

LOSS AND GAIN OF VEGETATION COVER IN MUBI METROPOLIS AND ENVIRONS, ADAMAWA STATE, NIGERIA: A SPATIO-TEMPORAL APPROACH

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Abstract: *The main objective of this study is to examine the changes in vegetation cover in the Mubi metropolis of Adamawa State, Nigeria, using Landsat satellite images taken for 1980, 1990, 2010, and 2020. Throughout the study period, alterations in the vegetation cover were monitored using a spatiotemporal approach. To get the coordinates of a few selected points for ground truthing, a global positioning system (GPS) instrument was utilized. The mapping and classification of the research region were done using ArcGIS 10.8 and ERDAS IMAGINE 2015. Deforestation, urban development, agricultural expansion, and natural catastrophes are the main causes of the region's notable loss in vegetation cover, according to the results and analysis of the land use land cover changes (LULCC) and Enhanced Vegetation Index/Normalised Difference Vegetation Index (EVI/NDVI). More stringent land use laws, reforestation programs, increased public awareness, more robust environmental enforcement, and frequent monitoring utilizing spatiotemporal techniques to direct conservation efforts are some of the recommendations made to mitigate this trend. This study underlines how urgently these environmental issues need to be resolved in order to protect biodiversity and ecosystem services, and it offers insightful information about the dynamics of vegetation cover changes in Mubi.*

Key words: Vegetation, LULC, EVI/NDVI, Spatio-Temporal, Landsat Images

Introduction

Urbanization is a significant global phenomenon that impacts both natural and human habitats (Mandelas et al., 2007). According to Rahman (2009), urban vegetation plays a crucial role in sustainable development, environmental preservation, and urban planning. Monitoring vegetation cover is important in assessing the strengths and weaknesses of local ecosystems and the environment (Zhu, et al., 2019). However, rapid urbanization is causing a decline in wetlands and wild animal habitats due to increasing human population (Khan, 2000). Nigeria and other African nations have experienced the highest annual rate of net forest loss between 2010 and 2020 (FAO, 2020). The combination of GIS and remote sensing makes it a potent tool for studying vegetation dynamics globally, particularly for detecting global forest change (Egide and Jacob, 2020). Musa and Adebayo (2004) used GIS and remote sensing to investigate how the Mubi region's ecosystem is degrading. The research showed that human activity has severely damaged a large portion of the area. Decision-making is aided by remote sensing and GIS, particularly when it comes to modeling and vegetation research (Mishra and Agarwal, 2015). Ujoh et al. (2011) used Landsat imagery to study the decline of plant cover and urbanization in Abuja from 1987 to 2006. They found that vegetation cover declined rapidly with increased built-up area. The Federal Capital City's population growth has led to land degradation, including loss of vegetation, garbage management, and contamination of surface water, farmlands, pastures, and secondary forests. Changes in forest coverings also threaten climate and food security. Ishaku et al. (2020) analyzed land use and land cover changes around Lake Tilla using satellite imagery from 1986, 1996, 2005, and 2015. They found significant changes in built-up area, vegetative cover, and agricultural land use, with a decline in greenery. Abdulwahab et al. (2019) study from 2001 to 2019 found that land use and land cover change in Adamawa State University Mubi, Nigeria, have significantly declined due to increased residential and institutional land use, agricultural development, and socioeconomic shifts, resulting in unsustainable use of natural resources.

