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SPECIAL ISSUE: CELEBRATING 20 YEARS OF GEOGRAPHY IN KADUNA STATE UNIVERSITY - ADVANCES AND FRONTIERS IN GEOGRAPHY

Analysis of the Spatial Growth of Dutsin-Ma Town, Dutsin-Ma Local Government Area, Katsina State, Nigeria

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ABSTRACT
Urban growth and expansion are among the most significant phenomena to study globally. This study examines the urban sprawl of Dutsin-Ma town, Dutsin-Ma Local Government Area of Katsina State, Nigeria, between 1990 and 2020. Three satellite images (Landsat ETM 1990, ETM+ 2010, and NigeriaSat-X 2020) provide data for analysts. Supervised image classification via the maximum likelihood algorithm was applied to the three images. Five land use classes were identified: built-up areas, vegetation, bare surfaces, rock-out crops, and water bodies. The results from the image data from the three different dates, that is, the 1990, 2010, and 2020 images, were merged as inputs to produce one image of the change detection results. Post-classification analysis was used to quantify the changes that took place during the study period. The findings revealed that there was a significant increase in built-up areas from 6.7 km^2 to 7.8 km^2 and 10.8 km^2 in 1990, 2010, and 2020, respectively. This represents a difference of 1.1 km^2 from 1990-2010 and 3.0 km^2 from 2010 to 2020, which indicates an overall increase of 61.20% in 2020, indicating that the area extent of Dutsin-Ma significantly expanded, leading to a decrease in agricultural land and vegetation within the period of study. The study recommends proper planning, layout, and monitoring of any kind of developmental activity, and environmental policies for resource sustainability.

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1 Introduction

Globally, the percentage of the total population living in urban areas has increased rapidly from 12 % in 1900 to 30 % in 1950 and to 56 % in 2020. This number is projected to grow above 68% by 2050 (United Nations, 2018). Since the end of 2008, more than half of the world's population has lived in urban areas, a trend driven by rapid urbanization in developing countries (Mendez et al, 2023). Like other anthropogenic–environment interactions, land cover changes respond to socioeconomic, political, cultural, demographic, and environmental conditions and are largely characterized by a concentration of humans (Samaila et al., 2024). Despite its small area coverage relative to the Earth's surface, dynamic urban growth processes, particularly the expansion of the urban population to a relatively large extent and urbanized areas, have a significant impact on the natural and human environments at all geographic scales (Abdullahi et al., 2025).

Urban growth is the rate at which an urban area increases and expands in size, strength, technology, and population (Angel, 2023). An increase in the population of urban areas is generally the basis for urban growth. Urban development, coupled with technological advancement, innovation, and population increase in urban centres, has been recognized as a significant factor responsible for the influx of people into towns (Khan & Khan, 2023). This is because many people flock from rural areas within the region and other urban centers to search for employment and better living standards (Tacoli et al., 2015).

Today, urban growth worldwide is one of the most significant geographic phenomena. This is particularly true for developing countries such as Nigeria, where the number of urban centers has increased very rapidly over time (Rouhana & Bruce, 2016). In Nigeria, for example, the high rate of population growth is among the attributing factors responsible for urban growth (Auwalu & Bello, 2023). The major cities experiencing rapid growth include Lagos, Abuja, Ibadan, Kano, and Kaduna (Ofoezie et al., 2022). This has been a major concern to the government and policymakers because it has continued to overstretch the available resources and physical facilities. When properly managed, this process makes urbanization an essential building block of prosperity, accounting for 50–80% of the national gross domestic product (GDP) of most countries (Collier & Venables, 2017).

Dutsin-Ma town has experienced a rapid population growth rate due to the siting of a Federal University in 2011. It is growing without a plan, and the area has continued to expand, resulting in violations of land use regulations and the building of residential houses without planning permission. The recent growth of urban areas requires standard urban planning and the attention of planning authorities (Tanimu, 2014).

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In addition to this problem, newly developing areas do not have physical planning inputs, lack proper accessibility due to haphazard physical development, poor land use planning practices, poor drainage, and insufficient facilities and utilities, which have resulted in poor environments (Tanimu, 2014). There is also no urban growth management strategy to coordinate, control, and enforce development in a planned manner; therefore, it is necessary to provide a strategy for controlling the growth of Dutsin-Ma town for the effective development and sustainability of the area. The unguided nature of such growth tends to present many challenges for decision makers. Therefore, there is a need for an in-depth understanding of the pattern, trend, and direction of growth, which will serve as a guide for coordinating and managing such growth to intervene in the situation before it becomes worse.

