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Landuse and Landcover Mapping to Assess Forest Ecosystem Change in Ihiala Lga, Southeastern Nigeria

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ABSTRACT

The result of landuse and landcover (LULC) change detection indices is very useful for natural resource monitoring and landuse management. Hence, this study aimed at assessing the forest ecosystem variation of Ihiala Local Government Area (LGA), southeastern Nigeria using remote sensing technique. The major source of the data were the LANDSAT-TM (1987), LANDSAT-7ETM (2003), LANDSAT OLI-TIRS (2015) and LANDSAT-8 (2022) satellite imageries that were acquired online from the website of U.S. Geological Survey. The research methodology was purely remote sensing analysis of the satellite imageries of 1987, 2003, 2015 and 2022. The classification resulted in six land use and land cover classes of built-up areas, forest cover, grassland/farmland, bare surface, Lake and other water body, while the ENVI version 5.0 and ArcGIS version 10.5 software were applied in digital image processing and thematic map production. The Maximum Likelihood as a widely used supervised classification method was employed, to detect the land cover types within the zone, ground truthing and error matrix analysis were done to validate the image classification results, the user accuracy and kappa index assessment falls within acceptable limit of 85%.The LULC image classification proved that there is a change in LULC classes with continuous reduction in forestland by 16,358.90 hectares in 1987 to 8,742.96 hectares in 2022 and a continuous increase in built-up area by 3,011.71 hectares in 1987 to15, 780.53 hectares in 2022. The study concludes that forest ecosystem in Ihiala LGA, like other tropical forests, has significantly declined in the availability of natural resources as a result of Landuse and landcover modification and weak policies. It therefore recommends that pertinent agencies in-charge of urban development should ensure control in developmental activities around the existing land areas to prevent unsustainable meddling into conserved areas. This control action will as well contribute to improving carbon storage potentials of the zone.

Keywords: Landuse and landcover change, Forest Ecosystem Assessment, Change Detection, Remote Sensing, and Southeastern Nigeria.

INTRODUCTION

Understanding ecosystems is a vital subject for scientific investigation, mostly due to the recognition of the rising costs of biodiversity loss and ecosystem degradation,caused by land clearing, bush burning, deforestation and urbanization, (TEEB, 2009). The effects of this decline and loss of forests and its services are quite devastating to the populace predominantly in sub-Saharan Africa where most of the countries have large rural population that depend on forest resources exploitation for their livelihood. Landuse and landcover change has resulted in the loss of forest habitat and fragmentation of forested area in Nigeria and based on the current trend of urbanization, it is likely that forested habitat will continue decrease in forest resources, (Richards and VanWey, 2015). On deforestation trend in Africa, FAO (2010) revealed that Nigeria has lost more than half of her forestland within the last fifty year making it one of the countries with the highest rate of

ISSN No. 2454-6186 | DOI: 10.47772/IJRISS |Volume VIII Issue VIII August 2024

deforestation in the world.

As the application possibilities of remote sensing increased in the last decades in the tropical forest conservation and monitoring, Arjan, (2011), revealed that tropical forest conservation cannot do without the involvement of remote sensing. The use of remote sensing in assessment of the impact of LULC dynamics on ecosystem service value reveals that great changes take place in LULC in different epochs with the most significant increase in large-scale expansion of the built-up area and decline forest land, (He, et. al.,2021; Soumen, Sambhunath and Debashish, 2021, Hishe, et. al., 2021).

In Nigeria, the expansion in built up areas and other developmental activities have greatly reduced forest resources which result to the loss. However, people's ignorance of the ecosystem services in relation to land use types, contributed to the loss of these benefits and services across rural communities, (Zhang, et. al., 2016). Yet, the impact of landuse change on a wide range of ecosystem services proved that cultivated land spread out over the forests making savannahs predominant, (Arowolo, Deng, Olatunji and Obaye, 2018). The study of Ecosystem Cover Dynamics and its Implications in the coastal zone of Ondo State, Nigeria by Olajide, Popoola and Otokiti, (2020), estimated the total land area for the ecosystems within the study area, showing the total land area coverage of ecosystem (146,682 ha), where the swamp forest ecosystem was the largest ecosystem depleted in terms of land area. Also, in trying to find out the rate of forest cover change in freshwater swamp forest, Igu and Duluora (2019) used remotely sensed data to conduct a thirty year study of 1987-2017 and landuse change and its drivers were noticed to have reduced the area of forest cover. In a survey determining the impact of urbanization on forest resources in Otukpo Local Government Area Benue State, Ancha, et. al, (2021) proved that the land use and land cover, changed from forested area to other land use categories which indicates that, expansion in built up areas and other developmental activities have greatly reduced forest resources resulting to the loss of natural vegetation.

