Assessment of Deforestation in Mbaav 1 Forest Reserve in Gwer East Local Government Area of Benue State, Nigeria

Verinumbe, I.[1], Ancha P.U.[2], Imeh S.T. [3], Umaru P.M.[4]
Department of Social and Environmental Forestry,
College of Forestry and Fisheries,
Joseph Sarwuan Tarka University, Makurdi
iverinumbe@yahoo.com[1] paulancha@gmail.com[2], shadrachimeh@gmail.com [3],
mercypa983@gmail.com[4]
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Abstract
The study investigates the ongoing issue of deforestation in Mbaav1 Forest Reserve, located in Gwer East Local Government Area (LGA), Benue State, Nigeria. Deforestation in the reserve is exacerbated by socio-economic factors such as agricultural expansion, population growth, logging, and development projects. Understanding these drivers is crucial for effective policy formulation and sustainable forest management. The primary aim of this study is to assess changes in forest cover in Mbaav1 Forest Reserve between 1989 and 2019, with particular emphasis on the socio-economic factors driving deforestation. The study specifically examines the socio-economic characteristics of local communities, land use changes, the extent of deforestation, and the key drivers of these changes. Data were collected using both primary and secondary methods. Primary data were gathered through semi-structured questionnaires and interviews with 387 community members, while secondary data were obtained from Landsat satellite imagery (1989, 2009, and 2019), For socio-economic analysis, simple descriptive statistics were used to present data on respondents' characteristics, including income, age, education, occupation, and household size. To examine the influence of socio-economic factors on deforestation, a binary logistic regression model was adopted. Landsat satellite imageries were analyzed using Geographic Information Systems (GIS) and remote sensing tools. The supervised and unsupervised classification methods were used to detect and classify land cover changes. The Normalized Difference Vegetation Index (NDVI) was also used to map vegetation changes. The results of analysis revealed significant relationships between deforestation and factors such as income, population growth, developmental projects, and land-use activities. Notably, income had the highest influence on deforestation, with a unit increase in income leading to a 1.35 increase in deforestation ($\beta = 1.35$, $p<0.05$). Population growth ($\beta = 1.02$, $p<0.05$) and development projects ($\beta = 0.77$, $p<0.05$) also significantly contributed to forest loss. Logging ($\beta = 0.10$, $p<0.05$) and farming ($\beta = 0.39$, $p<0.05$) further exacerbated deforestation, although to a lesser degree. The percentage of land cover change between 1989, 2009, and 2019 revealed a consistent decline in forest area. In 1989, the forest area covered 75.56% of the total land, but by 2019, this had dropped to 36.25%. Meanwhile, farmland increased from 5.86% in 1989 to 29.83% in 2019, reflecting the expansion of agricultural activities. The study concludes that the rapid deforestation in Mbaav1 Forest Reserve is driven by human activities, particularly agricultural expansion and logging, compounded by socio-economic pressures such as income and population growth. The study recommends that addressing these drivers through sustainable practices like agroforestry, improving forest management, and implementing policies that integrate forest conservation with agricultural development are essential. Furthermore, public awareness campaigns on the

environmental and socio-economic consequences of deforestation are crucial for fostering community participation in conservation efforts.

Key Words: *Deforestation, Forest Degradation, Mbaav1 Forest Reserve, Land-use Change, Remote Sensing and GIS.*

INTRODUCTION

The Forest Resources Assessment (FRA, 2006) defines deforestation as the conversion of forests to other land uses or a reduction in forest cover of less than 10% of their total area (0.5 hectares). The United Nations Framework Convention on Climate Change (UNFCCC) defines deforestation as the direct conversion of human-induced forest land to non-forest land. Deforestation is the conversion of forested areas to non-forest land use such as arable land, urban use, logged area or wasteland. Deforestation can result from deliberate removal of forest cover for agriculture or urban development, or it can be an unintentional consequence of uncontrolled grazing (which can prevent the natural regeneration of young trees). The combined effect of grazing and fires can be a major cause of deforestation in dry areas. The need to address and monitor deforestation, has been emphasized on numerous occasions, such as at the COP meeting in Bali, 2007 (FCCC/CP/2007/6), where the parties "acknowledge that forest degradation also leads to emissions, and needs to bead dressed when reducing emissions from deforestation".

Forests sequester carbon dioxide from the atmosphere and store the carbon in biomass as leaves, bark, and branches. When deforestation occurs the stored carbon is released as carbon dioxide into the atmosphere as the tree decomposes (Gibbs et al. 2007).

Deforestation is mainly caused by factors like population growth, social and economic issues, and activities such as commercial logging, farming, fuel wood collection, and land converting land for cattle ranching.

Over the years, the world has experienced unprecedented loss of its forests particularly in tropical areas, though it is observed on a global scale that the rate of deforestation has shown sign of a decrease. This is because the Food and Agriculture Organization (FAO, 2010) states that in the 2000s, about 13 million hectares of forest were converted to other uses – largely agriculture – or lost through natural causes each year as compared with 16 million hectares in the 1990s. That notwithstanding the rate of deforestation is still alarming because in 2010 it is observed that the world had just over 4 billion hectares of forested area, which corresponds to an average of 0.6 forest per capita (FAO, 2010).

