ASSESSMENT OF LAND USE AND VEGETATION COVER CHANGES OF A PUBLIC INSTITUTIONAL PREMISE IN BENIN CITY, EDO STATE

BY

FAITH OSAYAWE OKUNDIA (Miss)

LSC2006953

AN UNDERGRADUATE PROJECT SUBMITTED TO THE DEPARTMENT OF ENVIRONMENTAL MANAGEMENT AND TOXICOLOGY, FACULTY OF LIFE SCIENCES, UNIVERSITY OF BENIN, BENIN CITY, EDO STATE, NIGERIA; IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR AWARD OF BACHELOR OF SCIENCE (B.Sc) DEGREE IN ENVIRONMENTAL MANAGEMENT AND TOXICOLOGY.

NOVEMBER, 2025.

CERTIFICATION

This is to certify that this research titled **"ASSESSMENT OF LAND USE AND VEGETATION COVER CHANGES OF A PUBLIC INSTITUTIONAL PREMISES IN BENIN CITY, EDO STATE"** was carried out by **"Miss FAITH OSAYAWE OKUNDIA"** with matriculation number **"LSC2006953"** and presented to the Department of Environmental Management and Toxicology, Faculty of Life Sciences, University of Benin, Benin City; in partial fulfilment of the requirements for the award of Bachelor of Science (B.Sc.) in Environmental Management and Toxicology. It was conducted under suitable conditions, was carefully supervised and subsequently approved as having met the requirements for the award of a Bachelor of Science degree in Environmental Management and Toxicology.

______________________ ________________

Dr. N. O. Obayagbona
Project Supervisor **Date**

______________________ ________________

Prof. (Mrs) E. T. Aisien
Head of Department **Date**

DECLARATION

I "**FAITH OSAYAWE OKUNDIA**" declare that **"ASSESSMENT OF LAND USE AND VEGETATION COVER CHANGES OF A PUBLIC INSTITUTIONAL PREMISES IN BENIN CITY, EDO STATE"** is my own work and that all sources that I have used or quoted have been acknowledged by means of complete references and that this work has not been submitted before for any other degree at any other university.

FAITH OSAYAWE OKUNDIA (Miss)

…………………………
Date

DEDICATION

This project is dedicated to God for keeping me and giving me the strength to complete this journey, my parents Mr and Mrs Okundia and my siblings for the love and care and my Mentor Dr Maxwell S.U. Osagie for his encouragement and support, and lastly my supervisor, lecturers and Friends whose unwavering support and encouragement and support have inspired me to pursue my dreams.

ACKNOWLEDGEMENTS

I would like to express my gratitude to all those who contributed to the success of this project. I am especially thankful to my supervisor, Dr. N.O Obayagbona for his invaluable guidance and support throughout this endeavour.

I also appreciate Dr J.U. Ogbebor for his valuable advice and Rev. Dr. Maxwell S. U. Osagie, Mr. Joshua Nmoye, Master Israel Nmoye, for their guidance and support.

Finally, I would like to thank my family: Mr. Paul Okhonkpamwonyi Okundia, Mrs. Rachel Imahenakhue Okundia, Miss Ruth Okundia, Miss Divine Osaiyekemwen Okunida, Master Steven Osamuyimen Okundia, Miss Salvation Osayamon Okundia, Mrs. Bridget Osazemwinde, Mrs. Imahenakhue, and friends; Miss Agbaje Temitope, Miss Ebo Miracle, Master Nosa Agbonison, Master Osayande Agbonison, Master Marvellous Osazemwinde, Master Clinton Osazemwinde, Master James Elenbalulu, Miss Divine, Miss Uluvbo Eboreime, Master Miracle Asemota-Ero, Master Christian Edosa Avanrenren, Master Charles Ewere, Miss Pauline Woghiren, Master Oluwatosin Lukeman, Miss Suliyat Destiny Yakubu, Master Emmanuel Edet Elijah, Miss Testimony Oturu for their support and understanding during this time.

Thank you all for your contributions.

TABLE OF CONTENT

DEDICATION iii

ACKNOWLEDGEMENTS iv

LIST OF FIGURES vii

LIST OF TABLES viii

LIST OF PLATES ix

ABSTRACT 1

CHAPTER ONE 2

INTRODUCTION 2

1.1 Background to the Study 2

1.2 Aim and Objective of the Study 6

1.3 Objectives 7

CHAPTER TWO 8

LITERATURE REVIEW 8

2.1 Land Use and Land Cover Patterns in Nigeria 8

2.2 Factors Fostering Changes in Land Use and Land Cover 11

2.3 Environmental Impacts of Land Use and Land Cover Change in Nigeria 17

2.4 Social Impacts of Land Use and Land Cover Change in Nigeria 22

2.5 Methodologies for Assessing Land Use and Land Cover Changes in Nigeria 27

2.6 Review of Some of the Related Empirical Literature 33

CHAPTER THREE 41

MATERIALS AND METHODS 41

3.1 Study Area 41

3.2 Data Collection and Pre-processing 43

3.3 Normalized Difference Vegetation Index (NDVI) Analysis 43

3.4 Supervised Land Use/Land Coverage Classification 44

3.5 Integration of NDVI and LULC Results 45

3.6 Data Analysis and Presentation 45

3.7 Tree Identification 46

CHAPTER FOUR 47

RESULTS 47

4.1 Land Use and Land Cover Changes (1975-2025) in the Study Area. 47

4.2 Normalized Difference Vegetation Index (NDVI) Analysis (1975-2025) in the Study Area. 54

4.3 Tree Species Sample Collected in the Study Area. 59

CHAPTER FIVE ... 62
DISCUSSION ... 62
5.1 Land Use/Land Cover (LULC) ... 62
5.2 Normalized Difference Vegetation Index (NDVI) ... 63
5.3 Identified Tree Diversity ... 63
5.4 Recommendation ... 68
5.5 Conclusion ... 69
REFERENCES ... 70
APPENDIX ... 79

LIST OF FIGURES

Figure 3.1: Map of the study area - - - - - - - 42

Figure 4.2: LULC Map of the study area from 1975 - 2025 - - - - 53

Figure 4.3: NDVI Map of the study area from 1975 - 2025 - - - - 58

Figure 4.4: Graphical Representation of Land use/land cover (LULC) Trend - - 83

Figure 4.5: Graphical Representation of NDVI Trend - - - - 83

LIST OF TABLES

Table 4.1: LULC Report from 1975 – 2025 - - - - - 52

Table 4.2: NDVI Report from 1975 – 2025 - - - - - 57

Table 4.3: Tree species Sample collected - - - - - 61

LIST OF PLATES

Plate 1: Tree A - - - - - - - - 79

Plate 2: Tree B - - - - - - - - 79

Plate 3: Tree C - - - - - - - - 79

Plate 4: Tree D - - - - - - - - 79

Plate 5: Tree E - - - - - - - - 80

Plate 6: Tree F - - - - - - - - 80

Plate 7: Tree G - - - - - - - - 80

Plate 8: Tree H - - - - - - - - 80

Plate 9: Tree I - - - - - - - - - 81

Plate 10: Tree J - - - - - - - - 81

Plate 11: Tree K - - - - - - - - 81

Plate 12: Tree L - - - - - - - - 81

Plate 13: Tree M - - - - - - - - 82

Plate 14: Tree N - - - - - - - - 82

ABSTRACT

Land use and land cover changes within tertiary educational institutions significantly impact environmental sustainability, biodiversity, and ecological health. This study examined spatiotemporal variations in land use/land cover (LULC) and vegetation dynamics of the University of Benin, Ekehuan Campus, Benin City, Edo State, Nigeria, over a 50-year period from 1975 to 2025. Landsat satellite imagery from the years 1975, 1985, 1995, 2005, 2015, and 2025 respectively was processed using Google Earth Engine (GEE) and ArcGIS platforms, with classifications categorized into dense vegetation, sparse vegetation, agricultural land, built-up areas, and bare soil. Supervised Maximum Likelihood Classification was employed for LULC analysis, while the Normalized Difference Vegetation Index (NDVI) was computed to assess vegetation health. Field surveys documented remaining tree species in the study area. Results revealed catastrophic vegetation decline from 0.841334 km² (97.34%) in 1975 to complete elimination (0%) by 2015-2025. Built-up areas increased dramatically from 0% in 1975 to 0.671581 km² (77.70%) by 2025. Agricultural land fluctuated from 0% to 36.49% (2015) before declining to 16.06% in 2025. Bare soil emerged at 6.24% in 2025, indicating land degradation. NDVI values ranged from -0.077 to 0.400 across the study period, with maximum values declining from 0.400507 in 2005 to 0.26453 in 2025. Field surveys documented only 16 tree species in 2025, representing severe biodiversity loss compared to historical diversity. These findings revealed complete landscape transformation from a natural ecosystem to an urbanized environment, resulting in total habitat destruction, loss of ecosystem services, hydrological disruption, and biodiversity collapse. It is recommended that campus planning incorporate mandatory green infrastructure, sustainable urban drainage systems, and stringent land-use controls to mitigate environmental degradation and promote sustainability.

CHAPTER ONE

INTRODUCTION

1.1 Background to the Study

Studies focused on the dynamics of land use and land cover (LULC) within tertiary educational institutions have become relevant in the context of environmental and urban research, as these studies highlighted the significant impacts these changes have on ecological health, infrastructure longevity, and the overall sustainability of built educational landscapes (Salim and Ibrahim, 2021). As tertiary institutions expand to meet the needs of a growing student body and evolving academic programs, their campuses often serve as miniature models of broader urbanization, illustrating both the opportunities and challenges of land management in rapidly changing environments. This is particularly relevant in swiftly developing urban areas like Benin City, where on-going construction and increased human activity exert substantial pressure on limited land and indigenous vegetation, resulting in marked changes to the local landscape. The establishment and growth of universities can prompt extensive changes in land use, such as the transformation of agricultural or undeveloped land into residential, commercial, and academic spaces. Research has demonstrated that the construction of new university infrastructure-including lecture theatres, student residences, administrative offices, and recreational facilities-often reduces green spaces and fragments existing ecosystems (Salim and Ibrahim, 2021). These changes not only modify the physical environment but also have broad implications for local biodiversity, water cycles, and microclimates, potentially intensifying problems like urban heat, flooding, and soil degradation. To effectively analyse and manage these complex changes, a comprehensive methodological framework is essential, typically integrating advanced remote sensing for accurate data collection, GIS for sophisticated spatial analysis, and statistical or computational modelling for measuring and predicting change (Dome *et al.,* 2022). The use of multi-temporal satellite imagery, for instance, allows researchers to observe, classify, and monitor LULC changes over time, offering valuable insights into the pace and direction of land conversion both within and beyond institutional boundaries. Such methods have been effectively applied to map the expansion of built environments, the decline of vegetation, and the conversion of farmland, thereby supporting campus planning and environmental management (George *et al.,* 2019).

The importance of understanding LULC changes lies in their ability to expose fundamental patterns of deforestation, land degradation, desertification, and biodiversity decline, all of which are indispensable for evaluating both natural and human-driven processes. These findings are essential for gauging the risks linked to unsustainable resource exploitation, environmental dangers, and the sustainability of urban and institutional landscapes over the long term (Dome *et al.,* 2022). Land use and land cover modifications are now acknowledged as key contributors to global environmental shifts, with few natural landscapes remaining due to intensified human activity, especially from rapid population expansion and urban migration (Nkundabose *et al.,* 2021). The growth of tertiary institutions often parallels or even accelerates these global tendencies, acting as centres for infrastructure growth and land transformation. Human actions, particularly those associated with urban development and institutional expansion, are the main agents of biosphere change, making LULC change a vital indicator of anthropogenic effects on the earth's surface (Ayenikafo and Wang, 2021). In the case of Benin City, Edo State, Nigeria, the last decade and a half has seen a remarkable population increase, with over 90% of new urban development occurring on previously undeveloped land (Fabolude *et al.,* 2022). This rapid urbanization and campus expansion not only mirror global trends in human settlement but also highlight environmental consequences like habitat destruction, increased runoff, and higher infrastructure demands. Land, in this sense, is not simply a physical base; it is the earth's terrestrial surface- immediately above or below ground-characterized by specific qualities and acting as a focal point for environmental issues. It is a crucial resource that has historically supported human sustenance, shelter, and a variety of activities. According to the UNCCD, land is "the terrestrial bio productive system that comprises soil, vegetation, other biota, and the ecological and hydrological processes that operate within the system." Alternatively, land is described as "a delineable area of the earth's terrestrial surface, encompassing all attributes of the biosphere immediately above or below this surface, including those of the near-surface climate, the soil and terrain forms, the surface hydrology (including shallow lakes, rivers, marshes, and swamps), the near-surface sedimentary layers and associated groundwater reserve, the plant and animal populations (biodiversity), the human settlement pattern and physical results of past and present human activity (terracing, water storage or drainage structures, roads, buildings, etc.)." The drivers behind LULC change are complex, with rapid population growth, migration, and rural-to-urban conversion being the most significant. These transitions greatly affect land-atmosphere relationships and local climate, influencing rainfall, temperature, and air quality. By way of illustration, diminished vegetation can lead to a reduced capacity for carbon sequestration and increased susceptibility to natural disasters such as soil erosion and flooding. Over the last couple of decades, numerous studies have explored various facets of land use and land cover changes, including their root causes, functional mechanisms, and extensive repercussions across the environmental, social, and economic landscapes (Nedd *et al.,* 2021).

The rise in Benin City's population and the spread of urban development has led to more deforestation, hotter urban temperatures, and a decrease in ecosystem services and biodiversity (Fabolude *et al.,* 2022). As the city grows, more natural land is replaced by buildings and roads, resulting in the loss of tree cover and green spaces that help keep the environment balanced. This makes it harder for the city to store carbon, regulate its climate, and provide important services like clean air, water, and habitats for animals. Knowing what defines a forest helps clarify these changes. Generally, a forest is land over 0.05 hectares with at least 10% tree crown cover and trees reaching 2–5 meters. The FAO's definition is more specific: at least 0.5 hectares, 10% canopy cover, and trees at least 5 meters tall, not mainly used for agriculture. The UNFCCC's definition is 10–30% canopy cover, trees 2–5 meters tall, and at least 0.1 hectares (Karousakis and Coffee-Morlot, 2007). Forests are essential for life, supporting livelihoods, economies, biodiversity, and protecting soil and water. They also help fight climate change by absorbing carbon. Despite these benefits, forests are being lost to deforestation, which the FAO says is the permanent or long-term change of forests to other uses. While this is now mostly a problem in tropical and developing regions, it was once common in developed countries before they began restoring forests (Oluwajuwon, 2021). The effects of losing forests are serious: less biodiversity, fewer ecosystem services, and more urban problems like flooding and heat. In cities like Benin City, these problems are worse due to fast growth and higher land demand. This shows the need for land management that balances development and conservation. Tertiary institutions can help by using green infrastructure, conserving forests, and planning campuses sustainably. As centres of research and innovation, they can lead in knowledge, community engagement, and policy for better cities and regions. The connection between population growth, urbanization, and forest loss in Benin City highlights the wider challenges of urban growth. Addressing these challenges requires understanding land use, stewardship, and strategies that protect both people and the environment. These research initiatives underscore the inherently multidisciplinary characteristic of land use studies, highlighting the necessity for integrated strategies that combine ecological, technological, and policy viewpoints. The significance of these considerations is particularly acute within tertiary education institutions. Given that these campuses frequently encompass substantial land holdings and function as focal hubs for innovation, research endeavours, and community engagement, they encounter unique challenges in balancing the necessities of physical growth with the crucially of environmental stewardship. Effective campus planning aimed at sustainability necessitates a profound understanding of LULC dynamics, thereby enabling institutions to minimize harmful ecological effects while simultaneously supporting progressive advancement. This entails adopting ecological building practices, preserving native habitats, and fostering greater biodiversity across campus grounds (George *et al.,* 2019). Furthermore, through vigilant monitoring and meticulous analysis of LULC changes, university administrators, urban development experts, and government officials can make judicious decisions that nurture resilience, sustainability, and the overall welfare of both campus populations and surrounding communities. In this regard, tertiary academic institutions have the latent potential to serve as role models for sustainable land management practices, effectively demonstrating how human needs and environmental soundness can be successfully integrated. Through thorough preparation, innovative land use methodologies, and continuous investigation, these institutions have the opportunity to contribute substantively to broader sustainability objectives, extending beyond their own defined boundaries to positively shape the regions and urban centres that they influence (Salim and Ibrahim, 2021; Dome *et al.,* 2022; Nedd *et al.,* 2021).

1.2 Aim and Objective of the Study

The aim of the study is to ascertain the spatiotemporal changes of land use/cover and vegetation cover of the entire UNIBEN (University of Benin) Campus located at Ekehuan area of Benin City for a specific period; 1965-2025.

1.3 Objectives

The Objectives of the Study are to:

1. Determine the spatiotemporal changes of land use/cover of the entire tertiary institutional campus area.
2. Evaluate the spatiotemporal changes of vegetation cover of the entire tertiary institutional campus area using NDVI (Normalized Difference Vegetation Index).
3. Determining the rate of vegetation loss in the entire campus premises.
4. Identification of common trees growing within the institutional premises.

CHAPTER TWO

LITERATURE REVIEW

2.1 Land Use and Land Cover Patterns in Nigeria

Land Use and Land Cover (LULC) dynamics within Nigeria are experiencing profound and swift transformations, predominantly fueled by human-induced factors such as escalating population levels and intensified urban development activities (Ologunde *et al*., 2025; Agumagu *et al*., 2025). These metamorphoses have manifested distinctly across varied geographic regions, demonstrating unique and region-specific alterations in each land cover category.

