarantee comprehensive coverage of the study area

b. Digitization of Historical Grazing Routes

Historical maps and satellite imagery were loaded into ArcGIS software. Then, the historical maps were georeferenced to align them with the spatial reference of the GIS project. Subsequently, a line shapefile was created within ArcGIS to represent the grazing routes. The digitization process included using the editing tools within ArcGIS to trace and digitize the grazing routes from the georeferenced historical maps, ensuring accurate delineation of the paths using the line drawing tool.

c. Landsat Images Acquisition: Landsat images covering the North-Eastern region of Nigeria were sourced from the Google Earth Engine environment. Specifically, Landsat 4/5 images for 1992, Landsat 7 for 2002, Landsat 8 for 2012, and Landsat 8 for 2022 were selected.

d. Band Extraction: Land Use and Land Cover (LULC) classification requires various spectral bands. For this study,

multispectral bands including Red, Green, Blue, and Near-Infrared (NIR) bands were extracted from each Landsat image for the respective years.

e. Classification Criteria: Each Landsat image for the respective years was classified into different land cover classes based on spectral signatures and LULC criteria. Classes typically include Built-up Area, Vegetation, Bare Surfaces, and Water Bodies.

f. Classification Process: The extracted bands were classified using appropriate classification techniques within the Google Earth Engine environment.

g. Area and Percentage Calculation

i. **Attribute Table Analysis:** For each classified image, the attribute tables were examined to compute the area and percentages of each land cover class.

ii. **Changes Identification:** By comparing the area and percentages of land cover classes across the years, changes in land use and land cover dynamics were identified.

Presentation of Results

All the data were analyzed and presented in maps and tables.

Figure 2 provides a visual overview of Northeast Nigeria, indicating the distribution of grazing routes through dashed red lines and the presence of grazing reserves in green. These mapped features serve as essential elements of the region's pastoral landscape, contributing to the sustainable utilization of natural resources and the preservation of traditional land use patterns.

Figure 3 presents another aspect of the region's landscape by highlighting conflict zones in Northeast Nigeria with red dots. These conflict zones denote areas where tensions and disputes may arise over land use, resource access, and other socio-political factors.

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VOL.12 (2), May-August, 2024 https://ajemates.org