According to World Fact Book (2012), Nigeria was identified as one of the countries with the highest rate of biodiversity loss (3.3 percent) in the world. Since 1990, the country has lost 6.1 million hectares or 35.7 percent of its forest covers. It also recorded that Nigeria most diversity ecosystem is fast depleting at an unbelievable rate. For example, between 1990 and 2005, Nigeria lost an average of 409,700 hectares of forest every year equal to an average deforestation rate of 2.38 percent. As of 2005, Nigeria has the highest rate of deforestation in the world according to Food and Agriculture organization of the United Nations (FAO, 2010a; FAO, 2010b). The significant effect of loss of forest or vegetation is the exposure of bare surfaces to disaster such as erosion, pollution, and consequently climate change with an adverse effect on both physical and human environment (Sheyin, 2004; Jaiyeoba and Essoka, 2016).

STATEMENT OF THE PROBLEM

Research on deforestation have been conducted in many parts of Benue State; Jande *et al.* (2019), conducted an assessment of land use and land cover changes and urban expansion using

remote sensing and GIS in Gboko, Benue State. Ikyaagba *et al.* (2020), assessed the effects of land use and land cover change of TseGavar Forest Reserve, Vandeikya Local Government Area, Benue State. Also, Ikyaagba *et al.* (2020), investigated the impacts of Land-use practices on vegetation cover in Apa Local Government Area, Benue State. Ancha *et al.* (2021) investigated the impacts of urbanization on Forest Resources in Otukpo Local Government Area, Benue State.In Gwer East Local Government Area, documented work related to deforestation was the investigation of Charcoal Production in Gwer west and Gwer East Local Government Areas of Benue State, (Ekhumelo, 2017). The lack of information on the land use dynamics between 1989, 2009, and 2019, the extend of deforestation area and the socio-economic factors influencing deforestation in Mbaav1 Forest Reserve, Gwer East Local Government Area of Benue State hinders proper planning and sustainable management of the forest by decision-makers.

It's against this background that this study was conducted to provide information on deforestation of Mbaav1 Forest Reserve, Gwer East Local Government Area for decision-making and policy.

RESEARCH QUESTIONS

The study sought answers to the following research questions:

i. What are the socio-economic characteristics of the people in the communities adjoining the study area?
ii. What are the land use dynamics between 1989, 2009, and 2019 in the study area?
iii. What is the extent of deforestation in the study area?
iv. What are the socio-economic factors influencing deforestation in the study area?

