

**EVALUATING URBAN SPRAWL OF ETI-OSA LOCAL GOVERNMENT
AREA, LAGOS STATE**

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CERTIFICATION

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DEDICATION

This project is dedicated to God Almighty, to my family and friends for their love and support and also to my Lecturers as well.

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My sincere gratitude goes to God for His grace in the successful completion of my academic program. I appreciate ENGR. KELLY IGBINIDU E. for his supervision. My thanks also goes to my parents for their love and support. The academic and non-academic Staff of the Department of Geomatics, especially the DEAN of the Faculty of Environment Science, DR.ENGR.PROF. RALPH EHIGIATOR, SURV. OLADUSO OLUSHOLA (HOD) for their relentless effort to the students. I also appreciate my classmates, who have been a source of inspiration for me throughout the years.

ABSTRACT

The rapid urbanization and expansion of cities have become a global concern, with a profound impact on the environment, infrastructure, and the quality of life for residents. This study focuses on ETI-OSA Local Government Area, an area characterized by significant population growth and urbanization which makes it important to monitor and understand the dynamics of urban sprawl so as to ensure the well-being of the study area's residents and the responsible use of resources.

To assess urban sprawl in ETI-OSA, this study employed a multidisciplinary approach that integrates Remote Sensing and Geographic Information Systems (GIS). Landsat Satellite imageries were acquired for the periods under study, that is, Landsat 4-5 for 1994, Landsat 7 and 9 for 2004 and 2014, and Landsat 9 for 2024. The techniques employed in this research are mosaicking, image clipping and supervised classification.

The results of this study shed light on the extent and patterns of urban sprawl in ETI-OSA Local Government Area. The analysis indicates a significant increase in urbanized land areas over the study period of 30 years which quantifies the extent of urban sprawl and its spatial distribution. This trend is a clear manifestation of urban expansion and population growth in the region. The implications of these findings are profound, as they provide valuable insights for land-use planning, resource allocation, and infrastructure development.

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CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND TO THE STUDY

Land is a very important natural resource and it is necessary for both human activity and earthly existence. Despite its significance, people use it indiscriminately. Increase in human's activities and population has also resulted in increase in land and soil requests and for urbanisation, industrial, and agricultural applications. Land cover describes the surface of the earth's physical properties, such as its soil, vegetation, water, hills, and forests. Changes brought about by anthropogenic activity are shown by land use. Understanding land use and land cover (LULC) change is essential for assessing the current situation, managing natural resources, and ultimately resolving environmental issues (Azid, 2015).

Countless problems are caused by these changes in land use and cover, including an increase in urban heat, excessive runoff, and other ecological challenges. The sustainability of urban ecosystems and policymakers both benefit greatly from improvements in land use and cover (Hassan and Lee, 2015). One of the key primary drivers of land cover/use change, the urbanization process (urban growth and sprawl) is linked to the expansion of both human populations and economic activity. To give a specific accurate account of urban expansion and growth that is acceptable to the entire urban planning, research community, however, is challenging. Long considered a sign of regional economic power, urban expansion, specifically the transfer of commercial and residential land to rural areas on the outskirts of town areas, is on the rise (Azid, 2015).

However, its benefits were being more and more counterbalanced by ecosystem problems, such as the deterioration of water and air quality, the loss of pastureland and forests, and

socioeconomic factors including economic inequality, the cost of infrastructure, and social fragmentation. The fact that metropolitan areas are the most active was acknowledged by all the researchers. Urban planners, local government, and decision-makers can benefit greatly from information about changes in land use and land cover (LULC) as well as urban growth studies to build strategies for sustainable development in the future of each area (Sundara, 2012). The urban sprawl extension in the indefinite landscape time describes the urban sprawl as a pattern, whereas the change of urban sprawl patterns in a landscape in various periods describes the urban sprawl as a process. However, the term "urban sprawl" can be used to refer to both the process and the pattern of urban sprawl (Sarvestani and Ibrahim, 2011). Furthermore, the majority of urban spatial issues, including urban sprawl, are thought to be caused by the unchecked and distributed population increase.

Urban sprawl is now recognized as a critical component of urban growth. The case of urban development combines a broad variety of concepts with generic and thorough procedures. The operation of urban development should be discussed in light of relevant historical events as well as current variables including economic and social aspects over time (Safarpour, 2014). The earth's features have been actively recorded by remote sensing satellites in recent years for mapping and accurately reporting land use land cover (LULC) features.

With the use of modelling tools made possible by geographic information systems (GIS), land use planning, and appropriate methods of analysis for the analysis of land use/land cover concerns, it is now feasible to investigate changes in land cover at a lower cost, faster, and with higher accuracy (Sashikkuma, 2016). The accurate calculation of water resources, water cultivation, land degradation, forestry, geomorphological conditions, and other concerns relating to the environment and climate change are made possible by the interpretation of satellite data. GIS and remote sensing

techniques have been recognized as active and effective tools for identifying changes in the spatial and temporal distribution of the earth's properties at different scales.

1.2 STATEMENT OF PROBLEM

Urban sprawl is the rampant expansion of urban areas, generally described by the unplanned and often inadequate development of land which leads to the spread of urban development into previously rural areas. It is linked to low-density automobile-dependent development patterns, the loss of agricultural and natural lands, increased infrastructure costs, and social and environmental impacts (Randal, 2005).

ETI-OSA Local government Area as a case study is beginning to face some challenges due to rapid urbanization. Addressing these issues requires comprehensive urban planning, investment in infrastructure development, equitable distribution of resources and services, and sustainable environmental management practices. Some of the challenges face in this study area are i. Frequent flooding, especially during the rainy season ii. Coastal erosion and shoreline retreat iii. Pressure on land resources from real estate development iv. Encroachment on wetlands and mangrove ecosystems. These challenges make the area suitable for studies in environmental planning, urban resilience, and sustainable development using geospatial tools By acknowledging and addressing this issue, government agencies can work towards a more sustainable and inclusive future for ETI-OSA LGA.

1.3 AIM AND OBJECTIVES

Aim

Evaluating Urban Sprawl of ETI-OSA Local Government Area, Using Remote Sensing, and GIS, in Lagos State, Nigeria.

The objectives of this project are:

- i. Determine growth pattern in study area.
- ii. Create a land use land cover map to identify wetland reclamation (change detection in the study area from wetland to usable land) from 1994-2024.
- iii. Assess flood risk of the study area.

1.4 SCOPE OF THE PROJECT

The scope of this project exercise is:

- i. **Data Acquisition:** The collection of remote sensing data: that is satellite imageries.
- ii. **Data Processing and Analysis:** The collected remote sensing data will be processed and analysed.
- iii. **Urban Sprawl Assessment:** The evaluation of the spatial and temporal dynamics of urban sprawl, including the expansion of built-up areas, alterations in land use patterns, and the conversion of natural and agricultural lands into urban areas.
- iv. **Land Use and Land Cover (LULC) Prediction:** Building upon the analysis of historical data and the identification of urban sprawl patterns to predict future changes in land use and land cover.
- v. **Assessment of Impacts:** The assessment of the impacts of urban sprawl on the environment, e.g wetland encroachment.
- vi. **Planning and Policy Recommendations:** Based on the findings, the study will provide recommendations for urban planning and policy-making to effectively manage and mitigate the negative impacts of urban sprawl.

1.5 JUSTIFICATION FOR THE PROJECT

The selection of Eti-Osa LGA is justified due to: Its strategic location and diverse landscape, Rapid urbanization, offering a live model for LULC change, Availability of high-resolution satellite imagery, Existing spatial datasets for terrain, hydrology, and infrastructure Relevance to current sustainable development goals(SDG) targets on urban sustainability and climate resilience It is evident that urban sprawl provides certain benefits like access to larger homes, more open spaces, and opportunities for economic growth in suburban areas. It is important to check these benefits against the negative consequences like environmental, social, and economic consequences, which is the reason for studying and monitoring urban developments in ETI-OSA Local Government Area, Lagos State.

This project will help to understand the trend of urban land use changes in ETI-OSA LGA which will in turn help to curb the consequences of urban sprawl. As urban sprawl has far-reaching consequences in the study area and generally, it is crucial to necessitate proactive measures. This project aims to provide results that will help in sustainable urban planning and policy interventions.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 URBAN SPRAWL

According to Ewing and Hamidi, (2014). Urban sprawl is a phenomenon characterized by the rapid expansion of urban areas into surrounding rural and undeveloped lands. It is often associated with low-density, car dependent development patterns that have significant implications for the environment, society, and economy. This overview provides an understanding of the causes and impacts of urban sprawl, as well as highlighting mitigation strategies employed to address its negative effects.

2.1.1 Causes of Urban Sprawl

The following, as given by Brown (2020), are the causes of urban sprawling:

- i. **Population Growth:** Rapid population growth in urban areas leads to increased demand for housing, infrastructure, and services, resulting in the expansion of cities into previously undeveloped areas.
- ii. **Automobile Dependency:** The reliance on private vehicles as the primary mode of transportation encourages the spread-out development of urban areas to accommodate the need for extensive road networks and parking facilities.
- ii. **Land Use Policies and Regulations:** Inadequate land use planning, weak zoning regulations, and a lack of comprehensive urban development strategies contribute to uncontrolled and unplanned urban expansion.
- iii. **Economic Factors:** Factors such as lower land costs on the outskirts of cities, market forces favouring suburban development, and the availability of land contribute to the sprawl phenomenon.

- iv. Consumer Preferences: Some people prefer suburban living due to perceptions of improved quality of life, including larger homes and yards.
- v. Lack of Comprehensive Planning: Poor or outdated urban planning policies can fail to address the challenges of growth and development effectively.
- vi. Zoning Regulations: Zoning practices that segregate land uses and encourage large lot sizes can promote urban sprawl.

2.1.2 Impacts of Urban Sprawl

According to Kasanko and McCormick (2006) impacts of urban sprawl are:

- i. Loss of Agricultural and Natural Lands: Urban sprawl leads to the conversion of agricultural lands and natural habitats into built-up areas, resulting in the loss of valuable farmland, biodiversity, and ecosystem services.
- ii. Increased Infrastructure Costs: Expanding urban areas require the extension of infrastructure networks, including roads, utilities, and services, leading to increased costs for construction, maintenance, and operation.
- iii. Traffic Congestion and Air Pollution: The spread-out nature of urban sprawl contributes to longer commuting distances, increased vehicle use, traffic congestion, and higher levels of air pollution.
- iv. Social and Economic Consequences: Urban sprawl can lead to social segregation, limited access to amenities and services for marginalized communities, increased commuting time and expenses, and economic disparities between urban and suburban areas.
- v. Health Implications: Urban sprawl discourages walking and physical activity, contributing to sedentary lifestyles and related health issues.

- vi. Environmental Degradation: Sprawl contributes to habitat loss, deforestation, and destruction of green spaces. It leads to increased air and water pollution and contributes to the loss of agricultural land.

2.1.3 Limitations of Infrastructure in Urban Sprawl

According to Kasanko and McCormick (2006), limitations of infrastructure in urban sprawl are:

- i. Strain on Public Services: Urban sprawl places a strain on public services such as schools, healthcare facilities, and utilities. The expansion of urban areas requires the development of new infrastructure to accommodate the growing population. However, the cost of providing and maintaining these services can outpace the revenue generated, leading to financial challenges for local governments.
- ii. Inadequate Transportation Systems: The decentralized nature of urban sprawl often results in inadequate transportation systems. Public transportation may be less accessible or less efficient, forcing residents to rely heavily on private vehicles. This not only contributes to traffic congestion but also increases the carbon footprint and transportation costs for individuals.
- iii. Insufficient Water and Sewage Systems: Expanding urban areas require adequate water supply and sewage systems to meet the needs of the growing population. However, the infrastructure may not keep pace with the rate of expansion, leading to water shortages, inefficient wastewater management, and environmental pollution. This can have detrimental effects on both human health and the environment.

2.1.4 Mitigation Strategies for Urban Sprawl

The ways by which urban sprawl can be alleviated according to Shen and Zhao (2018) are:

- i. **Smart Growth:** Smart growth strategies emphasize compact, mixed-use development patterns, promoting walkability, public transportation, and the revitalization of existing urban areas.
- ii. **Transit-Oriented Development (TOD):** TOD focuses on creating vibrant, pedestrian-friendly neighbourhoods centred around public transportation hubs, reducing automobile dependency and encouraging a mix of residential, commercial, and recreational spaces.
- iii. **Urban Growth Boundaries:** Establishing growth boundaries helps contain urban expansion by setting limits on development outside designated areas, encouraging more efficient land use and the preservation of rural and natural lands.
- iv. **Mixed-Use Zoning and Infill Development:** Encouraging mixed-use zoning regulations and promoting infill development within existing urban areas helps optimize land use, reduce sprawl, and create vibrant, inclusive communities.
- v. **Conservation and Green Space Preservation:** Protecting and preserving green spaces, parks, and natural areas within urban environments enhances quality of life, provides recreational opportunities, and promotes environmental sustainability.
- vi. **Incentives for Redevelopment:** Providing incentives for redeveloping existing areas encourages revitalization and reduces the pressure to expand outward.
- vii. **Mixed-Use Zoning:** Allowing multiple land uses within the same area encourages pedestrian activity and reduces the need for long commutes.

2.2 LAND USE LAND COVER (LULC)

According to Turner II (2007), land use and land cover (LULC) are fundamental concepts that provide insights into the utilization and characteristics of the Earth's surface. These concepts play a crucial role in various disciplines, including geography, environmental science, urban planning, and agriculture.

2.2.1 Land Use

According to Sundara, (2012), land use is defined as the specific human activities and purposes for which land is utilized. It encompasses a wide range of activities that take place on the earth's surface, including residential, commercial, industrial, agricultural, recreational, and conservation purposes. Understanding land use is essential for effective urban and regional planning, natural resource management, and sustainable development. Application of land use are:

- i. **Urban Planning and Development:** Land use planning is a crucial component of urban development. It involves determining where different types of activities should occur within a city or region. This includes designating areas for residential zones, commercial districts, industrial parks, and public spaces. Proper land use planning helps create well-organized, functional, and livable urban environments.
- ii. **Zoning and Regulations:** Zoning regulations dictate how land can be used in specific areas. These regulations aim to prevent incompatible land uses from coexisting and to ensure that development aligns with the community's goals. Zoning plays a vital role in controlling factors like building height, density, and aesthetics.
- iii. **Agriculture and Rural Land Use:** Land is a finite resource, and its use for agriculture is essential for food production. Agricultural land use includes activities such as crop

cultivation, livestock farming, and agroforestry. Balancing urban expansion with the preservation of productive agricultural land is a challenge that requires careful planning.