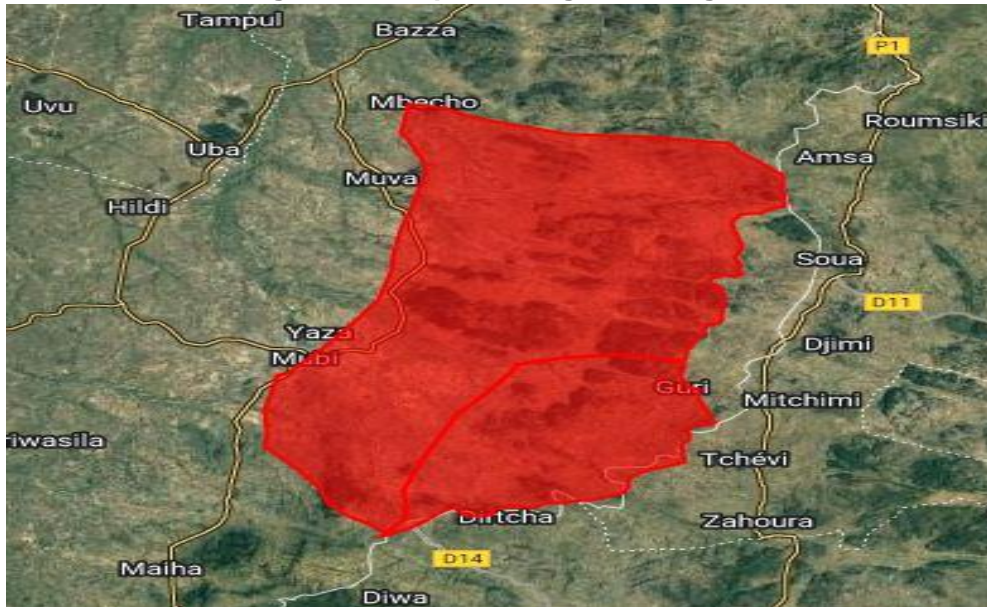
The Normalized Difference Vegetation Index (NDVI) is a widely used indicator for assessing vegetation phenology, greenness, and productivity. It is a green biomass index (Sabellek, 2010). Usman et al. (2012) measures the volume and dynamism of vegetation on surface areas. A study using satellite imagery in the Aba urban region between 1991 and 2005 found that built-up area increased, while water cover increased. This led to a decrease in vegetation cover, from 63.2 percent in 1991 to 41.1 percent in 2005. The study emphasizes the significance of NDVI in understanding land use patterns and changes over time, crucial for land degradation prevention. It aims to evaluate human activities' effects on vegetation cover in Mubi, Adamawa State, Nigeria, enabling better decision-making, development planning, and potential pressure points. Other objectives of this study were to:

- a) Examine the land use and land cover trends in the Mubi region from 1980 to 2020.
- b) Ascertain how the EVI/NDVI varies over the research region.
- b) To look at how the vegetation cover changed during the research period.

Materials and Method

The Study Area: Mubi North and Mubi South are the two Local Government Areas that make up Mubi Metropolis, a geopolitical entity according to Adebayo (2004). Between latitudes $10^{\circ} 05'$ and $10^{\circ} 30'N$ of the equator and longitudes $13^{\circ} 12'$ and $13^{\circ} 19'E$ of the Greenwich meridian are where the city is situated. Based on the National Population Census of 2006, 260,009 people live in the two local government areas (L.G.A.) that together cover 192,307 km. A boundary with Maiha L.G.A. to the south, Hong L.G.A. to the west, Michika L.G.A. and Cameroon Republic to the east as indicated on Fig. 01.

Figure 01: Map showing Mubi Region



Source: Author's work, 2024

Data Collection

Primary Data: The Global Positioning System (GPS) was utilized to gather the coordinates of features in the research region for ground trothing. In addition to field observation methods, to determine the accuracy level of the images classified according to the classes under study—such as water, vegetation, crop, built-up area, barren land, and clouds, the data was linked into the Geographic Information System (GIS) for error matrix analysis.

Secondary Data: The study area's Landsat imagery from Thematic Mapper (TM) and Enhanced Thematic Mapper Plus (ETM+) for the years 1980, 1990, 2010, and 2020 were sourced via the Global Land Cover Facility (GLCF), an Earth Science Data Interface. The features of the research area's images are displayed in Table 1. In order to gather data for the sample design and the models that would be created during the project, a field survey was conducted to validate, train, and calibrate the models. As a result, certain chosen sections of the project areas were used to gather Land Used Land Cover data within the study region. The CHIRPS data services were utilized to acquire information on sun and precipitation.

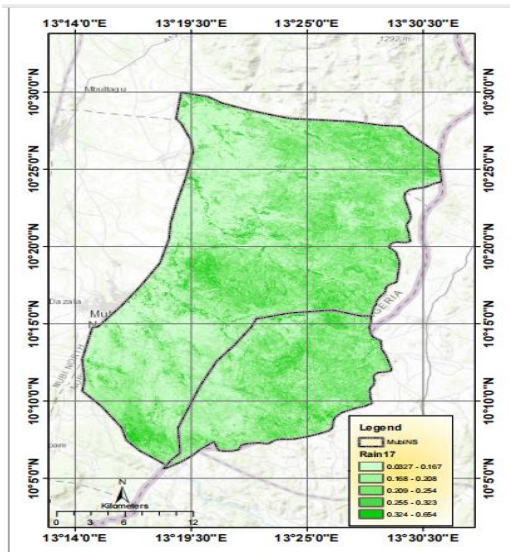
Table 01: Characteristics of the acquired satellite images