Ihiala Local Government Area (LGA), located in southeastern Nigeria, is a vast area of forest land, where over-exploitation, landuse changes, land fragmentation and urban developmental activities are evidently on increase. This landmass has attracted lots of companies, institutions and organizations leading to modification in the land use and land cover mostly in the three main hubs of the LGA, namely - Okija, Ihiala and Uli. The majority of their forests are known for the supply of different forest products, such as timber, firewood, medicinal materials, and foods like; African star apple (*Chrysophyllum albidum*), *Treculia Africana* (breadfruit), *Irvinga gabonensis* (bush mango), *Termitomyces Titanicus* (Mushroom), *Ambiaya albidium*, *Cola nitida* (Oji), *Brachystegia eurycoma* (Achi), and palm products. The rate of degradation affected the forests to the extent that almost every family buy all forest resource from the market including the commonly gathered *Irvingia gabonensis*. There is loss of timber, forest foods, livelihood and medicinal resources as a result of landuse/landcover change, population growth, over exploitation, agricultural practices, urban development, bush burning, ignorance, poverty and mismanagement of natural resources.

The use of remote sensing in understanding the change of landuse and landcover as an index of ecosystem depletion can assist geomatic engineers, environmental managers and policy makers to improve decision-making on natural resource and landuse measurement, management, monitoring and sustainability. Therefore, there is an urgent need to extend ecosystem service (ES) studies to forest-savanna ecological zone so as to capture its spatial temporal features using Ihiala L.G.A as case study.

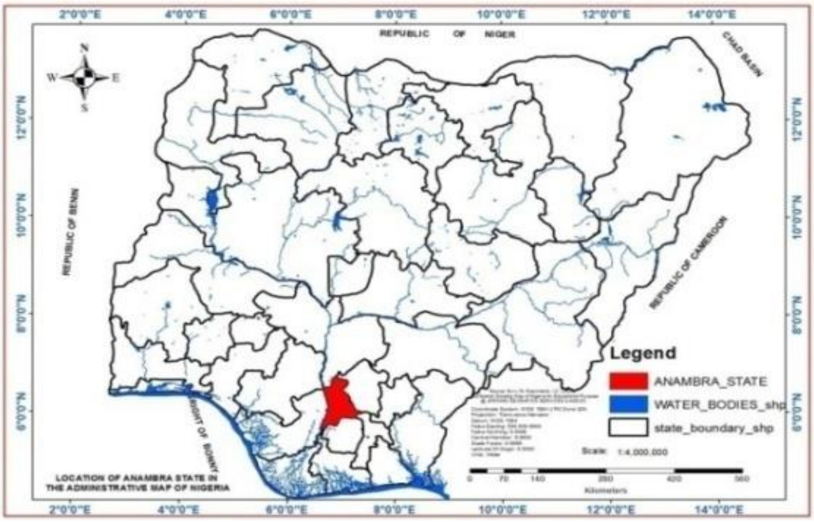
MATERIAL AND METHOD

Study Site

The study area is Ihiala Local Government Area in Anambra State, Nigeria (Figure 1). with its coordinates lying between Latitude 5° 45′ 00″ N to 5° 55' 35" N and Longitude 6°30′ 30″ E to 6° 50′ 35″ E. Ihiala L.G.A is located 48km North of Owerri and 40km South of Onitsha. It has a land mass of about 1,385sq.km It is located in the Southern part of Southeastern Nigeria, (Figure 2). The study area is bounded at the west by Ogbaru (in Ogbaru L.G.A, Anambra State), at the North by Ozubulu in Ekwusigo L.G.A, Anambra State, at the east by Ukpor and Orsumenyi in Nnewi South L.G.A, Anambra state and at the South by Egbuoma, Ohakpu, Ozara and Oguta in Egbema / Oguta L.G.A of Imo State, (Figure 3 and Figure 4).

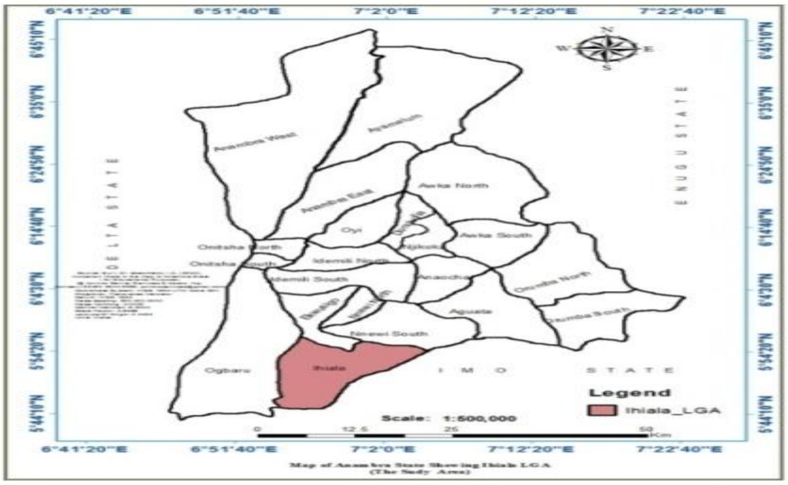
ISSN No. 2454-6186 | DOI: 10.47772/IJRISS |Volume VIII Issue VIII August 2024

