*Tropical Built Environment Journal. Volume 14, No. 2, 164-183, 2026* www.tbejournal.com
*ISSN: 1118-1790*

# Assessment of Urban Expansion and Its Environmental Implications in Asaba, Delta State, Nigeria

**[1]Gyok, Samuel Luka and [2]Okoye, Chinedu Oguejiofor**

**[1]Department of Environmental Management**
**Nnamdi Azikiwe University Awka, Anambra State Nigeria.**
**Corresponding Author's Email: gyokluka01@gmail.com**

**[2]Department of Urban and Regional Planning**
**Nnamdi Azikiwe University Awka, Anambra State Nigeria.**

## Abstract

*Urban expansion in cities like Asaba, Delta State, has brought about opportunities and environmental challenges for regional development and physical planning. In Asaba, urban expansion has been driven by rapid population growth, rural–urban migration, its designation as the Delta State capital in 1991, infrastructural development and economic activities. Agricultural land and vegetation have therefore been transformed into built-up areas over time. This research assessed urban expansion in Asaba between 1995 and 2025 through these objectives: (i) assessment of temporal and spatial LULC changes; (ii) identification of the drivers of urban expansion; and (iii) assessment of its environmental implications. The study employed a mixed-methods approach involving multi-temporal Landsat imagery (1995, 2005, 2015 and 2025), Geographic Information System (GIS) and Remote Sensing (RS) techniques, a survey of 400 household heads. The LULC analysis showed an increase in the proportion of built-up land in Asaba from 18.4% in 1995 to 43.3% in 2025, indicating substantial conversion of other land-cover types to built-up areas over the study period. Findings from the household survey further identified population growth, rural–urban migration, infrastructural development and economic activities as major factors associated with urban expansion, alongside reported environmental implications including loss of vegetation, conversion of agricultural land and changes in drainage and wetland areas. The findings demonstrate substantial urban expansion in Asaba and highlight the need for effective physical planning and environmental management. The study recommended real-time urban monitoring using GIS, urban growth boundary regulations, green infrastructure inclusion within development control, updating of the master plan, cloud-based spatial monitoring, safeguarding of vegetation and wetlands, and the use of nature-based approaches such as wetlands and drainage systems in flood control.*

## 1.1 Introduction

Urban expansion is the process by which built-up areas spread outward into previously undeveloped or non-urban land, resulting in the conversion of vegetation, agricultural land, wetlands, and other open spaces into urban uses. This process is commonly driven by population growth, migration, economic activities, and infrastructure development (Ayenachew & Abebe, 2024; Hailu et al., 2024). Urban expansion therefore represents a physical change in the extent of urban development, while land use/land cover (LULC) change describes the broader transformation of different land-cover types and human uses over time. Urban sprawl, on the other hand, refers to a form of urban expansion characterised by dispersed, low-density or poorly

coordinated development, often extending beyond existing urban boundaries. Although these concepts are related, they are not synonymous, as urban expansion may occur through planned and compact development, whereas urban sprawl reflects inefficient or poorly controlled patterns of growth.

In rapidly growing cities, urban expansion can exceed the capacity of existing planning systems and infrastructure, resulting in inefficient land use, environmental degradation, and pressure on urban services (Jiang et al., 2021). This makes physical planning important for achieving sustainable urban development, as reflected in Goal 11 of the Sustainable Development Goals (SDGs), which promotes inclusive, safe, resilient and sustainable cities and communities (Ogunbode et al., 2025). Across Africa, rapid urbanisation has resulted in substantial LULC changes, particularly through the transformation of peri-urban agricultural and vegetative land into built-up areas (Jiang et al., 2021). Despite the developmental benefits associated with urban growth, rapid and poorly coordinated expansion has also been associated with the loss of agricultural land, expansion of informal settlements, and increasing environmental pressures in cities such as Addis Ababa and Kampala, particularly where planning systems are weak (Mohamed & Worku, 2019; Muchelo et al., 2024). Similarly, rapid urban expansion in Nigerian cities has replaced areas of vegetation with built-up development, contributing to flooding, congestion, informal settlements, and increasing pressure on urban infrastructure and services (Koko et al., 2021).

The implications of urban expansion extend beyond changes in the physical size of a city. In this study, regional development implications refer to the effects of changing urban land-use patterns on the spatial distribution of population, economic activities, infrastructure, transportation, agricultural land, environmental resources, and public services within Asaba and its surrounding areas. Urban expansion can support regional development by providing space for housing, commerce, industries, transportation networks, and other infrastructure. However, when the conversion of land occurs faster than the provision and coordination of infrastructure and planning services, it can create uneven development, place pressure on surrounding peri-urban areas, reduce agricultural and ecological resources, and increase the cost of providing urban services. Consequently, the pattern and direction of urban expansion are important not only for understanding physical growth but also for assessing how urban development affects the wider spatial and economic development of the region.

Asaba, the capital city of Delta State, is one of the rapidly expanding cities in southern Nigeria. Situated across the River Niger from Onitsha, Asaba forms part of the economically active Asaba–Onitsha axis, which has experienced increasing commercial activities and infrastructural development (Ayadiuno & Ndulue, 2024). The city's administrative significance, economic activities, and strategic location within the Asaba–Onitsha corridor have contributed to urban expansion and increased development pressure on surrounding peri-urban settlements. These factors have accelerated the conversion of agricultural and vegetated land to urban uses, with implications for land-use planning, infrastructure provision, transportation, and the spatial distribution of economic activities within the wider region (Ayadiuno & Ndulue, 2024).

Furthermore, there has been a reduction in farmland within and around the capital city as economic activities shift from agriculture towards residential and other forms of construction

(Onyemaechi, 2025; Ashikodi & Chokor, 2025). This reflects wider peri-urban transformations observed in rapidly growing African cities (Muchelo et al., 2024). In Asaba, increasing development has also been associated with land-use conversion, settlement expansion, and pressure on urban infrastructure and services (Egbuna & Odumodu, 2024). These changes have environmental implications, including the loss of vegetation and agricultural land, increased flooding risks, and pressure on existing drainage and transportation systems (Ayenachew & Abebe, 2024). Thus, the environmental implications of urban expansion cannot be considered separately from its regional development implications, since changes in land cover and settlement patterns influence the availability of land and natural resources, the provision of infrastructure, and the spatial organisation of human activities.

Despite the rapid growth of Asaba, existing planning systems face challenges in adequately managing land conversion and the spatial expansion of development. Ashikodi and Chokor (2025), Ejemayovwi (2015), and Enaruvbe and Atedhor (2016) have examined land-use conversion and related changes in Asaba. However, these studies do not provide an assessment of LULC changes extending beyond 2020. Consequently, there is a need for updated spatial information on the pattern and extent of urban expansion in Asaba and its associated environmental and regional development implications. The current study therefore investigates urban expansion in Asaba from 1995 to 2025, with particular emphasis on temporal and spatial LULC changes, the drivers of urban expansion, and its environmental implications.