#	Image	Sensor	Resolution	Date of acquisition	Source	Band
1.	Landsat 7 2020	ETM+	30x30m	09/01/2020	GLCF	7 bands
2.	Landsat 7 2010	ETM+	30x30m	15/12/2010	GLCF	7 bands
3.	Landsat 7 1990	TM	30x30m	08/11/1990	GLCF	7 bands
4.	Landsat 7 1980	TM	30x30m	05/01/1980	GLCF	7 bands

Source: Global Land Cover Facility, 2023

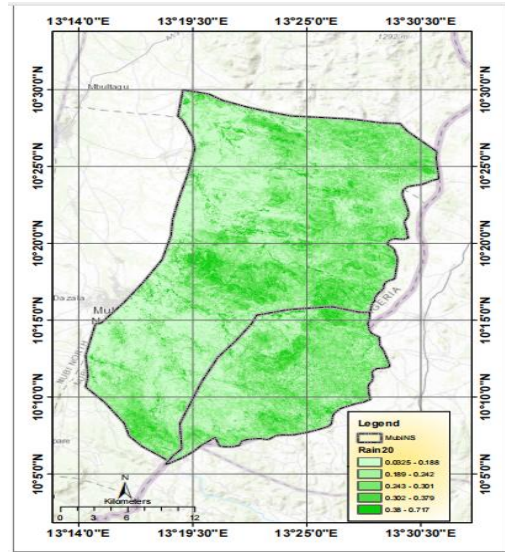
Rainfall Data

Figure 02a: Map of Mubi 2017 Rain Data



Source: Author's work, 2024

Figure 02b: Map of Mubi 2020 Rain Data

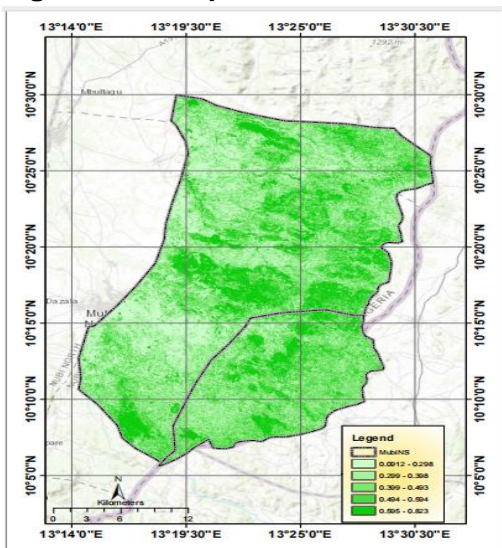


Source: Author's work, 2024

Between 2017 and 2020, the most precipitation was observed in green-colored areas, while the lowest was in regions with values between 0.0327 and 0.167mm. In 2020, the highest recorded totals were 0.38 to 0.717mm.

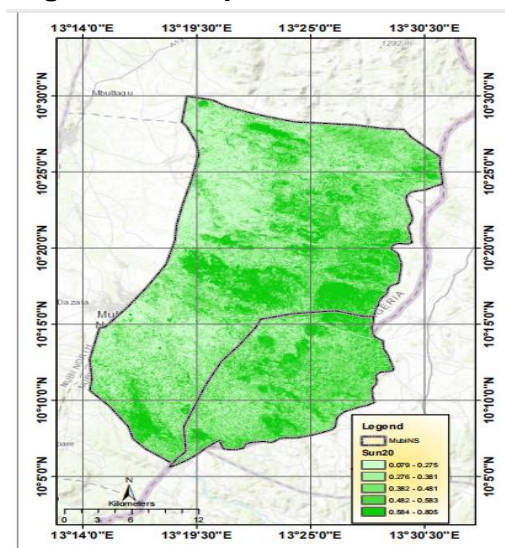
Sun Data

Figure 03a: Map of Mubi 2017 Sun Data



Source: Author's work, 2024

Figure 03b: Map of Mubi 2020 Sun Data



Source: Author's work, 2024

The maps above (Figure 03) show the sun's intensity from 2017 to 2020, with 2017 having the highest exposure at 0.823, and 2020 having the highest radiation at 0.584 to 0.805.

Hardware and Software

Hardware: The primary hardware used for this research was a handheld GPS unit (Garmin 72), an HP colour printer, and an HP 655 laptop.

