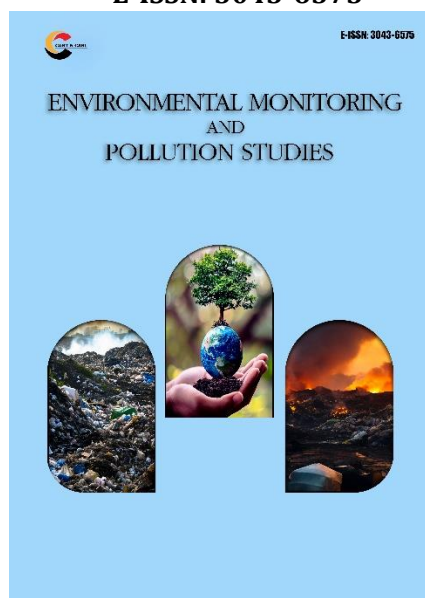




E-ISSN: 3043-6575



Geospatial Analysis of Land Use Changes and their Influence on Biodiversity Loss in Andoni LGA, Rivers State, Nigeria

Abstract

Geospatial analysis of land use changes and their influence on biodiversity loss in Andoni LGA, Rivers State, Nigeria. The study covered a period of 30 years (1986 to 2024). Secondary data such as multi-date images made up of Landsat 5 MSS, Enhanced Thematic Mapper Plus (ETM+), Enhanced Thematic Mapper (ETM+) and Landsat 8 OLI/TIRS (Operational Land Imager/ Thermal Infrared Sensor) were acquired for 1986, 2004, 2014 and 2024 were sourced from United States Geological Surveys (USGS) earth explorer. The classification resulted in five land use and land cover classes, water body, mangrove swamp, forest, farmland and built-up/bare surface. The results of the study showed that water body decreased by -752.76 hectares, mangrove swamp decreased by -684.27 hectares, forest decreased by -3,269.97 hectares, built-up area increased by 584.28 hectares, farmland increased by 4,122.72 hectares having the highest rate of total change for the period. The period witnessed an increase in farmland and built-up/bare surface. The land use and land cover changed from forested areas to other land use categories which indicated that expansion in built-up areas and other developmental activities have greatly reduced forest resources resulting in the loss of biodiversity. The study recommends the creation of a national park for the conservation and sustainable use of areas of high significance for biodiversity.

Keywords: Biodiversity, Urbanization, Land Use, Land Cover, Forest Degradation

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Received: 27 April 2025

Accepted: 25 May 2025

Published: 06 June 2025

Citation

Hermon, G.I., Obute, G.C., Komi, G.W. (2025). Geospatial analysis of land use changes and their influence on biodiversity loss in Andoni LGA, Rivers State, Nigeria. *Environmental Monitoring and Pollution Studies*, 2(1), 30 -39
<https://doi.org/10.70726/emps.2025.213039>

Introduction

Humans depend entirely on the environment for survival, but they know very little about how long the physical environment can last (Ohwo and Abotutu, 2015). Nigeria's base of natural resources is seriously threatened by this unsustainable exploitation of the environment. Urbanization is one of the biggest human activities affecting the quality of urban life and its sustainable development worldwide, and it poses one of the biggest risks to Nigeria's environment. Moving from rural to urban regions and transforming the rural environment into an urban one is known as urbanization, and it results in a growth in the population of cities, the area covered by urban land, and the number of settlements (UN DESA, 2019). Goal 11 of the Sustainable Development Goals (SDGs), Sustainable Cities and Communities, is in jeopardy due to the extraordinary rate of urbanization in the region. According to Filani (2008), urbanization in Nigeria predates colonialism by a significant amount. Although the nation experienced fast urbanization during the post-colonial era, the creation of states and Local Government Areas as a result of the nation's geopolitical restructuring following political independence in

1960 has accelerated urbanization's pace and geographic spread. Just 30% of people on Earth lived in cities in 1950; by 2050, that number is anticipated to rise to 68% (UN DESA, 2019). Today, 55% of people live in cities. Urbanization is a major factor contributing to biodiversity loss and species extinction (Simkin et al., 2022); the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) Global Assessment indicates that one million species may be at risk of extinction (Díaz, 2019). The environmental impact of urban areas increases with their size, and this impact is amplified not only by population growth but also by rising per capita resource demand.