### 1.2 Statement of the Problem

Asaba has experienced substantial urban expansion driven by population growth, increasing commercial activities, infrastructural development, and its strategic location along the Asaba–Onitsha economic corridor. This expansion has resulted in the conversion of vegetation and agricultural land to built-up areas, increasing pressure on available land and the physical environment (Ashikodi & Chokor, 2025). The continuing transformation of land-use and land-cover patterns raises concerns about how the spatial growth of the city is occurring and the extent to which existing physical planning measures are able to accommodate and manage these changes.

Previous studies have provided evidence of LULC changes and land-use conversion in Asaba. Ejemayovwi (2015) and Enaruvbe and Atedhor (2016) examined earlier patterns of land-use and land-cover change, while Ashikodi and Chokor (2025) assessed more recent changes in land use. However, these studies do not provide a continuous assessment of urban expansion extending to 2025. Consequently, there is limited up-to-date empirical evidence showing the extent, spatial pattern, and direction of built-up expansion in Asaba over the longer period from 1995 to 2025. This limits the ability to clearly establish the scale of recent land-use transformation and its implications for the management of vegetation, agricultural land, and other environmental resources.

The absence of current spatial evidence is particularly important for physical planning because effective management of urban growth depends on reliable information about where development is occurring, the land-cover types being converted, and the factors associated with such changes. Without updated information, planning and development-control efforts may not adequately respond to the changing spatial structure of the city or the environmental pressures

associated with expansion. There is therefore a need for an updated assessment that combines spatial evidence of LULC change with information on the drivers and environmental implications of urban expansion in Asaba.

This study therefore assesses urban expansion in Asaba between 1995 and 2025 using multi-temporal Landsat imagery, Geographic Information System (GIS), Remote Sensing (RS), and household survey data. Specifically, the study examines temporal and spatial LULC changes, identifies the major drivers of urban expansion, and assesses its environmental implications. The findings are expected to provide current empirical evidence that can support physical planning, development control, and sustainable management of land and environmental resources in Asaba.

### 1.3 Aim and Objectives

This study aims to analyse the spatial and temporal dynamics of urban expansion in Asaba, Delta State, using Geographic Information System (GIS) and Remote Sensing (RS) techniques, and to assess associated land-use and land-cover changes, drivers, and environmental implications for sustainable urban planning and environmental management.

The specific objectives are to:

1. Analyse the spatial and temporal changes in land use/land cover (LULC) in Asaba, Delta State, from 1995 to 2025 using GIS and RS techniques.
2. Identify and assess the major drivers of urban expansion in Asaba, Delta State.
3. Examine the environmental implications of urban expansion in Asaba, Delta State.

## 2.0 Literature Review

### 2.1 Conceptual Framework

This study is based on the concept of urban expansion, which is referred to as the increase in the area covered by built environment, resulting from the conversion of farmland, vegetation, wetlands, and other open spaces into urban uses (Ayadiuno & Ndulue, 2024). The process of urban expansion in urbanizing regions is highly influenced by population growth, migration, economic activities, infrastructure, and weak physical planning framework. One of the indicators of urban expansion is the change in LULC, providing evidence of the development in terms of space. In the this study, the LULC change from 1995 to 2025 will be used as the major indicator of urban expansion in Asaba.

Within the Asaba–Onitsha corridor, urban expansion has increasingly altered the spatial distribution of land uses, leading to the conversion of vegetation, wetlands, and other open spaces into built-up areas. Such transformations have significant environmental implications, including increased flood risk, vegetation loss, and ecosystem degradation, particularly in rapidly growing urban environments where land-use change is inadequately managed (Ogunbode et al., 2025). These outcomes highlight the importance of physical planning in promoting sustainable regional development.

### 2.2 Theoretical Framework

The two theories that govern this research are Urban Sprawl Theory and Central Place Theory (CPT). The urban sprawl theory describes the expansion of urban areas through land use changes

where natural land is transformed to built-ups. This theory provides the framework for explaining the spatial pattern of urban expansion and land use changes in Asaba. On the other hand, the Central Place Theory provides an explanation for the fast growth of Asaba due to its administrative, commercial and service functions.

## 2.3 Empirical Review

### 2.3.1 Spatial and Temporal Patterns of Urban Expansion (LULC Change)

The growing academic literature has consistently indicated that the spatial manifestation of urban expansion is linked to changes in LULC, with particular emphasis on vegetation, agricultural land, and wetlands being converted to built-up lands. The use of GIS and RS remains significant in measuring such transition patterns. Empirical evidence indicates that urban expansion typically occurs through the outward growth of cities into surrounding agricultural and undeveloped lands. This pattern has been widely observed across the world and is particularly evident in African cities, where rapid peri-urban development has accompanied increasing urbanization. Studies by Ngolo and Watanabe (2022) in Luanda, Mostafa et al. (2021) in Egypt, and Mnyali and Materu (2021) in Tanzania report substantial increases in built-up areas at the expense of vegetation and agricultural land, largely driven by population growth and weak land-use control. Similar trends have been observed in Nigeria. For example, Medayese et al. (2023) in Lafia and Faiyetole and Adewumi (2023) in Akure documented continuous urban expansion associated with population growth and infrastructural development. In Asaba, Ashikodi and Chokor (2025) reported a significant increase in built-up areas between 1990 and 2020 alongside a corresponding decline in undeveloped land, reflecting the effects of rapid and largely uncontrolled urban growth.

### 2.3.2 Drivers of Urban Expansion in Asaba and Comparable Contexts

Empirical literature identifies urban expansion as a product of interacting demographic, economic, infrastructural, and institutional factors. Globally, studies such as Dhanaraj and Angadi (2021) and Fontana et al. (2023) highlight population growth, housing demand, economic activities, and transport accessibility as key drivers of urban growth. In many developing regions, these factors are further reinforced by weak planning systems and ineffective land-use regulation. Across Africa, rapid population growth, rural–urban migration, expanding transport networks, and inadequate development control have been identified as major drivers of urban expansion. Studies by Hailu et al. (2024) and Ngolo and Watanabe (2022) demonstrate that increasing migration pressure, improved road accessibility, and weak institutional capacity significantly influence the outward growth of urban areas and the conversion of peri-urban land to built-up uses. In Asaba, previous studies consistently identify population growth, migration, infrastructural development, administrative centrality, and weak planning enforcement as the principal drivers of urban expansion (Egbuna & Odumodu, 2024; Eyetan & Dibosa, 2025; Ojanikele et al., 2020; Onyemenam et al., 2025). GIS-based studies further reveal a steady increase in built-up areas accompanied by a decline in undeveloped land, reflecting the influence of increasing development pressure and inadequate land-use control mechanisms (Ashikodi & Chokor, 2025). These findings suggest that urban expansion in Asaba is driven not only by demographic and economic growth but also by limitations in the planning and regulatory framework governing urban development.