Software: To manipulate and carry out feature identification, recognition, and classification, ERDAS IMAGINE 2015 was the GIS software program utilized. Area calculations and statistical analysis were also done with it. The mapping application utilized was ArcGIS 10.8.

Data Analysis

Land Use Land Cover: The Mubi metropolis area and environs was analyzed using Landsat data from 1980, 1990, 2010, and 2020. The LULC classifications were performed using an unsupervised approach on the ERDAS IMAGINE 2015 program, using the K-mean maximum iteration strategy. The Kappa coefficient was used to calculate the accuracy of categorization.

Vegetation Index

EVI Analysis: The EVI utilizes MODIS's advanced measurement capabilities, correcting for distortions in reflected light caused by airborne particles and vegetation. It reduces saturation, ambient noise, and background noise, enabling index calculation as a ratio between R and NIR values.

$$EVI = G * ((NIR - R) / (NIR + C1 * R - C2 * B + L))$$

NDVI Analysis: The Normalized Difference Vegetation Index (NDVI) is a widely used tool for calculating Earth's vegetation growth density, derived from the difference formula of near-infrared radiation minus visible radiation.

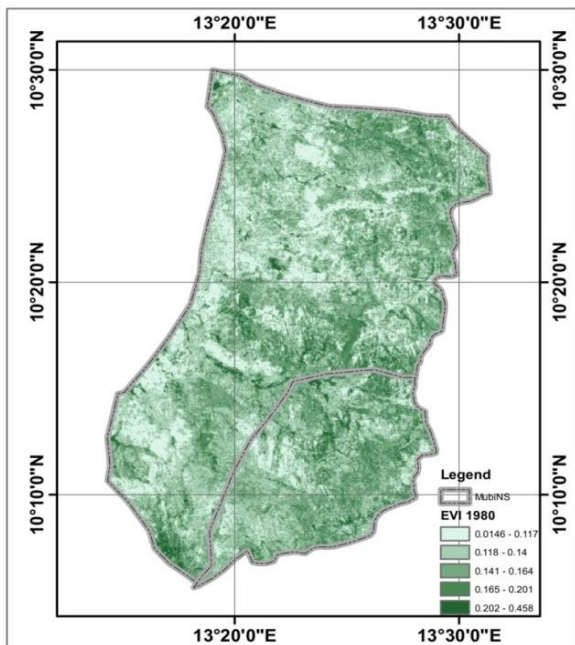
$$NDVI = (NIR - VIS) / (NIR + VIS)$$

The NDVI calculation for a specific pixel consistently falls between -1 and +1, with a zero indicating no vegetation, and green leaves yielding values close to zero.

Results and Discussion

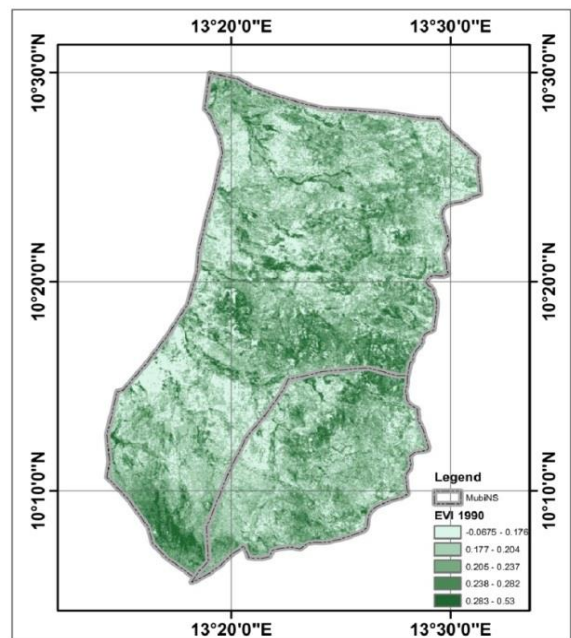
Spatio-Temporal Assessment of Enhanced Vegetation and Normalized Difference Vegetation Index