- iv. **Environmental Conservation:** Land use planning can include designating areas for environmental conservation, such as national parks, wildlife reserves, and protected habitats. These areas contribute to biodiversity conservation, ecosystem services, and recreational opportunities.
- v. **Transportation and Infrastructure:** Land use directly influences transportation needs. Placing residential areas near workplaces and services can reduce commuting distances and alleviate traffic congestion. Proper land use planning can also optimize the placement of transportation infrastructure like roads, highways, and public transit systems.
- vi. **Economic Activities:** Land is a critical asset for economic activities such as industrial manufacturing, retail, and office spaces. Efficient land use planning ensures that industrial areas are strategically located to minimize negative impacts on residential areas and the environment.
- vii. **Recreation and Open Spaces:** Land use planning includes allocating land for parks, recreational facilities, and open spaces. Access to these areas contributes to the quality of life in urban and rural areas, offering opportunities for leisure, exercise, and community interaction.
- viii. **Infrastructure Development:** Land use decisions impact the demand for infrastructure, including utilities like water supply, sewage systems, and energy distribution networks. Proper land use planning ensures that infrastructure is appropriately sized and located to support the needs of the community.

- ix. **Disaster Risk Reduction:** Strategic land use planning can help mitigate the impact of natural disasters. Avoiding construction in flood-prone areas or on unstable terrain can reduce vulnerability to events like floods, landslides, and earthquakes.
- x. **Cultural and Historical Preservation:** Land use planning can incorporate the preservation of cultural heritage sites and historical landmarks. Designating areas for cultural and heritage conservation helps maintain a sense of identity and history within a community.

2.2.2 Land Cover

Lambin, (2007) defined land cover as the physical and biological materials that occupy the earth's surface. It encompasses the diverse array of natural and artificial features found on the land, including forests, wetlands, urban areas, water bodies, agricultural fields, grasslands, deserts, and more. Land cover provides a comprehensive overview of the Earth's surface composition and reflects the complex interactions between human activities and the natural environment. Understanding land cover is vital for a range of disciplines, including environmental science, ecology, geography, urban planning, agriculture, and disaster management. It serves as a foundational dataset for numerous applications and analyses. The significance and application of land cover.

- i. **Environmental Monitoring and Analysis:** Land cover information is critical for assessing the state and health of ecosystems. It helps identify changes such as deforestation, urban expansion, wetland degradation, and agricultural expansion. This data aids researchers in understanding the impact of human activities on biodiversity, habitat loss, and ecosystem services.
- ii. **Habitat Assessment and Conservation:** Different land cover types provide various habitats for wildlife. By mapping and analysing land cover, researchers can identify areas that

- support important species and biodiversity hotspots. This information guides conservation efforts and helps design protected areas and corridors to maintain viable habitats.
- iii. **Natural Resource Management:** Land cover data is invaluable for managing natural resources such as water, forests, and agricultural land. It assists in evaluating soil erosion, water quality, and land degradation, which are crucial for sustainable land use planning and resource management.
 - iv. **Urban Planning and Development:** In urban areas, land cover maps help urban planners understand the distribution of built-up areas, green spaces, and infrastructure. This information supports decisions related to zoning, transportation planning, and managing urban growth while preserving open spaces.
 - v. **Agriculture and Land Use Planning:** Understanding land cover is essential for optimizing agricultural practices. It aids in identifying suitable areas for farming, analysing crop distribution, and assessing changes in agricultural land due to urbanization or changing land use patterns.
 - vi. **Disaster Risk Management:** Land cover data is crucial for assessing vulnerability to natural disasters such as floods, landslides, and wildfires. By identifying areas prone to such events, authorities can develop effective risk reduction strategies and emergency response plans.
 - vii. **Climate Change Studies:** Changes in land cover influence the Earth's energy balance and climate patterns. Monitoring shifts in land cover, such as deforestation or reforestation, helps researchers study their impact on local and global climates.
 - viii. **Land Use Policy and Decision-making:** Governments and policymakers use land cover information to formulate land use policies, regulations, and conservation plans. This data-driven approach ensures that decisions align with the current state of the landscape.

- ix. Remote Sensing and Technology: Remote sensing technologies, including satellite imagery and aerial photography, play a pivotal role in mapping and monitoring land cover. These
- x. technologies provide a bird's-eye view of vast areas, making it possible to analyse changes over time and at different spatial scales.

2.2.3 LULC Class and Description (Sundara, et., al., 2012)

Table 2.1: LULC Class and Description

Code	Land Class	Description
1	Vegetation	This refers to the various plants, including trees, shrubs, grasses, and other types of greenery, that collectively cover an area of land. It encompasses all forms of plant life in a specific ecosystem or geographical region and plays a crucial role in the environment by providing habitat, oxygen production, and contributing to overall ecosystem health.
2	Settlement	This refers to the expansion of residential and commercial developments into previously undeveloped or rural areas on the outskirts of a city. It involves the establishment of new housing, businesses, and infrastructure in these once-open spaces, contributing to the outward spread of urban areas.
3	Water bodies	This refers to a navigable route or passage for the transportation of water, typically used for purposes such as shipping, transportation, or recreation. Waterways can include natural bodies of water like rivers and lakes, as well as man-made channels, canals, and other constructed water routes.
4	fallow land	This refers to undeveloped, vacant land that does not have any buildings, structures, or significant improvements on it. It is land in its natural state, typically devoid of construction or development.

2.2.4 Relationship Between Land Use and Land Cover

According to Lambin (2006), land use and land cover (LULC) are closely interconnected and influence each other in the following ways:

- i. Human influence on Land Cover: Human activities significantly impact land cover patterns. For example, deforestation alters land cover from forested areas to open lands or agricultural fields. Urbanization transforms land cover from natural or agricultural areas to built-up environments.
- ii. Land Cover influence on Land Use: Land cover characteristics influence land use decisions. Soil fertility, slope, water availability, and vegetation cover influence the suitability of land for different purposes. For instance, areas with fertile soil and adequate water resources are often preferred for agricultural activities (Reenberg, 2007).
- iii. Environmental Implications: Changes in land use and land cover have profound environmental implications. Alterations such as deforestation, land degradation, or wetland conversion affect ecosystem services, biodiversity, hydrological cycles, and climate patterns

2.2.5 Importance of Land Use and Land Cover (LULC) Analysis

Land Use and Land Cover (LULC) analysis is a powerful tool for understanding, monitoring, and managing the Earth's surface and its transformations. Its applications span across various fields, including environmental monitoring, land management, climate change studies, agriculture, urban planning, and natural resource management. By harnessing the insights gained from LULC analysis, stakeholders can make informed decisions, formulate effective policies, and work towards sustainable and resilient landscapes.

According to Jensen, (2007), land use and land cover (LULC) analysis is a valuable tool for understanding and monitoring the Earth's surface and its transformations. By examining the spatial patterns and changes in land use and land cover, researchers and decision-makers can gain valuable insights into various environmental, social, and economic processes. The applications of LULC analysis and its significance in different fields are given below.

- i. **Environmental Monitoring and Conservation:** LULC analysis plays a crucial role in monitoring and assessing environmental changes and their impacts on ecosystems. It helps identify areas of deforestation, land degradation, urban expansion, and habitat loss. By tracking land cover changes over time, conservationists can better understand the rate and extent of environmental transformations, allowing for targeted conservation efforts and the protection of sensitive ecosystems.
- ii. **Land Management and Planning:** LULC analysis provides valuable information for land management and planning activities. It aids in identifying suitable areas for various land uses, such as agriculture, residential development, and infrastructure projects. By analysing land cover characteristics, planners can make informed decisions regarding land use zoning, urban growth boundaries, and the preservation of natural resources. LULC analysis also supports land management practices by assessing soil suitability, determining areas prone to erosion, and guiding land restoration efforts.
- iii. **Climate Change Studies:** LULC analysis is instrumental in studying the impacts of land cover changes on climate dynamics. Land use changes, such as deforestation or afforestation, affect surface albedo, energy balance, and carbon storage. By quantifying land cover changes and their associated greenhouse gas emissions, scientists can assess the contributions of land use activities to climate change and develop strategies for carbon sequestration and climate mitigation.

- iv. **Agriculture and Food Security:** LULC analysis is crucial for assessing agricultural suitability, crop mapping, and food security assessments. By examining land cover patterns, researchers can identify areas suitable for different crops, evaluate crop health, and monitor changes in agricultural land extent. This information helps optimize agricultural practices, improve crop yield predictions, and address food security challenges by identifying regions with potential for agricultural expansion or intensification.
- v. **Urban Planning and Infrastructure Development:** LULC analysis provides critical insights for urban planning and infrastructure development. It helps identify areas suitable for urban expansion, assess the efficiency of existing infrastructure networks, and evaluate the impact of urbanization on land cover and ecosystem services. By analysing land use patterns, planners can optimize urban growth, promote sustainable transportation, and allocate resources effectively.
- vi. **Natural Resource Management:** LULC analysis supports the management and conservation of natural resources. It aids in assessing water resource availability, monitoring changes in forest cover, and identifying areas vulnerable to soil erosion or degradation. By understanding the distribution and dynamics of land cover, resource managers can implement appropriate measures to protect and sustainably utilize natural resources.

Predicting Land Use and Land Cover Patterns

Remote sensing and GIS techniques contribute to the prediction of land use and land cover patterns by utilizing historical data, statistical models, and spatial analysis. These tools help identify factors influencing land use changes, such as population growth, economic activities, and policy interventions. By simulating future scenarios and

forecasting land use patterns, urban planners can proactively address issues related to urban sprawl, allocate resources efficiently, and implement appropriate land use policies.

2.2.6 APPLICATIONS OF REMOTE SENSING AND GIS IN EVALUATING URBAN SPRAWL

Application of Remote Sensing in Evaluating Urban Sprawl

Remote sensing plays a pivotal role in assessing urban sprawl by providing accurate and up-to-date information about the spatial extent and growth of urban areas. Through satellite imagery and aerial photography, remote sensing enables the identification of land use changes, expansion of built-up areas, encroachment on natural habitats, and conversions of agricultural land. This data helps urban planners and policymakers make informed decisions regarding land use, infrastructure development, and environmental conservation.

Data Classification

Data Classification involves categorizing the acquired data into different classes based on their spectral, spatial, or temporal characteristics. The classification allows us to understand the composition and distribution of land cover types within a study area. The key steps involved are:

- i. **Define Classes:** Defining the classes or land cover categories that will be used for classification. Common classes may include urban areas, vegetation, water bodies, agricultural land, forests, and bare soil.
- ii. **Training Data Collection:** Collect representative training data samples for each class. These samples should be selected from the acquired data and labelled with the appropriate class (Congalton, 2009).
- iii. **Classification:** The classifier assigns each pixel or object in the data

to one of the predefined land cover classes based on its spectral or spatial characteristics. This process generates a classified image or map representing the distribution of different land cover classes within the study area. iv. Post-classification Analysis: This may involve spatial filtering, majority voting, object-based analysis, or additional rule-based processing to improve the accuracy and thematic consistency of the classified map (Mas, 2016).

- iii. Accuracy Assessment: This assessment helps evaluate the reliability and quality of the classification results (Congalton, 1991).

Application of Geographic Information System (GIS) in Evaluating Urban Sprawl

According to Longley, (2015), Geographic Information Systems (GIS) play a crucial role in understanding, analysing, and managing the complex phenomenon of urban sprawl. Urban sprawl refers to the uncontrolled expansion of cities into surrounding rural areas, often resulting in low-density, car-dependent development patterns. Below is the application of GIS in urban sprawl evaluation:

- i. Data Collection and Integration: GIS allows the collection and integration of various data sources, such as satellite imagery, land use maps, population data, transportation networks, and socio-economic indicators. This comprehensive data helps urban planners and researchers assess the extent and patterns of urban sprawl.
- ii. Land Use and Zoning: GIS helps analyse land use changes over time. By overlaying historical land use maps, planners can identify areas that have undergone transformation from agricultural or natural land to urban developments. Zoning regulations and land use policies can also be integrated into GIS, allowing planners to visualize how different zones are distributed across the urban landscape.

- iii. **Spatial Analysis:** GIS provides tools for spatial analysis, allowing experts to measure various sprawl indicators like population density, housing density, and road density. These indicators help quantify the extent of sprawl and its impact on land use efficiency.
- iv. **Transportation Planning:** Urban sprawl often leads to increased car dependency. GIS can be used to model transportation networks, estimate traffic flows, and identify areas lacking efficient public transportation options. This information is crucial for designing sustainable transportation solutions and reducing congestion.
- v. **Environmental Impact Assessment:** GIS enables the assessment of environmental changes due to urban sprawl. It can track deforestation, loss of green spaces, and changes in air and water quality. By analysing these impacts, planners can make informed decisions to mitigate negative environmental effects.
- vi. **Infrastructure Planning:** GIS helps identify gaps in infrastructure provision caused by urban sprawl. Planners can determine where new utilities, roads, schools, and healthcare facilities are needed to accommodate growing populations.
- vii. **Risk Assessment and Emergency Management:** In sprawling urban areas, assessing vulnerability during natural disasters becomes essential. GIS can analyse areas prone to flooding, landslides, or other hazards. This information assists emergency responders and planners in developing evacuation plans and allocating resources effectively.
- viii. **Smart Growth Strategies:** GIS supports the implementation of smart growth strategies to counter urban sprawl. By identifying areas suitable for higher-density development, mixed land uses, and walkable neighbourhoods, planners can encourage compact and sustainable growth.

- ix. **Policy Formulation:** Informed policy decisions are crucial for managing sprawl. GIS-based analyses provide data-driven insights for policy formulation related to urban development, land use regulations, and preservation of green spaces.
- x. **Visualization and Public Engagement:** GIS offers interactive mapping tools that can help communicate the consequences of urban sprawl to the public. Visualizations make complex data accessible, encouraging citizen engagement and informed discussions about growth management.

2.2.7 REMOTE SENSING AND GIS TECHNIQUES IN EVALUATING URBAN SPRAWL

Various remote sensing and GIS techniques are employed to evaluate urban sprawl and predict land use and land cover patterns. These techniques, as given by Woodcock, et al., (2018) are:

- i. **Image Classification:** Segmentation and classification algorithms are applied to satellite imagery to distinguish different land cover types, such as urban areas, vegetation, and water bodies.
- ii. **Change Detection:** By comparing multi-temporal satellite images, changes in land use and land cover can be identified, allowing for the measurement of urban sprawl dynamics.
- iii. **Spatial Modelling:** GIS-based models, such as cellular automata and agent-based models, simulate the urban growth process and predict future land use patterns based on existing spatial relationships and socio-economic factors.
- iv. **Data Integration:** Combining remote sensing data with other geospatial datasets, such as census data, transportation networks, and environmental indicators, provides a holistic understanding of urban sprawl and its drivers.