### 2.3.3 Environmental Implications of Urban Expansion

Urban expansion is widely associated with environmental degradation due to the conversion of natural land cover to urban uses. Huang et al. (2019) and de Lima et al. (2023) demonstrate the existence of the link between urban expansion, warming of the surface, increasing cases of floods, and loss of ecosystem services owing to deforestation. Besides, the urban areas experiencing urban expansion suffer from growing air pollution and heat stress as noted by Rajagopal et al. (2022). In addition, Hailu et al. (2024) argue that urban expansion has led to a loss of ecosystem services in Addis Ababa. In Lagos, Nigeria, Kasim et al. (2021) reported an increased flood frequency as a result of urban expansion due to deforestation and destruction of wetlands. This corrobated with studies by Daukere (2025) and Onyedika and Idowu (2024) in Asaba, Delta State, where urban expansion has led to floods.

## 3.1 Methodology

### 3.1.1 The Study Area

Asaba, the capital of Delta State and administrative headquarters of Oshimili South Local Government Area, is reported in the literature to cover approximately 362 km² (Eyetan & Dibosa, 2025). However, the present study employed a specifically delineated GIS analytical boundary for the remote-sensing and land-use/land-cover analysis. Following the delineation and clipping of the satellite imagery to this study boundary, the resulting analytical area was 204.29 km². Consequently, the 362 km² figure reported in the literature is retained as the reported geographical extent of Asaba, while 204.29 km² represents the spatial extent used for the LULC classification and subsequent change analysis in this study.

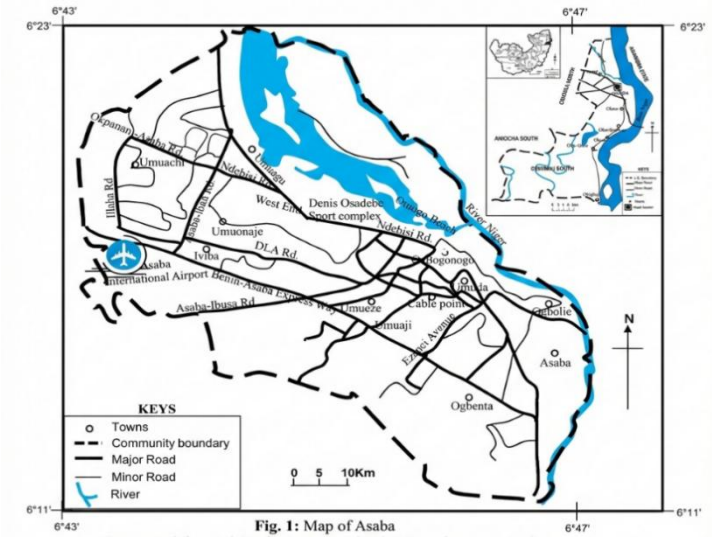



**Figure 1: Maps of Asaba**
**Source: Eyetan and Dibosa, 2025.**

The area has gently undulating to low-lying terrain, an average elevation of approximately 44 m above sea level, hydromorphic and sandy soils, and a humid tropical climate with annual rainfall of approximately 1,800–2,104 mm (Eyetan & Dibosa, 2025; Ojoh et al., 2023). These characteristics, together with increasing urban development, have contributed to changes in land use and land cover and environmental concerns, including flooding (Daukere, 2025).

### 3.2 Research Design

The study adopted an integrated **Geographic Information Systems (GIS), Remote Sensing (RS), and household-survey**. The geospatial component was used to analyse the spatial and temporal pattern of LULC change and urban expansion, while the household survey were used to examine perceived drivers and environmental implications of the observed expansion.

### 3.3 Data Collection

#### Remote-Sensing Data and Processing

Multi-temporal Landsat imagery for 1995, 2005, 2015 and 2025 was obtained from the United States Geological Survey (USGS). The datasets comprised Landsat 5 TM (1995), Landsat 7 ETM+ (2005), Landsat 8 OLI/TIRS (2015) and Landsat 9 OLI/TIRS (2025), all covering Path 189/Row 56 (Table 1). Images with relatively low cloud cover were selected to provide approximately decadal observations of LULC conditions.

**Table 1: Landsat Imageries Downloaded and Their Respective Features.**

| | Year | Landsat | Date | Time (GMT) | Sun Elevation | Cloud cover | Earth-Sun Distance | Path/row |
|---|---|---|---|---|---|---|---|---|
| **Asaba** | 1995 | 5 TM | 1995-12-24 | 09:15:19 | 45.12290105 | 0.20 | 0.9835719 | 189/56 |
| | 2005 | 7 ETM+ | 2005-01-28 | 09:39:46 | 50.24421257 | 1.00 | 0.9848438 | 189/56 |
| | 2015 | 8 OLI/TIR | 2015-12-10 | 09:51:05 | 52.83128498 | 0.58 | 0.9848647 | 189/56 |
| | 2025 | 9 OLI /TIR | 2025-01-11 | 09:51:07 | 51.11210493 | 0.12 | 0.9834458 | 189/56 |

**Source: Author's Compilation, 2026.**

The images were prepared for classification through radiometric calibration, atmospheric correction, geometric correction, cloud screening and image enhancement/layer preparation, as applicable to the respective Landsat products. Each image was subsequently clipped to the Asaba study boundary. Five LULC classes were identified and consistently applied across the four periods: built-up area, dense forest, sparse vegetation, bare land, and water/wetland. The use of a consistent classification scheme ensured comparability across the study periods.

A supervised Maximum Likelihood Classification (MLC) algorithm was implemented in ArcGIS. Training samples for each LULC class were selected from representative locations identified through field observations, satellite imagery and existing land-use information (Ashikodi & Chokor, 2025). The training samples were selected to adequately represent the spectral characteristics of the respective classes.

The classified images were subjected to accuracy assessment using an error/confusion matrix and independent reference samples. Overall accuracy and the Kappa coefficient were calculated for each classified Landsat image to assess the reliability of the LULC classification results. The accuracy assessment showed overall accuracies of 87.6%, 86.4%, 89.2%, and 91.5% for the 1995, 2005, 2015, and 2025 classifications, respectively, while the corresponding Kappa coefficients were 0.84, 0.82, 0.86, and 0.89. These results indicate a consistently high level of classification agreement across all assessment years, with all classifications meeting the acceptable accuracy level for subsequent LULC change-detection analysis.

### 3.3 LULC Change Detection

LULC change was determined using post-classification comparison of the independently classified maps for 1995, 2005, 2015 and 2025. The area occupied by each LULC class was calculated in square kilometers and expressed as a percentage of the total study area. Changes were examined for the successive periods 1995–2005, 2005–2015 and 2015–2025, as well as for the overall 1995–2025 period. The increase or decrease in the spatial extent of each LULC class was determined from differences in classified areas, while the expansion of the built-up class served as the principal spatial indicator of urban expansion. The results were presented using classified LULC maps, area statistics, and percentage distributions to show the magnitude and direction of land-cover changes.

