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PATTERN OF SPRAWL DEVELOPMENT ALONG THE ABUJA – KEFFI HIGHWAY CORRIDOR IN THE NORTH CENTRAL NIGERIA

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Abstract

The rapid expansion of urban areas worldwide is widely attributed to the growth of urban populations. The objective of this study is to examine the expansion of urban sprawl in the North Central area of Nigeria, specifically along the Abuja-Keffi highway corridor, over 29 years, from 1991 to 2020. The study utilized satellite imagery from three distinct spatiotemporal intervals (1991–2003, 2003–2015, and 2015–2020) and incorporated three different types of Landsat sensors, namely Enhanced Thematic Mapper (ETM), Enhanced Thematic Mapper Plus (ETM+), and Operational Land Imager (OLI). The study employed image processing and land use classification analysis techniques to generate land use and land cover (LULC). The analysis of the data reveals that there has been a significant increase in sprawling development along the Abuja-Keffi highway corridor. The built-up area of the region has undergone significant expansion over the past three decades, with the urbanized land area increasing from 1081.98 hectares (4.96%) in 1991 to 10263.15 hectares in 2020, accounting for 47.06% of the total built-up area. The research also documented two distinct forms of urban growth, specifically linear and leapfrog, throughout the corridor. The research recommends regional urban policy, urban growth boundaries as well as effective and efficient development control mechanisms in the selected settlements along the corridor. The Abuja Municipal Area Council and Karu Local Government are urged to promote urban renewal and infrastructure development through private partnerships, sustainable policies, waste management systems, and community engagement.

***Keywords**: Land Use, Land Cover, Urban Sprawl, Urban Growth*

1. Introduction

The rapid development and spread of urban areas worldwide, particularly at urban fringe areas, is a major factor contributing to the unprecedented rate of urban sprawl. The UN Population Division projected that 55% of the world's population lives in urban areas, with

35% of the projected growth between 2018 and 2050 being in notably few countries like China, India, and Nigeria (United Nations, 2018). Urban sprawl is characterized by unplanned and uneven growth patterns, driven by various processes, leading to inefficient resource utilization (Chandana *et al.*, 2012).

Lower-developed countries, particularly Nigeria, are experiencing rapid urbanization, leading to changes in land-use and land-cover. This growth is causing unplanned and uncontrolled growth in major towns, particularly at the urban fringe (Aguda. & Adegboyega, 2013). This growth presents opportunities for beneficial linkages between urban, suburban, and rural activities, but also presents challenges such as informal and squatter settlements in the suburbs (Ruhiiga, 2013).

The impacts of land use and land cover change have shifted from significant to threatening levels over the years, with anthropogenic activities in most towns and cities explaining the extent of these changes. The loss of natural vegetation and agricultural land, as well as land cover changes, results in a shortage of food production and environmental degradation (Dewi and Ekadinata, 2010). Land-cover changes account for approximately 30% of anthropogenic carbon dioxide efflux, making it the second largest driver of anthropogenic carbon dioxide efflux after fossil fuel burning (Robinson *et al.*, 2010).

Previous efforts in understanding urbanization processes and land use dynamics in Nigeria have primarily been descriptive, with no quantitative techniques capable of achieving sustainable urban development strategies (Mahmood *et al.*, 2010; Minale and Rao, 2011). Remote Sensing and Geographical Information Systems (GIS) are dynamic tools that can monitor and predict geospatial changes, environmental quality, and unprecedented urban expansion. These tools can detect, identify patterns, map, forecast, and monitor land use dynamics in the study area, providing a more reliable and effective approach to understanding urbanization and land use dynamics.

Urban sprawl poses a significant challenge for urban planners in developing development proposals. Predicting and controlling urban sprawl is difficult due to limited data. This study aims to analyze and establish the pattern of urban sprawl along the Abuja-Keffi highway growth corridor in Nigeria, focusing on the period between 1991 and 2020. The study covers FCT and Nassarawa state, including Nyanya, Mararaba, Koroduma, Ado/New Karu,

New Nyanya (Gwandara), and Masaka. The fast-emerging urban corridor along FCT Abuja-Keffi road, which spans 14.103 km, was understudied.

2. Materials and method

2.1. Study Area

This study investigates the highway corridor located in Abuja-Nasarawa State, the capital city of Nigeria. The corridor is positioned between latitudes 8° 25' and 9° 25' north of the Equator, and longitudes 6° 45' and 7° 45' east of Greenwich. Nasarawa State, situated in the northern central region of the country, exhibits a tropical zone climate and encompasses a land area of 27,137.8 square kilometres (NPC, 2018). The projected population of the state is estimated to be 2,679,415 individuals, as reported by the National Population Commission in 2018. The study area is seeing significant expansion as a result of its strategic positioning within the Federal Capital Territory (FCT), Abuja, and Nasarawa State. The region under consideration is characterised as one of the most expansive urban development agglomerations in the north-central part of Nigeria.

