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# GIS BASED ASSESSMENT OF LAND USE LAND COVER CHANGE AND ITS IMPACT ON AGRICULTURAL LAND USE IN IKPOBA-OKHA LGA, EDO STATE, NIGERIA

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***ABSTRACT***
*In Ikpoba-Okha Local* Government *Area (LGA), Edo State, rapid urbanization, population growth, and industrial expansion have led to the large-scale conversion of agricultural land into residential, commercial, and industrial uses. This study assesses the rate and drivers of land use and land cover (LULC) over 30 years (1993–2023), its impacts on agricultural land use, and the mitigation strategies adopted by farmers and landowners. A mixed-method approach was employed, integrating Remote Sensing and Geographic Information Systems (GIS) for spatial analysis, alongside questionnaires, Focused Group Discussions, and field observations. A purposive sampling technique was used to select farmers and landowners from ten communities. Data analysis involved descriptive statistics, including percentages, presented through tables, charts, and maps. Findings reveal a 263.30% increase in built-up areas, from 12.7% (106.662 km²) in 1993 to 46.16% (387.489 km²) in 2023, while agricultural land declined by 35.13%. The primary drivers of LULCC include urban expansion, population pressure, and weak land-use policies. The most commonly adopted public mitigation strategies are agroforestry, land tenure agreements, and land monitoring committees, while government-supported interventions and relocation efforts remain limited. The study concludes that LULCC has significantly reduced agricultural land, exacerbating land-use conflicts, food insecurity, and environmental degradation in Ikpoba-Okha. It recommends stronger zoning regulations, increased financial support for farmers, and improved infrastructure to balance urban growth with agricultural sustainability.*
***Keywords: GIS, LULC, Agricultural land use, rapid urbanization, industrial expansion, population growth***

## 1.0 INTRODUCTION

Land use and land cover change (LULCC) is an increasingly urgent global problem because it alters ecosystem function, reduces biodiversity, and threatens local food systems; effects that are especially acute where urbanisation, population growth, and agricultural pressures coincide (Food and Agriculture Organization (FAO), 2011). The FAO's global assessments highlight how competing demands for land and water create "systems at risk," with peri-urban agricultural areas frequently among the most vulnerable to conversion and degradation. In the Nigerian context, remote-sensing and GIS studies show strong, persistent trends of urban expansion, deforestation, and fragmentation of agricultural landscapes over recent decades (Ujoh *et al.,* 2011, Akinyemi *et al.,* (2019), Obafemi *et al.,* (2019). Landsat-era imagery remains the backbone of most national LULC analyses because it provides consistent, multi-decadal coverage that can quantify change trajectories (Alegbeleye *et al.,* 2024). National reviews emphasis that Nigeria's rapid urbanisation and population growth are primary indirect drivers of LULC change, and they call for more high-resolution, validated LULC maps to support planning and food-security policy. At the sub-regional scale, the expansion of Benin City and its peri-urban LGAs, including Ikpoba-Okha, has been documented by several satellite-based studies that report significant increases in built-up area and corresponding declines in vegetation and agricultural land. These studies demonstrate how horizontal urban sprawl (low-density outward growth) drives the conversion of farmland into residential, industrial, and infrastructure uses; processes that are associated with rising land values, informal parcelisation, and weakened enforcement of land-use controls (Odjugo, 2015; Fabolude and Aighewi, 2022). Benin City has expanded rapidly along major transportation corridors, with its urban area increasing from 220 km² in 1987 to 359 km² in 2013, reflecting sustained outward growth and land-use transformation (Odjugo *et al.,* 2015). Urban expansion has increasingly manifested as sprawl characterized by unplanned and uncontrolled spatial development, creating significant planning and environmental challenges (Odeyale, 2023). Benin City has expanded rapidly along major transportation corridors, with its urban area increasing from 220 km² in 1987 to 359 km² in 2013, reflecting sustained outward growth and land-use transformation (Odjugo *et al.,* 2015). Urban expansion has increasingly manifested as sprawl characterized by unplanned and uncontrolled spatial development, creating significant planning and environmental challenges (Odeyale, 2023).

Local investigations within Ikpoba-Okha confirm these general patterns and underscore their agricultural consequences. Change-detection studies that include Ikpoba-Okha (for example, multi-LGA assessments covering Oredo, Egor, and Ikpoba-Okha) report measurable conversion of cropland and tree cover to built-up and bare lands between the late 1980s/1990s and the 2010s; field studies in the LGA also document increasing soil exposure, higher sediment yields from agricultural plots, and localized loss of productive topsoil; processes that together reduce farm productivity and raise the cost of land rehabilitation (Dirisu *et al.,,,* 2015; British Journal of Environmental Sciences study on sediment yields in Ikpoba-Okha, 2021). These findings point to coupled land-cover and land-degradation pathways by which urban growth undermines agricultural resilience.

Methodologically, GIS and satellite remote sensing (Landsat series, Sentinel imagery, and, increasingly, cloud platforms such as Google Earth Engine) provide robust, reproducible tools for mapping LULC change, calculating conversion rates, and detecting hotspots of agricultural loss. Combining multitemporal classification with accuracy assessment and simple change-matrix analyses allows researchers to quantify both the extent and direction of change, for example cropland to built-up, and to link spatial patterns with proximate drivers such as road networks and expansion corridors, as well as distal drivers such as population growth and land policy weaknesses. Recent methodological reviews recommend validating classifications with ground-truth points and, where possible, integrating socioeconomic data to attribute drivers and impacts more confidently (Alegbeleye *et al.,* 2024). Despite these advances, important knowledge gaps remain for Ikpoba-Okha. First, there is still a lack of multi-decadal, spatially explicit reconstructions that consistently quantify agricultural land loss from 1990 to 2023. Second, local LULC studies rarely provide rigorous accuracy assessment and uncertainty reporting. Third, remote-sensing results are seldom integrated with field-based evidence on soil loss, crop production, and livelihoods, making it difficult to estimate the real-world consequences of land conversion. Addressing these gaps therefore requires combining Landsat-era change detection with targeted field sampling, including sediment-yield and soil-condition measurements already reported locally, as well as stakeholder interviews to identify the policy and market forces driving conversion. Addressing these gaps requires combining Landsat-era change detection with targeted field sampling, for example sediment-yield and soil condition measurements already reported locally, and stakeholder interviews to identify policy and market drivers of conversion.

The current study responds directly to this need by applying established GIS/RS workflows to map LULC (1993–2023), quantify conversion rates affecting agricultural parcels, and assess links to agricultural productivity and land management practices in Ikpoba-Okha.

In Nigeria, much of the existing research has concentrated on analysing LULC dynamics and patterns in major metropolitan areas such as Lagos, Akure, Kwara, Makurdi, Zaria, and Abuja, with emphasis on mapping changes and quantifying urban expansion. However, there remains a noticeable gap in empirical studies examining the specific impact of LULCC on agricultural land use in the southern region of the country, particularly in Ikpoba-Okha LGA. This gap underscores the need to assess the land use and land cover characteristics of the study area, determine the rate of LULC change over time, and evaluate how these changes affect agricultural land use. Accordingly, this study seeks to bridge this gap by employing remote sensing and GIS techniques to analyse the spatial dynamics of LULCC in Ikpoba-Okha. It aims not only to quantify the extent and rate of agricultural land conversion but also to identify the key drivers of change and assess the effectiveness of existing mitigation strategies. By doing so, the research contributes to knowledge and provides evidence-based insights for sustainable land use planning and agricultural land preservation in rapidly urbanizing areas.

## 2.0 Methodology

This study employs a survey research design within a case-study framework to examine how land use and land cover change (LULCC) has affected agricultural land use in Ikpoba-Okha between 1993 and 2023. Research design is defined as the comprehensive plan that details variables, methods, procedures for data collection, and analytical techniques (Osazee, Bloomfield, and Fisher, 2019). The case-study approach was chosen because it enables an in-depth, contextualized examination of complex spatial and social processes using multiple data sources (Omorogiuwa, 2006). To strengthen evidence and triangulate results, the study integrates GIS/remote sensing image analysis with field surveys (questionnaires, FGDs), direct observations, and GPS ground-truthing (Campbell and Fiske, 1959; Creswell, 2014). GIS is central to the methodology: satellite images provide spatial and temporal LULC information while field surveys provide socio-economic and institutional context to interpret drivers and mitigation strategies. The mixed-methods approach supports both quantitative measurement (area change, rates) and qualitative interpretation (local drivers, mitigation practices).

### 2.1 Study Area

Ikpoba-Okha Local Government Area lies in southern Edo State and forms part of the Benin metropolitan region around Benin City. The LGA occupies about 857 km² (85,700 ha) between 6°15′–6°25′N and 5°30′–5°50′E. Administratively, it is divided into ten political wards (Iwogban/Uteh, Oregbeni, Ogbeson, Aduwawa/Evbuomodu, St. Saviour, Gorreti, Ugbekun, Idogbo, Obayantor, and Ologbo) comprising multiple communities. The landscape is largely flat to gently undulating with isolated hills; drainage is organized around the Ikpoba River (principal channel) and tributaries including the Ossiomo and Ogba rivers, with numerous smaller streams draining the area during the rainy season. 2D maps of the study areas are presented in Figures 1 and 2.