Fig. 1: Map of Nigeria showing Anambra State



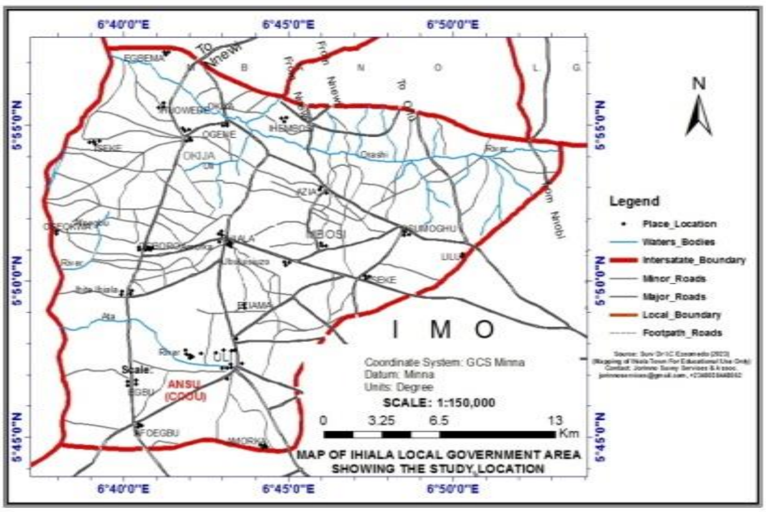
Source: Jorinno Survey Services, (2023).

Fig. 2: Map of Anambra State showing IhialaL. G. A



Source: Jorinno Survey Services, (2023).

Fig. 3: Map of IhialaL. G. A showing the ten communities



Source: Jorinno Survey Services, (2023).

ISSN No. 2454-6186 | DOI: 10.47772/IJRISS |Volume VIII Issue VIII August 2024

The study area is a tropical rain forest zone characterized by five different stratification layers typical of rain forest; from the emergent trees to the herb layer. The forests has important trees such as *Milicia excelsa*, *Chrysophyllum albidum* , *Treculia africana*, *Irvinga gabonensis* and *Elaeis guineensis*. The trees are of economic, nutritional and medicinal value, (Anoliefo, Nwokeji and Ikhajiagbe, (2015). The typical rainforest vegetation is gradually disappearing in the area, giving rise to derived savanna vegetation of shrubs and bushes. The climate is classified as tropical climate, with an average daily temperature ranging from 22ºC-32ºC. It has an average yearly rainfall of 1500mm (NIMET, 2012). The relief of the study area ranges between 83m and 162m above mean sea level. The area is drained mainly by Orashi River and its tributaries, the Awgbu River and Omai River in the Northern part (Okija), and Akazi River and Abanze River in the central part. There is also Enyinja and Atamili River in the Southern part (Uli). The Orashi and Akazi Rivers is the major rivers in this area. They all empty into River-Niger. The geology of the study area consists of two easily distinguishable geologic formations: the Ogwasi-Asaba formation (Oligocene-Miocene) and the Benin formation (Miocene-Pleistocene). The soils are derived from the underlying sandstone and shale units. The soils derived from Shales on lower slopes where drainage is poor. There is dark reddish brown clayey at the surface and a strongly mottled light grey and red soil. The soils are well drained and weakly consolidated in most parts (Ndukwe, et. al, 2013).

Data collection

This study used primary and secondary sources of data. The primary data wasobtained through GPS and satellite imagery, while journals, government publications, internet and conference proceedings were the secondary sources of data.

Method of data analysis

To show the overview of forest ecosystem in the study area and the extent at which it has depleted, the LULC classification was performed and the result revealed the spatial and temporal dynamics over the last 35 years in the study area. The results were presented in maps, charts and tables. Change detection approaches were employed using satellite imagery to derive LULC data and changes in the study area. The LULC classification was obtained from the analysis of satellite imageries of 1987, 2003, 2015 and 2022 acquired online from U.S. Geological Survey website, (table 1: Characteristics of Image used).

The extent of land use change was analyzed by subtracting the reference year (2022) from the base year (1987), Equation (1) with mathematical representation as:

$ET=B-A$ ……………………………………………… Equation 1

Where: ET =total extent of forest land, A= the base year, B=the reference year.

Table 1: Characteristics of Image used

S/N	YEAR ACQUIRED	IMAGE TYPE	BAND	SENSOR ID	PIXEL-CELL SIZE	PROJECTION	OUTPUT FORMAT
1	1987	LANDSAT	1-7	TM	30 m	UTM WGS84, Zone 32	GEOTIFF
2	2003	LANDSAT	1-8	7ETM	30 m	UTM WGS84, Zone 32	GEOTIFF
3	2015	LANDSAT	1-11	OLI TIRS	30 m	UTM WGS84, Zone 32	GEOTIFF
4	2022	LANDSAT	1-11	Landsat 8	30 m	UTM WGS84, Zone 32	GEOTIFF

Source: U.S. Geological Survey

Landsat satellite images were used because they capture longer-term landuse change dynamics compared to other data source (figures 4a-4d).

