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Analyzing the Impact of Delta State Capital Territory Development on Land Use Change in Local Communities Using Remote Sensing, GIS, and Qualitative Survey.

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Abstract

This paper demonstrates the spatial and temporal dimensions of land use change in Delta State Capital Territory and derives the policy implications and lessons for the planning and implementation of sustainable urbanization. It is based on the study which combined remote sensing, geographic information system and qualitative field survey. Satellite data generated by Landsat 5(TM), Landsat 7 (ETM+) and Sentinel 2B (MSI) for the years 1990, 2011 and 2020 were used. This was also analyzed using Erdas and ArcGIS 10.6.1 software. Results from this Geographic Information Systems (GIS) analysis were triangulated with data from key informant interviews and focus group discussion. The study hypothesis was tested by applying student t-test on data sets derived from the GIS analysis. Findings of the research include reduction of undeveloped land areas from 16% in 1990 to 0.09% in 2020 and increase in built –up land areas from 7% in 1990 to 29% in 2020. The observed unorganized spread of urbanization in the capital territory is linked to the absence of Master Plan and the fact that the Delta State Capital Territory Development Agency was established 24 years after the territory was designated. The paper concludes that the Delta State Capital Territory development process does not fully conform to the growth center theory of urbanization. It is imperative for urban planners and policymakers to formulate and implement Master Plans upfront for proper land zoning and sustainable land use. In addition, the growth center theory should be applied contextually for sustainable urban development.

Keywords: Urbanization, Growth Centre, Land Use Change, Geographic Information Systems.

INTRODUCTION

Urbanization, whether planned or unplanned, has significant environmental implications. Planned urbanization is typically a gradual process that ensures controlled infrastructure development and promotes sustainable economic growth. In contrast, unplanned urbanization, often driven by population migration to commercial and cultural centers, leads to rapid, unmanaged expansion. This type of growth can result in conflicts over land use, especially when fertile agricultural land is converted to urban spaces, causing tension between developers, conservationists, and environmentalists (Onokerhoraye, 1976; Mylott, 2009). In the context of African cities, particularly in Nigeria, urbanization has been characterized by fast-paced, disorganized expansion, often overwhelming existing infrastructure and amenities. Scholars such as Jelili (2012) and Attwairi (2017) have highlighted the leapfrogging population growth in Nigerian cities, which exacerbates the challenges of managing urbanization.

This study focuses on the urbanization process in Delta State Capital Territory, utilizing the Growth Centre theory as a framework for analysis. Delta State Capital Territory is a distinctive case in Nigeria, as it represents an effort by the government to centralize resources and foster territorial development. The underlying premise is that if urbanization in this area is effectively managed, it could have a significant impact on multiple communities with relatively minimal resource expenditure. The study employs a combination of remotely sensed data, Geographic Information System (GIS) technology, and qualitative survey methods to analyze land use changes over a 30-year period. The goal is to generate insights that will guide urban planning and policy decisions, benefiting both local policymakers and urban planners in Delta State and beyond.

The Capital Territory model of urban development, commonly used in Nigeria, aims to accelerate economic growth and ensure broader access to infrastructure and services. In Delta State, the creation of the Delta State Capital Territory was intended to expedite development in Asaba, the state capital, and other twelve constituent communities, namely Azagba Ogwashi, Aboh Ogwashi-Uku, Issele Azagba, Anwai, Okpanam, Okwe, Ibusa, Achalla Ibusa, Oko-Anala, Oko-Amakom, Oko-Obiokpu, and Ugbolu. However, without an approved Master Plan, the development process has largely unfolded in a disorganized manner, resulting in unsustainable land use patterns and environmental degradation. In response, the state government has launched several urban renewal initiatives to address these challenges, yet the effectiveness of these interventions remains under-researched.

Previous studies, such as those by Ejaro and Abdullahi (2013), Ejemayovwi (2015), and Enaruvbe and Atedhor (2015), have analyzed land use and land cover changes using GIS in cities like Suleja and Asaba. However, few studies have combined GIS with qualitative methods to offer a more holistic view of land use changes in the Delta State Capital Territory. This study bridges that gap by triangulating GIS data with qualitative survey techniques, which enhances data accuracy and provides a more comprehensive understanding of urbanization-driven land use changes. Moreover, the temporal aspect of land use changes within the Delta State Capital Territory has not been adequately explored, especially in terms of a 30-year reference period. This study aims to fill that gap, offering valuable insights into the spatial and temporal dimensions of land use change, and identifying policy implications for sustainable urbanization practices in the region. Key research questions include how the establishment of Asaba as the capital has influenced land use in surrounding communities, what GIS data reveals about land use and land cover changes, and how the capital territory's urban development model has impacted sustainable land use in these areas. The study hypothesizes that there has been no significant change in land use patterns before and after the creation of the Delta State Capital Territory (DSCT).

LITERATURE REVIEW

Rural-Urban Linkages as a Factor in Urbanisation

Places are connected because of the need for areas which have comparative advantages in the ownership and processing of natural resources, to provide for areas which do not have the required valuable resources. Studies have identified the role played by rural areas who provide ecosystem services (given freely by nature) to the urban areas through forests, water, agriculture etc. Resources

that are consumed and used for production in the urban areas are often provided/sourced from the surrounding rural areas. Rural and urban areas need each other for sustenance. Thus, it is important to maintain the linkage between rural and urban areas because both support themselves. It is expected that all stakeholders should ensure the preservation of urban and rural linkages to sustain access to these ecosystem services by the urban areas (Gebre and Gebremedhin 2019; Jiboye, 2011). Urbanization rapidly transforms human social roots on a global scale, and rural culture is rapidly replaced by predominant urban culture. Whereas rural relationships are characterized by close-knit, related people who share common values, bloodlines and behaviour, urban relationships are characterized by distant and unfamiliar relations, distant bloodlines and unhealthy competition.

Impact of Urbanisation on Rural Land Use

Opinions vary with respect to the impact of urban growth on rural agricultural farmlands and the environment. Some scholars find nothing wrong with the conversion of fertile agricultural lands to built-up areas since the use of land resources are driven by market forces (Alterman, 1997; Sroka, *et al*., 2018; Achamyeleh, 2020). Other scholars are concerned about the conversion of agricultural land to urban purposes and have argued that reduced social interaction, increased commuting time and distances pose issues of sustainability and livelihoods to farmers, as well as overall impacts on food security (Brueckner, 2000; Satterthwaite, McGranahan and Tacoli, 2010; Naab *et al*., 2013; Sengupta and Chattopadhyay, 2015; Locke and Henley, 2016). The conversion of fertile agricultural land to cities is seen as inevitable, because cities develop in response to immigration of people who are drawn by the presence and location of natural resources.