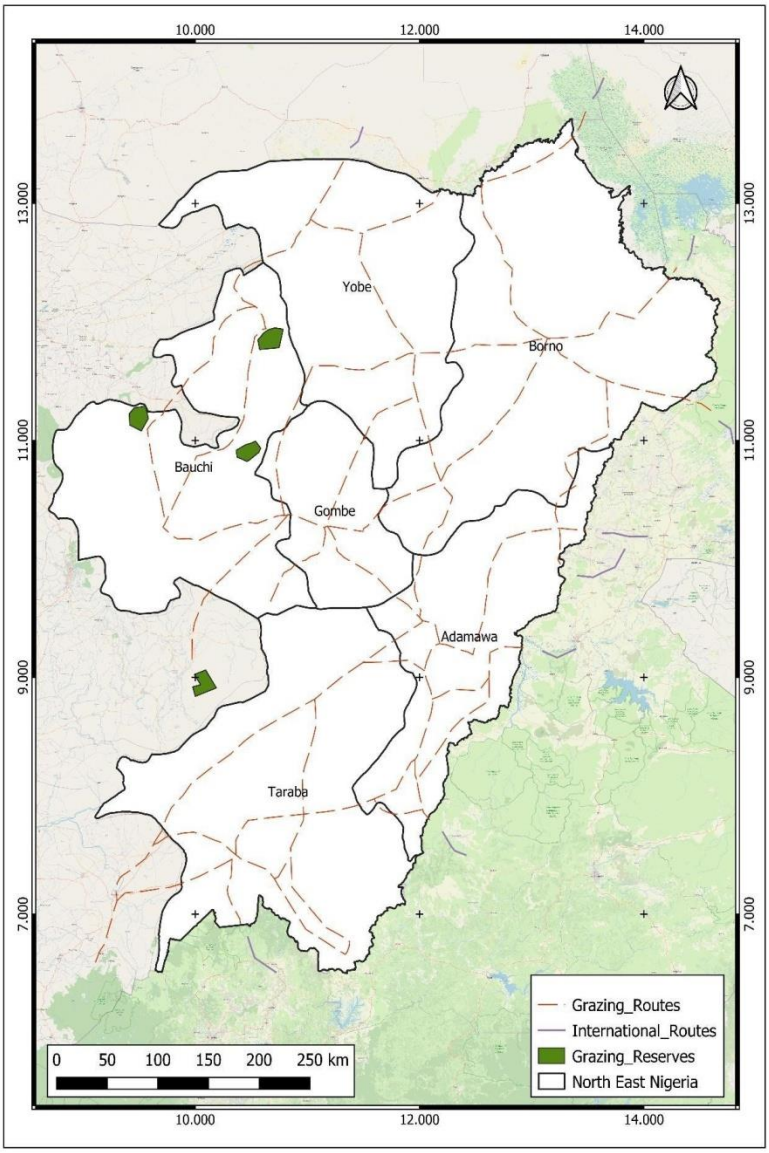


Figure 3: Map of North East Nigeria Showing Grazing Routes and Grazing Reserves
(Source: Researcher's analysis, 2023)

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VOL.12 (2), May-August, 2024 https://ajemates.org

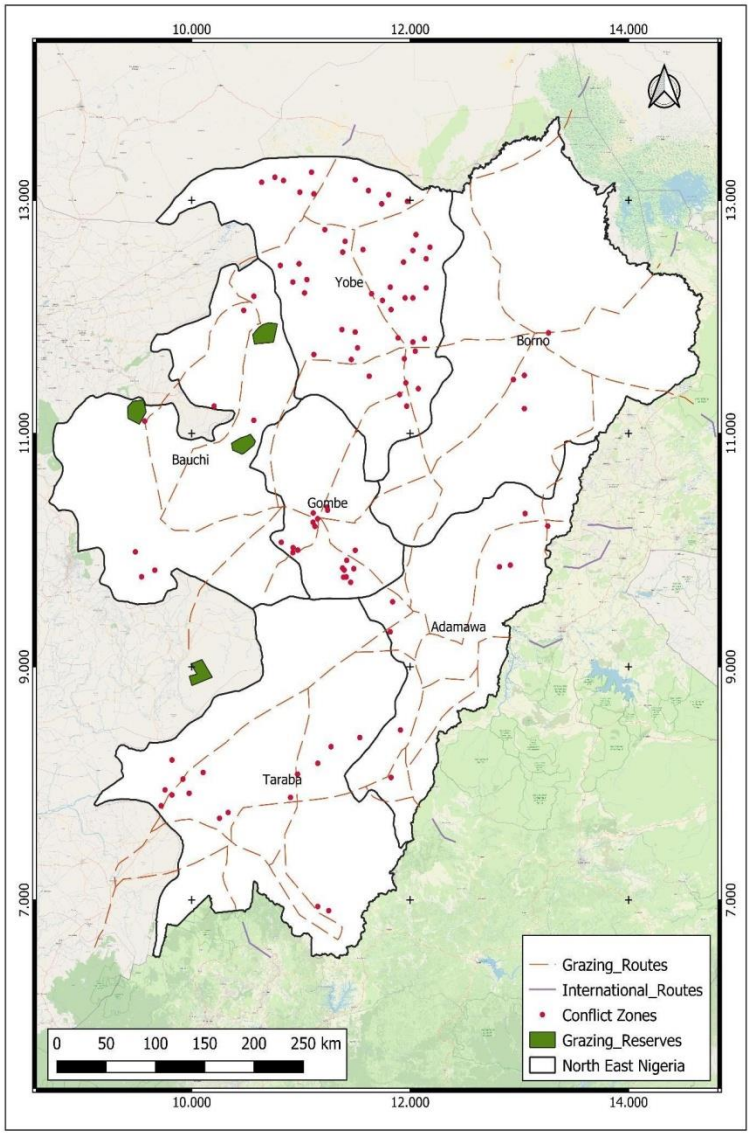


Figure 4: Map of North East Nigeria Showing Grazing Routes, Grazing Reserves and Conflict Zones (Source: Researcher's analysis, 2023)

Figure 3, provides a pictorial representation of the changing landscape depicted in the land use and land cover (LULC) categories discussed in Table .1. It visually illustrates the trends and transitions observed in built-up areas,

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African Journal of Educational Management, Teaching and Entrepreneurship Studies
VOL.12 (2), May-August, 2024 https://ajemates.org

vegetation cover, bare surfaces, and water bodies over the years. The graphical representation complements the quantitative data presented in Table .1, offering a more intuitive understanding of the evolving land use dynamics.

