

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

BY

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(PG/SSC/2015690)

UNIVERSITY OF BENIN,

BENIN CITY.

AUGUST, 2025

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**A PROJECT WRITTEN IN THE DEPARTMENT OF GEOGRAPHY AND
REGIONAL PLANNING AND SUBMITTED TO THE SCHOOL OF
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UNIVERSITY OF BENIN, BENIN CITY, EDO STATE, NIGERIA.**

SUPERVISOR

PROF. T. F. BALOGUN

AUGUST, 2025.

ATTESTATION

I, Akinlade Umemene Cordelia, hereby attest that this thesis, " Assessment of Land Cover Change and its impact on Agricultural Land Use in Ikpoba-Okha LGA, Edo State, Nigeria," is my original work. It has not been submitted, in whole or in part, for any other academic degree or qualification. All sources of information have been duly acknowledged, with references and in-text citations formatted according to the required guidelines. I express gratitude to all individuals and institutions that contributed to the completion of this research. Any external inputs have been appropriately credited, and this thesis represents my independent research, analysis, and conclusions. I take full responsibility for any errors or omissions in this work.

Akinlade Umemene Cordelia

CERTIFICATION

This is to certify that this research work was carried out by **AKINLADE Umemene Cordelia** in the Department of Geography and Regional Planning, Faculty of Social Sciences, University of Benin, Benin City, under my supervision.

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Date

Prof. J.E. Agheyisi

(Head of Department)

Date

DEDICATION

This research work is dedicated to God Almighty, whose infinite mercies, unwavering love, divine guidance, boundless knowledge, and enduring strength have been the foundation and driving force behind the successful completion of this study.

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ABSTRACT

Land Cover Change poses a significant challenge to agricultural land use, food security, and environmental sustainability. In Ikpoba-Okha LGA, Edo State, rapid urbanisation, population growth, and industrial expansion have resulted in large-scale conversion of agricultural land into residential, commercial, and industrial uses. This study assesses the rate, drivers of land cover changes, the land use changes across the study area over 30 years (1993–2023), its impacts on agricultural land use, and the mitigation strategies adopted by household heads. The study employed a mixed-method approach, integrating Remote Sensing and Geographic Information Systems (GIS) for spatial analysis, alongside questionnaires and focus group discussions. A purposive sampling technique was used to select household heads from ten communities across Ikpoba-Okha. Data analysis involved descriptive statistics, including percentages, presented through tables, charts, and maps. Results revealed that between 1993 and 2023, agricultural land decreased by 27.58%, while built-up areas increased by 33.45%, indicating significant urban encroachment. The most notable increase in built-up land occurred between 2013 and 2023, rising by 25.62%, whereas bare surfaces declined by 10.39% in the same period, suggesting land conversion. Water bodies showed minor but consistent growth (+0.16% overall). The sharpest decline in agricultural land (-21.93%) was observed between 1993 and 2003. The findings indicate that Land cover change has significantly reduced agricultural land, exacerbating land-use conflicts, food insecurity, and environmental degradation in Ikpoba-Okha. The study recommends stronger zoning regulations, financial support for farmers, and improved infrastructure to balance urban growth with agricultural sustainability.

CHAPTER ONE

INTRODUCTION

1.1 Background to the Study

Land Cover (LC) change remains a pressing global environmental concern with significant implications for ecosystems, biodiversity, food security, and human livelihoods. These changes are driven by both natural and human-induced factors, including rapid urbanisation, population pressure, land scarcity, technological innovation, and socioeconomic transformations (Zhou et al., 2020; Li et al., 2021; UNCCD, 2022). The rapid population growth and economic development over the past few decades have intensified the transformation of landscapes in urban regions. These transformations are especially pronounced in low- and middle-income countries, where urban expansion frequently encroaches upon agricultural lands, resulting in the loss of productive farmland and disruption of ecological systems (Kuddus et al., 2020; Ololade et al., 2022; UN-Habitat, 2023). As cities expand into agricultural areas, the availability of land for food production declines, altering natural landscapes and affecting ecosystem services and biodiversity (Bentinck, 2000; Regassa, 2020).

Among the key drivers of land cover change, urbanisation plays a dominant role, particularly in low- and middle-income countries where rapid urban expansion often occurs at the expense of agricultural land (Güneralp et al., 2020; Seto et al., 2020; Zhou et al., 2022). The environmental degradation resulting from the change in LULC is almost irreversible, making it difficult to restore to its original state, necessitating regular monitoring (Hatab et al, 2019; Hussain, 2020). Unlike high-income countries, where vertical expansion accommodates higher population densities with minimal land consumption, urban growth in many low- and middle-income nations such as Nigeria is predominantly horizontal. This form of expansion demands extensive land for housing, infrastructure, and industrial development, resulting in significant environmental and socioeconomic consequences (Adelekan et al., 2020; Ibrahim et al., 2021;

Ololade et al., 2023). The horizontal spread of cities results in the loss of agricultural land, increased pressure on the remaining farmland, and landscape modifications that affect both the environment and livelihoods (Ibrahim et al., 2021; Ndukwu et al., 2022; Ololade et al., 2023).

Agricultural land use classification schemes have been developed both domestically and internationally by organisations such as the Food and Agriculture Organisation (FAO). According to the FAO (2020), agricultural land includes arable land, permanent pastures, and areas used for perennial crops such as cocoa, coffee, and rubber. These lands are especially vulnerable to urban encroachment due to their frequent location on the fringes of urban areas, where expansion is most pronounced (Ibrahim et al., 2021; Ndukwu et al., 2022). The conversion of agricultural land to urban use has serious implications for food security, as it reduces the land available for food production while increasing pressure on the remaining farmlands (Ibrahim et al., 2021; Regassa, 2020).

Poor urban planning and weak enforcement of land use regulations have contributed significantly to Nigeria's rapid urban expansion (Ololade et al., 2023; Ndukwu et al., 2022). Ineffective planning regimes have facilitated the emergence of informal settlements and the conversion of agricultural land for urban purposes. Cities such as Benin City exemplify this trend, where urban growth has outpaced the development of infrastructure and services, resulting in environmental degradation and the loss of arable land (Ibrahim et al., 2021). Similarly, Nkeki and Onaiwu (2018) identify inadequate land management practices and weak institutional frameworks as key contributors to uncontrolled urban expansion and land use change. Their research emphasises the significance of stringent land use regulations and effective urban planning in mitigating the adverse impacts of urbanisation on agricultural land. Adegboyega and Oyetunji (2024) highlight the socioeconomic factors influencing land use change, noting that agricultural lands, particularly in peri-urban areas, are increasingly being converted to residential, commercial, and industrial uses due to rising population, rural-urban

migration, and new economic activities. This trend raises concerns about long-term food security as the demand for land continues to grow.

The impact of Land Cover (LC) is particularly evident in Ikpoba-Okha Local Government Area (LGA), which has experienced substantial land use transformations due to rapid urbanisation. Unlike cities in high income countries that often embrace vertical expansion, urban growth in Ikpoba-Okha has been predominantly horizontal. This has resulted in the widespread conversion of agricultural land to residential, commercial, and industrial uses, driven by socioeconomic opportunities and evolving policy frameworks (Adegboyega & Oyetunji, 2024; Ololade et al., 2023). The increasing encroachment on farmlands has heightened pressure on the remaining agricultural lands to meet the growing demand for food (Ibrahim et al., 2021; Ndukwu et al., 2022).

The rapid population growth and resulting land cover changes in Ikpoba-Okha provide a compelling case study of the dynamic relationship between land cover change and agricultural land use. As the population expands, urban development necessitates the construction of essential infrastructure such as roads, water supply systems, and electricity networks (Ibrahim et al., 2021; Ndukwu et al., 2022). However, this land cover change often comes at the expense of agricultural land, exacerbating concerns about food security and environmental sustainability (Ololade et al., 2023).

Given the rapid pace of land cover change and its impact on agricultural land use in Ikpoba-Okha LGA, there is an urgent need to assess its implications for food security and environmental sustainability. Geographic Information Systems (GIS) provide a powerful tool for analysing spatial and temporal land use changes, enabling policymakers to understand land cover dynamics and develop mitigation strategies (Regassa, 2020; Adegboyega & Oyetunji, 2024). This study utilises GIS-based techniques to assess land cover change drivers and

evaluate their impact on agricultural land use, contributing valuable insights for sustainable land use planning and policy formulation in rapidly urbanising regions.

1.2 Statement of the Problem

Cities in low and middle-income countries, such as Nigeria, are experiencing rapid transformations driven by population growth, urban expansion, and significant changes in land cover patterns (Adelekan et al., 2020). The demand from industrialisation, commercial ventures, and infrastructure development further exacerbates these difficulties, placing pressure on agricultural lands. These transformations often result in disorganised urban development, conflicting land uses, and the encroachment of urban areas into agricultural lands, leading to environmental degradation and challenges to the sustainable development ecosystem (Terfa et al., 2019; Busho et al., 2021). This is particularly true in Ikpoba-Okha, Edo State, where urban growth has taken over large areas of agricultural land, converting them into residential and industrial areas (Atewe, 2014).

Agricultural lands, which are crucial for food security and rural livelihoods, are among the most affected. These lands face increasing competition from more economically lucrative land uses such as residential, commercial, and industrial developments, often resulting in land use conflicts and threats to food security (Ololade et al., 2021). The conversion of agricultural land not only reduces the land available for food production but also disrupts ecosystems, alters hydrological cycles, and contributes to climate change (Seto et al., 2020; Liu et al., 2021). Studies by Adewara et al. (2019) have highlighted the growing impact of Land Cover Change in Nigeria, emphasising the need for sustainable land management strategies to mitigate its adverse effects on agricultural productivity and environmental stability. Although researchers have achieved some reasonable level of success, the application of remote sensing and GIS techniques to assess the impacts of LC change on agricultural land use in Ikpoba-Okha, Edo State, Nigeria, remains limited. In the study by Atewe (2014), the focus was primarily on

examining LC dynamics in Ikpoba-Okha, with comparatively limited emphasis placed on investigating the impact of these changes on agricultural land use.

This study fills this gap by demonstrating the use of remote sensing and GIS to analyse and monitor the impact of LC on agricultural land use in Ikpoba-Okha, Edo State, Nigeria. It also reveals the practicality of satellite imagery in monitoring and assessing the extent of LC during this period. The study identifies the LC changes across the study area. It also explores the rate of change and impacts of LC on agricultural activities. Furthermore, this study identifies the drivers of land cover change and examines mitigation strategies employed to combat the problem of agricultural land use encroachment in the study area.

Ideally, agricultural land should be preserved and effectively managed within the framework of sustainable urban planning. Land use policies should incorporate spatial planning tools such as Geographic Information Systems (GIS) and Remote Sensing (RS) to identify, monitor, and protect agricultural zones from urban encroachment. These tools enable planners to anticipate spatial change and intervene early, maintaining a balance between urban growth and agricultural sustainability (Verburg et al., 2021; Sun et al., 2023).

However, the current reality in areas like Ikpoba-Okha starkly contrasts this ideal. Urban expansion is occurring in a largely unregulated manner, with limited spatial data used to guide development (Atewe, 2014). The result is significant and largely unchecked land cover change, particularly the conversion of prime agricultural land into non-agricultural uses. The loss of agricultural land not only undermines local food security but also causes land degradation, biodiversity loss, and changes in microclimates (Abiodun et al., 2015; Lawanson et al., 2012).

This study aims to bridge this gap by utilising time-series satellite imagery and geospatial analysis to examine the patterns, rates, and drivers of land cover change in Ikpoba-Okha. By examining how these changes have specifically impacted agricultural land use over time, the

research will provide empirical data to support evidence-based land use planning. The study will inform policymakers, urban planners, and environmental stakeholders on the extent and consequences of LC change and offer strategic insights on mitigation and conservation practices (Dimobe et al., 2020; Asubonteng et al., 2021). Ultimately, the research contributes towards bringing the current uncontrolled land transformation closer to a more balanced and sustainable land use structure in Ikpoba-Okha.

1.3 Research Questions

The following research questions were raised for this investigation:

- i. What are the land cover changes across the study area from 1993 to 2023?
- ii. What are the rates of LC changes between the selected years?
- iii. What are the major drivers of LC change in the study area?
- iv. What is the impact of LC change on agricultural activities in the study area?
- v. What are the mitigation strategies employed to combat the problem of agricultural land use encroachment?

1.4 Aim and Objectives

The aim of the study is to assess land cover change and its impact on agricultural land use in Ikpoba-Okha, LGA, Edo State, between 1993 and 2023 using GIS and remote sensing techniques. The specific objectives are to:

- i. examine the Land Cover changes across the study area from 1993 to 2023.
- ii. analyse the rate of LC changes between the selected years.
- iii. assess the major drivers of LC changes in the study area,
- iv. examine the impact of LULC change on agricultural activities in the study area.
- v. examine the mitigation strategies employed to combat the problem of agricultural land encroachment.

1.5 Scope of the Study

Geographically, this study covers the entire Ikpoba-Okha local government area (LGA). Ikpoba-Okha was suitable for this investigation because farming is the predominant occupation of the people in the area. The research investigated the impact of LC change on agricultural land from 1993 to 2023. It analysed the land cover characteristics and identified the rate of LC changes between the selected years in the study area using GIS and remote sensing techniques. The research also assessed the drivers of these changes and examined the mitigation strategies employed to address the issue of encroachment on agricultural land use in Ikpoba-Okha. Ultimately, the research contributes to a better understanding of the spatial development of Ikpoba-Okha.

1.6 Significance of the Study

The research provides valuable insights into the relationship between LC and the rate of LC change in Ikpoba-Okha. It also examined the LC impact on agricultural land, assessed the major drivers of LC change, and examined the LC characteristics of Ikpoba-Okha. By employing GIS technology, researchers can analyse the spatial dynamics of land cover change, identify areas of agricultural land at risk, and propose informed land use management strategies. This approach also helps policymakers, urban planners, and stakeholders make data-driven decisions to balance the pressures of urban growth and the preservation of agricultural resources. Ultimately, GIS-based assessments play a crucial role in addressing the complex challenges posed by urban expansion on agricultural land use, ensuring sustainable development and the protection of valuable agricultural land.

1.7 Study Area

1.7.1 Geographical Location, Topography and Drainage

Ikpoba-Okha Local Government Area is situated in the southern part of Edo State (Figure 1.1), Nigeria. The study area has a total land area of 857 km² (85700 hectares). Geographically, Ikpoba-Okha is bordered by Uhumwonde LG to the North-East, Orhionmwon LG to the

South-East, Oredo LG to the South-West, Egor LG to the North-West, and the South-South by Delta State (Figure 1.2). The study area is divided into ten (10) political wards and consists of different communities. These political wards are Iwogban/Uteh, Oregbeni, Ogbeson, Aduwawa/Evbuomodu, St. Saviour, Gorreti, Ugbekun, Idogbo, Obayantor, and Ologbo. The terrain of the area is a mixture of lowlands, undulating plains, and isolated hills. The overall topography is relatively flat, with some gently sloping areas. The principal river in the area is the Ikpoba River, which flows through the Local Government Area. Other notable rivers include the Ossiomo and Ogba rivers. Additionally, numerous smaller streams and tributaries crisscross the region. The drainage pattern in the area is influenced by the natural terrain and watercourses. During the rainy season, water from the surrounding areas converges into the Ikpoba River and its tributaries, facilitating the effective drainage of the local government area.



Figure 1.1: Edo State map showing Ikpoba-Okha LGA
 Source: Edo State Geographic Information System (EDOGIS), 2023.

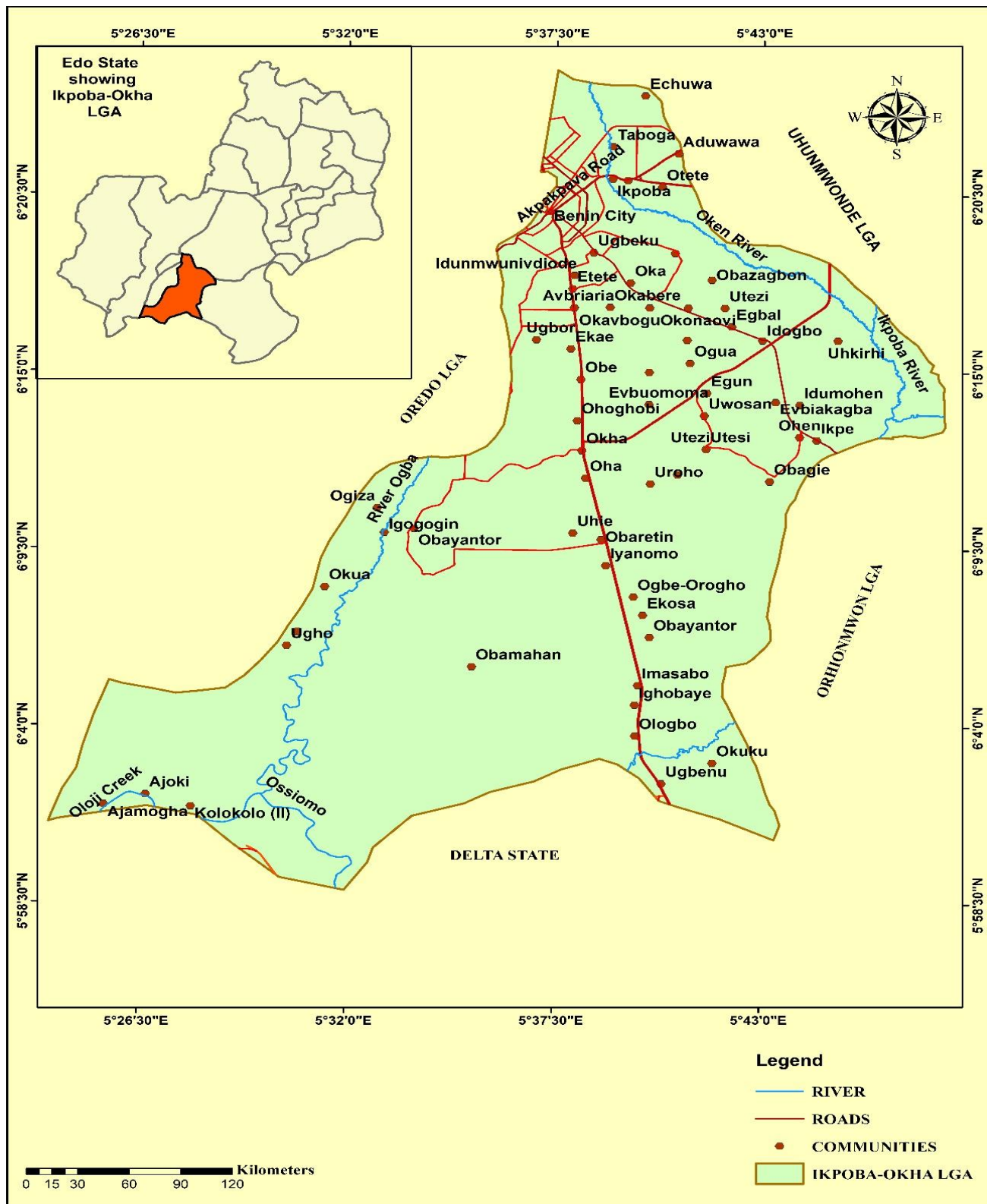


Figure 1.2: Ikpoba-Okha LGA and its communities.