The review of relevant literature revealed that a significant gap exists in the detailed, spatially explicit analysis of secondary towns undergoing rapid expansion due to specific institutional catalysts. Dutsin-Ma represents a critical location, where the establishment of the Federal University in 2011 has acted as a major driver of growth, yet its spatial dynamics remain unquantified and its planning implications unexplored in the academic literature. To address this gap, this study aims to analyze the spatial growth of Dutsin-Ma town between 1990 and 2020. The specific objectives are to:

i. Quantify the land use and land cover (LULC) changes, particularly the magnitude of change in built-up areas and other land cover classes.

ii. Determine the rate and spatial pattern (direction) of urban expansion across the study periods.

iii. Discuss the key drivers and the environmental and planning implications of the observed growth patterns.

This analysis will provide essential evidence to guide sustainable urban management and policy formulation for Dutsin-Ma and similar rapidly urbanizing towns.

2 Materials and Methods

2.1 Study Area

Dutsin-Ma LGA, Katsina State, between Latitudes 12° 27′18″ N to 12° 27′47″ N and Longitudes 7° 29′ 29″ E to7° 30′ 11″ E (Figure 1), and has its headquarters in the town of Dutsin-Ma. It is bounded by Kurfi LGA to the north, Safana and Dan-Musa LGAs to the west, Charanchi and Kankia LGAs to the east, and Dan-Musa and Matazu LGAs to the south (Salisu et al., 2025). The LGA has an area of 527 km² and a population of 169,671 as of the 2006 census, with Zobe Dam lying to the south of the town (Adesoji et al., 2023).

The region falls within the Sudan savannah agro-ecological zone, characterized by seasonal rainfall, moderate vegetation, and high evapotranspiration rates. The area experiences a tropical continental climate, with two distinct seasons: the wet season (May to October) and the dry season (November to April). Annual rainfall ranges between 700 mm and 1000 mm (Dahiru et al., 2026), which supports agricultural activities, including irrigation, particularly during the dry season. The surrounding communities rely heavily on the dam for farming, fishing, and domestic uses (Samaila et al., 2024). The inhabitants of this area are predominantly Hausa and Fulani by tribe. Their main occupation is farming and animal rearing.

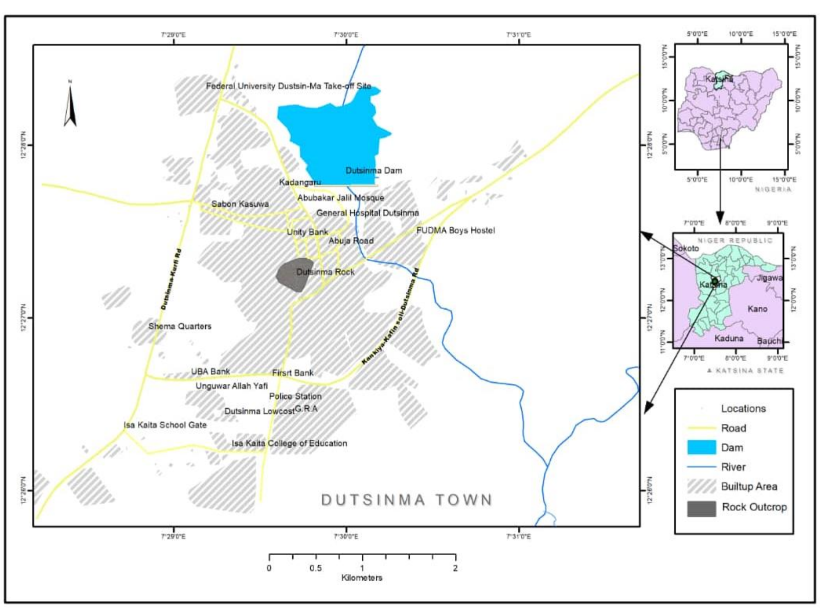

Figure 1: Dutsin-ma town
Source: Katsina State Geographic Information Service (KATGIS

2.2 Data Collection

Satellite imagery was obtained from the National Space Research and Development Agency (NASRDA). These include Landsat (Landsat ETM+ 1990, Landsat-7 ETM+ 2010). Details of the satellite images used are provided in Table 1.