Table 1 Land use Land cover distribution of North East Nigeria

LULC CATEGORY	1992		2002		2012		2022	
	AREA (Ha)	%	AREA (Ha)	%	AREA (Ha)	%	AREA (Ha)	%
Built-up Areas	327204	1.19	518316	1.90	681751	2.62	432027	1.58
Vegetation	2196602	80.00	17240545	62.87	10281910	39.44	6794352	24.78
Bare Surface	5044801	18.39	9633891	35.13	14732125	56.51	20090911	73.26
Water Body	84628	0.31	29908.	0.11	374098	1.43	105371	0.38

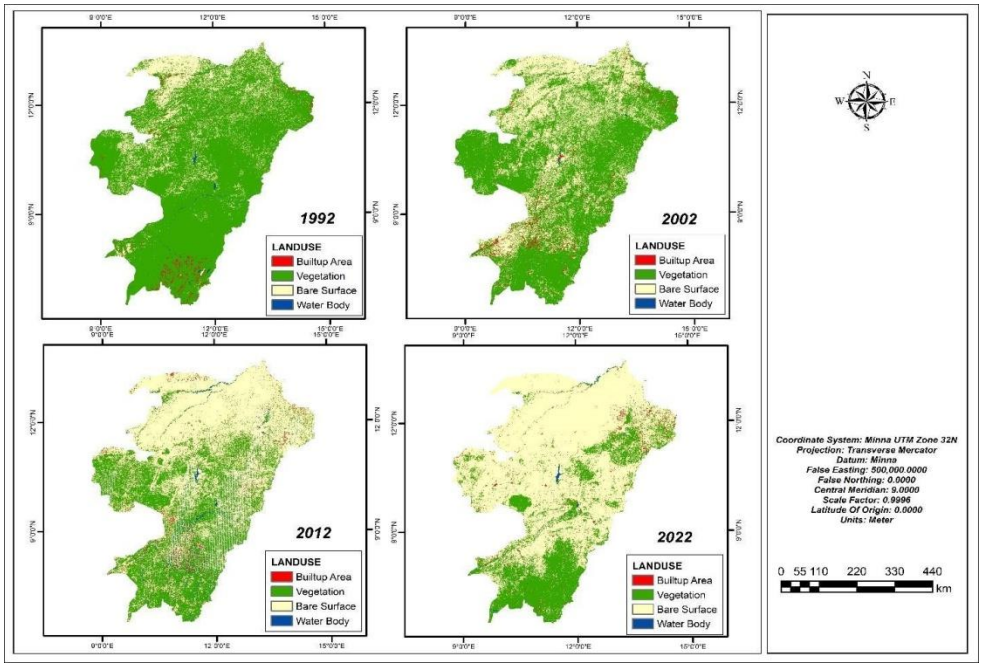


Figure 5: Land use/ Land cover map (1992-2022) of North East Nigeria
(Source: Researcher's analysis, 2023)

Vegetation Change Analysis

Change was carried out through image differencing. Two images were compared to give the location of changes and the rate in vegetation. The comparison was between the years 1992 and 2002, 2002 and 2012, 2012 and 2022 with the last one being 1992 and 2022.

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VOL.12 (2), May-August, 2024 https://ajemates.org

Table 2 illustrates the changes in vegetation cover from 1992 to 2022, providing insights into the trends and rates of change over different time intervals. From 1992 to 2002, there was a substantial decrease in vegetation cover, with the area shrinking from 21,966,602 Ha to 17,240,545 Ha, representing a rate of change of -17.13%. This period marked a significant loss in green cover.

The decline in vegetation cover continued from 2002 to 2012, with the area further decreasing from 17,240,545 Ha to 10,281,910 Ha, resulting in a rate of change of -23.43%. This period saw a pronounced acceleration in the loss of vegetation. Between 2012 and 2022, the rate of decline in vegetation cover moderated slightly. The area decreased from 10,281,910 Ha to 6,794,352 Ha, with a rate of change of -14.66%.