### 3.4 Household Survey and Sampling

The household survey involved the administration of 400 structured questionnaires across the eleven political wards of Asaba, of which 396 valid questionnaires were retrieved and used for analysis. A multistage sampling approach was adopted to ensure coverage of the eleven political wards. In the absence of reliable ward-level population figures, the questionnaires were approximately equally distributed across the eleven wards to provide balanced spatial representation of the study area. Within each ward, questionnaires were administered to selected households and eligible adult respondents who had sufficient knowledge of the area and its changing land-use conditions. The selection of respondents was guided by availability and willingness to participate, while efforts were made to obtain responses from different parts of each ward.

The sample size was determined using the Taro Yamane formula:

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

where:

- $n$= required sample size;
- $N$= estimated population size; and
- $e$= acceptable margin of error (0.05).

The 2006 population of Asaba was projected to 2025 using the exponential population growth model and the applicable annual growth rate, resulting in an estimated population of approximately 345,262. Substitution of this population estimate into the Taro Yamane formula at a 5% margin of error produced a sample size of approximately 400 respondents.

The questionnaire comprised sections covering respondents' socio-demographic characteristics, perceived drivers of urban expansion and perceived environmental implications. Driver and environmental-implication items were measured using a five-point Likert scale, ranging from 1 = strongly disagree to 5 = strongly agree. The criterion mean was therefore 3.00, calculated as:

$$\frac{1+2+3+4+5}{5} = 3.00$$

Mean scores above 3.00 indicated relatively higher agreement with an item, whereas scores below 3.00 indicated relatively lower agreement.

### 3.5 Validity and Reliability

The questionnaire was subjected to content validation by the research supervisor and other professionals with relevant expertise to assess the relevance, clarity and adequacy of the items in relation to the study objectives. A pilot test involving 20 respondents in Warri, who were excluded from the final sample, was conducted before the main survey. The internal consistency of the questionnaire was assessed using Cronbach's alpha, which yielded a coefficient of 0.78, indicating acceptable reliability of the instrument.

### 3.6 Data Analysis

The geospatial data were analysed using GIS and Remote Sensing techniques. For each observation year, the area and percentage coverage of the five LULC classes were calculated, and temporal changes were determined through post-classification comparison. Household-survey data were analysed using frequencies, percentages and mean scores. Frequencies and percentages were used to summarise respondents' socio-demographic characteristics, while mean scores were used to assess the perceived importance of the identified drivers and environmental implications of urban expansion.

For the environmental-implication assessment, questionnaire items were grouped into the environmental dimensions examined in the study, namely agricultural land conversion, deforestation, flooding, waste generation and noise pollution. Mean scores were calculated for individual items and interpreted against the 3.00 criterion mean.

## Discussion

The LULC maps revealed substantial spatial and temporal changes in Asaba between 1995 and 2025. However, the pattern of change was not a steady increase in built-up land throughout the entire period. Built-up land declined slightly between 1995 and 2005 before increasing substantially between 2005 and 2025. At the same time, dense forest and sparse vegetation experienced considerable changes, while water/wetland areas remained relatively stable. The spatial pattern shown in the maps indicates an expansion of built-up areas into previously vegetated and open areas, particularly during the later periods of the study (Figure 2).

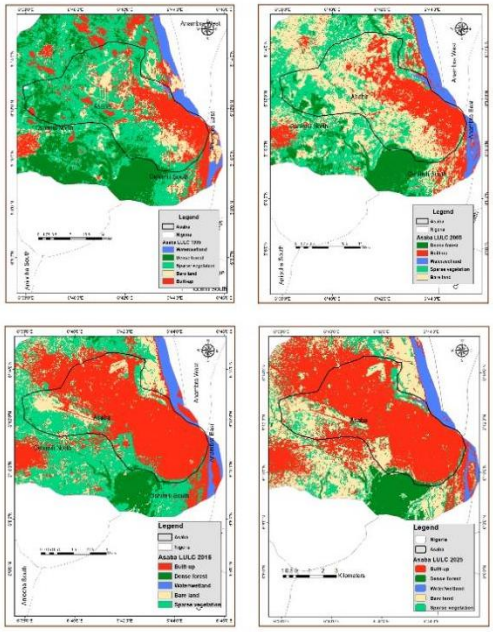


**Figure 2: LULC Maps of Asaba (1995, 2005, 2015 and 2025)**

**Source: Authors' Research, 2026.**

### 4.1 Land Use/Land Cover Dynamics in Asaba (1995–2025)

Table 2 shows substantial changes in the composition of LULC in Asaba between 1995 and 2025. In 1995, sparse vegetation constituted the largest LULC category, covering 44.6% of the study area, followed by dense forest at 22.8% and built-up land at 18.4%. This distribution indicates that the landscape was predominantly vegetated, with a comparatively smaller proportion occupied by built-up areas.

Between 1995 and 2005, built-up land declined slightly from 18.4% (37.57 km²) to 16.9% (34.45 km²). This reduction should not be interpreted as a reversal of urban development without further evidence. It may partly reflect differences in the spectral characteristics of land surfaces, classification of transitional or recently cleared areas, or the representation of developed land in the respective satellite images. The substantial increase in bare land during the same period, from 11.0% to 34.3%, suggests that some areas may have been classified as bare land rather than built-up land. Consequently, the 1995–2005 change should be interpreted cautiously rather than as evidence of an actual reduction in the physical extent of the city.

A markedly different pattern occurred between 2005 and 2015. Built-up land increased from 16.9% to 37.9%, representing an increase of approximately 21 percentage points. During the same period, dense forest declined from 10.4% to 6.2%, while bare land decreased substantially from 34.3% to 13.9%. Sparse vegetation, however, increased from 33.6% to 38.4%. The simultaneous reduction in bare land and increase in built-up land suggests that some previously cleared or exposed surfaces may have become developed during this period. The changes in vegetation classes also indicate that urban development was occurring within a landscape undergoing broader land-cover transformation rather than through a single-direction conversion process.

Between 2015 and 2025, built-up land continued to increase, rising from 37.9% to 43.3%, while sparse vegetation declined sharply from 38.4% to 14.1%. Dense forest increased slightly from 6.2% to 6.8%, while bare land increased from 13.9% to 32.0%. These results indicate continued expansion of developed surfaces alongside substantial changes in vegetation and exposed land. The increase in bare land in 2025 may reflect areas undergoing construction or other forms of land disturbance, although the classification alone cannot establish the specific processes responsible for these changes.

Across the entire 1995–2025 period, built-up land increased from 18.4% to 43.3%, an increase of 24.9 percentage points. In contrast, sparse vegetation declined from 44.6% to 14.1%, while dense forest declined from 22.8% to 6.8%. Water/wetland remained relatively stable, changing from 3.3% in 1995 to 3.9% in 2025. The overall pattern therefore indicates substantial urban expansion accompanied by major changes in vegetated and exposed land surfaces. The results provide spatial evidence of land-cover transformation but do not, by themselves, establish the exact land-use transition pathway for every location.