Land conversion is said to be controlled by the invisible hand of the economy, which ensures that resources are directed to the best and highest use. Development of urban areas seems to impose direct costs on the communities that are experiencing it, and indirect costs on the rural areas that are sacrificed for development to take place (Alterman, 1997; Heimlich and Anderson, 2001; Yazid *et al*., 2018). (Tanrivermis, 2003; Gebre and Gebremedhin, 2019).

Some of the incentives that promote the exclusive use of land for agricultural purposes include granting tax exemptions to farmers, and exemption of farmers from lawsuits on nuisance caused by certain agricultural practices. It was, however, discovered that many farmers hold on to the use of land for agricultural purposes but do not hesitate to sell the same land to developers who offer them attractive sums of money for the outright purchase of their farmlands (Alterman, 1997; Tanrivermis, 2003).

Effect of Urbanisation on Settlement Patterns

The United Nations State of the World Population report in 2007, projected that by the year 2030, 40.76% of the Indian population would live in urban areas (Pawan, 2016). Also, according to a World Bank report, India, China, Indonesia, Nigeria and the United States would lead the world's urban population surge by 2050 (ibid). Urbanization in India is perceived to have led to food shortages and strain on the country's environmental resources.

Urban sprawl is common at the boundaries between the urban areas and rural areas and provide refuge for the city poor who commute to work in the core urban areas on a daily basis. Urban sprawl leads to what Keivani (2009) refers to as the 'urbanization of poverty', since the surrounding rural areas are mostly inundated with poverty, sickness such as HIV and unorganized buildings of owner-occupied houses which are located away from the epicenters of social and commercial activities. Low-income individuals often live in squatter and illegal settlements that suffer neglect from development by the government and also lack basic amenities and infrastructure (Tarawneh, 2014; Agyeman, 2018). This reality negates the rationale for urbanization which is expected to improve the standard of both urban and rural dwellers.

Urban Spread and the Growth Centre Model

Urban areas are often fringed by degraded forests and other forest areas which taper off into rural areas. In simple terms, every land area is initially and primarily rural; it is the upsurge of residential, construction and infrastructural activities that create the characteristic features that are found in urban areas. Cities and towns are seen to achieve better economic, political and social mileages compared to the rural areas.

The process of urban spread through application of the Growth Centre model for planning has been identified as effective for developing countries. For example, India in over 20 years used the Growth Centre model to achieve decentralized urbanization, reduced poverty, reduced regional development inequalities and also enhance the capacity of rural areas to generate their own economic activities. Decentralized urbanization also helps to spread administrative responsibilities for sectoral urban development and allows the leadership of a Nation to focus on major macro-economic and central development issues (Sedeek and Krishna, 2018).

Negative effects of unplanned and uncontrolled urbanisation include the loss of fertile agricultural farmland and consequently the loss of means of livelihoods for the rural dwellers, loss of land-cover and natural vegetation, emergence of heat islands arising from the concretization of land surfaces, change in social and cultural value systems, etc. All of these may present severe environmental, socio-economic and cultural problems which may be of interest to researchers in the management of rural-urban dynamics and linkages in developing countries. These issues are also relevant in discourse related to environmental and socio-economic changes in rural communities (Lynch, 2005: UN-HABITAT, 2007; Daramola and Ibem, 2010; Jiboye, 2009; 2011; Jiboye and Ogunshakin, 2011).

The economics of land use weigh heavily in favour of land commodification and valuation amid human subjectivity, against intrinsic values such as preservation of fertile agricultural land. Land ownership usually falls in the hands of the highest bidder. Urban land use should be allocated according to overriding public interest to promote urbanization.

This paper is an integrated approach to the study of the linkage between the urban (Asaba capital) and rural areas (constituent communities of the capital territory), and how the people who find themselves in this divide cope with the situation. This study is further justified by the fact that the bulk of literature focuses on urbanization in terms of urban spread, urban decay and socio-economic pressures, with relatively scanty emphasis on the Capital Territory approach to urban development.

Conceptual Framework

This research is based on the growth centre theory encapsulated by Francois Perroux in 1958. The Growth Centre theory is a synthesis of the Central Place and the Core Periphery theories. The core is seen as the centre of development, which is characterised by increased economic activities, and development is structured through a process known as morphogenesis (Manyanhaire, Rwaga and Mutangadura, 2011). The interpreters and followers of Francois Perroux replaced the concept of economic space with geographic space. Growth centres were identified and selected as nuclei for industrial growth, to stimulate development in the surrounding areas, rather than focus only on the undeveloped areas. A growth centre is a geographical area that has a proven economic base, such as raw materials like crude oil, which can trigger development in surrounding areas. Growth centers generate, intercept and attract migrants. They are also capable of improving a region's potential for adopting innovations, saving in public investment on infrastructure, more efficient patterns of service delivery, and the dissemination of growth impulses throughout the areas with their span of control (Moseley, 1974). Some of the deliberate development measures that are put in place in growth centers include improved infrastructure, improved water supply and telecommunication network.

Growth centers which can otherwise be regarded as District Service Centers, are places which already have economic potentials but are further developed by the government as a regional planning strategy to reduce the difference in development between the core areas and their periphery. Growth centres are expected to provide higher end services to the peripheral areas and bridge the development gap between the rural and urban areas. Over time, development is expected to spread evenly, from the core to the periphery. At the same time, the population of the growth centres is expected to have requisite capacity to sustain them. At the point of developing a growth centre, restrictions are imposed on the establishment of other growth centres, to ensure that attention and patronage is dedicated to the development of the emerging growth centre.

The Growth Centre theory provides the conceptual framework for analyzing the effect of Asaba capital on urbanization in constituent communities of the

capital territory. Based on this framework, Asaba capital represents the Growth Pole in relation to the development of the constituent communities of the capital territory.

METHODOLOGY

Study Area

Delta State Capital Territory (Figure 1) was created more than 30 years ago, when Asaba was made capital of the newly created Delta State. With the creation of Delta State in 1991, the area now identified as Delta State Capital Territory was designated to encompass Asaba and other constituent communities namely, Aboh Ogwashi-Uku, Achalla-Ibusa, Anwai, Azagba Ogwashi, Ibusa, Issele Azagba, Oko-Obiokpu, Oko Anala, Oko-Amakom, Okpanam, Okwe and Ugbolu. Over time, development in the territory witnessed indiscriminate construction of buildings on natural drainage with attendant environmental problems, demolition of buildings to adjust building patterns, dislocation of traditional farmers, among other land use management issues.