Additionally, it is recognised as one of the places experiencing rapid growth on a worldwide scale (Rikko, 2013). The significant expansion of the FCT, Greater Karu Urban Area (GKUA), and other settlements can be linked to the prevailing belief among individuals that these areas offer superior career prospects and living conditions compared to other cities in Nigeria. The research area encompassed the region extending from Nyanya, a suburban area situated in the Federal Capital Territory's AMAC area council, to Masaka in Nasarawa State, which is located around 20 km away from the central district of Abuja. Nyanya, like to the majority of districts within the Federal Capital Territory (FCT), was a settlement predominantly inhabited by the Gwari ethnic group.

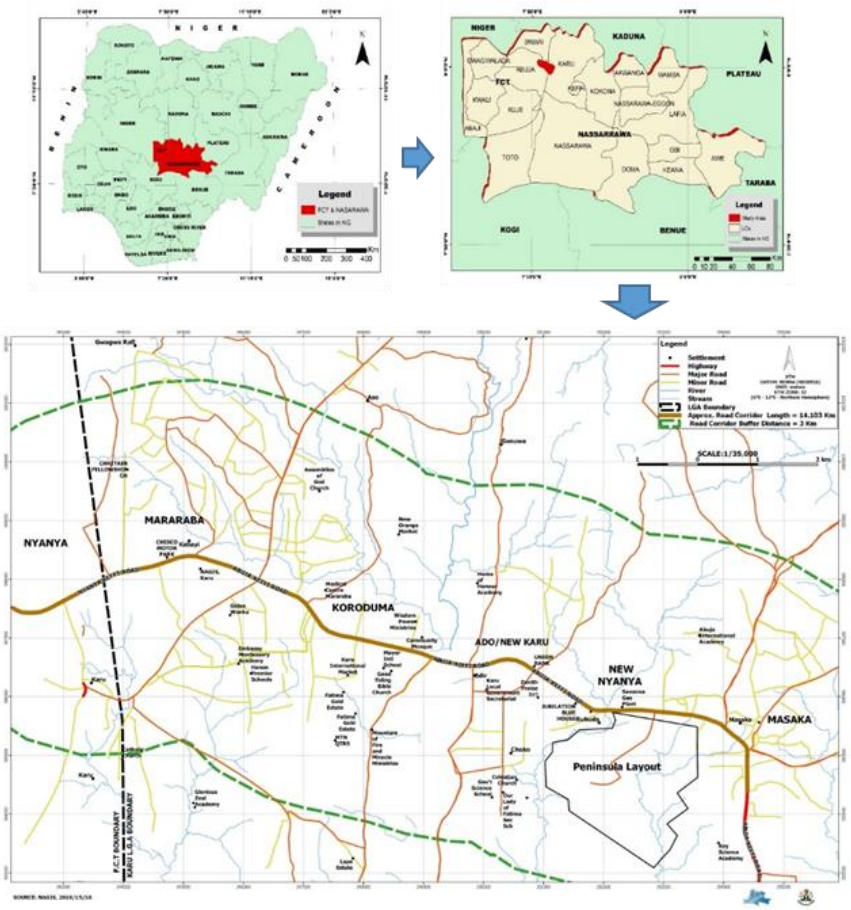

Figure 1. Abuja -Keffi Highway Corridor
Source: NAGIS, 2019.

2.2. Methods

The study utilised geospatial data from Landsat ETM, Landsat ETM+, and Landsat OLI, obtained from the United States Geological Survey (USGS) and the National Centre for Remote Sensing (NCRS), Jos. The data underwent image processing and land use classification analysis to create land use/land cover (LULC) maps for three different time periods (1991-2003, 2003-2015, and 2015-2020). These maps were used to assess the extent and pattern of urban sprawl in the study area. Additionally, the LULC maps from 1991 and 2020 were processed using CA-Markov land use modelling techniques in IDRISI TerrSet Land Change Modeller (LCM) to predict future urban growth trends in the area.