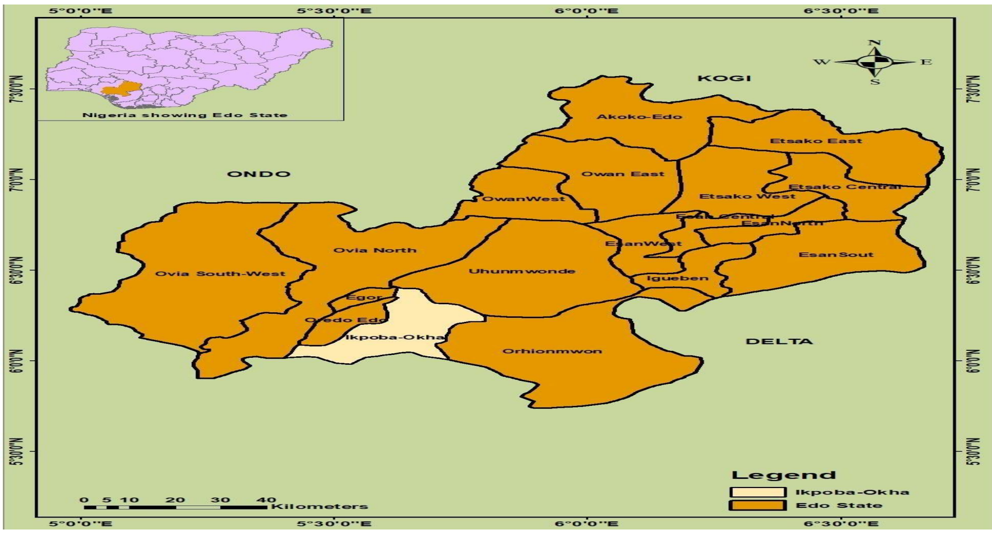


**Figure 1** : Edo State map showing the location of Ikpoba-Okha LGA. Source: Edo State Geographic Information System (EDOGIS), 2023.

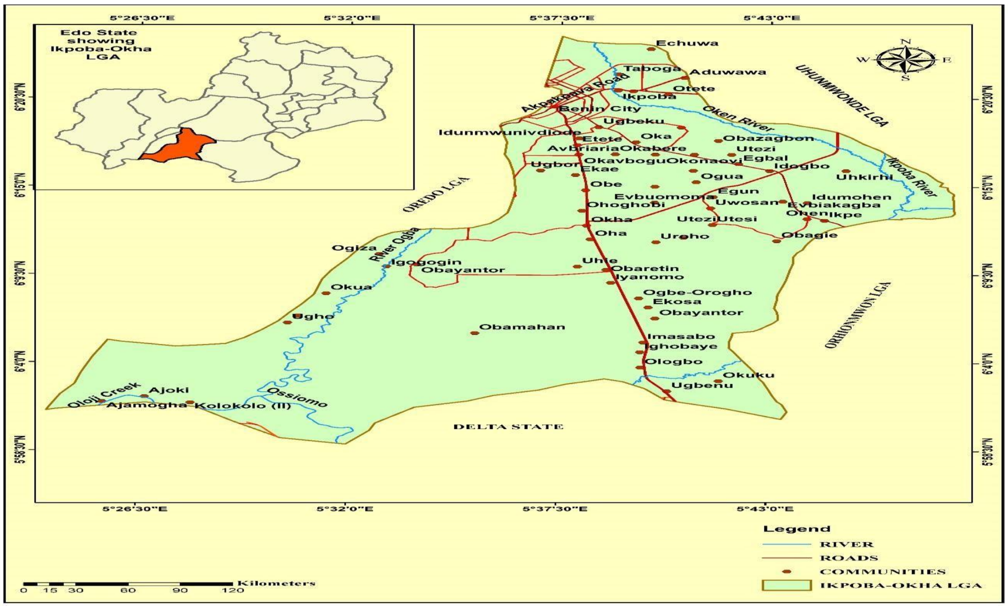


**Figure 2 :** Ikpoba-Okha LGA map showing the ten political wards and the communities studied (Iwogban/Uteh, Oregbeni, Ogbeson, Aduwawa/Evbuomodu, St. Saviour, Gorreti, Ugbekun, Idogbo, Obayantor, Ologbo). Source: Edo State Geographic Information System (EDOGIS), 2023.

**2.1.1 Climate and Agricultural Implications**

The climate is tropical equatorial (Köppen-Geiger Aw) with two main seasons: a wet season (April–October) and a dry season (November–March). Annual rainfall is high (≈2,025 mm), with peaks in July and September and a short August break; monthly extremes and temperature patterns recorded for the Benin City area show a small annual temperature range (warmest month ≈27.5 °C in April; coolest monthly means ≈24.5 °C in July). The pronounced wet season, high rainfall totals, and warm temperatures create favourable conditions for a wide range of crops, set the timing of planting and harvest cycles, and influence soil moisture, erosion risk, and the selection of cropping systems (Eroutor, 2014; Efe *et al.,* 2014; Iwena, 2018).

**2.1.2 Geology, Soils and Vegetation**

Underlying geology reflects sedimentary formations (notably the Benin Formation) and alluvial deposits; parent materials include sandstones, shales, and calcareous lenses. Dominant soils are tropical ferruginous, lateritic, and alluvial types. Ferruginous and lateritic soils are oxidic and often acidic, while alluvial soils on floodplains are comparatively fertile and hold nutrients better (Jeje, 2005; Edema *et al.,* 2002; Akinbode, 2006). Weathering has produced red and yellow earths with interbedded sands and clays; many upland soils are well drained but susceptible to leaching and internal drainage problems in places. Historically within the rainforest belt, the vegetation has been progressively modified by human activity into a derived savanna/fragmented forest mosaic, a change that reduces canopy cover, increases runoff, and raises susceptibility to erosion and soil degradation (Abotutu, 2016).

### 2.1.3 Demography, Economy and Land-Use Pressures

At the national census in 2006 the LGA had 372,080 inhabitants; later projections using a 2.5% growth assumption place the population near 563,000 by 2023 (NPC, 2006; NBS, 2023). The local economy mixes agriculture (staples such as cassava, yams, maize, vegetables), cash crops (oil palm, timber), livestock/poultry, market trade (notably Oka and Oregbeni markets), light industry, services, and artisanal activities (blacksmithing, lumbering). Industrial and market growth together with transport expansion have increased land demand and stimulated peri-urban development (Olotun *et al.,* 2010; Ikpoba-Okha LGA, 2022).

### 2.1.4 Anthropogenic Impacts on LULC and Agriculture

Rapid urban expansion, infrastructure development, sand mining, logging, and market enlargement are the principal anthropogenic drivers reshaping land cover. Urbanisation frequently converts agricultural plots to residential, commercial, or industrial uses; sand mining and road/market expansion physically remove topsoil and change drainage; timber extraction and clearing promote habitat fragmentation and reduced soil fertility. Waste disposal and localized pollution also degrade soils and water resources. These processes reduce available farmland, shrink farm sizes, and push farmers toward intensification, shifting cultivation, or conversion of marginal lands, all of which can lower long-term productivity and threaten local food security (NPC, 2006; NBS, 2023; Olotun *et al.,* 2010; Ikpoba-Okha LGA, 2022).

### 2.1.5 Agricultural Practices and Responses

Farmers in Ikpoba-Okha practice both subsistence and small-scale commercial farming. Major food crops (cassava, yams, maize, vegetables) dominate household diets and local markets; oil palm and timber provide cash income. Traditional cultivation methods prevail but there is gradual uptake of improved practices in some locations. Where agricultural land is lost or degraded, farmers respond by intensifying production (more inputs, reduced fallows), expanding into marginal or forested land, or relocating; adaptations that can increase erosion risk and reduce ecological resilience if not managed with sustainable soil and land-use policies (Olotun *et al.,* 2010; Ikpoba-Okha LGA, 2022). Ikpoba-Okha combines favourable agro-ecological potential with accelerating demographic and economic pressures. The interplay of climate, fertile alluvial pockets, and productive cropping systems offers strong agricultural potential; however, continuing urban and industrial expansion, extractive activities, and vegetation loss significantly threaten soil quality, water regulation, and farm viability. These dynamics underscore the need for integrated land-use planning, strengthened enforcement of zoning and environmental regulations, protection of high-value agricultural soils, and community-based measures such as market planning, reforestation, and erosion control to sustain food production and ecosystem services in the LGA.

**2.2 Reconnaissance and Field Preparation**

A reconnaissance survey of Ikpoba-Okha LGA was conducted to: (1) familiarise the researcher with the local landscape and social actors, (2) identify relevant landmarks and communities for ground-truthing, and (3) pre-empt logistical and social challenges during data collection. Community leaders and farmers were engaged to secure cooperation; a handheld GPS was used to record landmark coordinates and training samples for supervised classification (ground truth) during image analysis.