METHODOLOGY

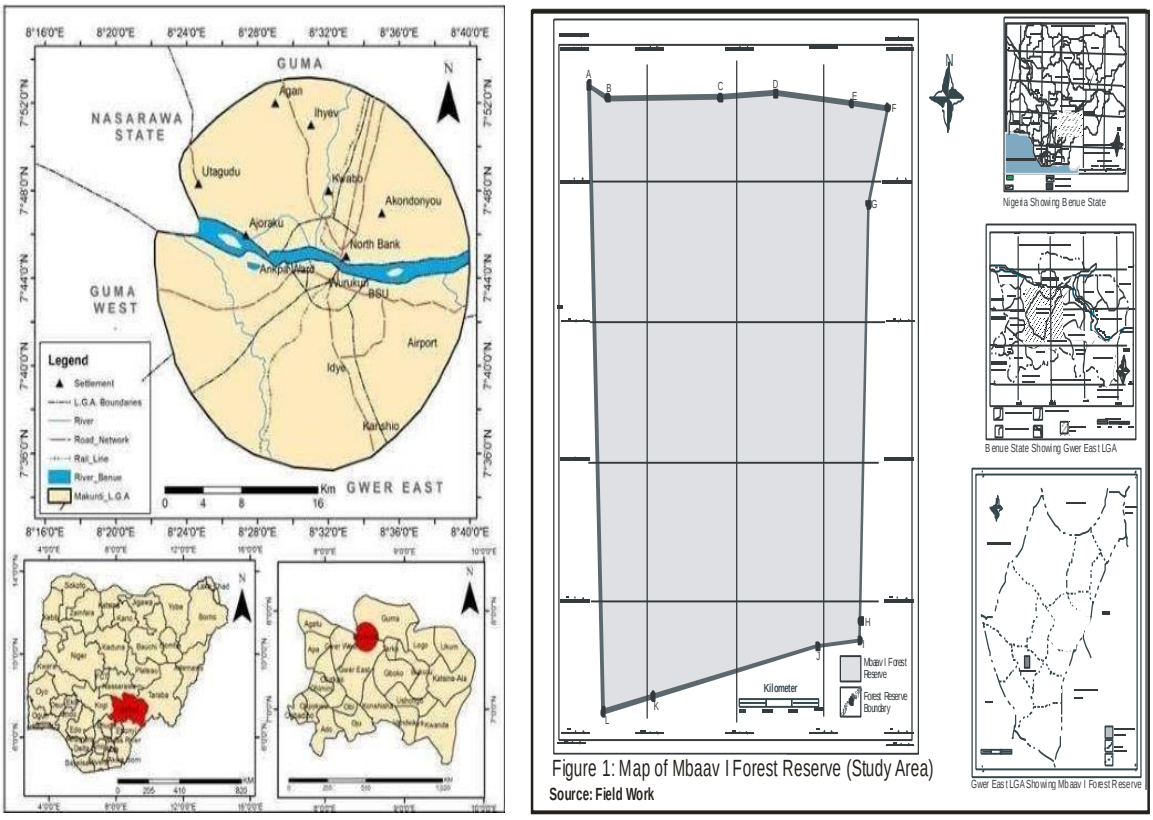

Figure 1. Map of the study area, Gwer East, Benue State

The study proposal was carried out in Gwer East Local Government Area of Benue State. Created in the year 1976, home of the Masev people. It lies between Latitude 7.3521º N and Longitude 8.3503º E. The study has an area of about 2,294 square kilometers and has an average temperature of 26 degrees centigrade.The annual rainfall typically ranges from 1,500 to 1,900 millimeters. However, rainfall can vary from year to year depending on specific local conditions and annual weather patterns. The headquarters of Gwer East Local Government Area is located in the town of Aliade, with an estimated population of 168,660 (2006 Census). The total population of these communities as projected to 2017 is 11,783 people (See table 1 below). The projection shall be done using the formula: -

$Pn=Po\ (1+r/100)^{n}$

Where: Pn = Population Projection, Po = Existing Population, 1 = Constant, r = Population Growth Rate (3.0 For Benue State), n = Number of years Population is to be Projected (26years).

Table1: Population of Communities as at 1991 Census, Projected to 2019 with Sample Size

S/N	Name of Community	1991 Population	Projection to 2017	Sample Size
1.	Mbaga I&II	2,235	4,820	159
2.	Mbayon	3,229	6,963	228
	Total	**5,464**	**11,783**	**387**

Source: Authors analysis, 2023

All the communities surrounding the reserve were sampled. Systematic sampling was used in the selection of households in each community for the study. Purposive sampling design was employed to respondents in each selected household. Knowing the population (11,783) of the study, sample size (n) for the study shall be determined using Taro Yamane's formula as follows:

$$n = \frac{N}{1 + N\,(e)^2}$$

Where: n = Sample size; N= Size of Population; 1= Constant; e= Error degree of tolerance 0.05.

Therefore, $n = \frac{11783}{1+11783\ (0.05)^2}$

n = 387 Respondents

The following materials, software and tools wereselected to aid in the collection and analysis of information and data for the purpose of the study.

- Computer for data processing and analysis
- German Hand-held GPS
- A semi-structured questionnaire for data collection
- Scanned maps with a minimum of 300dpi or 350 resolutions to soft copies to obtain minute details that will each be analyzed using QGIS.

The summery of materials and software utilized is presented on table 2 and 3 below.

Table 2: Software Components of the Research

S/N	Software	Purpose
1	Idrisi& ArcGIS 10.3	GIS analysis & classification of the Landsat images
2	Microsoft Excel	Statistical analysis for the calculation of percentage

Table 3: Characteristics of Landsat images used for the study

Date of Acquisition	Sensor	Path	Row	Multispectral Band	Thermal Band	Spectral Range (micrometers)	Spatial Resolution (pixel spacing)	Source
1989	TM	188	55	1to5 and 7	6	10.45-12.45	30	
2009	TM	188	55	1to5 and 7	6	10.45-12.45	30	USGS
2019	OLI	188	55	1to5 and 7	6	10.45-12.45	30	
	TIRS	188	55	1to7 and 9	10 & 11	10.60-12.51	30	

The data needed for the research work has been gathered from Primary and Secondary sources. The primary data was gathered through semi-structured questionnaire and oral interview. Oral interview was organized from major stakeholders such as chiefs, youth leaders, women leaders, forest community leaders, etc. The primary data collected include: socio-economic attributes of the people in the communities adjoining the Reserve, and data on the socioeconomic factors influencing deforestation of the reserve. The vegetation maps of Mbaav1 forest reserve for a period of 30 years (1989–2019) was obtained using remote sensing technology to determine the land use dynamics and the rate of vegetation lost. Landsat data was used. A period of thirty (30) years was analyzed (1989–2019). Three cloud free Landsat satellite imageries (remote sensing images) of the study area was acquired using Landsat-5 Thematic Mapper (TM) in 1989, Landsat-7 Enhanced Thematic Mapper (ETM) in 2001 and Landsat-8 Operational Land Imager (OLI) in 2019 was obtained from the US Geological Survey (USGS) Earth Explorer. The Landsat images used were classified into the various land use of the study area. The Normalized Difference Vegetation Index (NDVI) uses the Red and near Infrared Region (NIR) band and provide contrast between the reflectance of vegetation (which reflects NIR wavelengths) and the surrounding soils (which reflect Red wavelengths) (Ray and alfredo, 1991) thus separates green vegetation from its background soil brightness. The NDVI was calculated using the formula: -

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

Where: NIR=Near-Infrared reflectance, which measures the amount of near-infrared light reflected by vegetation.
R=Red reflectance, which measures the amount of red light reflected by vegetation.