The reliability of the classified LULC maps was assessed using an error/confusion matrix and independent reference samples. The classification achieved an overall accuracy of 85% and a Kappa coefficient of 0.80, indicating a satisfactory level of agreement between the classified maps and the reference data. These accuracy results provide support for using the classified LULC maps for subsequent change-detection analysis.

**Table 2: Asaba LULC Distribution, 1995–2025**

| S/N | LULC Type | 1995 Area (km²) | 1995 Area (%) | 2005 Area (km²) | 2005 Area (%) | 2015 Area (km²) | 2015 Area (%) | 2025 Area (km²) | 2025 Area (%) |
|---|---|---|---|---|---|---|---|---|---|
| **1** | Built-up | 37.57 | 18.4 | 34.45 | 16.9 | 77.35 | 37.9 | 88.44 | 43.3 |
| **2** | Dense forest | 46.55 | 22.8 | 21.30 | 10.4 | 12.77 | 6.2 | 13.87 | 6.8 |
| **3** | Water/wetland | 6.75 | 3.3 | 10.00 | 4.9 | 7.36 | 3.6 | 7.88 | 3.9 |
| **4** | Bare land | 22.37 | 11.0 | 69.99 | 34.3 | 28.32 | 13.9 | 65.36 | 32.0 |
| **5** | Sparse vegetation | 91.05 | 44.6 | 68.56 | 33.6 | 78.49 | 38.4 | 28.74 | 14.1 |
| **Total** | | **204.29** | **100.0** | **204.29** | **100.0** | **204.29** | **100.0** | **204.29** | **100.0** |

**Source:** Author's Research, 2026.

### 4.2 Drivers of Urban Expansion in Asaba

The results presented in Figure 3 indicate that respondents generally perceived all the listed factors as important contributors to urban expansion in Asaba, with mean scores above the criterion mean of 3.00. Population growth recorded the highest mean score (M = 4.58), followed by migration to Asaba (M = 4.52), increasing housing demand (M = 4.40), commercial activities (M = 4.36), private real estate development (M = 4.21), and the establishment of Asaba as the capital of Delta State (M = 4.17).

The high score for population growth suggests that respondents associate increasing population with greater demand for housing, infrastructure, commercial facilities and other urban services. Similarly, the high score for migration indicates that respondents perceive population movement into Asaba as an important factor contributing to demand for urban land. The scores for housing demand, commercial activities and private real estate development further indicate that respondents perceive both residential and economic activities as important factors in the transformation of land within the city.

The role attributed to Asaba's status as the capital of Delta State is also consistent with the administrative functions of the city. Government establishments and related economic activities can generate demand for infrastructure, housing and commercial services. However, because these findings are based on respondents' perceptions, the mean scores should not be interpreted as statistical proof that any individual factor caused urban expansion. Rather, they identify factors that residents considered important in explaining the observed development.

The findings can nevertheless be related to the LULC results. The substantial increase in built-up land from 18.4% in 1995 to 43.3% in 2025 provides spatial evidence that the physical extent of developed land has increased considerably. The respondents' perceptions provide complementary information concerning possible social and economic factors associated with this change. This combination of spatial evidence and household perceptions gives a broader understanding of urban expansion than either dataset alone.

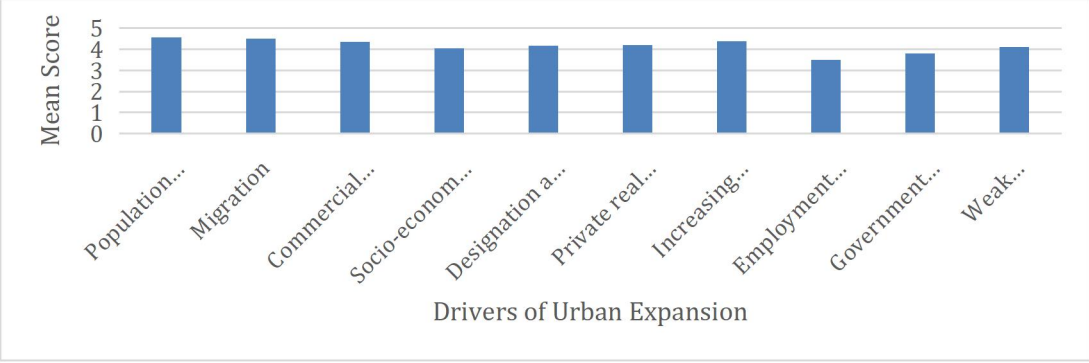



**Figure 3: Drivers of Urban Expansion**
**Source: Authors' Research, 2026.**

### 4.3 Environmental Implications of Urban Expansion

The results in Figure 4 show that respondents perceived several environmental implications associated with urban expansion in Asaba. Since these findings were obtained through the household questionnaire, they represent respondents' perceptions and should be distinguished from environmental impacts directly measured through field or geospatial analysis.

Noise pollution recorded the highest mean score (M = 4.55), indicating a high level of agreement among respondents that urban expansion has been associated with increased noise. Waste production (M = 4.36), flooding (M = 4.34), and environmental pollution (M = 4.29) also recorded high mean scores. These responses suggest that residents perceive increasing urban activity, construction, traffic and commercial activities as contributing to environmental pressures within the city.

The high score for flooding (M = 4.34) is particularly relevant to the LULC findings. The substantial increase in built-up land from 18.4% to 43.3% indicates a major expansion of developed surfaces, while sparse vegetation declined from 44.6% to 14.1%. Such changes provide an important spatial context for respondents' concerns about flooding, although the present LULC analysis does not directly measure changes in surface runoff or flood frequency. Previous research on Asaba has also identified flooding as an environmental concern associated with urban development (Daukere, 2025; Onyedika & Idowu, 2024).

Respondents also reported decline in vegetation cover (M = 4.27), cutting down of trees for construction (M = 4.14), and conversion of agricultural land to residential and commercial uses (M = 4.06). The perception of declining vegetation is broadly consistent with the satellite results, which show a reduction in sparse vegetation from 44.6% in 1995 to 14.1% in 2025 and a decline in dense forest from 22.8% to 6.8%. However, agricultural land conversion cannot be directly quantified from Table 2 because agricultural land was not included as a separate LULC class. The questionnaire result therefore provides evidence of respondents' perceptions of agricultural-land conversion rather than a measured agricultural-to-built-up transition.

Obstruction of natural drainage systems (M = 4.01) and reduction in open-space areas (M = 4.01) were also identified by respondents as environmental implications of urban expansion. These results point to perceived changes in the physical environment associated with increasing development. Nevertheless, the findings should be interpreted as reported perceptions rather than direct measurements of drainage obstruction or open-space loss.

Overall, the questionnaire results indicate that residents perceive urban expansion as being associated with several environmental pressures, particularly noise, waste generation, flooding, pollution and vegetation loss. The agreement between the perceived decline in vegetation and the observed changes in the LULC classification provides some complementary evidence, while the other environmental implications require additional field-based or environmental measurements for direct verification.