**2.3 Data Types and Sources**

The data used for the study include GPS coordinates, 386 semi-structured questionnaires administered to sampled farmers/landowners, focus group discussions (FGDs), and field observations. The questionnaires covered demographics, land-use history, perceptions of drivers, impacts on agriculture, and mitigation measures. Secondary data included Landsat satellite images for 1993, 2003, and 2023, downloaded from the USGS data portal; administrative and topographic maps from Edo GIS; and population figures from the NPC (NPC, 1991). National growth rates from the National Bureau of Statistics and population projection methods from the United Nations (2007) were used to update population estimates to 2023. A 30-year period (1993–2023) was chosen to capture multi-decadal land-cover dynamics and align with available Landsat archive imagery.

**2.4 Study Population, Sampling and Sample-Size Computation (Population and Sampling Frame)**

The target population comprised farmers and landowners across the LGA. One fringe community was purposively selected from each of the ten electoral/administrative wards to focus on areas most exposed to peri-urban change (Creswell, 2007). Purposive sampling was used to ensure respondents had direct experience with agricultural land use (Railway, 2005).

**2.5 Population Projection (Used to Estimate Current Population)**

The 1991 census total for the selected communities was 5,088 (NPC, 1991). Using the continuous growth model recommended by the UN (2007) and an annual growth rate of 2.5%:

$N_t = P\,e^{rt}$ (1)

Where: Nt = project ed population a t time t, P= initial population (5,0 88), e= 2.71828…, r= 0.02 5 (2.5% in decimal), t= years between census and projection (1991 → 2023: 32 years). Applying the formula produced an approximate 202 3 population of 11,213 across t he select ed communities (United Nations, 2007; National Bureau of Statistics).

**2.6 Sample Size (Yemane, 1967)**

Using Yemane's formula with $e$ = 0.05 (95% confidence, 5% precision):

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

For $N$ = 11,213:

$$n = 386 \qquad (3)$$

This yielded a target sample of 386 respondents, proportionally allocated to each community using the Pandey and Verma (2008) proportional allocation:

$$n_i = n\left(\frac{N_i}{N}\right) \qquad (4)$$

Table 1 shows the population and sample allocation used in the field.

**Table 1: Sample Allocation by Community (Projected 2023 Population and Sample $n_i$)**

| S/N | Community | 1991 pop | Projected 2023 pop | Sample size ($n_i$) |
|---|---|---|---|---|
| 1 | Idogbo | 262 | 577 | 20 |
| 2 | Ikpe | 443 | 433 | 33 |
| 3 | Iyanomo | 1,866 | 4,113 | 142 |
| 4 | Obagie | 482 | 1,062 | 35 |
| 5 | Obarentin | 495 | 1,091 | 37 |
| 6 | Obayantor | 533 | 1,175 | 40 |
| 7 | Ogheghe | 463 | 1,020 | 35 |
| 8 | Okha | 168 | 370 | 13 |
| 9 | Uhie | 223 | 491 | 17 |
| 10 | Utezi | 135 | 337 | 12 |
| | Total | 5,088 | 11,213 | 386 |

(Source: NPC, 1991; projections using UN method; allocation using Pandey and Verma, 2008)

### 2.7Data-Collection Instruments and Procedures

#### 2.7.1Questionnaire

A semi-structured questionnaire (N = 386) captured socio-demographics, land-use histories, drivers of LULC, impacts on farm productivity and livelihoods, and mitigation strategies. The questionnaire had four sections: (A) demographics; (B) drivers of change; (C) impacts on agriculture; and (D) mitigation/adaptation strategies.

#### 2.7.2 Focus Group Discussions (FGDs)

FGDs (one per community or aggregated across groups) involved purposively selected participants (farmers, landowners, local leaders) to probe community perspectives on drivers and community-level mitigation. Discussions were recorded, transcribed, and coded for thematic analysis.

### 2.8 Reconnaissance and GPS Ground Truth

GPS coordinate collection provided training and validation points for supervised classification of satellite imagery. Field checks validated classified land-cover classes and helped interpret ambiguous pixels.

### 2.9 Remote-Sensing and GIS Processing Workflow

#### 2.9.1 Pre-processing Image Selection

Landsat TM/ETM+ for 1993/2003; Landsat OLI-TIRS for 2023 (USGS archive). Resampling and coregistration: All images brought to consistent 30 m spatial resolution; geometric alignment checked and adjusted to the LGA shapefile to avoid misregistration artefacts (Lehmann and Casella, 2006). Windowing: clipped to the Ikpoba-Okha LGA boundary.

#### 2.9.2 Band Composites and Visual Interpretation

TM/ETM+: RGB = bands 4, 3, 2 (NIR, red, green).

OLI: RGB = bands 5, 4, 3 (NIR, red, green).

This combination renders vegetation in red tones (healthy vegetation high in NIR), built-up in light blue/grey, and water in dark tones, facilitating visual discrimination between classes.

#### 2.9.3 Supervised Classification and Accuracy Assessment

The Maximum Likelihood Classifier (MLC) was chosen for this study because of its strong statistical foundations and its reliable high-performance when class training data are adequate, as described by Lehmann and Casella. Six land-cover classes were used: built-up, water bodies, agricultural land (cultivated terrestrial vegetation), natural vegetation, semi-natural vegetation, and bare land; adapted from FAO-AFRICOVER. Training samples were obtained from field GPS points and, where available, high-resolution imagery. Accuracy assessment employed confusion (error) matrices and the Kappa coefficient, targeting an overall accuracy of at least 85% and interpreting Kappa according to standard thresholds (Kipling, 2012). Table 2 shows the simplified land-use/land-cover classification scheme.

Table 2: Simplified Land-Use/Land-Cover Classification Scheme (Adapted from FAO-AFRICOVER, 1998)

| Class | Description |
|---|---|
| Bare Land | Rock outcrops, sandy areas, unpaved roads |
| Built-up Areas | Settlements, paved roads, industries, commercial areas |
| Cultivated Terrestrial Vegetation | Cropped areas and harvestable vegetation |
| Natural Vegetation | Undisturbed native vegetation |
| Semi-natural Vegetation | Vegetation influenced by human use (grazing, logging) |
| Water Bodies | Rivers, lagoons, lakes, streams |

## 2.10 Change Detection and Rate Calculations

### 2.10.1 Change Detection Method

Simple image differencing and post-classification comparison were used. For each class, area differences between target years were computed from classified rasters.

### 2.10.2 Percentage and Annual Rate of Change Formulas

Let $t_0$ be the earlier year and $t_1$ the later year.

i. Class change (area):

$$\Delta = A_{t1} - A_{t0} \quad (4)$$

ii. Percentage class change:

$$PC = \frac{A_{t1}-A_{t0}}{A_{t0}} \times 100 \quad (5)$$

iii. Annual rate of change (percent per year):

$$A.R = \frac{PC}{\Delta t} \quad (6)$$

Where $\Delta t$= number of years between $t_0$ and $t_1$ (e.g., 10 or 20).

These measures quantify both magnitude and velocity of LULC shifts and allow identification of hotspots of conversion (Francis *et al.,* 2013; Atewe, 2014).

## 2.11 Statistical and Qualitative Analysis

### 2.11.1 Questionnaire and FGD Analysis

Quantitative survey responses were analysed using descriptive statistics (frequencies, percentages, cross-tabulations) to summarise perceptions of drivers, reported impacts on agricultural productivity, and use of mitigation strategies. Cross-tabulation with demographic variables (age, farm size, tenure type) helped reveal vulnerable subgroups. Qualitative FGD transcripts were coded thematically (drivers, institutional constraints, customary strategies), and synthesis from field notes informed the interpretation of remote-sensing results (Creswell, 2014).

## 3.0 Results and discussion

## 3.1 Spatial Analysis

### 3.1.1 Different Land Use Land Cover Classes in the Study Area

The mapping out o f different land use cl asses of Ikpoba-Okha Local Government Area in 1993, 2003, and 2023 was carried out by classifying and pol ygonising the satellite imageries into four major land use types as stated earlier. See Figure 3.