In order to map the changes of the surrounding vegetation from the period 1989–2019, the NDVI was applied to the Landsat images to generate NDVI maps of the study area. Simple descriptive statistical tools were employed in analyzing the relevant data collected. The binary logistic regression model was adopted to examine the socio-economic attributes and factors

influencing deforestation in the study area. Thematic Mapper (TM) of 1989, Enhanced Thematic Mapper (ETM+) 2009 and operational land imager (OLI) of 2019 was used to determine the land use dynamics between 1989, 2009, and 2019 in the study area. The study area was extracted from the scene, and a supervised classification method was carried out based on level 1 classification scheme of Anderson et al., (1976) and was used to classify and identify the land use and land cover categories of the study area. Four land use and land cover features were employed for the study (i.e., forest cover, vegetation, farm land, and bare surface). Change detection analysis and transition measurement was used for land use and land cover change detection. It requires the comparison of independently classified image for the different time interval. This shows a complete matrix of land use and land cover change detection (Singh, 1989). It helps in identifying the percentage and the rate of changes that occurs within the selected years.

To achieve this, the area in hectares and percentage change of each of the selected year was determined. The percentage change and the rate of changes that have occurred were calculated by dividing observed change by absolute sum of change as shown in the equations below.

$$\% \Delta = \frac{OC}{ASC} \times 100 \quad \text{equation} \quad [1]$$

$$\% \Delta \text{ in year} = \frac{Y_2 - Y_1}{Y_1} X\ 100 \quad equation \quad [2]$$

$$\text{Average Rate of } \Delta \ \frac{Y_2 - Y_1}{T_2 - T_1} \quad \text{equation} \quad [3]$$

$$\% \ mean\ rate = \frac{mean\ Rate\ of\ change\ (ha/yr)}{Difference\ in\ year} \times 100 \quad \text{equation} \quad [4]$$

Where: OC is the observed change; ASC is absolute sum of change i.e. fixed year (starting year); Y_2-Y_1 is the observed change; Y_2 is the ending year; Y_1 is the starting year; T_2-T_1 is the periodic interval between the initial period and the final period.

RESULTS

Socio-Economic Characteristics of the Respondents in the Communities Adjoining the Study Area

The socio-economic characteristics of the respondents in the study area (Table 4), based on the result, males were 75.3% and females were identified as 24.7%. The respondents majority (41.3%) were within the age brackets of 41-50 years, followed by 31-40 years with 34.7% of the respondents; 18% were between the ages of 21-30 years, while 4.7% of the respondents were between the ages of 50 years and above. The primary occupation of most (98.7%) of the respondents was farming, while 1.3% of the people were civil servants in the study area.

The result on the educational status of the respondents revealed that, 48% attained secondary school level, followed by 24% of the respondents had non-formal education, 22% had first leaving school certificate, while 6% of the respondents enrolled in tertiary institution. The result of respondents' marital status showed 79.3% of the respondents were single; with 20.7% of them married. The family size category of the respondents ranged between <5 to 15 household members, with 92% of the respondents catered for household members less than 5; followed by 7.3% of the respondents who had 5-10 household members, while 0.7% had 11-15 household members in the area. The monthly income of the respondents reveled that majority (37.3%) of the respondents stated that ₦26,000-40,000 was their income per month;

this was followed by 29.3% of the people who had a monthly income of <10,000, 21.3% had ₦11,000-25,000 per month and 10.7% and 1.3% had an income of ₦41,000-50,000 and ₦51,000 above, respectively per month.

Table 4: Socio-economic Characteristics of Respondents in the Study Area

Category		F (N=387)	%
Gender	Male	286	75.3
	Female	101	24.7
Age category	<20	11	1.3
	21-30	45	18.0
	31-40	119	34.7
	41-50	184	41.3
	> 50	28	4.7
Occupation	Farming	381	98.7
	Civil Servant	6	1.3
Educational status	No Formal Education	89	24.0
	Primary Education	86	22.0
	Secondary Education	199	48.0
	Tertiary Education	13	6.0
Marital status	Married	106	20.7
	Single	281	79.3
Household size	< 5	287	92.0
	5-10	96	7.3
	11 – 15	4	.7
Income level per month (₦)	<10,000	132	29.3
	11,000 -25,000	42	21.3
	26,000 – 40,000	165	37.3
	41,000 – 50,000	40	10.7
	>51,000	8	1.3

N= Number of Respondents (387)

Analysis of 1989 Land use and Land cover classification

Figure 2, Shows the landuse and landcover (LULC) change map of the study area for 1989. It revealed that forest area was the dominant land cover feature of the reserve covering about 146.34 Hectares (75.56%). This can be found on every section of the map but more at the center. Vegetation covers an area of 30.33Ha (15.66%) of the total land mass of the reserve. Similarly, farm land covers an area of 11.34Ha (5.86%), while bare surface covers 5.67 Ha (2.92%). The total land area of the forest reserve was 193.68 hectares at the time of the study.