Source: Edo State Geographic Information System (EDOGIS), 2023.

1.7.2 Climate

Ikpoba-Okha is an integral part of Benin City and, as such, shares the same climate. Using the Köppen-Geiger world climate classification, Ikpoba-Okha falls under the tropical equatorial climate, classified as Aw (rainy in winter and dry in summer). The area is characterised by two distinct climatic seasons: the rainy season and the dry season.

With an average annual precipitation of roughly 2025 mm, the rainy season lasts from April through October, with a two-week break in August (Iwena, 2018). According to Eroutor (2014), September has the highest rainfall at 338 cm, while January is often the driest month with about 9cm. It features a 329 cm annual rainfall range, two rainfall regimes, two annual maxima of rainfall (in July and September), and a brief dry season that runs from November to March. This dry season is typically accompanied by a cold, humid, and dusty harmattan wind, with the strongest gusts occurring in December and January (Efe et al, 2014). The warmest month, April, has an average temperature of 27.50°C, while July has the least mean temperature of roughly 24.5°C and an annual range of 3.0°C. Benin City's average annual temperature ranges from 26.1°C in the rainy season to 28.0 °C in the dry season (Eroutor, 2014).

1.7.3 Geology, Soil and Vegetation

The geology of Ikpoba-Okha, like much of Edo State, is characterised by sedimentary rocks and alluvial deposits. The area is underlain by formations such as the Benin Formation, belonging to the Kulfo series, which consists of sandstones, shales, and limestone. These sedimentary rocks were deposited during various geological periods and provide the foundation for the soil composition in the region.

The soil types in Ikpoba-Okha vary across different areas of the local government. The predominant soil types include tropical ferruginous soils, lateritic soils, and alluvial soils. Tropical ferruginous soils are reddish-brown in color and are rich in iron and aluminium oxides. Lateritic soils are often reddish or yellowish and are characterised by high clay content, poor

nutrient retention, and low fertility, particularly in tropical regions (Adebayo et al., 2020; Nwakaire & Eze, 2021). The alluvial soils found along riverbanks and floodplains are typically fertile and suitable for agricultural activities due to their nutrient-rich nature. The weathering profile consists mostly of red and yellow earths, as well as loose, poorly sorted sands, which are intermixed in some places with clay barns. The soils in Ikpoba-Okha exhibit a strongly acidic reaction and are generally easy to cultivate due to their friable texture. However, they are also prone to excessive internal drainage and intense leaching, which limits their fertility and agricultural productivity (Adeoye et al., 2020). The area lies within the rainforest belt of southern Nigeria, historically characterised by tall trees, dense undergrowth, and rich biodiversity. In recent years, however, the combined effects of population growth, urbanisation, and intensive human activities have contributed to significant ecological transformation. What was once a lush rainforest is increasingly giving way to a derived savannah landscape marked by stunted trees and grassland (Ezenwaka et al., 2021).

1.7.4 Population and Socio-Economic Activities

The population of Ikpoba-Okha, according to the 2006 population census conducted by the National Population Commission (NPC), was 372,080. The National Bureau of Statistics (NBS) projected the population to reach 563,000 by the year 2023, with a population growth rate of 2.5% (NPC, 2006; NBS, 2023). The socio-economic activities in Ikpoba-Okha are diverse and significantly contribute to the local economy. In addition, the area possesses substantial expanses of arable land suitable for agricultural development (Osayande et al., 2021).

Ikpoba-Okha is known for its vibrant markets, such as Oka and the Oregbeni market. These markets attract traders and buyers from within the local government and neighboring areas, serving as a hub for various commercial activities. Traders engage in the sale of a wide range of goods, including foodstuffs, textiles, household items, and more. There are industrial areas

and factories in Ikpoba-Okha, including those engaged in food processing, beverage production, manufacturing, and other industrial activities (www.manpower.com.ng). These industries provide employment opportunities and contribute to the local economy. Various services, including transportation, healthcare, banking, hospitality, and entertainment, contribute to the socio-economic fabric of Ikpoba-Okha. Transportation services, such as commercial vehicles and motorcycles, facilitate movement within and beyond the LGA. In addition to the mentioned activities, blacksmithing, hunting, and lumbering also play significant roles in the local economy of Ikpoba-Okha (www.manpower.com.ng).

1.7.5 Anthropogenic Activities

The rapid growth of human activities in Ikpoba-Okha has led to significant land use and land cover changes, affecting both agricultural land and natural ecosystems. Urban expansion has resulted in the conversion of agricultural lands into residential and commercial areas, with housing developments encroaching on previously cultivated lands (NPC, 2006; NBS, 2023). The establishment of industries, including manufacturing and food processing plants, has contributed to deforestation and the alteration of land surfaces, impacting soil stability and local biodiversity (www.manpower.com.ng). Sand mining, a prevalent activity in parts of Ikpoba-Okha LGA, has contributed to soil degradation and heightened vulnerability to erosion, thereby reducing the productivity and quality of arable land (Adeaga & Oluwatayo, 2020). Additionally, logging and lumbering, often carried out for timber production and charcoal-making, have contributed to deforestation, thereby affecting soil fertility and disrupting water cycles. Market expansions, such as those seen in Oka and Oregbeni markets, have also led to the clearing of vegetation to accommodate more commercial spaces and transport infrastructure. Furthermore, the indiscriminate disposal of waste from both industrial and household sources has resulted in pollution, affecting soil and water resources essential for agriculture (www.manpower.com.ng). These anthropogenic activities, while contributing to

economic growth, pose significant challenges to sustainable land use and environmental management in the LGA.

Consequently, the shrinking of agricultural land due to these pressures has led to reduced farm sizes, declining soil productivity, and increased competition for available land, threatening food security and long-term agricultural sustainability. As a result, farmers are pushed to less suitable lands, increasing land degradation and food insecurity. Rising land competition has sparked tenure conflicts, while declining productivity threatens local food supply and highlights the need for sustainable land management strategies (Adeaga & Oluwatayo, 2020; www.manpower.com.ng).

1.7.6 Agricultural Activities

Agriculture is one of the socio-economic activities in Ikpoba-Okha due to the presence of fertile soils that are suitable for cultivation. These soils support the production of staple crops such as cassava, yams, maize, and vegetables, which form a crucial part of the local food system. Livestock farming, poultry, and small-scale animal husbandry are also practised, contributing to the availability of protein sources and income for farmers. In addition to food crops, the region supports the cultivation of cash crops such as oil palm and timber, which are important for both local consumption and commercial trade (Olotun et al., 2010). Farmers in the area engage in both subsistence and commercial farming, ensuring food security and generating income. While traditional farming methods remain dominant, there is an increasing interest in modern agricultural techniques aimed at improving productivity and efficiency. The agricultural sector plays a vital role in the local economy, providing employment and sustaining livelihoods across various communities in Ikpoba-Okha (www.manpower.com.ng).

Agricultural expansion in Ikpoba-Okha has led to changes in Land Cover, with increasing farmland encroaching into forests and wetlands, altering natural ecosystems. Conversely,

urbanisation and infrastructural development are reducing available agricultural land, forcing some farmers to adopt more intensive farming practices or relocate. These shifts impact soil fertility, water availability, and overall agricultural productivity, influencing both subsistence and commercial farming sustainability.

CHAPTER TWO

CONCEPTUAL FRAMEWORK AND LITERATURE REVIEW

2.1 Conceptual Review

2.1.1 Land Use Land Cover

Land Use Land Cover is a multifaceted and fundamental concept in environmental and geographical studies, analysed from various disciplinary perspectives. It encompasses both the physical characteristics of the Earth's surface (land cover) and how humans utilise these surfaces (land use). Scholars, researchers, and institutions have provided diverse definitions and interpretations of Land use and land cover, highlighting its interdisciplinary significance.

According to Hussain et al (2020), land cover refers to the observed physical features of the Earth's surface (e.g., forest, water, soil, infrastructure, etc.), while land use defines the changes in land cover resulting from human usage for habitat and economic gains. This is especially true in Ikpoba-Okha, Edo State, where urban growth has taken over large areas of farmland, converting them into residential and industrial areas (Atewe, 2014). While land use alterations result primarily from socio-economic drivers, including population growth and economic development. This perspective highlights the importance of studying LULC changes to understand environmental transformations and policy implications.

Congalton et al (2014) proposed an updated and widely used classification scheme for land use and land cover, designed to accommodate advances in remote sensing technologies and data availability. They emphasised that land cover refers to the physical and biological cover on the Earth's surface, such as vegetation or water, while land use pertains to the human purpose or activity applied to these surfaces. Their classification system has been pivotal in enhancing the accuracy and consistency of LULC assessments using high-resolution satellite imagery and GIS tools.

Foley et al (2005) expanded the conceptual framework by linking LULC changes to global environmental challenges such as deforestation, climate change, and biodiversity loss. They argued that LULC transitions, particularly the expansion of agricultural and urban areas, significantly impact ecological processes, hydrological cycles, and atmospheric composition, making LULC a critical area of study in sustainability science.

Meyfroidt et al (2018) advanced a socio-ecological systems approach to LULC change, highlighting the dynamic feedbacks between human decisions and ecological processes. They emphasised that land use outcomes are shaped by complex, multi-scalar drivers such as global trade, policy interventions, institutional frameworks, and cultural values. Their work highlights the importance of integrated land system science, which combines social and ecological perspectives to better inform sustainable land governance and planning. The Food and Agriculture Organisation (FAO) of the United Nations (2016) defined land cover as the observed physical and biological attributes of land, including forests, wetlands, and urban areas, whereas land use describes how people utilise land for various purposes, such as farming, settlement, or conservation. This definition aligns with global efforts to monitor LULC changes for sustainable development planning. Keys et al, (2019) expanded on the human-dominated nature of land systems by examining land use telecoupling, how distant socio-economic and environmental systems are linked through land use decisions. They highlighted that globalisation, trade, and policy shift increasingly decouple land use drivers from their local environmental contexts. This emerging perspective advances the understanding that landscapes today are shaped by complex global interactions, reinforcing the need for socio-environmental frameworks that move beyond traditional biophysical land cover classifications.

Verburg et al, (2009) highlighted the role of modeling in understanding LULC changes, stating that predictive models are essential for assessing future land use scenarios and their potential environmental impacts. They stressed that LULC changes are driven by complex interactions

between demographic, economic, and policy factors, requiring interdisciplinary research approaches to address land management challenges effectively.

2.1.2 Urban Sprawl

The term “urban sprawl” continues to be widely discussed in recent urban studies. Urban sprawl is understood as the uncontrolled and uncoordinated expansion of metropolitan areas beyond their planned boundaries, often resulting in the degradation of surrounding landscapes and loss of social cohesion (Li et al., 2021; Zhang & Seto, 2020). This phenomenon includes diverse patterns of growth, which recent research categorises into spatial, economic, environmental, and social dimensions (Wang et al., 2022). Compared to compact urban development, sprawling cities tend to suffer from increased traffic congestion, overuse of local resources, and significant reduction of green spaces (Chen et al., 2023). Moreover, urban sprawl is commonly characterised by fragmented land use and inefficient infrastructure networks, which pose challenges for sustainable urban planning (Xu & Yeh, 2021). Regarding land use changes, urban sprawl is characterised by low density, lack of continuity, weak clustering, poor centrality, limited mixed-use development, and reduced proximity between urban functions (Wang et al., 2022; Liu & Zhang, 2021). Similarly, recent definitions emphasise sprawl as poorly planned, dispersed development that spreads a city’s population over a widening area, often encroaching upon rural lands and contributing to fragmented landscapes (Chen et al., 2023; Zhao & Huang, 2020).

Urban sprawl refers to a pattern of dispersed, low-density, automobile-dependent urban growth that often occurs without cohesive land use planning, leading to fragmented development across multiple jurisdictions (Wang et al., 2022; Zhao & Huang, 2020). This form of expansion has profound social and environmental consequences, including biodiversity loss, increased air and water pollution, intensified traffic congestion, and the encroachment on agricultural land (Chen et al., 2023). As cities expand outward, older metropolitan cores often decline, while

surrounding rural and suburban areas experience mounting development pressure. This not only reduces the availability of farmland but also strains food production systems and heightens competition for arable land, thereby threatening long-term agricultural sustainability (Liu & Zhang, 2021).

2.1.3 Agricultural Land

According to the Food and Agriculture Organisation (FAO, 2021), agricultural land comprises arable land, permanent crops, and permanent pastures. Arable land includes areas under temporary cultivation, such as cereals, vegetables, market gardens, and temporary meadows or fallow land (up to five years), excluding land abandoned from shifting cultivation. Permanent cropland refers to orchards, vineyards, coffee, cocoa, rubber, and similar plantations where crops do not require annual replanting. Permanent pastures are defined as lands used continuously for forage production for five or more years, whether naturally occurring or cultivated.

The World Bank (2023) defines agricultural land as the sum of arable land, permanent crops, and permanent pastures, highlighting its role in supporting food production, livestock, and ecological services such as biodiversity conservation and rural livelihoods.

As per the United States Department of Agriculture (USDA), agricultural land includes a range of categories such as cropland (for crop production), pastureland (for livestock grazing), orchards, groves, vineyards, farm forests, and farm roads. Agricultural land plays a crucial role in sustaining green spaces, preserving biodiversity, supporting rural landscapes, and ensuring access to locally sourced food, thereby contributing to both environmental and food system resilience (Pretty et al., 2018).

2.1.4 Sustainable Land Use Planning

Land use planning involves a systematic process of assessing land resources and current usage patterns while accounting for environmental, socio-economic, and cultural factors. The objective is to guide land allocation and development in a way that balances economic productivity, environmental protection, and societal needs (UN-Habitat, 2020; FAO, 2022). This process encompasses a range of activities, including agriculture, forestry, wildlife conservation, urban and industrial development, tourism, and amenities. Additionally, land use planning aids in resolving conflicts that may arise when different land use options compete for the same space.

Various factors drive land use planning, including the need for adaptive change, improved resource management, and responses to evolving environmental and socio-economic conditions. The goals of land use planning involve balancing competing interests, assessing current and projected population needs, evaluating land capacity, and formulating strategies to tackle present and future challenges (Li et al., 2021; Kumar & Singh, 2020). Additionally, land use planning seeks to develop innovative solutions that meet immediate demands while shaping sustainable community growth and development trajectories (UN-Habitat, 2020).

2.1.5 Remote Sensing (RS) and Geographic Information System (GIS)

Remote sensing (RS), also known as earth observation, is the process of collecting information about objects or areas on the Earth's surface without physical contact. This is typically done through the use of satellites, drones, aerial sensors, or radar systems that capture data from a distance (Li et al., 2020; Jensen, 2019). While remote sensing primarily focuses on Earth, observations from spacecraft extend its scope to other planets in our solar system.

Remote sensing is defined as the science and technique of obtaining information about objects or areas from a distance, typically through the analysis of data captured without direct contact (Mishra & Singh, 2021). It involves detecting and measuring electromagnetic energy reflected or emitted from the Earth's surface, which is then processed and analysed to study various environmental and land surface characteristics (Jensen, 2019). Remote sensing instruments such as multispectral cameras, scanners, radiometers, radar, and LiDAR systems record this energy, capturing details of natural and human-made features (Roy et al., 2014). Data collected are transmitted to ground stations where they undergo processing and interpretation, which considers factors like tone, texture, pattern, shape, size, shadow, and spatial association to classify land use and land cover types. Multi-temporal satellite data, including those from Landsat, Sentinel, and MODIS sensors, are widely used for monitoring spatiotemporal changes in land use and land cover (Wang et al., 2022).

Geographic Information System (GIS) serves as a powerful platform for storing, processing, and analysing data obtained from remote sensing and other sources to support informed decision-making. Essentially, GIS is a computer-based technology designed to capture, manage, analyse, and visualise geographically referenced information (Longley et al., 2021). It enables the integration of diverse datasets from multiple origins, facilitates complex spatial analyses, and represents data across spatial and temporal dimensions, making it indispensable for environmental monitoring, urban planning, and resource management.

Remote sensing and GIS technologies work synergistically to enhance the monitoring and analysis of urban environments and natural systems. While remote sensing offers comprehensive and consistent observations of Earth's surface over time, GIS provides powerful tools for managing, analysing, and visualising large spatial datasets. Together, they are essential for assessing the impacts of urban expansion on agricultural land use and environmental change (Xie et al., 2020; Liu & Zhang, 2019; Malczewski, 2020).

2.2 Theoretical Framework

2.2.1 Elinor Ostrom Social Ecological Systems (SES) Framework

Elinor Ostrom's Social-Ecological Systems (SES) Framework represents a landmark contribution to interdisciplinary research on the governance of shared natural resources. The SES framework was first introduced in 2007 and further refined in 2009; the SES framework provides a structured and flexible conceptual model for analysing the interactions between human societies and ecological systems. Ostrom, who was awarded the Nobel Prize in Economic Sciences in 2009, is widely recognised for challenging conventional economic theories that advocate centralised or privatised control over common-pool resources. Through decades of empirical research, she demonstrated that local communities, under the right conditions, can sustainably manage shared resources through self-governance, cooperation, and adaptive institutions.