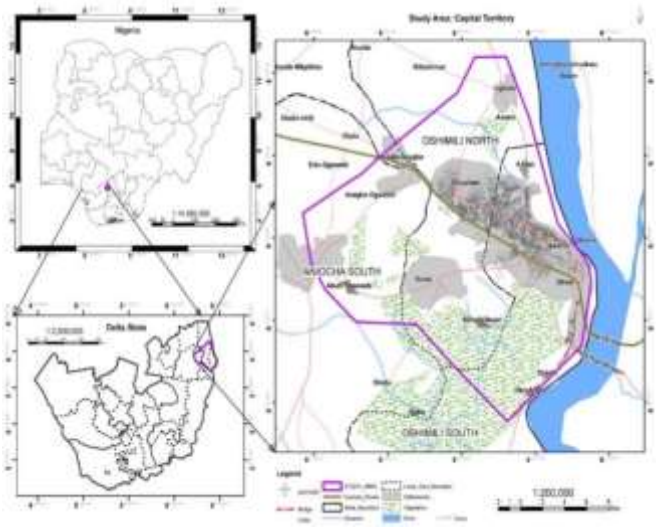

Figure 1: Map showing Delta State Capital Territory.
Source: Delta State Ministry of Lands and Survey (2021).

In a firm resolve to develop Delta State Capital Territory and achieve rational and sustainable urbanization, the State Government enacted and passed a law establishing the Delta State Capital Territory Development Agency on 3rd June 2015. This law defined Delta State Capital Territory as the area with boundaries located between longitude 60 38'E and 60 45'E of the meridian and latitude 60 06'N and 60 19'N of the Equator with a land area of 363.175km^2. The Agency was charged with the task of ensuring that Asaba and constituent communities of the capital territory are well planned with organised land use, effective infrastructure and sustainable environment. Development of Delta State Capital Territory is modelled along the provisions of the general Nigerian Town and Planning Ordinance implemented by both the state Ministry of Lands and Surveys and the Ministry of Urban Renewal.

Study Approach

The study approach is based on a triangulation of information and data from remote sensing, Geographic Information Systems (GIS) and qualitative survey. This study commenced in October 2021 and ended in April 2022. The study covered a 30 year reference period beginning from 1990 to 2020. 1990 was chosen as the base year for comparing land use and land cover changes, up till the year 2020, marking a 30-year period with 3 sets of complete 10 years' time interval. The principle was to generate a temporal analysis of developments in the study area. Ten years was considered long enough for significant land use changes to be detected in the study area, hence, the comparison of satellite images of 10 years interval - 1990, 2011 and 2020.

Data Collection

The study used secondary data from remote sensing and geographic information system, matched with primary data from qualitative field survey comprising key informant interviews and focus group discussion.

Remote sensing and Geographic Information System: Satellite imagery of the study area was sourced from the electronic database (website) s of the US Department of Geological Surveys, as well as Copernicus. Given the clarity of the satellite images used for the analysis and the absence of any form of cloud cover, there was no need for either geometric or atmospheric corrections on the satellite images. Erdas software was used to check for the accuracy of the geo-references in the satellite images for the ground-truthing process. As soon as it was established that the geo-referencing on the satellite map was correctly done, the satellite images were certified correct representations of the study area and consequently adopted for use in detecting land use and land cover changes for the

time under review. The ground truthing process entailed physical/field visits to the geo-referenced locations which were identified on the map, to compare the satellite images with observed physical features of the study area, identify the real life patterns and enable areal measurements in the study area, and to confirm if the remotely sensed information matched observed land use and land cover changes. The satellite image for the year 1990 was captured using Landsat 5 (TM sensor) at a resolution of 30m from the ground surface with a cloud cover of 0%; satellite image for 2011 was captured using Landsat 7 (ETM^+ sensor) at a resolution of 30m from the ground surface with a cloud cover of 0%; and satellite image for 2020 was captured using Sentinel 2B (MSI sensor) at a resolution of 10m from the ground surface with a cloud cover of 0%.

Table 1: Description and Source of Satellite Images used for Land Use Change Analysis

	Year	Sensor	Resolution	Cloud Cover	Date And Time	Source
Landsat 5	1990	TM	30m	0.00	1990-12-24/9:15	USGS
Landsat 7	2011	(ETM+)	30m	0.00	2010-01-18/09:42	USGS
Sentinel 2B	2020	MSI	10m	0.00	28-04-2020/9:50	Copernicus

Key Informant Interview and Focus Group Discussion: To obtain a field-level matching and context of secondary data from the remote sensing and geographic information system, the study employed qualitative survey techniques - key informant interview and focus group discussion. Heads of departments in the state's Ministry of Lands and Survey, Urban and Regional Planning Board, Urban Renewal and the Delta State Capital Territory Development Agency provided information on the availability of Master Plan and Building Plan regulation and urban renewal activities, while heads of the various constituent communities provided anecdotal accounts on land use changes in their communities.

Data Analysis

The obtained satellite images were analyzed with ArcGIS 10.6.1, with data pre-processed based on supervised GIS analytical methods. The supervised method has an advantage over unsupervised methods because it enabled us to first establish a set of 'training data' against which the field survey results were checked. We defined the various classes of data using the same spectral imagery to identify homogenous patterns and matched with the already established land use classification Table. By this method, spectral data sets were defined and classified appropriately as shrubs, water, built-up areas, and so on. Land use classification was therefore achieved using identified composite bands (i.e. the combination of different bands red, blue and green colors), as shown in Table 2.

Table 2: Training Data for the Classification of Land Use in the Study Area.

S/N	Band Name	Composite Band
1.	Detailed vegetation, Crop analysis, urban development, wetland, land use studies	3 2 1
2.	Soil moisture and vegetation condition, location of inland water	4 5 3
3.	Separation of urban use and rural land use, identifying water boundaries etc.	5 4 3

Land use change in the area was determined by comparing Normalized Difference Indices (NDI) for (i) Built-up area – Normalized Difference for Building Index (NDBI); (ii) Vegetation – Normalized Difference for Vegetation Index (NDVI); and (iii) Water – Normalized Difference for Water Index (NDWI). The reflective pixels for the various land use forms were measured and analysed using student-t test, then plotted and presented in a pictorial form to enable comparison of land use patterns for the three (3) time periods of 1990, 2011 and 2020. The variation in statistical data of normalised differences, indicated changes that occurred through the course of the indicated time. These changes were determined by the use of indices calculators, which include Vegetation Index = NIR - R/ NIR+R; Water Index = NIR - Short Infrared/ NIR + Short Infrared and Building Index = Short Wave-Near Infrared/ Short wave + Near Infrared.