2.2.8 Data Pre-processing

This process involves preparing the acquired data for analysis by applying various techniques to enhance its quality and compatibility. The following steps are considered steps in data pre-processing:

Georeferencing: This is the process of aligning the acquired data to a known coordinate system (Lu, 2004). This step establishes the spatial reference framework required for integrating different datasets within the GIS environment.

Image Enhancement: This is applied to improve the visual quality and interpretability of remote sensing data. These techniques include contrast stretching, histogram equalization, filtering, and sharpening.

Image enhancement helps in highlighting features and patterns relevant to urban sprawl analysis (Seto & Fragkias, 2007).

Mosaicking: Mosaicking is the process of combining multiple images or datasets to create a seamless composite (Chen and Gong, 2013). In the case of remote sensing data, mosaicking is performed to create a continuous image of the study area by stitching together individual satellite images or aerial photographs.

Data Subset and Clipping: In some cases, the acquired data may cover a larger area than the specific study area of interest. Data subset and clipping techniques are used to extract and retain only the relevant portions of the data for analysis, reducing the computational burden and focusing on the desired area.

2.2.9 Data Analysis and Interpretation

Once the data has been acquired, pre-processed, and classified, the next step is to analyse and interpret the results to gain meaningful insights (Jensen, 2005). The following steps are usually considered in the analysis and interpretation of data:

- i. **Spatial Analysis:** This can involve proximity analysis, overlay analysis, spatial statistics, and hotspot analysis. These techniques help identify clusters, trends, and spatial dependencies, providing valuable information about the spatial distribution of urban areas and other land cover types (Fotheringham, 2000).
- ii. **Change Detection:** This is done to identify and quantify the changes that have occurred over time in the land cover patterns. By comparing multiple datasets from different periods, it is possible to detect areas of urban expansion, land conversion, or changes in vegetation cover. Change detection helps in understanding the dynamics of urban sprawl and land use changes (Lu, 2004).
- iii. **Temporal Analysis:** This analysis can reveal patterns related to agriculture, vegetation phenology, or other temporal dynamics. Temporal analysis helps in understanding the seasonal variations and trends in land cover changes (Rashed and Weeks, 2003).
- iii. **Integration with Ancillary Data:** Integrate the land cover data with other ancillary datasets such as socio-economic data, infrastructure data, or environmental data. This integration provides a broader context for understanding the drivers and impacts of urban sprawl and land use changes. It allows for a more comprehensive analysis and interpretation of the land cover patterns (Woodcock 2018).
- iv. **Modelling and Prediction:** Utilizing spatial modelling techniques to predict future land cover changes and urban sprawl. This can involve the use of predictive models, such as cellular automata models, Markov chains, or machine learning algorithms, to forecast the future distribution of land cover classes based on historical data and identified trends.

Modelling and prediction provide valuable insights for urban planning and decision-making processes (Pontius, 2008).

2.2.10 Identifying Urban Sprawl Patterns

By analysing remote sensing data and utilizing GIS tools, insights can be gained into the spatial extent, intensity, and characteristics of urban sprawl (Li and Yeh, 2004).

- i. **Change Detection:** By identifying the changes in urban areas over time, intensification, contraction or expansion of urban sprawl can be detected. Change detection methods include image differencing, image ratios, and thresholding techniques (Weng, 2004).
- ii. **Urban Growth Analysis:** Analyse the growth patterns of urban areas by quantifying their spatial extent, shape, and configuration. Spatial metrics such as the density of urban patches, patch size distribution, and landscape metrics (e.g., fragmentation, edge density) can provide insights into the urban sprawl patterns and their characteristics (McGarigal, 2002).
- iii. **Land Use/Land Cover Classification:** Classify the land cover types within the study area, distinguishing between urban areas, vegetation, water bodies, agricultural land, and other land cover classes. This classification allows for the identification of urban areas and their spatial distribution (Congalton and Green, 2009).
- iv. **Spatial Analysis:** This identifies the spatial patterns and relationships of urban sprawl. Techniques such as proximity analysis, hotspot analysis, and spatial statistics can help identify clusters, concentrations, and expansion corridors of urban development. These analyses provide insights into the spatial dynamics and patterns of urban sprawl (Openshaw and Openshaw, 1997).

2.2.11 Assessment of Urban Sprawl Metrics

According to Kasanko, (2006), various metrics are used to assess urban sprawl, such as the urban sprawl index, compactness index, and fragmentation index. These metrics quantify the extent, shape, and connectivity of urban areas.

- i. **Urban Area Extent:** This metric measures the total spatial extent of urban areas within a study region. It quantifies the size of developed or built-up areas and provides a baseline understanding of urban expansion (Jantz, 2005).
- ii. **Urban Density:** Urban density is a metric that evaluates the concentration of urban development within a defined area. It measures the number of people or buildings per unit area and indicates the level of compactness or dispersion of urbanization (Ferreira and Alberti, 2017).
- iii. **Built-up Intensity:** Built-up intensity measures the degree of land transformation from natural or agricultural land to built-up areas. It assesses the level of urban land consumption and can help identify areas experiencing rapid urbanization (Seto, 2011).
- iv. **Fragmentation:** Fragmentation metrics evaluate the spatial fragmentation or discontinuity of urban areas. These metrics quantify the degree to which urban development is dispersed into smaller and disconnected patches, indicating the level of sprawl and loss of contiguous land cover (McGarigal, 2002).
- v. **Sprawl Index:** Sprawl index metrics provide an overall assessment of urban sprawl by combining multiple indicators such as urban area extent, density, and fragmentation. These indices offer a comprehensive measure of the spatial patterns and characteristics of urban sprawl (Ewing, 2019).

2.3 REVIEW OF RELATED LITERATURE

Assessment of Urban Sprawl Dynamics using Remote Sensing and GIS Techniques was conducted by Smith, et al., (2019). The research was based on analysing the dynamics of urban sprawl through the application of remote sensing and GIS methodologies. The study aimed to understand the changes in urban landscapes over a specific period and their implications.

The researchers employed remote sensing technologies, specifically utilizing satellite imagery such as Landsat data, to track changes in land cover over a designated timeframe. Geographic Information Systems (GIS) tools were utilized to process and analyse the collected data, enabling the visualization and mapping of urban sprawl patterns.

The study's outcomes provided insights into the extent and patterns of urban sprawl over the specified period. Through the integration of remote sensing imagery and GIS analysis, the researchers showed the transformation of land cover types, particularly the conversion of natural or agricultural land into urbanized areas. The results highlight the dynamic nature of urban expansion and its impact on the landscape.

Based on the findings, the research underscores the need for effective urban growth management strategies. It suggests that informed policies and regulations should be implemented to guide urban development and counteract the negative effects of uncontrolled sprawl. The study emphasizes the significance of utilizing remote sensing and GIS techniques for continuous monitoring and assessment of urban growth patterns.

A research by Chen and Zhang, (2011) titled Predicting Land Use Changes in a Growing Urban Region using

Machine Learning and GIS. The study utilized machine learning techniques in conjunction with Geographic Information Systems (GIS) to model and predict future land use patterns. The

authors combined machine learning methodologies with GIS tools. They likely employ techniques such as random forests, support vector machines, or neural networks to analyse historical land use data and associated variables. GIS is used to manage and analyse spatial data, which includes features like land cover types, infrastructure, and socioeconomic factors.

The study's outcomes involve predictive models that project land use changes over time. The results include maps or visualizations illustrating the anticipated shifts in land use categories. These predictions demonstrate how urbanization processes affect different areas within the growing urban region.

The research highlights the importance of accurate land use predictions for urban planning and management. It emphasizes the value of integrating machine learning and GIS technologies for proactive decision-making. The recommendations are:

Policy Formulation: Advising policymakers to use the predictive models to formulate informed land use policies that align with the expected growth trends.

Infrastructure Planning: Recommending the optimal placement of new infrastructure based on the projected land use changes.

Sustainability: Discussing the potential environmental and socioeconomic impacts of the predicted land use changes and suggesting strategies for sustainable growth.

Data Continuity: Highlighting the need for ongoing data collection and model updates to improve the accuracy of future predictions.

Lee and Park (2023) carried out a research on Remote Sensing Assessment of Green Space Loss Due to Urban Sprawl. They focused on evaluating the reduction of green spaces resulting from the expansion of urban areas.

The study employed remote sensing techniques to quantify the extent of green space loss and its implications. They employed remotely sensed data, that is, a high-resolution aerial imagery, to assess changes in green spaces over a specific time frame. Geographic Information Systems (GIS) was used to analyse and map the spatial distribution of parks, gardens, and other green areas.

The study's outcomes revealed a significant decrease in green spaces within urban environments. It provides quantifiable data illustrating the extent of the loss of natural and recreational areas due to the process of urban sprawl. By utilizing remote sensing imagery and GIS analysis, the study underscores the tangible impact of urban expansion on the availability of green spaces.

The research underlined the importance of preserving green spaces in urban settings. They suggested that the reduction of green areas due to urban sprawl can have adverse effects on residents' access to recreational and natural environments. The study's findings advocate for the integration of green infrastructure in urban planning to counterbalance the negative consequences of urban expansion.

The study titled "Modelling Urban Growth Patterns and Implications for Resource Management," conducted by Rodriguez, et al (2000), focused on analysing urban growth trends and their consequences for resource management. The research employed a combination of remote sensing data, socioeconomic indicators, and cellular automata modelling to simulate various urbanization scenarios.

The researchers integrated satellite imagery and land cover data, with. They employed cellular automata modelling, a computational technique, to simulate different patterns of urban growth. This method allowed them to project how urban areas expand under different conditions.

The study's findings highlighted the significance of urban growth patterns for resource management. It was discovered that the type of urban development pursued has implications for resource utilization, environmental impact, and overall sustainability. The research compared scenarios of compact, mixed-use development with sprawling, single-use development.

The research emphasized that compact and mixed-use urban growth patterns tend to utilize resources more efficiently and result in lower environmental impacts compared to sprawling patterns. The study underscores the importance of informed urban planning decisions to ensure sustainable resource management. They recommended that policymakers prioritize strategies that encourage compact development, preserve green spaces, and optimize infrastructure usage to mitigate the negative effects of urban sprawl on resource availability and environmental quality.

CHAPTER THREE

METHODOLOGY

3.1 STUDY AREA DESCRIPTION

DESCRIPTION OF THE STUDY AREA: Eti-Osa Local Government Area, Lagos State, Nigeria

Location and Boundaries

Eti-Osa is one of the 20 Local Government Areas (LGAs) in Lagos State, situated in the south-eastern part of Lagos Metropolis. It lies along the Atlantic coast, stretching from Victoria Island and Ikoyi in the west to Ajah and Lekki in the east.

Latitude: Approximately between 6.4°N and 6.5°N

Longitude: Between 3.4°E and 3.6°E

BOUNDARIES:

North: Lagos Lagoon and Lagos Island LGA

South: Atlantic Ocean

East: Ibeju-Lekki LGA

West: Lagos Island and Amuwo-Odofin LGAs Geography and Topography:

Eti-Osa is a coastal lowland area, characterized by:

Flat terrain, with average elevations generally less than 15 meters above sea level

Estuaries, creeks, and tidal inlets, especially near Lekki Peninsula

URBAN DEVELOPMENT:

Eti-Osa is a mix of urban and developing suburban environments. It includes: High-density residential and commercial areas (e.g., Ikoyi, Victoria Island), Emerging residential estates (e.g., Lekki Phase 1 & 2, Ajah), Major infrastructural developments, including: Lekki Free Trade Zone, Lekki Deep Seaport, Dangote Refinery, Lekki-Epe Expressway

LAND USE AND HUMAN ACTIVITY:

Residential: Estates and gated communities are rapidly expanding

Commercial: Headquarters of banks, hotels, embassies, and corporate offices

Tourism & Recreation: Beaches (Elegushi, Alpha), resorts, shopping malls

Agricultural pockets still exist in the fringes (especially east of Ajah)

Increasing real estate and construction activity

Significance as a Study Area:

Eti-Osa is ideal for studies in:

Urban sprawl and land use change

Coastal erosion and flood risk assessment

Cadastral and land management

Digital terrain modelling in coastal zones

Infrastructure development and planning

Sandy and swampy soils, with large areas covered by wetlands and mangroves

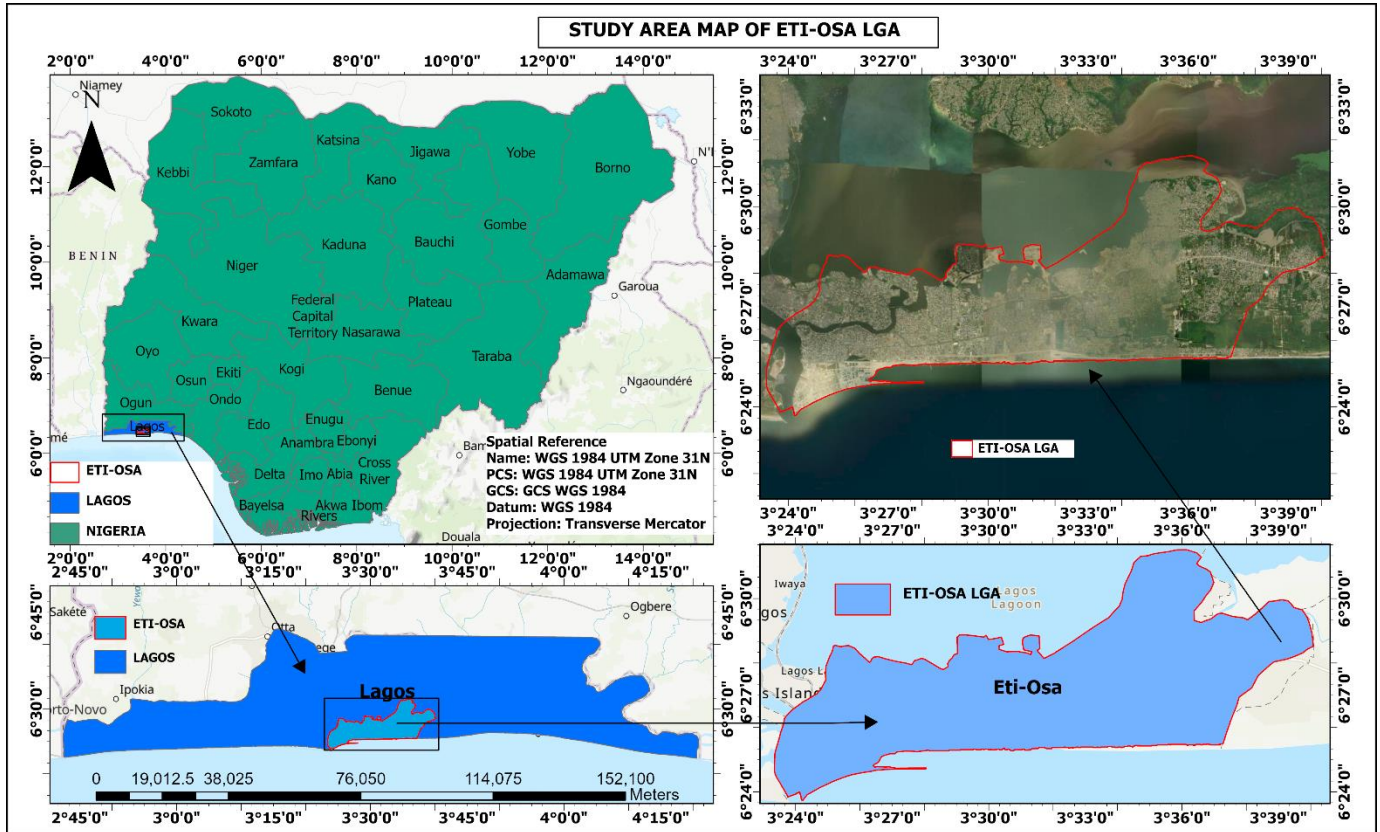


Figure 3.1 study area map of ETI-OSA LGA

3.2 MATERIALS USED

Datasets

In this research, the following data or materials are used:

- i. Nigeria road network.
- ii. Digital elevation model.
- iii. Landsat imagery from United States Geological Survey (USGS). Hardware i HP laptop Intel(R) Core (TM) i5-6200U CPU @ 2.30GHz 2.40 GHz, 8.00G of RAM Software
- iv. ArcGIS pro: This software is used for data analysis in this research.

- v. Google Earth Pro: This was used in generating coordinate in plotting a digital elevation map of the study area.
- vi. Microsoft Word and Spreadsheet (2016)
- vii. QGIS to fix scan line errors of landsat 7 data

3.3 DATA ACQUISITION

The satellite imagery data used in this study is gotten from United States Geological Survey (USGS) website (<https://www.earthexplorer.usgs.gov>). The table is generated from USGS Table

Satellite data acquisition:

Table 3.1: Satellite data acquisition

SATELLITE DATA ACQUISITION						
S/N	Data Type	Period of Acquisition	Path	Row	Resolution	Source
1	Landsat 8 and 9 EMT+	2024	189	055	30 meters	USGS
2	Landsat 7 EMT+	2014	189	055	30 meters	USGS
3	Landsat 7 EMT+	2004	189	056	30 meters	USGS
4	Landsat 4-5 C2L1	1994	191	055	30 meters	USGS

Procedure for satellite data acquisition

Login to USGS website> select address/place> add coordinates> select the place of interest using polygon>set cloud cover> click on datasets> Landsat 4-5> Landsat collection 2 level - 1> set date range> check footprint> download.

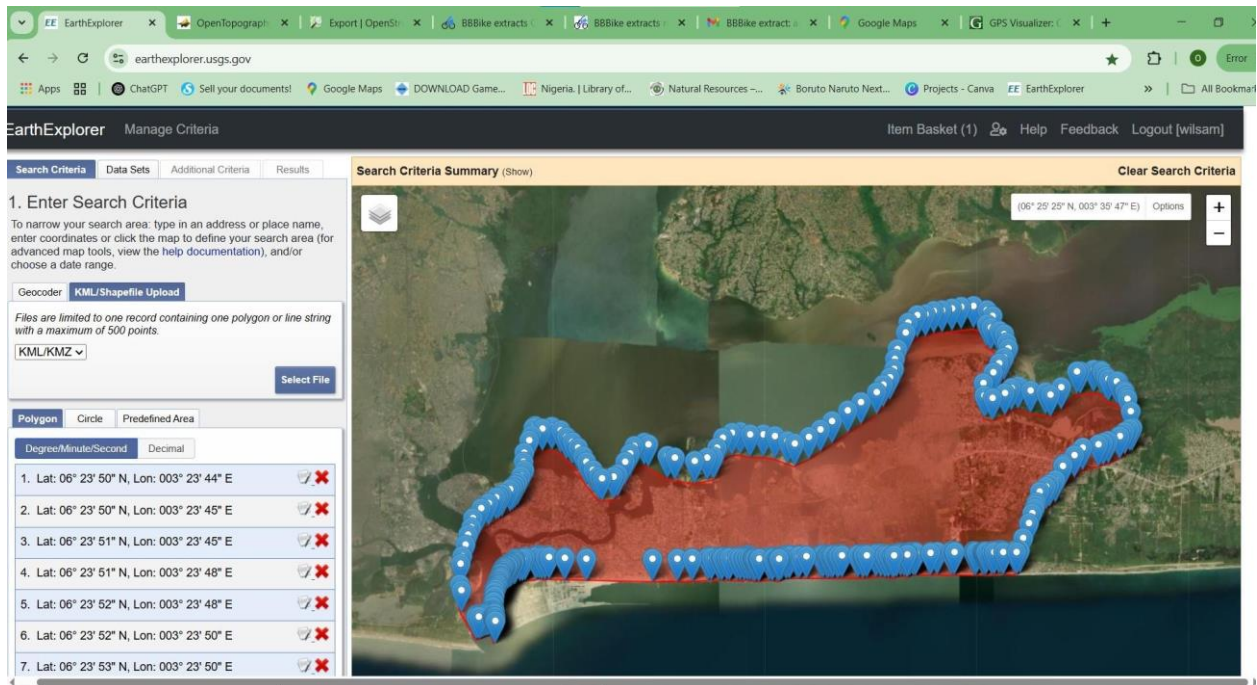


Figure 3.2 Data acquisition from United States Geological Survey (USGS)

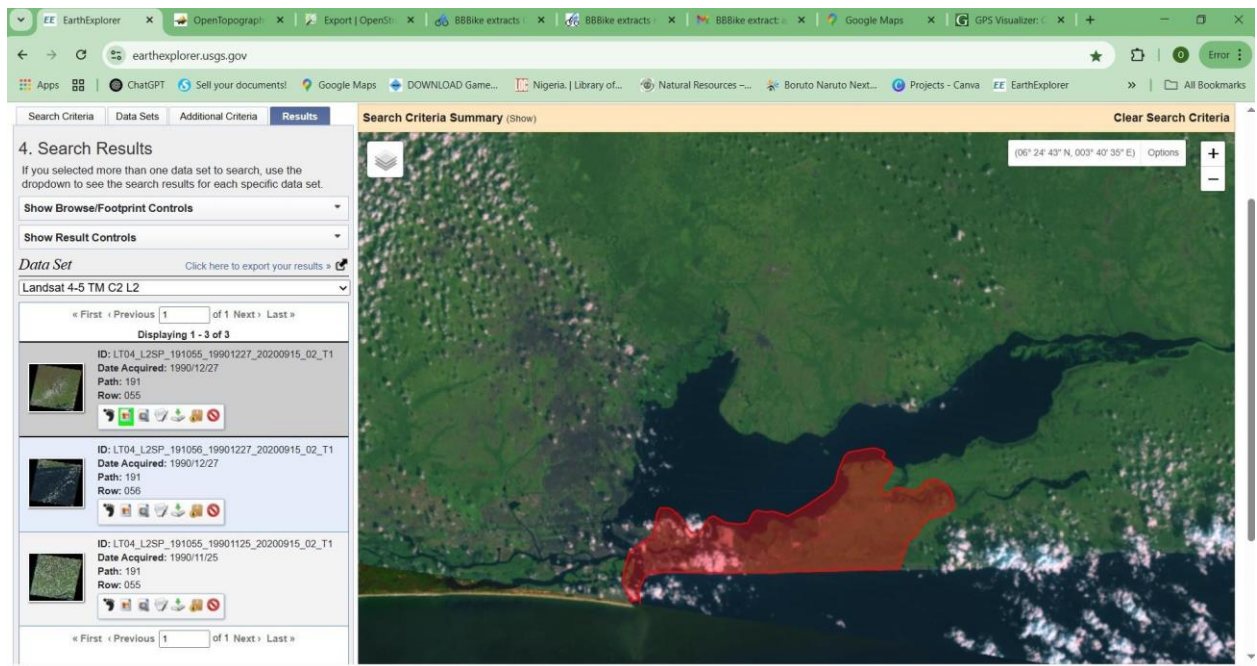


Figure 3.3 Making necessary set up before download

Road Networks

This analytical framework holds paramount importance in the evaluation of urban sprawl as it offers valuable insights into the extent and intricacies of urbanization within a specified geographical area or region. The meticulous examination of road networks encompasses a thorough assessment of the infrastructure, connectivity, and layout, shedding light on the evolving urban landscape and its associated implications on sustainable development, resource allocation, and societal well-being. Road network data was downloaded online to get ETI-OSA LGA transportation network. Road Network of ETI-OSA LGA.

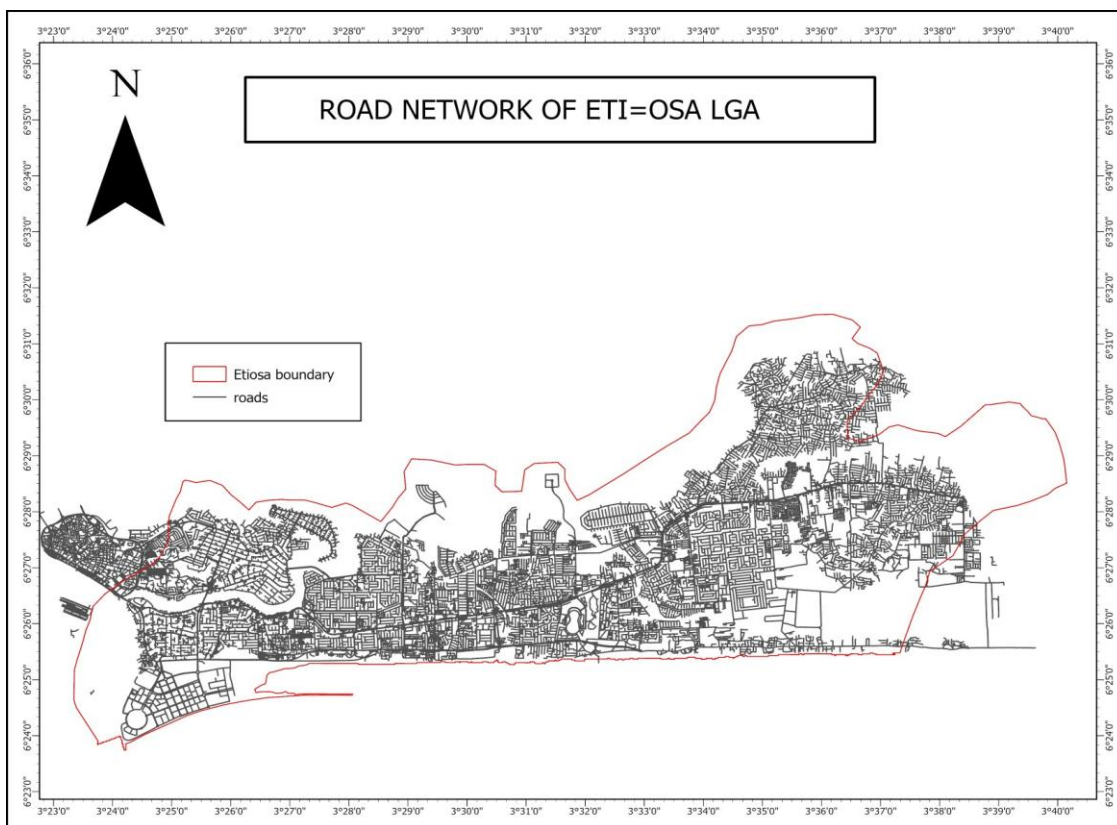


Figure 3.4 road network map of eti-osa lga

Digital Elevation Model (DEM)

The utilization of a digital elevation model (DEM) offers a comprehensive visualization of the topography of Eti-osa region, effectively delineating the extremes of elevation prevalent in the area. Specifically, areas characterized by the lowest elevations are visually distinguished with light gray and yellow, symbolizing the presence of wetlands. Conversely, the highest elevations seen in a red, designating prime upland locations conducive to strategic development and optimal land use planning. The figure below shows the DEM of ETI-OSA LGA gives the virtual representation of this information.

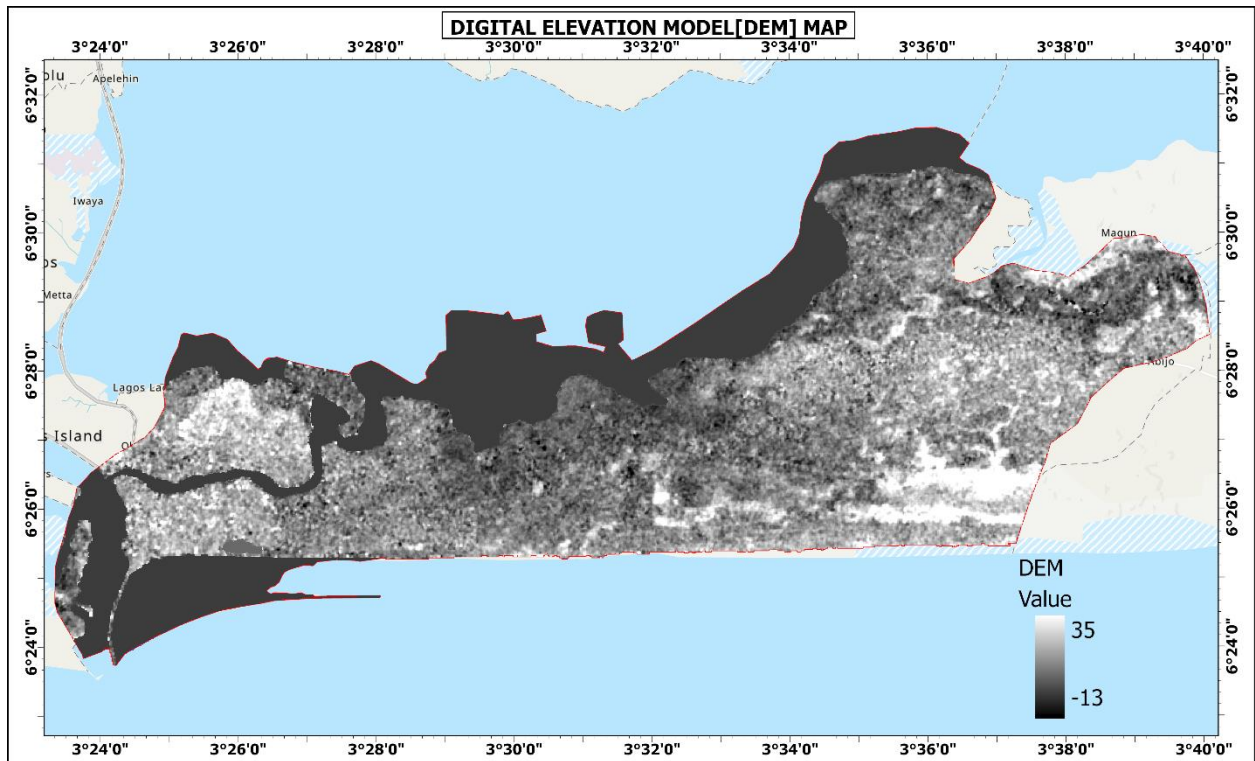


Figure 3.5 DEM of eti-osa lga

Data Pre-processing

This process involves preparing the acquired data for analysis by applying various techniques to enhance its quality and compatibility.