The SES framework was developed to extend the Institutional Analysis and Development (IAD) framework, which focused on institutional rules and collective action. The SES framework builds upon this foundation by incorporating ecological and environmental variables into the analysis. It allows researchers and practitioners to systematically investigate how different variables at multiple levels (ecological, institutional, and social) interact to influence outcomes in natural resource management. It is particularly useful for diagnosing challenges in sustainability and resilience in complex social-ecological systems.

Central to the SES framework is the concept of an "action situation," where individuals or groups (actors) make decisions and interact based on available information, institutional rules, and the broader context in which they are embedded. These action situations are influenced by a variety of factors, such as the type and characteristics of the natural resource, the social and institutional context, the actors' knowledge and behaviors, and external disturbances. By

analysing these elements in a structured way, the SES framework provides a platform for both in-depth case studies and comparative research across diverse settings.

A major strength of the SES framework lies in its “theory-neutral” nature. Rather than offering a specific explanation or hypothesis, it serves as a diagnostic tool that can accommodate multiple theoretical approaches and can be applied across disciplines. This flexibility enables scholars to tailor their analysis to specific contexts while maintaining a consistent structure for comparison and knowledge accumulation (McGinnis & Ostrom, 2014; Ostrom, 2009).

Numerous empirical studies have used the SES framework to understand how institutional arrangements, ecological conditions, and social dynamics contribute to the success or failure of resource governance systems. While the framework is rooted in the study of the commons and collective action (Partelow, 2018), it has evolved into a more comprehensive and generalisable analytical approach that applies to a wide range of sustainability challenges. It provides researchers with a shared vocabulary and set of variables to identify patterns, build theory, and develop context-specific policy recommendations (Ostrom & Cox, 2010; Basurto & Ostrom, 2009).

2.2.1 Structure and Components of the SES Framework

The SES framework is organised around a set of first-tier core subsystems, each of which is further divided into second-tier variables. These variables provide a detailed structure for analysing the components and interactions that influence outcomes in a social-ecological system. These components allow researchers to conduct both context-specific analysis at the local level and comparative analysis across multiple case studies. Each component is further broken down into second-tier variables, as shown in Table 2.1.

Table 2.1: 1st- and 2nd-tier variables of the SESF.

Source: Adapted from McGinnis and Ostrom (2014).

1st-tier variables	2nd-tier variables
Social, Economic, and Political Settings (S)	S1- Economic development S2- Demographic trends S3- Political stability S4- Other governance systems S5- Markets S6- Media organisations S7- Technology
Resource Systems (RS)	RS1- Sector (e.g., water, forests, pasture) RS2- Clarity of system boundaries RS3- Size of resource system RS4- Human-constructed facilities RS5- Productivity of the system RS6- Equilibrium properties RS7- Predictability of system dynamics RS8- Storage characteristics RS9- Location
Governance Systems (GS)	GS1- Government organisations GS2- Non-governmental organisations GS3- Network structure GS4- Property-rights systems GS5- Operational rules GS6- Collective choice rules GS7- Constitutional rules GS8- Monitoring and sanctioning
Resource Units (RU)	RU1- Resource unit mobility RU2- Growth or replacement rate RU3- Interaction among resource units RU4- Economic value RU5- Number of units RU6- Distinctive characteristics RU7- Spatial and temporal distribution
Actors (A)	A1- Number of relevant actors A2- Socioeconomic attributes A3- History or past experiences A4- Location A5- Leadership/entrepreneurship A6- Norms (trust-reciprocity/social capital) A8- Importance of resource (dependence) A7- Knowledge of SES/mental models A9- Technologies available

Interactions (I)	I1- Harvesting I2- Information sharing I3- Deliberation processes I4- Conflicts I5- Investment activities I6- Lobbying activities I7- Self-organising activities I8- Networking activities I9- Monitoring activities I10- Evaluative activities
Outcomes (O)	O1- Social performance measures O2- Ecological performance measures O3- Externalities to other SESs
Related Ecosystem (ECO)	ECO1- Climate patterns ECO2- Pollution patterns ECO3- Flows into and out of SES

2.2.2 The Concentric Zone Model

Burgess's concentric theory, developed in 1925 based on the study of land use in Chicago, represents one of the earliest land use theories. According to Burgess, land use patterns evolve outward from the inner city, known as the Central Business District (CBD). The city's oldest part is situated at the centre, while the newest developments are found on the outer edge. Burgess observed that the quality and size of housing tend to increase with distance from the CBD. However, the height of buildings peaks near the central area was due to high land values and limited space. Burgess aimed to establish a pattern for the social structure of the city and to investigate its growth dynamics. The concentric zone model serves as a descriptive framework for analysing the spatial organisation of land use in a city and its changes over time. Burgess made certain assumptions in developing the theory, including a uniform land surface, a free market, and accessibility to a single-centred city, a heterogeneous population, and a commercial-industrial base. Burgess's research on the distributional patterns of different societal groups led him to propose a city structure consisting of concentric zones, with the CBD at the core. The core represents the zone of major commercial, political, and social activities. Surrounding it is a transition zone with factories and slums, including older, lower residential

districts, gradually taken over by the expanding CBD. Next is the zone of lower-income housing, followed by successive zones with higher-income residences.

The underlying premise of the model is the concept of succession and invasion, wherein population groups move outward as their economic and social status improves. Mobility and the migrant influx were considered key factors in shaping the social pattern. As families attain affluence, they move to better housing districts on the periphery. Diversification in employment opportunities contributes to mixed land-use development, fostering outward expansion.

Improvements in the public transport system have facilitated commuting from outer zones to the CBD for work, complementing the concentric zone development model. While the model is straightforward, it serves as a useful framework for predicting urban land market dynamics and was intended to aid the study of urban growth and change.

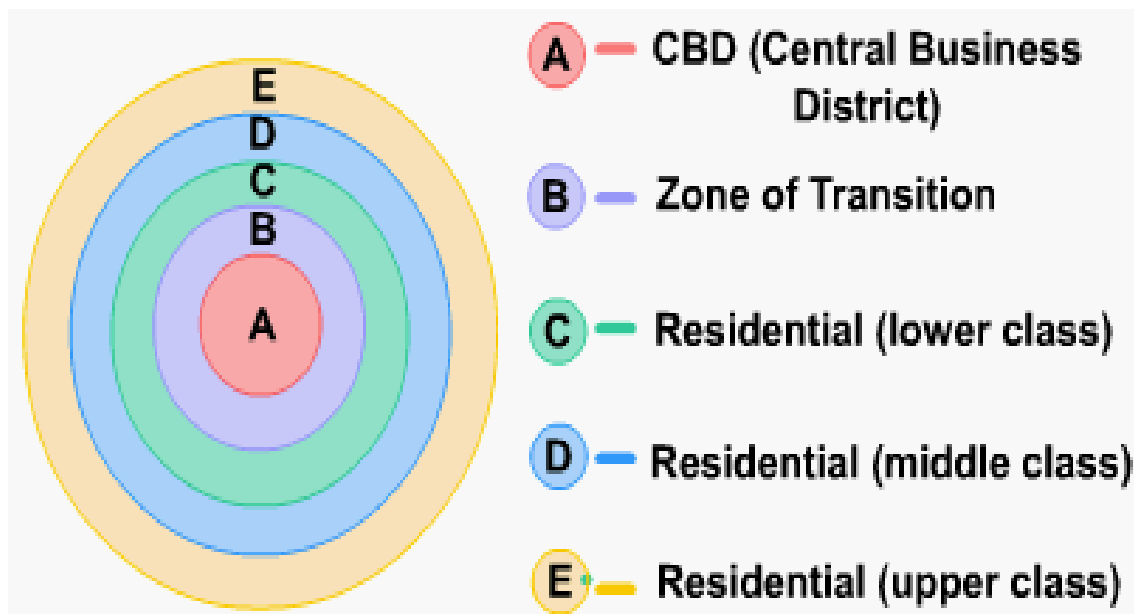


Figure 2.2: The Concentric Zone Model

Source: Rodrigue (2014).

2.3 Literature Review

2.3.1 Land Cover Change

Remote sensing (RS) and Geographic Information Systems (GIS) remain critical tools for monitoring urban growth, land use dynamics, and land cover changes with improved spatial and temporal resolution (Abdi, 2022; Zhang et al, 2023). Understanding current land usage and land cover information is crucial for optimal land utilisation. Additionally, it is essential to monitor how land use evolves in response to shifting population demands and natural processes that shape the landscape. Weng et al (2018) highlight the increasing effectiveness of GIS and remote sensing technologies in detecting and analysing urban land use and land cover changes. They emphasise that advancements in high-resolution imagery, machine learning, and spatial modelling have significantly enhanced the accuracy and applicability of these tools in urban environmental monitoring.

Land use and land cover studies have been conducted on various scales since the launch of the first remote sensing satellite, Landsat-1, in 1972. For instance, utilising data from the Landsat multi-spectral scanner between 1980 and 1982, the National Remote Sensing Agency (NRSA) conducted a 1:1 million, 55-scale mapping of wasteland in India, estimating that 16.2% of the land was wasteland. The Landsat Thematic Mapper is particularly suitable for providing comprehensive synoptic coverage of large areas, reducing the necessity for costly and time-consuming ground surveys for data validation. Oyinloye and Kufoniyi (2019) utilised remote sensing and GIS techniques to assess land use and land cover changes in parts of the Sokoto-Rima Basin, North-Western Nigeria. Their study revealed significant spatial transformations over time, with expansion in built-up areas emerging as the dominant trend, highlighting the pressures of urbanisation on natural and agricultural landscapes.

In India, the National Remote Sensing Agency (NRSA) conducted a nationwide urban land use thematic mapping project at a scale of 1:10,000 for 564 cities and towns. This comprehensive

mapping included state capitals, Union Territories, 23 cities with populations exceeding one million, NCR towns, and one town from each class (ranging from Class I to Class IV) from every state and Union Territory. The categorisation standards employed hierarchical ordering of classes from Level I to Level IV, with increasing levels of information content. These categories encompassed various land use and land cover types, including built-up areas, agricultural lands, forests, grazing lands, wastelands, wetlands, water bodies, and others. Additionally, to accommodate rural classes observed within urban administrative limits, the categorisation extended to some land cover classes up to Level II. At Level I, land uses comprised built-up areas, agricultural lands, forests, grazing lands/wastelands, wetlands, water bodies, and others. Further subdivision occurred at Level II, where built-up areas were categorised into Urban and Rural, and other land use types were divided into multiple subclasses. This classification system was applied to the land use and land cover mapping of Srinagar, India.

Fasona et al (2020) investigated the effects of urban expansion on agricultural lands in northern Nigeria using integrated Remote Sensing and GIS approaches. The study utilised multi-temporal Landsat imagery from 1986, 2000, and 2016, processed through supervised classification techniques to produce land use and land cover maps. Their analysis revealed a significant increase in built-up areas and a corresponding reduction in agricultural and vegetated lands, highlighting the accelerating pressure of urbanisation on peri-urban agricultural zones. The findings highlight the need for proactive spatial planning and land management to mitigate the adverse effects of unchecked urban sprawl on food production systems.

2.3.2 Rate of Land Cover Change

Urban research primarily seeks to analyse intra- and inter-urban spatial patterns and to understand the dynamic evolution of urban systems. Effective natural resource management

and regular updating of land cover data necessitate a thorough understanding of spatial-temporal urban changes (Li et al., 2021). Additionally, remote sensing is widely recognised as an essential technique for acquiring data to assess and map the spatiotemporal dynamics of land use change and urban expansion across multiple geographical scales (Li et al., 2020; Wang & Xu, 2018; Zhang et al., 2019). Similarly, Li and Gong (2016) emphasised the extensive application of remote sensing data in mapping and monitoring urban growth and expansion, highlighting improvements in spatial resolution and analytical methods that have enhanced urban studies.

Kumar et al. (2020) employed GIS and remote sensing techniques to analyse urban development and land use changes in the Jharia coalfield region, India, over the period from 1990 to 2018. Their study revealed substantial urban sprawl primarily encroaching on agricultural and flat upland areas surrounding the coalfields, contributing to infrastructural challenges within expanding urban settlements. The analysis showed that urban built-up areas expanded by approximately 70% during this period, driven by industrial growth and population influx. The spatial patterns indicated significant development towards the northeast and eastern parts of the region, with the emergence of new townships aimed at improving residential conditions away from industrial zones. The urban expansion caused fragmentation of vegetation cover and altered the geo-hydrological environment, negatively impacting local ecosystems. Kumar et al. (2020) emphasised the critical role of integrating multi-temporal satellite imagery with GIS databases to support comprehensive urban planning and sustainable land management in rapidly changing industrial landscapes.

Nguyen et al. (2019) utilised Landsat 5 TM and Landsat 8 OLI images from 1990 and 2018, complemented by field surveys and cadastral maps, to examine urban expansion and agricultural land conversion in the Ho Chi Minh City metropolitan area. Using maximum likelihood classification, they quantified the extent, rate, and spatial patterns of urban growth

and agricultural land loss. Urban land cover maps were overlaid with administrative boundaries and transportation networks within a GIS framework to analyse development trends. Their results indicated significant conversion of agricultural land into residential, commercial, and industrial uses, driven primarily by rapid population growth and economic development. The study highlights the ongoing challenge of balancing urbanisation with the preservation of agricultural resources in fast-growing cities.

Adewale and Olagunju (2018) applied GIS and remote sensing techniques to analyse settlement growth in Ilorin, Kwara State, from 1980 to 2015. Their study documented a rapid expansion of built-up areas, particularly between 1990 and 2010, followed by a moderated growth rate in the later years, reflecting changing urban dynamics. Similarly, Olanipekun and Akinola (2021) conducted a spatiotemporal analysis of urban sprawl in the peri-urban areas of Ibadan, Southwestern Nigeria, using Landsat imagery and GIS. They demonstrated how these tools effectively quantified urban growth patterns, revealing a significant increase in built-up land from about 240 km² in 1984 to 315 km² in 2018, with projections indicating continued expansion driven by population growth and infrastructural development.

Akinwale and Adegbite (2018) analysed Landsat satellite imagery from 1984, 2000, and 2015 to assess the spatial growth and land use transformation in Akure, Ondo State. Their findings revealed a substantial conversion of agricultural and vegetated areas into built-up land, with urban expansion radiating outward from the city centre. This growth was attributed to population increase, infrastructural development, and socio-economic activities. Similarly, Ojo and Abiodun (2020) employed remote sensing and GIS to investigate land use and land cover changes in Akure between 1986 and 2018. Their study showed a marked decline in forested areas alongside an increase in residential and institutional land uses, driven by urbanisation, industrial activities, and the presence of major public institutions like the Federal University of Technology Akure (FUTA).

Ogunleye and Adebayo (2021) employed remote sensing and GIS techniques using multi-temporal Landsat imagery from 1990, 2005, and 2020 to assess urban sprawl in Abuja, Nigeria's Federal Capital Territory. Their change detection analysis revealed a marked increase in built-up areas, expanding from 9% in 1990 to 31% in 2020, alongside a sharp decline in vegetation cover, which reduced from 48% to 21% over the same period. Water bodies remained relatively constant, while bare surfaces and rocky outcrops showed varying trends due to ongoing infrastructural development. The study linked this rapid urban expansion to rising population pressure and government-led housing schemes, stressing the need for sustained spatial monitoring and urban planning to manage future growth effectively.

Adebayo and Fashoto (2020) conducted a geospatial analysis of urban expansion in Akure, Nigeria, from 1990 to 2020, using topographic maps and multi-temporal Landsat imagery. Through ground validation and maximum likelihood classification, their findings revealed a significant increase in built-up areas by approximately 160%, with corresponding decreases in agricultural land and forest cover. The study highlighted the spatial transformation driven by population growth, infrastructural development, and institutional expansion.

Salami and Olanrewaju (2021) assessed the impact of urban sprawl on agricultural land in Offa, Kwara State, using Landsat data from 1990, 2005, and 2020. Using ArcGIS and ERDAS Imagine, they applied supervised classification to measure land use change. Results showed a reduction in agricultural land from 150.22 km² in 1990 to 102.47 km² in 2020, with built-up areas expanding from 19.8 km² to 68.6 km² during the same period, an increase of over 246%. The study highlighted the urgent need for sustainable urban planning to address the continued encroachment of agricultural land.

2.3.3 Drivers of Land Cover Change

Various scholars have identified a range of factors driving land cover change. Seto et al. (2012) emphasise that urban expansion is influenced by complex interactions among demographic trends, economic activities, institutional frameworks, and infrastructural development. They note that rapid population growth and rural-to-urban migration continue to be dominant drivers, often resulting in informal settlements and pressure on urban infrastructure. Similarly, Lambin and Meyfroidt (2011) argue that land use and cover changes are shaped by a combination of proximate causes such as land demand by households, industries, and agriculture, as well as underlying drivers, including policy decisions, market dynamics, and environmental limitations. These perspectives highlight the need for integrated land management strategies that consider both socio-economic pressures and environmental constraints.

Land cover change is driven by a complex interplay of forces operating across global, regional, and local scales. While natural disturbances such as wildfires, extreme weather events, and geophysical hazards contribute to environmental change, human-induced activities remain the dominant drivers of land use and land cover change (IPBES, 2019). According to the United Nations (2022), key anthropogenic drivers include rapid population growth accelerating urbanisation (Liu et al., 2020; Chen et al., 2020), agricultural intensification and expansion (Laurance et al., 2014), livestock grazing (Henderson et al., 2017), and globalised economic processes such as trade and investment flows (Meyfroidt et al., 2022). These drivers are interconnected and often reinforce one another, highlighting the importance of integrated policy responses and spatial planning to mitigate adverse impacts on ecosystems and sustainable land use.