Nigeria signed the Convention on Biodiversity (CBD) in 1994, pledging to adhere to its three main goals: conservation of biodiversity, sustainable use of its components, and fair and equitable sharing of resources resulting from the efficient use of genetic resources. Nigeria's environment is rich in ecological potential, which is essential for human development and transformation, but it is currently under threat from over-exploitation and misuse, which is causing a decline in both quality and quantity at an alarming rate. The environment offers resources necessary for all socio-economic activities as well as a life support system, but the main threats to the environment in general and these abundant and finite natural resources, in particular, are human activity and natural resources (Gasu et al., 2005 in Anwadike 2020). Rapid population growth, excessive resource exploitation, poverty, poor economic performance, a weak institutional and legal framework, poor agricultural practices and a high reliance on biomass fuel, land disturbance, excessive grazing, soil contamination, deforestation, land degradation, environmental pollution, vehicular pollution, urbanization, and erosion are some of the potential causes of environmental degradation and potentially biodiversity loss (UN 2002 in Anwadike 2020). The effects are felt by the growing human population and by changes in the global environment, including climate

change, rising sea levels, desertification, droughts, flooding, variations in rainfall, greenhouse effects, loss of biodiversity, degradation of coastal and marine habitats, freshwater contamination, land degradation, pollution of the air and water, and urbanization. The term "biological diversity" refers to the diversity of plant and animal life found throughout an environment, a community, a species, and even at the genetic level.

The term "biodiversity" was first used in scientific discourse in 1988. "The variability among living organisms from all sources including, inter alia, terrestrial, marine, and other aquatic ecosystems and the ecological complexes of which they are part: this includes diversity within species, between species, and ecosystems," is how the term was first defined at the 1992 United Nations Convention on Biodiversity (Juan Antonio et al., 1992 in Anwadike 2020). According to estimates of global species richness, there are between 3 million and 100 million species on Earth. The majority of these species are found in tropical and subtropical regions, which are home to many of the world's hot spots for conservation priority. The majority of biodiversity measurements and reports are made at the species level, considering traits including species richness, species diversity, and uniqueness to particular regions (UN 2002 in Anwadike 2020). The phrase is all-encompassing and comprehensive, covering both higher plants and animals as well as other lesser organisms, which is what conservation efforts are mostly focused on.

In many regions of the world, unplanned development-related changes in land use and land cover are currently the main factors contributing to the loss of biodiversity (Hansen et al., 2005). Growing civilizations' urban areas and infrastructure do have a significant impact on biodiversity. The majority of developing-nation towns are finding it extremely difficult to manage how infrastructure affects biodiversity. Urban areas require a significant amount of fresh water daily, and careless abstraction can seriously affect the diversity and composition of species. Common occurrences in and

around cities, including channelization, have the potential to significantly change the physical properties and decrease the variety of habitats that riparian vegetation offers. Urbanization undoubtedly plays a role in the decline of biodiversity. Global urbanization rates have risen drastically during the last 50 years in particular. These tendencies will probably not change. The UN World Urbanization Prospects gives projections for global urban share through 2050. Thus, this study aims to determine the pattern of land use and land-cover changes between 1986 to 2024 and relates it to the loss of biodiversity in Andoni LGA using GIS and Remote Sensing Technology and examine the influence of land use on species in the study area.

Materials and Method

Study Area

This study was carried out in Andoni Local Government Areas of River State, Nigeria (Figure 1). Its headquarters is in Ngo Town. It has an area of over 233 km² and according to NPC 2006, the projected population of the LGA in 2022 is 311,500 spread among 218 settlements. Andoni was created in 1991 during the regime of General Ibrahim Badamosi Babangida. It is bounded in the north by Khana LGA, in the south by the Atlantic Ocean, in the east by Opobo/Nkoro, and in the west by Bonny LGA. The LGA occupies a landmass of 233sq. Km. The projected population of the LGA in 2022 is 360,271 spread among 218 settlements. The predominant occupation of the people is fishing, while the major religion is Christianity with a few adherents to African Traditional Religion. It forms part of the rainforest in Nigeria. The Andoni people are related to the Ijaw people of the Niger Delta in Nigeria they speak the Obolo language, their villages and towns are situated on islands and some of them are Ikuru, Unyeangala, Asukama, Agana, Egwede, Ayamboko, Agwut Obolo, Ilotombi, Ekede town and Oyorokoto (the largest fishing settlement in Rivers State). The people are