Uncontrolled human development without adequate consideration for the environment has led to incessant loss of land cover and natural resources such as water in many parts of the world (Adewumi, 2013.). Consequently, human and environmental challenges of varying magnitude are rapidly emerging. Interestingly, only few efforts are channelled towards the reclamation of the deteriorating land cover pattern and control of future environmental damages, particularly in the developing countries (Adewumi, 2013.).

With respect to Ado-Odo Ota Local Government Area within Ogun State, a study which spanned the period 2015 to 2023 highlighted a notable surge in the extent of built-up land, which increased by an impressive 138.2 square kilometres (Owolabi *et al*., 2020). Additionally, there was a considerable increment in areas characterized by sparse vegetation, which expanded by 28.7 square kilometers over the same period (Owolabi *et al*., 2020). In contrast, regions classified as forest or dense bushland recorded the most dramatic contraction, shrinking by 153.7 square kilometres (Owolabi *et al*., 2020). This significant decline predominantly corresponds to conversion into sparse vegetation, indicative of an ongoing transition toward agricultural land uses (Owolabi *et al*., 2020). Water bodies and bare land areas also diminished, decreasing by 3.8 and 9.5 square kilometers respectively. These trends underscore the dominant influence of rapid urbanization processes, which have catalyzed the transformation of both vegetated and aquatic landscapes into built environments (Ologunde *et al*., 2025).

For the Niger Delta Region (NDR), substantial LULC changes have been documented over a nearly four-decade interval from 1986 through 2024 (Agumagu *et al*., 2025). This area experienced an extraordinary expansion in built-up zones by roughly 8,229 square kilometers, marking a staggering 561% increase. Agricultural lands similarly expanded, growing by approximately 6,727 square kilometers a 79% rise (Agumagu *et al*., 2025). Such expansive growth was achieved primarily at the expense of vital natural ecosystems; mangrove forests, which play crucial ecological and socio-economic roles, contracted sharply by 14,350 square kilometers, representing a loss of roughly 54%. Similarly, general vegetative cover was reduced by 10,844 square kilometers, equating to a 42% decline (Agumagu *et al*., 2025). These figures reveal the extent to which human activities have encroached upon and altered sensitive coastal and inland habitats (Agumagu *et al*., 2025).

In the rapidly urbanizing Lagos City, population growth and city expansion between 2000 and 2020 resulted in a 33.57% rise in built-up land, reflecting intense urban sprawl (Gilbert and Shi, 2023). Concurrently, critical natural land categories experienced considerable decreases: vegetation cover dropped by 21.77%, bare land by 5.14%, and water bodies by 17.13% (Gilbert and Shi, 2023). Predictive models for the subsequent decade, 2020 to 2030, have forecasted a further accelerated urban expansion of approximately 42.44%, coupled with ongoing reductions in forested areas (anticipated at 19.18%) and general vegetation cover (projected to decline by 16%), emphasizing the continuing pressure on green spaces and natural habitats amid urban growth (Gilbert and Shi, 2023).

In the Ogun River Basin, between 1984 and 2020, significant LULC alterations were recorded, with substantial losses in natural wetland and aquatic environments. Forest areas contracted by 29.0%, wetlands plummeted by 58.3%, and water bodies diminished drastically by 84.5%. Contrarily, farmland areas witnessed a dramatic expansion, doubling in size with a 104% increase. Built-up zones also grew moderately by 20%, reflecting a pattern of agricultural intensification alongside urban development. Projected scenarios for 2040 and 2060 suggest these trends will persist, with further encroachment of farmland into forests and wetlands anticipated (Ojelabi *et al*., 2025).

Examining trends over an extended timeframe in Ekiti State, covering approximately 45 years from 1972 to 2017, analysis revealed a substantial reduction in forested and woodland areas, which declined by 51.25%. Meanwhile, regions characterized by built-up development, cropland, rocky or bare soils, and water bodies experienced significant expansions, underscoring a shift in land cover from predominantly natural vegetation toward human-dominated uses (Olorunfemi *et al*., 2020). Similarly, in Benin City, Edo State, between 2017 and 2023, an 11.9% decrease in tree cover was observed (Okoye, 2025). This loss corresponded with growth in built-up land, increasing from 9.49% to 15.29%, as well as expansions in cropland by 2.15%, and rangeland by 4.19%. Projections further indicated that urban built-up areas in Benin City may reach an estimated 542.32 square kilometers by the year 2050, emphasizing ongoing urban spatial growth (Okoye, 2025).

On a national scale, cropland expansion has been identified as a predominant driver of LULC changes across Nigeria from 2000 to 2020. During this period, cropland increased by approximately 62%, highlighting the escalating demand to support food security requirements in the face of a growing population and changing socio-economic conditions (Chiaka *et al*., 2024).

2.2 Factors Fostering Changes in Land Use and Land Cover

The extensive and intricate transformations evident in Nigeria's Land Use/Land Cover (LULC) patterns are a direct outcome of a sophisticated interplay among several fundamental forces: demographic shifts, the evolving nature of economic activities, dynamic environmental conditions, and the pervasive influence of governance frameworks (Allan *et al*., 2022; Ologunde *et al*., 2025). These multifaceted drivers are not isolated but rather interact in complex ways, collectively exerting profound pressures that lead to significant alterations across Nigeria's diverse landscapes.

2.2.1 Demographic Pressures

Accelerated human population growth has been identified as a paramount and consistently recognized driver behind the shifts in LULC across Nigeria (Ojelabi *et al*., 2025). This burgeoning populace engenders an escalating and often insatiable demand for land resources, which are crucial for accommodating the burgeoning need for housing, supporting the expansion of vital infrastructure, and ensuring sufficient food production to sustain a rapidly expanding populace (Faisal Koko *et al*., 2021; Agumagu *et al*., 2025; Okoye, 2025; Ologunde *et al*., 2025). This demographic explosion, when combined with broader national aspirations for economic development, has demonstrably intensified the rate of landscape modification, with urban areas experiencing the most pronounced and rapid transformations (Ologunde *et al*., 2025). Studies utilizing advanced remote sensing data, have consistently indicated a notable expansion of built-up areas and areas characterized by sparse vegetation. This expansion frequently occurs at the direct expense of critical natural assets, such as forest cover and water bodies, vividly illustrating the intense urbanization and agricultural encroachment driven by this relentless population pressure (Olaleye *et al*., 2023).

Furthermore, the compelling trend of rural-to-urban migration acts as a powerful accelerant to these changes. This demographic movement significantly contributes to the rapid physical expansion of urban centers and, consequently, to the regrettable reduction of invaluable green spaces both within and immediately surrounding these burgeoning cities (Akpan and Ebong, 2021; Ologunde *et al*., 2025). The continuous influx of people into urban areas intensifies the competition for limited urban land, compelling the conversion of previously undeveloped or agriculturally productive lands into dense residential zones, sprawling commercial hubs, and burgeoning industrial areas. This process fundamentally reshapes the natural landscape, frequently proceeding without adequate foresight, comprehensive planning, or strict regulatory oversight. Such unmanaged growth bears long-term implications for the sustainability of urban environments, the preservation of biodiversity, and the overall quality of the natural environment (Nzoiwu *et al*., 2017; Fashae *et al*., 2020). The increasing concentration of populations in urban areas can also contribute to the proliferation of informal settlements and slums, which further strain existing urban infrastructure leading to unregulated and environmentally detrimental land conversions (Adelekan and Oduniyi, 2022).

2.2.2 Economic Activities

The pressing need for augmented food production remains a dominant economic force, serving as a primary impetus for the extensive clearing of invaluable forested and mangrove lands, which are then repurposed for agricultural activities (Chiaka *et al*., 2024; Agumagu *et al*., 2025; Ojelabi *et al*., 2025). This relentless expansion of agricultural frontiers, encompassing both traditional practices such as shifting cultivation and more intensive, modernized farming techniques, accounts for a substantial proportion of the ongoing tropical forest clearing observed across Nigeria (Laurance *et al*., 2014). The conversion of sensitive ecosystems like wetlands and floodplains, particularly for intensified rice cultivation, significantly disrupts natural hydrological regimes and alters critical ecological functions, often leading to unforeseen environmental consequences (Ismail *et al*., 2020).

Beyond the agricultural sector, the forces of industrialization and infrastructure development exert a profound influence, acting as powerful agents contributing to widespread vegetation loss and significant land conversion. Activities such as commercial logging, the pervasive and often unsustainable collection of firewood for diverse energy needs (both domestic and industrial), and the construction of extensive road networks and various building projects directly facilitate the dramatic transformation of natural landscapes into built environments (Macarringue *et al*., 2022; Agumagu *et al*., 2025; Ologunde *et al*., 2025). Uncontrolled urban sprawl, a frequent byproduct of rapid industrialization, often results in the conversion of fertile agricultural lands and ecologically sensitive forest areas into burgeoning residential and industrial zones. This process frequently proceeds without the benefit of proper strategic planning or thorough environmental impact assessments (Lawal *et al*., 2021). This unmanaged expansion frequently encroaches upon designated protected areas and is often linked to illicit land acquisitions and developments (Andreasen *et al*., 2023).

Specifically within the highly sensitive Niger Delta region, oil exploration and production operations, which involve extensive land clearing for seismic surveys, the construction of well pads, and the dredging of intricate waterways for oil transportation, continue to be major drivers of forest degradation and widespread ecosystem disruption (Agumagu *et al*., 2025). Furthermore, mining activities conducted across various parts of Nigeria substantially contribute to LULC alterations, directly converting productive agricultural land and forested areas into active mining sites. These operations necessitate the physical removal of vast natural habitats and introduce a cascade of severe adverse environmental impacts, including significant water pollution from toxic wastewater discharge, widespread air pollution from dust and smelting operations, and profound degradation of soil quality, rendering it largely unsuitable for future agricultural or ecological regeneration (Osmani *et al*., 2023; Ejenma *et al*., 2024). The construction of large-scale dams, whether for hydropower generation or extensive irrigation projects, also leads to the significant inundation of land and the widespread alteration of surrounding ecosystems and their natural services (Bello *et al*., 2021).

2.2.3 Climate Change and Environmental Factors

Climate change is known to profoundly influence LULC patterns by fundamentally altering ambient temperature and precipitation regimes across territorial area (Ologunde *et al*., 2025). These climatic shifts subsequently disrupt delicate ecological systems and compel human populations to make adaptive and often reactive land-use decisions (Ologunde *et al*., 2025). Rising average temperatures, coupled with increasingly erratic and unpredictable rainfall patterns, contribute directly to observable shifts in vegetation distribution and overall species composition. This can lead to diminished agricultural productivity in specific regions, thereby incentivizing the conversion of natural forests into agricultural lands or spurring the expansion of urban areas as communities seek more hospitable conditions for their livelihoods (Ologunde *et al*., 2025). Such climatic variability, including the increased frequency and intensity of extreme weather events like prolonged droughts and devastating floods, can directly result in the loss of arable land, shortened growing seasons, and reduced crop yields, thus compelling significant adjustments in existing land use patterns as communities strive to adapt to new environmental realities (Ologunde *et al*., 2025).

The synergistic impact of rapid urbanization and climate change further exacerbates a multitude of existing environmental challenges. This powerful combination intensifies issues such as inefficient or poor water resource management, leading to increased instances of water scarcity in some areas and heightened flood risks in others, particularly in vulnerable urban and peri-urban areas. Moreover, it contributes to localized microclimate warming, a phenomenon commonly referred to as the urban heat island effect, where densely urbanized areas experience significantly higher temperatures than their surrounding rural counterparts (Ologunde *et al*., 2025). These compounded environmental stressors place immense and unsustainable strain on natural resources, leading to extensive habitat destruction, widespread soil degradation, increased rates of erosion, and a general decline in overall environmental quality across affected regions (Phillips *et al*., 2025). The impact of climate variability is also significantly observed in the reduced capacity of ecosystems to provide essential services, such as effective carbon sequestration and natural flood regulation, which in turn further exacerbates the negative effects of LULC change and reduces ecological resilience (Phillips *et al*., 2025).

2.2.4 Policy and Governance Influences

The overall effectiveness of land management in Nigeria is critically undermined by deep-seated inadequacies within its prevailing policy and governance frameworks. A primary and persistent challenge lies in the weak enforcement of existing environmental regulations and established land use planning laws. This systemic weakness, coupled with overlapping and often ambiguous responsibilities among various governmental agencies involved in land administration, and the pervasive issue of corruption, collectively present substantial impediments to the implementation of effective and sustainable land management practices (John and Bello, 2025; RSIS International, 2025). The lack of stringent enforcement frequently allows for unauthorized land conversions, rampant illegal logging, as well as widespread environmental degradation to persist unchecked, thereby significantly undermining national efforts towards achieving sustainable development goals (Yaakob, 2014).

Furthermore, significant and pervasive institutional capacity deficits are widely evident across the sector. These deficiencies typically stem from chronic insufficient funding allocated to land management agencies and a critical shortage of technical expertise among relevant personnel involved in land administration and environmental protection (Enoguanbhor *et al*., 2021; John and Bello, 2025; RSIS International, 2025). These fundamental shortcomings severely hinder the ability of Governmental bodies to effectively plan land use, diligently monitor environmental changes with precision, and rigorously enforce the regulations deemed essential for sustainable land resource management (Enoguanbhor *et al*., 2021). The enduring impact of the Land Use Act of 1978, which effectively centralized land ownership and management under state governors, has been consistently identified by various studies as a contributing factor to bureaucratic inefficiencies, inequities in land allocation, and a pronounced lack of transparency, further complicating effective land governance and equitable access to land resources (Olaleye *et al*., 2023; RSIS International, 2025).

In addition to these well-established factors, recent research increasingly illuminates the potent role of insecurity as an emerging and significant driver of LULC changes. Persistent conflicts, including communal clashes, the menace of banditry, and the prolonged and often violent herder-farmer conflicts across various regions of Nigeria, consistently lead to the mass displacement of populations, the abandonment of vast tracts of agricultural lands, and a subsequent increase in human pressure on new areas for both settlement and farming (Obayomi and Obayomi, 2023). This forced migration and displacement further complicates existing land management and planning efforts, often resulting in rapid, unplanned, and environmentally detrimental LULC transformations in host communities (Obayomi and Obayomi, 2023).

Despite these formidable challenges, significant advancements in remote sensing (RS) and Geographic Information Systems (GIS) are proving to be increasingly invaluable tools for monitoring and understanding the complex dynamics of LULC in Nigeria. These sophisticated technologies provide high-resolution imagery and robust spatial data, enabling researchers, urban planners, and environmental managers to accurately track urban growth patterns, assess infrastructure development, and precisely classify diverse land cover types with unprecedented accuracy and efficiency (Shaamala *et al*., 2025). The strategic integration of satellite imagery with GIS capabilities empowers the detection and vivid visualization of intricate land use change trends over extended periods. This furnishes crucial and actionable data for informed and truly sustainable development decisions and policy formulations (Singh and Bhadauria, 2025). While these technological tools offer immense potential for improved land management and environmental monitoring, the fundamental challenges related to governance, policy formulation, and consistent implementation remain paramount to achieving sustainable LULC outcomes across Nigeria (Ologunde *et al*., 2025).

2.3 Environmental Impacts of Land Use and Land Cover Change in Nigeria

Land use and land cover (LULC) changes in Nigeria have triggered a wide array of environmental consequences, many of which have intensified over recent decades due to rapid population growth, urbanization, agricultural expansion, and infrastructural development (Afuye *et al*., 2024). These alterations to the natural environment affect not only ecological integrity but also hydrological cycles, biodiversity, climate systems, and public health (Afuye *et al*., 2024).

Nigeria's rapid and extensive land use and land cover (LULC) changes have unleashed a cascade of severe environmental consequences across the nation. (Nnaemeka-Okeke, 2016) These transformations, primarily driven by burgeoning urbanization, agricultural expansion, and resource exploitation, profoundly alter natural systems, leading to a range of interconnected ecological challenges (Akindoyin and Obafemi, 2025).

2.3.1 Hydrological Hazards

The alteration of land cover types has profoundly disrupted Nigeria's natural hydrological systems. Historically, vegetation such as forests, grasslands, and wetlands played a critical role in regulating the water cycle by enhancing infiltration, maintaining soil stability, and reducing surface runoff (Agumagu *et al*., 2025). However, as these natural covers are increasingly replaced by impervious surfaces such as concrete, asphalt, and compacted soils from agricultural activities the water-holding capacity of the land declines significantly (Ologunde *et al*., 2025; Agumagu *et al*., 2025; Ojelabi *et al*., 2025).

This shift in land surface properties has resulted in increased rates of surface runoff during precipitation events (Prokešová *et al*., 2022). Rather than infiltrating into the ground and replenishing aquifers, rainwater rapidly flows across the land surface, leading to higher volumes of water entering drainage systems, rivers, and streams in a short period of time (Prokešová *et al*., 2022). This is a primary factor contributing to both flash floods and seasonal flooding in many parts of Nigeria (Macarringue *et al*., 2022). Particularly in urban centers like Lagos, the rise in impervious cover has drastically reduced the land's capacity to absorb rainwater. As a result, even moderate rainfall events now pose a serious risk of flooding (Faisal Koko *et al*., 2021; Idowu and Zhou, 2021).