According to Sumbo et al. (2025), rapid population growth, migration influx, and speculative land acquisition significantly contribute to the transformation of peri-urban agricultural lands into residential and commercial enclaves, particularly in fast-growing cities such as Lagos.

Their study using structural equation modelling and GIS data revealed that ineffective land-use regulation, coupled with rising demand for housing and infrastructure, has accelerated unplanned expansion into farmland. Similarly, Atu et al. (2022) highlight that in both Nigeria and Ghana, the conversion of rural agricultural zones is largely influenced by infrastructure-driven development, compulsory land acquisition, and the formalisation of customary land tenure. These processes are intensified by poor urban governance and a lack of integrated spatial planning, leading to the fragmentation of agricultural landscapes and a decline in food production potential at the urban fringe.

A major driver of land cover change in peripheral regions is the continued increase in urban population, particularly in developing countries. According to Ajayi et al. (2023), urban areas in sub-Saharan Africa are experiencing rapid population growth, primarily due to rural–urban migration rather than natural population increases alone. This migration is motivated by perceived economic benefits, including access to employment, education, healthcare, and urban infrastructure. Recent projections by UN-Habitat (2022) confirm that Africa continues to exhibit the highest rate of urbanisation globally, with urban population growth rates surpassing those of other regions. As urban populations expand, the pressure for land intensifies initially for residential development and subsequently for commercial investments and infrastructure, especially in peri-urban zones where land values are lower and regulatory enforcement is weaker. This trend has resulted in the widespread conversion of agricultural land to non-agricultural uses, thereby raising concerns over food security and sustainable urban development (Odeyemi et al., 2024). The displacement of rural communities and the commodification of farmland near urban centres highlight the complex socio-economic challenges posed by rapid and unregulated urban growth.

The World Bank (2023) highlights several structural and socio-economic factors that predispose African cities to rapid and often unplanned urbanisation. These include pervasive

violence, uneven economic growth, insufficient urban planning frameworks, low educational attainment, weak governance institutions, overexploitation of natural resources, and heightened vulnerability to climate-induced disasters. Furthermore, the report emphasises persistent challenges such as inadequate access to clean water and electricity, fragmented healthcare systems, limited educational infrastructure and quality, high unemployment rates, gender inequalities in development programs, and policies that disproportionately benefit political and economic elites. Collectively, these factors constrain sustainable urban development and exacerbate social inequalities across the continent.

Okoro and Adeoye (2022) asserted that Nigeria's rapid urban population growth and expansion are largely driven by declining mortality rates coupled with sustained high fertility rates, resulting in significant natural increase within urban areas. Furthermore, Ajayi and Aluko (2023) highlight that rapid urbanisation in Nigeria is influenced not only by natural population growth but also by rural-to-urban migration and the strategic establishment of governmental institutions, educational centres, industrial parks, commercial zones, and tourism hubs. These factors collectively stimulate urban sprawl and intensify land use changes, particularly in metropolitan and peri-urban regions.

Lawal and Ibrahim (2025) employed a mixed-methods approach combining remote sensing, GIS analysis, and household surveys to quantify land use changes over the past three decades. Their study found an average annual urban encroachment rate of approximately 14.8 km², culminating in the loss of over 500 km² of agricultural land between 1990 and 2020. This rapid conversion is primarily attributed to intensified development projects driven by sustained internal migration, rising demand for residential and commercial infrastructure, and limited enforcement of land use policies. The findings highlighted the urgent need for integrated spatial planning to balance urban growth with agricultural land preservation.

2.3.4 Impact of Land Cover Change on Agricultural Activities

Agricultural activities constitute the primary livelihood source for communities residing in urban fringe areas across various countries (Deribew, 2020). However, the ongoing conversion of agricultural land to urban and other non-agricultural uses has significantly reduced the availability of viable farmland, posing serious challenges to food security and sustainable land management (Wang et al., 2021). Terfa et al. (2019) highlight significant impacts on the environment and land components due to the conversion of agricultural fields into urban areas, resulting in the transformation of natural vegetation into impervious surfaces (Teferi & Abraha, 2017).

LC change contributes to the loss of farmlands and open spaces. Studies indicate that in the United States alone, urban sprawl is projected to consume 7 million acres of farmland, 7 million acres of environmentally sensitive land, and 5 million acres of other lands between 2000 and 2025 (D'Amour et al., 2017; Wang et al., 2016; Yirsaw et al., 2017). The encroachment of urban expansion on agricultural land adversely affects agricultural productivity globally, as observed by Arsiso et al. (2018) and Shiferaw et al. (2017). Jiang et al. (2013) further indicate that LULCC, particularly urban expansion onto agricultural land, is linked with both reduced agricultural land areas and heightened levels of urban development. The former leads to increased land pressure, while the latter creates more off-farm work opportunities. However, this growth and economic development can also result in increased pressure on agricultural land, intensification of land use, and labour shortages in the agricultural sector (Food and Agriculture Organisation (FAO), 2022; World Bank, 2021).

The declining intensity of agricultural land use and farmland abandonment have been observed in numerous regions and for various crops, predicting future farmland expansion at the expense of other ecosystems (Addis, 2020; Lesiv et al., 2022). These trends pose new challenges for preserving ecosystems and ensuring food security (Fitton et al., 2019). To comprehensively

analyse the environmental impacts of farmland expansion and the sustainability of land resource utilisation, understanding how LULCC influences the intensity of agricultural land use is crucial. Furthermore, the nature and extent of their interaction can directly impact a nation's ability to feed its population and influence the utilisation of agricultural land (d'Amour et al., 2017).

Van Vliet et al. (2017) observed that the irreversible conversion of farmland into built-up areas through urban expansion significantly undermines long-term agricultural capacity and food production systems. Similarly, UN-Habitat (2020) highlighted that rapid rural-to-urban migration in developing countries continues to disrupt traditional agricultural practices, as many rural dwellers abandon farming in search of employment in urban industries and informal sectors. FAO (2021) further emphasised that this trend contributes to labour shortages in rural areas and heightens food insecurity, particularly among low-income urban populations who struggle with the increasing cost of accessing healthy and nutritious meals.

Adebayo et al. (2022) identified several environmental issues stemming from urban growth, including biodiversity loss, land degradation, desertification, and soil erosion. Okon and Etim (2023) contend that urban expansion in the Uyo metropolis negatively impacts agricultural land, with nearly 85% of nearby arable land lost to suburbanisation and urban sprawl. Moreover, there is a shortage of a suitable agricultural labour force, with over 75% of skilled individuals who were previously engaged in agriculture now working in metropolitan areas, residing on the rural-urban fringe, and commuting into the city. Adetunji and Ogunlade (2024) utilised GIS and remote sensing techniques to investigate the impact of rapid expansion in metropolitan Lagos, based on Landsat images from 2000 and 2020. The results indicated a decline in land under water and vegetation, accompanied by significant increases in built-up areas and some expansion of peri-urban agricultural activities.

Similarly, Adeoye and Afolabi (2021) in Ogbomosho and Eze and Oladipo (2022) in Akure found that urban expansion has accelerated the conversion of productive agricultural land into urban uses, resulting in the depletion of fertile farmland. Al-Mahdi et al. (2020), using Landsat TM and OLI satellite imagery, demonstrated that urban sprawl in the Nile Delta has caused extensive transformation of rich agricultural soils into built-up areas. In Benin City, Ibekwe and Okeke (2023) analysed multi-temporal satellite images and reported significant growth in built-up land, largely influenced by the development of educational institutions and migration of low-income populations to the city's periphery.

While urban growth brings numerous benefits, including increased employment opportunities and improved access to goods and services, it also has an adverse impact on agricultural land, such as farmland loss, solid waste disposal, land degradation, and confined environments.

2.3.5 Mitigation Strategies Employed to Combat the Problem of LC Change on Agricultural Land Use

The mitigation of land cover change on agricultural land is essential to sustain food production, conserve ecosystems, and promote resilient urban environments. Recent studies emphasise the critical role of integrated land use planning frameworks that balance urban development with agricultural land preservation (Seto et al., 2022). Effective land use planning employs zoning laws and spatial policies to separate urban growth from prime agricultural areas, thereby reducing land use conflicts (Liu et al., 2021). Holistic land management approaches incorporate agricultural conservation, sustainable infrastructure development, and stakeholder engagement to safeguard productive farmland while accommodating urban expansion (Chen & Zhang, 2023).

Smart growth strategies, as emphasised by Smith et al. (2021), focus on compact, mixed-use developments that prioritise infill and redevelopment to manage urban growth while protecting

open spaces and agricultural lands. These approaches promote higher-density living, transit-oriented development, and the integration of green infrastructure to curb urban sprawl, reduce land consumption, and foster sustainable land use patterns. Similarly, Transfer of Development Rights (TDR) programs remain an effective market-based tool for agricultural land conservation. Recent evaluations by Johnson and Lee (2022) highlight how TDR schemes enable landowners to shift development potential from rural to urban areas, incentivising farmland preservation while guiding growth to appropriate urban zones. Empirical studies continue to confirm the success of TDR in mitigating development pressures on agricultural landscapes (Martinez et al., 2023).

Government-sponsored agricultural land preservation programs continue to play a crucial role in sustaining farmland amid increasing urbanisation pressures. Recent studies highlight the use of financial incentives, tax reliefs, and conservation easements to encourage landowners to maintain agricultural lands in perpetuity (Nguyen & Parker, 2021). These programs aim to protect prime farmland, preserve rural landscapes, and ensure agricultural productivity remains viable. Similarly, Urban Growth Boundaries (UGBs) remain an effective tool for managing urban expansion. As demonstrated by Martinez et al. (2022), UGBs establish regulated limits for urban development, concentrating growth within designated areas to optimise land use efficiency, support infrastructure planning, and conserve surrounding agricultural lands and natural environments.

Government-led agricultural land preservation initiatives remain vital in safeguarding farmland amid mounting urbanisation pressures. Contemporary research highlights the effectiveness of financial incentives, tax benefits, and conservation easements in motivating landowners to maintain agricultural land use over the long term (Chen & Wu, 2023). These measures help protect valuable farmland, conserve rural landscapes, and sustain agricultural productivity. Likewise, Urban Growth Boundaries (UGBs) continue to serve as a strategic planning

instrument for controlling urban sprawl. Recent analyses by Silva et al. (2024) demonstrate that UGBs effectively delineate urban development limits, promoting concentrated growth, enhancing infrastructure efficiency, and preserving adjacent agricultural and natural areas.

Moreover, promoting agroforestry and diversified cropping systems has been shown to improve agricultural sustainability and contribute to effective land conservation (Mendez et al., 2021). Additionally, strategies involving the acquisition and stewardship of agricultural land for long-term use play a critical role in preventing its conversion to non-agricultural purposes (Johnson & Martinez, 2020).

2.4 Summary of Review and the Research Gap

The reviewed literature identified land cover change as a major environmental and socio-economic challenge in rapidly urbanising areas, largely driven by urban growth, population increase, infrastructure development, and socio-economic shifts. These changes negatively affect agricultural land use by reducing arable land, disrupting ecosystems, and threatening food security. Urban expansion into farmlands has led to the displacement of farmers and decreased agricultural output. The studies emphasised that LC change results from complex factors such as poor policy implementation, inadequate land management, and rising demand for urban land. The literature outlines several mitigation strategies to address the impact of land cover change on agricultural land. These include land use planning, smart growth, and Urban Growth Boundaries (UGBs) to manage urban expansion. Other tools, such as transfer of development rights, government preservation programmes, and financial incentives, help protect farmland. Sustainable approaches like agroforestry, diversified cropping, and urban agriculture are also encouraged. Additionally, public awareness and participatory planning are seen as vital for long-term farmland conservation. Despite the wealth of research on land cover change and its implications for agricultural land use in Nigeria, most studies have focused on large urban centres such as Lagos, Akure, Kwara, Makurdi, Zaria, and Abuja. These

investigations tend to concentrate on the extent and patterns of land cover dynamics, often using geospatial tools to quantify land cover change and agricultural land loss. However, there exists a significant gap in the literature in rapidly developing areas such as the Ikpoba-Okha Local Government Area in Edo State. Specifically, there is limited empirical research that provides long-term quantification of agricultural land cover loss within the study area. In addition, the specific socio-economic drivers of land cover change and the contextual effectiveness of mitigation strategies remain limited. This gap in knowledge necessitates a focused study on Ikpoba-Okha, where urban growth is accelerating, yet the agricultural sector remains vital to the local economy and food systems. The current study aims to fill this gap by assessing the rates of land cover change, analysing the impacts on agricultural land use, identifying the drivers of change, and evaluating the strategies employed to mitigate agricultural land encroachment. Through the application of Remote Sensing and Geographic Information Systems (GIS), this research provides evidence-based insights and contributes to a detailed understanding of land cover dynamics and agricultural sustainability in peri-urban Nigeria.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Research Design

Research design refers to a comprehensive plan that outlines the independent and dependent variables being examined, the methodology to be used, the procedures for data collection, and the statistical techniques specified for analysis (Osazee et al., 2019). According to Kothari and Garg (2022), survey design systematically clarifies the characteristics, facts, and elements relevant to a particular study. This study adopts a mixed-method approach, combining both longitudinal and cross-sectional research designs. A cross-sectional design captures data at a single point in time, offering a snapshot of the phenomenon under investigation (Bryman, 2016). Conversely, a longitudinal design involves repeated data collection over time, allowing for the analysis of changes and trends (Caruana et al., 2015). The combination of these designs enabled a comprehensive and detailed investigation through multiple data sources, including questionnaires and focused group discussions. Geographic Information System tools were used to visualise the impact of land cover change on agricultural land use within the study area (see Figure 3.1). The integration of qualitative and quantitative methods in a single study, often called methodological triangulation, was originally proposed by Campbell and Fiske (1959). This methodology blended field surveys, such as questionnaire administration, to gather qualitative and quantitative (empirical) data simultaneously, facilitating a comprehensive analysis and interpretation of the findings (Creswell, 2014).

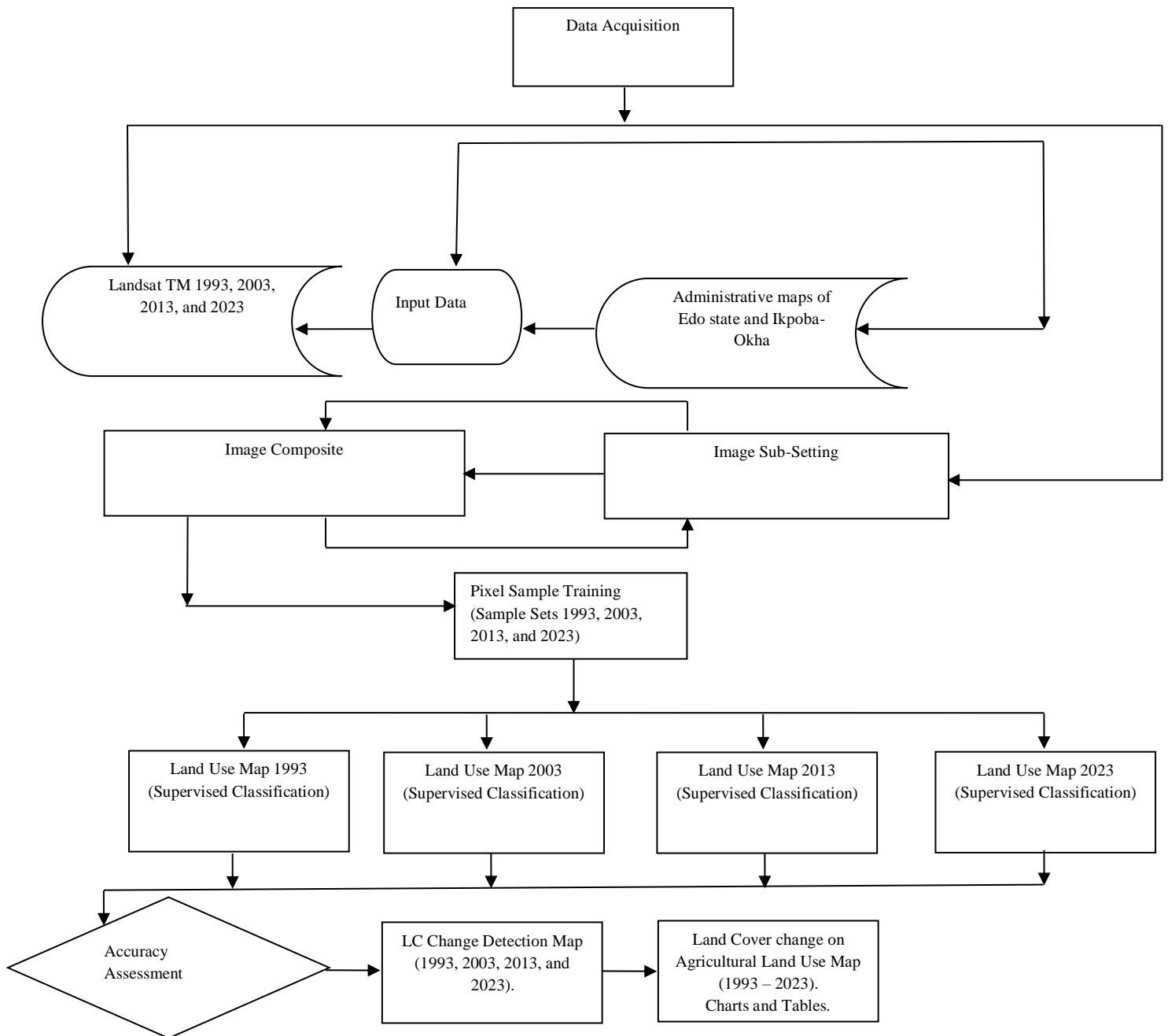


Figure 3.1: Methodology Flow Chart
 Source: Researcher’s Conceptualisation, 2023.