Table 1: Characteristics of satellite images used

Sensor	Resolution (m)	Path/Row	Date	Cloud Cover (%)
Landsat TM	30	189/051	12-02-1990	0.00
Landsat ETM+	30	189/051	02-01-2010	0.08
NigeriaSat-X	22	-	28-01-2020	1.3

These were chosen because they provide only the necessary detail required and at no cost.

2.3 Image Processing

Geometric correction was carried out to re-project all the images to UTM Zone 32. Specifically, the Scanline error on Landsat 7 was corrected using the Focal Analysis on ERDAS Imagine 2014. Subsequently, the shapefile of the study area was used to extract the Area of Interest. All the images were resampled to 22 meters to have uniform spatial resolution.

2.4 Data Analysis

Supervised image classification was performed to identify and assign real-world thematic classes to the image pixels. In this study, image classification was performed in two stages: unsupervised and supervised classification. Unsupervised classification was performed first to determine the number of training sites used in the supervised classification. The ISOATA clustering algorithm in ERDAS Imagine 2014 was used to classify the images according to the number of classes required and the number of pixels available in the unsupervised classification method. The unsupervised classified images served as a reference and helped to understand the distribution of the number of different digital numbers.

In the random sampling method, each class has an equal number of pixels, which are compared with the corresponding pixels from each class in the image (Yang & Lo, 2002; Forman, 1995). In the accuracy assessment, the following metrics were calculated: the overall accuracy, the kappa coefficient, the user accuracy, and the producer accuracy.

The accuracy assessment was performed via a high-resolution satellite image from Google Earth, where random sampling was created in the classified images and saved in a KML file. The KML file was exposed to Google Earth, and identified each land cover to the respective points created; they extracted the value of each land cover at the particular points.

For the classification-based approach, supervised classification was performed on the 1990, 2010, and 2020 images for both test sites. The main advantage of using supervised classification is that it is able to produce the same number of classes for each set of images. The classifications were then combined to produce a map of all class transitions (ERDAS Imagine 2014). The transitions were then assigned colors, on the basis of the type of change that was occurring, and the final output image was produced. The maps clearly express the spatial coverage of settlements in 1990, 2010, and 2020.

To detect the changes in the spatial growth of Dutsin-Ma in different years, a post-classification comparison of the change detection techniques was performed. A comparison between the classified maps was subsequently carried out on a pixel-by-pixel basis. Furthermore, the percentage change was identified by showing the area in km^2 and the proportion represented by that area for each year (1990, 2010, and 2020). This is calculated using Equation (1).

$$\%\ \text{change} = \frac{\text{change in area}}{\text{total area}} \times 100 \quad (1)$$

Additionally, the growth rate of Dutsin-Ma was calculated for all classified land cover types for each period and added together to serve as the basis for calculating the growth rate, especially the growth rate using the standard percent change formula, given as Equation (2):

$$\text{Growth Rate} = \frac{\text{Current Year} - \text{Previous Year}}{\text{Previous Year}} \times 100\% \quad (2)$$

3 Results

3.1 Land use/landcover of Dutsin-Ma town (1990-2020)

Figures 2, 3, and 4 represent the land use and land cover maps of 1990, 2010, and 2020, respectively, which show the five different classes, with the built-up area being red, green for vegetation, blue for water bodies, yellow for bare land, and black for rock outcrops. Table 2 presents the land use/landcover of Dutsin-Ma town between 1990 and 2020 in square kilometers (km^2).

The accuracy assessment revealed that for the classified image of the 1990 image, the producer's accuracy was 91. 82%, and the user accuracy was 92.10%, whereas the overall accuracy was 92%, and the kappa coefficient value was 0.90 for the 1990 image; the producer accuracy was 91. 89%, the user accuracy was 92.20%, the overall accuracy was 92%, and the kappa coefficient value was 0.90 for the 2010 image. The producer’s accuracy for the 2020 satellite image was 89.10%, and the user's accuracy was 88.85%. The kappa coefficient of the accuracy result was 0.86, and the overall accuracy was 86%.

Following the supervised classification method, the three images were classified into five classes: built-up area, vegetation, bare land, water body, and rock outcrop. Figures 2, 3, and 4 show the different classes produced, while Table 2 shows the area covered by each class in each of the 1990, 2010, and 2020 satellite images.