predominantly fishermen. Some parts of the Andoni tribe can be assessed by road and all parts by sea. It is rich in wildlife elephants (*Loxodonta africana*), monkeys (*Macaca fascicularis*), species of pythons (*Testudinidae*), tortoise (*Testudinidae*) etc. and mineral resources and It is a growing tourist location in Rivers State.

Data collection and analysis

The study made use of remote sensing data through the Geographic Information System (GIS) to assess the trends, rate, magnitude and direction of changes in land-uses in the area for the last 30 years (1986-2024). Landsat imageries were sourced from United States Geological Survey (USGS) database. The imageries source and type of sensor is shown in Table 1. In sourcing for Landsat imageries for the analysis, cloud-free Landsat satellite imageries of Path 188 and Row 057 from United State Geological Survey (USGS) which covers the whole of Andoni local government area and other parts of Rivers State. The imageries were pre-processed and corrected for geometrical errors using ERDAS IMAGINE 2014 software. A check of the geometric accuracy was done by overlaying the imageries on study area features and the alignment was satisfactory before proceeding. The acquired imageries were pre-processed and classified with the aid of Anderson's classification technique using supervised classification method. At this point, supervised signature extraction was adopted in conjunction with a maximum likelihood algorithm to derive classes from the images. Two forms of spatial analysis were undertaken: area calculation of the land use/cover for each year and post-classification change detection. While the former involves comparison of the land use statistics derived from the classified images, the latter is an area-specific change detection procedure (point-by-point). With these two techniques, information on the nature, location, magnitude, trend and rate of changes were highlighted.

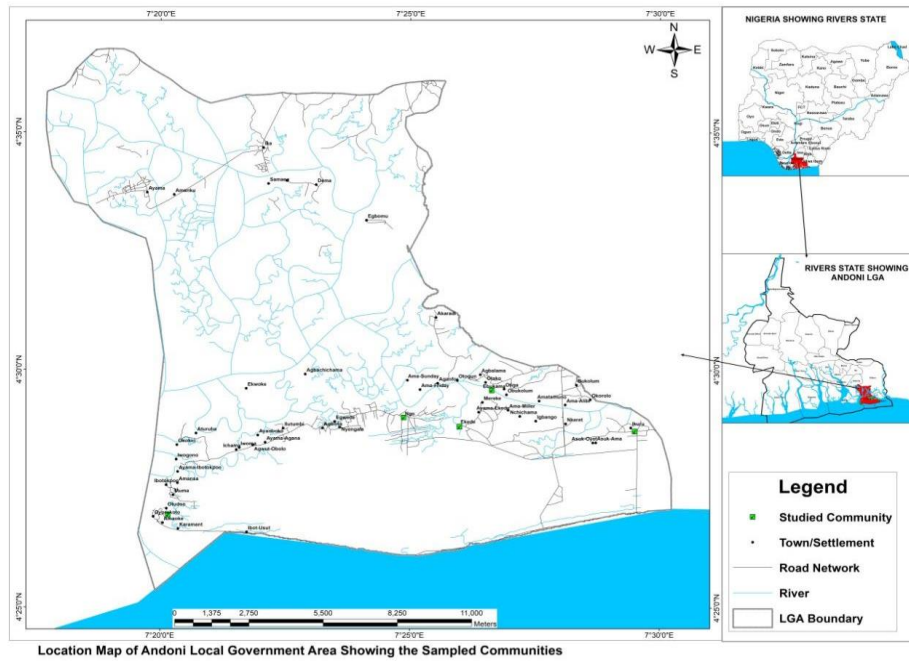


Figure1: A Map showing Andoni LGA (Study Area)