3. Results and Discussion

3.1. Land use and Land cover (LULC) Change (1991 – 2020)

Table 1 presents the results of the Land Use and Land Cover (LULC) analysis conducted along the Abuja-Keffi highway corridor in 1991. In 1991, the most common land use category in the study area was Vegetation, covering 10127.88 hectares (46.44%) of the total area. The built-up area occupies only 1081.98 hectares, which accounts for 4.96% of the total area. In contrast, the bare ground occupies a significantly larger area of 7242.30 hectares, representing 33.21% of the total. The marshy area occupies 3354.66 hectares, making up 15.39% of the total area. The data indicates a clear division between settlements during this time period, with the towns and villages in the study area being notably small (see Figure 2). During this time period, the population was relatively small, and the inhabitants were main occupation was farming and engaging in other primary activities.

Table 1. Land Use and Land Cover between 1991 and 2020

Land use	1991		2003		2015		2020	
	Area (Ha)	(%)	Area (Ha)	(%)	Area (Ha)	(%)	(Ha)	(%)
Built-up Area	1081.98	4.96	5112.27	23.44	8896.76	40.8	10263.2	47.06
Marshy Area	3354.66	15.39	3298.77	15.13	3242.63	14.87	3051.09	13.99
Vegetation	10127.9	46.44	7507.35	34.43	6479.45	29.71	3422.61	15.7
Bare Ground	7242.3	33.21	5888.43	27	3187.98	14.62	5069.97	23.25
Total	**21806.8**	**100**	**21806.8**	**100**	**21806.8**	**100**	**21806.8**	**100**

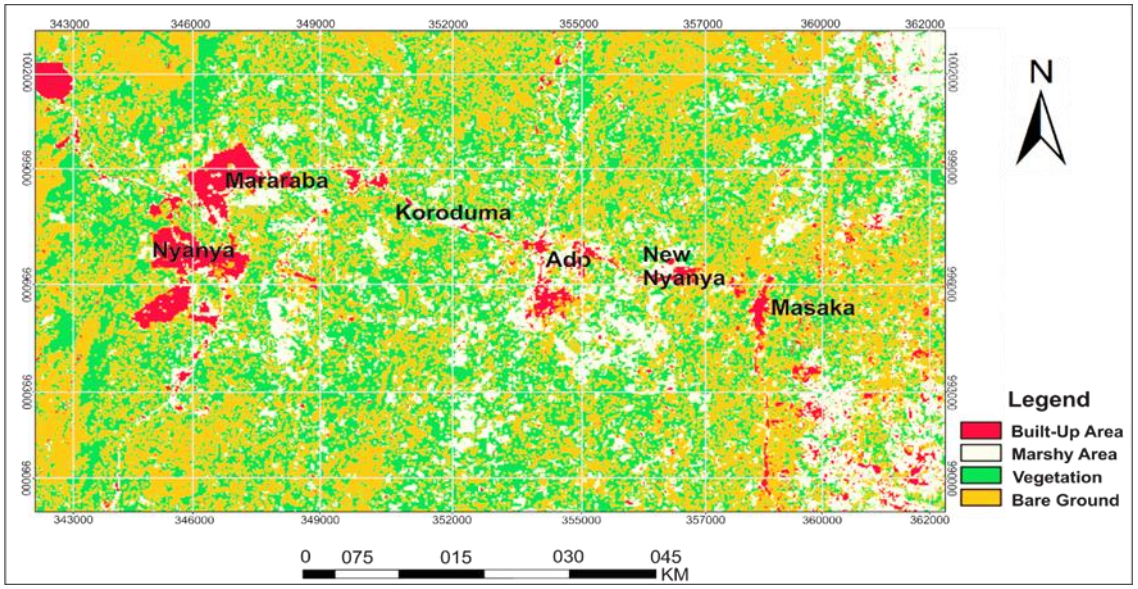

Figure 2. Classified land use/ land cover map of study Area, 1991

In 2003, the Abuja - Keffi highway corridor had a significant amount of vegetative cover, occupying the highest class with 7507.35 hectares, which accounted for 34.43% of the total area. In the given year, the built-up area accounted for 5112.27 hectares, which represents 23.44% of the total area. The marshy area covered 3298.77 hectares, which represents 15.13% of the total area. On the other hand, the bare ground accounted for 5888.43 hectares, making up 27.00% of the total area. During this time period, there was a significant rise in the overall size of settlements, as indicated by the expanding effect observed along the road corridor. This led to the gradual formation of a conurbation, as depicted in Figure 3.