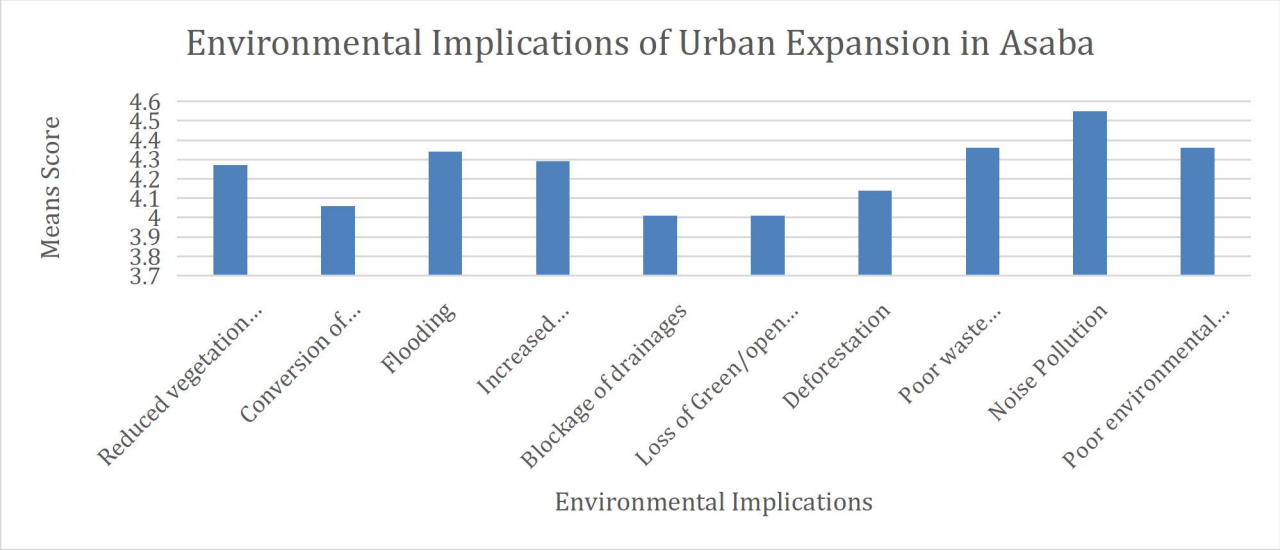



**Figure 4: Environmental Implications of Urban Expansion.**
**Source: Authors' Research, 2026**

### 4.4 Key Findings

The study identified substantial changes in the LULC composition of Asaba between 1995 and 2025. The change was not linear throughout the entire period. Built-up land declined slightly from 18.4% in 1995 to 16.9% in 2005 before increasing sharply to 37.9% in 2015 and 43.3% in 2025. The major increase after 2005 therefore represents the clearest evidence of physical urban expansion in the classified imagery. The large increase in bare land between 1995 and 2005 also indicates that land-cover transformation during the study period included substantial changes in exposed surfaces, although the available classification does not establish the precise transition of each location.

The vegetation classes experienced considerable changes over the study period. Dense forest declined from 22.8% in 1995 to 6.8% in 2025, while sparse vegetation declined from 44.6% to 14.1%. In contrast, water/wetland remained relatively stable, increasing from 3.3% to 3.9%. The overall pattern is consistent with substantial transformation of vegetated and open land alongside the expansion of built-up surfaces. The classification achieved an overall accuracy of 85% and a Kappa coefficient of 0.80, providing support for the reliability of the classified LULC maps.

The observed expansion is consistent with the findings of Ashikodi and Chokor (2025), who reported increasing urbanisation and declining undeveloped areas in Asaba. The present study extends the temporal assessment to 2025 and shows that the built-up share of the classified landscape was substantially higher in 2025 than in 1995. The findings therefore provide updated spatial evidence of the continued transformation of Asaba's land-cover composition.

The household survey further showed that respondents perceived population growth (M = 4.58), migration (M = 4.52), housing demand (M = 4.40), commercial activities (M = 4.36), private real estate development (M = 4.21), and the city's capital status (M = 4.17) as important factors associated with urban expansion. These findings are broadly consistent with previous studies that have linked demographic, economic, administrative and infrastructural processes with urban development in Asaba and comparable urban areas (Egbuna & Odumodu, 2024; Eyetan &

Dibosa, 2025; Ojanikele et al., 2020). However, the survey results represent perceived drivers and should not be interpreted as establishing causal relationships.

The environmental findings similarly show a distinction between measured and perceived change. The satellite analysis objectively recorded substantial reductions in dense forest and sparse vegetation, while respondents reported noise pollution, waste production, flooding, environmental pollution, vegetation decline, tree removal, agricultural-land conversion, drainage obstruction and reduction in open spaces as environmental implications. The perception of vegetation decline corresponds with the remotely sensed evidence, while claims concerning flooding, noise, waste and drainage require additional environmental measurements for direct empirical verification. The findings are nevertheless consistent with studies identifying flooding and environmental degradation as important concerns associated with urban development in Asaba (Koko et al., 2021; Daukere, 2025; Onyedika & Idowu, 2024).

The findings can also be interpreted in relation to the theoretical perspectives used in the study. From the perspective of Urban Sprawl Theory, the increase in built-up land and the transformation of previously vegetated and open areas provide evidence of outward urban growth. However, the available LULC data alone do not establish all dimensions of sprawl, such as fragmentation, leapfrog development or development density. Therefore, the findings are consistent with aspects of urban sprawl rather than constituting a complete empirical test of the theory.

The findings also have relevance to Central Place Theory, given Asaba's administrative and commercial functions and its position within the Asaba–Onitsha urban corridor. The respondents' high rating of commercial activities and the city's status as the state capital supports the view that the concentration of administrative and economic functions can generate demand for urban land and services. Nevertheless, the present study does not directly test the hierarchical distribution of settlements or service centres required for a comprehensive test of Central Place Theory. The theory therefore provides a useful interpretive framework rather than a variable that was statistically tested in the study.

Overall, the results indicate that Asaba experienced substantial LULC transformation between 1995 and 2025, with the strongest expansion of built-up land occurring after 2005. The GIS/remote-sensing findings provide evidence of changes in the physical landscape, while the household survey provides residents' perceptions of the socioeconomic factors associated with urban expansion and its environmental implications. Together, these findings provide a more comprehensive understanding of urban change in Asaba while maintaining a distinction between remotely observed land-cover change, perceived drivers, and perceived environmental consequences.

### 5.1 Summary and Conclusion

This study assessed urban expansion and its environmental implications in Asaba, Delta State, between 1995 and 2025 using Geographic Information Systems (GIS), Remote Sensing (RS), household survey and Key Informant Interview (KII) approaches. The findings provide evidence of substantial changes in the spatial composition of the study area over the 30-year period.