A B

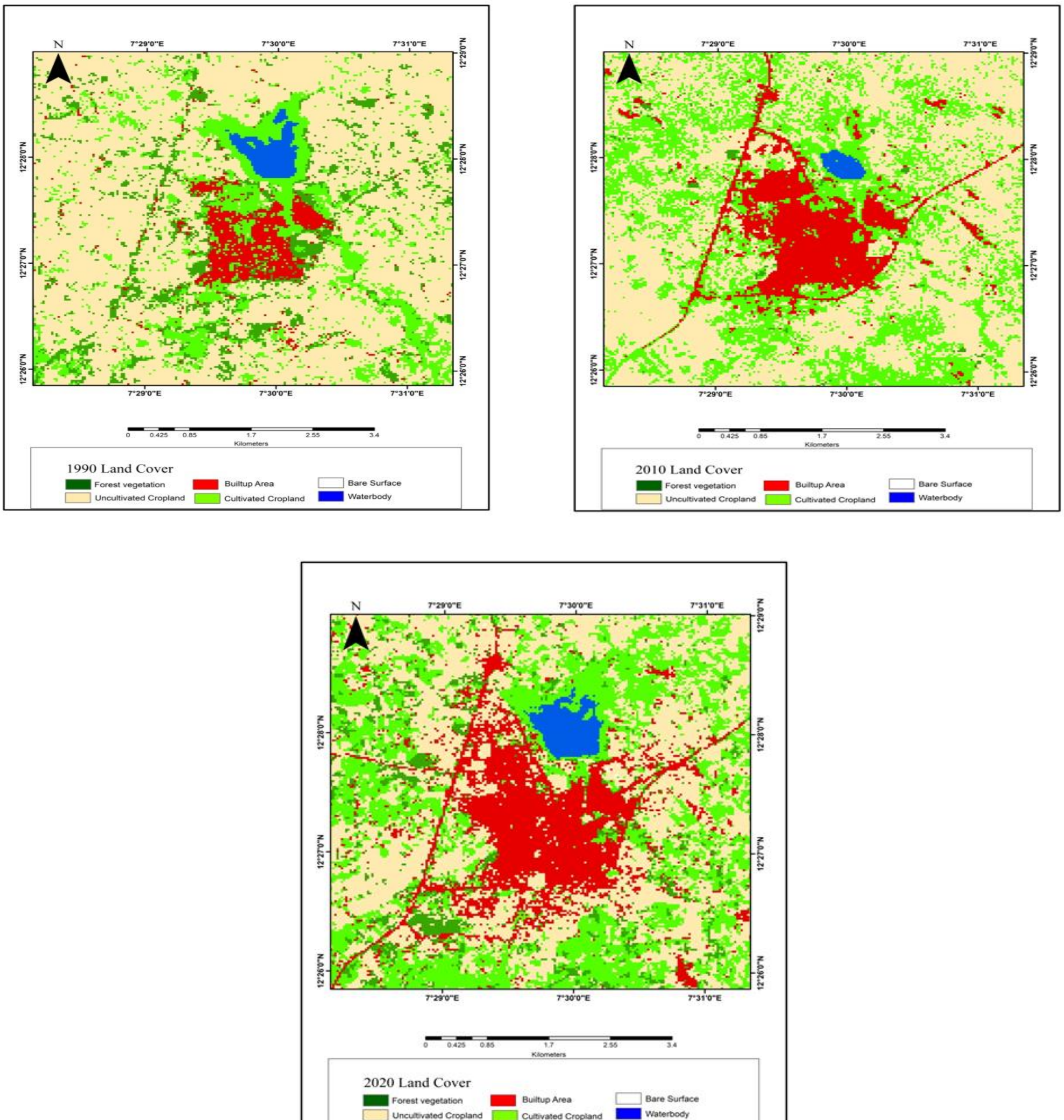

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Figure 2: Dutsin-Ma town land use/land cover: (a) 1990, (b) 2010, and (c) 2020

Table 2: Area Extents of Land Use/Land Cover of Dutsin-Ma Town (1990–2020)

Land use/land cover (Classified)	Area covered in 1990 (km^2)	Area covered in 2010 (km^2)	Area covered in 2020 (km^2)
Built-up area	6.7	7.8	10.8
Forest/Vegetation	9.4	8.7	5.6
Water body	0.7	0.6	0.7
Cultivated land	7.9	7.8	8.1
Rocky outcrop	1.2	1	0.7
Total area cover	25.9	25.9	25.9