In addition to the increased flood risk, changes in land use practices have led to severe soil erosion (Ologunde *et al*., 2025). The removal of vegetative cover exposes topsoil to the direct impact of rainfall and wind, leading to accelerated rates of erosion, especially on sloped lands (Ologunde *et al*., 2025). Land clearing for agriculture, road construction, and urban development disturbs the natural soil structure and reduces the binding strength of root systems, further contributing to land degradation. As fertile topsoil is lost, agricultural productivity declines, forcing farmers to either overexploit remaining land or encroach further into forested areas (Ologunde *et al*., 2025).

Moreover, the sediment washed away by erosion often ends up deposited in nearby rivers, lakes, and reservoirs. This siltation reduces the water-holding capacity of these bodies, increasing the risk of overflow during rainy seasons and reducing water availability during dry periods (Schleiss *et al*., 2016). These cascading hydrological effects not only endanger infrastructure and settlements but also threaten the long-term sustainability of water resources, particularly in regions already facing climate-induced variability (Schleiss *et al*., 2016).

2.3.2 Biodiversity Loss and Ecosystem Degradation

Nigeria is recognized as one of Africa's most ecologically diverse countries, home to a wide range of ecosystems including rainforests, mangroves, savannas, wetlands, and montane regions (Olajuyigbe, 2018). However, this biodiversity is increasingly threatened by the widespread and unregulated transformation of land (Olajuyigbe, 2018). The continuous conversion of forests and other natural habitats into farmlands, residential estates, and industrial zones is among the leading causes of biodiversity loss in the country (Afuye *et al*., 2024).

Deforestation, in particular, has been accelerating due to increased demand for agricultural land and timber. Large tracts of forest are cleared every year for crop cultivation and livestock grazing, often with little regard for conservation practices (Macarringue *et al*., 2022; Agumagu *et al*., 2025). This process has devastating impacts on forest ecosystems, which support a significant portion of Nigeria's terrestrial species. Once the trees and undergrowth are removed, species that depend on these habitats for food, shelter, and reproduction either migrate or perish due to habitat fragmentation (Agumagu *et al*., 2025).

Mangrove forests in the Niger Delta represent another critical ecosystem under immense pressure (Agumagu *et al*., 2025). These coastal wetlands provide vital breeding grounds for fish and serve as natural buffers against coastal erosion and storm surges (Agumagu *et al*., 2025). However, human activities such as land reclamation, oil exploration, pollution, and infrastructure development have led to the large-scale degradation of these sensitive environments, placing the species that depend on them at serious risk of extinction (Agumagu *et al*., 2025).

Ecosystem degradation also reduces the ability of natural systems to provide vital services to humans (Okoye, 2025). These ecosystem services include water purification, soil fertility regulation, climate moderation, and pollination of crops (Olorunfemi *et al*., 2020). The loss of such services increases human vulnerability to environmental changes and disasters (Okoye, 2025). Moreover, habitat fragmentation due to expanding road networks, settlements, and monoculture plantations breaks up wildlife corridors, isolating animal populations and reducing their genetic diversity (Okoye, 2025; Olorunfemi *et al*., 2020).

2.3.3 Urban Heat Island Effect and Microclimate Alterations

Urbanization, as a major form of land use change, has contributed to significant changes in Nigeria's local climate, particularly through the Urban Heat Island (UHI) effect (Okoye, 2025). This phenomenon occurs when urban areas experience significantly higher temperatures than their surrounding rural regions, primarily due to the concentration of man-made surfaces that absorb and retain heat (Okoye, 2025).

Natural landscapes such as forests, grasslands, and wetlands have high albedo and moisture content, which allow them to cool through evapotranspiration. However, when these are replaced with buildings, roads, and other impermeable infrastructure, the land's ability to regulate temperature diminishes (Olorunfemi *et al*., 2020). Urban surfaces like asphalt and concrete retain heat during the day and slowly release it at night, leading to consistently elevated temperatures in city environments (Olorunfemi *et al*., 2020).

In Nigerian cities such as Benin City, studies have revealed a significant increase in areas with high land surface temperatures, directly linked to the expansion of built-up zones (Okoye, 2025). The absence of green spaces and vegetation cover further exacerbates this trend. As cities continue to grow in size and density, the severity and spatial extent of the UHI effect also increase (Okoye, 2025).

The implications of the UHI effect are multifaceted. First, it increases thermal discomfort among urban dwellers, especially the elderly, children, and low-income populations who may not have access to adequate cooling systems. Second, it raises the demand for electricity due to increased use of fans and air conditioners, placing additional pressure on Nigeria's already strained energy infrastructure (Okoye, 2025). This, in turn, contributes to higher emissions of greenhouse gases, creating a feedback loop that intensifies both local and global warming (Okoye, 2025).

Moreover, UHI conditions can influence local meteorological patterns (Abulibdeh, 2021). Elevated urban temperatures can alter wind circulation, decrease relative humidity, and affect rainfall distribution (Abulibdeh, 2021). In some cases, the localized warming can lead to the formation of convective storms, while in others, it may suppress rainfall, contributing to prolonged dry spells (Okoye, 2025). Air quality may also deteriorate due to increased ground-level ozone formation and reduced dispersion of pollutants (Okoye, 2025). Ultimately, these microclimatic changes reduce the livability of cities and increase vulnerability to climate-related health problems, such as heat strokes, respiratory issues, and vector-borne diseases (Abdul-nabi *et al*., 2025). The management of UHI effects thus requires urban planning interventions that prioritize green infrastructure, tree planting, sustainable building materials, and proper land-use zoning (Elmarakby and Elkadi, 2024).

Land use and land cover changes in Nigeria have produced a cascade of environmental impacts that extend well beyond the immediate areas where changes occur (Okoye, 2025). The hydrological balance has been disrupted, resulting in increased flooding and erosion. Natural ecosystems have been fragmented and degraded, leading to biodiversity loss and weakening of essential ecosystem services (Odoh *et al*., 2024). At the same time, urban expansion has intensified localized climate effects such as the Urban Heat Island phenomenon, altering microclimates and increasing energy demands (Odoh *et al*., 2024). These challenges are interconnected and often reinforce each other. For instance, the loss of forest cover not only affects biodiversity but also exacerbates climate change and reduces water quality. Similarly, urban flooding is not only a result of poor drainage systems but also of upstream deforestation and soil erosion. (Okoye, 2025).

2.4 Social Impacts of Land Use and Land Cover Change in Nigeria

The changes in land use and land cover (LULC) across Nigeria have resulted in a wide range of social, economic, and environmental consequences that extend far beyond mere alterations in the landscape (Ologunde *et al*., 2025). While environmental impacts such as deforestation, desertification, and biodiversity loss are often emphasized, the social dimensions of LULC change, particularly those affecting food security, rural livelihoods, and urban development, are equally critical (Ologunde *et al*., 2025). The socio-economic fabric of Nigerian society is deeply intertwined with how land is managed, used, and conserved (Garba and Adamu, 2024). As such, any disruption in land systems inevitably leads to disruptions in people's lives, especially in a country where a significant portion of the population is directly or indirectly dependent on land-based resources (Garba and Adamu, 2024).

2.4.1 Food Insecurity

An immediate and visible social consequence of land use and land cover change in Nigeria is the growing threat of food insecurity (Ugwukah, 2022). Nigeria's agricultural sector, which is known to serve as a source of income for the majority of its rural population, is highly dependent on land quality and availability (Ugwukah, 2022). However, due to widespread land degradation, primarily caused by over-farming, deforestation, poor irrigation practices, and the expansion of agricultural land into fragile ecosystems, the productive capacity of the country's arable land has been significantly diminished (Chiaka *et al*., 2024). The deterioration of soil quality, nutrient loss, and reduced water retention capacity in soils have all contributed to declining crop yields, undermining the nation's ability to produce sufficient food (Chiaka *et al*., 2024).

The situation is further exacerbated by the effects of climate change, which interacts with land misuse to intensify the challenges faced by farmers. Increasingly erratic rainfall patterns, prolonged droughts, and rising temperatures affect both crop cycles and harvest quality. As a result, farmers are often left with no choice but to clear additional land in an attempt to compensate for reduced yields, creating a vicious cycle of land degradation and unsustainable expansion (Ologunde *et al*., 2025). What is particularly alarming is that most of the increase in agricultural production over the past decades in Nigeria has not come from better farming practices or technological innovations, but from horizontal land expansion, bringing more land under cultivation at the expense of forests and savannas (Akpan and Ebong, 2021).

This method of agricultural expansion is inherently unsustainable. Not only does it accelerate deforestation and habitat destruction, but it also leads to increased carbon emissions and the loss of ecosystem services such as pollination, flood regulation, and nutrient cycling. In the long term, the country's dependence on land conversion rather than land productivity improvement endangers national food security. It makes the food system more vulnerable to environmental shocks and diminishes the country's capacity to meet the nutritional needs of its growing population. Therefore, the social impact of LULC change on food security is both direct, through lower agricultural output and indirect, through ecological damage that compromises future productivity (Akpan and Ebong, 2021).

2.4.2 Livelihood Impacts

Beyond agriculture, the consequences of LULC change deeply affect rural livelihoods, especially for those communities whose economic and cultural survival is directly linked to natural ecosystems (Munthali *et al*., 2022). In Nigeria, many rural households depend not only on farming but also on fishing, hunting, and gathering forest products such as firewood, herbs, and fruits. These practices are intricately connected to the health and availability of forested and savanna landscapes (Heubach *et al*., 2011). However, the rapid decline in forest cover and the encroachment of human activities into formerly natural areas have drastically reduced the availability of these resources (Macarringue *et al*., 2022).

As forests are cleared for timber, agriculture, or settlement, the socio-economic stability of forest-dependent communities becomes increasingly fragile. Females, who are traditionally responsible for collecting firewood and non-timber forest products, must now travel longer distances to find these resources, exposing them to risks and reducing the time available for other income-generating activities or childcare (Wan and Powell, 2011). Similarly, communities that rely on local rivers or wetlands for fishing and irrigation face declining fish stocks and reduced water availability due to land degradation and upstream development (Wan and Powell, 2011). The result is a gradual but steady erosion of traditional livelihoods and a rising dependence on uncertain wage labor or informal economic activities (Agumagu *et al*., 2025).

Another important trend linked to LULC change is the increasing migration of rural youth to urban areas. As agricultural profitability declines and land becomes scarcer or less fertile, young people often leave their villages in search of better opportunities in cities (Ologunde *et al*., 2025). This rural-to-urban migration results in a reduced agricultural workforce, aging rural populations, and the further neglect of agricultural land and infrastructure (Ologunde *et al*., 2025). In turn, this increases the likelihood of poor land stewardship, unregulated land use, and environmental degradation, creating a feedback loop of poverty and vulnerability (Akpan and Ebong, 2021).

Moreover, the socio-cultural fabric of rural communities is weakened as traditional knowledge systems, particularly those related to sustainable land use, indigenous farming practices, and environmental management, are lost with the outmigration of the younger generation (Akpan and Ebong, 2021). The disappearance of these knowledge systems not only diminishes community resilience but also hampers national efforts toward sustainable development (Akpan and Ebong, 2021).

2.4.3 Settlement Challenges and Urbanization Pressures

A major area wherein LULC change is causing profound social disruption in Nigeria is in human settlements and urban growth (Ademiluyi *et al*., 2008). Rapid population increase, coupled with the continual migration of people from rural areas, has led to accelerated urbanization. Unfortunately, much of this urban expansion is occurring in a largely unplanned and haphazard manner (). Cities and towns across Nigeria are expanding into agricultural lands, forests, and floodplains, resulting in the destruction of natural buffers and vital ecosystem services. This uncontrolled expansion is creating complex challenges related to urban housing, infrastructure, sanitation, and transportation (Faisal Koko *et al*., 2021).

As cities swell beyond their planned limits, informal settlements, often referred to as slums, have proliferated on the urban periphery. These areas are typically characterized by substandard housing, lack of access to clean water and sanitation, overcrowded living conditions, and inadequate waste disposal systems (Salami and Von Meding, 2017). Such environments not only pose serious public health risks but also undermine human dignity and quality of life. Many of these settlements are built on ecologically vulnerable land, such as wetlands and riverbanks, which are prone to flooding and landslides (Salami and Von Meding, 2017). The destruction of these ecosystems for urban development increases the risk of natural disasters, which disproportionately affect the urban poor who lack the resources to recover (Faisal Koko *et al*., 2021). The transportation systems in many Nigerian cities are also under strain due to LULC change. As more land is converted for residential and commercial use without corresponding investments in infrastructure, traffic congestion becomes a daily reality, leading to lost productivity, increased air pollution, and rising transportation costs (Adewunmi and Agbasi, 2024). The lack of green spaces and recreational areas further reduces urban livability, while the uneven distribution of infrastructure development exacerbates social inequality between urban neighbourhoods (Faisal Koko *et al*., 2021).

Inadequate land governance and weak enforcement of urban planning regulations have allowed land speculation, illegal land acquisition, and the proliferation of unregulated building practices to flourish (Faisal Koko *et al*., 2021). This has not only distorted land markets but also led to conflicts over land ownership and displacement of low-income communities. The long-term sustainability of Nigerian cities is at risk unless proactive policies are put in place to manage land use, protect natural landscapes, and ensure equitable access to urban infrastructure and services (Faisal Koko *et al*., 2021). The social impacts of land use and land cover change in Nigeria are profound, multifaceted, and interdependent.

The degradation and mismanagement of land resources undermine food production, push rural communities into deeper poverty, and contribute to the chaotic and inequitable growth of urban settlements (McGranahan *et al*., 2004). These issues are not isolated they are part of a broader systemic challenge that connects environmental sustainability with economic opportunity and social equity (McGranahan *et al*., 2004).

2.5 Methodologies for Assessing Land Use and Land Cover Changes in Nigeria

The rigorous assessment of land use and land cover (LULC) changes across Nigeria fundamentally relies on the application of cutting-edge geospatial technologies and sophisticated analytical methods (Fatima and Javed, 2021). These advanced approaches are crucial for understanding the dynamic transformations occurring within the Nigerian landscape and for informing effective land management strategies (Fatima and Javed, 2021).

2.5.1 Remote Sensing (RS)

Stand as the cornerstone technology for the comprehensive monitoring, precise mapping, and in-depth analysis of LULC changes over extended periods (Olorunfemi *et al*., 2020; Macarringue *et al*., 2022; Gilbert and Shi, 2023; Agumagu *et al*., 2025; Ojelabi *et al*., 2025; Okoye, 2025; Ologunde *et al*., 2025). Through its ability to acquire information about an object or phenomenon without making physical contact, it enables the systematic collection of data across vast areas (Ojelabi *et al*., 2025). A diverse array of satellite imagery serves as the primary and most vital source of raw data for the subsequent classification of LULC types (Macarringue *et al*., 2022). Specifically, various generations of Landsat images are predominantly utilized due to their long-term data continuity and spectral characteristics (Gilbert and Shi, 2023). This includes data from Landsat 5 TM (Thematic Mapper), Landsat 8 OLI (Operational Land Imager), Landsat MSS (MultiSpectral Scanner), and Landsat ETM+ (Enhanced Thematic Mapper Plus) (Olorunfemi *et al*., 2020; Macarringue *et al*., 2022;

Gilbert and Shi, 2023; Agumagu *et al*., 2025; Ojelabi *et al*., 2025; Okoye, 2025; Ologunde *et al*., 2025). The consistent acquisition of data over several decades by the Landsat program provides an invaluable archive for conducting multi-temporal analyses, which are essential for identifying and quantifying changes in land cover and land use patterns over significant periods (Ojelabi *et al*., 2025). Once the satellite imagery is acquired, a suite of advanced image processing and classification techniques are meticulously applied to interpret the raw spectral data and accurately categorize different land cover features (Gilbert and Shi, 2023). Among the commonly employed methodologies are:

2.5.1.1 Supervised Maximum Likelihood Classification

This is a widely adopted parametric classification algorithm that relies on a statistical approach (Agumagu *et al*., 2025). Researchers first define "training areas" for known land cover categories (e.g., forest, water, urban) based on ground truth or ancillary data. The algorithm then calculates the probability that each unclassified pixel belongs to a particular class, assigning it to the class with the highest likelihood based on the statistical properties (mean and covariance) of the training data (Olorunfemi *et al*., 2020; Agumagu *et al*., 2025). Its effectiveness lies in its ability to account for the variability within classes.

2.5.1.2 Random Forest Algorithm

As a powerful machine learning classification technique, Random Forest constructs an ensemble of decision trees during the training phase. Each tree is built using a random subset of the training data and a random subset of features (Ojelabi *et al*., 2025). For classification, the algorithm aggregates the predictions from individual trees (e.g., by majority vote), resulting in a more robust and often more accurate classification (Ojelabi *et al*., 2025). Its advantages include handling high-dimensional data, being relatively resistant to overfitting, and providing insights into feature importance (Ojelabi *et al*., 2025).

2.5.1.3 Post-Classification Comparison Methods

This change detection technique involves independently classifying two or more satellite images acquired at different points in time (Alawamy *et al*., 2020). Once individual LULC maps are generated for each date, they are then systematically compared on a pixel-by-pixel or polygon-by-polygon basis to identify and quantify areas where land cover has transitioned from one class to another (Alawamy *et al*., 2020). This method is highly effective for directly quantifying the extent, location, and nature of LULC changes (Gilbert and Shi, 2023).

To facilitate these complex image processing and spatial analysis operations, researchers extensively utilize professional software platforms such as ESRI ArcGIS Pro and ERDAS Imagine (Ologunde *et al*., 2025; Gilbert and Shi, 2023). These industry-standard software suites offer comprehensive toolsets for a wide range of geospatial tasks, including image rectification, radiometric and atmospheric correction, enhancement, multi-spectral classification, and advanced spatial analysis functions crucial for change detection and mapping (Gilbert and Shi, 2023).