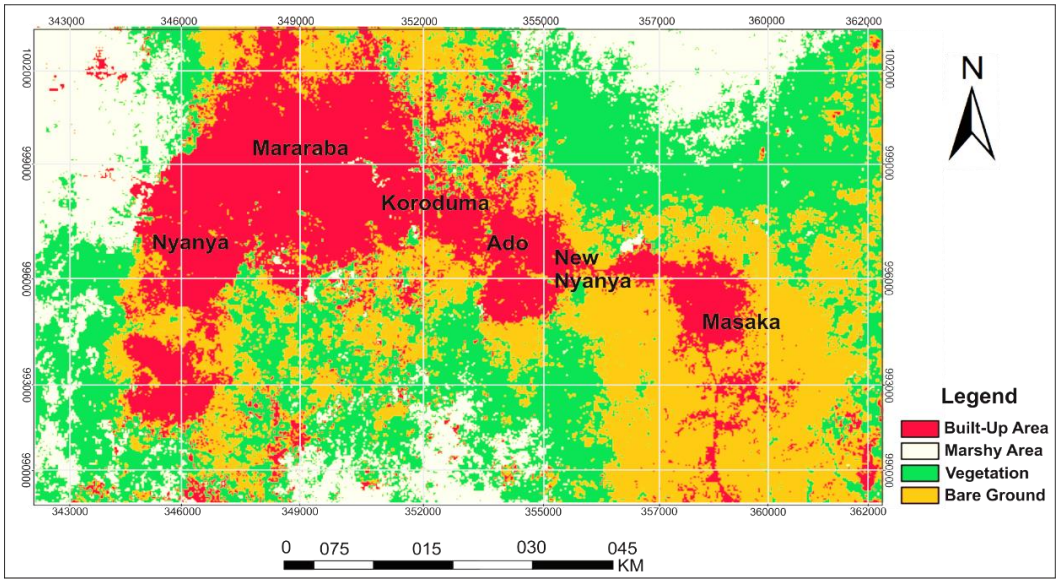

Figure 3. Classified land use/ land cover map of study Area, 2003

The result of LULC along Abuja – Keffi highway corridor in 2015 showed further increase in the extent of built-up area covering 8896.76 hectares (40.80%) of the total area in 2015. Marshy area declined to 3242.63 hectares (14.87%). Vegetation area covered 6479.45 hectares (29.71%), while Bare Ground accounted for 3187.98 hectares (14.62%) of the total area in 2015 as presented in Figure 4. The further increase in the Built – up Area from 5112.27 hectares in 2003 to 8896.76 hectares representing 315.37 hectares annual change accounting for 74.03% change in the Built-up Area. This transition is less compared to first spatio-temporal period (1991-2003) which witnessed 372.49% (4030.29 hectares) increase. On the other hand, Vegetated areas decreased from 7507.35 hectares in 2003 to 6479.45 hectares in 2015, denoting 1027.9 hectares magnitude of change representing 13.69% change. Marshy Area and Bare Ground also experienced a reduction in total area between the two periods.

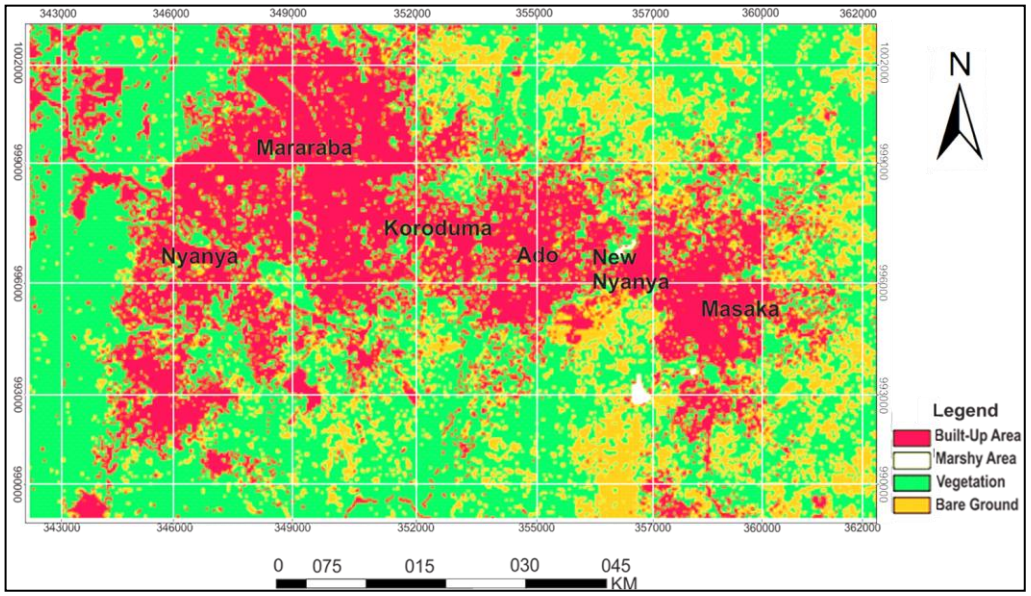

Figure 4. Classified land use/ land cover map of study Area, 2015

The LULC extent along Abuja – Keffi highway corridor in 2020 showed further increase in the extent of Built - up Area covering 10263.15 hectares representing 47.06% of the total area in 2020. Marshy Area has also increased to 3051.09 hectares representing 13.99% of the total area. Vegetation show a decline in coverage to 3422.61 hectares (15.70%), while Bare Ground accounted for 5069.97 hectares (23.25%) of the total area in 2020 as presented in Figure 5.