Add images on ArcGIS> data management tool> raster> raster dataset> mosaic to new raster> add images> output location> mosaic

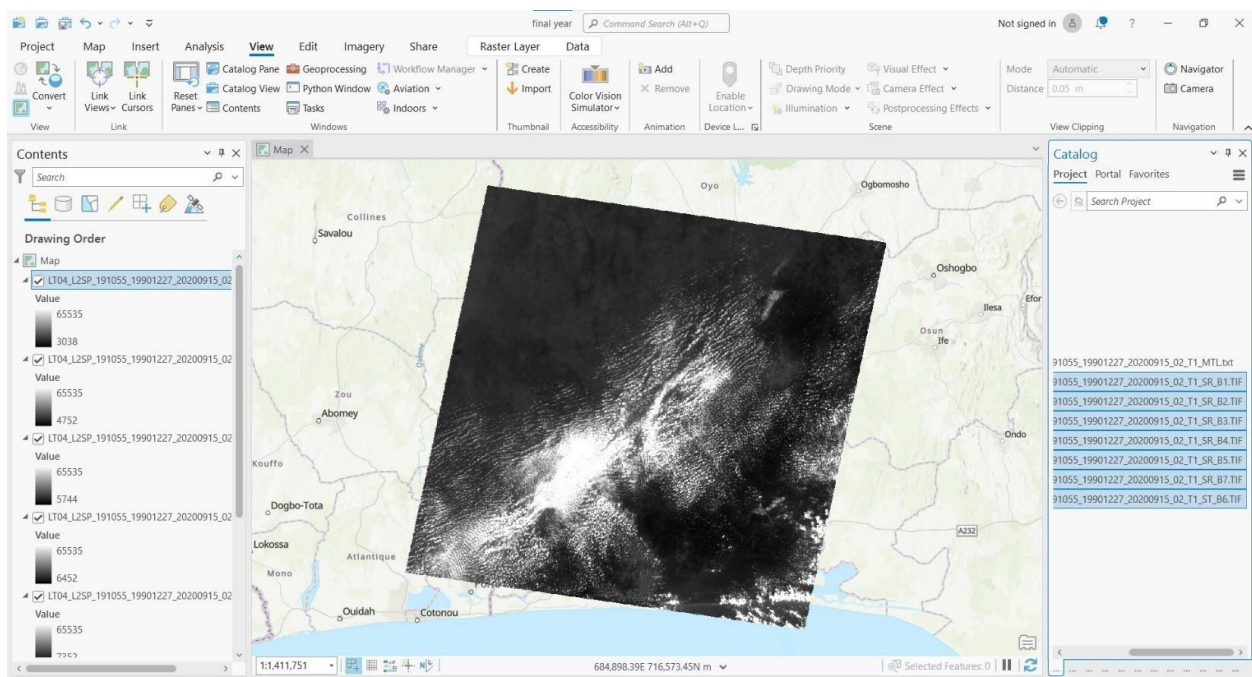


Figure 3.6 Combined Images and Shape file

Add image> data management tool> raster> raster processing> composite bands> add bands> name and save> properties> symbology

Creating a Composite Band

Add the downloaded image to ArcGIS> add shape file> select band combination (vegetation)> draw polygon> take lot of samples> select all samples> merge training samples> rename

(vegetation)> change colour> select band combination (water body)> draw polygon> take lot of samples> select all samples> merge training samples> rename (water body)> select band combination (settlement)> change colour> draw polygon> take lot of samples> select all samples> merge training samples> rename (settlement > change colour> select band combination (fallow)> draw polygon> take lot of samples> select all samples> merge training samples> rename (fallow)> change colour> classification> supervised classification.

After creating a composite band I georeferenced the satellite image of 1994 etiosa lga to use as a base map for a more accurate supervised classification

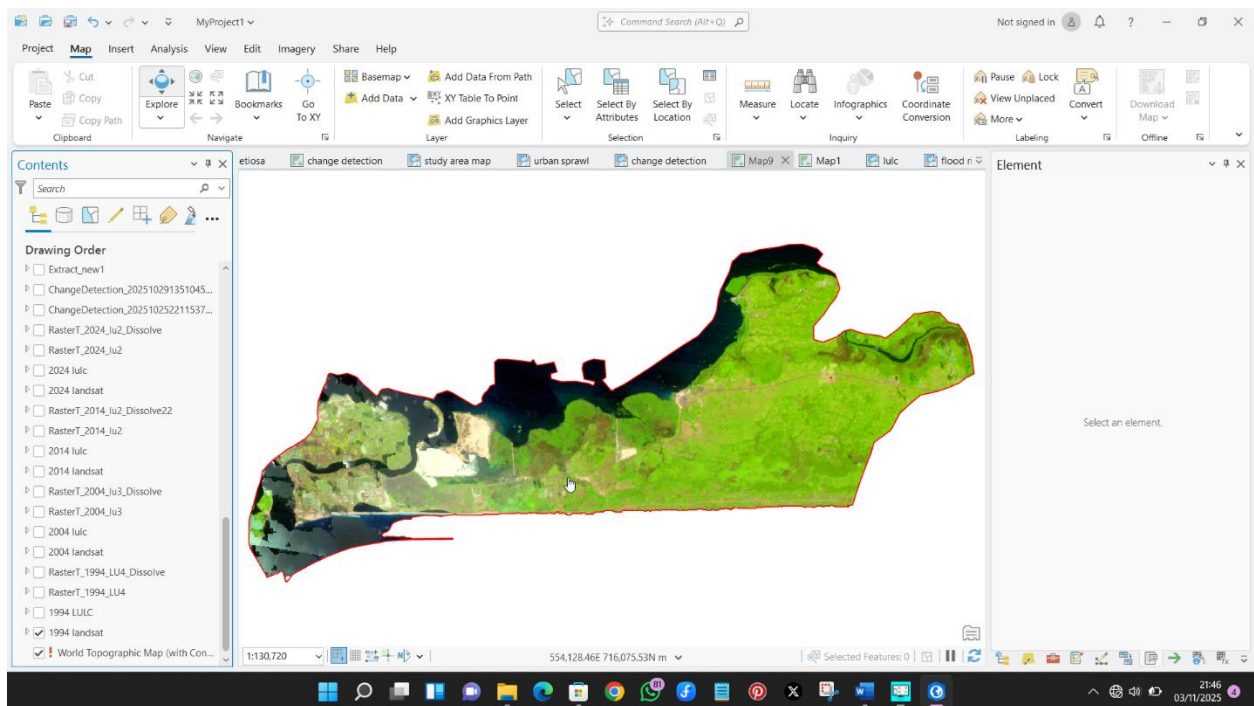


Figure 3.7 Composite band



Figure 3.8 1994 satellite imagery



Figure 3.9 2004 satellite imagery



Figure 3.10 2014 satellite imagery

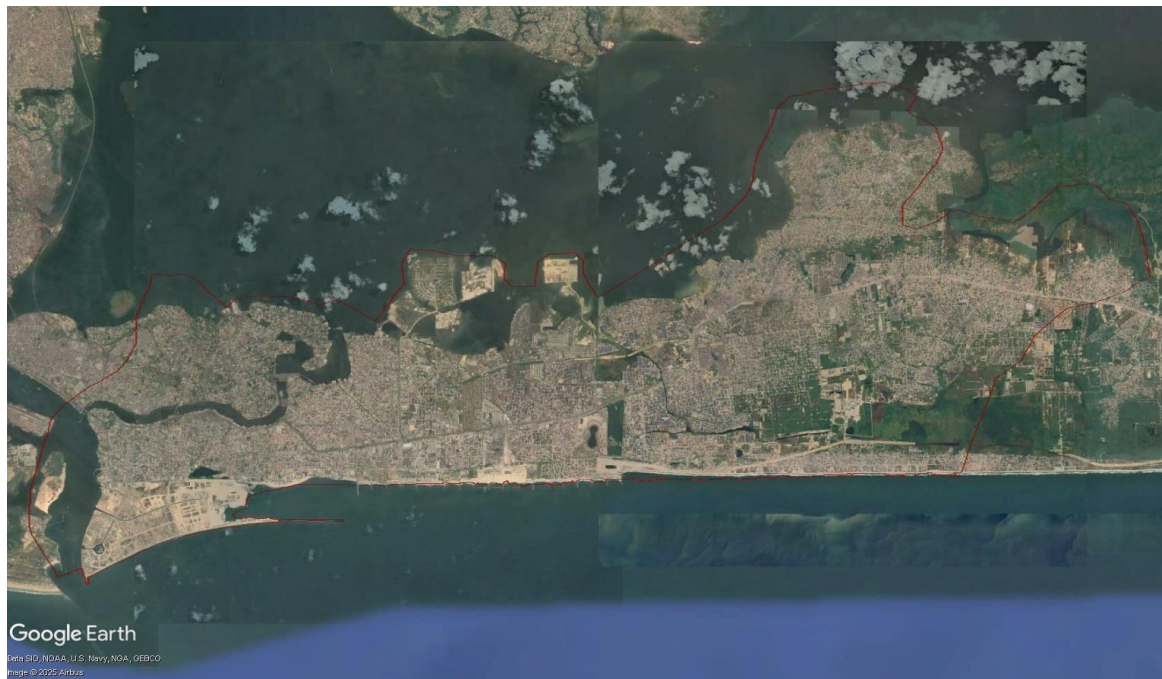


Figure 3.11 2024 satellite imagery.

3.4 FLOOD RISK ASSESSMENT OF THE STUDY AREA

Flooding is one of the most critical environmental hazards in coastal and rapidly urbanizing regions, particularly in low-lying areas such as Lagos State. Flood risk assessment integrates multiple environmental and anthropogenic factors to identify susceptible areas and guide disaster-mitigation planning (Smith, 2004). In this study, a geospatial multi-criteria evaluation (MCE) approach was adopted to assess flood risk in the study area using Digital Elevation Model (DEM), slope, proximity to streams, and Land Use/Land Cover (LULC) data. These variables are widely recognized as major determinants of surface runoff and inundation patterns in coastal urban environments (Ologunorisa, 2009; Aderogba, 2012).

Digital Elevation Model (DEM) data were processed to derive elevation values, which play a critical role in flood analysis. Areas with lower elevations tend to accumulate runoff and are more vulnerable to flooding than higher-elevation sites (Youssef et al., 2011). The DEM also served as the basis for generating a **slope** raster through spatial analysis. Slope influences runoff velocity and infiltration rates; flatter terrain slows water movement and increases flood potential, while steeper slopes facilitate faster runoff and reduce flood accumulation (Burrough & McDonnell, 2011).

A proximity-to-stream layer was generated to represent hydrological influence zones. Areas closer to streams, drainage channels, and lagoonal creeks exhibit higher susceptibility to flooding due to overflow and direct channel-water interactions during storm events (Chow et al., 1988). Buffering and Euclidean distance tools were applied to determine areas exposed to potential fluvial flooding and tidal backflow.

Land Use/Land Cover (LULC) data were classified to account for the influence of human activities and surface characteristics on flood dynamics. Impervious surfaces such as built-up and reclaimed lands enhance runoff, reduce infiltration, and intensify flood hazards, whereas natural wetlands and vegetation areas help retain floodwaters and attenuate surface flows (Lu & Weng, 2007; Richards & Jia, 2006). In rapidly urbanizing coastal settings like Eti-Osa, extensive wetland reclamation and land conversion further exacerbate flood risk by altering natural drainage systems—a trend highlighted in recent studies on Lagos coastal development (Adelekan, 2016).

Each factor was reclassified and integrated using a weighted overlay model to produce a composite flood-risk map. This spatial decision-support technique allows the harmonization of multiple criteria based on their relative influence on flood susceptibility (Malczewski, 1999). The resulting map identifies zones at high, moderate, and low flood-risk levels, providing a valuable tool for land-use planning, infrastructure development, and environmental management in the study area.

3.4.1 Data Acquisition

Spatial data required for this study were obtained from reliable secondary sources. These include:

Digital Elevation Model (DEM) (30m resolution or better)

Land Use/Land Cover (LULC) data

Hydrography data (streams and rivers)

All datasets were projected to a common coordinate reference system suitable for the study area.

3.4.2 Data Preparation

The input layers were pre-processed to ensure spatial consistency:

Clipping

All datasets were clipped to the study area boundary to enhance processing efficiency.

3.4.3 Projection

All data layers were projected to the same coordinate system to prevent spatial misalignment.

3.4.4 Derivation of Slope Layer

Slope influences surface runoff and water accumulation.

The Slope tool in ArcGIS Pro (Spatial Analyst) was applied to the DEM to generate a slope raster (in degrees).

Higher slope values represent lower flood susceptibility, while flatter areas indicate higher susceptibility.

3.4.5 Derivation of Proximity to Stream Layer

Proximity to rivers/streams is an important determinant of flood risk.

The Euclidean Distance tool was used to generate a raster showing distance from streams.

Distance values were reclassified, assigning higher flood risk to areas closer to streams.