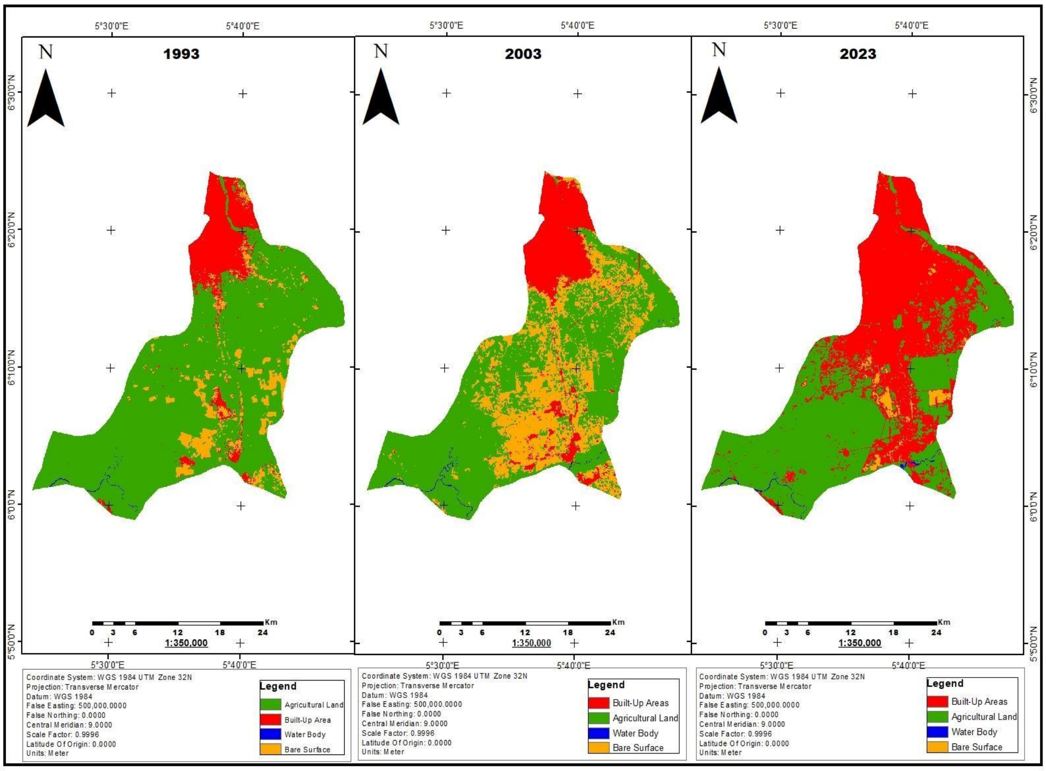


**Figure 3:** Land use Land cover classes of Ikpoba-Okha LGA of 1993, 2003 and 2023.

**Table 3: Different Land use classes in Ikpoba-Okha between 1993 and 2023 in Area ($Km^2$)**

**Source: Author's Analysis, 2025.**

| Land Use/Land Cover | 1993 Area (Km²) | 1993 (%) | 2003 Area (Km²) | 2003 (%) | 2023 Area (Km²) | 2023 (%) |
|---|---|---|---|---|---|---|
| Agricultural Land | 659.2020 | 78.52 | 475.0550 | 56.59 | 427.6500 | 50.94 |
| Bare Surface | 72.3042 | 8.61 | 230.5280 | 27.46 | 21.6324 | 2.58 |
| Built-Up Area | 106.6620 | 12.70 | 131.2660 | 15.64 | 387.4890 | 46.16 |
| Water Body | 1.3662 | 0.16 | 2.6658 | 0.32 | 2.7315 | 0.16 |

From Table 3, the land-use and land-cover (LULC) changes in Ikpoba-Okha Local Government Area between 1993 and 2023 show a marked transformation driven by urban expansion, population growth, and socio-economic activities. The most notable trend is the rapid increase in built-up area, from 12.70% in 1993 to 46.16% in 2023, which is attributable to infrastructural development, industrialization, improved transport networks, and in-migration for economic opportunities (Seto *et al.,* 2011; United Nations, 2018). Agricultural land declined from 78.52% to 50.94% over the same period, a loss commonly associated with urbanisation and the conversion of farmland for residential, commercial, and industrial uses (Foley *et al.,* 2005; Brend'Amour *et al.,* 2017). Bare surfaces fluctuated, rising from 8.61% (1993) to 27.46% (2003) before falling to 2.58% (2023), which reflects land-clearing preceding development (Lambin *et al.,* 2003; Dewan and Yamaguchi, 2009). Water bodies remained effectively stable (≈0.16–0.32%), likely due to reliance on alternative water sources and conservation measures (Turner *et al.,* 2007; Wang *et al.,* 2014). Classification validation using an error matrix and Kappa analysis showed high reliability (overall accuracy > 85%; Kappa > 0.80), with built-up and agricultural classes achieving the highest user's and producer's accuracies and bare surfaces showing moderate spectral confusion (Congalton and Green, 2019). See Figure 4

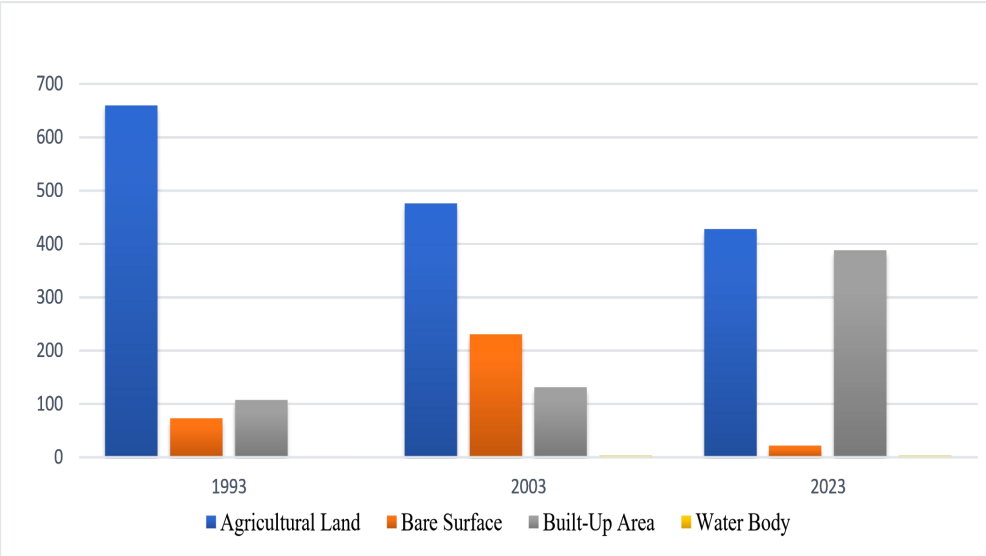


**Figure 4:** Bar Chart of Land use Land cover classes.

### 3.1.2 Rate of LULC Changes

The rate of change in land use and land cover (LULC) is a critical indicator of the dynamics and transformations occurring within the study area over time. The rate of LULC changes in Ikpoba-Okha between 1993 and 2023, as shown in Table 4, reveals significant shifts in land-use patterns, particularly in urban growth, agricultural land, bare surfaces, and water bodies. The rates of change for each land-use type provide insights into the processes driving these transformations and their implications for the environment and society.

**Table 4: Rate of LULC changes in Ikpoba-Okha**

| Land Use/Land Cover | 1993 Area (Km²) | 2003 Area (Km²) | 2023 Area (Km²) | Net Change (Km²) | Rate of Change (%) | Annual Change (Km²/year) | Annual Change (%/year) |
|---|---|---|---|---|---|---|---|
| Agricultural Land | 659.202 | 475.055 | 427.650 | -231.552 | -35.13 | -7.72 | -1.17 |
| Bare Surface | 72.3042 | 230.528 | 21.6324 | -50.672 | -70.08 | -1.69 | -2.34 |
| Built-Up Area | 106.662 | 131.266 | 387.489 | +280.827 | +263.30 | 9.36 | +8.77 |
| Water Body | 1.3662 | 2.6658 | 2.7315 | +1.366 | +99.92 | 0.046 | +3.33 |

Ikpoba-Okha Local Government Area as seen in table 4, experienced a pronounced shift from farmland to urban land between 1993 and 2023: built-up area rose from 106.662 km²

(12.70%) to 387.489 km² (46.16%) (Δ = +280.827 km²; +263.30%), while agricultural land fell from 659.202 km² (78.52%) to 427.650 km² (50.94%) (Δ = −231.552 km²; −35.13%). Urban expansion, driven by infrastructure, industrialisation, improved transport, and in-migration, is the principal cause of this conversion (Seto *et al.,* 2011), a pattern echoed in regional studies (Adepoju *et al.,* 2019). Land speculation and rising land values have accelerated farmland sales for development (Deng *et al.,* 2010), a process comparable to conversions reported elsewhere in West Africa (Yeboah and Shaw, 2013). Agricultural decline raises food-security and livelihood concerns, consistent with findings on urban pressure on cropland (Foley *et al.,* 2005) and the combined effects of land degradation and climatic stress (Lambin and Meyfroidt, 2011; Oyinloye and Oloukoi, 2019). Bare surfaces showed a transient spike (8.61% → 27.46% → 2.58%), reflecting clearing before building (Lambin *et al.,* 2003; Akinyemi, 2017). Water extent remained nearly stable (~0.16–0.32%), suggesting limited direct hydrological loss to date (Adegun and Adedeji, 2020; Ganiyu and Abiodun, 2015).

Overall, the spatial tr ends point to rapid, largely unplanned urbanisation wi th significant agricultural los s and policy implications: stronger land-use planning, la nd-protection measures and continuous GIS monitoring are needed to balance development and food security.

## 3.2 Statistical Analysis

### 3.2.1 Socio-Demographic Characteristics of Respondents

This section deals with the analysis of the socio-demographic characteristics of respondents in the study area such as sex, age, marital status, educational attainment, and occupation.