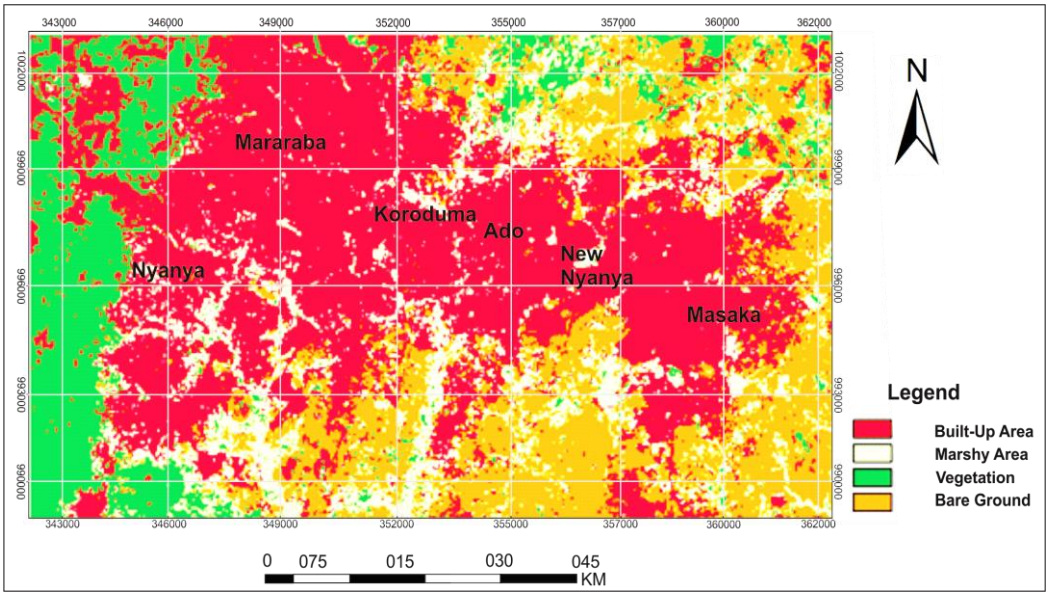

Figure 4. Classified land use/ land cover map of study Area, 2020

3.1.2. Settlement Growth Rate between 1991 and 2020

The utilisation of the settlement growth rate serves as a valuable proxy for examining the rate at which urban development and population distribution are expanding within the designated study area. According to the data presented in Table 2, the Built-up Areas or urban development in the study area experienced a significant increase of 4030.29 hectares between 1991 and 2003, indicating a growth rate of 31.04%. In the second spatio-temporal period (2003-2015), the Built-up Areas experienced an increase of 3784.49 hectares, indicating a growth rate of 6.17%. Subsequently, between 2015 and 2020, the Built-up Areas saw an increase of 1476.39 hectares, with a growth rate of 3.36%. According to the results, there has been a significant increase in the average annual growth rate of physical development along the corridor over a 29-year period (1991 to 2020). The growth rate amounted to 9181.17 hectares, representing a growth rate of 29.26%.

Table 2. Settlement Growth rate (1991 – 2020)

Spatio-Temporal periods	Magnitude of change (Area in hectare)	Annual Growth rate (%)
1991 – 2003	4030.29	31.04%
2003 – 2015	3784.49	6.17%
2015 – 2020	1476.39	3.36%

Spatio-Temporal periods	Magnitude of change (Area in hectare)	Annual Growth rate (%)
Average Growth Rate (1991-2020)	9181.17	29.26%

3.1.3 Pattern of Urban Sprawl in the Abuja – Keffi Highway Corridor (1991-2020)

The urban sprawl pattern for settlements along the Abuja-Keffi highway corridor between 1991 and 2020 was examined to determine the physical development along the corridor. In 1991, urban sprawl mostly exhibited low-density expansion in the form of linear or strip patterns along the corridor, including Nyanya, Mararaba, Koroduma, Ado/New Karu, New Nyanya, and Masaka settlements as shown in figure 6. However, some dispersed, leapfrogging developments were observed in the far hinterland of road development, mainly in the southern Mararaba and Masaka axes, heading towards Kuchikau settlement. The pattern of sprawl in 1991 primarily followed the Abuja-Keffi highway outward from urban cores, resulting in well-developed land areas adjacent to the corridors and sparsely built-up areas without direct access and undeveloped areas.