Changes in built-up and vacant areas through the years were identified using ArcGIS 10.8, thus enabling the classification of land use in the order indicated in Table 3.

Table 3: Classification of Land Use in Delta State Capital Territory

Classification	Land Use Characteristics
Bare Ground	Undeveloped land
Built-up Areas	Land which has structures on it.
Intensive Agriculture	Clusters of plants and trees which indicate intensive agricultural activities such as plantation agriculture.
Shrubs/Grassland	This indicates subsistence farming activities of food crops and plants of not more than 3m height), and water bodies
Sparse Vegetation	Uncultivated land for example grassland
Water	Ground covered by water, including streams, rivers and lakes

The hypothesis for the study was tested with the independent t-test using the formula

$$t = \frac{(xy)}{S\sqrt{\frac{1}{n}+\frac{1}{m}}} \quad \text{(1)}$$

Where:

x represents the mean observation of the amount of undeveloped land before the establishment of Delta State Capital Territory (DSCT)

y is the mean observation of the amount of undeveloped land after the establishment of Delta State Capital Territory

S is the sample standard deviation (of the entire m and n observations)

The analysis was computed with the statistical package for social sciences (SPSS). Other methods used for analyzing data are Tables and charts.
Undeveloped land areas are spaces where no physical development or built activities have taken place such as vegetation surface (dense or sparse), farmland, grassland and bare soil.

The datasets employed in this analysis were extracted from a land-use; land cover GIS-based supervised classification of 2 temporal satellite images of the study area. The first temporal span is before 1991 (prior to creation of DSCT), while the second temporal span is after the creation of DSCT. In other words, the 2 satellite images were captured in 1990 and 2020. The areas (hectares) of land patches from the supervised classified datasets corresponding to undeveloped land category were computed within the GIS environment and the values were used for performing the analysis and test of the hypothesis.

DISCUSSION

Land Use and Land Cover Changes in Delta State Capital Territory from 1990 to 2020

Table 4 presents the areal values of land categories in the study area for the years 1990, 2011 and 2020. The figures form the basis for the conclusions made for land use and land cover changes in the Delta State Capital Territory, in the years that were reviewed.

Figure 2 shows the satellite image of Asaba and the fringe communities within the Capital Territory as captured by Landsat 5 (TM) in 1990.

Table 4: Distribution of Land Use Patterns for the Years 1990, 2011 and 2020

Object ID	Class of Land Use	Area in 1990 (%Ha)	Area in 2011 (%Ha)	Area in 2020 (%Ha)
1	Bare Ground	16	0.27	0.09
2	Sparse Vegetation	32.8	38.3	32
3	Built-Up Areas	7	14.4	29
4	Shrubs/Grassland	33.3	32.2	1.83
5	Intensive Agriculture (Plantation Farming etc.)	10.8	14.6	36.5
6	Water	0.10	0.23	0.58

Source: Analysis of Satellite Images, 2021.

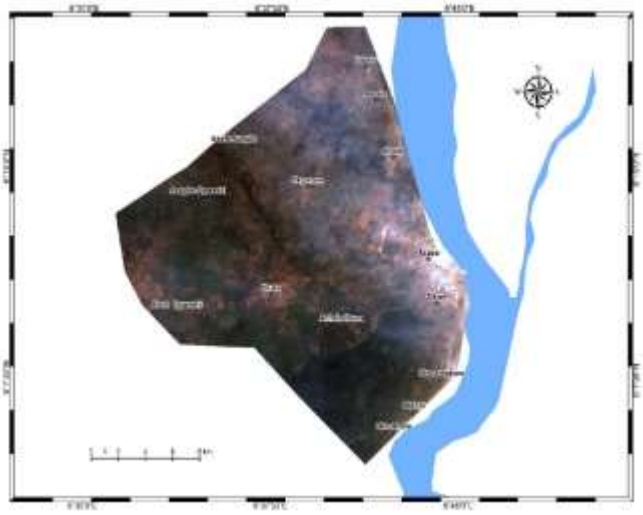

Figure 2: Land Use Patterns in the Study Area as at Year 1990.
***Source*:** Landsat 5 (TM), 9.15am 24th December 1990.

Figure 3 shows that there were signs of socio-economic activities in the study area at this time, as translated in the percentage distribution for vegetation (shrubs/grassland, sparse and dense), built-up areas and water body. It was also observed that as at 1990, human activities were concentrated along the banks of the River Niger, indicating that human interests had not extended beyond the traditional dwellings of the native persons in Asaba, as at the time the state was created and Asaba was made capital of Delta State in 1991.
Also from Figure 3, it can be deduced that the land cover was predominantly vegetation (shrubs/grassland, dense and sparse vegetation) and undeveloped areas or bare ground. Built-up areas only dotted the land surface. The study area is also flanked by River Niger, which constrains the spread of built-up areas and vegetation on that side of the capital territory.

Figure 3 also shows that the total built-up area at this time, was 7%, with the other land use forms of vegetation making up the remaining part of land cover. Bare ground constituted about 16% of the total land surface; shrubs/grassland made up 33.3% of the total land surface; sparse vegetation (food crops such as cassava, yam and fruit trees not more than 3metre tall) - 32.8%; Intensive Agriculture 10.8% and water - 0.10%. Shrubs/grassland, sparse