Figure 04a: EVI Mubi Map of 1980



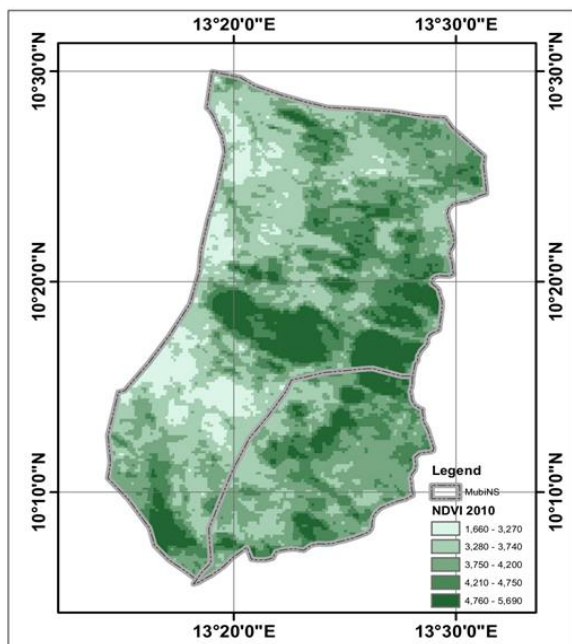
Source: Author's work, 2024

Figure 04b: EVI Mubi Map of 1990



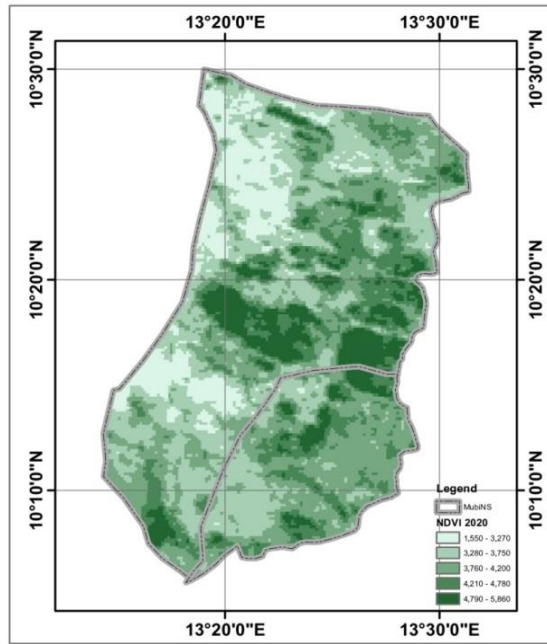
Source: Author's work, 2024

Figure 04c: NDVI Mubi Map of 2010



Source: Author's work, 2024

Figure 04d: NDVI Mubi Map of 2020

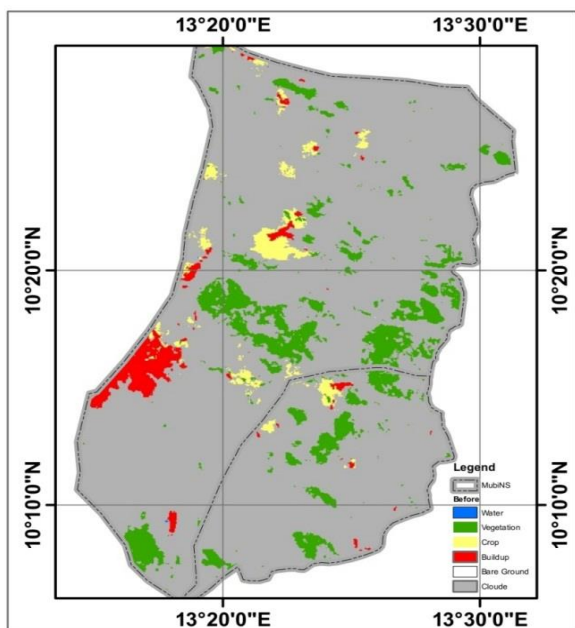


Source: Author's work, 2024

The maps (Fig. 04) display NDVI and EVI readings from 1980 to 2020, assessing vegetation health and density. The highest EVI values in 1980 ranged from 0.202 to 0.459 mm, while the lowest values were between 0.0146 and 0.117 mm, indicating dense vegetation. EVI readings, ranging from -0.0675 to 0.176 mm, were the lowest in 1990, while the highest readings were 0.283 to 0.53 mm. In 2010, the highest NDVI values ever recorded were from 0.476 to 0.569 mm, indicating dense and vigorous vegetation, while the lowest values were observed between 0.166 and 0.327 mm. The highest recorded NDVI values were found in the 0.479 to 0.586 mm region, while the lowest values were found in the 0.155 to 0.327 mm range in 2020.