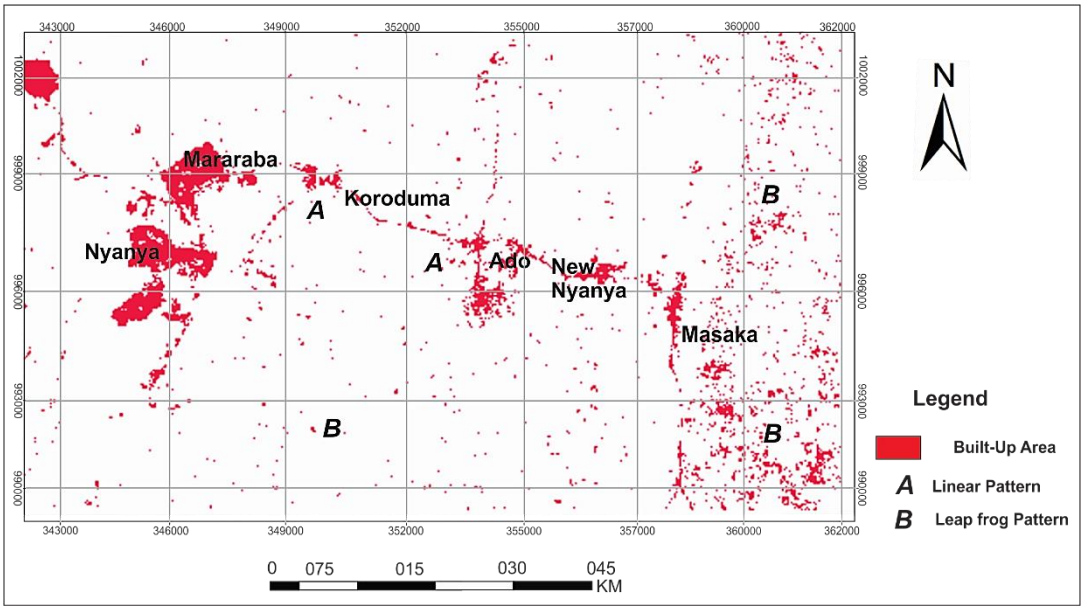

Figure 6. Sprawl Pattern along the corridor in 1991

In 2003, urban sprawl along the Abuja-Keffi highway corridor was observed, revealing a spatial increase in built-up areas and intense development. The pattern of sprawl development in the area consists of dense and compact developments, forming conurbations among settlements.

Nyanya, Mararaba, Koroduma, Ado/New Karu, New Nyanya, Masaka, and Kuchikau along the highway corridor have grown and expanded, forming conurbations (Junaid *et al.*, 2020). The spatial characteristics of urban sprawl along the highway corridor relate to the patterns and dynamics of land development. Nyanya expanded southward, forming Jukoyi, Kpeyi, and Kurudu settlements, while Mararaba extended northward, forming Kabiyi settlements. Additionally, leapfrogging development was identified in the north-east part of Mararaba, Southern Nyanya, Koroduma, Ado/New Karu, New Nyanya, and eastern Masaka. Settlements such as Gwagwa Rafi, Karu, Jikoyi, Kpeyi, Rubuda, Kuchikau, and Uke also experienced leapfrogging development during the study period as presented Figure 7.