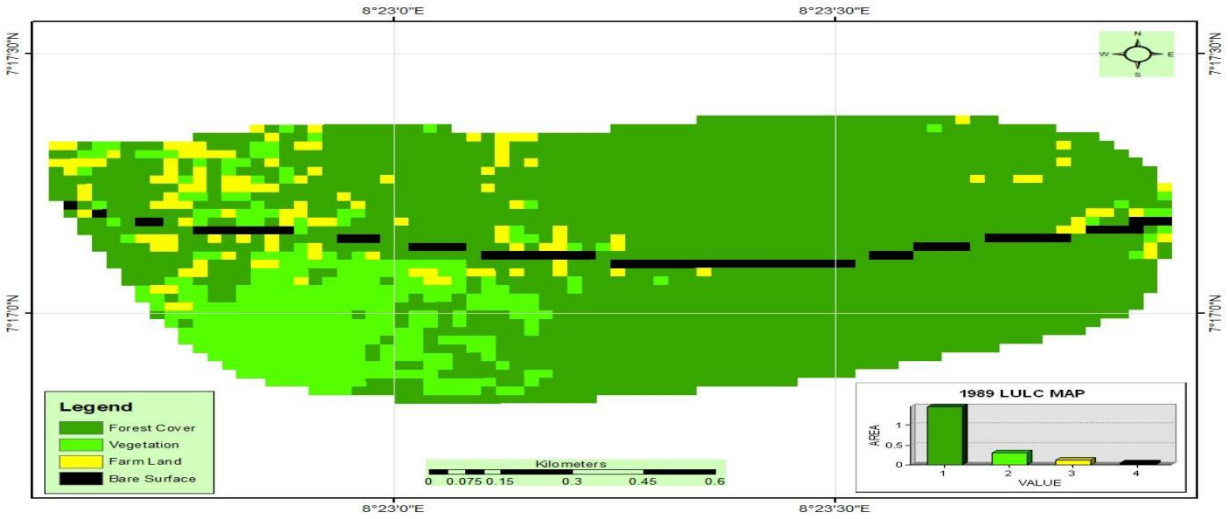

Figure 2: 1989 Landuse/Landcover distribution Map generated from LandSat 4 TM
Source: Authors Analysis, 2023

Analysis of 2009 Land use and Land cover classification

Figure 3; Shows the Land use and Landcover map of the study area for 2009, which indicates that forest cover was still the dominant feature occupying an area of 98.28 Hectares (51%). However, there was a decrease in forest cover of 48.06Ha (24.56%) within the time period. On the other hand, vegetation increased from 30.33Ha (15.66%) in 1989 to 57.78Ha (29.98%). Farm land increased to 33.75Ha (17.52%) in 2009 from 11.34Ha (5.86%) in 1989. This increase could be as a result of population growth. Bare surface was 3.87Ha (1.50%) in 2009.

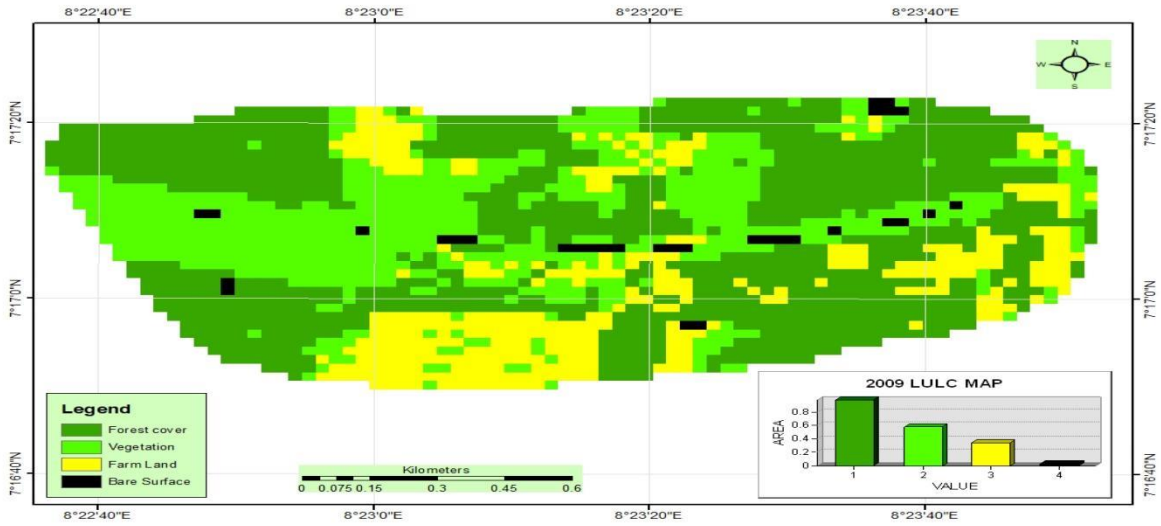

Figure 3: Classified 2009 LULC distribution of the study area generated from LandSat 7 ETM+
Source: Authoys Analysis, 2023