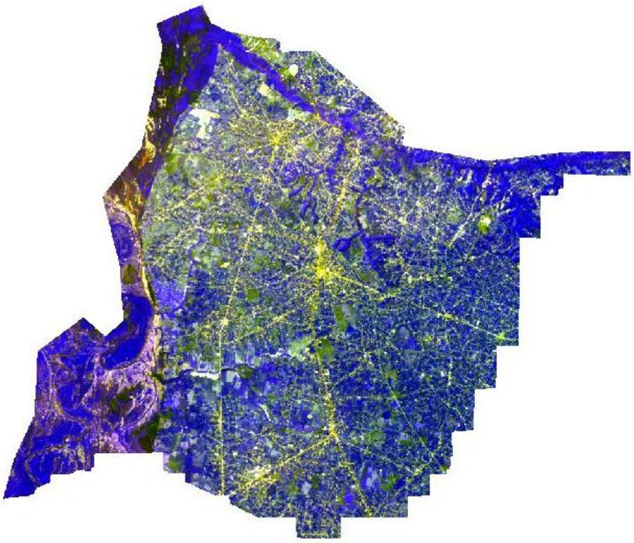


Figure 4a: Landsat-Tm (1987)

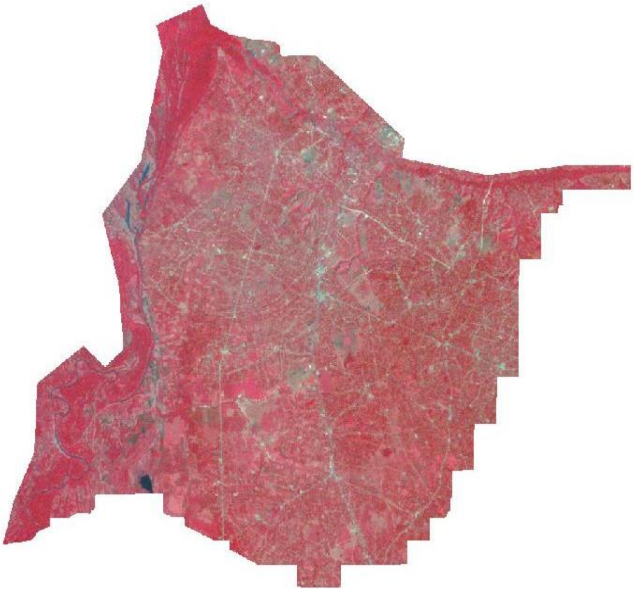


Figure 4b: Landsat-7etm (2003)

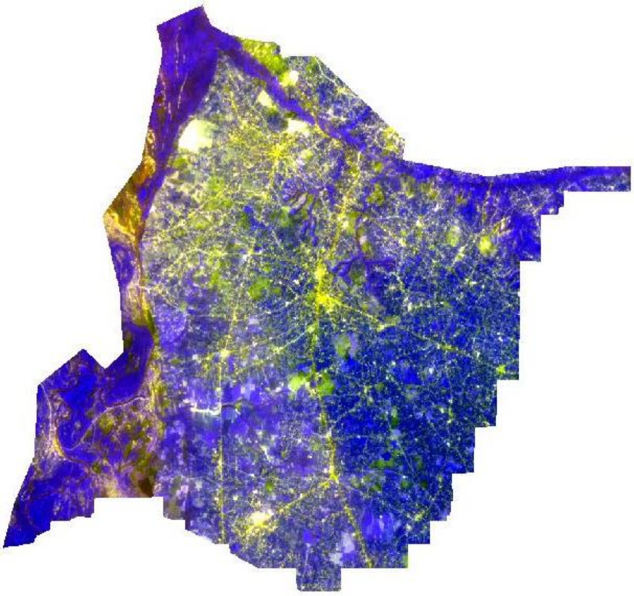


Figure 4c: Landsat Oli-Tirs (2015)

ISSN No. 2454-6186 | DOI: 10.47772/IJRISS |Volume VIII Issue VIII August 2024

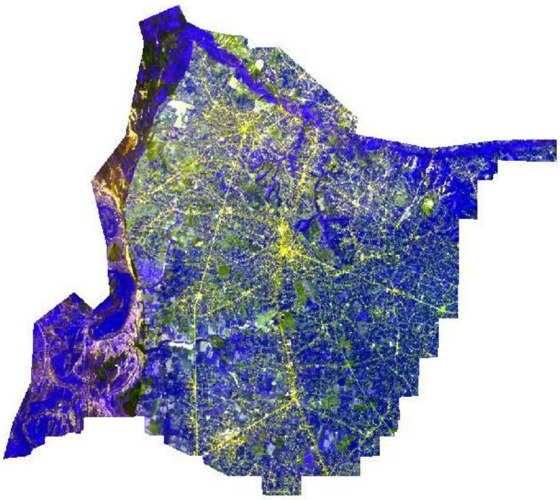


Figure 4d: LANDSAT-8 (2022)

Source: Image courtesy of the U.S. Geological Survey

The classification resulted in six land use and land cover classes of built-up areas, forest cover, grassland/farmland, Lake, bare surface and water body, while the ENVI version 5.0 and ArcGIS version 10.5 software was applied in digital image processing and thematic maps production. The Maximum Likelihood as a widely used supervised classification method was employed, to detect the land cover types within the zone, ground truthing and error matrix analysis was done to validate the image classification results, the user accuracy and kappa index assessment falls within acceptable limit of 85%.