2.5.2 Geographic Information Systems (GIS)

Geographic Information Systems (GIS) play a pivotal role in the analysis and assessment of land use and land cover changes by offering powerful tools for spatial data manipulation, visualization, and interpretation (Kucera, 2020). GIS enables the integration of multiple datasets, such as land cover maps, topographic information, climatic data, and socioeconomic indicators, which are essential for a comprehensive understanding of the factors driving land use changes (Kucera, 2020; Usmani *et al*., 2020).

With the aid of GIS, researchers can conduct detailed spatial analyses to quantify the magnitude, rate, and spatial distribution of land cover changes (Kucera, 2020). Geo-statistical techniques and spatial statistics within GIS frameworks are often used to explore spatial patterns, identify hotspots of change, and examine correlations with environmental or anthropogenic drivers (Usmani *et al*., 2020).

Change detection is one of the most fundamental capabilities of GIS in land use studies. This process typically involves comparing land cover data from different time periods to identify and quantify areas where significant transformations have occurred (Liu *et al*., 2023). Among the commonly used change detection methods are image differencing, which highlights alterations by computing the difference between pixel values across time, and post-classification comparison, where classified images from different dates are compared to detect transitions in land use classes (Liu *et al*., 2023).

Additionally, GIS is known to enable the generation of transition matrices, which illustrate the movement of land from one category to another over time (Kucera, 2020). These matrices offer valuable insights into the dynamics and directionality of land use transformations, such as forest to agriculture or rural to urban transitions (Kucera, 2020).

2.5.3 Ground Truthing and Field Surveys

Field-based validation is an essential component of any land use and land cover study that relies on remote sensing or GIS analyses. Ground truthing refers to the process of collecting field data to verify and calibrate remote sensing outputs (Vali *et al*., 2020). This involves direct observation and recording of land cover types, land use practices, and relevant environmental variables on the ground to ensure that remote sensing classifications are accurate and reliable (Vali *et al*., 2020).

Field surveys not only enhance the precision of land use maps but also provide contextual information that remote sensing alone cannot capture (Vali *et al*., 2020). For instance, surveys and interviews with local communities can yield insights into the socio-economic drivers of land use change, such as shifting agricultural practices, urban development pressures, or changes in land tenure systems (Nzunda *et al*., 2013). These ground-level observations serve as a crucial feedback mechanism that helps refine and interpret remotely sensed data (Vali *et al*., 2020).

2.5.4 Statistical and Modelling Approaches

To analyze and predict land use changes and their underlying causes, researchers frequently rely on statistical analyses and spatial modeling approaches (Wang *et al*., 2022). These methods are instrumental in identifying correlations and causative relationships between land use transformations and a range of explanatory variables, including population growth, economic development, policy shifts, and environmental changes (Wang *et al*., 2022).

Commonly applied statistical techniques include linear and logistic regression, which help in quantifying the influence of independent variables on observed land use outcomes (Xu *et al*., 2022). Recently, machine learning approaches such as random forests, support vector machines, and artificial neural networks have been increasingly utilized due to their ability to handle complex, nonlinear relationships and large datasets (Wang *et al*., 2022; Xu *et al*., 2022).

Furthermore, simulation models that incorporate spatial dynamics are employed to project future land use scenarios based on historical data and hypothetical conditions (Tong and Feng, 2020). Prominent examples include the CLUE-S (Conversion of Land Use and its Effects at Small regional extent) and LUCIA (Land Use Change Impact Assessment) models, which integrate biophysical and socioeconomic data to simulate potential land use outcomes (Tong and Feng, 2020). These models often employ techniques such as Markov chain analysis to estimate transition probabilities, cellular automata to simulate spatial processes, and agent-based models to represent individual decision-making behaviors (Nath *et al*., 2020).

These modeling frameworks are highly valuable for policy analysis and strategic planning, as they allow decision-makers to evaluate the potential impacts of land use regulations and development strategies under different scenarios (Nath *et al*., 2020).

2.5.5 Integration of Multi-Source Data

A robust and comprehensive assessment of land use and land cover changes often necessitates the integration of data from multiple sources (Chen *et al*., 2021). Combining information from remote sensing, field surveys, socioeconomic statistics, and climate models creates a multi-dimensional perspective that enhances the accuracy and explanatory power of land use studies (Zong *et al*., 2020).

This integrative approach helps to overcome the limitations of individual datasets. For example, high-resolution remote sensing imagery might lack contextual socioeconomic data, while survey-based information may be rich in detail but limited in spatial coverage (Zong *et al*., 2020; Chen *et al*., 2021). By synthesizing these diverse datasets, researchers can derive more meaningful insights and produce more reliable conclusions about land use dynamics (Zong *et al*., 2020; Chen *et al*., 2021).

2.5.6 Objectives of adopting methodologies for land use change assessment

2.5.6.1 Detailed monitoring of urban growth

Accurately tracking the outward expansion and densification of built-up areas, including residential, commercial, and industrial developments, which is crucial for urban planning (Ologunde *et al*., 2025).

2.5.6.2 Assessment of infrastructure changes

Identifying and mapping the development, modification, or removal of key infrastructure elements like roads, bridges, and other construction projects (Okoye, 2025).

2.5.6.3 Accurate classification of land cover types

Precisely categorizing the Earth's surface into distinct classes such as dense forests, various types of agricultural lands (croplands, plantations), water bodies, barren lands, and grasslands (Ologunde *et al*., 2025; Okoye, 2025).

2.5.6.4 Timely detection of land degradation

Promptly identifying areas experiencing a decline in ecosystem health and productivity, often manifested through processes like deforestation, soil erosion, desertification, and wetland degradation, thereby allowing for timely intervention (Ologunde *et al*., 2025; Okoye, 2025).

These advanced models empower researchers to predict plausible future patterns of land use and land cover. For instance, projections frequently indicate a continued increase in farmland and built-up areas, often occurring at the direct expense of critical natural ecosystems such as forests and wetlands (Ojelabi *et al*., 2025). Such predictive insights are invaluable for anticipating the environmental and socio-economic consequences of ongoing development trajectories (Ojelabi *et al*., 2025). The application of these advanced predictive techniques marks a significant evolution in LULC assessment methodologies (Ologunde *et al*., 2025). It represents a strategic shift from merely documenting what has happened to actively generating future-oriented information (Ologunde *et al*., 2025; Ojelabi *et al*., 2025).

2.6 Review of Some of the Related Empirical Literature

Fatima and Javed (2021) conducted a detailed assessment of land use and land cover (LULC) change detection in Southeast Rajasthan, India, utilizing geospatial techniques. The study employed multi-temporal satellite imagery and GIS analysis to monitor LULC dynamics over selected years. Their findings revealed a substantial transformation of land cover categories, particularly an increase in agricultural land and built-up areas, alongside a decline in forest and water body coverage. These trends were attributed to growing anthropogenic pressures such as agricultural expansion, urbanization, and infrastructural development. The study emphasized that these LULC changes could significantly affect regional environmental quality and resource sustainability. Through the application of supervised classification methods and accuracy assessments, the authors demonstrated the effectiveness of remote sensing in capturing spatiotemporal changes in land use patterns, offering crucial insights for land management and planning.

Adewumi (2013) analyzed the pattern and transformation of land use and land cover along the River Benue channel in Adamawa State, Nigeria, focusing on spatial distribution and implications. Using Landsat imagery from 1986, 1999, and 2005, the study identified significant changes in land cover, especially the expansion of agricultural land and the reduction of forest and water bodies. The author highlighted that these shifts were largely driven by population growth, increased farming activities, and human settlement expansion along the river channel. The research showed that such unregulated changes in land use could potentially lead to environmental degradation, flood risks, and the disruption of aquatic ecosystems. Through comparative analysis across time periods, the study provided essential data for watershed management, emphasizing the need for integrated land-use policies that protect riparian zones.

Ologunde *et al.* (2025) investigated land use and land cover changes in Nigeria through an empirical case study using remote sensing and GIS-based techniques. The study explored how rapid changes in land use, particularly the expansion of urban areas and agricultural zones, have influenced environmental and socio-economic conditions. By analyzing satellite data from multiple decades, the authors documented a progressive decline in forest cover and wetlands, which they attributed to deforestation, infrastructure development, and population pressure. The results indicated that LULC changes significantly altered hydrological patterns, increased surface runoff, and reduced natural vegetation, which in turn impacted rural livelihoods and food security. The study concluded that effective land governance, improved spatial planning, and environmental monitoring are critical for mitigating the negative consequences of LULC transformation.

Afuye *et al*. (2024) conducted a comprehensive global trend assessment of land use and land cover changes using a systematic review approach. The study synthesized empirical findings from various regions to evaluate the drivers, patterns, and consequences of LULC change. It revealed consistent global trends such as deforestation, urban sprawl, wetland loss, and agricultural intensification. Key drivers identified included demographic growth, policy changes, climate variability, and economic development. The authors emphasized the importance of remote sensing and GIS technologies in tracking these transformations and called for the development of integrated frameworks that link LULC monitoring with sustainable land management. The review underscored the urgency of adopting proactive planning and policy reforms to address the ecological and social challenges arising from land transformation, particularly in rapidly developing countries.

Akpan and Ebong (2021) explored the relationship between agricultural land use and population growth in Nigeria, arguing for the need to harmonize both elements for sustainable agricultural development. Drawing from secondary data and empirical analyses, the study revealed that population growth has intensified pressure on available agricultural land, often leading to overuse and expansion into marginal or forested areas. The authors noted that most increases in food production have been achieved through land expansion rather than productivity enhancement, a trend they identified as unsustainable. They further observed that this expansion frequently results in deforestation, soil degradation, and reduced land suitability. The study concluded by advocating for integrated land-use planning, investment in agricultural technologies, and population management strategies to improve food security and preserve environmental resources.

Chiaka *et al*. (2024) conducted a spatial assessment of land suitability potential for agriculture across Nigeria, employing GIS-based multi-criteria analysis to evaluate the agricultural capacity of various land types. The study integrated variables such as slope, soil type, rainfall, and land cover to generate a suitability map for different crop types. Results revealed that a significant portion of Nigeria's landmass falls within low to moderate suitability classes due to ongoing land degradation, unplanned expansion of agricultural land, and encroachment into unsuitable zones. The authors emphasized that current agricultural land use practices are not aligned with ecological suitability, thereby exacerbating food insecurity and environmental stress. The study concluded that adopting spatially guided land use planning and enforcing environmental safeguards are essential to optimizing agricultural productivity while conserving fragile landscapes.

Agumagu *et al*. (2025) examined land use and land cover change dynamics in the Niger Delta region of Nigeria from 1986 to 2024, using a combination of Landsat satellite data and GIS tools. The study found significant increases in built-up areas and farmlands, alongside marked reductions in mangroves and natural vegetation cover. These changes were largely attributed to oil exploration, urbanization, and population pressure. The authors highlighted the socio-environmental implications of such transitions, including loss of biodiversity, increased vulnerability to flooding, and declining livelihoods among resource-dependent communities. By tracking spatiotemporal trends over nearly four decades, the study provided crucial insights into how human activities have reshaped one of Nigeria's most ecologically sensitive regions. It recommended stricter environmental regulations and community-inclusive land governance to curb further ecological decline.

Faisal Koko *et al*. (2021) analyzed urban growth and land cover change in Lagos, Nigeria, utilizing multi-temporal satellite imagery and GIS techniques to assess changes over time and their implications for flood risk. The study observed rapid expansion of impervious surfaces, largely due to unregulated urban development, which contributed to reduced natural drainage and increased urban flooding. From 1984 to 2019, built-up areas in Lagos expanded significantly, replacing wetlands and vegetated zones that previously served as natural flood buffers. The researchers applied scenario modeling to simulate future urban growth and its potential environmental impacts. Their findings underscored the critical need for flood-mitigation strategies, sustainable land management, and urban planning frameworks that integrate green infrastructure and enforce spatial development controls.

Ojelabi *et al*. (2025) investigated the impacts of anthropogenic activities on land use and land cover change within the Ogun River Basin, Nigeria, covering a temporal range from 1984 to 2020. The study applied supervised classification methods on satellite imagery and analyzed trends in deforestation, agricultural expansion, and settlement growth. The findings revealed that forest cover declined drastically, while agricultural and built-up areas expanded rapidly. The authors linked these trends to increased population pressure, unsustainable farming practices, and weak land-use regulation. Consequences identified included altered hydrology, reduced water quality, and heightened flood risks in downstream areas. The study advocated for integrated watershed management and land-use planning policies that balance human needs with environmental sustainability across the basin.

Okoye (2025) conducted a temporal assessment of land use and land cover (LULC), land surface temperature (LST), and urban heat island (UHI) effects in Benin City, Edo State, Nigeria, comparing data from 2017 and 2023. Using remote sensing techniques and GIS analysis, the study observed that built-up areas increased significantly during the six-year period, while vegetated areas declined. These changes corresponded with a noticeable rise in land surface temperatures, indicating intensification of the urban heat island effect. The research highlighted that urban expansion without adequate green space integration is contributing to increased thermal discomfort and health risks for residents. The study concluded that effective urban greening policies and climate-sensitive urban planning are essential to mitigate the adverse thermal effects associated with rapid LULC changes in urban environments.

Macarringue *et al*. (2022) conducted a regional assessment of land use and land cover change impacts on ecosystem services and community livelihoods in Mozambique. Using spatial modeling, remote sensing data, and field surveys, the study evaluated the consequences of LULC transitions, particularly forest conversion to agricultural land on provisioning, regulating, and cultural ecosystem services. Findings indicated that land cover changes significantly reduced the availability of fuelwood, non-timber forest products, and clean water, thus increasing livelihood vulnerability for forest-dependent communities. Although the research focused on Mozambique, its relevance extends to Nigeria and other sub-Saharan contexts where rural livelihoods are closely tied to natural resource access. The authors advocated for landscape-level management approaches that integrate conservation with rural development planning, in order to preserve ecosystem functionality and enhance community resilience.

Enoguanbhor *et al*. (2021) investigated the planning deficits and governance challenges in managing land use within the Abuja City-Region. The study identified systemic issues such as weak regulatory frameworks, lack of environmental assessments, and proliferation of informal settlements. The authors recommended a holistic land use planning system that accounts for environmental integrity, social equity, and institutional efficiency.

Allan *et al*. (2022) reviewed global literature on land use change and categorized the key drivers into economic, policy-related, environmental, and technological factors. Through bibliometric analysis, they highlighted the importance of adaptive and region-specific governance frameworks in managing LULC transitions. Their findings underscore the role of institutional innovation in achieving land use sustainability, particularly in countries with rapid development trajectories like Nigeria.

Gilbert and Shi (2023) studied the changing land cover in Lagos over a 30-year span using geographic information systems and remote sensing. They observed a consistent increase in urban development, with corresponding losses in natural habitats and wetland areas.

The authors proposed the integration of land monitoring systems into urban governance structures to improve planning accuracy and environmental accountability.

Idowu and Zhou (2021) focused on the impact of LULC changes on flood risk in Lagos. Using hydrological simulations, they demonstrated that unchecked urban sprawl leads to increased surface runoff and heightened vulnerability to flooding. Their study suggested zoning regulations and sustainable drainage systems as crucial elements of urban land use planning.

John and Bello (2025) explored the institutional barriers impeding effective land use governance in Nigeria. The study found that corruption, limited technical capacity, and fragmented policies contribute significantly to poor land management. They called for institutional reforms aimed at enhancing transparency, accountability, and stakeholder participation in land governance systems.

Olorunfemi *et al*. (2020) applied GIS and remote sensing tools to evaluate LULC changes in Ekiti State and their implications for environmental sustainability. Their findings showed that rapid deforestation and informal urban expansion have led to significant declines in biodiversity and ecosystem services. The study emphasized the utility of geospatial technology in supporting evidence-based environmental planning.

Nnaemeka-Okeke (2016) investigated urban sprawl trends across Nigerian cities, linking the phenomenon to weak planning institutions, socio-economic disparities, and fragmented infrastructure systems. The research recommended adopting compact urban models and strategic land use practices to address the multifaceted challenges of uncontrolled urban growth.

Akindoyin and Obafemi (2025) explored how insecurity and conflict dynamics shape land use decisions in Nigeria. The study observed that internal displacement due to violence has led to pressure on safer regions, resulting in unregulated land conversion and degradation. They advocated for incorporating conflict-sensitive strategies into land use policies to enhance both environmental sustainability and social cohesion.

CHAPTER THREE

MATERIALS AND METHODS

3.1 Study Area

University of Benin Ekehuan campus, located in the southern part of Nigeria, served as the study area for this research. Ekehuan campus covers an approximate landmass of 0.24 km^2 (24 hectares) with a population of about three thousand (3000). The campus is situated within the Niger Delta region, characterized by a tropical monsoon climate with distinct wet and dry seasons. Rainfall peaks between July and August, while the dry season spans from November to March. The ecological conditions and land use dynamics of the area makes it suitable for vegetation monitoring and land use/land cover (LULC) analysis.