#### 3.2.1.1 Sex and Age of Respondents

Table 5 shows the age and gender distribution of respondents. The data reveals that 75.0% of the respondents are male, while 25.0% are female. The predominance of male respondents suggests that land-related activities, particularly farming and land ownership, are male-dominated in the study area. The largest age group is 21–35 years, making up 40.1% of respondents. This is followed by the 36–50 years age group at 29.9%. About 20.1% of respondents fall within the 51–65 years age category, while 4.9% are either below 20 years or above 65 years. These results indicate that most respondents are economically active, which is critical for understanding agricultural land-use changes. The dominance of young and middle-aged respondents suggests that they are more likely to be involved in farming, land transactions, and decisions related to land-use changes.

**Table 5: Sex of Respondents by Age**

| Age of Respondents | Male (Count) | Female (Count) | Total | Male (%) | Female (%) | Total (%) |
|---|---|---|---|---|---|---|
| 20 years | 12 | 7 | 19 | 63.2 | 36.8 | 100.0 |
| 21–35 years | 115 | 39 | 154 | 74.7 | 25.3 | 100.0 |
| 36–50 years | 86 | 29 | 115 | 74.8 | 25.2 | 100.0 |
| 51–65 years | 55 | 22 | 77 | 71.4 | 28.6 | 100.0 |
| Above 65 years | 20 | 9 | 29 | 52.6 | 47.4 | 100.0 |
| Total | 288 | 96 | 384 | 75.0 | 25.0 | 100.0 |

### 3.2.1. 2 Educational Attainment of the Respondents

Table 6 presents the educational background of respondents, consisting of farmers and landowners across the selected communities in Ikpoba-Okha. The data shows that majority of respondents (40.1%) attained secondary education, followed by those with primary education (25.0%) and tertiary education (25. 0%). A small er proportion, 9.9%, had no formal education. Based on these findings, a significant number of farmers and landowners have at least basic education, which may influence their awareness and adaptation to land use changes in the study area. Higher education levels may enable farmers to ad opt mod ern agricultural techniques and navigate land policies, while lower education levels could result in reliance on traditional farming methods.

### 3.2.1.3 Occupation by Marital Status of Respondents

As shown in Table 7, a significant number of respondents are farmers and landowners, reflecting the agricultural nature of the study area. Most respondents (60.2%) are married, while 29.9% are single, and 9.9% are widowed or divorced. Among farmers, 124 (64.2%) are married, suggesting that farming is a primary livelihood for family-based households. Single respondents (41, 21.2%) are also engaged in farming, though at a lower proportion. Business owners and civil servants are also mostly married, making up 53 (27.5%) and 40 (20.7%) of the married category, respectively. These findings align with studies that show married individuals tend to engage in more stable and long-term occupations such as farming due to economic security and family responsibilities (Adesina and Djato, 1997; Doss, 2001). Additionally, marriage provides access to family labour, making farming a more viable option compared to less stable occupations (FAO, 2011).

**Table 6: Educational Attainment of Respondents**

| Community | No Formal Education (%) | Primary Education (%) | Secondary Education (%) | Tertiary Education (%) | Total (%) |
|---|---|---|---|---|---|
| Idogbo | 10 (18.2) | 20 (36.4) | 15 (27.3) | 10 (18.2) | 55 (100.0) |
| Ikpe | 6 (18.2) | 12 (36.4) | 9 (27.3) | 6 (18.2) | 33 (100.0) |
| Iyanomo | 25 (17.6) | 38 (26.8) | 52 (36.6) | 27 (19.0) | 142 (100.0) |
| Obagie | 12 (34.3) | 14 (40.0) | 6 (17.1) | 3 (8.6) | 35 (100.0) |
| Obarentin | 8 (21.6) | 12 (32.4) | 9 (24.3) | 8 (21.6) | 37 (100.0) |
| Obayantor | 10 (25.0) | 16 (40.0) | 8 (20.0) | 6 (15.0) | 40 (100.0) |
| Ogheghe | 8 (22.9) | 10 (28.6) | 12 (34.3) | 5 (14.3) | 35 (100.0) |
| Okha | 4 (30.8) | 3 (23.1) | 3 (23.1) | 3 (23.1) | 13 (100.0) |
| Uhie | 6 (35.3) | 6 (35.3) | 3 (17.6) | 2 (11.8) | 17 (100.0) |
| Utezi | 4 (33.3) | 5 (41.7) | 2 (16.7) | 1 (8.3) | 12 (100.0) |
| Total | 93 (24.2) | 136 (35.4) | 124 (32.3) | 73 (19.0) | 384 (100.0) |

Source: Field Survey, 2025.

**Table 7: Occupation of Respondents by Marital Status**

| Occupation of Respondents | Single (%) | Married (%) | Widowed/Divorced (%) | Total (%) |
|---|---|---|---|---|
| Farmers | 41 (21.2) | 124 (64.2) | 28 (14.5) | 193 (100.0) |
| Business | 19 (24.7) | 53 (68.8) | 5 (6.5) | 77 (100.0) |
| Civil Servants | 12 (21.1) | 40 (70.2) | 5 (8.8) | 57 (100.0) |
| Others | 16 (28.1) | 14 (24.6) | 27 (47.3) | 57 (100.0) |

| | | | | |
|---|---|---|---|---|
| Total | 88 (22.9) | 231 (60.2) | 65 (16.9) | 384 (100.0) |

**3.2.2 Drivers of Land Use Land Cover (LULC) Change in Ikpoba-Okha**

Figure 5 provides insights into respondents' perceptions of the major drivers of Land Use Land Cover (LULC) change in Ikpoba-Okha. The findings indicate that urban development is the most significant driver, with 193 respondents (50.3%) identifying it as the primary cause of land-use changes. This suggests that rapid urban expansion, driven by population growth and infrastructure development, is leading to the conversion of agricultural land into residential and commercial areas. Migration was also identified as a key factor, with 96 respondents (25.0%) attributing LULC changes to population influx. This aligns with studies such as Olayiwola and Oladeji (2021), which found that rural-urban migration in southern Nigeria has contributed to increased land demand for housing and commercial activities, consequently reducing available farmland. Population growth, cited by 57 respondents (14.8%), further exacerbates land-use changes. Population expansion increases the need for housing, roads, and other infrastructure, thereby accelerating the conversion of farmland. According to the United Nations (2019), rapid population growth in sub-Saharan Africa is a key driver of urban sprawl, often leading to the displacement of agricultural activities.

Lastly, other factors such as industrialization and economic activities were identified by 38 respondents (9.9%). These include factors like deforestation, land speculation, and changes in government policies, which influence land tenure and land-use planning. The Food and Agriculture Organization (FAO, 2020) reports that economic drivers, including large-scale industrial farming and real estate expansion, have contributed to the reduction of arable land in Nigeria.

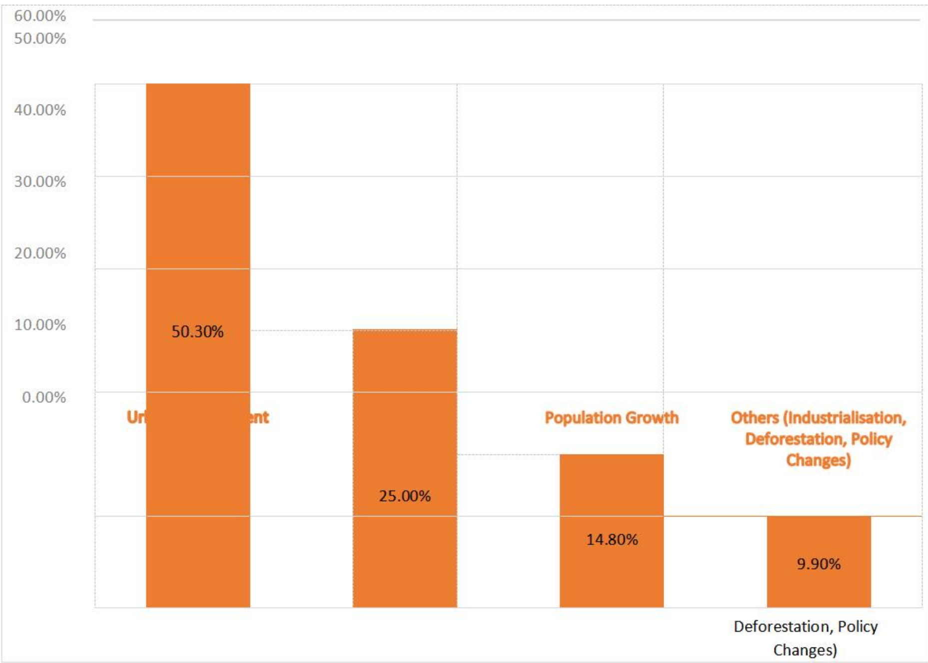


**Figure 5:** Drivers of Land Use Land Cover Change

The findings confirm that urban development is the most significant driver of LULC change in Ikpoba-Okha. This is consistent with Akinyemi (2017), who highlighted that land conversion for residential and commercial purposes is one of the major threats to agricultural land in peri-urban areas of Nigeria. The conversion of farmlands into urban infrastructure has led to a decline in available agricultural land, affecting food production and livelihoods. Migration and population growth further intensify this pressure. Studies have shown that rural-urban migration leads to increased land fragmentation and competition for space (Adepoju, 2019).