The total land area of Dutsin-Ma town, shown in Figures 2, 3, and 4, is 25.9 square kilometers (25.9 km^2). Land use changes were observed to vary among classes from 1990 to 2020. For example, the built-up area changed and increased from 6.7 km^2 in 1990 to 7.8 km^2 in 2010 and increased to 10.8 km^2 in 2020. This means that the built-up area increased by 1.1 km^2 between 1990 and 2010 but by 3.0 km^2 between 2010 and 2020. Forest/vegetation, which was 9.4 km^2 in 1990, decreased to 8.7 km^2 in 2010 and further decreased to 5.6 km^2 in 2020, which means that there was a decrease of 0.7 km^2 between 1990 and 2010 and a decrease of 5.1 km^2 between 2010 and 2020. The results revealed that there was a great decrease in vegetation cover from 2010 to 2020 compared with that from 1990 to 2010. This means that the vegetation between these periods is being cut down to provide room for the expansion of Dutsin-Ma town.

Water bodies occupied an area of 0.7 km^2 in 1990, decreased to 0.6 km^2 in 2010 (a reduction of 0.1 km^2), and subsequently increased back to 0.7 km^2 in 2020 (a gain of 0.1 km^2 from the 2010 level). The cultivated land area decreased from 7.9 km^2 in 1990 to 7.8 km^2 in 2010, and increased to 8.1 $km^{2\ in}$ 2020. There was a small decrease in cultivated land between 1990 and 2010, losing 0.1 km^2, but it slightly increased by 0.3 km^2 from 2010 to 2020. Rocky outcrop areas decreased from 1.2 km^2 in 1990 to 1.0 km^2 in 2010 and further decreased to 0.7 km^2 in 2020. This shows that there was a greater decrease in rock outcrop area between 2010 and 2020 (0.3 km^2) than between 1990 and 2010 (0.2 km^2).

This pattern of built-up expansion and vegetation loss aligns with findings from a recent study in Kaduna Metropolis, which recorded a 121 km^2 increase in built-up area and a 192 km^2 loss in tree cover between 2003 and 2023, further underscoring the common trajectory of rapid urbanization in northern Nigerian towns (Musa & Abubakar, 2024). The results of land use/landcover changes reported by Mmaduabuchi et al. (2020) show that land use/landcover changes in Talata Mafara cultivated land increased from 117.00 km^2 to 158.20 km^2, the grass/shrub/thicket ratio decreased from 20.13 km^2 to 12.50 km^2, and the bare surface area increased from 5.38 km^2 to 27.13 km^2 between 1986 and 1995. This pattern is corroborated by a recent study of Funtua, another secondary town in Katsina State, which documented a 152% increase in built-up area between 1998 and 2018, primarily at the expense of vegetated and agricultural land, highlighting a common regional trajectory of rapid, consumption-driven urban sprawl in Nigeria's north-western urban centers (Koko et al., 2023).

In these studies, there is a similar trend of increasing built-up areas and bare land areas and a decline in vegetation cover and water bodies, which can be inferred to mean that at a global scale, there is increasing deforestation and bare surface areas. The built-up area in most of these studies is increasing, which appears to have corresponding land use/landcover (LULC) changes. This agrees with the fact that rapid urbanization is due to population growth, and rural urban migration, administrative towns, and economic growth have serious impacts on LULC changes and hence land degradation. Other anthropogenic activities, such as bush burning, overgrazing, intensification of land use activities, and deforestation for fuel wood and other land use patterns, also account for LULCC more than natural factors, such as desertification, climate change, and drought.

3.2 Change Detection

For this research, the type of change detection adopted was post-classification comparison between the three satellite images from 1990, 2010, and 2020, as presented in Table 3.