With respect to the first objective, which examined spatial and temporal changes in LULC, the classified Landsat imagery showed that the pattern of change was not linear throughout the study

period. Built-up land declined slightly from 18.4% in 1995 to 16.9% in 2005 but subsequently increased substantially to 37.9% in 2015 and 43.3% in 2025. Over the entire period, dense forest declined from 22.8% to 6.8%, while sparse vegetation declined from 44.6% to 14.1%. Water/wetland remained relatively stable, changing from 3.3% to 3.9%, while bare land showed considerable fluctuations. The results therefore indicate substantial expansion of built-up surfaces alongside significant changes in vegetated and exposed land-cover categories. The classification achieved an overall accuracy of 85% and a Kappa coefficient of 0.80, supporting the reliability of the classified LULC maps.

For the second objective, the household survey showed that respondents perceived population growth (M = 4.58), migration to Asaba (M = 4.52), increasing housing demand (M = 4.40), commercial activities (M = 4.36), private real estate development (M = 4.21), and the establishment of Asaba as the capital of Delta State (M = 4.17) as important factors associated with urban expansion. These findings indicate that demographic, residential, commercial and administrative factors are perceived to play important roles in the growth of the city. However, because these findings were based on respondents' perceptions, they should not be interpreted as direct statistical evidence of causation.

Regarding the third objective, respondents identified several environmental implications associated with urban expansion. The highest-rated implications were noise pollution (M = 4.55), waste production (M = 4.36), flooding (M = 4.34), environmental pollution (M = 4.29), decline in vegetation cover (M = 4.27), cutting down of trees (M = 4.14), conversion of agricultural land to residential and commercial uses (M = 4.06), obstruction of natural drainage systems (M = 4.01), and reduction in open spaces (M = 4.01). While these findings represent residents' perceptions, the reported decline in vegetation is also supported by the remotely sensed LULC results.

Overall, the study concludes that Asaba experienced substantial urban expansion and LULC transformation between 1995 and 2025, particularly after 2005. The spatial evidence demonstrates a considerable increase in built-up land and reductions in major vegetation classes, while the household findings indicate that residents associate this expansion with demographic, migratory, residential, commercial and administrative factors and perceive several environmental pressures alongside the growth. The findings therefore highlight the need for urban development and environmental management approaches that respond to continued land-cover transformation while protecting vegetation, managing drainage and addressing other environmental pressures associated with urban growth.

### 5.2 Recommendations

Based on the findings of the study, the following recommendations are proposed:

1. **Strengthen development control and land-use monitoring.**
   The Delta State Ministry of Urban Renewal and the relevant planning authorities of Asaba and Oshimili South Local Government Area should strengthen monitoring of land-use changes and development approvals. This is particularly important given the increase in built-up land from 18.4% in 1995 to 43.3% in 2025. Regular monitoring can help ensure that new developments conform to approved land-use plans and development standards.
2. **Update and implement the urban master plan.**
   The Delta State Government, Ministry of Urban Renewal and relevant planning agencies should review and update the existing planning framework for Asaba to reflect current

patterns of urban growth. The updated plan should provide clear development zones, identify areas requiring environmental protection, and guide the future expansion of residential, commercial and infrastructural development.

3. **Integrate green infrastructure into new development.** Planning authorities should require appropriate green infrastructure in new developments, including green spaces, trees, permeable surfaces and other measures that can support environmental management. This recommendation responds particularly to the substantial decline in sparse vegetation and dense forest observed in the LULC analysis and the respondents' perception of declining vegetation cover.
4. **Strengthen flood and drainage management.** The Delta State Government, Asaba municipal authorities and relevant environmental agencies should improve drainage management and consider nature-based measures such as wetland protection and restoration, urban retention areas, vegetation-based drainage buffers and appropriate natural drainage channels. This recommendation is linked to the high respondent rating for flooding (M = 4.34) and obstruction of natural drainage systems (M = 4.01), as well as existing environmental concerns relating to urban development in Asaba.
5. **Protect remaining vegetation and environmentally sensitive areas.** Relevant environmental and planning authorities should identify and protect important vegetation and environmentally sensitive areas from unnecessary conversion. This is warranted by the observed reduction in dense forest from 22.8% to 6.8% and sparse vegetation from 44.6% to 14.1% between 1995 and 2025. Development approvals in environmentally sensitive locations should therefore be subject to appropriate planning and environmental assessment requirements.
6. **Establish a continuous GIS-based urban growth monitoring system.** The **Delta State Government and relevant planning institutions**, in collaboration with universities and GIS professionals, should establish a regularly updated GIS and Remote Sensing monitoring system for Asaba. Platforms such as Google Earth Engine can support the processing and visualisation of multi-temporal satellite imagery and help planning authorities identify changes in built-up areas, vegetation and other LULC categories more efficiently.
7. **Improve coordination among urban development stakeholders.** Relevant government ministries, local planning authorities, environmental agencies, traditional/community stakeholders and private developers should improve coordination in managing urban growth. Such coordination should focus on development control, infrastructure provision, environmental protection, drainage management and compliance with land-use regulations. This is particularly relevant given the multiple demographic, commercial, residential and administrative factors that respondents associated with urban expansion.
8. **Improve environmental management alongside urban development.** The relevant environmental authorities should strengthen waste-management, pollution-control and environmental-awareness measures as the city continues to develop. This recommendation responds to respondents' high ratings for waste production (M = 4.36), environmental pollution (M = 4.29) and noise pollution (M = 4.55), which indicate areas of environmental concern requiring attention alongside physical urban growth.

**References**

Ashikodi, M., & Chokor, A. (2025). Analyzing the impact of Delta State capital territory development on land use change in local communities using remote sensing, GIS, and qualitative survey. *Global Journal of Environmental Science and Sustainability*, *2*(1), 21–36. https://doi.org/10.69798/56495638

Ayadiuno, R., & Ndulue, D. (2024). Integrating Remote Sensing and GIS-Based Map Analysis in Determining Spread of Built-Ups and Land-Use Dynamics of Terrain of Onitsha Metropolis, Anambra State, Nigeria. *Land*. https://doi.org/10.3390/land13111896.

Ayenachew, Y. A., & Abebe, B. G. (2024). The dynamics of urbanization, land use land cover changes, and land expropriation in Addis Ababa, Ethiopia. *Frontiers in Environmental Science*, *12*. https://doi.org/10.3389/fenvs.2024.1439954

Baqa, M., Chen, F., Lu, L., Qureshi, S., Tariq, A., Wang, S., Jing, L., Hamza, S., & Li, Q. (2021). Monitoring and Modeling the Patterns and Trends of Urban Growth Using Urban Sprawl Matrix and CA-Markov Model: A Case Study of Karachi, Pakistan. *Land*. https://doi.org/10.3390/land10070700.

Daukere, B. (2025). Geographical and Demographical Influence of Flood Vulnerability and Infrastructural Inequalities in Delta State, Nigeria. *Journal of Applied Sciences and Environmental Management*. https://doi.org/10.4314/jasem.v29i7.33.

Dhanaraj, K, & Angadi, D. (2021). Urban expansion quantification from remote sensing data for sustainable land-use planning in Mangaluru, India. *Remote Sensing Applications: Society and Environment*. https://doi.org/10.1016/j.rsase.2021.100602.