Table 1: Dataset and Sources for Assessing Land-Use Dynamics in Andoni LGA

S/N	Imagery	Sensor	Year
1	Landsat 5	Landsat 5 MSS	1986
2	Landsat 7	Enhanced Thematic Mapper Plus (ETM+)	2004
3	Landsat 7	Enhanced Thematic Mapper (ETM+)	2014
4	Landsat 8	Landsat 8 OLI/TIRS (Operational Land Imager/ Thermal Infrared Sensor)	2024

Spatial References: WGS84 UTM Zone; ZONE 32, **Path/Row:** Path 188; Row: 057, **Resolution:** 30m × 30m, **Cloud Cover:** 0%, **Source:** United State Geological Survey, (USGS)

After the classification of the images in ERDAS IMAGINE, the actual cartographic production of the land use/cover maps and generation of statistics for inventory were completed using ARCGIS 10.8. It is important to note that Erdas Imagine was used due to its robust and advance image analysis functionalities, while the use of ArcGIS was prompted by its flexibility in spatial data handling and analysis. The mapping of the different land uses completed exploiting the robust mapping capabilities of the same software.

The detection of the changes provided an understanding of the land use and land cover changes that occur on the catchment over years. The changes in percentage were

then calculated using the equation adapted from Lambin (2011), which is given as:

$$\text{Percentage Change} = \frac{OC}{ASC} \times 100 \quad (1)$$

Where: OC is the observed change, and ASC is the absolute sum of change.

$$\text{Annual Rate of Change} = \frac{Y2 - Y1}{N} \quad (2)$$

Where: N is the number of years, Y1 is the starting year and Y2 is the ending year.

Results

The Land-Use/Land-Cover Analysis in Andoni LGA between 1986-2024

Some identified land use types in Andoni LGA were, Mangrove swamps, Water bodies, Forest, Built-up/deforested areas, and farmland. The land use/ land cover characteristics for Andoni are displayed for the year 1986, 2004, 2014 and 2024 in [Figure 2](#). The land use/land cover analysis for Andoni LGA indicated that mangrove swamps have recorded a decrease over the years while forest depreciation is at a very rapid rate every decade. Built-up and bare surfaces were observed to be at the increase likewise farmland. This shows that the reduction in forested areas is a result of urbanization and intense agricultural and industrial practices. From the analysis of satellite imagery of 1986, it was revealed that water bodies cover 25.28% of Andoni LGA which is about 6501.69 hectares, and mangrove and forested area covers 32.4% and 28.6% respectively. While farmland and built-up/deforested area covers 8.27% and 5.36% respectively. From this analysis, it shows that mangrove swamps and thick forests were the only land cover that occupied the largest proportion of Land cover of the study area (32.43% and 28.65% respectively). In 2004, the result indicated that the water body reduced by 2% from 6501.6 hectares (25%) to 5915.79 (23%). Similarly, mangrove swamps increased from 32.43% to 38.31% at the expense of forest which dropped by 1.91%. Also, farmland decreases by 2.4% while built-up area increases from 5.36% to 6.11%. In 2014, the water body covers 26.1%, mangrove swamps reduced to 34% while forest and farmland cover 17% and 14% respectively. While built-up/deforested areas accounted for 6.9% of coverage. This indicates the continuous reduction in forested areas and mangrove swamp vegetation over the past years. In 2024, it is clear that the water body decreased to 22% which now covers 5748 hectares. Mangrove swamps and thick forests also recorded reductions of 4.62% and 1.64% respectively. On the other hand, built-up areas recorded an increase likewise cultivated farmland.