These findings are visually represented in Figure 6, which offers a pictorial representation of the data presented in Table .2. The graphical depiction enhances the understanding of the trends and patterns in vegetation changes over the years, highlighting the urgency of addressing deforestation and promoting sustainable land management practices.

Table 2 Vegetation changes between 1992 to 2022

YEAR	Image 1		Image 2		RATE OF CHANGE	
	AREA(Ha)	%	AREA(Ha)	%	AREA(Ha)	%
1992-2002	2196602	80	17240545	62.87	15043943	-17.13
2002-2012	17240545	62.87	10281910	39.44	-6958635	-23.43
2012-2022	10281910	39.44	6794352	24.78	-3487558	-14.66
1992-2022	2196602	80	6794352	24.78	4597750	-55.22

82

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VOL.12 (2), May-August, 2024 https://ajemates.org

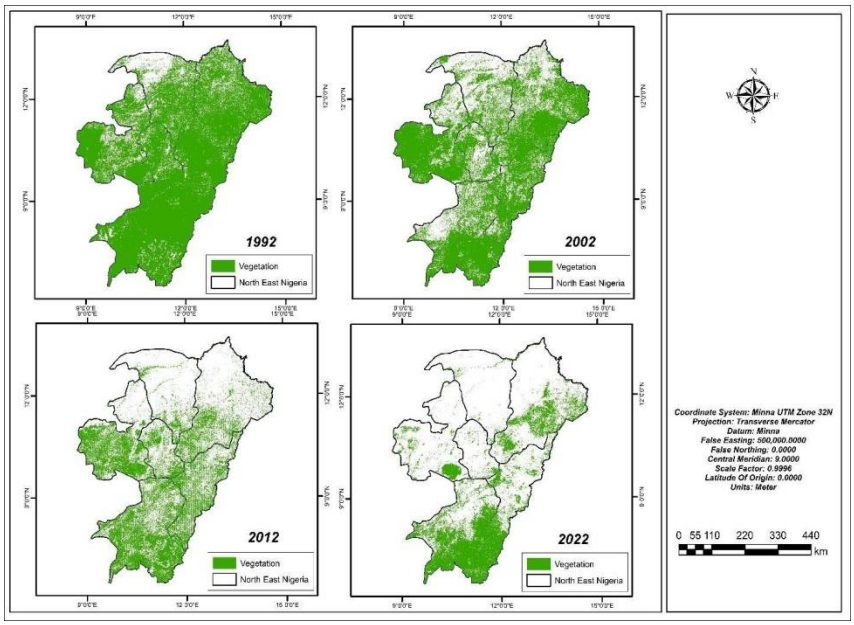


Figure. 6: Vegetation Changes (1992-2022) of North East Nigeria
(Source: Researcher's analysis)

Determine the Relationship between Vegetation Changes, Grazing Routes and Conflict Zones

Dependent variable

The dependent variable in this analysis is the classification of zones into "Conflict" and "No Conflict" categories. Conflict zones refer to areas where tensions or disputes between local communities and livestock grazers are prevalent, while No Conflict zones denote areas with minimal or no such conflicts. Figure 7 gives an illustration of these variables.

Independent variable

Grazing Route Density serves as a crucial independent variable in this analysis. It represents the concentration or intensity of livestock grazing paths within a given area. Higher grazing route density may indicate increased competition for grazing resources, potentially leading to conflicts between local communities and grazers. Figure 8 shows the grazing route density with red color indicating high density and green color indicating low density. Figure 9 shows the Conflict Potential Zones indicating a very high zone in red and moderate zone in yellow.