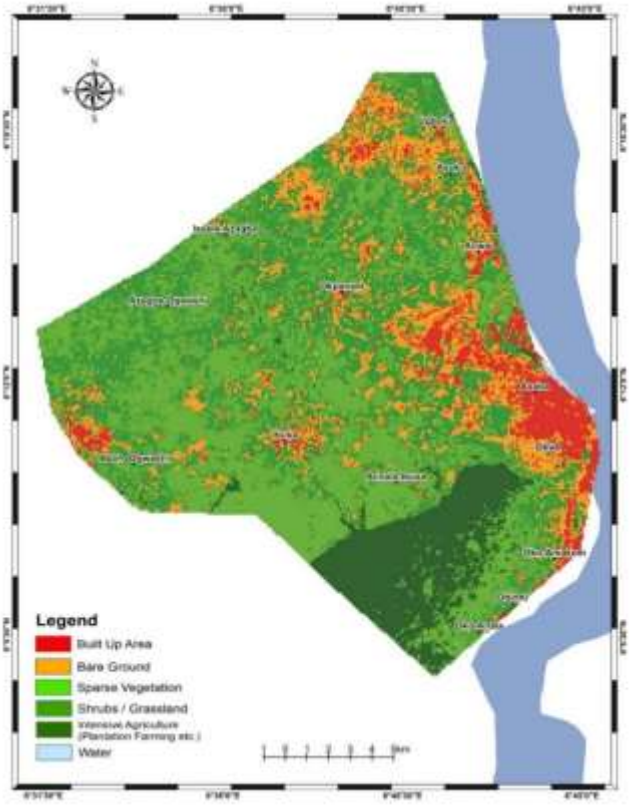

Figure 3: Land Use Pattern in the Study Area as at 1990.

vegetation, bare ground and Intensive Agriculture (Plantation Farming etc.) took up a sizeable chunk of the land surface area in the year 1990. Intensive Agriculture (Plantation Farming etc.) in the context of this study, includes thick ferns and weeds that are found in swampy areas which was found to be common in Oko-Anala, Oko-Amakom and Oko-Obiokpu communities that have spells of flooding). Small part of the land was built-up, while evidence of water bodies was negligible.

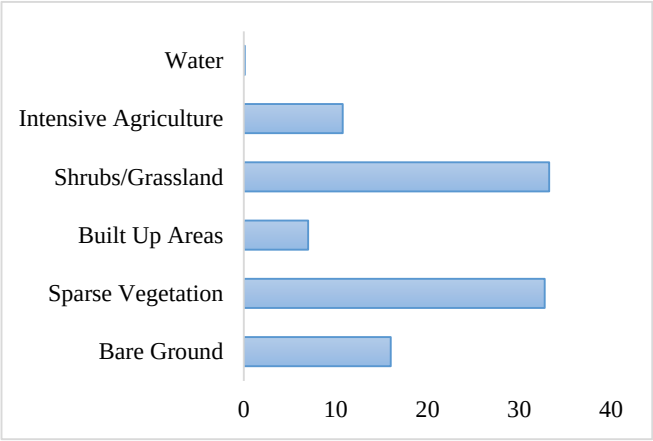

Figure 4: Land Use Distribution of the Area in 1990 (Before Asaba became State Capital).

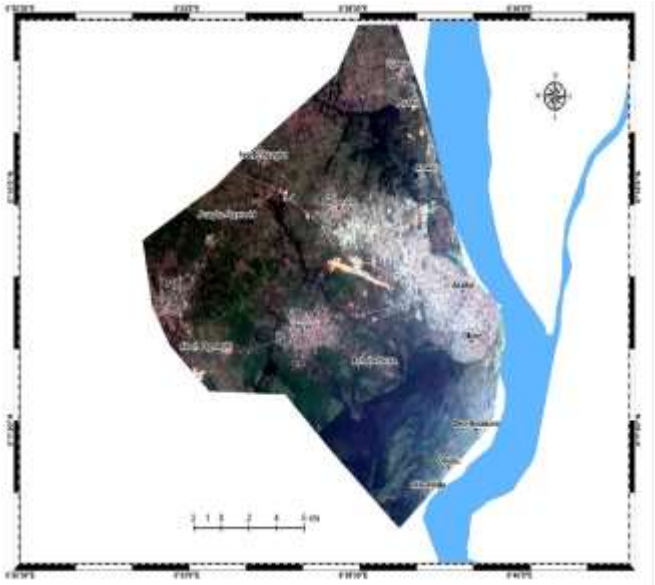

Figure 5: Land Use Patterns in the Study Area for the Year 2011.

Analysis for the year 2011 showed very significant reduction in bare ground from 16% in 1990, to 0.27% in 2011. Most of the Land use was either vegetation, built-up or water (minimal). This reflects the already mounting pressure on land resources for construction purposes. The area covered by buildings significantly increased from 7% in 1990 to 14.4% in 2011 and 29% in the year 2020, indicating a higher percentage difference in growth of 14.6% between 2011 and 2020 compared to 1990 – 2011 (7.4%) within the same 10-year interval.

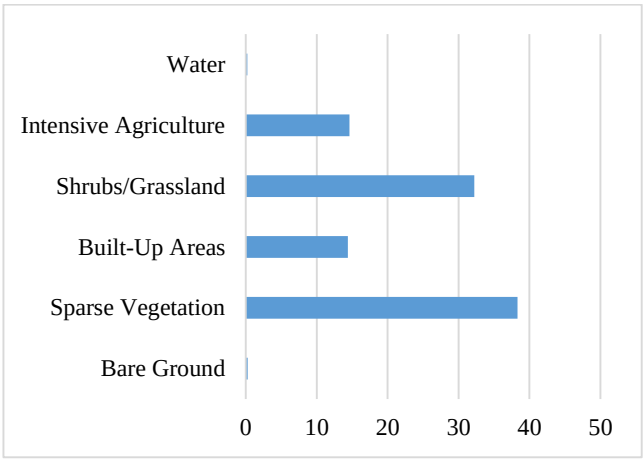

Figure 6: Pictorial Presentation of Land Use Patterns in the Study Area as at 2011.

In 2011, the area covered by shrubs/grassland reduced to 32.2%. This may not appear significant as it means only 1.1% increase in land area, but there was a very sharp decline in the area covered