RESULT

Attributes of Forest Ecosystem in Ihiala L.G.A

The geographic attribute information of the sampled communities and their forests in the study area are presented in table 2 which includes their names, locations and coordinates. The attribute information in table 2 and the classified images of figure 5a to 5d, were used to produce LULC map of the study area using 6 regions of interest; farmland, forestland/grassland, built-up area, water bodies, bare surface and Lake, (figure 6). The built up area expands mostly along the major roads, due to continuous influx of people, organizations and companies, who buy lands for developmental activities. This expansion is also obvious from Okija-Ihiala, mostly along the Onitsha-Owerri expressway, down to Uli. Also there is a significant development around the Chukwuemeka Odumegwu Ojukwu University, Uli, through the Ansu-Egbu road.

Table 2: Showing the attributes of community forests in the study area

S/N	Name of Community	Name of Sampled Forest	Latitude	Longitude
1	Umuohi (Okija)	IkpaOgwugwu	5° 56' 41.009"	6° 49' 48.594"
2	Umuogu (Okija)	Umuogu forest	5°53' 48.712"	6°51' 51.066"
3	Umuabalike (Ihiala)	Mgbu and Okotoba Forests	5°50' 42.166"	6°50' 0.265"
4	Ubahuekwem (Ihiala)	OgwugwuUbahuekwem	5°52' 55.654"	6°50' 59.227"
5	Eziama (Uli)	Atammiri forest	5°50' 9.139"	6°52' 4.54"
6	Amamputu (Uli)	Ogada forest	5°48' 28.436"	6° 47' 58.869"
7	Isseke (Ebenesi)	Ihueke Forest	5°46' 58.905"	6° 53' 39.661"
8	Azia (Ebenesi)	Akaba Forest	5°53' 43.452"	6° 54' 54.73"

ISSN No. 2454-6186 | DOI: 10.47772/IJRISS |Volume VIII Issue VIII August 2024

Source: Researchers' Fieldwork, 2023

The maps in figures 5a-5d are the classified images of 1987, 2003, 2015 and 2022 respectively. The identified LULC classes are represented in the key as built-up area (red), forest land (green), water bodies (blue), farm land/grassland (yellow), lake (torques blue) and bare surface (purple). The 1987 image showed much of forestland and less of other classes, where image of 2003 showed reduction in forestland and increase in built-up and farmland areas. But 2015 image showed a drastic reduction in forestland, with much increase in built-up area and farmland. This continuous reduction in forestland may be attributed to the increase in people's interest to developmental activities in Ihiala L.G.A as it is one of the urban developing areas in Anambra state. Thus, companies and other organizations are attracted by the vast landmass for different forms of establishment.

On the other hand, the increase in farmland is attributed to hardship and hunger in the country. So, more people continue to go into farming as a coping strategy for household survival. Finally, 2022 satellite image showed very much increase in built-up area, with a little increase in forestland and little reduction in farmland/grassland. The continued increase in built-up area may perhaps be ascribed to insecurity issues that kept bringing people and their businesses back home from different parts of the country. The little increase in forestland is as a result of previously cultivated lands that are going into fallow which thus reduced the percentage of farmland.

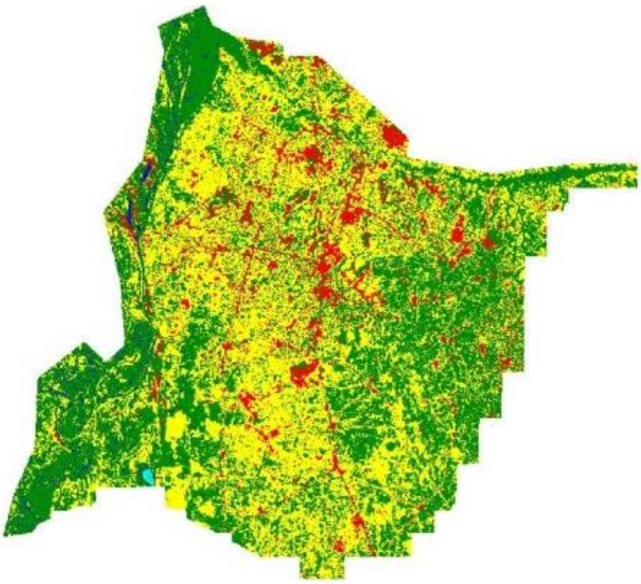


Figure 5a: Landsat-Tm (1987)

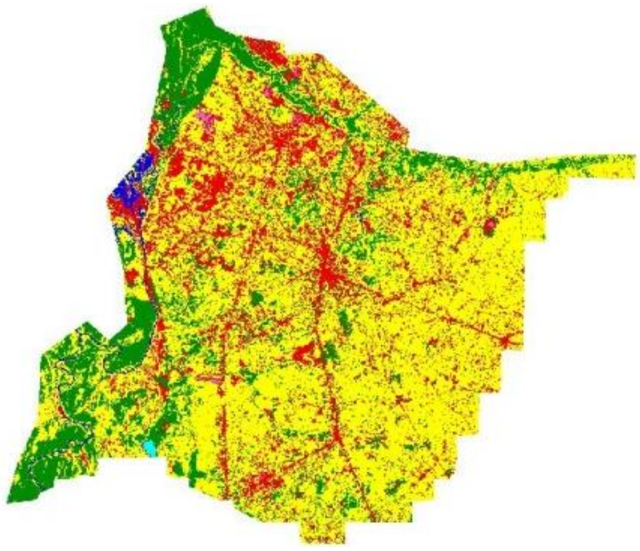


Figure 5b: Classified LANDSAT-7ETM (2003)