3.2 Reconnaissance Survey

As part of this research, a reconnaissance survey was carried out in Ikpoba-Okha to assess the current state of agricultural land. This enabled the researcher to become acquainted with the surroundings as well as observe the drivers of LC change. This understanding helped identify the mitigation strategies used by residents to adjust to the impact of LC change on agricultural

land use in the study area. During the survey, the researcher interacted with community members and leaders to solicit their support and assistance for this study. Additionally, the reconnaissance survey also provided the researcher with ample opportunity to pre-empt possible challenges that would be faced during data collection and to explore possible ways to avert them.

3.3 Types and Sources of Data

This research employed primary and secondary data to answer the research questions and stated objectives.

3.3.1 Primary Data

Primary data were obtained through the administration of semi-structured questionnaires, field observations, and focused group discussions.

3.3.2 Secondary Data

The secondary data included satellite images (1993, 2003, 2013, and 2023), population data, and administrative and topographic maps of the study area. Population data for the study area were obtained from the National Population Commission (NPC), Benin City, to support the attribute data. Topographic and administrative maps of Ikpoba-Okha were obtained from Edo GIS, Benin City, as reference layers. Landsat images of 1993, 2003, 2013, and 2023 for the study area were downloaded from the United States Geological Survey (USGS) website (<http://usgs.gov>). A study period of 30 years (1993–2023) was used for this study.

3.4 Study Population and Sample Size

The study population for this research comprises household heads across the ten selected fringe communities in Ikpoba-Okha Local Government Area (LGA), Edo State, Nigeria. The shift to household heads as the unit of analysis is intentional, considering that household heads are often the primary decision-makers in matters related to land use, agricultural activity, and land ownership. This approach ensures that the study captures critical drivers influencing land cover

LC change. This focus is supported by empirical research emphasising the significance of household-level dynamics in understanding land resource management (Ajayi & Afolayan, 2020; Odjugo & Ikhuoria, 2022). According to the 1991 Population Census by the National Population Commission (NPC,1991), the selected communities had a combined population of 5,070 persons. To estimate the 2023 population, the United Nations population projection formula was applied using a 2.6% annual growth rate, in line with current NPC recommendations (NPC, 2021):

$$N_t = P e^{rt} \dots\dots\dots \text{(Equation 3.1)}$$

Where: N_t = The number of people at a new or future date,

P = the initial population,

e = the natural logarithm base of 2.71828,

r = Annual growth rate in percent,

t = the time interval.

Applying the compound growth formula, the total population of the selected communities in Ikpoba-Okha Local Government Area (LGA) was projected to the year 2023, yielding an estimated population of approximately 11,527. Based on the average Nigerian household size of six persons per household, as reported by the National Bureau of Statistics (NBS, 2022), the number of household heads in the study area was estimated at 1,921.

3.5 Sample Size Determination

The sample size for administering the questionnaire was determined using the Yemane (1967) formula. The Yamane (1967) formula is a simplified formula used for determining the sample size needed from a given population. It is particularly useful in survey research when you need

to decide how many subjects to include in your sample. The formula (Equation 3. 2) is given by:

$$n = \frac{N}{1+N(e)^2} \dots\dots\dots\text{Equation 3.2}$$

Where:

n = Sample size

N = total population size

e = the degree of precision (0.05).

Using this formula with a 95% confidence level and a 5% (0.05) error margin, for a total population of 1,921 household heads, the calculated sample size was 331 respondents. These were proportionately administered across the Ikpoba-Okha local government area. The Pandey and Verma (2008) proportion allocation formula (equation 3) was used to further disaggregate the sample size based on each community's population. The formula is expressed as:

$$n_i = n \left[\frac{N_i}{N} \right] \dots\dots\dots \text{(Equation 3.3)}$$

Where:

n_i = Sample size for stratum i;

N_i = Population size for stratum i;

n = Total sample size,

N = total population.

The sample size for each selected community was calculated and presented in Table 3.1. The population of each community was used in determining the sample size from the calculated sample for Ikpoba-Okha.

Table 3.1: Sample Size Allocation by Communities

S/N	Communities in Ikpoba-Okha	1991 Population Census Data	Projected Population Data (2023)	Estimated Household Head	Sample Size
1	Idogbo	263	596	99	17
2	Ikpe	445	1011	168	29
3	Iyanomo	1866	4243	707	122
4	Obagie	482	1095	183	32
5	Obarentin	495	1125	187	32
6	Obayantor	533	1211	202	35
7	Ogheghe	463	1052	175	30
8	Okha	168	381	64	10
9	Uhie	223	507	85	15
10	Utezi	135	307	51	9
Total	10	5070	11,527	1921	331

Source: NPC (1991).

3.6 Method of data collection

3.6.1 Structure of the Questionnaire

The questionnaire served as the tool for data collection and was completed independently by respondents and with the assistance of the researcher. A total of 331 questionnaires were administered to respondents across selected communities (as shown in Table 3.1). The questionnaire was designed to elicit information on LC change and its impacts on agricultural land use. The questionnaire was grouped into four sections. The first section contained questions on respondents' demographic information, while the other sections focused on questions relating to the drivers of land cover changes, impacts of agricultural land use encroachment on agricultural activities, and the mitigation strategies employed to combat the problems of land cover change on agricultural land use.

3.6.2 Focus Group Discussion

Focus Group Discussion (FGD) was conducted to provide qualitative insights into mitigation strategies for agricultural land use encroachment in Ikpoba-Okha LGA, addressing Objective

5 of this research. Five purposively selected household heads shared their experiences and perspectives on land cover changes and mitigation efforts. The discussion was recorded, transcribed and supplemented with field observations to provide contextual support. Key themes explored included traditional land tenure practices, community-led conservation initiatives, challenges in policy enforcement, and the effectiveness of existing strategies.

3.7 Sampling Technique

The study employed a purposive sampling method. This non-probability sampling technique enables researchers to intentionally select participants who possess specific characteristics or knowledge relevant to the study objectives, thereby ensuring the collection of rich and targeted data (Palinkas et al., 2015). The choice of purposive sampling was justified because the phenomenon under investigation was present in the selected communities. Given that these communities are primarily farming communities, purposive sampling ensured that participants who were directly involved in agricultural activities were included in the study.

3.8 Data Analysis

3.8.1 Land Cover Change Characteristics

The analysis outlined here aimed to address objective “1”. The initial step involved image resampling to adjust for variations in image resolution. While the images were originally at 30m resolution, the resampling process was necessary due to alignment issues in the ArcGIS software. This was followed by image windowing of the study area from the Landsat images using the local government area shapefile. Subsequently, a Raster Band Composite was generated from the Landsat images to facilitate visual interpretation. This composite combined the RGB bands for the three series of Landsat sensors, with Landsat TM and ETM+ using RGB bands 4, 3, 2, and Landsat OLI-TIRS using RGB bands 5, 4, 3. In this configuration, built-up areas appeared light blue, vegetation in varying shades of red, and water bodies in dark blue or black.

Supervised classification was then conducted on the images to categorise pixels into land use and land cover classes. Drawing upon prior knowledge and ground truth data, the classification included built-up, water body, agricultural land (cultivated terrestrial vegetation, natural vegetation, and semi-natural vegetation), and bare land. The Maximum Likelihood Algorithm was employed for its statistical robustness and optimality properties, with an accepted error margin of 5% (Lehmann and Casella, 2006).

Following classification, the area in hectares (ha) and percentages (%) for each land use land cover class were computed and compared across the years. Additionally, error matrix and Kappa analysis were performed to evaluate the accuracy of the results (Kipling, 2012).

Table 3.2: Land Use Classification Scheme (Adapted from FAO-AFRICOVER, 1998).

Land Use/ Land Cover Types	Description
Bare Land	Includes rock outcrops, sandy lands, and unpaved roads.
Built-Up Areas	Includes commercial areas, settlements, paved roads, industries, factories, and government facilities.
Cultivated Terrestrial Vegetation	Encompasses all vegetation planted or cultivated with the intent to harvest, including all categories of crops.
Natural Vegetation	Areas where natural vegetation is relatively undisturbed and unaltered by human activities
Semi-Natural Vegetation	Includes all vegetation not planted by humans but influenced by human activities such as grazing and logging.
Water Bodies	Comprises rivers, waterlogged areas, lagoons, lakes, and streams.

Source: FAO (1998).

3.8.2 Rate of Changes Between 1993 and 2023

Objective “2” aimed to utilise the land cover classification maps obtained in Objective “1” to analyse and quantify the spatial patterns and rates of change in the area’s land use and land cover over the review period. The analysis compared land cover classes from four different years (1993, 2003, 2013, and 2023), using the first image (1993) as the reference point.

Change detection was the primary focus, comparing images from the three periods to identify and quantify land-use changes. The simple differencing method was employed for this analysis, which entailed subtracting pixel responses in one image from corresponding pixel responses in

another image (denoted as t1-t0), representing the change between the current and previous inventory data.

The percentage change was then calculated to determine the rate of change by dividing the observed change for each land use class by the initial year's data and multiplying by 100. Additionally, the annual rate of change was determined by dividing the percentage change for each class by the number of years (ten years and twenty years, respectively, for the first and second intervals).

Mathematically, this is given as:

i. Class change = $t1 - t0$

ii. Percentage Class Change = $\frac{t1 - t0 \times 100}{t1}$

Where:

t1 = Land Cover of the initial image

t0 = Land cover of the latter year

iii. Annual rate of change = $\frac{PC}{\text{Number of years}}$

Where:

PC = Percentage of Change

3.8.3 Statistical Analysis

The data collected from the questionnaire and field observations for objectives 3-5 were analysed and presented using descriptive statistics, including tables, graphs, percentages, and frequency counts. These methods facilitated the description, interpretation, and explanation of findings related to the drivers of LC changes, the impact of land cover change on agricultural activities, and the mitigation strategies employed to combat this problem.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Results

4.1.1 Spatial Analysis

4.1.1.1 Different Land Cover Classes across the Study Area from 1993 to 2023

The mapping out of different land cover classes of Ikpoba-Okha Local Government Area in 1993, 2003, 2013, and 2023 was carried out by classifying and polygonising the satellite images into four major land use types as stated earlier. See Figure 4.1

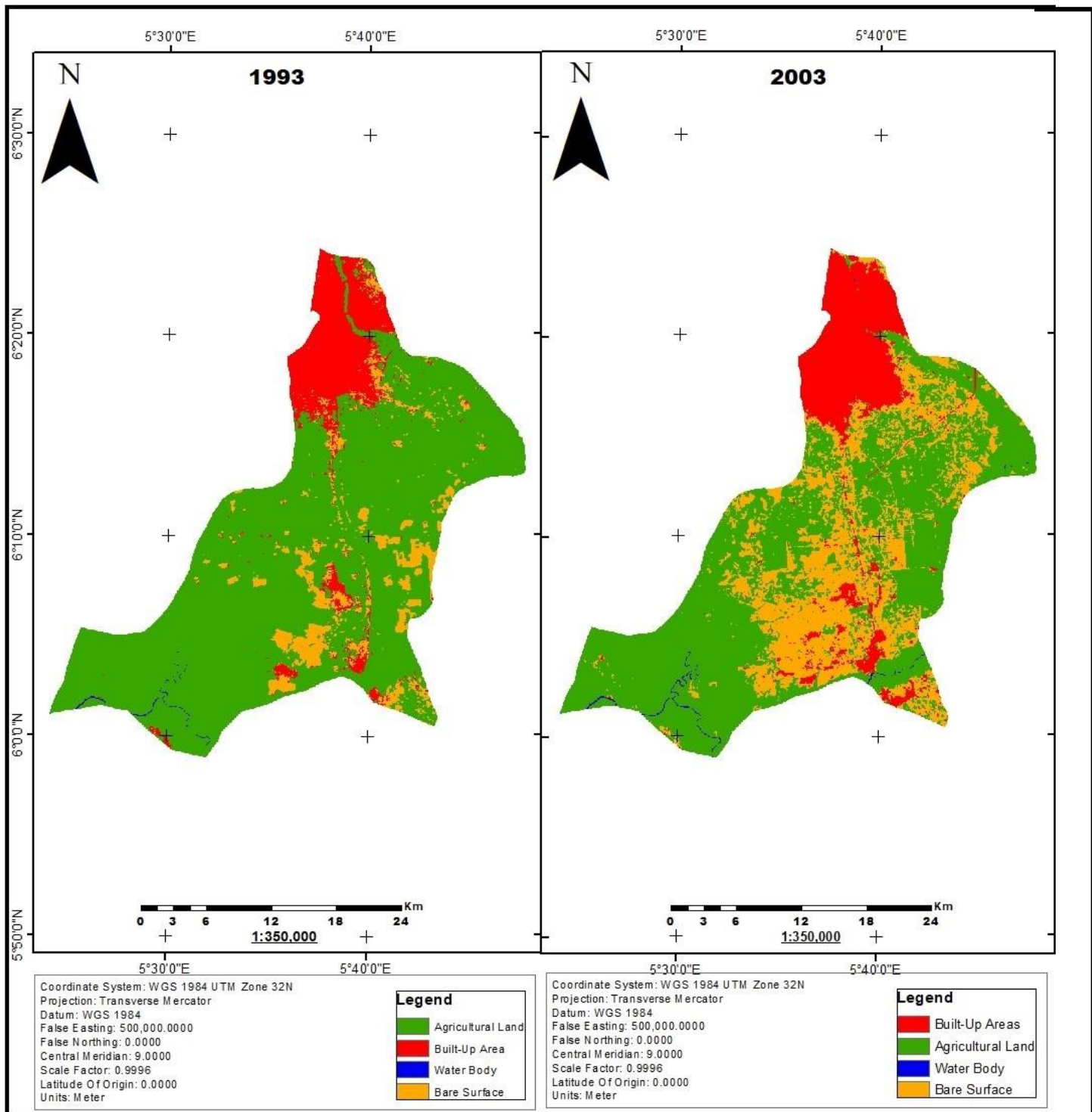


Figure 4.1: Land cover classes of Ikpoba-Okha LGA of 1993 and 2003
 Source: Author's Analysis, 2025.

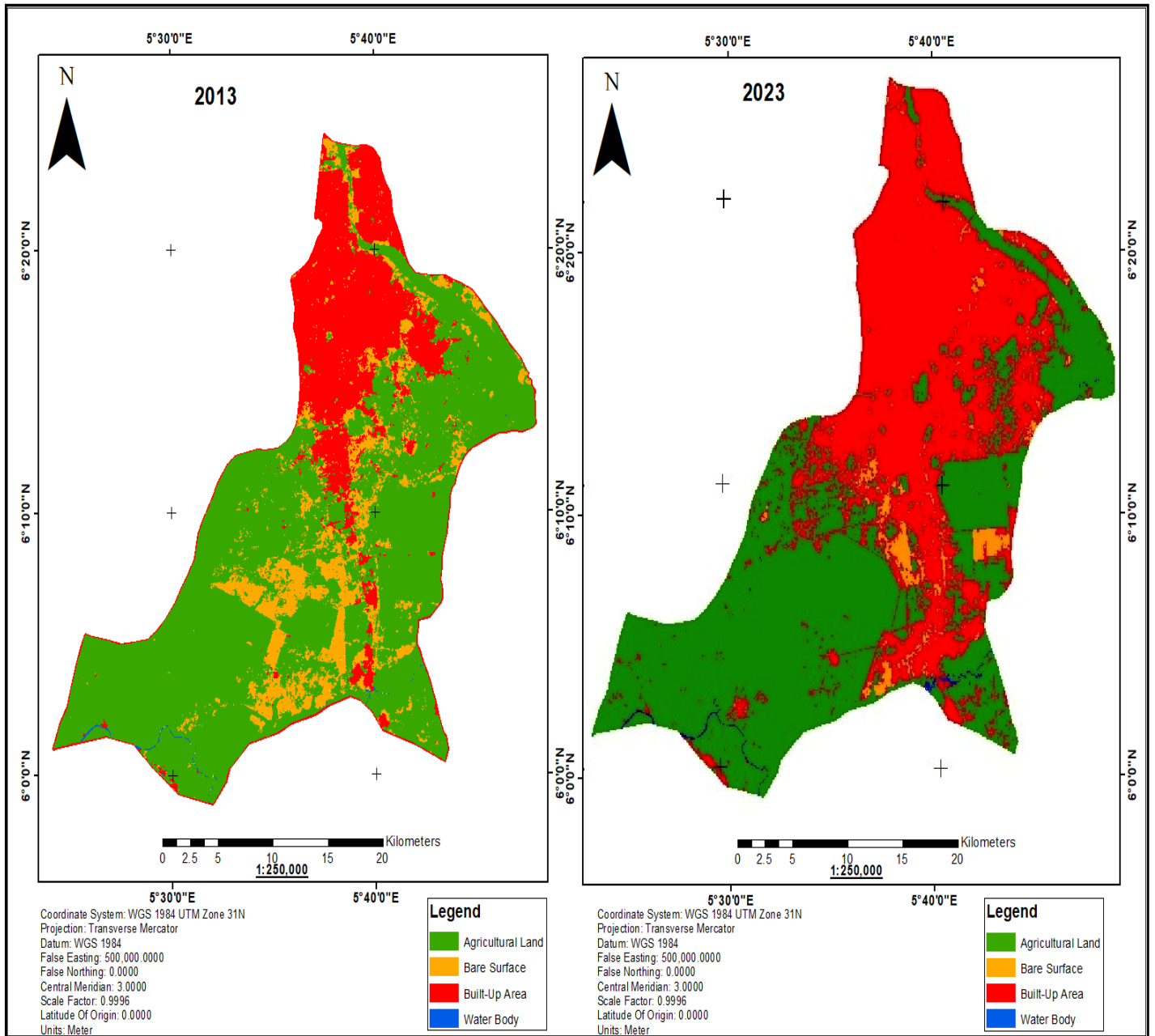


Figure 4.2: Land cover classes of Ikpoba-Okha LGA of 2013 and 2023.

Source: Author's Analysis, 2025.