3.4.6 Reclassification of Criteria Layers

To harmonize the inputs for overlay analysis, each factor was reclassified into standardized flood-risk classes. The Reclassify tool (Spatial Analyst) was used to assign values (e.g., 1 = low, 5 = high susceptibility):

DEM: low elevations assigned higher flood risk

Slope: gentle slopes assigned higher flood risk

LULC: water bodies, wetlands, and built-up areas assigned higher risk; forests and vegetation lower risk

Proximity to Stream: closer areas assigned higher risk

3.4.7 Weighted Overlay Analysis

To combine the factors into a single flood risk map, a weighted overlay was conducted using the Weighted Sum tool in ArcGIS Pro. The weights assigned to each criterion were based on their relative influence on flooding:

Factor	Weight
Land Use/Land Cover (LULC)	0.30
Digital Elevation Model (DEM)	0.30
Slope	0.20
Proximity to Stream	0.20

The weighted overlay equation applied was:

$$\text{Flood Risk} = (\text{LULC} \times 0.3) + (\text{DEM} \times 0.3) + (\text{Slope} \times 0.2) + (\text{Proximity to Streams} \times 0.2)$$

3.4.8 Flood Risk Classification

The resulting composite raster was classified into three flood risk zones using the Natural Breaks (Jenks) classification method:

Very low Risk

Low Flood Risk

Moderate Risk

High

Very High

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

This section of the project presents an in-depth analysis of the application of remote sensing and Geographic Information Systems (GIS) in evaluating urban sprawl and predicting land use land cover changes. The results are presented in maps after analyzing the satellite data. The objectives of this study included observing the existing pattern of urban development, identifying change detection and identifying urban hotspots.

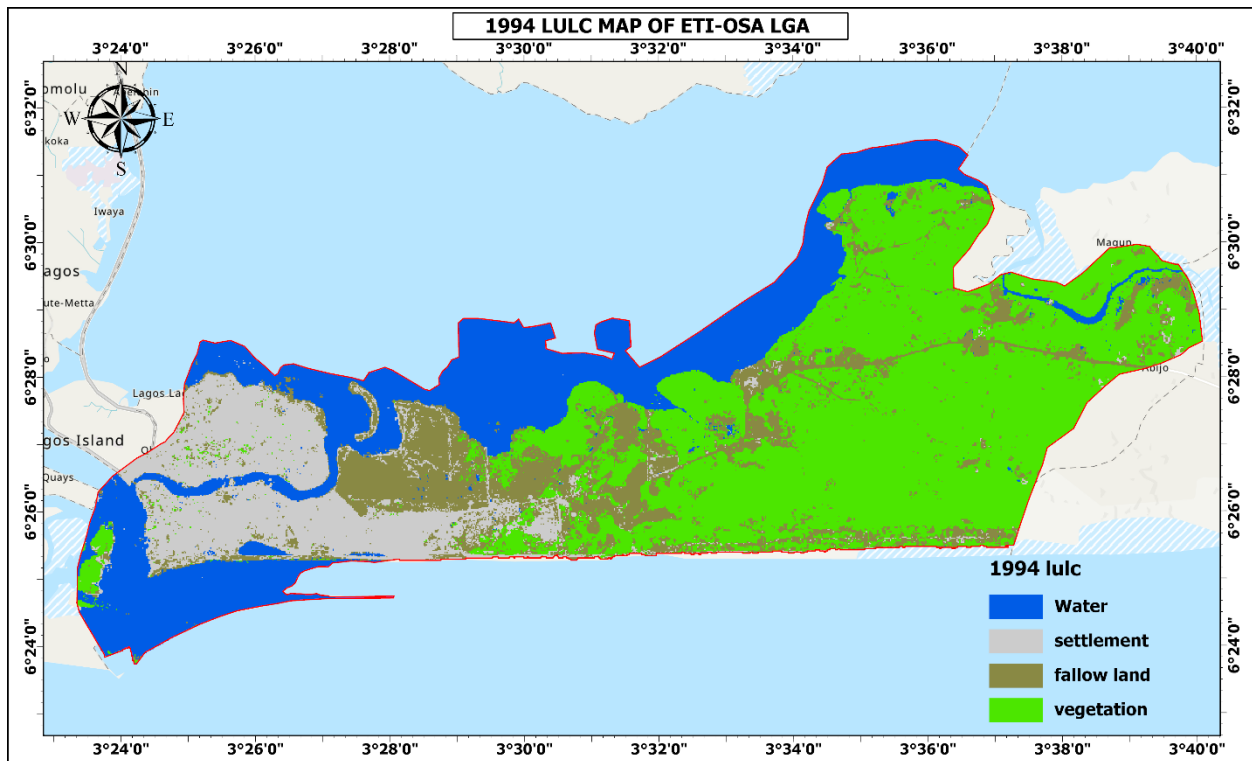
The project's results demonstrate the significant role of remote sensing and Geographic Information Systems (GIS) in comprehensively evaluating urban sprawl and predicting land use land cover changes. Through the integration of satellite imagery and GIS data, existing development patterns were observed, showcasing the distribution of land cover types. Change detection analysis unveiled the expansion of built-up areas and the replacement of natural land covers, highlighting the ongoing urbanization process. Urban hotspots were identified with precision, aiding in understanding areas of rapid development and infrastructure demand.

These results emphasize the effectiveness of remote sensing and GIS in urban planning and environmental management. The project's findings contribute to sustainable urban development, informed decision-making, and policies that balance growth with conservation. Access to accurate spatial data, analysis, and visualization through these technologies proves crucial in shaping resilient and well-planned cities for the future.

The LULC maps depicts the distribution of land use pattern in ETI-OSA LGA. Different colours were used in representing each category example vegetation in green, waterway in blue, fallow in brown and settlement in gray.

4.1 LULC Classification for 1994

Figure 4.1 shows the land use and land cover (LULC) map for the year 1994. The map employs a colour-coded system to represent various features within the landscape. In this scheme, green is used to depict areas with lush vegetation, brown designates fallow land, gray signifies settlement regions, and blue represents waterways. This colour scheme simplifies the visual interpretation of the map's contents, making it accessible and informative for all observers.



4.1.1 Figure 4.1: Land Use Land Cover (LULC) Map for 1994

The analysis of land use land cover (LULC) provides essential insights into the spatial distribution and composition of land cover classes within the study area. This research shows LULC outcomes specific to ETI-OSA LGA in the year 1994. The findings, as shown in table 4.1, detail the identified land cover classes along with its corresponding areas measured in square kilometres (km²) and their respective percentage coverage.

Table 4.1: LULC Classes for 1994

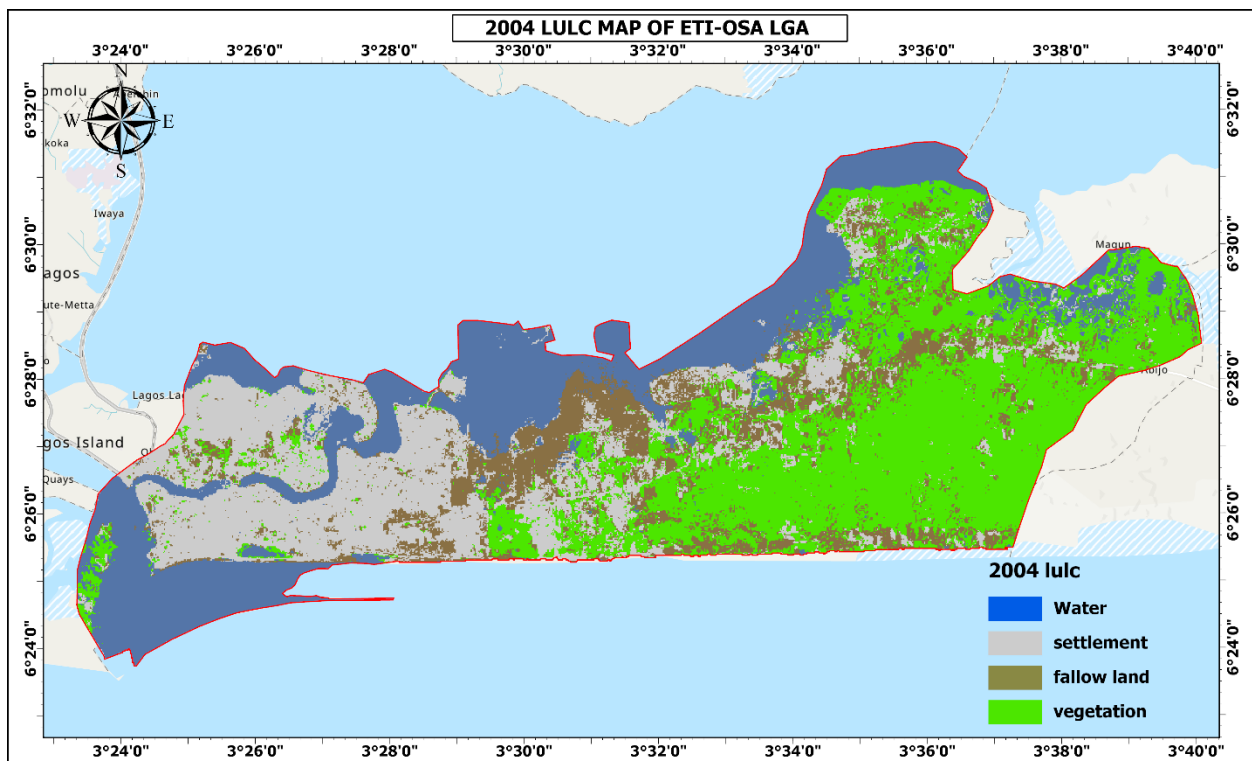
Class	Area (km ²)	Percentage % covered
Vegetation	87.7	44.8
settlement	28.2	14.4
Water body	48.9	24.9
fallow land	31.0	15.9
Total	195.9	100

- i. Settlement: In 1994, settlement area was 28.2 square kilometers covering 14.4 percent of the entire region.
- ii. Water bodies: This includes rivers, lakes, and ponds, which occupied a total area of 48.9 square kilometres, constituting 24.9% of the entire region. These aquatic features play a critical role in the hydrological cycle and serve as vital ecological habitats.
- iii. Vegetation: The predominant land cover class in ETI-OSA LGA during 1994, covering a substantial 87.7 square kilometres, accounting for an impressive 44.8% of the total area. Encompassing dense forests, woodlands, and areas rich in vegetation, this class provides invaluable ecosystem services such as carbon sequestration, biodiversity conservation, and wildlife habitat.
- iv. Fallow land: This constituted the smallest land cover class, covering 31.0 square kilometres or 15.9% of the total area. Typically characterized by exposed soil, rocks, or limited vegetation cover, fallow land may be attributed to anthropogenic activities, natural disturbances, or transitional phases between various land cover types.

In 1994, ETI-OSA LGA encompassed a total area of 195.9 square kilometres, with the cumulative land cover classes accounting for 100% of this area. These findings offer crucial insights into land cover patterns, thus facilitating informed land management strategies, environmental planning, and conservation initiatives.

4.2 LULC Classification for 2004

The green sections on the LULC map shown in figure 4.2 represent areas with lush vegetation, providing a visual indicator of the region's greenery and plant life. The brown part signifies open and fallow land. The gray areas denote zones of urban settlement, reflecting the presence of residential and commercial structures. The blue segments on the map represent water bodies highlighting the significance of waterways in the study area.



4.2.1 Figure 4.2: Land Use Land Cover (LULC) Map for 2004

In assessing the land-use and land-cover (LULC) patterns in Ovia North-East for 2012, notable alterations in land cover classes become apparent, as depicted in table 4.2.

Table 4.2: LULC Classes for 2004

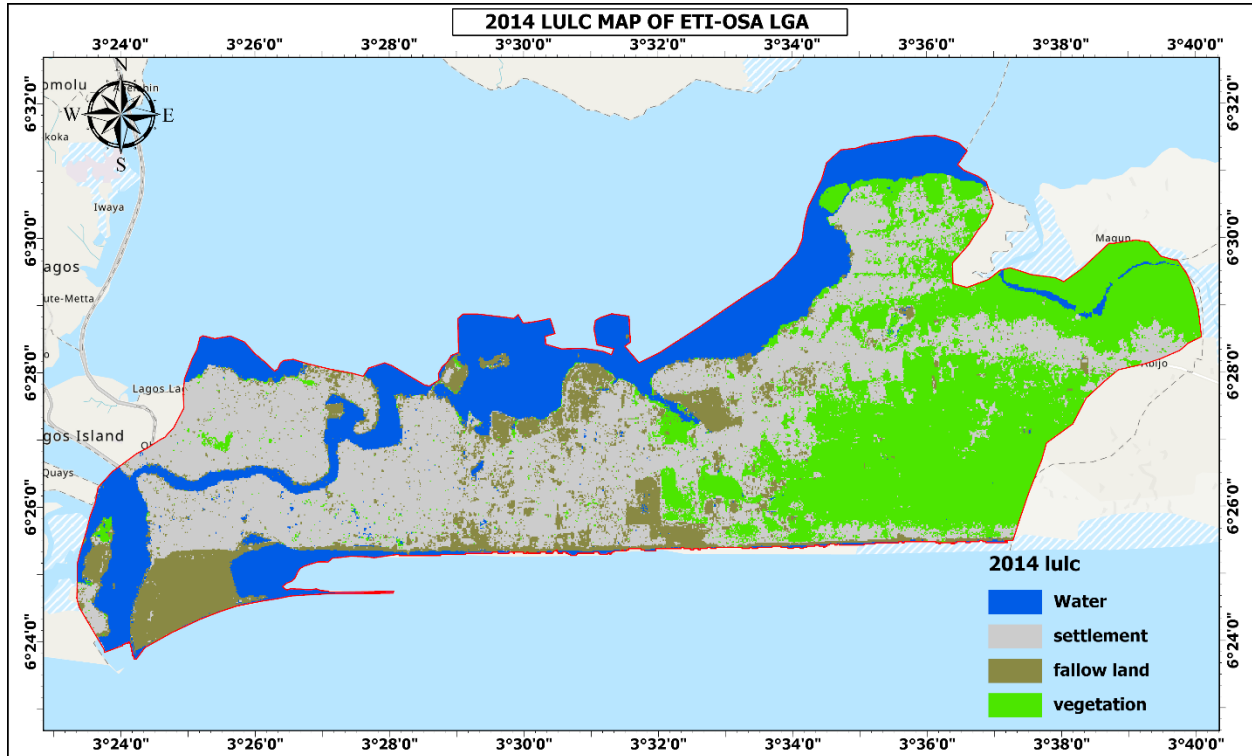
Class	Area (km ²)	Percentage % covered
Vegetation	69.6	35.5
Settlement	47.5	24.2
Water bodies	50.8	25.9
fallow land	28.0	14.3
Total	195.9	100

- i. Settlements: This covered 47.5 square kilometers accounting for 24.2 percentage in the total area.
- ii. Water bodies: The coverage of waterways remained relatively stable, exhibiting a marginal increase of 50.8 square kilometres, constituting 25.9% in 2004.
- iii. Vegetation: The area covered by vegetation saw a reduction from 85.2 to 69.6 square kilometres, accounting for 35.5% in 2004. This suggests a potential decline in forest cover or a transformation of vegetation into other land cover classes.
- iv. Fallow land: fallow land on the other hand, experienced a minor decrease of 3.3 square kilometres in 2004.