Egbuna, O. K., & Odumodu, U. J. (2024). *Urban growth and flood vulnerability in Asaba, Delta State*. *International Journal of Climate Change and Environmental Sustainability, 1*(2) 1-16. https://acrobat.adobe.com/id/urn:aaid:sc:EU:245462a8-10c4-4ccf-9eb8-b08cd9331819

Ejemeyovwi, D. O. (2015). Change detection in landuse/landcover mapping in Asaba, Niger Delta between 1996 and 2015: A remote sensing and GIS approach. *British Journal of Environmental Sciences, 3*(3), 42–61. https://acrobat.adobe.com/id/urn:aaid:sc:EU:641f6a08-fb4a-4789-b158-6f6edeb786da

Enaruvbe, G. O., & Atedhor, G. O. (2016). Spatial analysis of agricultural landuse change in Asaba, Southern Nigeria. *Ife Journal of Science*, *17*(1), 65–74. https://doi.org/10.4314/ijs.v17i1.

Eyetan, T., & Dibosa, F. (2025). Population characteristics and migration patterns in Asaba. *Journal of Management and Social Science Research*. https://doi.org/10.47524/lipr.v6i1.39.

Faiyetole, A., & Adewumi, V. (2023). Urban expansion and transportation interaction: Evidence from Akure, southwestern Nigeria. *Environment and Planning B: Urban Analytics and City Science, 51*, 57 - 74. https://doi.org/10.1177/23998083231169427.

Fontana, A., Nascimento, V., Ometto, J., & Amaral, F. (2023). Analysis of past and future urban growth on a regional scale using remote sensing and machine learning. *Frontiers in Remote Sensing*. https://doi.org/10.3389/frsen.2023.1123254.

Hailu, T., Assefa, E., & Zeleke, T. (2024). Urban expansion induced land use changes and its effect on ecosystem services in Addis Ababa, Ethiopia. *Frontiers in Environmental Science*. https://doi.org/10.3389/fenvs.2024.1454556.

Jiang, S., Zhang, Z., Ren, H., Wei, G., Xu, M., & Liu, B. (2021). Spatiotemporal Characteristics of Urban Land Expansion and Population Growth in Africa from 2001 to 2019: Evidence from Population Density Data. *ISPRS International Journal of Geo-Information*, *10*(9), 584. https://doi.org/10.3390/ijgi10090584

Kasim, O., Wahab, B., & Oweniwe, M. (2021). Urban expansion and enhanced flood risk in Africa: The example of Lagos. *Environmental Hazards, 21*, 137 - 158. https://doi.org/10.1080/17477891.2021.1932404.

Kookana, R. S., Drechsel, P., Jamwal, P., & Vanderzalm, J. (2020). Urbanisation and emerging economies: Issues and potential solutions for water and food security. *The Science of the Total Environment*, *732*, 139057. https://doi.org/10.1016/j.scitotenv.2020.139057

Medayese, S., Magidimisha-Chipungu, H. H., & Chipungu, L. (2023). Spatial Matrices of urban expansion in Lafia, North-Central Nigeria. *Forum Geografi*, *37*(1). https://doi.org/10.23917/forgeo.v37i1.18068

Mnyali, E., & Materu, S. (2021). Analysis of the Current and Future Land Use/Land Cover Changes in Peri-Urban Areas of Dar es Salaam City, Tanzania using Remote Sensing and GIS Techniques. *Tanzania Journal of Science*. https://doi.org/10.4314/tjs.v47i5.12.

Mohamed, A., & Worku, H. (2019). Quantification of the land use/land cover dynamics and the degree of urban growth goodness for sustainable urban land use planning in Addis Ababa and the surrounding Oromia special zone. *Journal of Urban Management*. https://doi.org/10.1016/j.jum.2018.11.002.

Mostafa, E., Li, X., Sadek, M., & Dossou, J. (2021). Monitoring and Forecasting of Urban Expansion Using Machine Learning-Based Techniques and Remotely Sensed Data: A Case Study of Gharbia Governorate, Egypt. *Remote. Sens., 13*, 4498. https://doi.org/10.3390/rs13224498.

Muchelo, R. O., Bishop, T. F. A., Ugbaje, S. U., & Akpa, S. I. C. (2024). Patterns of urban sprawl and agricultural land loss in Sub-Saharan Africa: the cases of the Ugandan cities of Kampala and Mbarara. *Land*, *13*(7), 1056. https://doi.org/10.3390/land13071056

Ngolo, A., & Watanabe, T. (2022). Integrating geographical information systems, remote sensing, and machine learning techniques to monitor urban expansion: an application to Luanda, Angola. *Geo-spatial Information Science, 26*, 446 - 464. https://doi.org/10.1080/10095020.2022.2066574.

Ogunbode, T., Oyebamiji, V., Sanni, D., Akinwale, E., & Akinluyi, F. (2025). Environmental impacts of urban growth and land use changes in tropical cities. *Frontiers in Sustainable Cities*. https://doi.org/10.3389/frsc.2024.1481932.

Ojanikele, A. W., Ojiako, J. C., & Igbokwe, E. C. (2020). Mapping and analysis of the pattern and distribution of socio-economic facilities in Asaba, Delta State, Nigeria using remote sensing and geographic information system. *International Journal of Advanced Engineering Research and Science, 7*(8), 2854. https://acrobat.adobe.com/id/urn:aaid:sc:EU:ed104f91-3f2d-4084-a4f7-b4c144ef6203

Ojoh, O., Ifuwe, C., Efetobo, O., & Eyetan, T. (2023). Assessment of Industrial Waste on Soil Pollution in Asaba, Delta State, Nigeria. *Tropical Journal of Science and Technology*. https://doi.org/10.47524/tjst.v4i1.38.

Onyedika, E., & Idowu, S. (2024). Mapping and analysis of urban drainage system in Asaba metropolis delta state using remote sensing and geographic information system. *Global Journal of Engineering and Technology Advances*. https://doi.org/10.30574/gjeta.2024.18.3.0030.

Onyemaechi, A. (2025). Assessment of the effects of Asaba's growth on rural communities: resource allocation, employment and income implications for urban development policies. *Sokoto Journal of Geographical Studies*. https://doi.org/10.65760/sjgs.v1.i1.24.

Onyemenam, P. I., Eyetan, T. E., Obi, U. N., & Ojoh, C. O. (2025). Deconstructing the Affordability versus Quality Nexus: A Principal Component Analysis of Latent Housing Deficits in Urban Informal Settlements in Asaba, Delta State-Nigeria. *Urban-Rural Community Studies*, *1*(2), 15–21. https://doi.org/10.64229/nwzk6x78

Rajagopal, P., Priya, R., & Senthil, R. (2022). A review of recent developments in the impact of environmental measures on urban heat island. *Sustainable Cities and Society*. https://doi.org/10.1016/j.scs.2022.104279.