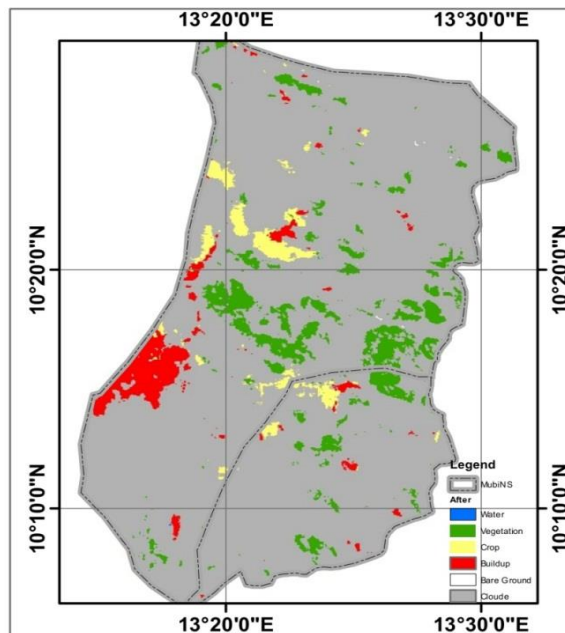
Spatio-Temporal Assessment of Land Use Land Cover

Figure 05a: LULC Mubi Map of 2017



Source: Author's work, 2024

Figure 05b: LULC Mubi Map of 2020



Source: Author's work, 2024

Table 02: Land Use Land Cover Changes from 2017 to 2020

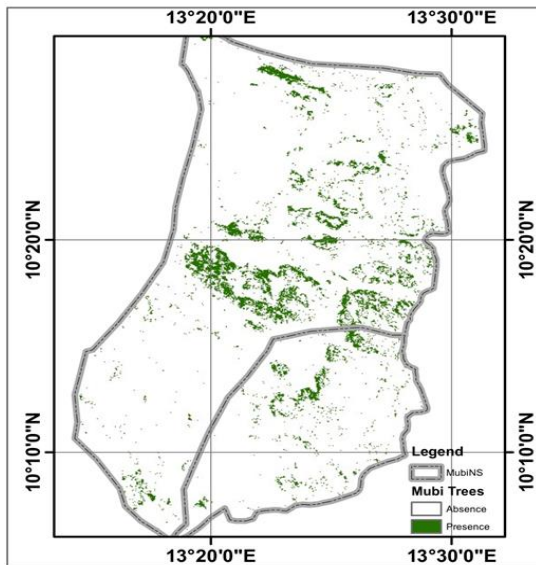
#	Land use/Land Cover	Year 2017 Area (Sq. Km.)	Area (percent)	Year 2020 Area (Sq. Km.)	Area (percent)
1.	Water	332.1623329	38.3	332.1548219	38.3
2.	Vegetation	49.34026107	5.7	35.45228075	4.1
3.	Crop	12.17545489	1.4	12.30314319	1.4
4.	Buildup	12.82140747	1.5	17.06516565	2.0
5.	Bare Ground	0.030044306	0.0	0.127688299	0.0
6.	Cloud	459.7604993	53.1	469.1869002	54.2
	Grand Total	866.29	100	866.29	100

Source: Author's work, 2024

The land use and land cover data for the two distinct years, 2017 and 2020, are shown in the fig. 05 and table 02 above. The area in square kilometers and the proportion of the total area for each category of land use and land cover are shown in the table. In 2017, water covered 38.3 percent of the total area, while clouds covered 53.1 percent. Vegetation covered 5.7 percent, crops 1.4 percent, and buildup 1.5 percent, while bare ground covered 0.0 percent. In 2020, water accounted for 38.3 percent of the total area, followed by clouds at 54.2 percent. Vegetation, crops, and buildup covered 4.1 percent, 1.4 percent, and 2.0 percent respectively, while bare ground covered 0.0 percent. Between 2017 and 2020, vegetation and build-up underwent slight alterations.