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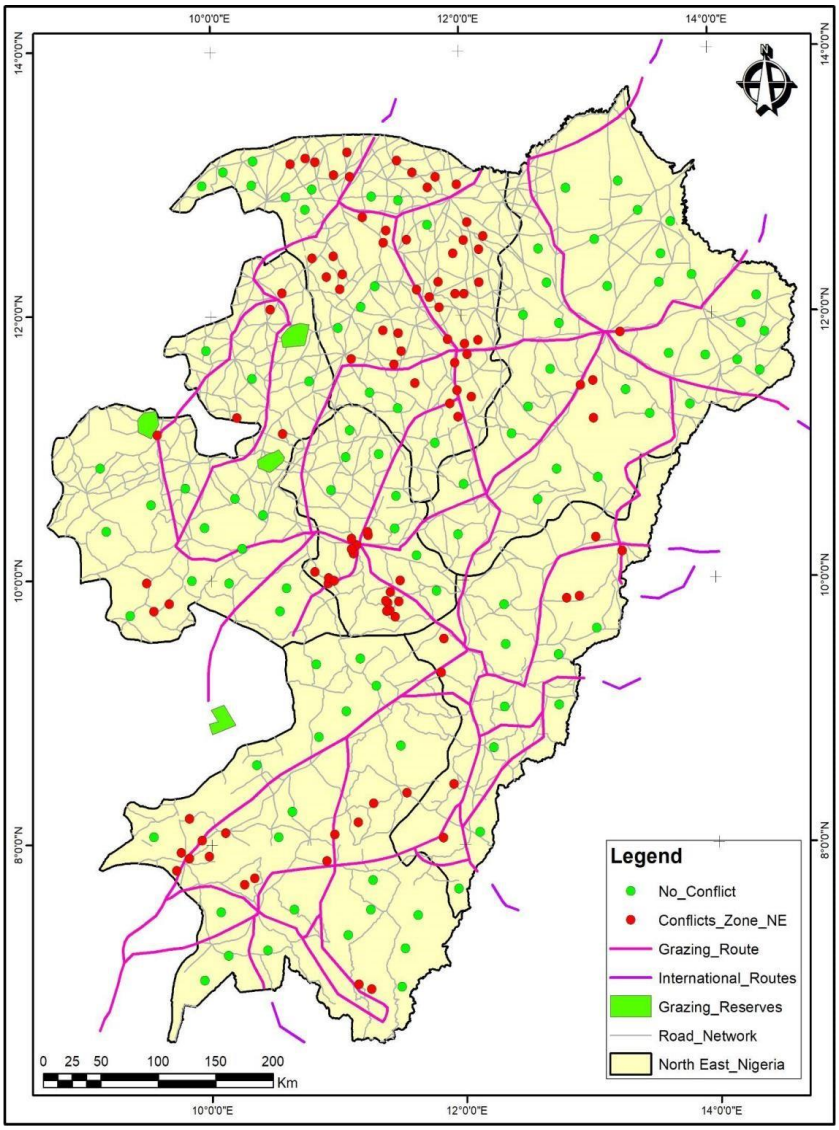


Figure 7: Conflict and No Conflict Category of North East Nigeria

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VOL.12 (2), May-August, 2024 https://ajemates.org