In many developing regions, land previously used for farming is being repurposed for housing and commercial ventures, reducing the land available for food production (FAO, 2020). The 9.9% of respondents who cited "other factors" suggest that beyond urbanisation and population changes, there are additional pressures such as industrial expansion and shifting economic priorities. In some cases, government policies on land use and speculative land buying have influenced the pace of land conversion (Olawale and Abiodun, 2022).

### 3.2.3 Current State of Agricultural Land and Instances of Agricultural Encroachment in Ikpoba-Okha

Figure 6 provides insights into the current condition of agricultural land in Ikpoba-Okha, as perceived by respondents. The findings indicate that agricultural land in the area is predominantly in poor condition, with 193 respondents (50.3%) rating it as "bad" and 96 respondents (25.0%) describing it as "extremely bad." This suggests that a significant portion of farmland is degraded, possibly due to urban expansion, deforestation, and soil depletion. Only 57 respondents (14.8%) rated the land as "good," while 38 respondents (9.9%) considered it "very good."

Instances of agricultural encroachment were reported by 270 respondents (70.3%), highlighting the widespread conversion of farmland into residential, industrial, or commercial zones. This confirmed the result of the interpreted image and also aligns with studies such as Akinyemi (2017), which found that peri-urban areas in Nigeria experience increasing land fragmentation, threatening food security and rural livelihoods. Conversely, 115 respondents (29.9%) indicated that they had not observed encroachment, possibly due to variations in land-use intensity across different locations.

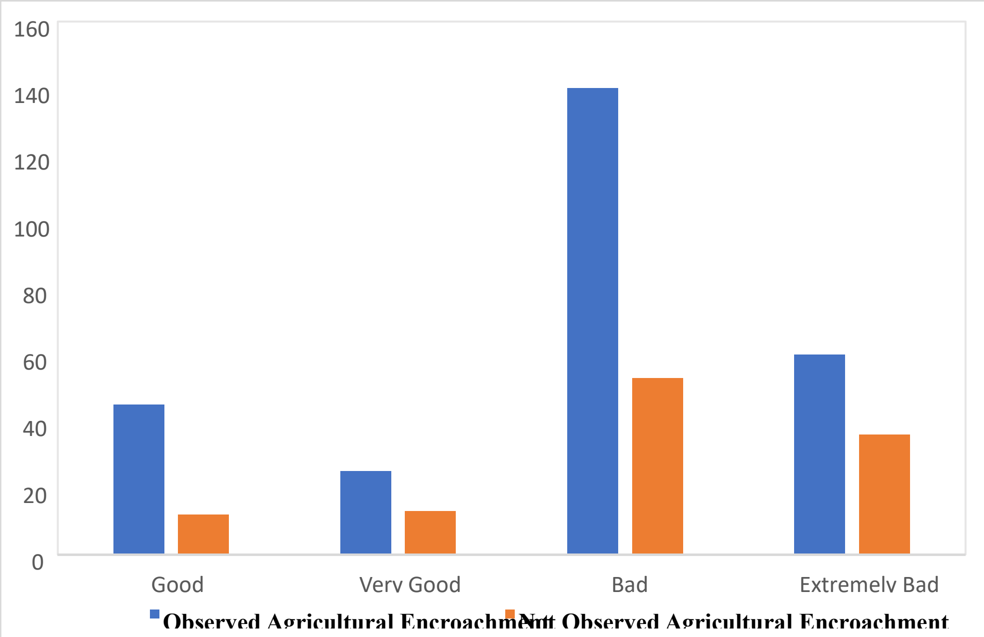


**Figure 6:** Current State of Agricultural Land as Perceived by Respondents.

The findings indicate that agricultural land in Ikpoba-Okha is experiencing substantial degradation and encroachment pressures, with the predominance of "bad" and "extremely bad" land condition ratings suggesting declining soil quality, loss of farmland to urban development, and reduced agricultural productivity. These results are consistent with studies conducted in other parts of Nigeria, where the conversion of agricultural land to residential, commercial, and industrial uses has disrupted traditional farming systems and undermined food production (Olawale & Abiodun, 2022). Furthermore, the fact that 70.3% of respondents reported agricultural encroachment highlights the increasing pressure of urban expansion on farmlands, a trend identified by the Food and Agriculture Organization (FAO, 2020) as a major driver of farmland loss across sub-Saharan Africa. Although 29.9% of respondents did not perceive direct encroachment, this variation may reflect differences in geographical location, accessibility, and land tenure arrangements, as farmers with secure land rights are generally less vulnerable to displacement than those operating on communal or leased lands (Adepoju, 2019). Overall, the findings demonstrate that agricultural land in Ikpoba-Okha is under significant threat from both degradation and encroachment, posing serious challenges to local food security, agricultural sustainability, and rural livelihoods.

### 3.2.4 Impact of Land Use Land Cover (LULC) Change on Agricultural Activities

The impact of LULC change on agricultural activities in Ikpoba-Okha is multifaceted, affecting land accessibility, productivity, and environmental sustainability. The analysis explored land availability, productivity changes, environmental degradation, and perceptions of whether the impact is positive or negative.

The majority of the respondents, 289 (75.3%), indicated that their land size had decreased over time, suggesting that LULC change has led to significant farmland loss. Only 38 respondents (9.9%) reported an increase in land size, while 57 respondents (14.8%) indicated no change.

This aligns with findings from Akinyemi (2017), who reported that urban expansion and industrial development have contributed to declining farmland availability in peri-urban Nigeria. Regarding productivity, 154 respondents (40.1%) cited lower agricultural output as a direct consequence of land loss, while 115 respondents (29.9%) noted that inaccessibility to land had limited their ability to expand farming operations. These trends mirror studies by FAO (2020), which highlight that land fragmentation and urban encroachment reduce agricultural efficiency and food production.

The data also reveals that 77 respondents (20.1%) identified environmental degradation, such as soil depletion and pollution, as key challenges associated with LULC changes. Additionally, 38 respondents (9.9%) reported land fragmentation, which affects mechanized farming and long-term soil fertility.

These findings are consistent with Olawale and Abiodun (2022), who observed that unregulated urban growth often results in deforestation and loss of arable land. The findings also indicate that 250 respondents (65.1%) believe the impact is negative, primarily due to land loss, declining productivity, and environmental issues. However, 77 respondents (20.1%) cited positive impacts, such as employment opportunities and increased market access due to urban expansion. The remaining 57 respondents (14.8%) viewed the impact as both positive and negative. See Figure 7.

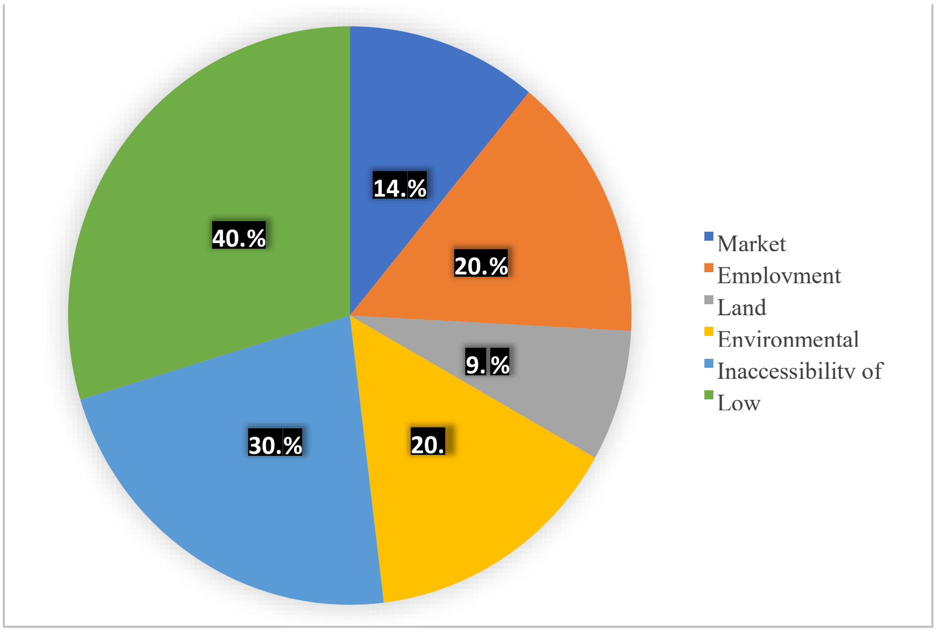


**Figure 7:** Impact of LULC Change on Agricultural Activities by Perception

These results suggest that LULC change has largely had a negative impact on agriculture in Ikpoba-Okha, particularly in terms of land accessibility, declining productivity, and environmental concerns. This supports previous research by Adepoju (2019), who found that urban expansion in southern Nigeria disproportionately affects smallholder farmers by reducing arable land and limiting their ability to compete with commercial developers. Although some respondents noted positive impacts, such as employment opportunities and improved infrastructure, the overwhelming evidence suggests that agricultural sustainability is at risk. FAO (2020) warns that without proper land-use planning, continued urban encroachment will worsen land scarcity, increase food insecurity, and reduce rural incomes.