Trends, Rate, and Magnitude of Land-Use Changes between 1986-2024

[Table 2](#) shows the trend and magnitude of land-use changes in Andoni between 1986 and 2024. The result shows that the water body has been changing negatively over the past decades in the area. Mangrove swamps are under threat likewise thick forest. For instance, over the years under consideration, water bodies have been reduced by 752.76 hectares. Mangrove and thick forest have reduced by 684.27 and 3269.97 hectares respectively. On the other hand, farmland and built-up/bare surfaces have increased by 4122.72 and 584.28 hectares respectively. United Nations Environmental Program (2002) Estimate shows that 21.1 million hectares of African forest have been lost since 1970 accounting for about 30 percent of the original extent while land under cultivation has increased by 3 million hectares or over 21 percent. Anthropogenic activities that have resulted in the degradation of the forest include, clearing and burning of the forest; over-harvesting of plants and animals, indiscriminate use of persistent or recalcitrant chemical pesticides, draining and filling of wetlands, destructive fishing practices, air pollution and the conversion of protected lands for agricultural and urban development purposes. These activities are the result of population explosion and increasing poverty as well as economic policies and priorities. The Nigerian forests are rich in biodiversity and cover Edo, Ondo and Cross River states respectively and because of the vast resources that can be obtained from them, they have been massively exploited for economic and development purposes. This is also in line with the First National vegetation and land-use studies carried out in 1976. The study revealed that the natural vegetation was altered by human activities such as grazing, cultivation, bush burning and logging over a long period. The disturbances in the vegetation have resulted in a complex patchwork of vegetation with different ages and forms, particularly in densely populated areas. The 1976 studies were updated