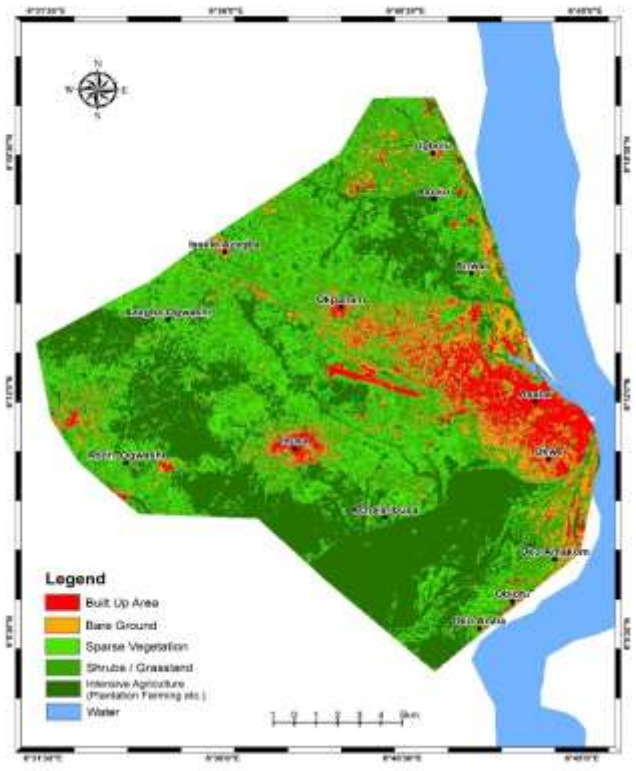

Figure 7: Land Use Patterns in the Study Area as of 2011.

by shrubs/grassland, in addition to a very sharp decline in farmland areas during the period. Also, as can be observed in figure 7, there was an increased spread of built-up areas (coloured red).

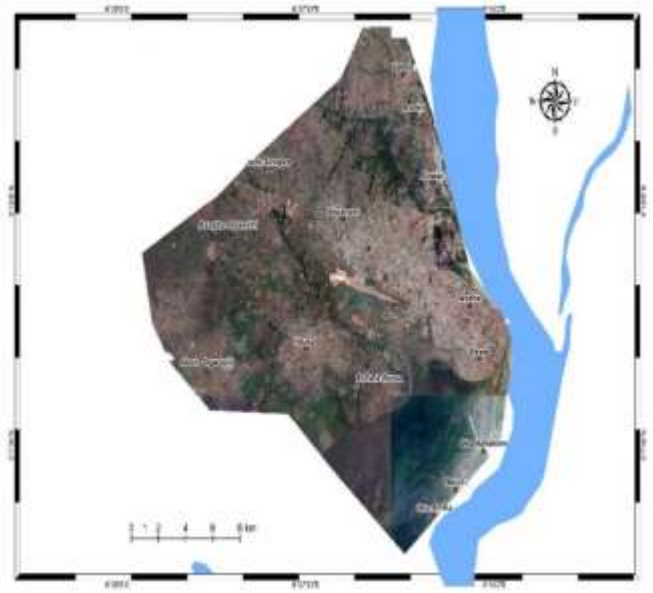

Figure 8: Land Use Patterns in the Study Area for the Year 2020.
Source: Sentinel 2B (MSS, TM), 9.50am 28th April 2020.

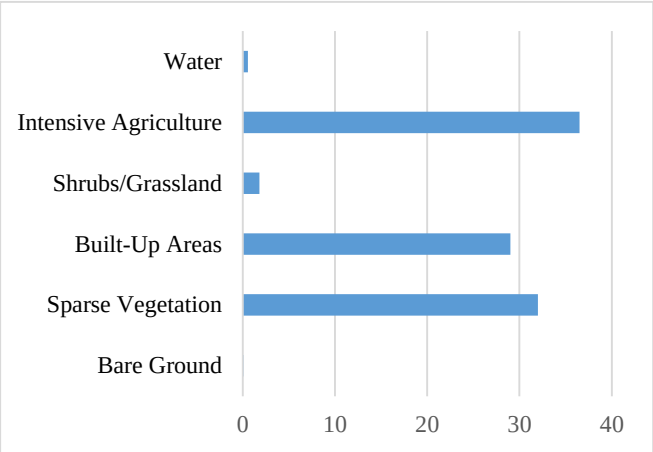

Figure 9: Pictorial Presentation of Land Use Patten in the Study Area as at 2020.

Figures 8 and 9 show satellite image acquired using Sentinel 2B (MSS, TM) and a bar-chart which depicts the distribution of land use in the study area as at the year 2020. Figure 9 (data in Table 4) shows that built-up areas have passed the 25% mark. It also shows the near absence of bare ground, as land cover was either vegetation or built up. The total built-up area at this time, 29 years after the creation of state capital in Asaba, was 29% of land available in the study area. The analysis shows that in the year 2020, a greater portion of the land area was developed (built-up), compared to the previous years. There was hardly any part of the land that was left bare or undeveloped. Land was either developed (built-up) for residential and industrial use or used for agriculture – crop and plantation. Intensive Agriculture (Plantation Farming etc.) also spiked in the year 2020, indicating increase in urban agricultural activities such as the use of swampy flood plains for plantation agriculture (e.g. plantain plantation), vegetable farming and oil palm plantation.

Figure 10 shows a greater clustering of built-up areas within Asaba and also the emergence of towns outside the Capital City, particularly in Ibusa, Okwe, and Okpanam. Other emergent towns include Issele-Azagba and Ogwashi. This observation was better appreciated during the ground truthing exercise. The same areas are places where many people who work in the state capital live. The area also provides a good environment for the establishment of industries, markets and shopping malls.

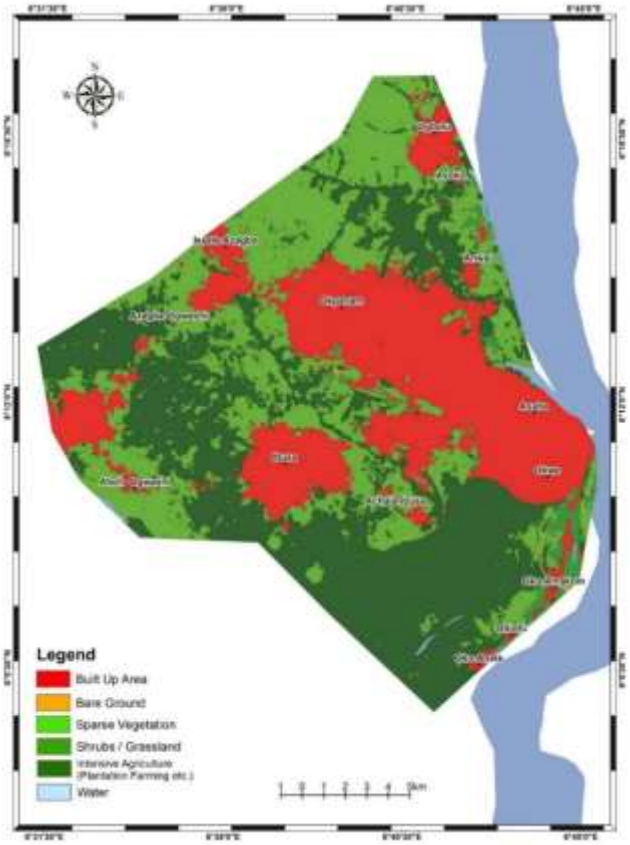

Figure 10: Land Use Patterns in the Study Area as at 2020.