ISSN No. 2454-6186 | DOI: 10.47772/IJRISS |Volume VIII Issue VIII August 2024

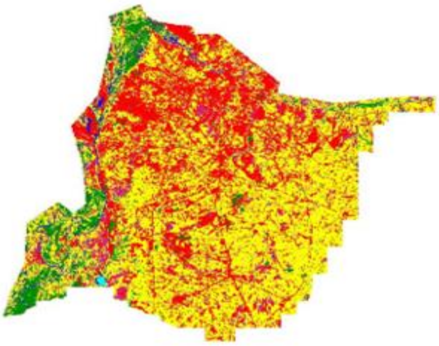


Figure 5c: Classified Landsat Oli-Tirs (2015)

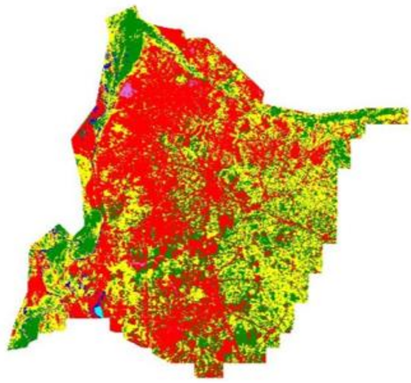


Figure 5d: Classified Landsat-8 (2022)

Key:

Built- up Area (BUA)
Forest/grass Land (FOL)
Water Bodies (WAB)
Farm Land (FML)
Lake (LAK)
Bare Surface (BAS)

Nevertheless, to show a clearer view of the forest cover in the study area, a vegetation map of the area was produced (figure 6), with more interest on forests, farmland and grassland. The map shows that thick forests are found mostly around the water bodies with some patches of forest within the land areas.

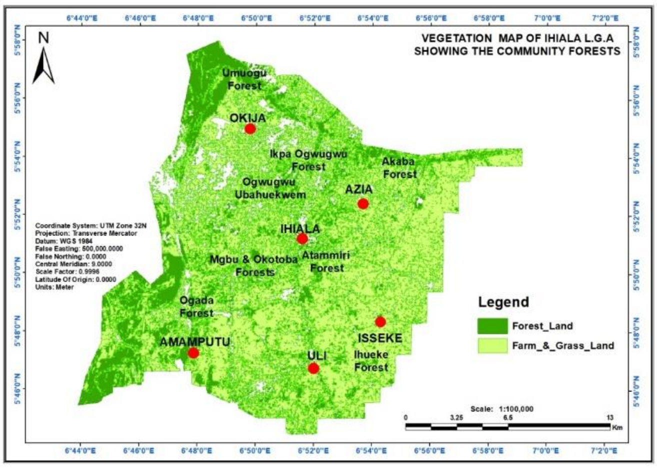


Figure 6: The vegetation map of Ihiala L.G.A

ISSN No. 2454-6186 | DOI: 10.47772/IJRISS |Volume VIII Issue VIII August 2024

During the fieldwork, the researcher observed that most of the patches of forests within the land area that people referred to as “thick forests” are actually sacred groves located in most places in the study area. Examples of such forests are; Umuanuebunwa ancestral shrine and Atammiri ancestral forest in Uli, which has not been degraded, (Plate 4.1 for Umuanuebunwa ancestral shrine).

Plate 1: Umuanuebunwa Ancestral Shrine

Analysis of landuse and landcover classification

LULC Landsat image classification of 1987, 2003, 2015 and 2022 which was carried out, proved that there is change in the landuse/landcover classes with much significance in forestland (FOL), built up areas (BUA), farmland (FML) (figure 7a-7d). Result from figure 8a indicated that in 1987, forest land and farmland were almost the same percent of 44.88 and 45.38 respectively. However, build up area was on a minimal level of 8.26.