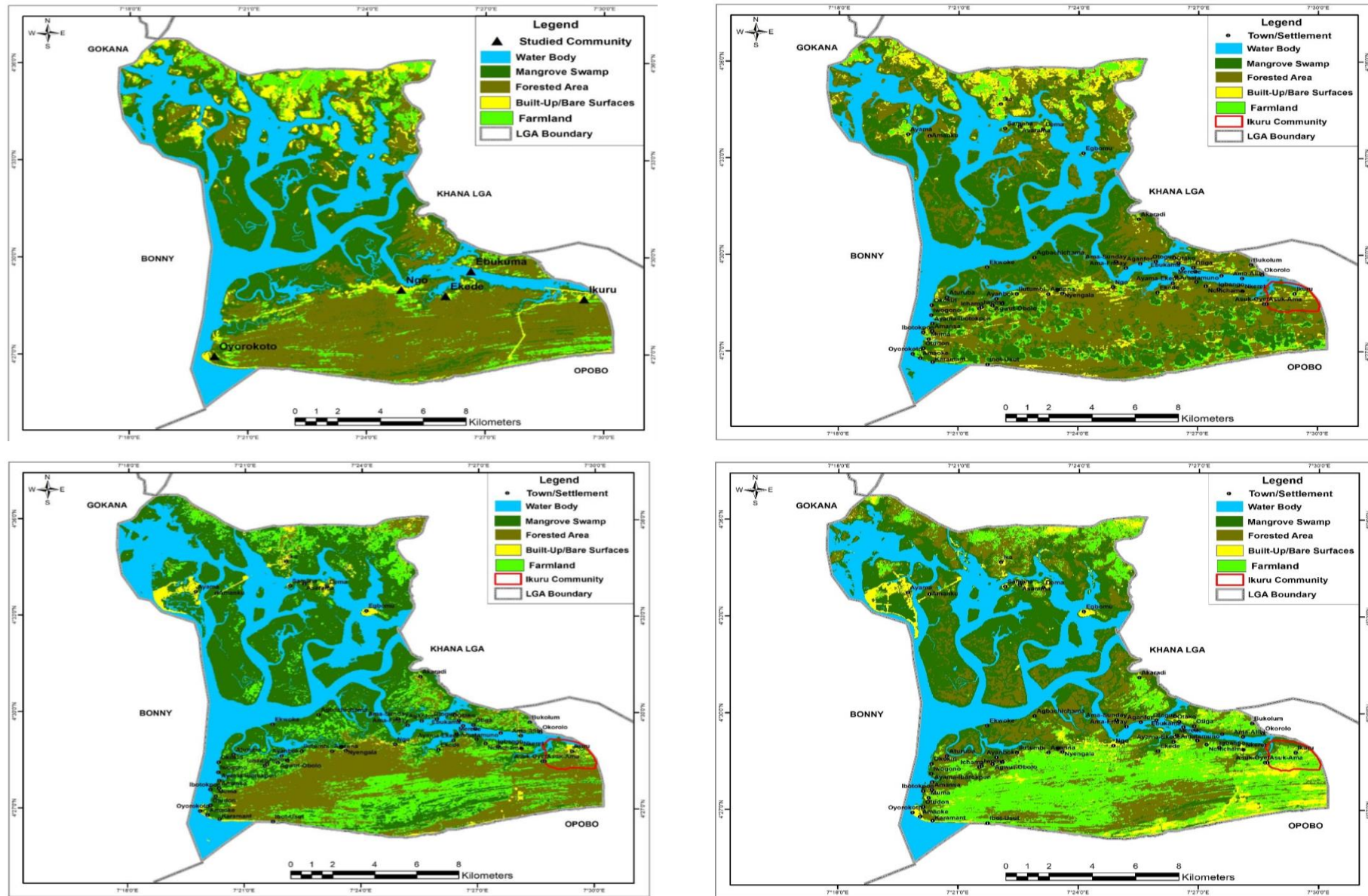


Figure 2: Land-Use/Land-Cover characteristics of Andoni LGA in 1986, 2004, 2014 and 2022

Table 2: Tables Showing the Pattern and Rate of Landuse/Landcover Changes in Andoni

Land-use classes	Change between 1986 & 2004			Change between 2004 & 2014			Change between 2014 & 2024			Overall Change between 1986 & 2024		
	1986	2004	Change	2004	2014	Change	2014	2024	Change	1986	2024	Change
water body	6501.69	5915.79	-585.90	5915.79	6716.79	801.00	6716.79	5748.93	-967.86	6501.69	5748.93	-752.76
mangrove swamp	8342.19	9853.29	1511.10	9853.29	8845.83	-1007.46	8845.83	7657.92	-1187.91	8342.19	7657.92	-684.27
Thick forest	7370.1	6878.88	-491.22	6878.88	4522.50	-2356.38	4522.50	4100.13	-422.37	7370.1	4100.13	-3269.97
farmland	2127.6	1502.28	-625.32	1502.28	3850.92	2348.64	3850.92	6250.32	2399.40	2127.6	6250.32	4122.72
Built-up/deforested area	1379.52	1570.86	191.34	1570.86	1785.06	214.20	1785.06	1963.80	178.74	1379.52	1963.80	584.28

Source: Extracted from Satellite Imageries (1986, 2004, 2014 and 2024)

Note: Values represent land size in hectares

through another study in 1995. The study shows drastic changes in the vegetation over those of 1976.

Species present in the study area

The descriptive findings of endemic species present in the study area were as depicted in Table 3 showing monkey (69.59 per cent) as the most endemic species and eagle as the least endemic species (11.49 %).

Influence of land use on some species in the study area

The respondents' views of the influence of land use on some species were summarized in Table 4. The most important influence of land use on some species was habitat disturbance which accounted for 85.81 per cent, and change of habitat which was the least at 2.7 %.

Table 3: Some Species Present in the Study Area

Species in the study area	Freq.	%
Monkey (<i>Macaca Fascicularis</i>)	83	24.56
Crocodile (<i>Crocodylus porosus</i>)	79	23.37
Bush Dog (<i>Speothos venaticus</i>)	45	13.31
Elephant (<i>Loxodonta africana</i>)	43	12.72
Hippopotamus (<i>Hippopotamus amphibius</i>)	39	11.54
Eagle (<i>Ictinaetus malaiensis</i>)	17	5.03
*Others	32	9.47

*Antelope (*Tragelaphus scriptus*)-2, Grasscutter(*Thryonomys swinderianus*)-1, Iguana (*Iguana iguana*)-3, Alligator (*Alligator mississippiensis*)-3, Porcupine (*Erethizon dorsatum*)-2, Squirrel (*Sciuridae*)-2, Bushpig (*Potamochoerus larvatus*)-2, Bush dog (*Speothos venaticus*)-1, Fox (*Vulpes vulpes*)-1, Snakes (*Python bivittatus*)-1, Tortoise (*Centrochelys sulcata*)-2, Turtle(*lepidochelys olivacea*)-2.