The impact of LULC change on agriculture in Ikpoba-Okha is predominantly negative, driven by land loss, declining productivity, and environmental degradation. However, certain economic opportunities arise from urban expansion, highlighting the need for balanced land-management policies to protect farmland while accommodating development.

**3.2.5 Mitigation Strategies for Land Use Land Cover (LULC) Change**

The mitigation of LULC change in Ikpoba-Okha requires a combination of government interventions and community-driven initiatives. Given the rapid urban expansion and increasing pressure on agricultural land, addressing LULC change effectively demands a multifaceted approach that integrates policy implementation, spatial analysis, and active community participation.

**3.2.5.1 Mitigation Strategies for Land Use Land Cover (LULC) Change**

Government policies play a crucial role in mitigating the negative impacts of LULC change. The effectiveness of various government strategies, including land-use zoning, agricultural subsidies, environmental regulations, and afforestation programs, was evaluated based on feedback from stakeholders. The results indicate varying levels of effectiveness.

**Table 8: Perceived effectiveness of Government strategies by Respondents**

| Government Strategy | Ineffective Count | Ineffective (%) | Somewhat Effective Count | Somewhat Effective (%) | Effective Count | Effective (%) | Total |
|---|---|---|---|---|---|---|---|
| Landuse Zoning | 112 | 29.2 | 157 | 40.9 | 115 | 29.9 | 384 |
| Agricultural Subsidies | 145 | 37.8 | 124 | 32.3 | 115 | 29.9 | 384 |
| Environmental Regulations | 98 | 25.5 | 156 | 40.6 | 130 | 33.9 | 384 |
| Afforestation Programs | 67 | 17.4 | 144 | 37.5 | 173 | 45.1 | 384 |

Source: Field Survey, 2025.

As seen in Table 8, the perceived effectiveness of government strategies in mitigating LULC change varies significantly. Land-use zoning, designed to regulate urban expansion and protect agricultural land, was perceived as ineffective by 29.2% of stakeholders. This is likely due to weak enforcement and inadequate planning policies, as highlighted by Akinyemi (2017). Furthermore, spatial analysis through GIS indicates that many areas designated for agriculture are still experiencing encroachment, underscoring the gaps in policy enforcement.

Similarly, agricultural subsidies, intended to support farmers and reduce land conversion, were viewed as ineffective by 37.8% of stakeholders, reflecting issues such as limited access, bureaucratic bottlenecks, and mismanagement (FAO, 2020). Many farmers reported that subsidy programs are not reaching their intended beneficiaries, leading to continued financial struggles and a reliance on alternative land-use strategies that contribute to LULC change.

In contrast, environmental regulations and afforestation programs were perceived as more effective. About 33.9% of stakeholders considered environmental regulations effective, likely due to their role in reducing pollution and protecting natural resources. However, challenges such as inconsistent monitoring and weak institutional frameworks were noted. Afforestation programs received the highest effectiveness rating, with 45.1% of stakeholders viewing them as effective. This aligns with Seto *et al.,* (2011), who emphasized the importance of tree-planting initiatives in restoring degraded land and mitigating the impacts of deforestation. GIS analysis further reveals that areas where afforestation programs have been implemented show reduced land degradation compared to non-intervention zones.

Despite these efforts, policy fragmentation and enforcement challenges persist. The overlapping responsibilities between government agencies often lead to inefficiencies, reducing the impact of land-management strategies. Strengthening inter-agency collaboration and integrating spatial data into policy planning can enhance the effectiveness of these interventions.

**3.2.5.2 Community Collaboration and Personal Involvement**

Community-led initiatives are key to mitigating LULCC. Respondents provided insights on how communities collaborate to balance urban development with agricultural land preservation, as well as their involvement in conservation efforts (Figure 8).

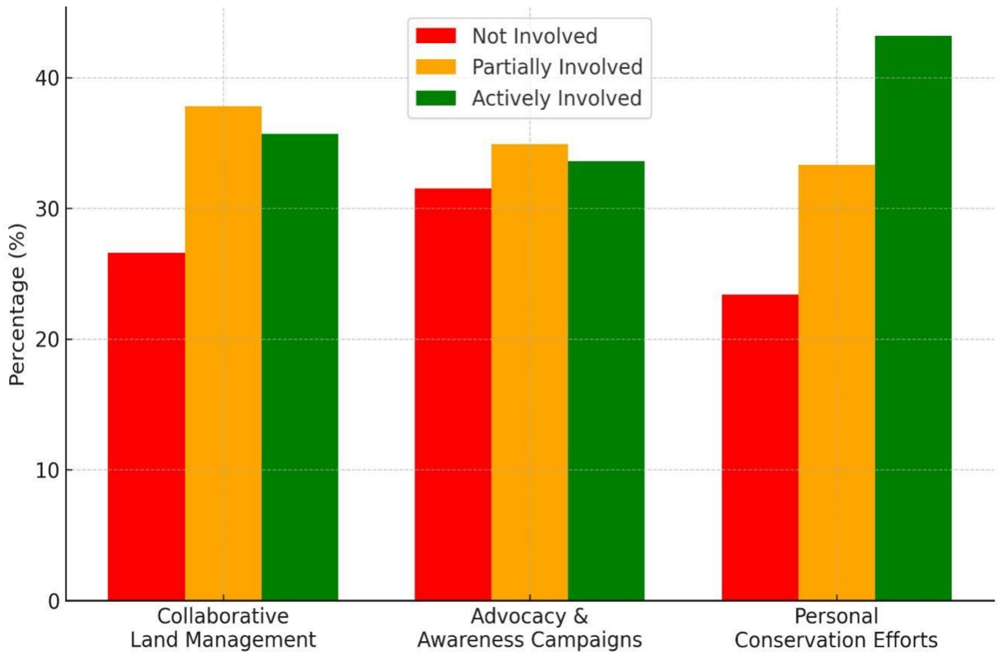


**Figure 8:** Community Collaboration and Personal Involvement

Collaborative land management involves community-driven efforts to manage land resources sustainably. One hundred and thirty-seven respondents (35.7%) reported active involvement in such initiatives, highlighting the importance of local governance in addressing LULC change. According to FAO (2020), community-based land management is critical for ensuring the sustainable use of land resources, particularly in regions where government policies are weak or poorly enforced.

Advocacy and awareness campaigns aim to educate communities about the importance of sustainable land use. One hundred and twenty-nine respondents (33.6%) reported active participation in these campaigns, indicating a growing awareness of the need to balance urban development with environmental conservation. Olayiwola and Oladeji (2021) emphasized that awareness campaigns are essential for mobilizing communities to take action against unsustainable land-use practices. However, socio-economic barriers such as limited access to information and financial constraints prevent some community members from actively participating in these initiatives. Personal conservation efforts, such as tree planting and soil conservation, were the most widely adopted strategy, with 166 respondents (43.2%) actively involved. This reflects the willingness of individuals to take direct action to preserve their land. According to Lambin *et al.,* (2001), personal conservation efforts are a key component of sustainable land management, as they empower individuals to take ownership of their environment.

Despite community involvement, challenges remain. Some respondents cited land tenure insecurity, lack of financial incentives, and competing economic priorities as barriers to sustained conservation efforts. To enhance participation, government and non-governmental organizations should provide incentives, training programs, and financial support to encourage sustainable land-management practices.

This observation is further supported by a focus group discussion conducted in Ikpoba-Okha, where participants shared insights on the mitigation strategies adopted to address agricultural land encroachment in the study area, noting that:

A farmer from Obagie stated:

*"In recent years, we have started implementing agroforestry practices to reduce the pressure on farmland. By planting economic trees along with our crops, we can maintain soil fertility and create a buffer against land encroachment."*

**Another participant from Iyanomo added:**

*"The community has come together to set up local land monitoring committees. These committees help us report illegal encroachments, and we also engage with traditional rulers to resolve land disputes before they escalate."*

**A landowner from Uhie commented:**

*"One major strategy we have employed is the use of land tenure agreements. Farmers who do not have land security are often displaced when developers or industries move in. Through these agreements, we have been able to secure farmland for longer periods."*

**A participant from Ogheghe stated**:

*"The government needs to be more proactive. While some farmers have started adopting conservation agriculture to sustain soil fertility, we still need stronger policies to prevent further encroachment. Clear zoning laws should be enforced to protect farmlands.*

**A farmer from Idogbo shared:**

*"We have been advocating for more government intervention, especially in providing alternative land for displaced farmers. Some of us have had to relocate to other areas, but access to land remains a challenge."*

**4.0 Summary**

This study employed GIS and remote-sensing techniques to assess Land Use Land Cover (LULC) characteristics of Ikpoba-Okha LGA from 1993 to 2023, revealing significant transformations driven by urban expansion, population growth, and economic development. The results showed a steady decline in agricultural land, largely due to increasing demand for residential, commercial, and industrial spaces. Over the three decades, built-up areas expanded at the expense of farmlands, altering the spatial dynamics of land use in the region. The rate of LULC change indicated a rapid loss of agricultural land, with encroachment accelerating in recent years. The study found that agricultural land decreased by 35.13% between 1993 and 2023, demonstrating the growing pressure on farmland from urbanization and infrastructural development.