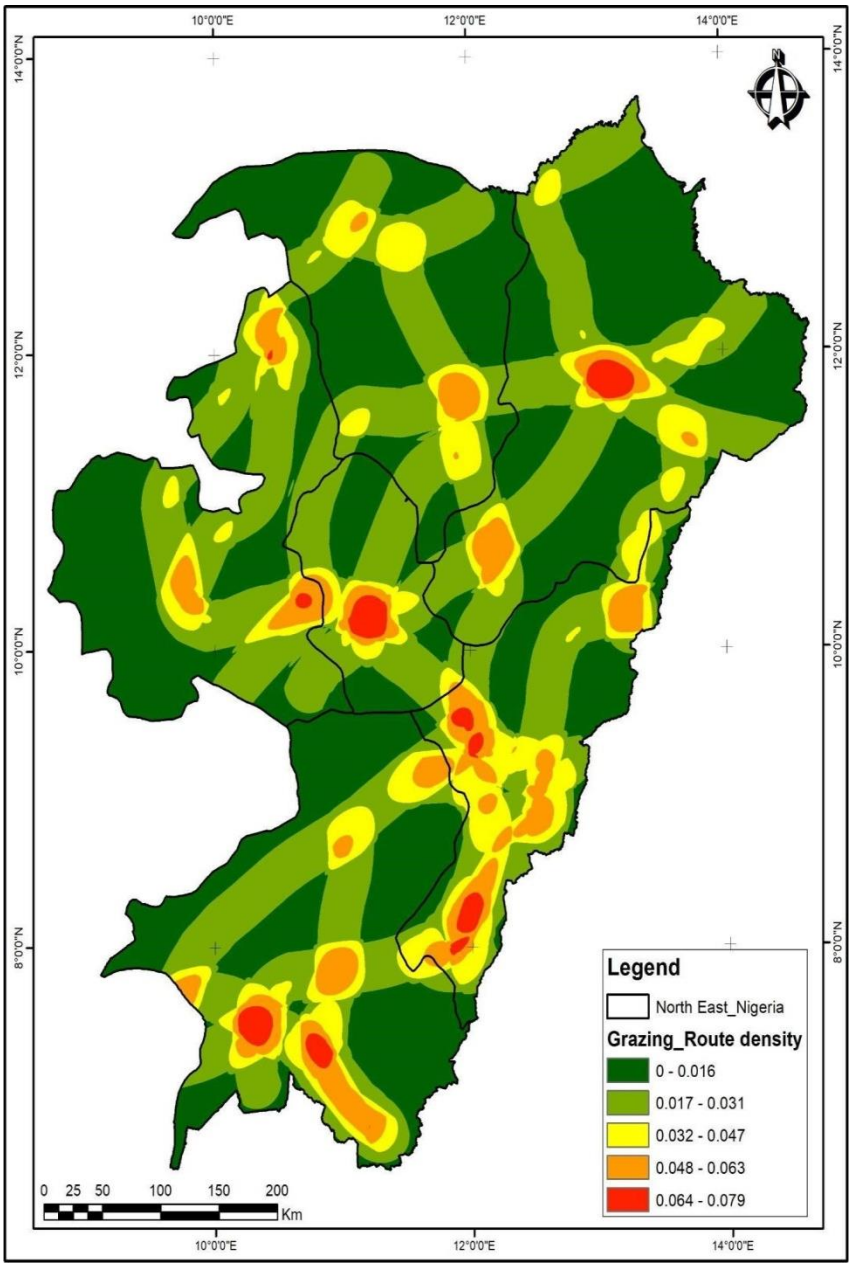


Figure 8: Grazing Route Density (Source: Researcher's analysis 2023)

85

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African Journal of Educational Management, Teaching and Entrepreneurship Studies
VOL.12 (2), May-August, 2024 https://ajemates.org