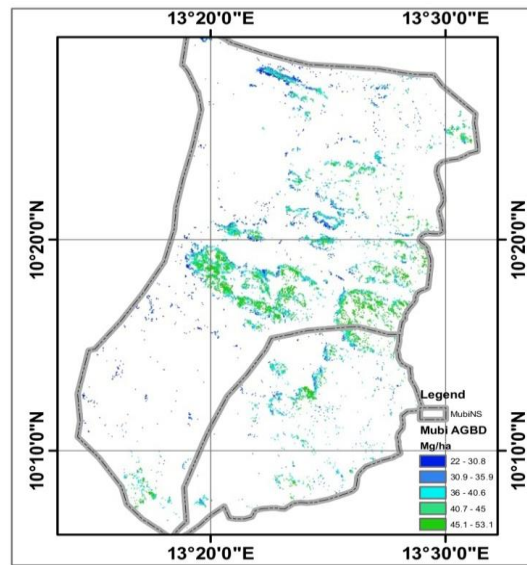
Spatial Assessment of Tree Cover and Aboveground Biomass Density

Figure 06: Mubi Map Showing Trees



Source: Author's work, 2024

Figure 07: Aboveground Biomass Density



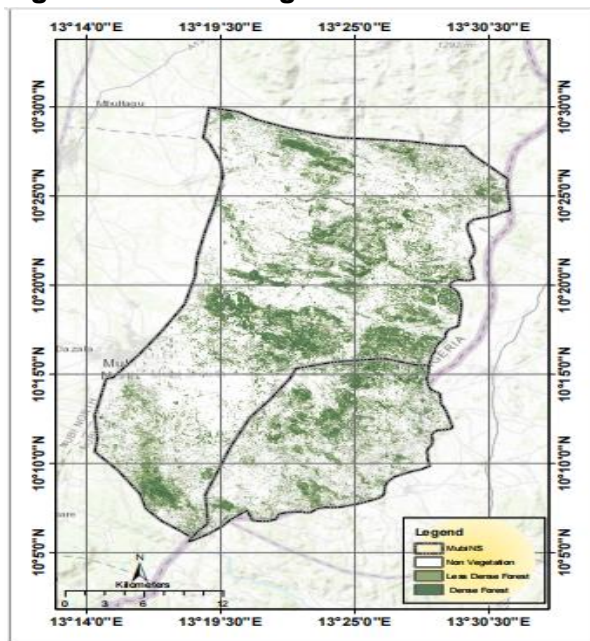
Source: Author's work, 2024

The locations of trees and their absence in Mubi are depicted on the map (Fig. 06) above. The Mubi region has experienced significant deforestation due to human activities such as agricultural expansion, unethical logging methods, and land clearing for infrastructure development. As the population grows, tree cover decreases due to conversion of forest areas into farmlands, and the need for more arable land for food production. The Food and Agriculture Organization of the United Nations reported a net loss of 178 million hectares in global forest area from 1990 to 2020 (FAO, 2020). Asner et al.'s 2005 study revealed that selective logging and deforestation for subsistence agriculture are the primary drivers of forest

loss in the Brazilian Amazon. Similarly, a study by Hansen et al. (2013) showed that forest loss in Indonesia was primarily due to the expansion of oil palm and pulpwood plantations. Aboveground biomass density refers to the total amount of live plant material above ground in an area. In the Mubi, areas with green coloration have the highest density (values between 45.1 and 53.1), while blue coloration has the lowest (values between 22 and 30.8) see Figure 07 above.

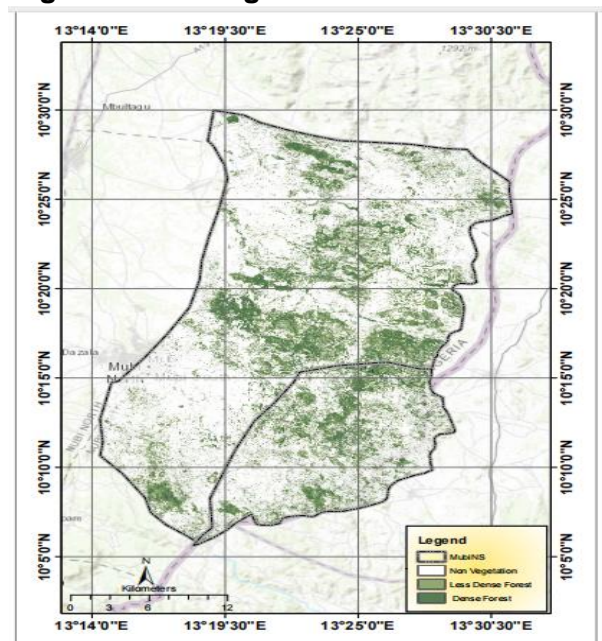
Spatio-Temporal Assessment of Vegetation Cover from 2017 to 2020