Analysis of 2019 Land use and Land cover classification
The result of 2019 satellite image revealed an increase in other land use and land cover features of the study area (figure4). Forest covers an area of 70.2Ha (36.25%). There was a decrease in forest cover by 76.14Ha (40.31%) between 1989 and 2019. Farm land and vegetation increased to 57.78Ha (29.83%) and 59.13Ha (30.53%) respectively, bare surface also increased to 6.57Ha (3.39%) as a result of forest resources exploitation .

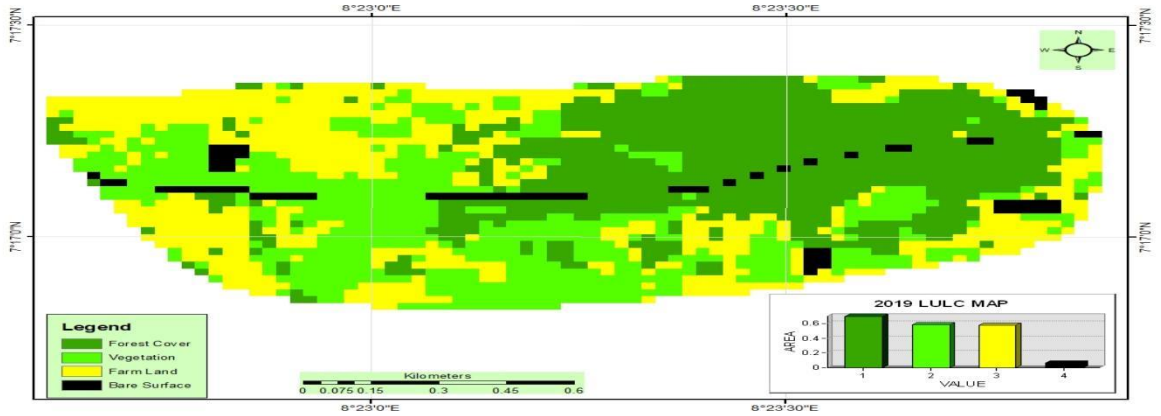

Figure 4: 2019 Landuse/Landcover distribution generated from LandSat8 (OLI).
Source: Authors Analysis, 2023

Table 5: Percentage of Land use/Landover in Mbaav1 Forest Reserve (1989, 2009, and 2019)

Classification Category	1989		2009		2019	
	Area (Ha)	Area (%)	Area (Ha)	Area (%)	Area (Ha)	Area (%)
Forest	146.34	75.56	98.28	51	70.2	36.25
Vegetation	30.33	15.66	57.78	29.98	59.13	30.53
Farmland	11.34	5.86	33.75	17.52	57.78	29.83
Bare surface	5.67	2.92	3.87	1.50	6.57	3.39
Total	193.68	100	193.68	100	193.68	100

Source: Authors Analysis, 2023

Magnitude and percentage of change in Land use and Land cover between 1989, 2009 and 2019

Table 6 Shows to what extent has deforestation been witnessed in the study area. The table revealed that in 1989 which is the base year for the study, forest cover was 146.34 hectares (75.56%). However, in 2009 there was a decline in forest cover of 98.28 Ha (51%). In year 2019, the forest area declines further to 70.2 Ha (36.25%).

Table 6: The Extent of forest Land use and Land cover changes in 1989, 2009 & 2019

S/N	Year	Forest Area	(%)
1	1989	146.34	75.56
2	2009	98.28	51
3	2019	70.2	36.25

Source: Authors Analysis, 2023

Spatial extent and rate of forest decline in the study area

Table 7 shows the spatial extent and rate of forest decline in the study area, it indicates the extent and rate of forest loss. The extent of forest loss was -48.06, -28.08, and -76.14 for 1989, 2009 and 2019, respectively.

Table 7: **The Spatial Extent and Rate of Forest Loss in the study area**

Forest land				Extent of Forest land		Rate of Forest land loss
Period	**Time interval**	**Year**	**(Ha)**	**(Ha)**	**Percent**	**Km²/Year**
1989-2009	20	1989	146.34	-48.06	-32.84	2.40
2009 - 2019	10	2009	98.28	-28.08	-28.57	2.81
1989 - 2019	30	2019	70.2	-76.14	-52.09	2.54

Source: Authors Analysis, 2023

Trend of Forest Decline

Between the periods of 1986 - 2009 covering 20 years, forest decrease to 48.08 ha (24.56%) while between 2009 – 2019 forest cover continues to decrease to 28.08 ha (14.75%) as shown on Figure 5. The result shows that the rate of forest decline within ten (10) years is higher than

20 years, this could be attributed to increase in population as well as the quest by the people in the area exploiting the forest as a means of livelihood through charcoal for fuel wood, fire wood, timber for commercial and domestic use among other needs that resulted to the over – exploitation of the forest reserve. This declining trend further indicates continuous land use conversion mainly from forest to other land use like farming, lumbering and other activities.