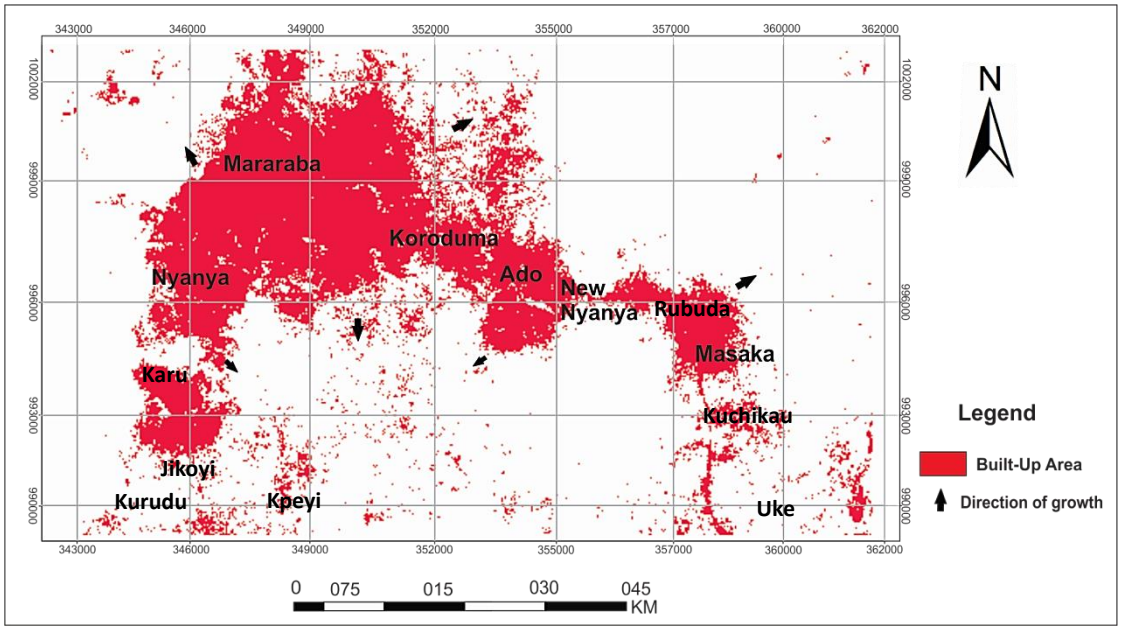

Figure 7. Sprawl Pattern along the corridor in 2003.

In 2015, urban sprawl in the study area revealed expansion and densification of spaces, with Ado/New Karu, New Nyanya, and Masaka experiencing conurbation (see Figure 8). However, at the peripheries, urban expansions reflected a leapfrog pattern of new developments around Masaka, Rubuda, New Nyanya, and Ado/New Karu areas. Koroduma is expanding southward, forming a conurbation with Gidan Waziri, while northern Koroduma has urban development extended to Kabusu. Masaka has expanded northward, forming conurbations with Sabon Rabu, Kunjipa, and Gidan Rago. In the southern part of Masaka, physical development has extended to Kuchikau and Auta Balefi. Settlements like Mararaba, Koroduma, Ado, New Nyanya, and Masaka have experienced expansion and further densification of physical developments. The

observed leapfrog sprawl was caused by inexpensive land on the outskirts of towns and a lack of effective development control mechanisms (Rikko *et al.*, 2012; Laraba and Shola, 2013; Dekolo *et al.*, 2015). The Federal Government's restoration of the Abuja Master Plan between 2003 and 2015 led to forceful evictions and strict planning regulations, causing a massive influx of people from the federal capital city to emergent areas along the Abuja-Keffi highway corridor (Jibril, 2014).

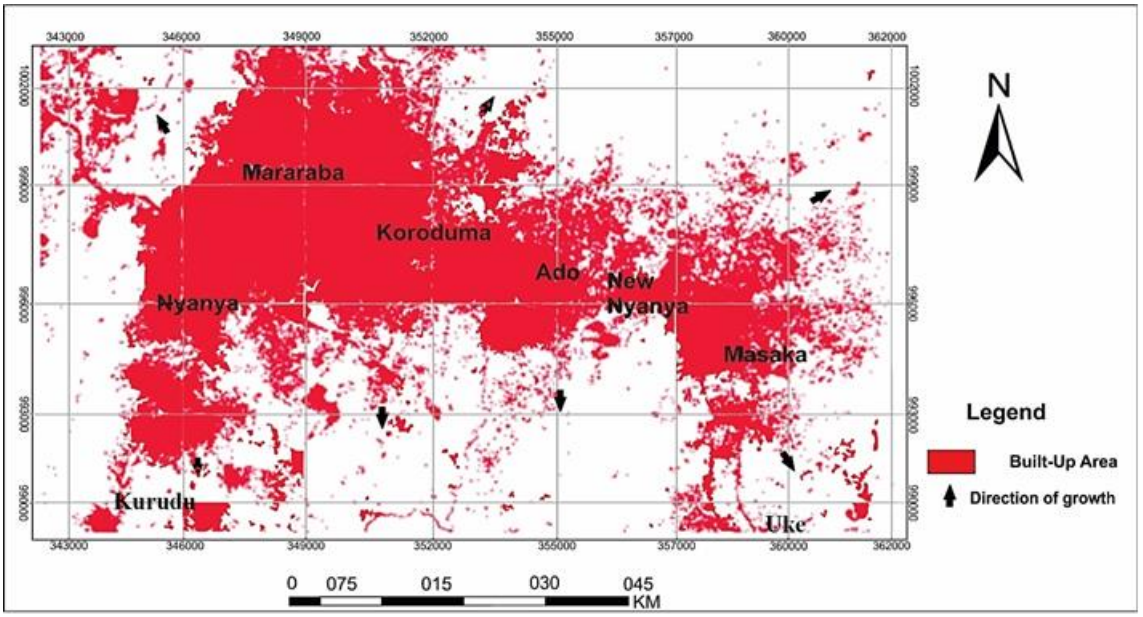

Figure 8. Sprawl Pattern along the corridor in 2015.