Table 4.1: Different Land cover classes in Ikpoba-Okha between 1993 and 2023

Land Cover Classes	1993 (Km ²)	%	2003 (Km ²)	%	2013 (Km ²)	%	2023 (Km ²)	%
Agricultural Land	659.202	78.520	475.055	56.587	556.98	66.353	427.65	50.941
Bare Surface	72.3042	8.612	230.528	27.460	108.802	12.962	21.6324	2.577
Built-Up Area	106.662	12.705	131.266	15.636	172.403	20.538	387.489	46.157
Water Body	1.3662	0.163	2.6658	0.318	1.239	0.148	2.7315	0.325
Total	839.5344		839.5148		839.424		839.5029	

Source: Author’s Analysis, 2025.

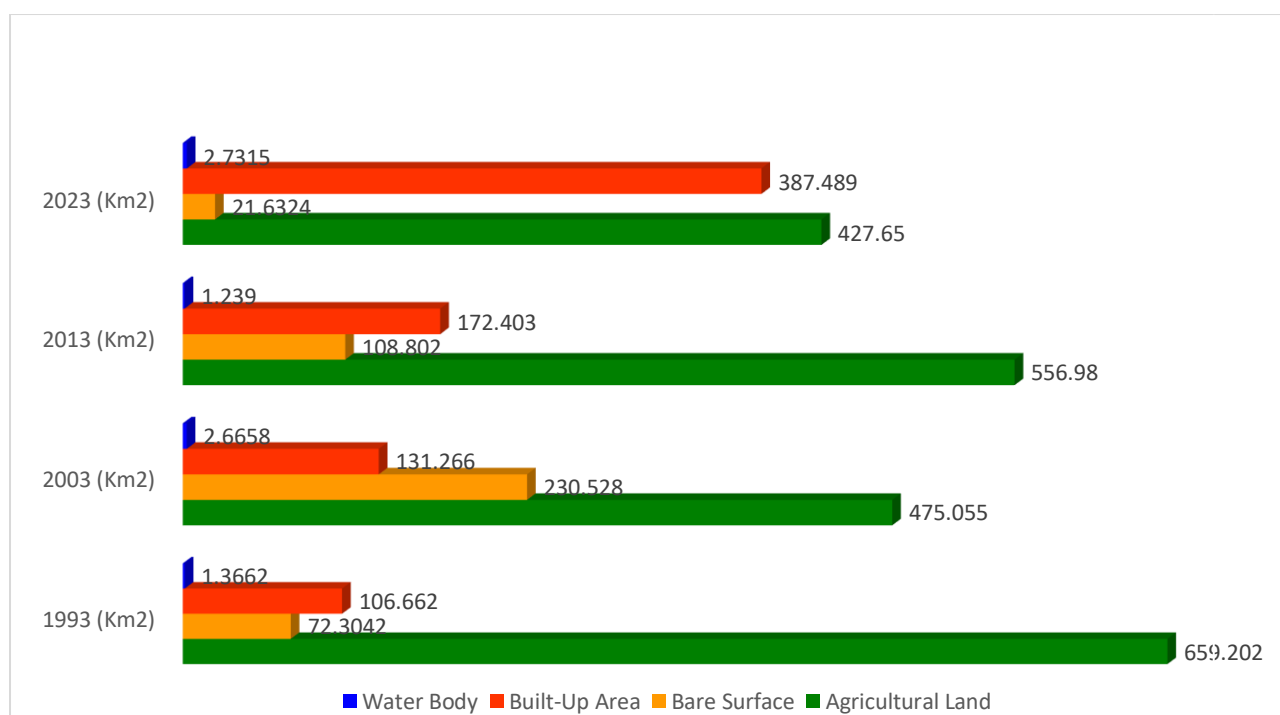


Figure 4.3: Bar of Land cover classes across the study area from 1993 to 2023.

Source: Author’s Analysis, 2025.

4.1.1.2 Accuracy Assessment

The confusion matrix assessment was utilised to evaluate the accuracy of classified maps. Each classified map’s overall accuracy was computed by dividing the sum of the diagonal entries by the total entries in the confusion matrix. The overall accuracy and Kappa values for all the classified maps were between 85% to 95% and 0.76 to 0.93, respectively, as presented in Table 4.4. This result shows that all the overall accuracies are above 85%, signifying an effective

image processing approach used in the study. It also produced kappa values above 0.75, signifying a substantial and almost perfect kappa coefficient, indicating an unbiased classification assessment.

Table 4.2: 1993, 2003, 2013, and 2023 Accuracy Assessment

1993 confusion matrix					
Land Cover Classes	Built-Up Areas	Agricultural Land	Water Bodies	Bare Surface	Total
Built-Up Areas	1479	770	80	105	2434
Agricultural Land	755	5710	380	137	6982
Water Bodies	141	20	11,369	54	11,584
Bare Surface	393	245	61	347	1046
Total	2768	6745	11,890	643	22,046

Overall accuracy = (19,059/22,046) = 85.75%
Kappa coefficient = 0.7643

2003 confusion matrix					
Land Cover Classes	Built-Up Areas	Agricultural Land	Water Bodies	Bare Surface	Total
Built-Up Areas	2977	739	4	105	3825
Agricultural Land	410	8553	120	19	9102
Water Bodies	1	0	5177	0	5178
Bare Surface	507	9	38	588	1142
Total	3895	9301	5339	712	19,247

Overall accuracy = (17,295/19,247) = 89.86%
Kappa coefficient = 0.8450

2013 confusion matrix					
Land Cover Classes	Built-Up Areas	Agricultural Land	Water Bodies	Bare Surface	Total
Built-Up Areas	8092	981	87	9	9169
Agricultural Land	1035	10,291	34	0	11,360
Water Bodies	1	5	4517	0	4523
Bare Surface	145	59	7	1085	1296

Total	9273	11,336	4645	1094	26,348
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Overall accuracy = $(23,985/26,348) = 91.03\%$

Kappa coefficient = 0.8641

2023 confusion matrix

Land Cover Classes	Built-Up Areas	Agricultural Land	Water Bodies	Bare Surface	Total
Built-Up Areas	5119	336	2	94	5551
Agricultural Land	299	7957	26	49	8331
Water Bodies	0	1	11,523	3	11,527
Bare Surface	127	56	288	345	816
Total	5545	8350	11,839	491	26,225

Overall accuracy = $(24,944/26,225) = 95.12\%$

Kappa coefficient = 0.9254

4.1.1.2 Rate of LC Changes

The rate of change in land cover (LC) is a critical indicator of the dynamics and transformation occurring within the study area over time. The rate of LC changes in Ikpoba-Okha between 1993 and 2023, as shown in Tables 4.2 and 4.3, reveals significant shifts in land use patterns, particularly in built-up areas, 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 4.3: Rate of LC changes (Km²) in Ikpoba-Okha

Rate of Change (Km ²)	Agricultural Land	Bare Surface	Built-Up Area	Water Body
1993 - 2003	-184.147	158.2238	24.604	1.2996
2003 - 2013	-129.33	-87.1696	215.086	1.4925
1993 - 2023	-231.552	-50.6718	280.827	1.3653

Table 4.4: Rate of LC changes (%) in Ikpoba-Okha

Rate of Change (%)	Agricultural Land	Bare Surface	Built-Up Area	Water Body
1993 - 2003	-21.933	18.847	2.931	0.155
2013 - 2023	-15.412	-10.385	25.619	0.178
1993 - 2023	-27.579	-6.036	33.452	0.163

Source: Author's Analysis, 2025.

4.1.2 Statistical Analysis

4.1.2.1 Drivers of Land Cover (LC) Change in Ikpoba-Okha

Table 4.3 provides insights into respondents' perceptions of the major drivers of Land Cover (LC) change in Ikpoba-Okha. Responses from the field survey indicate that urban development is perceived as the most significant driver of land cover change in Ikpoba-Okha. Out of the total respondents, 166 individuals, representing 50.2% identified urban expansion as the primary force influencing changes in land utilisation within the area. Migration was cited by 83 respondents, accounting for 25.1% of the total, while 49 respondents (14.8%) pointed to population growth as a contributing factor. In addition, 33 respondents (9.9%) mentioned other influences such as industrialisation, deforestation, land speculation, and shifts in government policy as relevant drivers of LC change.

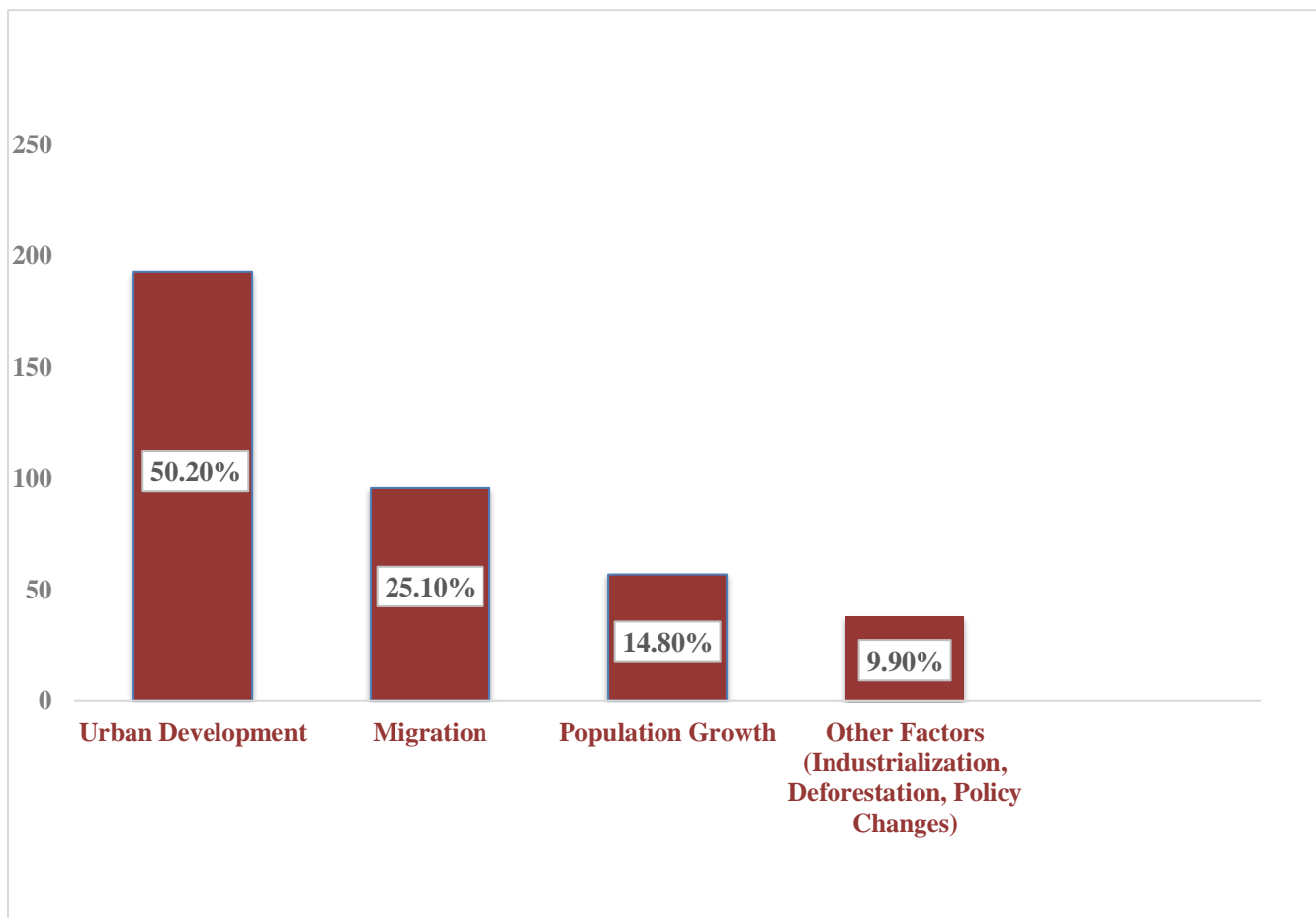


Figure 4.4: Drivers of Land Cover Change

Source: Field Survey, 2025

4.1.2.2 Impact of Land Cover Change on Agricultural Activities

The impact of Land Cover change on agricultural activities in Ikpoba-Okha is multifaceted, affecting land accessibility, productivity, and environmental sustainability. The analysis focused on aspects such as land availability, productivity shifts, environmental challenges, and perceptions of change.

The majority of respondents, about 249 (75.2%), reported that their land size had decreased over time, suggesting significant farmland loss attributed to LC change. Meanwhile, 33 respondents (10.0%) experienced an increase in land size, and 49 respondents (14.8%) indicated no change.

In terms of productivity, 133 respondents (40.1%) cited low agricultural productivity as a consequence of farmland loss. Additionally, 98 respondents (29.6%) reported inaccessibility of land as a barrier to expanding farming operations. Environmental degradation, including soil depletion and pollution, was identified by 67 respondents (20.2%), while 33 respondents (9.9%) reported land fragmentation as a challenge affecting mechanised farming and soil fertility. Limited market access was mentioned by 49 respondents (14.8%), and 66 respondents (19.9%) noted that employment opportunities in the agricultural sector had declined.

Table 4.5: Impact of LC Change on Agricultural Activities in Ikpoba-Okha

Impact of LC Change	No. of Respondents	Percentage (%)
Low Productivity	133	40.1%
Inaccessibility of Land	98	29.6%
Environmental Degradation	67	20.2%
Employment Opportunities Affected	66	19.9%
Market Access Affected	49	14.8%
Land Fragmentation	33	9.9%

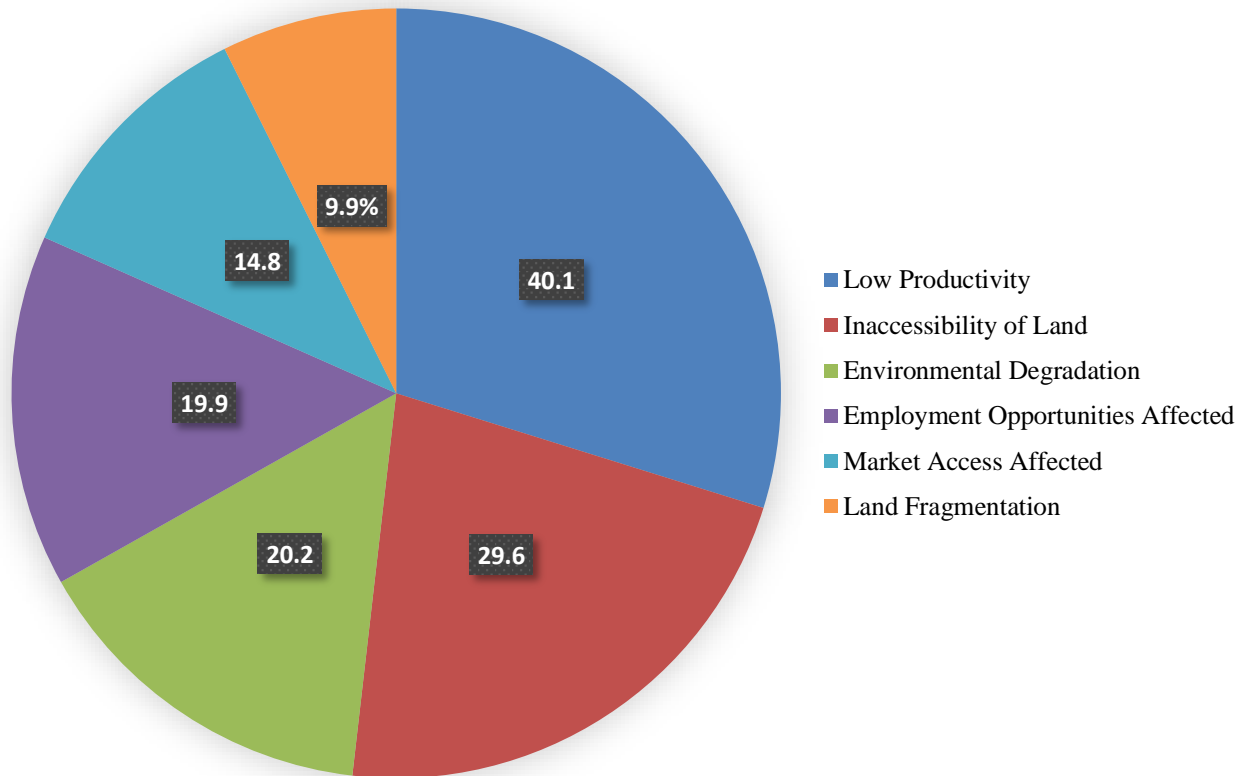


Figure 4.5: Impact of LC Change on Agricultural Activities by Perception

Source: Field Survey, 2025.

4.1.2.3 Mitigation Strategies employed to combat the problem of Agricultural Land use encroachment

4.1.2.3.1 Government Strategy by Effectiveness

The effectiveness of government strategies in addressing the negative impacts of land cover change was assessed using stakeholder feedback. The strategies evaluated include land use zoning, agricultural subsidies, environmental regulations, and afforestation programmes. The results are summarised in the table below:

Table 4.6: Perceived Effectiveness of Government Strategies by Respondents

Government Strategy	Ineffective (Count)	Ineffective (%)	Somewhat Effective (Count)	Somewhat Effective (%)	Effective (Count)	Effective (%)	Total
Land Use Zoning	97	29.3%	135	40.8%	99	29.9%	331
Agricultural Subsidies	125	37.8%	107	32.3%	99	29.9%	331
Environmental Regulations	84	25.4%	135	40.8%	112	33.8%	331
Afforestation Programmes	58	17.5%	124	37.5%	149	45.0%	331

4.1.2.3.2 Community Collaboration and Individual Involvement

Community-led initiatives are key to mitigating LC change. Respondents provided information on their level of involvement in three key areas: Collaborative Land Management, Advocacy & Awareness Campaigns, and Personal Conservation Efforts.