This transformation has been fueled by weak land-use policies, ineffective zoning regulations, and the lack of stringent enforcement mechanisms. As urban development continues, the reduction in arable land has implications for food security and the sustainability of agricultural livelihoods in Ikpoba-Okha. The major drivers of LULC change were identified as population growth, urbanisation, industrialisation, and socio-economic activities. Rapid population increase has heightened the demand for housing and infrastructure, leading to the conversion of farmland into built-up areas. Industrial activities, including manufacturing and sand mining, have also contributed to deforestation, soil degradation, and erosion, further reducing the availability of productive land. Additionally, weak land-management policies have exacerbated uncontrolled land conversion, making it difficult to regulate urban sprawl.

The impact of LULC change on agricultural activities has been profound, leading to reduced farmland availability, declining soil fertility, and increased competition for arable land. Many farmers have been forced to adopt intensive farming practices, relocate, or abandon farming altogether due to land scarcity. Soil and water pollution from urban expansion have further affected agricultural productivity, posing challenges for sustainable food production.

The displacement of farmlands has also heightened the risk of food insecurity, as the availability of locally grown crops declines. To address these challenges, several mitigation strategies have been employed, including agroforestry, land-tenure agreements, and the establishment of local land-monitoring committees. Some farmers have attempted to integrate modern agricultural techniques to enhance productivity on smaller land areas. However, the study found that government-supported interventions remain limited, with weak enforcement of land-use regulations hindering effective mitigation efforts. Strengthening policy implementation, encouraging community participation, and investing in sustainable land-management practices will be critical in mitigating further agricultural land loss and ensuring balanced land-use planning in Ikpoba-Okha.

### 4.1 Conclusion

The study assessed the impact of land use land cover (LULC) change on agricultural land use in Ikpoba-Okha LGA, Edo State, Nigeria, using GIS and Remote Sensing. Based on the findings, the following conclusions are drawn:

i. The study revealed substantial Land Use Land Cover (LULC) changes in Ikpoba-Okha over the past three decades, with a 35.13% reduction in agricultural land between 1993 and 2023. This decline is primarily due to rapid urban expansion, population growth, and economic activities, leading to increased land conversion for residential, commercial, and industrial purposes.

ii. Ineffective land-use policies, weak zoning regulations, and poor enforcement have contributed to uncontrolled urban growth. The lack of proper planning has led to conflicts over land use, with agricultural land continuously being encroached upon by urban development.

iii. The key drivers of LULC change in Ikpoba-Okha include rapid population growth, urbanization, industrialization, and inadequate land management frameworks. These factors have led to increased pressure on agricultural land, causing deforestation, land degradation, and environmental challenges.

iv. The reduction in farmland has resulted in declining agricultural productivity, soil fertility loss, and increased competition for arable land. Many farmers have resorted to intensive farming on smaller plots, while others have abandoned agriculture due to land scarcity, environmental degradation, and pollution from urban activities.

v. Some mitigation strategies, such as agroforestry, land tenure agreements, and community-led land monitoring, have been implemented. However, their effectiveness has been limited due to weak enforcement of land-use regulations and insufficient government support.

vi. To balance urban expansion with agricultural sustainability, proper land-use planning is necessary. Encouraging urban vertical growth, strengthening zoning regulations, and providing financial support to farmers will help protect agricultural land. Additionally, incorporating GIS-based monitoring systems will enhance land management and promote sustainable development in Ikpoba-Okha.

**4.2 Contribution to Knowledge**

Based on the findings of this study, the following contributions have been made:

i. This study presents a GIS-based methodology for assessing Land Use Land Cover Change (LULCC) and its impact on agricultural land use in Ikpoba-Okha LGA. By integrating remote sensing techniques with field surveys, the research enhances the understanding of spatial and temporal land transformations, providing a replicable framework for similar studies in other rapidly urbanising regions.

ii. The study quantifies agricultural land loss over 30 years (1993–2023) and identifies the socio-economic and policy-related drivers of LULCC. By highlighting weak land-use policies and ineffective mitigation strategies, it offers valuable insights for policymakers, emphasizing the need for stronger land-use planning and agricultural land conservation efforts.

**5.0 Recommendations**

Based on the findings, the following recommendations are proposed:

**i. Enhancing Land Use Planning and Zoning Regulations**

Government authorities should implement and enforce zoning policies to protect agricultural land from uncontrolled urban expansion. Proper zoning policies should be enforced to ensure that designated agricultural lands are protected, and urban growth is directed towards areas less suitable for farming. Establishing clear urban growth boundaries will help regulate expansion, while regular monitoring using GIS technology will enable authorities to track land use changes effectively and take timely action against unauthorised developments. Encouraging urban vertical growth instead of horizontal expansion will help reduce land consumption, preserving more farmland for agricultural use.

ii**. Strengthening Support for Farmers**

There is a need for improved government support for farmers to help them cope with the challenges posed by urban expansion. Farmers should have access to financial assistance through grants, low-interest loans, and subsidies that will enable them to invest in modern farming techniques. Secure land tenure is also essential, as many farmers are at risk of losing their farmlands due to land acquisition for urban projects. Strengthening land rights and providing alternative farming solutions such as greenhouse and vertical farming will help sustain agricultural productivity despite shrinking farmland availability.

iii. **Implementing Environmental Conservation Strategies**

Environmental conservation measures should be intensified to counteract the negative effects of urban expansion on farmland.

Construction and industrial activities should be regulated to minimize land degradation, and companies involved in these sectors must be required to implement land restoration programs. Afforestation and soil conservation initiatives should be promoted to restore degraded lands and improve soil fertility. Additionally, strict environmental regulations should be enforced to control pollution from urban development projects, ensuring that agricultural lands are not contaminated by industrial waste or other harmful activities. Sustainable land management practices, such as agroforestry and crop rotation, should be encouraged to enhance soil quality and reduce land depletion. Community-led environmental awareness programs should also be promoted to ensure responsible land use and conservation efforts at the local level.

iv. **Promoting Community-Based Land Management**

Community-based land management initiatives should be encouraged to promote local participation in land conservation. Farmers, landowners, and urban planners should collaborate in designing strategies that will allow both urban expansion and agricultural activities to coexist. Community-led farmland protection programs, cooperative farming, and stakeholder engagement forums will help create a balanced approach to land-use planning. Encouraging communal land ownership models can also provide farmers with more security against displacement and reduce land conflicts arising from urban expansion.

v. **Expanding GIS and Remote Sensing Applications**

The use of GIS and remote sensing technology should be expanded for better land monitoring and planning. A GIS-based land monitoring system will help policymakers and planners make informed decisions regarding urban growth and agricultural land preservation. Real-time satellite imagery and spatial analysis can be used to assess the extent of farmland encroachment, enabling authorities to take proactive steps in controlling urban expansion. Local government officials should also receive training in GIS applications to enhance their capacity for sustainable land management.

vi. **Improving Agricultural and Rural Infrastructure**

Infrastructure and livelihood opportunities should be improved to support both urban and agricultural communities. Investments in rural infrastructure such as roads, water supply systems, and electricity will enhance agricultural productivity and ease transportation challenges faced by farmers. Additionally, the government should establish agribusiness hubs and agro-processing industries to provide alternative employment opportunities for those affected by urban expansion. These initiatives will ensure that displaced farmers and rural workers can transition into other productive sectors without losing their sources of income.

vii. **Conducting Periodic Environmental and Socioeconomic Assessments**

Periodic environmental and socioeconomic assessments should be conducted to evaluate the impact of LULC changes on agricultural land use. Environmental impact assessments should be mandatory before any large-scale development projects are approved in agricultural zones. Furthermore, regular surveys should be carried out to assess the effectiveness of existing land use policies and to make necessary adjustments where required. Establishing an early warning system to detect unsustainable land use patterns will enable timely interventions that prevent excessive farmland loss.

viii. **Ensuring Sustainable Urban-Agricultural Balance**

By implementing these recommendations, stakeholders including government agencies, urban planners, and local communities can work together to create a sustainable framework for urban development that does not compromise agricultural sustainability. With proper planning and policy enforcement, urban growth and agricultural activities can coexist, ensuring food security, environmental protection, and economic stability in Ikpoba-Okha.

### 5.1 Suggestions for Future Research

i. Future research should conduct a detailed scientific evaluation of land-use policies and governance frameworks in controlling agricultural land encroachment in Ikpoba-Okha. This study should assess the effectiveness of existing policies, regulatory enforcement mechanisms, and government interventions in managing urban expansion and agricultural land conservation. The findings will provide essential data for improving policy implementation and ensuring sustainable land-use planning.

ii. Research should focus on integrating advanced remote sensing technologies and predictive modelling for enhanced monitoring of Land Use Land Cover Change (LULCC). The study should explore the application of machine learning, artificial intelligence (AI), and high-resolution satellite imagery to improve the accuracy of LULCC assessments and predict future land-use trends. This will support proactive land management strategies and sustainable agricultural land conservation efforts.

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