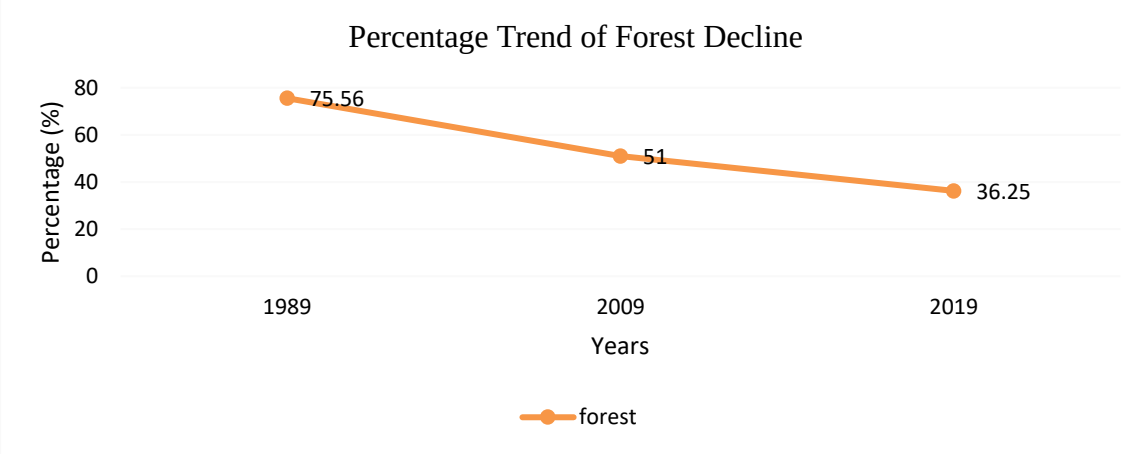

Figure 5: Trend Analysis of Forest decline in the Study Area
Source: Authors Analysis, 2023

Socioeconomic factors influencing deforestation in the forest reserve

The socioeconomic factors influencing deforestation of Mbaav1 Forest Reserve (Table 8) include income, population growth, developmental projects, age, poverty, farming, logging, and distance from adj0ining villages.

Income had a significant positive influence on deforestation (β =1.353, $p<0.05$). The β statistics indicates that a unit increase in income of the people increased deforestation by 1.353 in the area. Based on the Exp (β) value of 3.870, income was ranked the highest factor influencing deforestation in the study area.

Population growth also had a significant positive influence on deforestation (β =1.024, $p<0.05$). The β statistics indicates that a unit increase in income of the people would increase deforestation by 1.024 in the area. Population growth was ranked the second highest factor influencing deforestation in the area based on Exp (β) value of 3.085.

Similarly, growth-oriented projects had a significant positive influence on deforestation (β =0.776, $p<0.05$). An increase in development projects in the area would increase deforestation of the reserve by a factor of 0.776. Developmental projects were ranked 3rd in the study based on Exp(β) value of 2.972.

Logging in the reserve had a significant positive influence on deforestation of the reserve (β =0.108, $p<0.05$). This implies a unit increase in logging activities will increase deforestation of the reserve by a factor of 0.108. Logging activities was ranked 4th factor influencing deforestation of the reserve based on Exp (β) value of 2.314.

Farming in the reserve had a significant positive influence on deforestation (β =0.391, $p<0.05$). This indicate that a unit increase in farming in the reserve will increase deforestation by a factor of 0.391. Farming in the reserve was ranked 5th factor influencing deforestation of the reserve based on Exp(β) value of 1.478.

Age of the people a negative non-significant influence on deforestation of the reserve (β = -0.002 $p>0.05$). This implies that an increase in age of the people will decrease deforestation of the reserve by a factor of 0.002. Age was ranked 6th based on Exp(β) value of 0.998.

Distance from the community to reserve had a negative non-significant influence on deforestation of the reserve (β = -0.033, p>0.05). This implies that a unit increase in the distance of the community from the reserve will result to a decrease in deforestation by a factor of 0.033. Distance from the community to reserve was ranked 7th based on the Exp (β) value of 0.968. Poverty level of the people also had a positive non-significant influence on deforestation of the reserve (β =0.035, p>0.05). A unit increase in the poverty level of the people will increase deforestation by a factor of 0.035. Poverty was ranked the least (8^{th}) among the factors influencing deforestation of the reserve based on the Exp (β) value of 0.966.