Table 4.7: Levels of Community Involvement in LC Mitigation Strategies

Initiative	Not Involved (Count)	Not Involved (%)	Partially Involved (Count)	Partially Involved (%)	Actively Involved (Count)	Actively Involved (%)	Total
Collaborative Land Management	89	26.9%	105	31.7%	137	41.4%	331
Advocacy & Awareness Campaigns	95	28.7%	107	32.3%	129	39.0%	331
Personal Conservation Efforts	77	23.3%	88	26.6%	166	50.2%	331

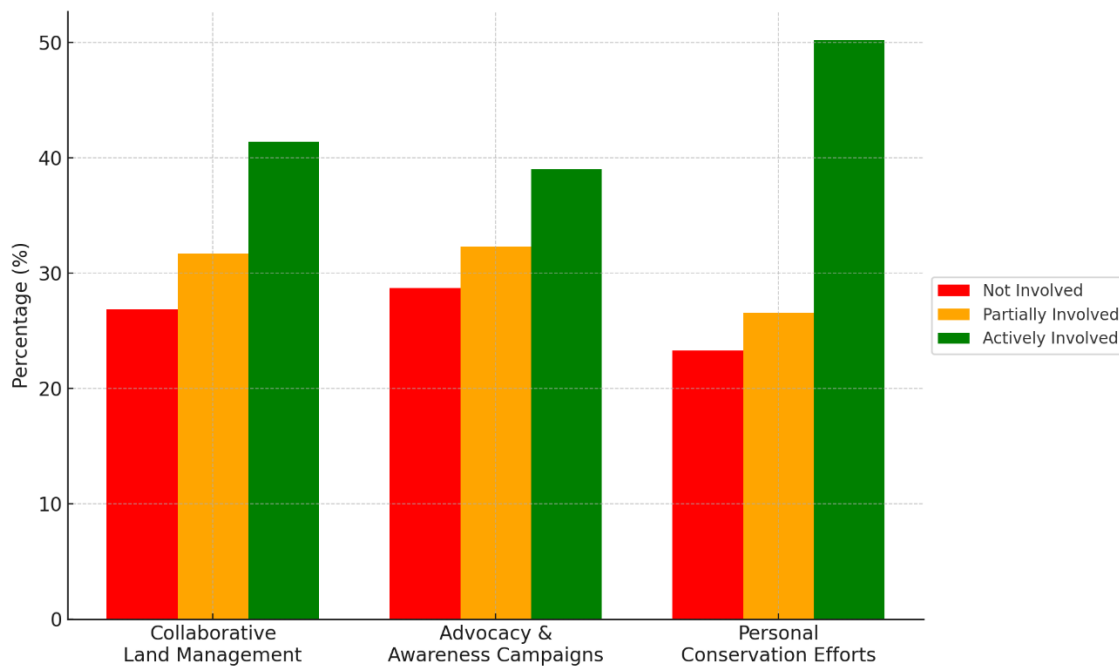


Figure 4.6: Community Collaboration and Individual Involvement

Source: Field Survey, 2025

4.2 Discussion of Findings

4.2.1 Land Cover Changes across the Study Area

The land cover dynamics observed in Ikpoba-Okha over the 30 years between 1993 and 2023 reflect a significant transformation in land use patterns, driven largely by urbanisation, population growth, and evolving socio-economic activities. The satellite imagery and classification data across the four years (1993, 2003, 2013, and 2023) reveal a continuous expansion of built-up areas, a concurrent reduction in agricultural land, fluctuations in bare surface extent, and relative stability in the coverage of water bodies. These patterns provide a broader regional and global trend, particularly in peri-urban and rapidly urbanising environments, where the encroachment of development into previously rural or agricultural landscapes is becoming increasingly common (Seto et al., 2011; United Nations, 2018).

The most significant change in Ikpoba-Okha's land cover is the dramatic increase in built-up areas. In 1993, built-up area accounted for 12.705% of the total land cover, equivalent to 106.662 km². By 2003, this figure had increased to 15.636% (131.266 km²), rising further to 20.538% (172.403 km²) in 2013 and ultimately reaching 46.157% (387.489 km²) by 2023. This fourfold expansion in built-up land is indicative of the intense pressure exerted by urbanisation and infrastructure development in the region. The rapid growth of the urban footprint can be attributed to factors such as increased rural-to-urban migration, population pressure, industrialisation, and improvements in transportation and road networks. As observed in other Nigerian peri-urban settings, such as Ibadan and Abuja, the demand for residential and commercial space has often led to the conversion of agricultural lands and natural vegetation into concrete-dominated landscapes (Ayanlade & Chima, 2020; Akinyemi, 2017). This phenomenon aligns with global patterns, particularly in the Global South, where urbanisation has been identified as one of the leading drivers of land cover change and environmental degradation (Bren d'Amour et al., 2017).

Correspondingly, agricultural land experienced a steady and significant decline over the study period. In 1993, agriculture dominated the landscape, occupying 78.520% (659.202 km²) of the land. However, by 2003 this figure had fallen to 56.587% (475.055 km²), then to 66.353% (556.98 km²) in 2013, and finally to 50.941% (427.65 km²) in 2023. This reduction reflects the direct impact of urban expansion on farmland availability. As settlements grow outward from urban cores, fertile agricultural lands are often the first to be converted due to their proximity, relatively flat topography, and accessibility. Moreover, many landowners are incentivised to sell or lease their farmland for residential or commercial development, owing to the higher immediate financial returns compared to agricultural yields. This shift from agriculture to real estate development poses serious implications for food security, rural livelihoods, and

environmental sustainability, particularly in regions already grappling with land scarcity and rising urban poverty (Foley et al., 2005; Okunlola et al., 2019).

The pattern of change in bare surfaces is particularly notable for its fluctuation over time. In 1993, bare surfaces covered 8.612% (72.304 km²) of the area, rising sharply to 27.460% (230.528 km²) by 2003. This increase likely reflects widespread land clearing activities, sand excavation, deforestation, and other preparatory activities for construction and infrastructure development. However, by 2013, the coverage of bare surfaces had decreased to 12.962% (108.802 km²), and further declined to just 2.577% (21.632 km²) in 2023. This decline is as a result of a land-use transition, where previously cleared areas were gradually absorbed into built-up infrastructure such as buildings, roads, and industrial facilities. Similar transitions have been observed in studies conducted in urbanising regions of Asia and Africa, where land conversion follows a typical cycle from vegetated or agricultural cover to bare surface (during site preparation) and eventually to built-up area (Lambin et al., 2003; Dewan & Yamaguchi, 2009). The diminishing presence of bare surfaces in recent years also suggests a reduction in available land for new construction, highlighting the extent to which the landscape has already been transformed.

Water bodies, in contrast to other land cover types, demonstrated relative stability over the 30 years. In 1993, water bodies accounted for a minimal 0.163% (1.366 km²) of the total land area, which increased slightly to 0.318% (2.666 km²) in 2003 and reached 0.148% (1.239 km²) in 2013, before returning to 0.325% (2.732 km²) in 2023. The minor fluctuations may be attributed to temporary waterlogging, increased rainfall, seasonal flooding, or the development of artificial ponds and drainage retention zones as part of urban infrastructure. However, the overall stability suggests that these features have not been significantly encroached upon, possibly due to regulatory protections or their limited suitability for development.

The land cover changes observed in Ikpoba-Okha present a clear narrative of urban-driven landscape transformation. The rapid expansion of built-up areas, at the expense of agricultural and open lands, highlighted the need for integrated land management strategies that balance development with environmental and food security concerns. Without targeted interventions such as urban planning policies, green space preservation, and land use zoning Ikpoba-Okha may continue to face the adverse consequences of uncontrolled urban growth, including environmental degradation, loss of biodiversity, and socio-economic dislocation. These findings align with global perspectives that advocate for sustainable urbanisation pathways in developing countries, where land resources are increasingly under pressure (UN-Habitat, 2020; FAO, 2021).

4.2.2 Accuracy Assessment

The confusion matrices demonstrate consistently high classification accuracy (85.75-95.12%) and Kappa reliability (0.76-0.93), validating the methodological robustness of this study (Foody, 2020). However, beyond these accuracy metrics, the misclassification patterns expose critical land cover transitions that define the region's evolving landscape.

A dominant narrative emerges of built-up areas systematically encroaching into agricultural zones, with misclassified pixels between these classes peaking during transitional phases of urban expansion. For instance, the 739 agricultural pixels misclassified as built-up in 2003 (Table 4.1) coincide with the period of most rapid farmland loss (184 km², 1993–2003). This aligns with observations in Nigeria's Niger Delta, where 60% of urban expansion between 2000-2015 occurred at the expense of croplands (Ujoh et al., 2021). The encroachment follows a predictable spatial logic: prime agricultural land near transport corridors was preferentially converted, mirroring the "path-dependent urbanisation" model described by Seto et al. (2018) in developing economies.

Simultaneously, Bare surfaces displayed a cycle of rapid increase followed by sharp decline, initially expanding by 158 km² (1993-2003) as land was cleared for development, then contracting by 87 km² (2013-2023) as these areas were absorbed into the urban fabric. The confusion matrices capture this transition through misclassifications like the 507 bare surface pixels erroneously labelled as built-up in 2003, a diagnostic signature of land in transitional states (Herold et al., 2022). This two-phase conversion (agricultural → bare → built-up) reflects what Lambin and Meyfroidt (2020) term "land use succession," a hallmark of unplanned urban expansion in the Global South.

Agricultural systems displayed signs of stress and abandonment, particularly in marginal areas. The persistent misclassification of farmland as bare surfaces (e.g., 245 pixels in 1993) suggests degradation preceding full conversion, a pattern documented in Nigeria's Middle Belt, where soil exhaustion drove 32% of farmland abandonment between 2005–2015 (Eze et al., 2022). This degradation encroachment feedback loop exacerbates food security risks, as the highest-quality farmland is urbanised first, leaving less productive areas for cultivation (FAO, 2022).

Water bodies demonstrated remarkable stability, with minimal misclassification ($\leq 0.3\%$ of pixels annually), reflecting both natural resistance to encroachment and potential policy protections. This contrasts sharply with Lagos' 25% wetland loss from 2000–2020 (Adelekan et al., 2023), suggesting Ikpoba-Okha's water management may offer lessons for other Nigerian cities.

The temporal progression of these changes reveals an urbanisation life cycle: early-phase farmland conversion (1993-2003), mid-phase land clearing and infill development (2003-2013), and late-phase consolidation (2013-2023). This mirrors the S-curve urbanisation model observed by Angel et al. (2021) in 200 global cities, though Ikpoba-Okha's transition occurred at accelerated rates characteristic of African secondary cities (Niyomugabo et al., 2022).

Policy implications are significant, for without interventions like urban growth boundaries or agricultural land reserves, the region risks completing what Seto et al. (2018) call the "urban transition", a point of no return where natural and agricultural systems are irreversibly displaced. The stability of water bodies shows environmental protections can work, but their limited scope (0.16–0.33% of total area) highlights the need for expanded safeguards

4.2.3 Rate of Land Cover Change

The land cover changes in Ikpoba-Okha between 1993 and 2023 reveal a profound transformation characterised by rapid urbanisation and its resulting impacts on agricultural land, bare surfaces, and water bodies. The data spanning four years (1993, 2003, 2013, and 2023) demonstrate that built-up areas expanded aggressively from 106.662 km² (12.705%) to 387.489 km² (46.157%), marking a 263.30% increase (280.827 km²) at an average annual rate of 9.36 km². This growth was particularly pronounced between 2013 and 2023, when built-up land increased by 215.086 km² (25.619%), reflecting accelerated infrastructure development and population pressure (Seto et al., 2018). Similar patterns have been documented in Lagos, where urban land cover grew by 15% annually between 2000 and 2020, displacing agrarian communities (Adepoju & Adelekan, 2022).

Concurrently, agricultural land declined from 659.202 km² (78.520%) to 427.65 km² (50.941%), with the most severe reduction occurring between 1993 and 2003 (-184.147 km²). Although there was a temporary recovery during 2003-2013 (+81.925 km²), likely due to fallow land reuse or policy interventions, the period 2013-2023 saw a renewed decline of 129.33 km². This net loss of 231.552 km² (35.13%) signifies the threat to food security, mirroring trends in Kano, where farmland reduction correlated with a 20% drop in crop yields (Oyinloye et al., 2021). The conversion of fertile land to various urban uses is exacerbated by climate stressors, such as erratic rainfall and soil degradation, which further diminish agricultural viability (Lambin & Meyfroidt, 2020).

Bare surfaces showed an irregular pattern of change, peaking at 230.528 km² (27.460%) in 2003 during active land clearing for development, then sharply declining to 21.632 km² (2.577%) by 2023 as these areas were absorbed into urban infrastructure. The 70.08% overall reduction suggests that Ikpoba-Okha has reached an advanced stage of urbanisation, where undeveloped land is scarce. This aligns with observations in Abuja, where bare surfaces transitioned to built-up areas within 5-10 years of initial clearing (Akinyemi, 2021).

Water bodies remained relatively stable, fluctuating between 1.366 km² (0.163%) in 1993 and 2.732 km² (0.325%) in 2023. The minor increase of 1.366 km² (99.92%) likely stems from artificial water retention projects, contrasting sharply with Lagos, where wetland reclamation reduced water bodies by 40% (Adegun et al., 2023). The stability in Ikpoba-Okha may reflect the enforcement of environmental protections or the unsuitability of waterlogged areas for development.

These findings provide the need for integrated land-use policies that balance urban growth with agricultural preservation. The unchecked expansion of built-up areas mirrors global trends in the Global South, where cities often lack the planning frameworks to mitigate sprawl (UN-Habitat, 2022). Lessons from Accra's urban agriculture initiatives (Yeboah et al., 2021) could inform strategies to protect farmland while accommodating growth.

4.2.4 Drivers of Land Cover Change

The study findings point to urban development as the most dominant driver of land use and land cover change in Ikpoba-Okha. Respondents consistently identified the expansion of built-up areas for residential, commercial, and infrastructural purposes as a key factor behind the transformation of land in the area. This observation is not surprising, given the proximity of Ikpoba-Okha to the urban core of Benin City, which exerts significant developmental pressure on surrounding peri-urban zones. According to Akinyemi (2017), urban sprawl in Nigeria's

peri-urban regions often results in the encroachment of fertile agricultural land by housing estates, road networks, and other urban infrastructure. These transformations not only reduce the area of cultivable land but also displace farming communities and alter traditional land use patterns.

This trend of urbanisation is closely intertwined with the region's population dynamics. Rapid population growth increases the demand for housing, transportation, education, and health infrastructure. As noted by the United Nations (2019), sub-Saharan Africa has one of the fastest-growing populations globally, and this demographic pressure is a major catalyst for urban expansion. The consequence is often the conversion of farmland, forest land, and other natural spaces into human settlements. In Ikpoba-Okha, as in many other developing areas, such growth is rarely accompanied by adequate land use planning, resulting in uncontrolled expansion and a corresponding loss of ecological and agricultural assets (Eze & Agbo, 2020). In addition to population growth, migration, has been highlighted as a contributor to LC change. Respondents noted the influx of people from rural parts of Edo State and neighbouring states seeking better economic opportunities in urban areas. This movement intensifies land pressure, as newcomers require land for shelter, commerce, and livelihood activities. Olayiwola and Oladeji (2021) emphasised that migration-driven expansion in southern Nigerian cities often leads to informal settlements and haphazard development that encroach on productive agricultural land. Similarly, Adepoju (2019) argued that migration causes urbanisation in sub-Saharan Africa, exacerbates land fragmentation and contributes to the decline of traditional land uses such as farming and forestry.

Other contributing drivers identified by the respondents include industrialisation, deforestation, land speculation, and policy-related issues. Industrialisation, particularly the establishment of small and medium enterprises (SMEs) and manufacturing plants like the ethanol plant in Ologbo, often demands significant land resources, which are usually sourced from previously

agricultural or forested areas. In Nigeria, the promotion of industrial corridors without adequate environmental safeguards has led to extensive land cover change, especially around growing cities (Aderoju & Ogundele, 2021). In Ikpoba-Okha, the development of light industries, markets, and service centres has contributed to such transformation.

Deforestation is also a critical issue. Respondents linked forest clearing, often for fuelwood collection, timber sales, or land preparation, to widespread changes in land cover. The Food and Agriculture Organisation (FAO, 2020) noted that deforestation in Nigeria has reached alarming rates, driven largely by unsustainable agricultural practices and energy demands. In many communities, particularly those on the periphery of expanding cities, tree removal is often the first step in preparing land for development.

Land speculation further complicates the landscape. Respondents observed that individuals and developers frequently acquire large tracts of land for future resale or development, leading to idle but fenced lands that are no longer used for productive agriculture. This practice contributes to land scarcity and distorts land prices, making it difficult for small-scale farmers to retain or access arable land (Olawale & Abiodun, 2022). Moreover, speculative activities often lead to the commodification of land, where its economic value outweighs its agricultural or ecological functions.

Policy factors, including weak enforcement of zoning regulations and inconsistent land use planning, were also mentioned as key drivers. In Nigeria, land administration frameworks cannot often enforce development control or prevent encroachments on protected or agriculturally zoned lands (Ajibade & McBean, 2014). This policy gap creates room for unregulated land conversion, resulting in environmental degradation and the erosion of local food systems.

Collectively, these drivers reflect the multifaceted and interlinked causes of LC changes in Ikpoba-Okha. While urbanisation and demographic changes are primary factors, economic

motivations, institutional weaknesses, and environmental degradation also play substantial roles. The findings reflect broader regional patterns observed in peri-urban West Africa, where rapid socio-economic transformations are reshaping land use dynamics (Teye et al., 2020).

The result of these trends is far-reaching. The continued loss of agricultural land not only threatens food security but also undermines rural livelihoods and increases vulnerability to climate-related shocks. In addition, the fragmentation and degradation of land resources reduce ecosystem services such as water regulation, soil fertility, and biodiversity preservation. As Ojo and Oni (2023) argue, without proactive land governance strategies, LULC changes in Nigeria's urban fringe areas will continue to accelerate, with dire consequences for both human and environmental health.

4.2.5 Impact of Land Cover Change on Agricultural Activities

The findings of this study reveal that land cover change in Ikpoba-Okha has predominantly adverse effects on agricultural activities. The most notable impacts include a reduction in available farmland, decreased productivity, environmental degradation, and a decline in overall agricultural sustainability. These outcomes reflect broader patterns of land transition commonly observed in peri-urban areas across Nigeria and sub-Saharan Africa.