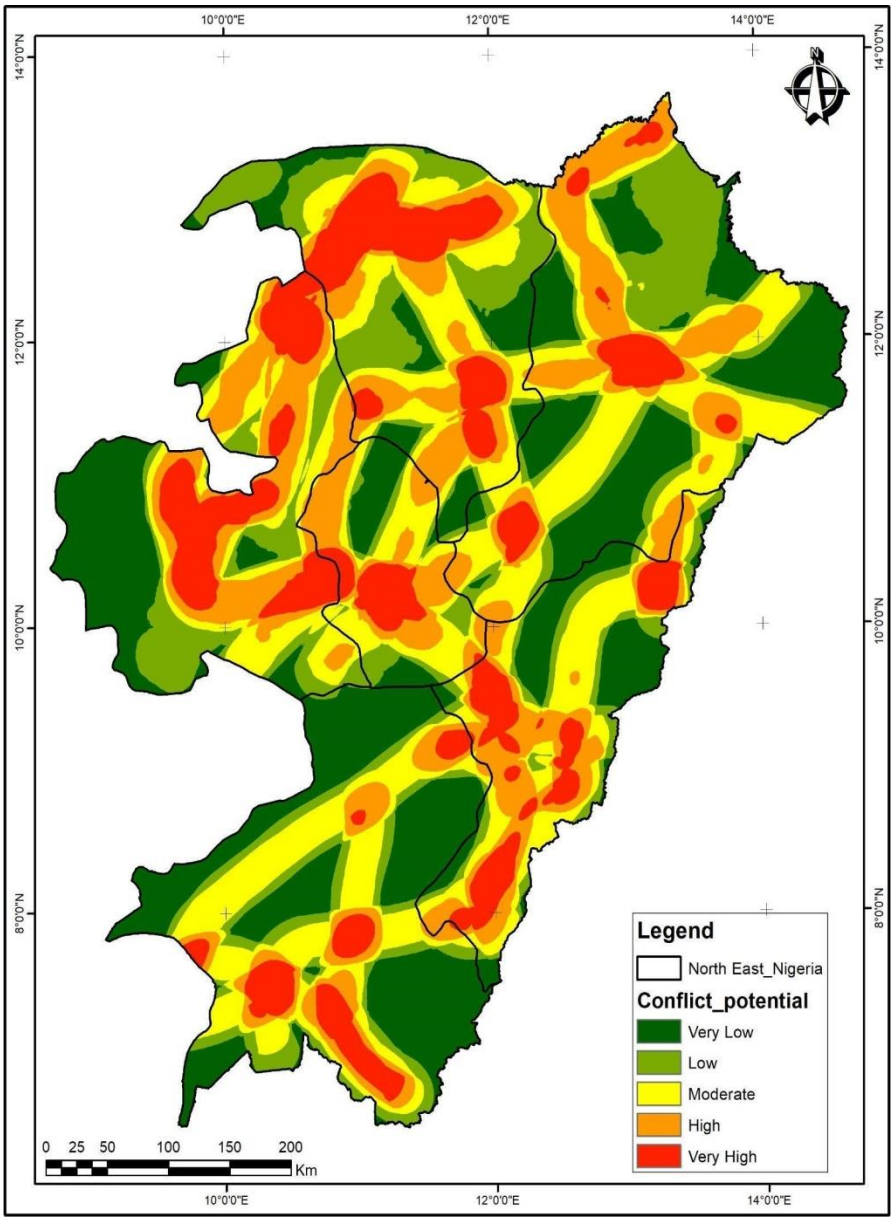


Figure 9: Conflict Potential Zones (Source: Researcher analysis 2023)

Discussion of Results

The analysis of the North-Eastern Region of Nigeria provides a comprehensive overview of the complex interactions between land use, resource management, and conflict dynamics. This region, marked by pastoral practices and

86

agricultural activities, faces challenges due to the competing needs of various stakeholders. The findings from this study highlight critical aspects of land use changes, the impact on grazing routes, and the conflict potential that arises from these dynamics.

The identification of grazing routes and reserves is crucial for understanding the pastoral landscape and its sustainable utilization of natural resources. As depicted in Figures 1 and 2, the mapping of these routes and reserves provides a visual representation of the region's pastoral dynamics. The presence of conflict zones within the same area as grazing routes and reserves suggests the potential for disputes over land use and resource access. This overlap highlights the need for effective management strategies to mediate between pastoral and Agricultural interests.

The analysis of vegetation changes using Land Use/Land Cover (LULC) data reveals a concerning trend of declining vegetation cover over the years. The decrease from 80% in 1992 to 24.78% in 2022 indicates significant deforestation and land degradation. This trend coincides with an increase in bare surfaces, further exacerbating environmental challenges. Such changes can lead to conflicts over shrinking resources and environmental sustainability. Figures 5 and 6 provide visual depictions of these trends, reinforcing the urgency of implementing measures to address deforestation and promote sustainable land management practices.

Mapping the overlapping locations of grazing routes and local communities has led to the identification of conflict potential zones. The majority of the analyzed area falls within moderate to very high conflict potential, which calls for focused conflict resolution strategies and resource allocation. Understanding the distribution of conflict potential can inform policymakers and stakeholders in prioritizing efforts for mitigating risks and fostering peaceful coexistence between pastoralists and local communities.

The findings from this study underscore the need for integrated land use planning and conflict management in the North-Eastern Region of Nigeria. The complex relationship between grazing routes, vegetation changes, and conflict zones requires a multifaceted approach to ensure sustainable land management and peaceful interactions between different land users. This study provides a foundation for future research and policy interventions aimed at promoting sustainable development and reducing conflicts in the region.

3. Conclusion

The research aimed to utilize geospatial techniques to identify conflict-prone areas along cattle routes in North-Eastern Nigeria. Through four main objectives, the study sought to identify grazing routes, examine vegetation changes, determine the relationship between vegetation changes and grazing routes, and identify areas of high conflict potential by mapping overlapping

87

locations of grazing routes and local communities. The analysis of the North-Eastern Region of Nigeria has unveiled critical insights into the complex interplay between land use, resource management, and conflict dynamics. The identification of grazing routes, examination of vegetation changes, and determination of conflict potential zones underscore the pressing need for integrated land use planning and conflict management strategies

Based on the research findings and analysis, the recommendations are directed to various stakeholders, including government agencies, community organizations, and other relevant entities involved in land use and conflict management in North-Eastern Nigeria.

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