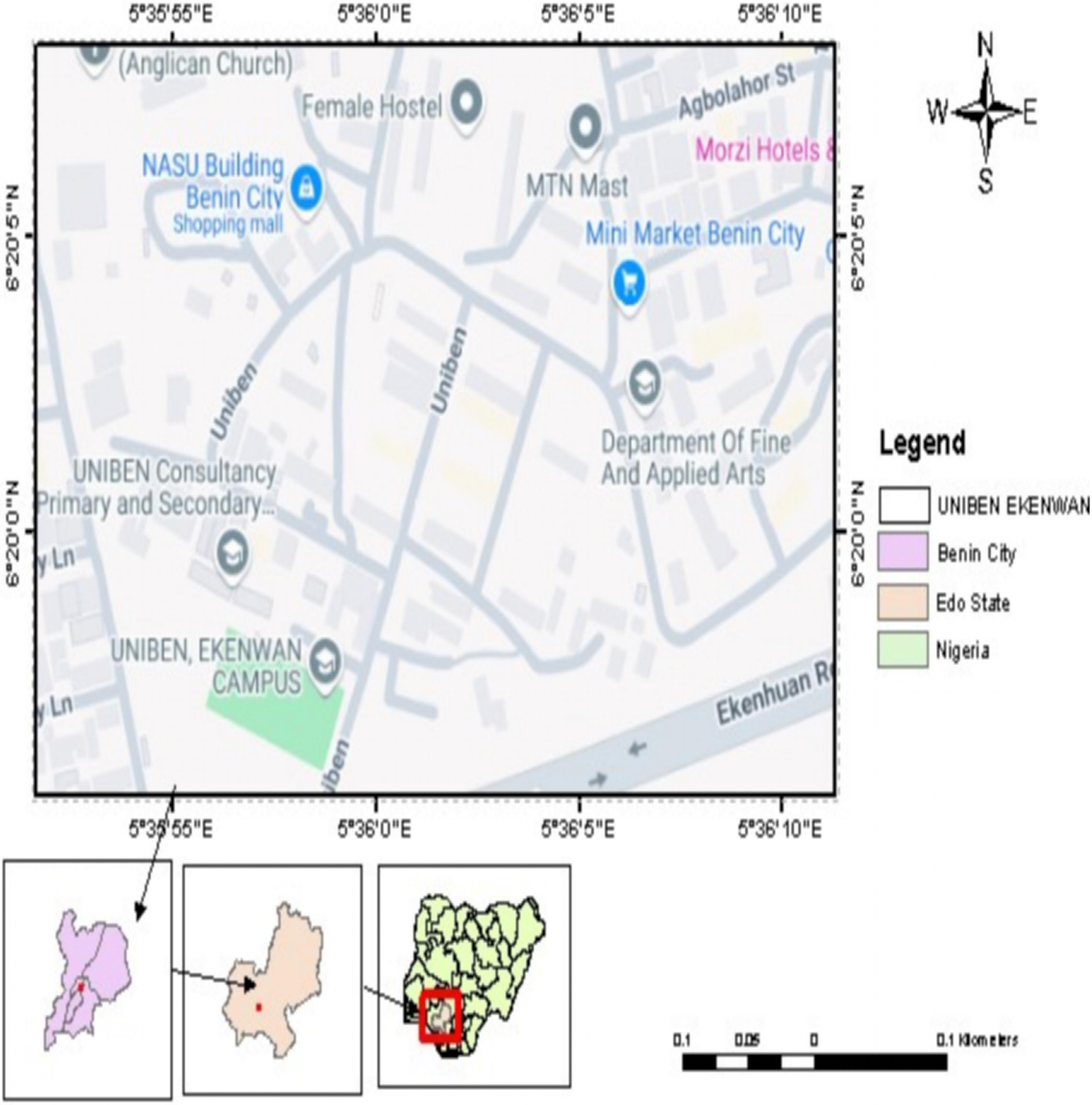


Figure 3.1: Map of the Study Area.

3.2 Data Collection and Pre-processing

Satellite imageries used for this study were sourced from the United States Geological Survey (USGS) Earth Explorer and Google Earth Engine (GEE) platforms. Landsat 5 TM, Landsat 7 ETM+, and Landsat 8/9 OLI/TIRS datasets were selected for different temporal windows, ensuring minimal cloud cover and dry-season acquisitions for consistency (Gorelick *et al.,* 2017; USGS, 2024). Pre-processing steps included:

i. Band Stacking: Selection and combination of relevant spectral bands for vegetation and LULC changes.

ii. Cloud Masking: Application of Quality Assessment (QA) bands to remove cloud-affected pixels.

iii. Clipping: Study area boundaries were applied using administrative shapefiles of Edo State.

3.3 Normalized Difference Vegetation Index (NDVI) Analysis

NDVI was employed to assess vegetation vigor and distribution. The NDVI was computed using the formula:

NDVI = (NIR - RED) / (NIR + RED)

Where;

- NIR = Near-Infrared reflectance (Band 4 for Landsat 5 TM/7 ETM+, Band 5 for Landsat 8/9 OLI).

- RED = Red reflectance (Band 3 for Landsat 5 TM/7 ETM+, Band 4 for Landsat 8/9 OLI).

The index ranges between -1 and +1. Positive values close to +1 indicate dense vegetation, values around zero represent sparse vegetation or mixed land cover, and negative values signify water, bare soil, or non-vegetated surfaces.

The NDVI images were reclassified into vegetation density classes: high, low, and non-vegetated. This enabled spatial and temporal analysis of vegetation dynamics across the study area (Rouse et al., 1974; Tucker, 1979).

3.4 Supervised Land Use/Land Coverage Classification

Supervised classification was conducted to categorize land use and land cover in the study area. The methodological steps included:

3.4.1 Training Sample Collection

Training data were digitized based on prior knowledge, high-resolution Google Earth imagery, and existing literature (Lillesand *et al.,* 2015; Jensen, 2016). Major LULC classes identified included:

1. Built-up areas
2. Agricultural land
3. Forest/vegetation
4. Water bodies
5. Bare surfaces

3.4.2 Classification Algorithm

The Maximum Likelihood Classifier (MLC) was employed due to its statistical robustness and effectiveness in handling spectral variability. The classification was carried out in both Google Earth Engine (GEE) and ArcGIS environments.

3.4.3 Post-Classification Processing

Misclassifications were minimized using majority filtering techniques. Classified outputs were re-clipped to the study boundaries for consistency.

3.4.4 Accuracy Assessment

Accuracy assessment was performed using ground-truth points and reference imagery. A confusion matrix was generated, and the following metrics were computed:

- Overall Accuracy (OA)
- Producer's Accuracy (PA)
- User's Accuracy (UA)
- Kappa Coefficient (κ)

Classification reliability was considered acceptable at overall accuracy values above 80% and Kappa coefficients above 0.75 (Congalton and Green, 2019).

3.5 Integration of NDVI and LULC Results

The NDVI maps were integrated with LULC classification outputs to provide enhanced interpretation of vegetation distribution relative to land use categories. This integration facilitated:

- Identification of land cover types supporting healthy vegetation.
- Monitoring of deforestation and agricultural expansion impacts.
- Comparative temporal analysis of vegetation changes and LULC transitions.

3.6 Data Analysis and Presentation

Processed NDVI and LULC datasets were analyzed in ArcGIS 10.4 and Google Earth Engine platforms. Spatial statistics, and temporal comparisons were conducted to highlight vegetation cover changes and land use dynamics. The results were presented in the form of maps, graphs, and tabulated summaries for clear visualization and interpretation.

3.7 Tree Identification

Photographs of trees were taken at each location and the general morphologies of each pictured tree were utilized by Dr. J.U. Ogbebor in the identification of the respective pictured tree specimens using several flora taxonomic monographs.

CHAPTER FOUR

RESULTS

4.1 Land Use and Land Cover Changes (1975-2025) in the Study Area.

The changes in land use and land cover in the study area from 1975 to 2025 are shown in Table 4.1 and Fig 4.2. Table 4.1 shows that as at 1975, there were large patches of dense vegetation covering nearly the entire study area, while built-up areas, agricultural land, and bare soil were not part of the study area. Dense vegetation dominated at 0.841334 km² (97.34%), with only minimal sparse vegetation at 0.022991 km² (2.66%). As at the year 1985, the area of dense vegetation had decreased substantially to 0.468205 km² (54.17%), while sparse vegetation increased significantly to 0.385748 km² (44.63%), and agricultural land appeared for the first time at 0.010372 km² (1.2%).

In 1995, the landscape showed slight stabilization, with dense vegetation recording a marginal increase to 0.478663 km² (55.38%) and sparse vegetation remaining relatively stable at 0.385662 km² (44.62%), while agricultural land completely disappeared from the study area. As at the year 2005, dense vegetation had declined dramatically to only 0.208129 km² (24.08%), representing less than one-quarter of the study area, while sparse vegetation expanded considerably to 0.656196 km² (75.92%), becoming the dominant land cover type. Built-up areas, agricultural land, and bare soil remained absent during this period.

The most significant transformation occurred between 2005 and 2015. As at the year 2015, dense vegetation had completely disappeared (0.00 km², 0%), and sparse vegetation had collapsed to only 0.015904 km² (1.84%). Simultaneously, built-up areas emerged dramatically at 0.315392 km² (61.67%), and agricultural land increased substantially to 0.525164 km² (36.49%), while bare soil remained at 0.00 km². As at the year 2025, the smallest vegetated area was recorded, with both dense and sparse vegetation completely absent from the study area (0.00 km², 0%). Agricultural land had decreased to 0.130167 km² (16.06%), while bare soil appeared for the first time at 0.053934 km² (6.24%). Built-up areas made up the majority of the study area at 0.671581 km² (77.70%), representing more than three-quarters of the total landscape.

The general trends in land use/land cover in the study area as presented in Table 1.0 revealed that as at 1975, dense vegetation at 0.841334 km² (97.34%) covered the largest land use in the study area, representing a near-pristine natural ecosystem, while the least land use area was sparse vegetation at 0.022991 km² (2.66%). Agricultural land, built-up areas, and bare soil were completely absent, indicating minimal human disturbance. This baseline condition represented the natural state of the landscape before significant anthropogenic intervention.

In the year 1985, a decade later, it was observed that the dense vegetation area declined significantly to 0.468205 km² (54.17%), representing a loss of 0.373129 km² or a 44.35% reduction in absolute terms. Sparse vegetation areas increased dramatically to 0.385748 km² (44.63%), gaining 0.362757 km² or a 1,577% increase. Agricultural land emerged for the first time at 0.010372 km² (1.2%), marking the beginning of agricultural activities in the study area. Built-up areas and bare soil remained absent. This period indicated the first major wave of land transformation, likely driven by initial settlement and agricultural expansion.

As at the year 1995, dense vegetation showed a slight recovery to 0.478663 km² (55.38%), increasing by 0.010458 km² (2.23%) from the 1985 level, while sparse vegetation remained relatively stable at 0.385662 km² (44.62%), showing negligible change of only -0.000086 km². Agricultural land completely disappeared during this period (0.00 km², 0%), declining from 1.2% to zero. Built-up areas and bare soil continued to be absent. This decade represented a brief stabilization period, though the disappearance of agricultural land suggested possible land abandonment or ecological stress.

In the year 2005, it was observed that the dense vegetation area declined drastically to 0.208129 km² (24.08%), losing 0.270534 km² or 56.51% from the 1995 level. This represented a critical threshold where dense vegetation fell below one-quarter of the study area. Sparse vegetation areas increased substantially to 0.656196 km² (75.92%), gaining 0.270534 km² or 70.14% from 1995, becoming the dominant land cover for the first time. Agricultural land, built-up areas, and bare soil remained at 0.00 km². This period indicated accelerated forest degradation and fragmentation, with dense vegetation converting primarily to sparse vegetation cover.

The year 2015 marked the most catastrophic transformation in the study area's history. Dense vegetation completely disappeared to 0.00 km² (0%), eliminating all remaining 0.208129 km² from 2005 indicative of a 100% loss. Sparse vegetation collapsed dramatically to only 0.015904 km² (1.84%), declining by 0.640292 km² or 97.58% from 2005 levels. In stark contrast, built-up areas emerged explosively at 0.315392 km² (61.67%), and agricultural land increased massively to 0.525164 km² (36.49%), collectively accounting for 98.16% of the study area. Bare soil remained absent. This decade represented complete deforestation and the transition from a natural to an entirely anthropogenic landscape, likely driven by major urban development or resettlement programs.

In the year 2025, it was observed that both dense and sparse vegetation remained completely absent at 0.00 km² (0%), confirming the complete loss of natural vegetation cover. Agricultural land areas declined substantially to 0.130167 km² (16.06%), losing 0.394997 km² or 75.21% from 2015, which was indicative of conversion of farmland to other uses. Bare soil areas appeared for the first time at 0.053934 km² (6.24%), suggesting active construction, land degradation, or soil exposure from development activities. Built-up areas expanded significantly to 0.671581 km^2 (77.70%), gaining 0.356189 km^2 or 112.94% from 2015, and covering the largest land area in the study area. This final period confirmed the complete urbanization of the landscape, with built-up areas dominating nearly four-fifths of the total area.

The rate of land cover change varied notably across the decades. Between 1975 and 1985, dense vegetation decreased at an average rate of 0.0373 km^2 per year (3.73 km^2 per century), while sparse vegetation increased at 0.0363 km^2 per year. The 1985-1995 decade showed relative stability with minimal changes in both vegetation categories. However, the 1995-2005 period witnessed accelerated dense vegetation loss at 0.0271 km^2 per year and corresponding sparse vegetation gain at the same rate.

The 2005-2015 period recorded the most rapid transformation, with total vegetation (dense and sparse combined) declining at a catastrophic rate of 0.0643 km^2 per year, while built-up areas increased at 0.0315 km^2 per year and agricultural land at 0.0525 km^2 per year. The 2015-2025 period continued urban expansion at 0.0356 km^2 per year, while agricultural land declined at 0.0395 km^2 per year, demonstrating the conversion of farmland to urban uses.

In terms of percentage distribution, dense vegetation declined progressively from 97.34% (1975) to 54.17% (1985), increased marginally to 55.38% (1995), dropped sharply to 24.08% (2005), and completely disappeared by 2015 and 2025 (0%). Sparse vegetation showed an inverse initial trend, increasing from 2.66% (1975) to 44.63% (1985) and 44.62% (1995), then surging to 75.92% (2005) before collapsing to 1.84% (2015) and 0% (2025).

Built-up areas, absent until 2015, exploded to 61.67% and further expanded to 77.70% by 2025, representing a 16.03 percentage point increase in just one decade. Agricultural land fluctuated dramatically from 0% (1975) to 1.2% (1985), back to 0% (1995-2005), then surging to 36.49% (2015) before declining to 16.06% (2025). Bare soil, absent throughout most of the study period, appeared at 6.24% in 2025, indicating recent land disturbance or degradation.

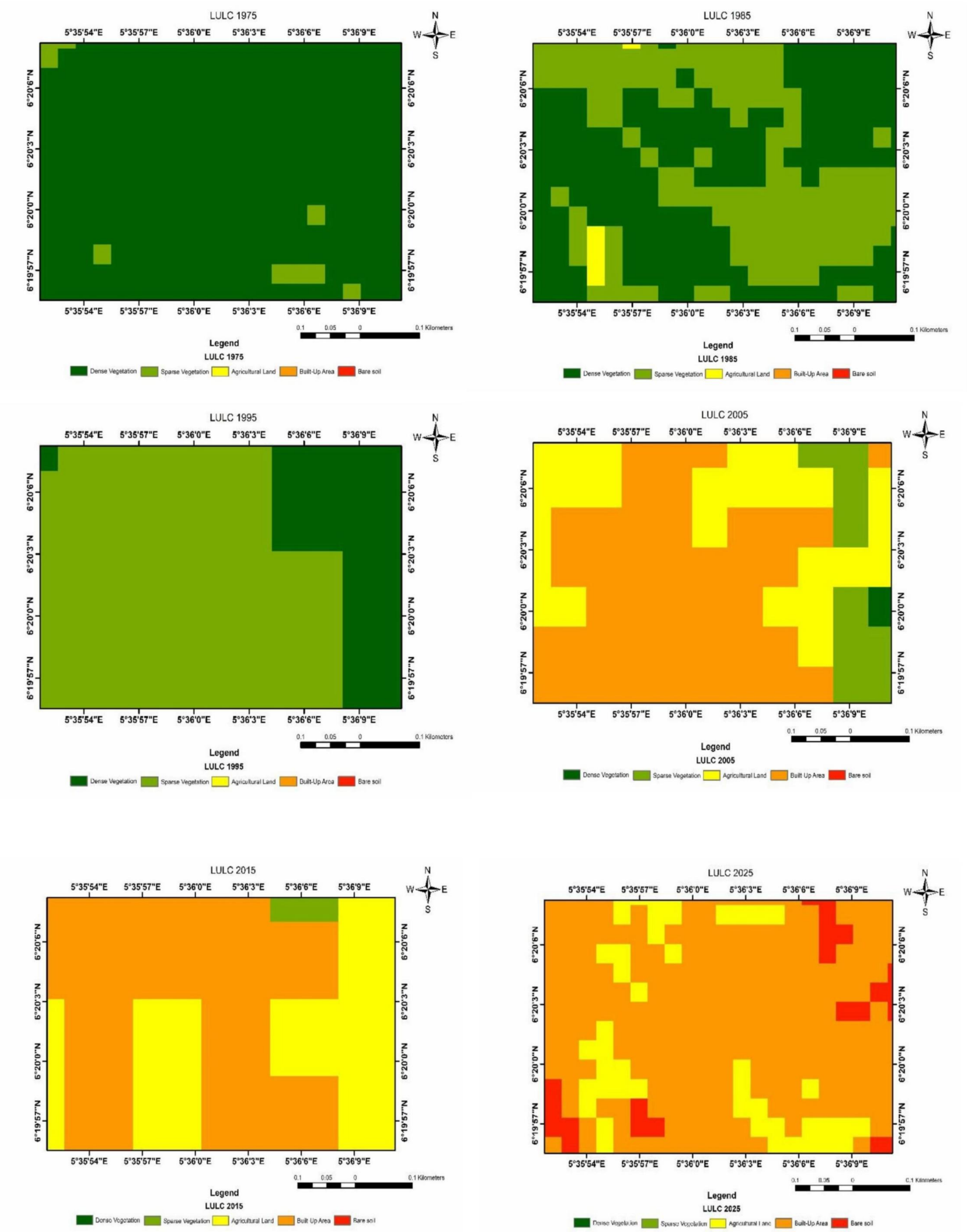
Over the entire 50-year study period (1975-2025), the landscape experienced complete transformation. Dense vegetation suffered a 100% loss, declining from 0.841334 km² to 0.00 km². Sparse vegetation also experienced complete elimination, ultimately declining from its peak of 0.656196 km² (2005) to 0.00 km². Built-up areas increased from 0.00 km² to 0.671581 km², representing infinite growth in percentage terms and the emergence of urban dominance. Agricultural land showed volatile patterns, ultimately stabilizing at 0.130167 km² (16.06%) after being absent initially. Bare soil emerged at 0.053934 km² (6.24%), indicating landscape degradation.