Table 4: Influence of land use on some species in the study area

Influence	Freq.	%
Habitat disturbance	127	39.69
Habitat destruction	116	36.25
Encroachment	38	11.88
Extinction of species	35	10.94
Others (change of habitat)	4	1.25

Field survey, 2024

Discussion

This study based on the land use analysis of Andoni LGA using remote sensing data through GIS to assess the trends, rate, magnitude and direction of changes in the land uses in the area for the past 30 years (1986-2024) shows that mangrove swamp is under threat likewise thick forest. Forest depreciation is at a very rapid rate every decade. For instance, over the years under consideration, water bodies have been reduced by 752.76 hectares. Mangrove and thick forest have reduced by 684.27 and 3269.97 hectares respectively. On the other hand, farmland and built-up/bare surfaces have increased by 4122.72 and 584.28 hectares respectively. This shows that the reduction in forested areas is a result of urbanization and intense agricultural practices. The reduction in mangrove and thick forests in Andoni LGA as demonstrated in the mapping shows that many species (both plant and animal) have reduced. With the mapping showing an expansion in built-up area and farming portion, it indicates that as urbanization increases in Andoni, buildings and road surfaces are coming up to replace thick vegetation thereby driving away much biodiversity. More so, as agricultural activities increase in the area, thick forests and mangroves are destroyed thereby forcing animal species to migrate while others are killed. Similarly, these activities lead to the destruction of many plant species in the area.

Thus, the decreasing vegetation cover is an indication that forest lands are being encroached and this has

adverse implications on forest resources, which will eventually lead to loss in biodiversity. This finding aligns with the findings of Nti (2023) and Eludoyin (2017) that the practices associated with forest encroachment are on the increase and these activities are causing a decrease in the spatial extent of forest cover which are largely logging and construction projects. Moreso, it was noted that the results of encroachment activities are usually serious environmental degradation. This pressure is a result of activities like intensified logging, agriculture and developmental construction projects leading to a decreasing amount of forestland biodiversity and intensified land degradation. The outstanding upshot influence of land use on endemic species was habitat disturbance, which accounted for 85.81 per cent, followed by habitat destruction (78.38%), encroachment (25.68%), extinction of species (23.65%) and others which include housing (2.7%).

The result from the field survey is in line with Nsikak et al. (2020) who opined that habitat fragmentation and degradation may have contributed to the migration or disappearance of endemic species such as *Cercopithecus sclateri* (Sclater's guenon - white-throated monkey). Other high-profile species including *Trichechus senegalensis* (manatee) and *Pan troglodytes* (chimpanzee) have not been sighted in many years. According to (Nsikak et al 2020) Particularly striking is the fact that hunters attribute the paucity in the availability of wildlife and bush meat trade to disappearing vegetation (deforestation, habitat

fragmentation and degradation) and continuous gas flaring which makes the animals unsettled at night seasons. This is a factor in species migration. Farmers also alluded to the fact that indicator species such as dung beetles and certain insects are "rarely seen these days". This observation lends credence to the fact that "land-use change may both confound and compound the influence of global climate change on biodiversity," due to deforestation.

Conclusion

The study examined the impact of urbanization on the biodiversity of some selected communities in Andoni LGA, Findings revealed that mangrove swamps are under threat likewise the thick forest. For instance, over the years under consideration, water bodies have been reduced by 752.76 hectares. Mangrove and thick forest have reduced by 684.27 and 3269.97 hectares respectively. On the other hand, farmland and built-up/bare surfaces have increased by 4122.72 and 584.28 hectares respectively. Result given the influence of Land Use on some Species, the outstanding upshot influence of land use on endemic species was habitat disturbance, which accounted for 85.81 per cent, followed by habitat destruction (78.38%), encroachment (25.68%), extinction of species (23.65%) and others which include housing (2.7%). Considering the disclosures of this survey, the going with proposition made was that. Before allowing industries into the area, a proper environmental impact assessment should be carried out to ensure that the area is not adversely affected due to industrialization and developmental projects. There is a strident call to the state for the protection of the marine and coastal biodiversity in the study area to save the depleting habitats in the region taking it from mere "Paper Parks ie, Parks on Paper to Real parks and funds be allocated for the protection of this area.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Credit Authorship Contribution Statement

Hermón, G.I.: Conceptualization, Methodology, Formal analysis, Investigation, Resources, Data curation, Visualization, Project administration, Writing - original draft. **Obute, G.C. and Komi, G.W.:** Supervision, Methodology, Validation, Formal analysis, Data curation, Visualization, Review & Editing.

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