Conclusively, built-up area in 2004 reveals an expansion of settlements, a slight reduction in thick vegetation, a modest increase in light vegetation, and subtle changes in waterway bodies and bare land. These changes collectively imply an ongoing process of urbanization and potential shifts in land use within the ETI-OSA LGA region over the Ten-year period.

4.3 LULC Classification Result for 2014

The LULC map in figure 4.3 simplifies information through colours: green for lush vegetation, brown for fallow land, gray for bustling settlements, and blue for essential waterways. This visual representation helps stakeholders make informed decisions about the region's future.



4.3.1 Figure 4.3: Land Use Land Cover (LULC) Map for 2014

Table 4.3: LULC Classes for 2014

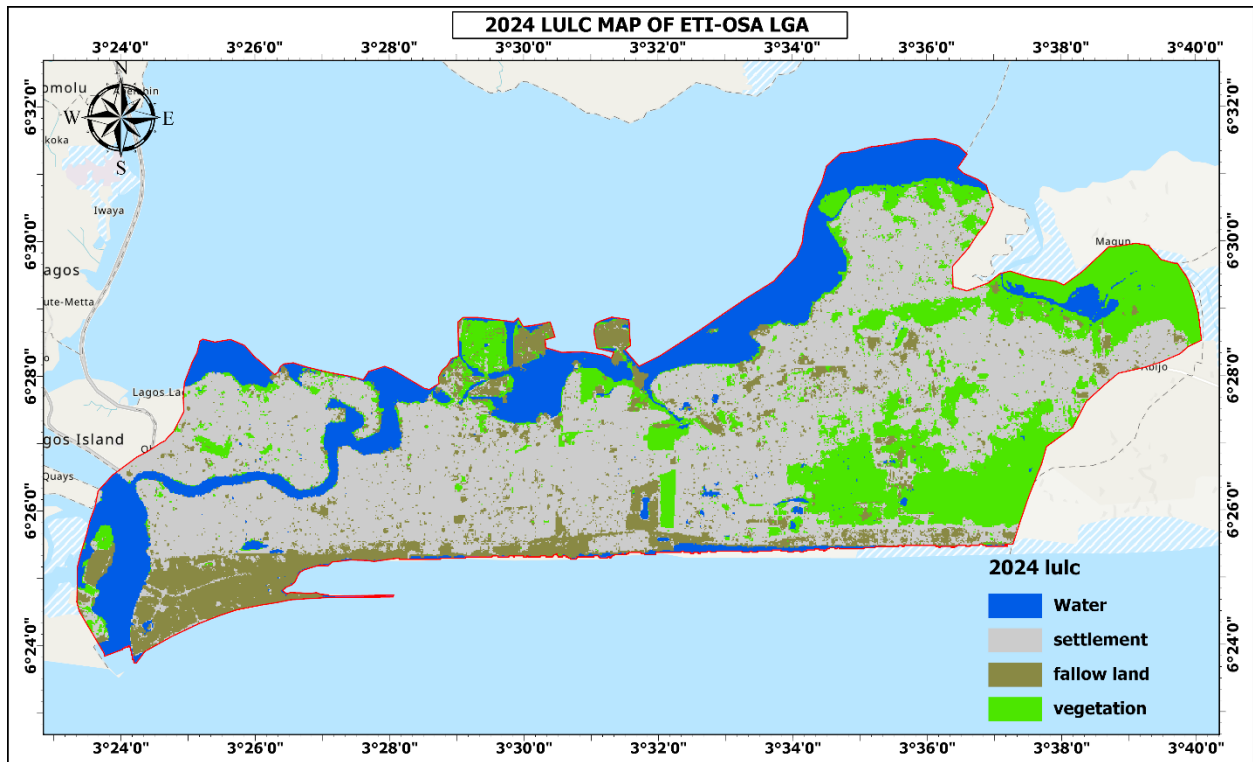
Class	Area (km ²)	Percentage % covered
Vegetation	54.9	28.0
Settlements	80.3	41.0
Water bodies	38.9	19.9
Fallow land	21.7	11.1
Total	195.8	100

- i. Settlements: This covered a total of 80.3 square kilometers in 2014 which is 41.0 percent of the land mass in ETI-OSA LGA.
- ii. Water bodies: The coverage of water bodies for 2014 was 38.9 square kilometers which is 19.9 percent of the total land mass.
- iii. Vegetation: The expanse covered by dense vegetation was 54.9 square kilometers in the year 2014 which is 28.0 percent of the total land mass.
- iv. Fallow land: The areas designated as fallow land became 21.7 square kilometers covering 11.1 percent in 2014 which strongly indicates shifts in land use potentially encompassing deforestation or Land degradation.

The LULC analysis in 2014 underscores a further expansion of settlements, minor modifications in water body coverage, a slight reduction in dense vegetation, a reduction in light vegetation, and a decrease in fallow land. These alterations collectively denote an ongoing urbanization process, a possible decline in forest cover, and shifts in vegetation patterns within the ETI-OSA region over the Ten-year interval.

4.4 LULC Classification Result for 2024

The LULC map in figure 4.4 employs a clear colour-coding system to convey vital landscape information. Green represents healthy vegetation, brown denotes undeveloped land, gray marks settlements, and blue signifies waterways. These colours simplify complex data, aiding researchers, urban planners, and policymakers in making informed decisions about the area's development and preservation.



4.4.1 Figure 4.4: Land Use Land Cover (LULC) Map for 2024

The LULC data for 2024 in ETI-OSA region reveals notable shifts in land cover categories. The findings are presented in table 4.4.

Table 4.4: LULC Classes for 2024

Name	Area (km ²)	Percentage (%) covered
Vegetation	37.4	19.1
Settlement	103.6	52.9
Water bodies	31.6	16.1
fallow land	23.4	11.9
Total	195.9	100

- i. Settlement: This accounted for 103.6 square kilometers in 2024 which is 52.9 percent of the land mass.
- ii. Water bodies: The coverage of the water way was 31.6 square kilometers in 2024 which is 16.1 percent of the total land mass.
- iii. Vegetation: This accounted for 37.4 square kilometers in 2024 which is 19.1 of the land mass.
- iv. Fallow land: This area became 23.4 square kilometers in 2022 accounting for a total land mass of 11.9 percent.

The LULC for 2024 shows a consistent expansion of settlements, marginal alterations in waterway bodies, a reduction in dense vegetation, and minor changes in bare land. These changes imply ongoing urbanization, potential loss of forest cover, and shifts in vegetation patterns within ETI-OSA over the Ten-year period.

4.5 LULC classification Summary Result and Sprawl Pattern

To effectively decipher the map, it is imperative to understand each colour. The blue segments on the map represent the built-up areas in 1994, while the green portions signify the built-up areas in 2004, the yellow colour for 2014 settlement and the red colour for 2024 built-up area.

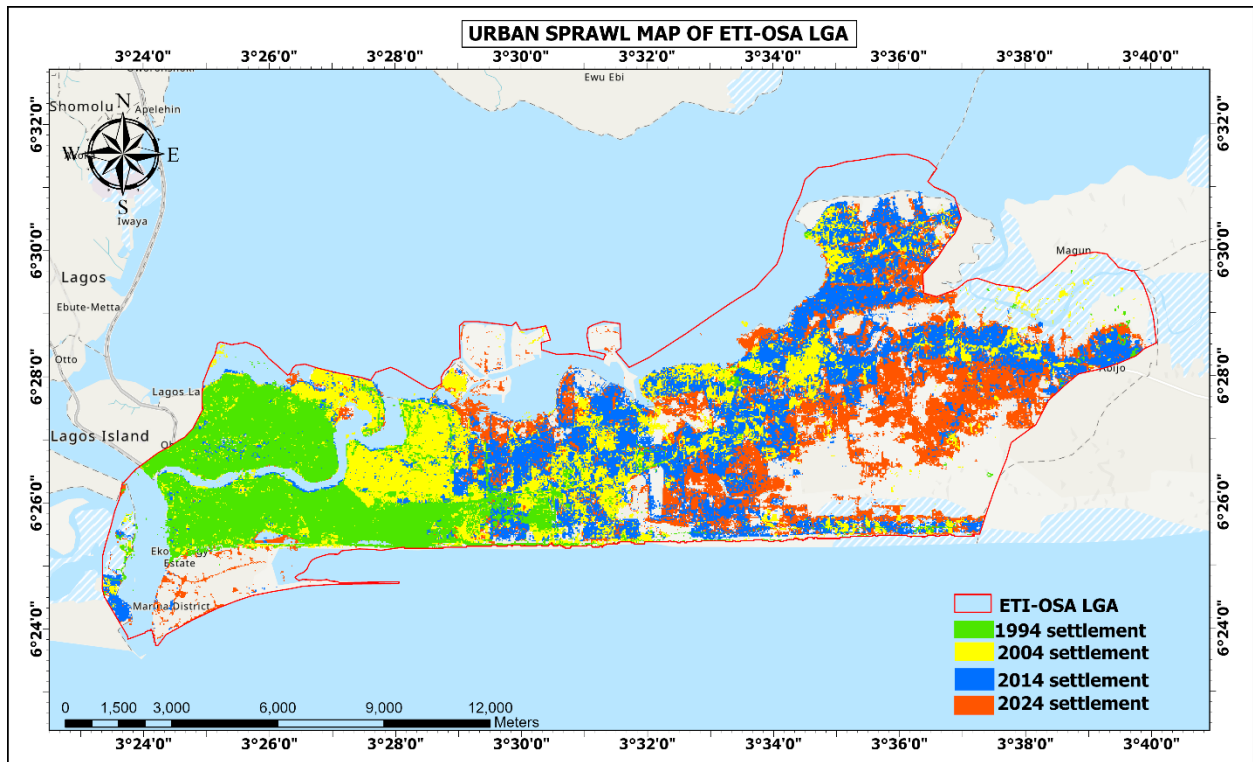


Figure 4.5: urban sprawl Map

Table 4.5:urban sprawl class

Year	Name	Area (km ²)	Percentage (%) covered
1994	Settlement	28.2	14.4
2004	Settlement	47.5	24.2
2014	Settlement	80.3	41.0
2024	Settlement	103.6	52.9

Table 4.6: LULC and Urban Sprawl Summary (1994–2024)

LULC	1994		2004		2014		2024	
Class	LULC Area (km ²)	Percentage (%) covered	LULC Area (km ²)	Percentage (%) covered	LULC Area (km ²)	Percentage (%) covered	LULC Area (km ²)	Percentage (%) covered
Vegetation	87.7	44.8	69.6	35.5	54.9	28.0	37.4	19.1
Settlement	28.2	14.4	47.5	24.2	80.3	41.0	103.6	52.9
Water bodies	48.9	24.9	50.8	25.9	38.9	19.9	31.6	16.1
fallow land	31.1	15.9	28.0	14.3	21.7	11.1	23.4	11.9
Total	195.9	100	195.9	100	195.9	100	195.9	100

4.5.1 LULC and Urban Sprawl Summary (1994–2024)

This table represents Land Use Land Cover (LULC) changes over a 30-year period (1994 to 2024) and clearly highlights trends in urban sprawl within the area studied.

Vegetation

1994: 87.7 km² (44.8%)

2024: 37.4 km² (19.1%)

Change: -54.3 km² (-25.7 percentage)

Interpretation:

There is a significant decline in vegetation cover, indicating deforestation or land clearing, likely due to urban expansion or agriculture conversion.

Settlement (Urban Area)

1994: 28.2 km² (14.4%)

2024: 103.6km² (52.9%)

Change: +75.4 km² (+38.5 percentage)

Interpretation:

Massive growth in settlement area shows clear urban sprawl. This is the most prominent trend, suggesting rapid urbanization and possibly unregulated development.

Water Bodies

1994: 48.9km² (24.9%)

2024: 31.6km² (16.1%)

Change: -17.3 km² (-8.8 percentage)

Interpretation:

Water bodies have moderately declined, potentially due to encroachment, pollution, or climate impacts, further supporting urban pressure on natural resources.

Fallow Land

1994: 31.1km² (15.9%)

2024: 23.4km² (11.9%)

Change: -7.7 km² (-4 percentage)

Interpretation:

Fallow land has also decreased, possibly due to conversion to built-up areas or agriculture, consistent with urban development.

Total Area

Constant at 195.9 km² over all years.

Urban Sprawl Summary

The data strongly indicates urban sprawl, characterized by:

$$\text{percentage increase} = \frac{\text{new value} - \text{old value}}{\text{old}} \times 100$$

Settlement area

Old value (1994) = 28.2km²

New value (2024) = 103.6km²

$$\text{Percentage increase} = \frac{103.5-28.2}{28.2} \times 100 = 267.02\%$$

A 267.02% increase in settlement area (from 28.2 to 267.02km²).

Corresponding decline in vegetation, water bodies, and fallow land.

Over half (52%) of the total land is now classified as settlement in 2024, compared to just 14.4% in 1994.

summary

The landscape has undergone a significant transformation from predominantly vegetated and natural areas to urban settlements. This trend suggests:

High urban growth, likely due to population increase or economic development.

Environmental stress, with a reduction in ecological zones (vegetation, water).

Need for sustainable urban planning and conservation measures to mitigate environmental impacts.

4.5.2 Wetland Reclamation

Wetland reclamation is the process of converting wetlands—areas naturally saturated with water such as swamps, marshes, and mangroves—into land that can be used for human activities like agriculture, settlement, or infrastructure development. It typically involves draining water, filling the land with soil or sand, and constructing embankments or drainage systems.

Key Points about Wetland Reclamation:

Purpose

1. Expand land for farming, housing, or industry.
2. Control flooding and manage water resources.
3. Provide space for urban growth.

Methods

1. Draining: Using canals, pumps, or ditches to remove water.
2. Filling: Adding soil, sand, or rocks to raise land above water level.
3. Diking and Embankments: Building barriers to prevent water inflow.