The study area, totaling approximately 0.864 km² based on 1975 data, underwent complete land use transformation from a natural, vegetation-dominated ecosystem to an urbanized, human-modified landscape. Natural vegetation cover declined from 100% to 0%, while human-modified surfaces (built-up areas, agricultural land, and bare soil) increased from 0% to 100%.

Table 4.1: LULC report from 1975 to 2025.

	Color	Color Code	Area (Km^2)	Percentage (%)
1975 Report	Dark Green	Dense Vegetation	0.841334	97.34
	Light Green	Sparse Vegetation	0.022991	2.66
	Yellow	Agricultural Land	0	0
	Orange	Built-Up Area	0	0
	Red	Bare Soil	0	0
1985 Report	**Color**	**Color Code**	**Area (Km^2)**	**Percentage (%)**
	Dark Green	Dense Vegetation	0.468205	54.17
	Light Green	Sparse Vegetation	0.385748	44.63
	Yellow	Agricultural Land	0.010372	1.2
	Orange	Built-Up Area	0	0
	Red	Bare Soil	0	0
1995 Report	**Color**	**Color Code**	**Area (Km^2)**	**Percentage (%)**
	Dark Green	Dense Vegetation	0.478663	55.38
	Light Green	Sparse Vegetation	0.385662	44.62
	Yellow	Agricultural Land	0	0
	Orange	Built-Up Area	0	0
	Red	Bare Soil	0	0
2005 Report	**Color**	**Color Code**	**Area (Km^2)**	**Percentage (%)**
	Dark Green	Dense Vegetation	0.208129	24.08
	Light Green	Sparse Vegetation	0.656196	75.92
	Yellow	Agricultural Land	0	0
	Orange	Built-Up Area	0	0
	Red	Bare Soil	0	0
2015 Report	**Color**	**Color Code**	**Area (Km^2)**	**Percentage (%)**
	Dark Green	Dense Vegetation	0	0
	Light Green	Sparse Vegetation	0.015904	1.84
	Yellow	Agricultural Land	0.525164	36.49
	Orange	Built-Up Area	0.315392	61.67
	Red	Bare Soil		0
2025 Report	**Color**	**Color Code**	**Area (Km^2)**	**Percentage (%)**
	Dark Green	Dense Vegetation	0	0
	Light Green	Sparse Vegetation	0	0
	Yellow	Agricultural Land	0.130167	16.06
	Orange	Built-Up Area	0.671581	77.70
	Red	Bare Soil	0.053934	6.24

Fig 4.2 LULC Maps of the Study Area from 1975-2025.



4.2 Normalized Difference Vegetation Index (NDVI) Analysis (1975-2025) in the Study Area.

The NDVI values for the study area from 1975 to 2025 are presented in Table 4.2 and figure 4.3. Table 4.2 shows that in 1975, the NDVI ranged from a minimum of -0.0774908 to a maximum of 0.114754, with a range of 0.192245. The negative minimum value indicated the presence of water bodies, bare soil, or non-vegetated surfaces within the predominantly vegetated landscape, while the relatively low maximum value of 0.114754 suggested either seasonal timing effects, atmospheric conditions, or naturally moderate vegetation productivity despite 97.34% dense vegetation cover.

As at the year 1985, the NDVI range shifted dramatically to between 0.207771 (minimum) and 0.338075 (maximum), with a range of 0.130304. Notably, the minimum value became positive, indicating the absence of water bodies or completely bare surfaces, and both minimum and maximum values increased substantially. The maximum NDVI of 0.338075 represented the second-highest vegetation health recorded across the entire study period, suggesting that remaining vegetation patches, though reduced in area to 54.17% dense vegetation, exhibited improved vigor and productivity.

As at the year 1995, the NDVI range exhibited concerning characteristics, spanning from -0.084939 (minimum) to 0.0502761 (maximum), with a range of only 0.135215. The maximum NDVI of 0.0502761 represented the lowest value recorded throughout the entire 50-year period, indicating severely stressed vegetation despite the LULC data showing 55.38% dense vegetation cover. The negative minimum suggested increased presence of bare soil or water, while the extremely low maximum indicated that even the healthiest vegetation was experiencing significant stress, possibly due to drought, disease, pest infestation, or severe environmental degradation.

As at the year 2005, the NDVI demonstrated remarkable recovery, ranging from 0.15501 (minimum) to 0.400507 (maximum), with a range of 0.245497 the widest range observed. The maximum NDVI of 0.400507 represented the highest vegetation health value recorded across all study years, indicating exceptionally healthy and productive vegetation. This paradoxical improvement occurred despite dense vegetation declining to only 24.08% of the study area, suggesting that the remaining vegetation patches received enhanced resources (sunlight, water, nutrients) due to reduced competition, or were actively managed and maintained. The positive minimum indicated absence of completely bare surfaces.

In the year 2015, the NDVI ranged from 0.0565709 (minimum) to 0.231999 (maximum), with a range of 0.175428. Both values declined substantially from 2005 levels, consistent with the catastrophic loss of natural vegetation recorded in the LULC data (dense vegetation at 0%, sparse vegetation at 1.84%). The moderate maximum NDVI of 0.231999 likely reflected the agricultural land that had emerged at 36.49% of the study area, as crops and cultivated vegetation typically exhibit moderate NDVI values. The low but positive minimum suggested limited completely bare surfaces, with most non-vegetated areas consisting of built-up surfaces (61.67%).

As at the year 2025, the NDVI ranged from 0.0608354 (minimum) to 0.26453 (maximum), with a range of 0.203695. The maximum NDVI showed slight improvement from 2015 (increasing by 0.032531), while the minimum remained relatively stable (increasing marginally by 0.0042645). This moderate NDVI signature, despite complete absence of natural vegetation (0% dense and sparse vegetation), confirmed that the recorded vegetation indices were derived entirely from agricultural land (16.06%) and possibly urban vegetation such as parks, gardens, street trees, or landscaped areas within the 77.70% built-up environment.

The shift from negative in 1975 to positive in 1985 was indicative of no water bodies or notable reduction in bare soil areas. The return to negative values in 1995 (-0.084939) suggested re-emergence of bare surfaces or water, potentially due to land degradation. The positive minimum in 2005 (0.15501) and subsequent years indicated that even the least vegetated areas maintained some vegetation cover or consisted primarily of built surfaces rather than bare soil. The declining minimum values from 2005 to 2015 (63.5% decrease) reflected increasing proportions of built-up areas and bare surfaces. The marginal increase from 2015 to 2025 (7.5% increase) suggested stabilization of the urban landscape.

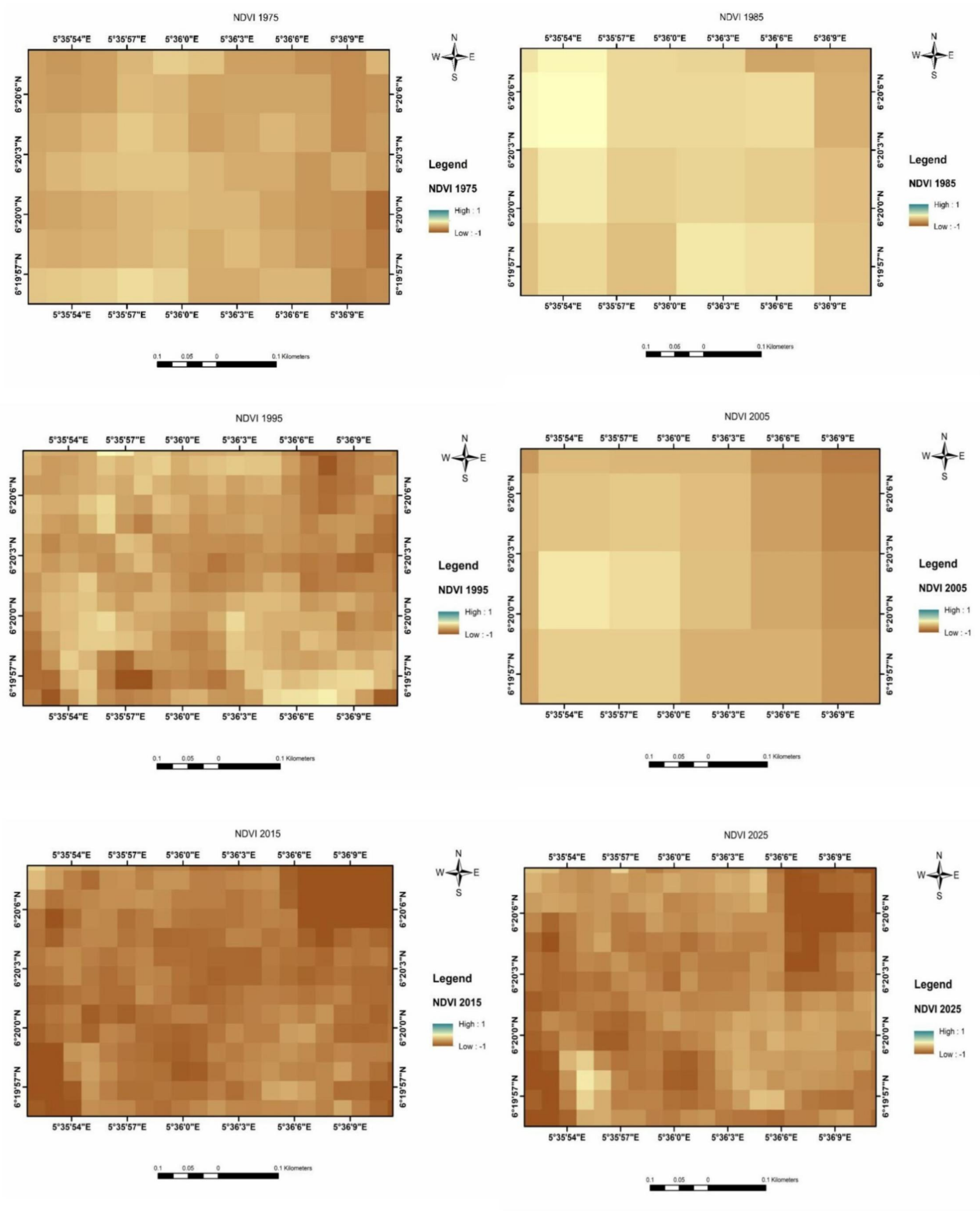
Cross-referencing NDVI data with LULC changes revealed important relationships. In 1975, despite 97.34% dense vegetation cover, the maximum NDVI of only 0.114754 suggested measurement timing during dry season, atmospheric interference, or naturally low-productivity vegetation types. The 1985 improvement in NDVI maximum to 0.338075, despite 43.17 percentage point loss in dense vegetation, demonstrated the "less-but-healthier" phenomenon where remaining vegetation thrived.

The 1995 NDVI crisis (maximum 0.0502761) despite maintaining 55.38% dense vegetation indicated severe vegetation stress not apparent from area measurements alone, highlighting the importance of vegetation indices in detecting health conditions. The 2005 peak NDVI (0.400507) with only 24.08% dense vegetation confirmed that vegetation health and vegetation area are distinct metrics small areas of vegetation can be highly productive.

Table 4.2: NDVI report from 1975 to 2025.

Year	Minimum	Maximum
1975	-0.0774908	0.114754
1985	0.207771	0.338075
1995	-0.084939	0.0502761
2005	0.15501	0.400507
2015	0.0565709	0.231999
2025	0.0608354	0.26453

Fig 4.3: NDVI Maps of the Study Area from 1975 to 2025.



4.3 Tree Species Sample Collected in the Study Area.

A total of 14 tree species were documented in the study area in the year 2025 as shown In Table 4.3 and they include *Delonix regia* (Flame of the forest), *Terminalia ivorensis* (Black Afara), *Licania rigida* (Oiticica), *Magnifera indica* (Mango), *Psidium guajava* (Guava), *Citrus* sp. (Lime), *Greenwaeodendron suavolens* (African Teak), *Citrus sinensis* (Orange), *Anacardium occidentale* (Cashew), *Azadirachta indica* (Neem Tree), *Terminalia catappa* (Indian Almond), *Elaeis guineensi* (Oil palm), *Persea Americana* (Avocado), *Plumeria* sp. (Temple Tree). From the aboved species mentioned, only *Terminalia ivorensis* (Black Afara), *Greenwaeodendron suavolens* (African Teak), and *Elaeis guineensi* (Oil palm) were revealed to be indigenous to the study area while the others were identified as Exotic trees and non-indigenous to the study area.

These surviving indigenous species (*Terminalia ivorensis* (Black Afara), *Greenwaeodendron suavolens* (African Teak), and *Elaeis guineensi* (Oil palm)) share common traits including tolerance to urban conditions (air pollution, soil compaction, heat stress), ornamental value leading to deliberate retention, economic importance (fruit production, timber value), cultural or religious significance prompting preservation, hardy growth characteristics enabling survival in degraded conditions, and adaptability to fragmented, isolated growing conditions.

The spatial distribution of these 14 tree specimens is necessarily constrained by the current land use configuration. With 77.70% built-up areas, 16.06% agricultural land, and 6.24% bare soil comprising 100% of the study area, trees can only persist in marginal spaces such as street verges, compound gardens, agricultural field boundaries, within the institutional grounds (study area), and possibly along watercourses or drainage channels if still present.

These trees exist as isolated strands or small groups rather than as functional forest communities. Unlike the historical forest ecosystem that supported complex ecological interactions, including mycorrhizal networks, pollinator communities, seed dispersers, herbivores, and decomposers, the current scattered tree distribution precludes most natural ecological processes. The 14 remaining species experienced reduced genetic diversity due to small population sizes and isolation, limiting their long-term viability.

Table 4.3 Tree species Sample collected (See Appendix for Images).

Tree Code	Location	Common Name	Botanical Name
A	Graphic Design Studio	Flame of the forest	*Delonix regia*
B	Felio and Eki Hostel	Black Afara	*Terminalia ivorensis*
C	Graphic Design Studio	Oiticica	*Licania rigida*
D	Department of Theatre Arts	Mango	*Magnifera indica*
E	Audit Unit	Guava	*Psidium guajava*
F	Theatre Hall	Lime	*Citrus* sp.
G	All Saints Chapel	African Teak	*Greenwaeodendron suavolens*
H	Media Centre	Orange	*Citrus sinensis*
I	Department of Fine and Applied Arts	Cashew	*Anacardium occidentale*
J	Institute of Education	Neem Tree	*Azadirachta indica*
K	Institute of Education	Indian Almond	*Terminalia catappa*
L	Institute of Education	Oil Palm	*Elaeis guineensis*
M	Institute of Education	Avocado	*Persea Americana*
N	Audit Unit	Temple Tree	*Plumeria* sp.

CHAPTER FIVE

DISCUSSION

5.1 Land Use/Land Cover (LULC)

The LULC analysis indicated that as at the year 1975, the study area was characterized by an overwhelming dominance of dense vegetation, representing a near-pristine natural ecosystem. This condition rapidly deteriorated, with the first major shift occurring by 1985, marked by a substantial loss of dense vegetation which converted primarily into sparse vegetation. The most critical period of change was recorded between 2005 and 2015, resulting in the complete disappearance of all dense vegetation. Simultaneously, built-up areas emerged explosively to become the largest single land category. By the final assessment year of 2025, built-up areas dominated more than three-quarters of the landscape, confirming the total urbanization of the premises and the total and irreversible loss of natural vegetation cover.

This study's finding of a complete shift from dense vegetation to a built-up environment aligns precisely with the macro-level LULC dynamics observed across Nigeria, which are experiencing profound and swift transformations fueled by escalating population and intensified urban development activities (Ologunde *et al*., 2025; Agumagu *et al*., 2025). The catastrophic loss of all dense vegetation reflects the national challenge where urban expansion is achieved at the expense of vital natural ecosystems (Agumagu *et al*., 2025; Ojelabi *et al*., 2025). Furthermore, the substantial growth of built-up land at the cost of tree cover specifically mirrors the trends documented in the local context of Benin City, Edo State (Okoye, 2025).