Table 8. Factors Influencing Deforestation in Mbaav1 Forest Reserve, Gwer-East Local Government Area, Benue State, Nigeria

Variable	B	S.E.	Wald	df	Sig.	Exp(β)	Ranking	Remarks
Annual Income	1.35	0.53	6.64	1	0.03	3.857	1	Sig.
Household size	1.25	0.14	76.04	1	0.05	3.490	2	Sig.
Poverty	1.11	0.18	40.52	1	0.06	3.034	3	NS
Population growth	1.04	0.62	2.80	1	0.41	2.829	4	NS
Developmental Projects	1.02	0.49	4.26	1	0.63	2.773	5	NS
Farming in reserve	0.47	0.33	2.01	1	0.04	1.600	6	Sig.
Logging in reserve	0.22	0.24	0.82	1	0.05	1.246	7	Sig.
Age	-0.02	0.04	0.20	1	0.08	0.980	8	Sig.
Distance from Home to reserve	-0.62	0.18	11.42	1	0.51	0.538	9	SN
Constant	-0.13	1.47	0.01	1	0.67	0.878	-	-

Number of cases = 387, Model Chi-square= 72.4 (p<0.05), -2LL = 182.32; Overall percentage = 96.8 %, Negelkerke R^2 = .092, Exp (β) = Odds ratio (probability of success/probability of failure), SE= standard error of the estimate, Sig =significance, β = regression coefficients which stand for the odds ratio of probability of success to the probability of failure and Wald statistics = $(β/ SE)^2$, d.f = degree of freedom.

CONCLUSION

Based on the result of the study of land use and land cover in Mbaav1 forest reserve in the past 30 years' period from 1989 to 2019. The following conclusions were made:

i. Land use changes between 1989 and 2019 show that the forest area was the predominant land cover feature, spanning approximately 146.34 hectares (75.56%). In 1989, vegetation cover occupied 30.33 hectares (15.66%). By 2009, the forest cover had decreased to 98.28 hectares (51%), reflecting a reduction of 48.06 hectares (24.56%) over the period. Meanwhile, vegetation cover increased from 30.33 hectares (15.66%) in 1989 to 57.78 hectares (29.98%).

ii. The increase in vegetation might be due to specific exploitation activities such as commercial logging and forest farming. Between 1989 and 2019, forest cover decreased by 76.14 hectares (40.31%). This significant reduction in forest cover can be attributed to the conversion of forested land for agriculture and fuelwood gathering. Evidence from the 1980s and the 1990s indicates a massive loss of tropical forests during that period.

iii. The socioeconomic factors that significantly influenced deforestation were income, population growth, developmental projects, logging and farming. These factors increased deforestation by (1.353, 1.024, 0.776, 0.108 and 0.391 units respectively.

RECOMMENDATIONS

Based on the results of this finding, the following recommendations are made:

1. Forest Conservation Programs: Implement comprehensive forest conservation programs that include reforestation and afforestation efforts to restore lost forest cover and maintain ecological balance.
2. Sustainable Land Use Practices: Promote sustainable land use practices among local communities, emphasizing agroforestry and conservation agriculture to reduce the pressure on forest resources.
3. Alternative Energy Sources: Encourage the use of alternative energy sources, such as biogas and solar energy, to reduce reliance on fuel wood gathering, thus preserving the remaining forest areas.
4. Strengthening Regulations: Enhance the enforcement of existing regulations and introduce stricter measures against illegal logging and land conversion activities. This can include regular monitoring and the use of technology like satellite imagery.
5. Economic Incentives for Conservation: Provide economic incentives for local communities to engage in conservation activities. This could include payments for ecosystem services or financial support for sustainable livelihoods.
6. Community Education and Engagement: Increase awareness and educational initiatives about the importance of forest conservation and sustainable practices. Engage local communities in the planning and decision-making processes to ensure their cooperation and commitment.
7. Population Management: Develop family planning and population management programs to address the influence of household size on forest resources, ensuring sustainable use of the reserve.
8. Income Diversification: Support income diversification strategies that reduce dependence on activities leading to deforestation. Promote small-scale enterprises, ecotourism, and other sustainable economic activities.

CONTRIBUTION TO KNOWLEDGE

The study established that:

i. In 1989, vegetation cover occupied 30.33 hectares (15.66%). By 2009, the forest cover had decreased to 98.28 hectares (51%), reflecting a reduction of 48.06 hectares (24.56%) over the period. Meanwhile, vegetation cover increased from 30.33 hectares (15.66%) in 1989 to 57.78 hectares (29.98%).

ii. Between 1989 and 2019, forest cover decreased by 76.14 hectares (40.31%). This significant reduction in forest cover can be attributed to the conversion of forested land for agriculture and fuelwood gathering.

iii. The socioeconomic factors that significantly influenced deforestation ($p<0.05$) were income, population growth, developmental projects, logging and farming. These factors increased deforestation by (1.353, 1.024, 0.776, 0.108 and 0.391) units respectively.

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