The variation in the spread of land cover is further explained by the graph presented as Figure 11. A close look at Figure 11 shows that the area which constitutes bare ground or undeveloped land decreased significantly immediately after the creation of the state capital in Asaba, but the area covered by water remained significantly unchanged for the entire period from 1990 to 2020. In the same vein, built-up areas and areas covered by Intensive Agriculture (Plantation Farming etc.) progressively increased from what they were in 1990, through 2011 and 2020.

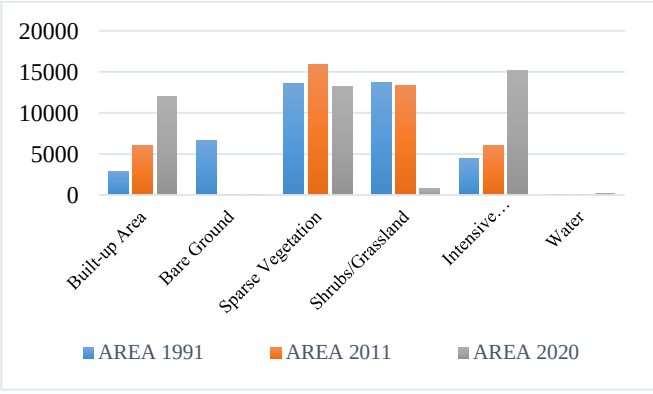

Figure 11: Comparison of Different Classes of Land Use – 1990, 2011 and 2020

TEST OF HYPOTHESIS

H_0 – There is no significant change in land use before and after the establishment of Delta State Capital Territory (DSCT).

The H_0 which states that there is no significant change in land use before and after the establishment of Delta State Capital Territory (DSCT) was tested with the independent samples t-test at a 0.05 degree of confidence, and the results are presented in Tables 5 and 6. Table 5 shows that the number of undeveloped land area patches in the study area before the establishment of DSCT was 3,736 while that of the undeveloped land area patches after DSCT was created was 1,441. This implies that before the establishment of DSCT, there were several numbers of undeveloped lands, but these have since reduced by 2,295 patches after DSCT was established.

The mean quantity of undeveloped land areas before the establishment of DSCT was 1,026.328 acres and the mean quantity of undeveloped land areas after establishment of DSCT was 91.1025 acres. This shows that since the establishment of DSCT, there has been a decline in undeveloped lands in the study area. The difference in the means (before the establishment of DSCT and after the establishment of DSCT) in Tables 5 and 6 revealed that an average of 935.226 acres of undeveloped lands had been lost to development.

Table 5: Group Statistics for the Independent Samples Test of the Hypothesis

Group	N	Mean	Std. Deviation	Std. Error Mean
Before the creation of DSCT	3736	1026.3284986	14547.48382832	238.00410590
After the creation of DSCT	1441	91.1025205	341.54412200	8.99735435

Table 6 presents information for the test of hypothesis. The interpretation of the result provided by Levene's test reveals that $p<0.05$ with an F-value of 14.358. By implication, the significant value in the first section (Levene's test for equality of variances) of Table 6 is 0.001 and this is less than the degree of confidence of 0.05 upon which the hypothesis is stated making the test statistically significant at a 0.05 degree of confidence.

Table 6: The Independent Samples T-test for Validating the Hypothesis.

	Levene's Test for Equality of Variances		t-test for Equality of Means				
	F	Sig.	t	Df	Sig. (2-tailed)	Mean Difference	Std. Error Difference
Equal variances assumed	14.358	0.0001	2.440	5175	0.015	935.22597810	383.29028318
Equal variances not assumed			3.927	3745.663	0.0001	935.22597810	238.17411029

Hence, the null hypothesis of no significant difference is rejected. This means that there is a significant difference between the quantity of undeveloped lands before and after the establishment of DSCT. This result confirms that the establishment of DSCT resulted in the reduction of undeveloped land areas in the constituent communities of the capital territory. This was also shown by the second section of Table 6 where a positive *t*-value indicates that the mean of the first category (quantity of undeveloped land area before the establishment of DSCT) is significantly higher than the mean of the second category (quantity of developed land area after the establishment of DSCT).

In view of the foregoing analysis, it is concluded that there has been a significant change in land use before and after the establishment of Delta State Capital Territory.

Key informants who were heads of departments in the state's Ministry of Lands and Survey, Urban

and Regional Planning Board, Urban Renewal and the Delta State Capital Territory Development Agency, informed that there was no approved Master Plan for the Capital Territory. Instead, there are building regulations, laws and edicts that guide the operations of land developers within the capital territory. Land developers in the capital territory seek approval for building from the relevant government regulatory agencies. Monitoring activities by these government agencies subsequently reveal defaulters who are appropriately sanctioned, leading to the demolition of such unapproved/illegal structures.

In the same vein, anecdotal information given by heads of constituent communities who participated in the focus group discussion revealed that because of the increased building of residential houses, government facilities and infrastructure, the land size available to farmers in their communities had greatly reduced. Consequently, many farmers who lived in the constituent communities before the establishment of the capital territory had been displaced from their homes and farmlands.