5.2 Normalized Difference Vegetation Index (NDVI)

The NDVI analysis confirmed the severe degradation of vegetation health and cover, correlating strongly with the LULC changes. The overall trend revealed a substantial decline in both minimum and maximum NDVI values across the temporal scale, reflecting the catastrophic loss of natural vegetation. The index also detected severe vegetation stress in an earlier period (1995), despite a relatively high remaining area of vegetation. The maximum NDVI values recorded in the final periods are likely attributable to the presence of cultivated agricultural land or managed campus landscaping.

The severe degradation of vegetation health and the resulting landscape dominated by impervious surfaces directly correlates with the literature's warnings about hydrological and environmental impacts. The conversion of natural covers reduces the land's water-holding capacity, enhancing surface runoff and increasing the risk of flash floods a problem documented in urban centers where the rapid expansion of impervious surfaces occurs (Faisal Koko *et al*., 2021). The resulting loss of the vegetative cover also contributes to the urban heat island effect, which the literature identifies as an exacerbated challenge due to urbanization and LULC change (Ologunde *et al*., 2025; Okoye, 2025).

5.3 Identified Tree Diversity

The tree survey documented a total of 14 tree species remaining in the study area by 2025. The documented trees served as ornamental and shade trees for aesthetic purposes and were found to be non-indigenous tree specimens of Nigeria. The results from the NDVI and LULC maps proved that the increase in built-up areas resulted in partial extinction of indigenous tree species from the study area and that the tree species currently present are exotic and were planted as part of the aesthetic value of the campus, and also for teaching purpose as a part of the small green areas reserved as farmlands. The study revealed a notable increase in the number of exotic species compared to the number of indigenous tree species i.e. 11 out of the 14 tree species documented from the survey were identified as exotic trees and non-indigenous, while 3 were identified as indigenous to the study area.

Among the exotic species documented in this study, *Azadirachta indica* (Neem tree) stood out as a particularly significant urban tree with substantial ecological and socioeconomic importance. The presence of Neem in the heavily urbanized landscape (77.70% built-up area) demonstrated its remarkable adaptability to degraded environmental conditions characteristic of urban ecosystems. The Neem tree's persistence in the study area could be attributed to its multiple ecosystem services and utilitarian values. Neem is renowned for its medicinal properties, pest control applications, and ability to thrive in harsh urban conditions including air pollution, soil compaction, and heat stress. Its deep root system enabled survival even in marginal spaces such as street verges and compound gardens where the documented specimens were found. The tree's tolerance to poor soil conditions and minimal water requirements made it particularly suited for survival in areas with 6.24% bare soil coverage.

Studies had documented Neem's widespread cultivation across tropical and subtropical regions, noting its exceptional drought tolerance and ability to establish in disturbed landscapes (Adhikari *et al*., 2020). These findings aligned with this study's observation that exotic species like Neem had successfully colonized urban spaces where indigenous species struggled to survive (Adhikari *et al*., 2020). Other studies which examined the performance of Neem trees in Indian urban environments reported survival rates exceeding 85% in highly urbanized areas with significant anthropogenic pressure (Malakar *et al*., 2025). The research emphasized Neem's role in air quality improvement through particulate matter absorption, a critical function in built-up areas. This corroborated the survival advantage exotic species demonstrated in the study area's predominantly built environment (Malakar *et al*., 2025).

Research on urban tree diversity in Ilorin metropolis, Nigeria revealed that Azadirachta indica accounted for 6.36% of urban tree species composition, representing one of the most frequently occurring species (Moshood *et al*., 2024). This aligned with this study's findings where Neem persisted as one of the dominant exotic species in the heavily urbanized landscape. The research further documented Neem's ecological and economic importance in Nigerian urban environments, highlighting its preference by urban planners due to adaptability and multiple benefits (Moshood *et al*., 2024). Studies on the physical and mechanical properties of Neem timber in Nigeria classified A. indica as strength class D40, demonstrating its structural utility beyond ornamental and medicinal applications (Jimoh and Aina, 2017). This timber value likely contributed to its deliberate retention in the study area, as indicated by the observation that surviving species shared economic importance as a common trait. The research documented that Neem timber possessed suitable properties for structural use, reinforcing its multi-functional significance in Nigerian contexts (Jimoh and Aina, 2017).

However, concerns were raised about the dominance of exotic species like Neem in urban plantations, with arguments that while these species provided immediate benefits, they might compromise native biodiversity and alter local ecological processes (Remadevi, 2022). Research in Delhi showed that areas dominated by exotic plantations exhibited 40% lower native insect diversity compared to areas with indigenous tree cover, which highlighted potential ecological trade-offs evident in this study where only three indigenous species persisted (Remadevi, 2022).

Terminalia ivorensis (Black Afara) represents one of the three indigenous species that survived the extensive land use transformation in the study area. Its persistence was particularly notable given that indigenous species constituted only 21.4% (3 out of 14) of the documented tree diversity. Black Afara is a valuable timber species native to West African tropical forests, traditionally important for both ecological functions and economic value. In its natural forest ecosystem, *T. ivorensis* plays crucial roles in carbon sequestration, soil stabilization, and providing habitat for native fauna. The species' documented survival in marginal spaces suggests retention due to its timber value and possibly cultural significance, as indicated in the study results.

Research had documented that *T. ivorensis* (*Terminalia ivorensis*) was extensively used as timber for structural applications in Nigeria, highlighting its significant economic value (Moshood *et al*., 2024). The study revealed that Black Afara possessed desirable material properties including density, modulus of elasticity, and bending strength suitable for construction purposes. This timber value likely explained why *T. ivorensis* was among the three indigenous species that survived in the study area despite extensive urbanization (Moshood *et al*., 2024).

Studies on the bioaccumulation potentials of selected tree species demonstrated that *T. ivorensis* possessed high metal accumulation capacity, particularly at toxic contamination levels (Olayiwola *et al*., 2021). The research found that *T. ivorensis* significantly accumulated copper (7.65 mg/kg) and lead at triple contamination levels compared to other species tested. This characteristic suggested that beyond its timber value, Black Afara could serve important phytoremediation functions in urban environments with soil contamination, though this ecosystem service remained underutilized in the study area (Olayiwola *et al*., 2021).

The conservation status of *Terminalia* species in West Africa was reported to have significant population declines due to habitat fragmentation and agricultural expansion (Ofosu-Asiedu and Cannon, 1976). It was noted that *T. ivorensis* suffered from widespread die-back in plantations throughout Ghana and Ivory Coast, with abnormally chlorotic leaves and branch die-back as characteristic symptoms. This pattern was strikingly similar to this study where indigenous trees persisted only in fragmented, isolated conditions (Ofosu-Asiedu and Cannon, 1976). Research reported that *Terminalia superba*, a closely related species, experienced declining populations in Côte d'Ivoire, Ghana, Nigeria, Cameroon and Congo due to heavy exploitation (Demenou *et al*., 2018). The study documented that while *Terminalia* species were pioneer trees with abundant regeneration potential, localized supplies had dwindled significantly, with surviving populations predominantly found in agricultural landscapes and settlements, which directly supported this study's observation that indigenous species existed as isolated strands or small groups rather than as functional forest communities (Demenou *et al*., 2018).

Studies investigating *T. ivorensis* cultivation in agroforestry systems in Nigeria revealed that survival rates of tree crops during establishment averaged only 52.7% (Kalu *et al*., 2011). The research identified numerous challenges including inadequate monitoring, absence of field staff, and insufficient incentives that affected *T. ivorensis* survival in managed systems. These findings suggested that even with deliberate cultivation efforts, *Terminalia* species faced significant establishment challenges, which could explain the limited number of surviving indigenous specimens in the study area (Kalu *et al*., 2011). Research examining

seed germination and seedling growth of *T. ivorensis* documented highest germination percentages under topsoil conditions with specific watering regimes (Ibe *et al*., 2015). The study emphasized that *T. ivorensis* required particular propagation conditions for successful establishment, highlighting the species' specific ecological requirements. This contrasted sharply with exotic species like Neem that demonstrated functional independence, further explaining why indigenous species struggled to persist in the degraded, fragmented conditions of the study area (Ibe *et al*., 2015).

Compared to the exotic Neem tree, Black Afara faced greater survival challenges in urban environments due to its specific ecological requirements, including mycorrhizal associations and dependence on native pollinators and seed dispersers. While Neem demonstrated functional independence enabling survival in isolated conditions, indigenous species like *T. ivorensis* required intact ecological networks that had been disrupted by the extensive urbanization (77.70% built-up area) documented in this study.

5.4 Recommendation

The study's results lead to the following key recommendations and these recommendation strategies must move beyond standard administrative procedures to encompass both ecological restoration and proactive urban planning, ensuring the long-term sustainability and resilience of the campus environment.

The first strategic pillar focuses on Green Infrastructure and Ecological Restoration. To counteract the widespread habitat destruction and the associated ecological pressures, particularly the potential for the urban heat island effect, a mandatory Green Infrastructure Policy must be immediately enforced. This policy should mandate the integration of vegetation from street trees and landscape buffers to green roofs and vertical gardens into all existing built-up areas and future development plans. It is also recommended that the planting of native trees in the bare areas within the campus should be initiated.

The second pillar targets hydrological and land use management to address the challenges posed by the dominance of impervious surfaces. The total elimination of natural cover has significantly compromised the land's capacity for natural drainage, increasing surface runoff and the risk of flash flooding. Therefore, a comprehensive mitigation of hydrological hazards strategy is imperative, requiring the large-scale deployment of sustainable urban drainage systems (SUDS). This includes replacing traditional impermeable paving with porous pavements and permeable materials in pedestrian and parking areas, and constructing bio-swales and retention ponds to manage storm-water flow. These efforts must be supported by stringent land-use controls that strictly limit any further encroachment on the few remaining open spaces. As a public institutional entity, the premises must embrace its latent potential to serve as a model for sustainable land management practices, demonstrating how comprehensive planning can reverse the negative ecological trajectories documented in this assessment.

5.5 Conclusion

This study revealed that the public institutional premises underwent a complete and rapid land cover transformation, moving from a near-natural ecosystem to a predominantly urbanized landscape between 1975 and 2025. This was driven by aggressive infrastructural development and urbanization, leading to the complete elimination of all natural vegetation classes. The analysis indicated a strong correlation between LULC and NDVI, validating the utilization of remote sensing to monitor the extent and health of vegetation cover.

REFERENCES

Abdul-Nabi, S. S., Al Karaki, V., Khalil, A., and El Zahran, T. (2025). Climate change and its environmental and health effects from 2015 to 2022: A scoping review. *Heliyon*, **11**(3).

Abulibdeh, A. (2021). Analysis of urban heat island characteristics and mitigation strategies for eight arid and semi-arid gulf region cities. *Environmental Earth Sciences*, **80**(7), 259.

Adewumi, A. S. (2013). Analysis of land use/land cover pattern along the River Benue channel in Adamawa State, Nigeria. *Academic Journal of Interdisciplinary Studies*, **2**(5), 95-107.

Adewumi, R., and Agbasi, O. E. (2024). Assessing the impact of land cover and land use change on urban infrastructure resilience in Abuja, Nigeria: a case study from 2017 to 2022. *Structure & Environment*, **16**(1), 6-17.

Adhikari, K., Niraula, D., and Shrestha, J. (2020). Use of neem (Azadirachta indica A. Juss) as a biopesticide in agriculture: A review. *Journal of Agriculture and Applied Biology*, **1**(2), 100-117.

Afuye, G. A., Nduku, L., Kalumba, A. M., Santos, C. A. G., Orimoloye, I. R., Ojeh, V. N., and Sibandze, P. (2024). Global trend assessment of land use and land cover changes: A systematic approach to future research development and planning. *Journal of King Saud University-Science*, **36**(7), 103262.

Agumagu, O. O., Marchant, R., and Stringer, L. C. (2025). Land use and land cover change dynamics in the Niger Delta region of Nigeria from 1986 to 2024. *Land*, **14**(4), 765. https://doi.org/10.3390/land14040765.

Akindoyin, D. I., and Obafemi, A. O. (2025). Evaluating the impact of insecurity on Nigeria's national development since the Fourth Republic. *African Journal of Stability and Development*, **17**(1), 91-107.

Akpan, S. B., and Ebong, V. O. (2021). Agricultural land use and population growth in Nigeria. The need for synergy for a sustainable agricultural production. *Journal of Agribusiness and Rural Development*, **61**(3), 261-270.

Alawamy, J. S., Balasundram, S. K., Mohd. Hanif, A. H., and Boon Sung, C. T. (2020). Detecting and analyzing land use and land cover changes in the region of Al-Jabal Al-Akhdar, Libya using time-series landsat data from 1985 to 2017. *Sustainability*, **12**(11), 4490.

Allan, A., Soltani, A., Abdi, M. H., and Zarei, M. (2022). Driving forces behind land use and land cover change: A systematic and bibliometric review. ***Land***, **11**(8), 1222. https://doi.org/10.3390/land11081222.

Andreasen, M. H., Agergaard, J., Kofie, R. Y., Møller-Jensen, L., and Oteng-Ababio, M. (2023). Urban encroachment in ecologically sensitive areas: drivers, impediments and consequences.

Ayenikafo, O. M., and Wang, Y. F. (2021). Land use/land cover changes analysis in Sudano-Guinean region of Benin. *Applied Ecology and Environmental Research*, **19**(1), 715–726. https://doi.org/10.15666/aeer/1901_715726.

Bajwa, A. A., & Javaid, M. M. (2022). Neem (*Azadirachta indica* A. Juss.) as a resource for biopesticides: A review of commercial products and their applications. *Environmental Science and Pollution Research*, *29*(9), 12729-12746. https://doi.org/10.1007/s11356-021-17890-8

Chiaka, J. C., Zhen, L., Xiao, Y., Hu, Y., Wen, X., and Muhirwa, F. (2024). Spatial assessment of land suitability potential for agriculture in Nigeria. ***Foods***, **13**(4), 568. https://doi.org/10.3390/foods13040568.

Congalton, R. G., and Green, K. (2019). Assessing the accuracy of remotely sensed data: Principles and practices (3rd ed.). *CRC Press*.

Demenou, B. B., Doucet, J. L., and Hardy, O. J. (2018). History of the fragmentation of the African rain forest in the Dahomey Gap: insight from the demographic history of Terminalia superba. *Heredity*, **120**(6), 547-561.

Demessie, S. F., Dile, Y. T., Bedadi, B., Tarkegn, T. G., Bayabil, H. K., and Sintayehu, D. W. (2025). Assessing and projecting land use land cover changes using machine learning models in the Guder watershed, Ethiopia. *Environmental Challenges*, **18**, 101074.

Duminil, J., Abessolo, D. T. O., Bourobou, H. P. B., Doucet, J. L., Loo, J., Hardy, O. J., and Heuertz, M. (2017). History of the fragmentation of the African rain forest in the Dahomey Gap: Insight from the demographic history of *Terminalia superba*. *Heredity*, **118**(6), 547-558. https://doi.org/10.1038/hdy.2017.5

Elmarakby, E., and Elkadi, H. (2024). Prioritising urban heat island mitigation interventions: Mapping a heat risk index. *Science of the Total Environment*, **948**, 174927.

Enoguanbhor, E. C., Gollnow, F., Walker, B. B., Nielsen, J. O., and Lakes, T. (2021). Key challenges for land use planning and its environmental assessments in the Abuja City-Region, Nigeria. *Land*, **10**(5), 443. https://doi.org/10.3390/land10050443.

Fabolude, G., and Aighewi, I. T. (2022). Evaluation of the extent of land use-land cover changes of Benin City, Edo State, Nigeria from 1987-2019. *Journal of Applied Sciences and Environmental Management*, **26**(8), 1443-1450.

Faisal Koko, A., Yue, W., Abdullahi Abubakar, G., Hamed, R., and Noman Alabsi, A. A. (2021). Analyzing urban growth and land cover change scenario in Lagos, Nigeria using multi-temporal remote sensing data and GIS to mitigate flooding. *Geomatics, Natural Hazards and Risk*, **12**(1), 631-652. https://doi.org/10.1080/19475705.2021.1887940.

Fatima, N., and Javed, A. (2021). Assessment of land use land cover change detection using geospatial techniques in southeast Rajasthan. *Journal of Geoscience and Environment Protection*, **9**(12), 299-319.

Garba, K., and Adamu, N. (2024). Introduction to issues of environmental theory and practice in Nigeria. *Issues of Environmental Theory and Practice in Nigeria*, **1**(1).

George, O. O., Okeyo, J. B., and Daniel, O. N. (2019). How university establishment influence land use and land cover changes in Kenya: A case of Rongo University, Migori County, Kenya. *International Journal of Environmental Sciences & Natural Resources*, **21**(5), 556075. https://doi.org/10.19080/IJESNR.2019.21.556075

Gilbert, K. M., and Shi, Y. (2023). Land use/land cover changes detection in Lagos City of Nigeria using remote sensing and GIS. *Advances in Remote Sensing*, **12**(4), 145-165.

Gorelick, N., Hancher, M., Dixon, M., Ilyushchenko, S., Thau, D., and Moore, R. (2017). Google Earth Engine: Planetary-scale geospatial analysis for everyone. *Remote Sensing of Environment*, **202**, 18–27. https://doi.org/10.1016/j.rse.2017.06.031

Heubach, K., Wittig, R., Nuppenau, E. A., and Hahn, K. (2011). The economic importance of non-timber forest products (NTFPs) for livelihood maintenance of rural west African communities: A case study from northern Benin. *Ecological Economics*, **70**(11), 1991-2001.