Table 3: Changes in land use/landcover in Dutsin-Ma town from 1990 to 2020

Classes	1990 (km²)	Percent	2010 (km²)	Percent	2020 (km²)	Percent	Change between 1990 and 2010	Change between 2010 and 2020
Built-up area	6.7	25.87	7.8	30.12	10.8	41.70	1.1	3
Vegetation	9.4	36.29	8.7	33.59	5.6	21.62	-0.7	-3.1
Water body	0.7	2.70	0.6	2.32	0.7	2.70	-0.1	0.1
Cultivated land	7.9	30.50	7.8	30.12	8.1	31.27	-0.1	0.3
Rock outcrop	1.2	4.63	1	3.86	0.7	2.70	-0.2	-0.3
Total	**25.9**	**100.0**	**25.9**	**100.0**	**25.9**	**100.00**		

Table 3 illustrates a significant transformation in land use and land cover in Dutsin-Ma between 1990 and 2020, characterized primarily by rapid urban expansion at the expense of natural vegetation. The built-up area, constituting 25.87% (6.7 km²) of the total area in 1990, increased steadily to 30.12% (7.8 km²) by 2010 and then accelerated sharply to 41.70% (10.8 km²) by 2020, reflecting a net gain of 4.1 km² over the thirty years, with the most significant change (+3 km²) occurring in the last decade. This urban growth directly corresponds with a severe decline in vegetation cover, which decreased from 36.29% (9.4 km²) in 1990 to 33.59% (8.7 km²) in 2010, and then dramatically to 21.62% (5.6 km²) in 2020, amounting to a total loss of 3.8 km², half of which occurred after 2010. Meanwhile, cultivated land remained relatively stable, showing a slight net increase, while water bodies exhibited minor fluctuation and rock outcrops experienced a consistent reduction. The result underscores a period of accelerated, likely unplanned, urbanization post-2010, where the conversion of vegetated land has been the primary spatial cost of the town's physical growth. This was compared with Abubakar and Abdussalam (2024), who examined land use changes in Kaduna Metropolis from 196 to 2023 using Landsat images, revealing an increase in built-up areas by 194.9 km². The study concluded that settlement expansion and agricultural activities were the primary drivers of land use and land cover changes in Kaduna Metropolis.

3.3 Rate of Expansion/Growth

The rates of expansion and growth of Dutsin-Ma town from 1990 to 2010 and from 2010 to 2020 are presented in Table 4.

Table 4: Growth rates of Dutsin-Ma from 1990 to 2020

Years	Built-Up Area	Growth rate			Duration
		km²	Percentage (%)	Per Annum (%)	
1990	6.7			4.3%	
2010	7.8	1.10	16.42%		10
2020	10.8	3.00	38.46%		10
Total		4.1	-		20

Table 4 presents the growth rate of Dutsin-Ma town between 1990 and 2020 in the built-up area; it shows the differences between 1990 and 2010 and between 2010 and 2020. It also shows the percentage (%) and the annual growth. Dutsin-Ma town recorded a substantial increase from 1990 to 2020 in the built-up area from 6.7 km² in 1990 to 7.8 km² in 2010 and 10.8 km² in 2020. This shows a difference of 1.10 km² from 1990 to 2010, with a growth rate percentage of 16.42%, whereas from 2010 to 2020, the difference was 3.00 km², with a growth rate percentage of 38.46%. The reason for this low percentage of growth rate from 1990 to 2010 was that Federal University Dutsin-Ma was established at that time, and with the establishment of the university, it was in its early stages. This revealed that there was a slow or low percentage increase from 1990 to 2010 compared with that from 2010 to 2020; however, with an overall increase of 61.20% from 1990 to 2020, the area extent increased more than threefold, as summarized in Table 4.

The annual growth rate of 4.3% in Dutsin-Ma town shows no similarities with the results obtained by Oluborode et al. (2004) for Nigerian cities such as Ilesha, with an annual growth rate of 5.01%. The growth of Dutsin-Ma town resulted from the establishment of the Federal University of Dutsin-Ma, Katsina State, in 2010. The settlement has also continued to attract an increasing number of immigrants, staff, and students at the university, who came in search of more secure education and employment, all of whom contributed significantly to the growth of Dutsin-Ma town from 1990 to 2020. In terms of the direction of the growth of Dutsin-Ma town, it increases toward the northwestern part of Dutsin-Ma town.