Figure 08a: 2017 Vegetated Mubi Area



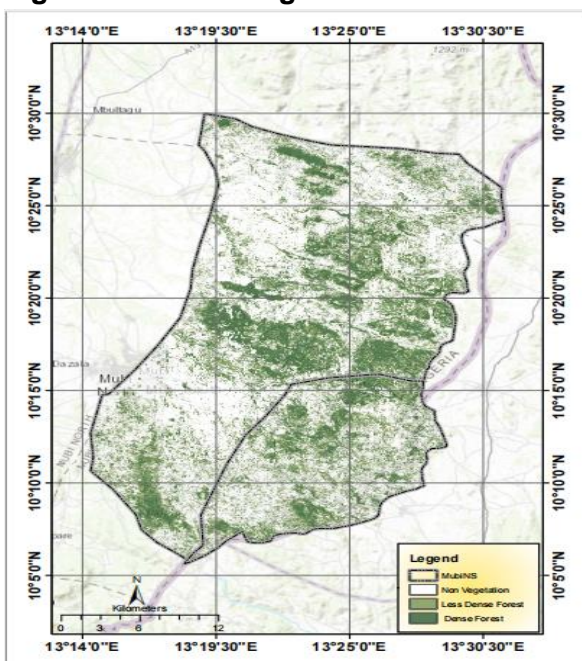
Source: Author's work, 2024

Fig 08b: 2018 Vegetated Mubi Area



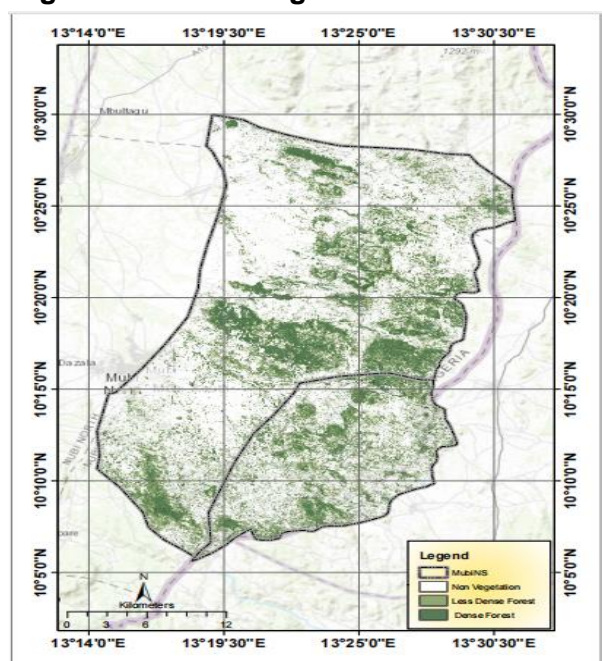
Source: Author's work, 2024

Figure 08c: 2019 Vegetated Mubi Area



Source: Author's work, 2024

Figure 08d: 2020 Vegetated Mubi Area



Source: Author's work, 2024

The research focuses on the changes in vegetation cover, agricultural areas, and urban development in Mubi between 2017 and 2020. The area was known for abundant vegetation

and productive agriculture, including peanuts, sorghum, and millet as cash crops. By 2020, vegetation cover in the area has significantly decreased due to factors such as deforestation, increased agricultural production, urbanization, insurgency operations, and climate change. Farmers cleared more vegetation to plant crops, which resulted in an extension of agricultural grounds. The necessity to boost livelihoods and meet the growing demand for food was the driving force behind this. There was a considerable urban expansion during this time. The town's growth resulted in the transformation of green spaces into residential, commercial, and infrastructure projects.

Conclusion and Recommendations

The study's conclusions show that Mubi's vegetation cover significantly decreased during the course of the research. Natural disasters, agricultural practices, urbanization, and deforestation are some of the causes of this loss of vegetation cover. The satellite images from 1980 to 2020 that were used to perform the study provided evidence of this. As the area becomes less green, there is a risk to biodiversity, ecosystem services, the local ecology, and ultimately climate change due to the fast decrease in vegetation cover. Some of the recommendations are; Strictly enforce land use planning and laws to regulate in agricultural practices, urban growth, and deforestation in Mubi, promote afforestation and reforestation initiatives to increase biodiversity and replace lost vegetation cover, raise public awareness and educate the public on the value of protecting plant cover and the advantages it offers the ecosystem, tighten penalties for unlawful land cutting and logging, as well as environmental law enforcement, use spatiotemporal methods to track advancements and guide future conservation efforts by conducting routine monitoring and assessments of changes in vegetation cover.

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