One of the most striking observations is the loss of farmland due to urban encroachment and infrastructural development. This trend is consistent with the work of Akinyemi (2017), who emphasised that rapid urban expansion in peri-urban zones has resulted in the conversion of agricultural land into residential, commercial, and industrial uses. The encroachment reduces the capacity of farmers to sustain food production and maintain livelihoods, leading to both economic and social dislocation, particularly among smallholder farmers.

In addition to reduced land access, agricultural productivity has declined significantly. This decline appears to be directly linked to both land loss and a growing inaccessibility of productive areas. FAO (2020) highlights that urban-driven LC change leads to the

fragmentation of farmland, making it difficult for farmers to adopt large-scale or mechanised agricultural techniques. Fragmented plots not only limit operational efficiency but also increase input costs, reduce economies of scale, and weaken the overall resilience of agricultural systems.

Environmental degradation further compounds the negative impacts of LC change. Soil depletion, pollution, and the destruction of vegetation cover have all been reported as consequences of unregulated development. These environmental concerns are not isolated to Ikpoba-Okha; Olawale and Abiodun (2022) observed similar patterns in other parts of Nigeria, where rapid land conversion due to urbanisation results in the loss of ecosystem services and declining agricultural potential. The long-term fertility of soils is compromised, which threatens food security and sustainable rural development.

While the majority of respondents viewed the impacts as negative, a portion acknowledged certain benefits arising from the LC change, namely, improved employment opportunities and access to markets due to better infrastructure. These positive perceptions, although limited in scope, align with Adepoju's (2019) assertion that urban development can sometimes generate economic benefits for rural dwellers, especially when it leads to the establishment of transport networks and commercial centres. However, these gains are often short-term or unevenly distributed, favouring commercial developers and wealthier stakeholders over subsistence farmers.

The overall picture that emerges is one of imbalance. While some socio-economic opportunities may arise from urban expansion, they do not offset the widespread disruptions to agriculture. The sustainability of agricultural land use is under threat, and this situation calls for more inclusive and strategic land management frameworks. FAO (2020) warns that the

absence of coherent land use policies will continue to undermine agricultural productivity, increase food insecurity, and exacerbate rural poverty.

The findings strongly suggest that the LC change in Ikpoba-Okha is contributing to a decline in agricultural viability. The dual challenge of land loss and environmental degradation is placing pressure on farming households, while the limited economic benefits from urbanisation fail to compensate for these losses. This highlights the urgent need for policy interventions that strike a balance between development and agricultural preservation. Integrating land use planning with rural development strategies is essential to mitigate the adverse effects of LC change and ensure sustainable livelihoods for farming communities.

4.2.6 Mitigation Strategies to combat Agricultural Land use encroachment

4.2.6.1 Government Strategy by Effectiveness

The effectiveness of government interventions aimed at mitigating the impacts of LC change in Ikpoba-Okha shows significant variation across different strategies. Stakeholder perceptions indicate that while some strategies are gaining traction, others remain largely ineffective due to systemic and institutional challenges.

Land use zoning, designed to regulate urban development and safeguard agricultural zones, was largely perceived as ineffective or only moderately effective. Nearly one-third of stakeholders considered the policy to be ineffective, which reflects ongoing challenges with enforcement and urban encroachment. This aligns with Akinyemi (2017), who observed that weak regulatory oversight and poor urban planning practices have limited the success of zoning policies in peri-urban Nigeria. Moreover, GIS analyses of the region have demonstrated continued land conversion in zones designated for agricultural purposes, suggesting that zoning regulations are not being effectively implemented on the ground. Agricultural subsidies, which are meant to enhance productivity and disincentivise land conversion, also received poor

ratings. A significant proportion of stakeholders found these programmes ineffective, a finding consistent with FAO (2020), which reported that subsidy programmes in many African countries often fail due to bureaucratic inefficiencies, corruption, and lack of targeting. In the context of Ikpoba-Okha, discussions with local farmers suggest that many farmers either do not benefit from these subsidies or are unaware of their availability, leading them to seek alternative livelihoods that contribute to land-use changes.

In contrast, environmental regulations were viewed more positively, with a considerable number of respondents rating them as either somewhat effective or effective. This may be attributed to increased awareness of environmental sustainability, as well as targeted enforcement actions in some parts of the LGA (Iyanomo community). However, as noted by Olawale and Abiodun (2022), the success of environmental regulations is often undermined by fragmented institutional mandates and limited monitoring capacity, which also applies in the present context.

Afforestation programmes received the highest effectiveness ratings among all evaluated strategies. Nearly half of the respondents considered these programmes effective, which suggests growing recognition of their role in reversing land degradation and restoring ecosystem services. Seto et al. (2011) emphasised the role of afforestation in mitigating deforestation impacts and enhancing land resilience, particularly in urban fringe areas. Additionally, GIS-based assessments corroborate stakeholder perceptions, revealing a visible improvement in vegetation cover and reduced erosion in areas targeted by afforestation initiatives.

Despite the relative success of some strategies, significant policy fragmentation and inter-agency coordination issues persist. The lack of synergy among governmental departments often leads to duplication of efforts, policy overlap, and resource wastage. As Agyeman et al. (2023)

recommend, integrated land governance frameworks and participatory planning approaches are essential for achieving coherent and effective land-use policies.

In summary, while afforestation and environmental regulations show promise in mitigating LC impacts in Ikpoba-Okha, land use zoning and agricultural subsidies remain hindered by enforcement and administrative inefficiencies. A more collaborative, data-driven approach that incorporates spatial analysis, stakeholder engagement, and institutional reforms is needed to enhance the overall effectiveness of government strategies.

4.2.6.2 Community Collaboration and Individual Involvement

Community involvement has emerged as a vital strategy in mitigating the adverse effects of land cover change in Ikpoba-Okha. The findings reveal active participation in various grassroots initiatives, with a particular emphasis on collaborative land management, advocacy and awareness campaigns, and personal conservation efforts. These interventions, while community-led, serve as critical buffers against the encroachment of agricultural land and the degradation of natural resources in the face of expanding urbanisation.

Collaborative land management is a notable example of how local governance and communal cooperation can serve as a counterforce to LC-driven degradation. With over a third of respondents indicating active participation, it is evident that communities are taking ownership of land resource governance. This corroborates findings by FAO (2020), highlighting the importance of decentralised and community-led land management systems in regions where formal government regulations are either ineffective or inconsistently enforced. In such contexts, traditional institutions and informal structures often fill the governance void, supporting sustainable land practices at the grassroots level.

The qualitative data from focus group discussions further illuminate these dynamics. Participants described the adoption of agroforestry practices, such as the integration of

economic trees with staple crops, as a locally-driven method for improving soil fertility while reducing vulnerability to encroachment. This form of land use intensification aligns with recent studies, such as that of Agyeman et al. (2023), who argue that agroecological innovations, when scaled through community structures, contribute significantly to both environmental sustainability and local livelihoods.

Advocacy and awareness campaigns also play a pivotal role in shaping public attitudes toward sustainable land use. While participation in these campaigns was moderate, the findings suggest a growing recognition of their importance. According to Olayiwola and Oladeji (2021), awareness campaigns are essential for sensitising rural populations to the long-term implications of unchecked land conversion and for promoting behavioural change. However, the study also revealed that socio-economic barriers, including limited access to information, low literacy levels, and economic insecurity, continue to hinder broader participation. These barriers are consistent with findings from Ezeaku et al. (2021), who noted that awareness alone is insufficient unless it is accompanied by access to resources and practical support mechanisms.

The strongest level of involvement was reported in personal conservation efforts, such as tree planting, mulching, composting, and soil erosion control. This reflects an encouraging trend towards individual agency in land stewardship. As Lambin et al. (2020) suggest, grassroots conservation efforts form the backbone of sustainable land use, especially when complemented by supportive policies and institutional frameworks. The respondents' willingness to undertake such practices without external compulsion highlights the intrinsic value placed on land by rural residents, particularly those whose livelihoods depend on its productivity.

However, these positive actions are not without constraints. Focus group participants cited land tenure insecurity as a recurring barrier. One landowner from Uhie noted that farmers without

secured tenure are often displaced when external investors acquire land, sometimes through informal or opaque channels. This finding is supported by Adepoju (2019), who documented widespread land displacement due to poor tenure systems in peri-urban regions of southern Nigeria. Secure tenure not only protects farmers from eviction but also incentivises them to invest in long-term land conservation strategies.

Another issue raised is the lack of institutional support. Respondents called for clearer and more enforceable zoning laws, enhanced government responsiveness, and greater financial backing for local initiatives. As noted by Olawale and Abiodun (2022), the success of local conservation efforts often hinges on the enabling environment provided by formal institutions. In the absence of such support, community efforts risk being overwhelmed by the rapid pace of urban expansion and speculative land development. 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.”

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Summary

This study assessed Land Cover change and its impact on agricultural land use in Ikpoba-Okha LGA from 1993 to 2023 using GIS and field survey. The results revealed 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 LC change indicated a rapid loss of agricultural land, with encroachment accelerating in recent years. Findings revealed that built-up areas increased by approximately 156.6%, expanding from 56.64 km² (1993) to 145.45 km² (2023), while agricultural land declined by about 41.73%, shrinking from 99.05 km² to 57.71 km² over the same period. 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 LC 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 LC 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.

5.2 Conclusion

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

1. The study revealed that built-up areas expanded significantly while agricultural land declined, indicating a continuous shift from vegetative and agricultural land to urban uses.

2. Between 1993 and 2023, built-up land increased by approximately 156.6%, while agricultural land decreased by about 41.73%. This confirms rapid urbanisation as the dominant land transformation trend in the region.
3. Major drivers included urban population growth, economic activities, infrastructure development, and weak land-use governance, which collectively accelerated the conversion of agricultural and forested lands.
4. The reduction in agricultural land has negatively affected farming livelihoods, leading to land fragmentation, intensified land use, and, in some cases, a shift away from agriculture due to reduced access to cultivable land and environmental degradation.
5. Community-led efforts such as agroforestry, land tenure agreements, and land monitoring were identified, but their impact remains limited without stronger institutional support and enforcement.

5.3 Contribution to Knowledge

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

1. This study addresses a notable gap in regional literature by applying GIS and remote sensing techniques as to assess Land Cover Change and its impact on agricultural land use in Ikpoba-Okha LGA, Edo State, in southern Nigeria, which has been largely overlooked in previous research.
2. The study contributes a replicable GIS-based methodology that combines satellite image analysis with field survey data to monitor long-term land use transformations.
3. The study quantifies agricultural land loss over 30 years (1993–2023) and identifies the socio-economic and policy-related drivers of land cover change.
4. The research highlights the disconnect between policy intent and implementation, especially in how government programs targeting farmers are often inaccessible or poorly communicated. It brings attention to the underreported issue of farmer exclusion

in formal land-use planning and subsidy programs, contributing to policy debates on equitable access and inclusive agricultural development.

5.4 Recommendations

Based on the findings, the following recommendations are proposed:

1. Implement stricter land-use monitoring using satellite and GIS tools. Regular tracking of land changes will help local authorities identify and manage areas at risk of losing agricultural land early.
2. Enforce zoning laws to slow down urban sprawl into farmlands. The high rate of land conversion, especially to built-up areas, calls for clear development boundaries to protect agricultural zones.
3. Strengthen land governance and regulate land sales in peri-urban areas. Urbanisation and weak land-use policies are major drivers. Stronger institutional control is needed to prevent unplanned development.
4. Provide support for farmers affected by land loss, such as land tenure security and agricultural incentives. As farmlands shrink, farmers need assistance to continue food production sustainably and avoid full abandonment.
5. Promote community-based land conservation efforts like agroforestry and local land committees. Since top-down government interventions were found limited, empowering local communities will improve resilience and land stewardship.

5.4 Suggestions for Future Research

Based on the findings of this study, the following areas are recommended for future research:

1. Future studies should examine how continuous reduction in farmland affects household income, rural livelihoods, food prices, and migration patterns over time in peri-urban communities.

2. There is a need to evaluate how current urban planning laws and land governance frameworks perform in protecting agricultural land and identify where they fall short.
3. Explore how land loss and land-use change differently affect men and women in farming communities, particularly in terms of access to land, decision-making, and food security.
4. Investigate how climate variability interacts with land cover change to influence agricultural productivity, land degradation, and resilience in urban-fringe areas like Ikpoba-Okha.
5. Future research could compare Ikpoba-Okha with other LGAs in Edo State or similar peri-urban areas in Nigeria, using a standardised GIS-based approach.

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APPENDIX I: QUESTIONNAIRE SURVEY

**DEPARTMENT OF GEOGRAPHY AND REGIONAL PLANNING,
FACULTY OF SOCIAL SCIENCES,
UNIVERSITY OF BENIN, BENIN CITY.**

I am an M.Sc. student of the above-named department carrying out academic research on the topic: **ASSESSMENT OF LAND COVER CHANGE AND ITS IMPACT ON AGRICULTURAL LAND USE IN IKPOBA-OKHA, LGA.** Please, kindly respond sincerely to the following questions by ticking (✓) and making appropriate comments where necessary. I pledge that the answers supplied to these questions will be used strictly for the research purpose for which it is intended.

Thank you.

SECTION A: DEMOGRAPHIC CHARACTERISTICS

1. **Neighbourhood of Respondent**.....
2. **Sex of Respondent:** Male [] Female [].
3. **Age of Respondent:** 0-20 years [] 21-35 years [] 36-50 years [] 51-65 years []
Above 65 years [].
4. **Marital Status of Respondent:** Single [] Married [] Widowed []
Divorced/Separated [].
5. **Educational Status of Respondents** Non Formal Education [] Primary [] Secondary [] Tertiary [].
6. **Occupation of Respondent:** Farmer [] Landowner []

SECTION B: SIZE OF FARM AND LANDS, DRIVERS OF LAND COVER CHANGE

7. Are you fully engaged in farming? Yes No
8. How long have you been involved in farming? 5-10 yrs 11-15 years 16-20 years Others specify
9. What is the ownership status of your farm or land? Owner Lease Rent Others specify
10. What is the size of your farm or land in hectares? 0-3 4-6 7-9 Others (Specify).....
11. Has there been a decrease in your farm or land over the last decade? Yes No
12. If yes, what do you believe are the major drivers of these changes? Urban expansion Agricultural activities Industrialisation Natural factors (e.g., climate change, natural disasters) Others, specify
13. Do you believe the reduction in the sizes of cultivated farmland has affected the quantity of agricultural output in the study area? Yes, significantly Yes, but insignificantly No, not at all .

SECTION C: IMPACT OF LAND COVER CHANGE ON AGRICULTURAL LAND USE

14. How would you describe the current state of agricultural land use in your area? Good Very good Bad Extremely bad Fair
15. Have you noticed any changes in agricultural activities due to urban expansion? Yes No
16. If yes, please rate the following statements based on your observations

S/N	Impacts of Land Cover	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	A decrease in the availability of agricultural land	1	2	3	4	5
2	Increased competition for agricultural resources.	1	2	3	4	5
3	Changes in farming practices	1	2	3	4	5

17. How would you rate the current level of agricultural activities in the study area?

High [] Moderate [] Low []

18. In your opinion, has there been any noticeable change in the quantity of agricultural output in the study area over the past decade? Significant Increase [] Slight Increase [] No Significant Change [] Slight Decrease [] Significant Decrease [].

19. In your opinion, has urban expansion influenced farmers' decisions to engage in agricultural activities? Yes, it has encouraged them to engage more. No, it hasn't influenced their decisions significantly. Yes, it has discouraged them from engaging in agricultural activities[].

20. How do you perceive the relationship between farmland size reduction and agricultural productivity?

S/N	Farmland size reduction and agricultural productivity	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	Larger farmland sizes lead to higher agricultural productivity	1	2	3	4	5
2	Farmland size has no significant impact on agricultural productivity	1	2	3	4	5
3	Smaller farmland sizes lead to higher agricultural productivity	1	2	3	4	5

SECTION D: MITIGATION STRATEGIES TO COMBAT AGRICULTURAL ENCROACHMENT ON AGRICULTURAL LAND USE

21. Have you or your neighbours adopted new management practices in response to the changing land use dynamics? Yes [] No []
22. If yes, specify.....
23. Has the government developed any strategy to combat the problem of agricultural encroachment in your community? Yes [] No []
24. If yes, what are these strategies? Agricultural Zoning [] Purchase of development rights [] Conservation easements [] Others specify.....
25. Is this strategy effective? Yes [] No [] Partially [] No idea []
26. Has this strategy played a role in land use changes around your farm or land? Yes [] No []
27. If yes, specify
28. Would you agree that these strategies are the best? Strongly agree [] Strongly disagree [] Partially agree [] Fair []

29. If no, what would you suggest as the best strategy and solution to this problem?.....
30. Are there any successful case studies or examples from other areas that could be applied in this area to mitigate this impact? Yes [] No []
31. How do you think the local government and the communities can collaborate to balance urban development with the preservation of agricultural land?
.....
32. Have you personally or your community been involved in any initiatives or efforts to preserve agricultural land from urban expansion? Yes [] No []
33. If yes, specify.....

APPENDIX II: FOCUS GROUP DISCUSSION GUIDE

DEPARTMENT OF GEOGRAPHY AND REGIONAL PLANNING

FACULTY OF SOCIAL SCIENCES

UNIVERSITY OF BENIN

1. What traditional or community-led strategies have been most effective in mitigating agricultural land use encroachment in your area?
2. How have agroforestry and conservation agriculture practices helped in sustaining farmland, and what challenges have you encountered in their implementation?
3. What role do local land monitoring committees and traditional rulers play in preventing land encroachment? How effective have these interventions been?
4. To what extent have land tenure agreements helped secure farmland for long-term agricultural use? Are there any limitations or areas for improvement?
5. What are the major barriers to effective policy enforcement regarding land use regulation?
6. What specific government actions would strengthen the protection of farmlands?
7. How has land displacement affected farmers in this region, and what alternative land-use strategies or support mechanisms could help address this issue?
8. Based on your experiences, what additional measures should be introduced at the community or government level to further protect agricultural land from encroachment?