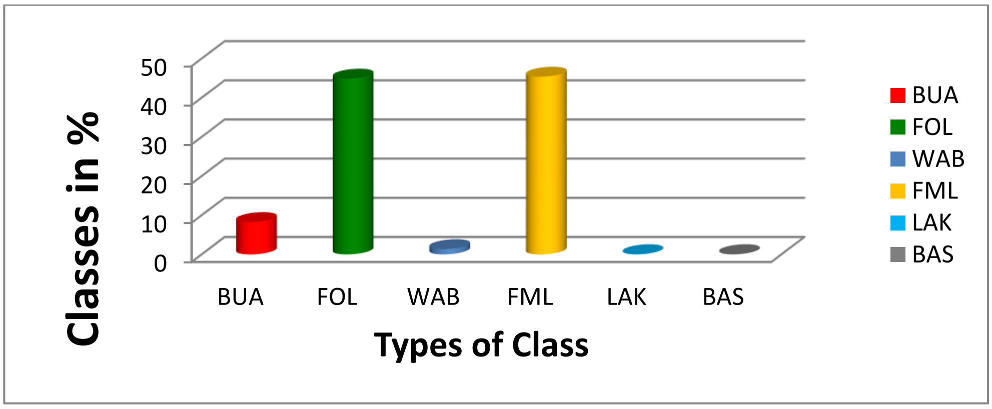


Figure 7a: 1987 Ihiala Classified Landuse/Landcover image result

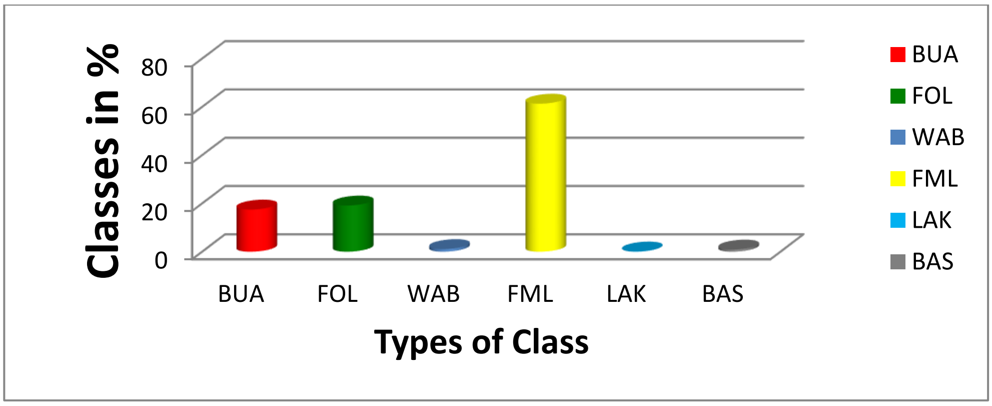


Figure 7b: 2003 Ihiala Classified Landuse/Landcover image result

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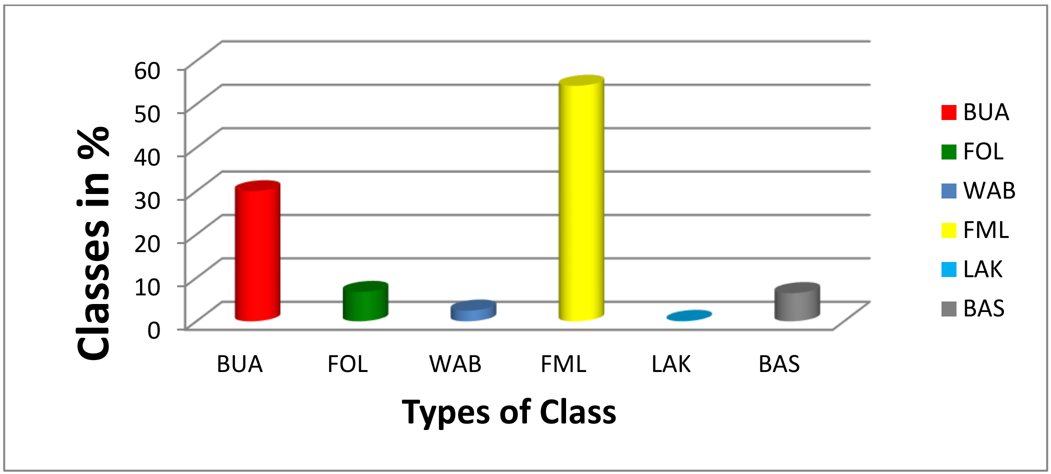

Figure 7c: 2015 Ihiala Classified Landuse/Landcover image result

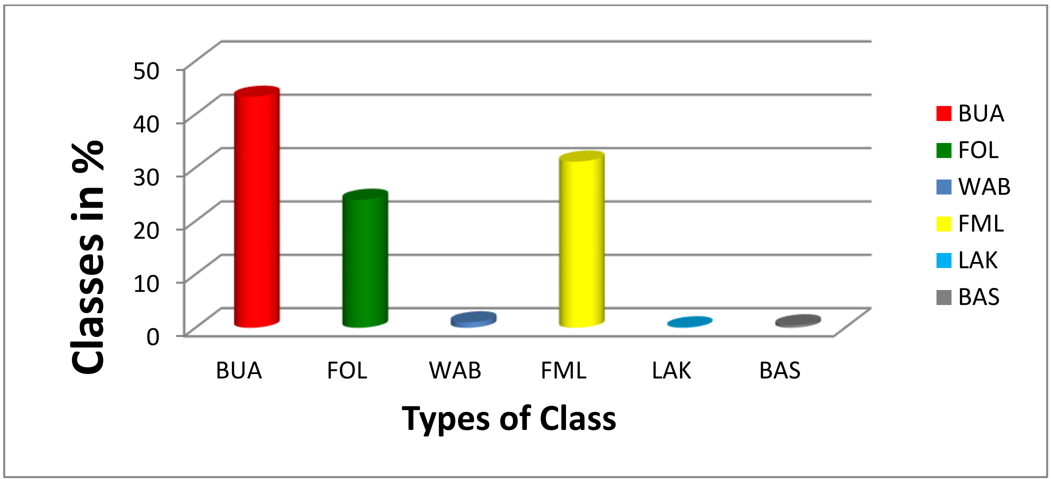

Figure 7d: 2022 Ihiala Classified Landuse/Landcover image result

Extent of LULC change across the epochs

The extent at which LULC change occurred across the epochs in the study area is presented in table 4.4. The table reveals that the change was progressive.