Ibe, A. E., Adeyemi, A. A., Nwuda, B. N., Asiabaka, C. C., and Onuoha, G. N. (2015). Seed germination and seedling growth of Terminalia ivorensis (A. Chev) in different growth media. *FUTO Journal Series*, **1**(2), 138-145.

Idowu, D., and Zhou, W. (2021). Land use and land cover change assessment in the context of flood hazard in Lagos State, Nigeria. *Water*, **13**(8), 1105.

Jensen, J. R. (2016). Introductory digital image processing: A remote sensing perspective (4th ed.). *Pearson Education*.

Jimoh, A. A., and Aina, S. T. (2017). Characterisation and Grading of two selected timber species grown in Kwara State Nigeria. *Nigerian Journal of Technology*, **36**(4), 1002-1009.

John, E. I., and Bello, I. E. (2025). Assessing the role of good governance and policy making in land use abuse monitoring and management in Nigeria. *International Journal of Research and Innovation in Social Science*, **9**(1), 377-393.

Kalu, C., Oboho, E. G., and Ihama, O. E. (2011). Contribution of agroforestry practice to artificial forest regeneration in Edo State, Nigeria. *Journal of Agriculture and Environment*, **7**(1), 77-86. https://www.ajol.info/index.php/jagrenv/article/view/236512

Laurance, W. F., Sayer, J., and Cassman, K. G. (2014). Agricultural expansion and its impacts on tropical nature. *Trends in Ecology & Evolution*, **29**(2), 107-116.

Lillesand, T., Kiefer, R. W., and Chipman, J. (2015). Remote sensing and image interpretation (7th ed.). *Wiley*.

Long-Term Ecological Research Network. (2023, January 16). *Land Use Institutions, Land Use Land Cover Change, and the Distribution of Ecosystem Services***.** https://lternet.edu/working-groups/land-use-institutions-land-use-land-cover-change-and-the-distribution-of-ecosystem-services/

Macarringue, L., Bolfe, É., and Pereira, P. (2022). Developments in land use and land cover classification techniques in remote sensing: A review. *Journal of Geographic Information System***, 14**(1), 1–28. https://doi.org/10.4236/jgis.2022.141001.

Malakar, A., Dutta, S., Shukla, N., Dasgupta, S., Singh, R. P., Dwivedi, S., and Sinha, A. (2025). Genetic variability and ecosystem services of Neem (Azadirachta indica A. Juss): A two-decadal systematic study for harnessing global sustainable goals. *Trees, Forests and People*, **22**(1), 101014.

McGranahan, G., Satterthwaite, D., and Tacoli, C. (2004). *Rural-Urban Change, Boundary Problems and Environmental Burdens*. International Institute for Environment and Development.

Moshood, F. J., Muhali, M. O., and Ugbong, E. A. (2024). Evaluating urban tree diversity and the "10-20-30" rule of urban forestry in Ilorin metropolis, Nigeria. *Journal of Agriculture and Environment*, **20**(2), 177-187.

Mukherjee, S., Patel, A. K., and Kumar, M. (2019). Water scarcity and land degradation nexus in the anthropocene: reformations for advanced water management as per the sustainable development goals. *Emerging Issues in the Water Environment during Anthropocene: A South East Asian Perspective* (pp. 317-336). Springer Singapore.

Munthali, M. G., Davis, N., Adeola, A. M., and Botai, J. O. (2022). The impacts of land use and land cover dynamics on natural resources and rural livelihoods in Dedza District, Malawi. *Geocarto International*, **37**(6), 1529-1546.

Nedd, R., Light, K., Owens, M., James, N., Johnson, E., and Anandhi, A. (2021). A synthesis of land use/land cover studies: Definitions, classification systems, meta-studies, challenges and knowledge gaps on a global landscape. *Land*, **10**(9), 994. https://doi.org/10.3390/land10090994.

Nkundabose, J. P., Nshimiyimana, F., Twagirayezu, G., and Irumva, O. (2021). Employing remote sensing tools for assessment of land use/land cover (LULC) changes in Eastern Province, Rwanda. *American Journal of Remote Sensing*, **9**(1), 23–32. https://doi.org/10.11648/j.ajrs.20210901.1.

Nnaemeka-Okeke, R. (2016). Urban sprawl and sustainable city development in Nigeria. *Journal of Ecological Engineering*, **17**(2). 1-11.

Nzunda, N. G., Munishi, P. K. T., Soka, G. E., and Monjare, J. F. (2013). Influence of socio-economic factors on land use and vegetation cover changes in and around Kagoma forest reserve in Tanzania. *Ethiopian Journal of Environmental Studies and Management*, **6**(5), 480-488.

Odoh, B. I. N., Nkiru, C., and Odinye, A. (2024). Impact of land use and land cover changes on hydrological characteristics and drainage density in urban and semi-urban areas of Abia State, Southeastern Nigeria. **7**(3), 147-163.

Ofosu-Asiedu, A., and Cannon, P. (1976). *Terminalia ivorensis* decline in Ghana. *PANS*, **22**(2), 239-242. https://doi.org/10.1080/09670877609412371

Ojelabi, O. K., Lawin, A. E., Amichiatchi, N. D. J., and Oluwasemire, K. O. (2025). Impacts of anthropogenic activities on land use land cover change dynamics in the Ogun River Basin, Nigeria. *Journal of Water and Climate Change*, **16**(1), 174-188. https://doi.org/10.2166/wcc.2025.586.

Okoye, D. (2025). Temporal assessment of land use land cover (LULC), land surface temperature, and urban heat island changes in Benin City, Edo State, Nigeria: A case study of 2017 and 2023. *Journal of Global Health and Social Medicine*, **1**(1), 1-13.

Olajuyigbe, S. (2018). Green gold of Africa: Nigeria's forest, a depleted but resilient renewable resource. *Irish Forestry*, **75**(1). 92-112.

Olayiwola, V. A., Afolabi, J. O., and Ihediuche, C. I. (2021). Bioacumulation Potentials of Selected Tree Species in Heavy Metal Contaminated Soil. *Nigeria Agricultural Journal*, **52**(2), 247-257.

Ologunde, O. H., Kelani, M. O., Biru, M. K., Olayemi, A. B., and Nunes, M. R. (2025). Land use and land cover changes: A case study in Nigeria. *Land*, **14**(2), 389. https://doi.org/10.3390/land14020389.

Olorunfemi, I. E., Fasinmirin, J. T., Olufayo, A. A., and Komolafe, A. A. (2020). GIS and remote sensing-based analysis of the impacts of land use/land cover change (LULCC) on the environmental sustainability of Ekiti State, southwestern Nigeria. *Environment, Development and Sustainability*, **22**(2).

Oluwajuwon, T. (2021). Global and Nigerian deforestation trends, drivers and implications: An overview. *Academia Letters*, Article 3241. https://doi.org/10.20935/AL3241

Owolabi, D. R., Ajibola, M. O., and Oluwunmi, A. O. (2020). Challenges and prospects of property ownership in Ado-Odo/Ota Local Government Area, Ogun State, Nigeria: A review of literature. **8**(1), 2384-5716.

Phillips, H. R., Cameron, E. K., Eisenhauer, N., Burton, V. J., Ferlian, O., Jin, Y., ... and Beaumelle, L. (2024). Global changes and their environmental stressors have a significant impact on soil biodiversity, a meta-analysis. *Iscience*, **27**(9).

Prokešová, R., Horáčková, Š., and Snopková, Z. (2022). Surface runoff response to long-term land use changes: Spatial rearrangement of runoff-generating areas reveals a shift in flash flood drivers. *Science of the Total Environment*, **815**, 151591.

Remadevi, O. K. (2022). Status, issues, and challenges of biodiversity: Forest insects. *Biodiversity in India: Status, issues and challenges,* **7**(4), 325-362.

Rouse, J. W., Haas, R. H., Schell, J. A., and Deering, D. W. (1974). Monitoring vegetation systems in the Great Plains with ERTS. In Third Earth Resources Technology Satellite-1 Symposium. *NASA SP-351*. **1**, 309-317.

Salami, R., Giggins, H., and von Meding, J. (2017). Vulnerability of human settlements to flood risk in the core area of Ibadan metropolis, Nigeria. *Jàmbá: Journal of Disaster Risk Studies*, **9**(1), 1-14.

Salim, M. Y., and Ibrahim, N. A. (2021). Time Series Analysis Using Digital Classification of Data on Land Use and Land Cover in Dohuk Governorate**.** ***IOP*** *Conference Series: Earth and Environmental Science*, **910**(1), 012124**.** https://doi.org/10.1088/1755-1315/910/1/012124**.**

Schleiss, A. J., Franca, M. J., Juez, C., and De Cesare, G. (2016). Reservoir sedimentation. *Journal of Hydraulic Research*, **54**(6), 595-614.

Seyam, M. M. H., Haque, M. R., and Rahman, M. M. (2023). Identifying the land use land cover (LULC) changes using remote sensing and GIS approach: A case study at Bhaluka in Mymensingh, Bangladesh. *Case Studies in Chemical and Environmental Engineering*, **7**, 100293.

Shaamala, A., Yigitcanlar, T., Nili, A., and Nyandega, D. (2025). Machine learning applications for urban geospatial analysis: A review of urban and environmental studies. *Cities*, **165**, 106139.

Singh, A., and Bhadauria, S. S. (2025). Integration of remote sensing and GIS for environmental assessment. *Environmental Reports; an International Journal,* **6**(1), 35-40.

Tan, L., LK, R. T., and Zhang, Z. (2024). Analysis of land use/land cover changes and driving forces during the period 1992–2022: a case study of Jinan City, China. *AQUA Water Infrastructure, Ecosystems and Society*, **73**(3), 584-607.

Teshome, A., Halefom, A., and Gadissa, E. (2019). An analysis on land use/land cover change using remote sensing and GIS-A case study in Amjaye District, South Gondar, Ethiopia. International Journal of Scientific and Technical Research in Engineering (IJSTRE), **4**(6), 2581-9941.

Tine, D., Faye, G., Faye, G., Ndour, M. M. M., and Faye, M. (2022). Detection and predictive modeling of land use changes by CA-Markov in the northern part of the

Southern rivers: From Lower Casamance to Gêba river (Guinea Bissau). *Journal of Ecology and The Natural Environment*, **14**(1), 1-14.

Tucker, C. J. (1979). Red and photographic infrared linear combinations for monitoring vegetation. *Remote Sensing of Environment*, **8**(2), 127–150.

Ugwukah, A. C. (2022). The Nigerian agricultural sector: analysis of influential impediment factors to its growth, development and prospects for improvements. *Journal of Agriculture and Crops*, **8**(4), 299-308.

United Nations Convention to Combat Desertification. (2017). *The Global Land Outlook, first edition*. Bonn, Germany. **ISBN: 978-92-95110-48-9**, 20–29.

United States Geological Survey (USGS). (2024). EarthExplorer: Satellite imagery and data portal. *Available at* https://earthexplorer.usgs.gov. (Accessed 28th October, 2025).

Wan, M., Colfer, C. J., and Powell, B. (2011). Forests, women and health: opportunities and challenges for conservation. *International Forestry Review*, **13**(3), 369-387.

Yaakob, A. (2014). A Legal Analysis on Law and Policy on Conservation of Forest in Peninsular Malaysia, University of Malaya (Malaysia). *ProQuest Dissertations & Theses,* **30595198**.

APPENDIX

Plate 1: Tree A.

Plate 2: Tree B.

Plate 3: Tree C.

Plate 4: Tree D.

Plate 5: Tree E.

Plate 6: Tree F.

Plate 7: Tree G.

Plate 8: Tree H.

Plate 9: Tree I.

Plate 10: Tree J.

Plate 11: Tree K.

Plate 12: Tree L.

Plate 13: Tree M.

Plate 14: Tree N.

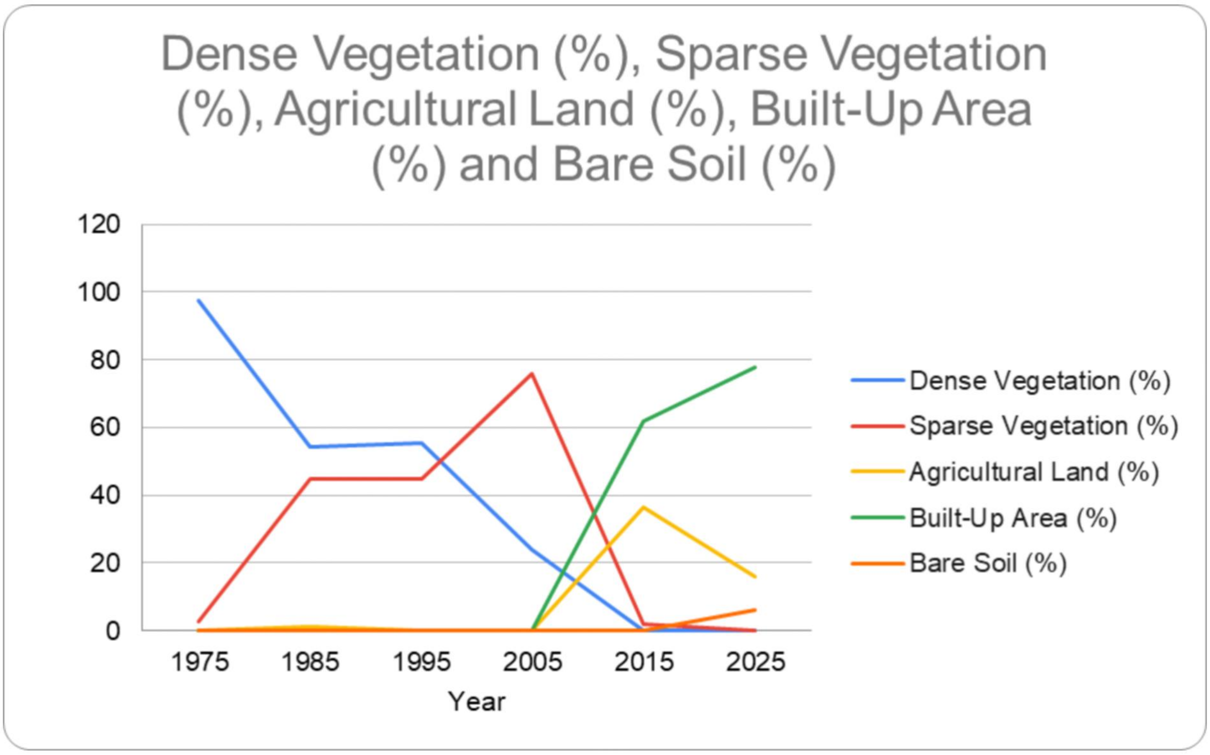


Fig 4.4: Graphical Representation of the LULC trends.

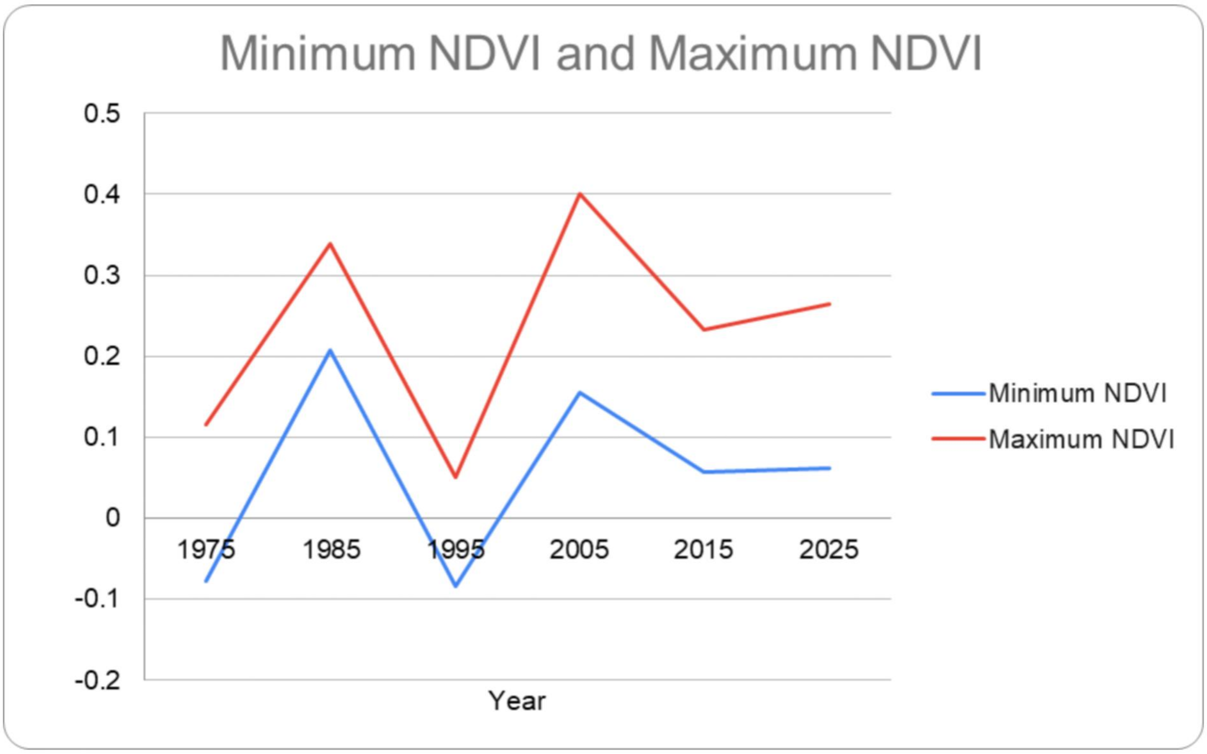


Fig 4.5: Graphical Representation of the NDVI trends.