Figure 9 displays the 2020 sprawl characteristics in the Abuja-Keffi highway corridor, revealing continuous intensification and densification of development. Nyanya, Mararaba, Koroduma, Ado/New Karu, New Nyanya, and Masaka settlements have fully densified and merged, forming a conurbation that rapidly extends outward. Nyanya is expanding southward, merging with Jukoyi, Kpeyi, and Kurudu settlements, while Masaka has expanded southward and merged with other settlements. Nyanya, Mararaba, and Koroduma have only increased the density of development and the number of people living in those settlements through gentrification.

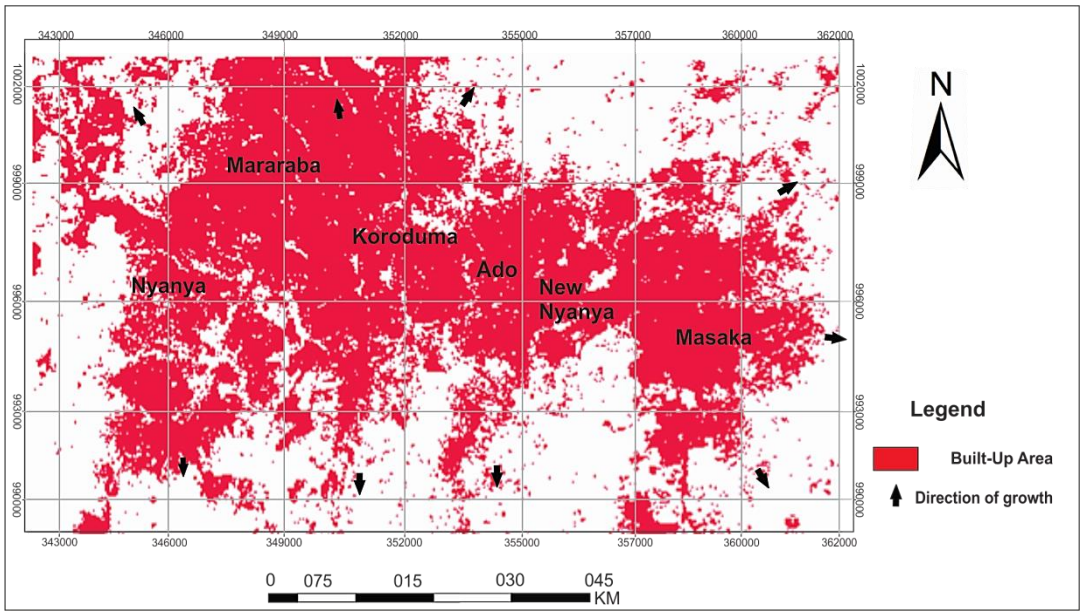

Figure 9. Sprawl Pattern along the corridor in 2020.

In overall, the period from 2015 to 2020 witnessed substantial growth and development in the Abuja-Keffi corridor, resulting in the emergence of a cosmopolitan region. These settlements served as residential areas for individuals engaged in entrepreneurial activities, as well as a significant proportion (over 60%) of individuals with low- and medium-income occupations in sectors such as construction, labour, and service provision (UN-Habitat, 2012; Ejaro & Abubakar, 2013). The findings of this study demonstrate a consistent and discontinuous trend of urban growth along primary transportation routes since 1991. This expansion has persisted and intensified, resulting in the formation of a closely connected network of cities and villages by the year 2020.

4. Conclusion

The present study has conducted an analysis to ascertain and establish the discernible pattern of urban sprawl along the Abuja-Keffi highway corridor during the time frame spanning from 1991 to 2020. As previously noted, there has been a significant and swift escalation in the rate of urban development along the corridor. The observed development patterns demonstrate both linear and leapfrog characteristics. The study proposes the establishment of a regional urban land use strategy supported by legal measures as a crucial step towards achieving sustainable and dynamic clustering of settlements along the Abuja-Keffi highway corridor. This policy aims to effectively manage and coordinate the growth and development along the

corridor. The implementation of urban growth boundaries throughout the corridor is necessary to regulate the expansion of urban development and facilitate the supply of fundamental urban services and infrastructure for the communities located along the corridor.

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