Table 4.4: Extent of LULC change of Ihiala from 1987 to 2022 (35yrs)

Years LULC Classes	**2003-1987 (%)**	**2015-2003 (%)**	**2022-2015 (%)**	**2022-1987 (%)**	**Rate of Change (%)**	**Projection 2042-2022 (%)**
Built-up Area	9.209	12.491	21.7	35.04	1.00	20.00
Forest Land	-25.747	-12.373	17.23	-20.89	-0.597	-11.94
Water Bodies	-0.254	1.364	-1.44	-0.33	-0.009	-0.18
Farm Land	15.939	-7.069	-23.1	-14.23	-0.407	-8.14
Lake	0.025	-0.005	0.00	-0.02	-0.7	-14.00
Bare Surface	0.834	5.583	-6.02	0.397	0.011	0.227

In table 4.4, it was observed that the rate of LULC change of the Built-up Area is 1% from 1987 to 2022, and by the year 2042 the built up area will likely increase by 20%. Remember that the percentage of built-up area was 8.26 % in 1987 and 43.30% in 2022 respectively. The implication is that by year 2042 the built-up area will be around 63.30% if this rate is sustained.

DISCUSSION

The observed patches of forests within the land area by the researcher during fieldwork support the idea of Arjan, (2011) and Rasmussen, et. al. (2016), who concluded that tropical forest conservation, cannot be studied without the involvement of conventional fieldworkand remote sensing for a better ecosystem assessment. More so, figure 8b showed that in 2003, forestland reduced to 19.133, while built up area and farmland increased to 17.469 and 61.319 correspondingly. This showed that increase in population and landuse and landcover change from forested area to other land use categories indicate that, expansion in built up areas, other developmental activities and overexploitation of some forest products have greatly reduced forest resources resulting to the loss of natural vegetation, (Ancha, et. al, 2021; Igu and Duluora, 2019). 2015 classified result in figure 8c showed that forestland and farmland reduced to 6.76% and 54.25% respectively, while built-up area and bare surface increased to 29.96% and 6.48% respectively, indicating the beginning of developmental activities and the effect on forest ecosystem, thus supports the work of Ferreira, et al. (2019).

Result from figure 8d revealed that built-up area is on a continuous increase of 43.30%, showing that there is an urban developmental activity on going. Bare surface land that increased to 6.48% in 2015 was developed to buildings and structures, adding to the increased percentage of built-up area. The increase in forestland from 6.76 in 2015% to 23.99% in 2022 could be as a result of some farm lands that were allowed to fallow within these years which added to the percentage of forestland. This is thus in line with the work of He, et. al., (2021), who proved that great changes have taken place in LULC in the main urban area of their study area, of which the most significant was the large-scale expansion of the built-up area that occurred through degradation of the forest and cultivated land.

CONCLUSIONS

The LULC Landsat image classification of 1987, 2003, 2015 and 2022 proved that there is a change in LULC classes with continuous reduction in forestland of 16,358.90 hectares in 1987 to 8,742.96 hectares in 2022 and a continuous increase in built-up area of 3,011.71 hectares in 1987 to 15, 780.53 hectares in 2022. Therefore, forest ecosystem in Ihiala L.G.A, just like other tropical forests, significantly decline in the availability of natural resources as a result of Landuse/landcover change with continuous reduction in forestland, continuous increase in built-up and farmland areas. This continuous increase in built-up area is attributed to people’s interest in developmental activities in Ihiala LGA; as an urban developing area. On the other hand the continuous increase in farmland areas and clearing of forestlands are as a result of farming activities by households as a coping strategy to high rate of hunger in the country.

RECOMMENDATIONS

Urban planners should ensure control and planning in developmental activities around existing land areas to prevent unsustainable meddling into area of conservation. More so, since domestication of important species of resources and traditional regulations has helped in scanty conservation of some of the forest resources, this study therefore recommends that communities in areas of poor supply and poor conservation should strengthen their forest policies through the application of a viable community participation policy, for restoration of ecosystem in those forests and continuous conservation of endangered species.

Community heads should liaise with the government in establishment of other non-forest sources of livelihood such as building of modern markets for creation of more opportunities for people to make a living, thus reducing pressure of depending mostly on what they gathered from their community forests.

There should be more palm plantations and forestry of important species for log, timber and firewood in areas of poor vegetation cover, and already altered forest covers. Furthermore, because of the high survival rate of *bambusa vulgari and its* multiple uses in the area, communities are encouraged to engage in bamboo plantation

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for economic and other purposes.

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