Benefits

1. Creates land for economic activities (farmland, settlements, roads).
2. Reduces mosquito-breeding zones in some cases.
3. Allows infrastructure development in urban areas.

Drawbacks

1. Loss of biodiversity and natural habitats.
2. Increased flooding risk (wetlands act as natural sponges).
3. Disruption of water cycles and groundwater recharge.
4. Climate impact due to release of stored carbon in wetlands.

Examples

Netherlands: Large-scale land reclamation from wetlands and seas (polders).

Nigeria (Lagos, Eti-Osa): Wetland reclamation for housing estates, e.g., Lekki Peninsula projects.

China: Reclaimed wetlands for agriculture and urban expansion.

Sustainable Alternatives

Instead of reclaiming, wetlands can be managed for eco-tourism, fisheries, and flood protection.

Use of integrated land-use planning to balance development with conservation.

In summary, wetland reclamation provides immediate land for human needs but has serious long-term ecological costs if not managed carefully.

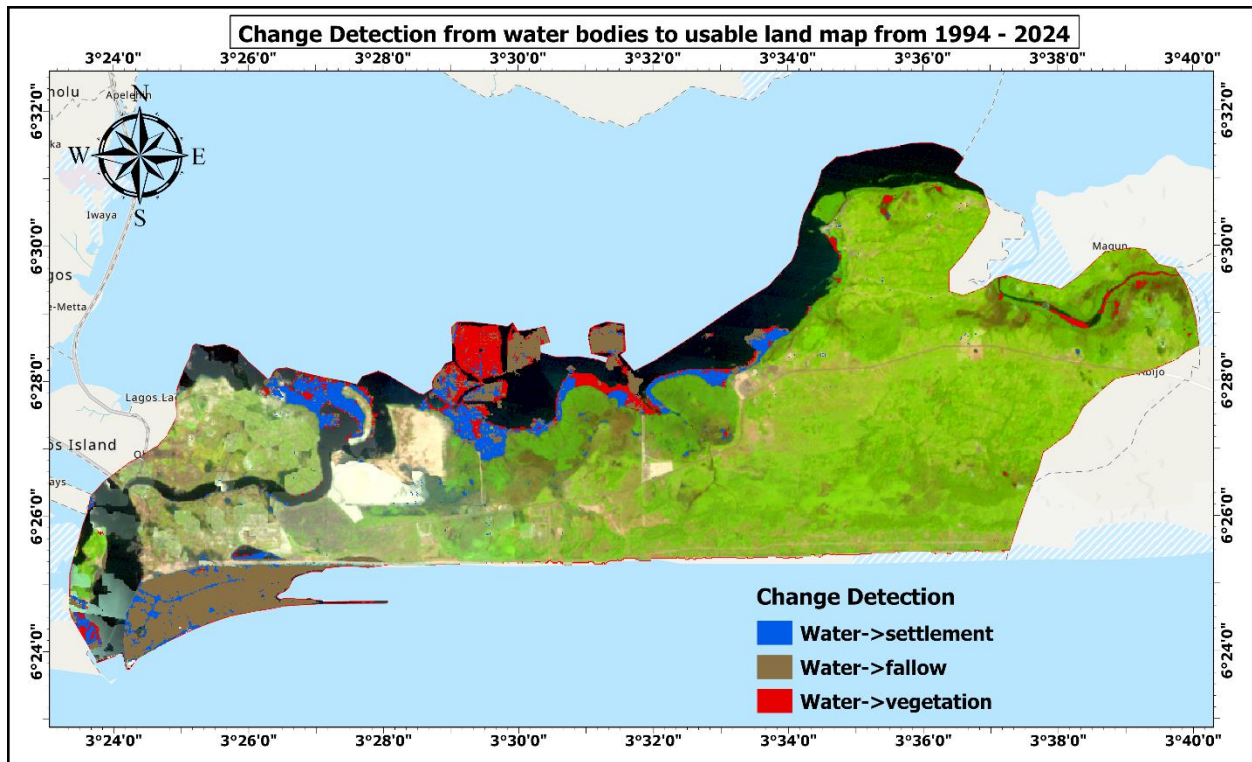


Figure 4.6 Change Detection from water bodies to usable land map 1994 -2024

Name	Area (km ²)	Description
Water bodies->settlement	5.8	Indicates direct encroachment of urban development on aquatic ecosystems
Water bodies->fallow land	10.3	Suggests possible land conversion for temporary, unused purposes (possibly agriculture).
Water->vegetation	4.6	Indicates that 4.6 km ² has being converted to bareland that has being covered by vegetation
Total	20.7	Indicates that 20.7 km ² has been converted from water bodies to usable land between 1994-2024

Total Water Body Loss Identified: 20.7 km²

This represents the cumulative area of water bodies that have been converted into other land uses, with the majority going to fallow land (10.3 km²).

Implications

Urban Expansion Pressure

5.8 km² of water area lost to settlements highlights urban sprawl impacting natural resources.

Environmental Degradation

10.3km² turning into fallow land could reflect water depletion, land drying, or mismanagement.

Reduced Ecosystem Services

Loss of water bodies can negatively affect local biodiversity, groundwater recharge, and microclimate regulation.

4.6 FLOOD RISK ASSESSMENT

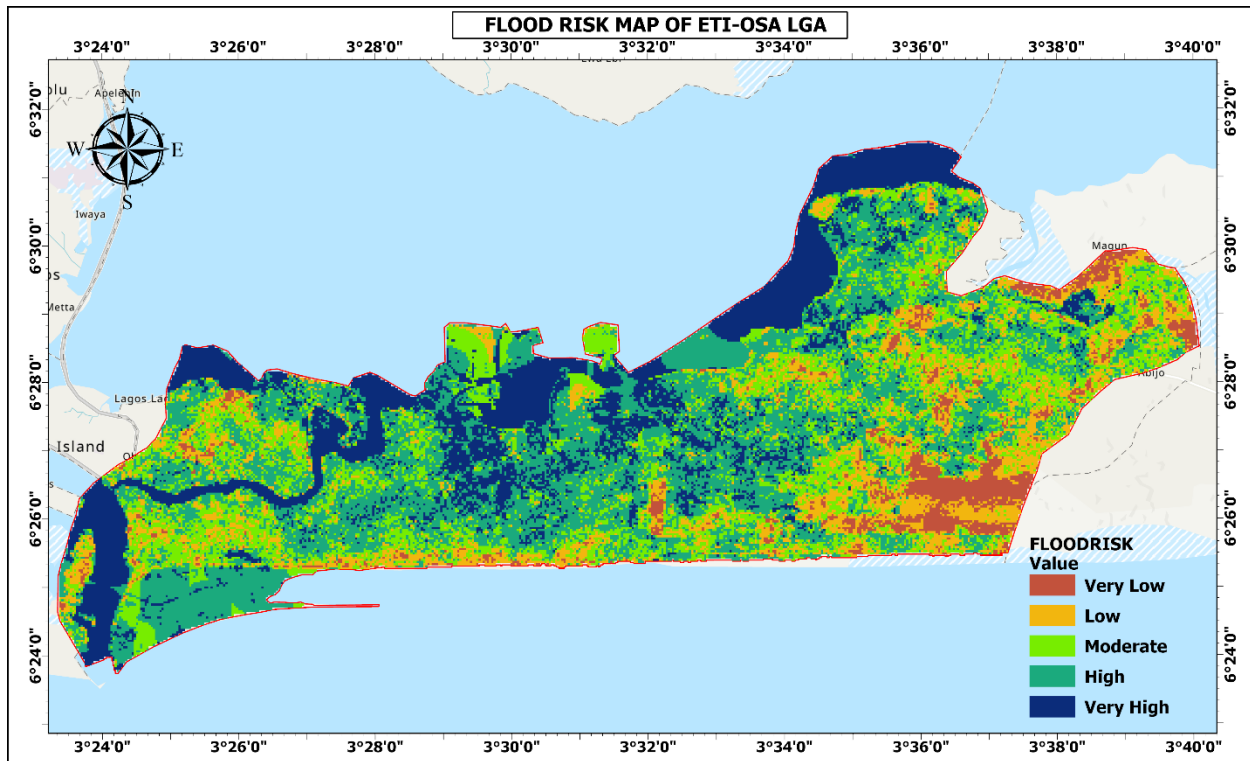


Figure 4.7 flood risk map

FLOOD RISK ASSESSMENT OF ETI-OSA LGA, LAGOS STATE, NIGERIA

The flood-risk map of Eti-Osa Local Government Area (LGA), Lagos State, presents the spatial distribution of flood susceptibility within the coastal metropolitan region. Using geospatial analysis, flood risk was modeled based on four major environmental parameters: proximity to streams, Digital Elevation Model (DEM), land-use/land-cover (LULC), and slope. These parameters were classified, weighted, and integrated to generate a composite flood risk surface. The output map categorizes the area into five risk classes: Very Low, Low, Moderate, High, and Very High risk zones.

Spatial Flood Risk Pattern

The resulting map indicates significant spatial variability in flood exposure across the LGA. Large portions of the central and southern coastal areas exhibit high to very high flood risk, depicted by deep green to dark blue tones. These high-risk zones align primarily with low-lying terrain, swampy coastal environments, river channels, and floodplains, especially around Lekki Peninsula, Ilasan, Ajah, Sangotedo, and the Eti-Osa shoreline. The prevalence of wetlands and poorly drained soils, coupled with dense urban expansion, contributes to the elevated flood susceptibility in these zones.

Conversely, patches of moderate to low-risk zones (yellow to green tones) occur in relatively elevated and more consolidated land areas, including some built-up zones and gradually rising inland terrain. Very low-risk areas are limited, representing isolated elevated zones with favorable drainage and lower exposure to water bodies.

4.6.1 INFLUENCE OF CONTRIBUTING FACTORS

Proximity to Streams: Areas closer to water bodies and drainage channels show higher flood magnitude due to overflow and tidal intrusion from the Lagos Lagoon and Atlantic Coast.

Digital Elevation Model (DEM): Low-lying and flat terrain dominated the high-risk areas, confirming that elevation plays a major role in flood susceptibility in Eti-Osa.

Land-Use/Land-Cover (LULC): Built-up areas, wetlands, and vegetated swamp zones exhibit higher vulnerability due to reduced infiltration capacity, rapid urbanization, and disturbance of natural drainage systems.

Slope: Gentle or flat slopes, common across the LGA, increase accumulation of runoff and slow drainage, thus enhancing flood potential.

4.6.2 Interpretation and Implications

The flood-risk map underscores the vulnerability of Eti-Osa to both pluvial and coastal flooding. The region's rapid urban development on reclaimed and naturally flood-prone land intensifies risk, demanding proactive flood management, improved drainage infrastructure, and sustainable land-use planning. The spatial pattern emphasizes the urgency of climate-resilient planning measures, especially as Eti-Osa remains one of the fastest-growing urban corridors in Lagos.

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATIONS

5.1 CONCLUSION

The culmination of the project exploring the application of remote sensing and Geographic Information Systems (GIS) in evaluating urban sprawl and predicting land use land cover changes underscores the transformative potential of technology in urban planning and environmental management. Through meticulous analysis, integration of spatial data, and advanced modelling, the project has not only met its objectives but also shed light on the intricate dynamics of urbanization.

The results reveal that remote sensing and GIS play pivotal roles in understanding existing development patterns, tracking change detection and identifying urban hotspots. These outcomes provide urban planners, policymakers, and stakeholders with invaluable insights to make informed decisions that balance urban growth with environmental conservation.

Furthermore, the project emphasizes the need for a multi-disciplinary approach that merges technology, expertise, and data-driven decision-making. The findings underline the importance of sustainable urban development that considers social, economic, and environmental factors. As cities continue to expand and evolve, the lessons learned from this project will serve as a guidepost for shaping resilient and liveable urban landscapes.

The project's journey demonstrates the power of remote sensing and GIS in revealing hidden patterns, predicting trends, and guiding policies. With the ever-growing urbanization challenges, this project serves as a testament to the potential of harnessing technology for creating harmonious and sustainable cities.

Overall, the flood-risk modeling demonstrates that Eti-Osa is predominantly at high to very high flood risk, particularly in coastal and low-elevation areas. The integration of proximity to streams, DEM, LULC, and slope effectively captures the environmental and anthropogenic drivers of flooding, offering valuable insights for disaster mitigation, infrastructure development, and environmental policy formulation in Lagos State.

5.2 RECOMMENDATION

In light of the successful outcomes and insights garnered from this study, these recommendations aim to further enhance the utilization of these technologies for informed urban planning, sustainable development, and effective environmental management.

Continuous Monitoring: Establish a regular monitoring system that utilizes remote sensing and GIS to track urbanization trends and land use changes over time. This will provide a continuous stream of data for urban planners and policymakers to make proactive decisions.

Multi-Disciplinary Collaboration: Foster collaboration between urban planners, geographers, environmental scientists, and data analysts. This multidisciplinary approach ensures comprehensive data interpretation and holistic decision-making.

Capacity Building: Invest in training programs to enhance technical skills in remote sensing and GIS technologies among urban planning professionals. Empowering experts with these tools will enable more accurate analysis and prediction.

Data Accessibility: Promote open data policies to increase accessibility to remote sensing data and GIS datasets. Easy access to reliable data sources will facilitate research, planning, and decisionmaking processes.

Integration of Social Factors: Incorporate social and economic data into the analysis to understand the human dimensions of urban sprawl. Consider factors such as population growth, income distribution, and community needs.

Model Refinement: Refine land use prediction models by integrating advanced machine learning and artificial intelligence techniques. This will enhance the accuracy of predictions and contribute to more effective urban planning strategies.

Public Awareness: Educate the public about the benefits of remote sensing and GIS in urban planning. Increasing awareness can garner public support and engagement in sustainable development initiatives.

Policy Formulation: Utilize the project's findings and insights to inform the formulation of urban planning policies. Ensure that policies reflect the need for balanced urban growth, environmental preservation, and community well-being.

Adaptive Planning: Embrace adaptive planning strategies that respond to changing urban dynamics. Use remote sensing and GIS to continually assess the impact of urban sprawl and adjust planning accordingly.

Replication and Scaling: Share the project's methodology and success with other regions facing similar urbanization challenges. Encourage the replication and scaling of the approach to address urban sprawl on a larger scale.

By implementing these recommendations, the project's impact can be extended beyond its immediate scope. Remote sensing and GIS technologies, when integrated effectively into urban planning and management, have the potential to transform cities into sustainable and resilient spaces that harmonize human development with environmental preservation.

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