Key Findings

1. The study shows that development had spread from the core of Asaba to other constituent communities of the capital territory namely Okwe, Okpanam, Issele-Azagba, Azagba Ogwashi, Ugbolu, Anwai, Achalla Ibusa, Ibusa, Oko-Anala, Oko-Amakom, Oko-Obiokpu and Aboh Ogwashi-Uku. This aligns with the findings of Ejaro and Abdullahi (2013), Ejemayovwi (2015), Enaruvbe and Atedhor (2015) in their study of land use and land cover change using GIS data acquisition and analytical methods in Suleja Niger State and Asaba, Delta State, respectively.
2. The study concurs with the findings of Ejemeyovwi (2015) who projected that Asaba would be crowded by the year 2020 and recommended that the government should provide incentives for growth in the surrounding communities to steer migration, private investments and industrialization activities away from the core of the state capital. This recommendation was addressed with the institution of Delta State Capital Territory Development Agency in 2015 by the Delta State Government. The Agency among other functions has the task of ensuring that Asaba and constituent communities of the capital territory are well planned, with effective infrastructure and clean and healthy environment. However, the absence of a Master Plan for the area and the long lag in the establishment of the Agency, left a gap in the planning and development of the Capital Territory. Development in the capital territory has been observed to be unorganised and makeshift, with adjustments made to correct physical land development errors. In spite of the various institutional provisions for the control of land use in the area, land developers seem to be monitored 'after the fact'. Demolitions are carried out only when buildings/structures lie on the path of government projects, or when there is need to clear the drainage system. A Master Plan would have ensured that all aspects of development of the proclaimed Delta State Capital Territory are factored into development of the area and would have also served as a guide for the statutory government agency that approves buildings and other structures in the area.
3. Findings from this research show that land in Delta State Capital Territory is under pressure as there are competing demands on land use by the State Government for public infrastructure, public utilities, public buildings and service amenities and private individuals who require land for farming, housing and commercial purposes.
4. Evidently, from the satellite images and the analyses carried out, there have been remarkable changes in land use in the capital territory from 1990-2020. Before the creation of Delta State in 1991, and the establishment of Asaba as the state capital, the study area as observed from the analysed high resolution multispectral satellite image showed that the area maintained the historical urbanization pattern with which it was identified. This implied that urbanization activities/built-up areas were concentrated along the banks of the River Niger, which was an old colonial trade route. Over time, beginning from 1991, the clusters of development spread from the shorelines of the River Niger to the outer borders of the state capital. This was in response to the increased need for development of housing units for migrants to

the State Capital, as well as the establishment of industries (see Plates 1 and 2).

5. Responses from key informant interviews and focus group discussions confirmed that the observed spread in development has taken place within the context of already existing socio-economic pressures in the constituent communities (for example Plate 3). Roads and drainages were constructed across the terrain to facilitate movement of man and materials for economic growth. Government constructed public buildings to boost administration of the Capital Territory and an agro-industry to boost the food processing value chain. However, in the course of these development activities, farmers were sometimes forced to harvest food crops prematurely to give way to government projects, while ancestral land with cultural heritage was either taken over/acquired by government or sold to private investors by other family members.
6. The intensified demand for land to build residential buildings led to over-run of bare ground or undeveloped rural lands to the extent that private buildings were sited underneath major electricity transmission routes, and around the waste treatment facility (Plates 3 and 4).
7. The observed drastic reduction of bare ground is an indication of land scarcity which has led to encroachment of forest reserves that had remained relatively untouched in the entire 30-year period. This also suggests that land was being put to more functional use such as building of residential, industrial and educational facilities.
8. Intensive Agriculture (Plantation Farming etc.) which is represented by urban agricultural activities such as plantation farming of cassava, oil palm and plantains, increased from 10.8% in 1990 to 14.6% in 2011, and to 36.5% in 2020, well indicating productive human activities over the years. This can also be attributed to increased human activities in the swampy areas to take advantage of the soil and moisture characteristics which favours vegetable farming and plantain plantation, both hallmarks of urban agriculture.
9. Oral historical accounts from key informants such as government officials corroborate findings from the satellite image analysis. The narrative was that Asaba was a relatively small peaceful town with moderate levels of socio-economic activities which mostly existed to serve the needs of residents only. At this period, key informants reported that land use in the pre-capital period was less complex and rural-based, with a great deal of natural areas and undeveloped lands or bare grounds. In the same vein, farming activities were carried out outside the clusters of residential buildings.
10. The absence of a master plan for Delta State Capital Territory, has resulted in haphazard development with irregular land use patterns. Development of infrastructure and housing in Asaba the state capital, has been in phases. In fact, there are six (6) phases of the Government Reserved Area (GRA) in Asaba; phase I, phase II, phase III, phase IV, phase V and phase VI (please see figure 12). This may be attributed to spontaneous forms of development that has taken place in the area over time, predicated on the dearth of substantial land space in the urban core for the GRA.

Figure 12: Six (6) Phases of Government Reserved Area (GRA) Located in the Capital Territory.

Plate 1: Steel Mill Located in the Capital Territory.
Source: Field Work, 4th April 2022

Plate 2: Steel Mill Located in the Capital Territory.
Source: Field Survey, 4th April 2022

Plate 3: Houses Built Along the Grid-Line of Transmission Company of Nigeria, Reflecting Scarcity of Land in Asaba.
Source: Field Survey, 29th April 2022

Plate 4: Waste Treatment Facility in the Capital Territory
Source: Field Work, 4th April 2022

CONCLUSION

This research offers a unique contribution by combining a 30-year temporal analysis with a triangulated approach that integrates GIS data and qualitative surveys, including key informant interviews and focus group discussions. This methodological triangulation provides a comprehensive understanding of the spatial and temporal dynamics of urban development in the Delta State Capital Territory. Both GIS analysis and qualitative data converge on the conclusion that significant land use changes have occurred, with urban development extending from Asaba to the surrounding constituent communities. This expansion has increased pressure on rural agricultural lands and contributed to the rise of urban agriculture. Land use patterns are shifting from large undeveloped areas to built-up and intensively farmed zones, heightening competition for land, which in turn poses risks for unsustainable urbanization, urban decay, land degradation, and environmental decline. The urbanization process in the Delta State Capital Territory deviates from the Growth Centre theory due to imperfections in the spread of development from the capital city to its surrounding communities, suggesting that the theory should be contextually adapted in similar urban studies.

Recommendations

1. A comprehensive Master Plan should be developed and implemented for sustainable urban growth in newly emerging urban areas to prevent disorganized development and mitigate issues such as flooding, erosion, and other environmental challenges.

2. In areas like the Delta State Capital Territory, where development has progressed without a Master Plan, existing building, environmental, and public health regulations should be rigorously enforced to maintain spatial order and prevent environmental degradation.
3. To address the increased land pressure in the constituent communities, policies promoting intensive agriculture should be adopted to protect the agricultural economy and the livelihoods of traditional farmers.
4. Land zoning and land use planning should be integrated into the urbanization process to promote socially desirable land use patterns, optimize land space management, and ensure long-term sustainability.

Future research should focus on developing context-specific approaches to applying the Growth Centre theory, particularly in understanding urbanization processes within diverse regional contexts.

Declaration of Interest: The authors declare that there is no conflict of interest in the publication of this paper.

Data Availability Statement: Information and required data for the study was satisfactorily provided by the relevant government agencies, Heads and members of the constituent communities of the capital territory**.** Satellite imagery data in this study are available from web-based resources provided by the US Department of Geological Surveys, and Copernicus.

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