The implications or effects of the uncontrolled expansion and growth of Dutsin-Ma town from 1990 to 2020 include a decrease in agricultural land. Urban growth is one of the foremost threats facing agricultural land in Dutsin-Ma town. The conversion of agricultural land to urban development is a phenomenon that currently affects the study area as its population grows and the town grows. This conversion of agricultural land to built-up areas and bare land has led to a reduction in food production, which threatens national food security. Loss of vegetation: Another implication of the uncontrolled growth of Dutsin-Ma town is the clearance of vegetation cover for other purposes, especially buildings. Satellite imagery reveals that forests are facilitating the expansion of Dutsin-Ma town. Beyond the loss of agricultural and forest/vegetation land quantified in this study, unplanned urban expansion, as observed in Kaduna, typically leads to increased landscape fragmentation. This process disrupts ecological connectivity, degrades habitats, and can exacerbate urban heat island effects (Musa & Abubakar, 2024), representing a critical secondary layer of environmental impact for Dutsin-Ma.

Another implication of such growth is the lack of proper accessibility in Dutsin-Ma town and the lack of good drainage patterns, which can lead to soil degradation or soil erosion. In contrast to the provision of public services and infrastructure, Dutsin-Ma town needs to be provided with more roads, electricity, water, schools, and health centers, among other services, to meet the needs of residents. However, owing to the unplanned growth pattern of Dutsin-Ma, providing infrastructural facilities is more difficult.

4 Conclusion

The study highlights an obvious and rapid rate of urban sprawl in Dutsin-Ma town from 1990 to 2020, which has remarkably changed its landscape. The built-up area has increased by 61.2% over the past thirty years, especially from 2010 onwards. The gradual change from a relatively low growth rate of 16.42% from 1990 to 2010 to a relatively higher growth rate of 38.46% from 2010 to 2020 can be linked to the establishment of Federal University, Dutsin-Ma, in this town.

The expansion in space, especially in the northwest direction, has occurred at a cost to the environment. The most noticeable outcome is the loss in vegetation cover, which has regressed by over 50%, especially in the second decade. This trend, together with the transformation of agricultural land, indicates a direct trade-off between the expansion in the town and the agricultural and environmental base. The nature of the expansion, as seen from the results, is quite unplanned, resulting in haphazard development.

Therefore, it is evident that the findings identified a crucial turning point for the town of Dutsin-Ma. The growth of the town from being a small agglomeration into becoming an emerging university town has failed to be controlled by effective spatial planning. The present course is posing severe threats to sustainability, food security, and environmental quality. The study thus provides a valuable insight by emphasizing through evidence that, in the absence of intervention, the adverse effects of this uncontrolled spatial expansion of the town will continue to worsen.

Based on the findings related to the rapid and disorganized growth, the study recommends stakeholder-centric intervention on an immediate basis. The authorities at Dutsin-Ma LGA should therefore partner with Katsina Urban Planning & Development Authority (KUPDA) to ensure the formulation and legal recognition of a Master Plan to regulate future expansion through a controlled development framework to control disorganized structures. The authorities of the Federal University Dutsin-Ma should champion the formulation of a "*Town-Gown*" Spatial Planning Framework to ensure the future growth and housing needs of the students within the institution are addressed. Finally, there is a need for a public enlightenment program through the Ward Heads and the mass media to create awareness about the significance of planning permits. A regular geospatial audit must be undertaken to ensure alignment between infrastructure development and spatial growth.

References

Abdullahi, J. A., Tanko, A. S., & Samaila, I. (2025). Assessment of Urban Expansion in Parts of Kaduna Metropolis and Its Driving Factors. Kaduna Journal of Geography, 7(1), 197-208. https://doi.org/10.47514/kjg.2025.07.01.022

Abubakar, S. M., Kudanmiya, Y. R., and Eyong, P. N. (2002). Assessment of Environmental Degradation Using Satellite Remote Sensing Technologies in Talata Mafara Area, Northern Nigeria. Environmental Review, 4(1), 577-586.

Abubakar, M. L., & Abdussalam, A. F. (2024). Geospatial analysis of land use changes and wetland dynamics in Kaduna Metropolis, Kaduna, Nigeria. Science World Journal, 19(3), 687-696. https://doi.org/10.4314/swj.v19i3.15

Adesoji, A. T., Onuh, J. P., Palang, I. P., Liadi, A. M., & Musa, S. (2023). Prevalence of multi-drug resistant Pseudomonas aeruginosa isolated from selected residential sewages in Dutsin-Ma, Katsina State, Nigeria. Journal of Public Health in Africa, 14(2), 2152. https://doi.org/10.4081/jphia.2023.2152

Angel, S. (2023). Urban expansion: theory, evidence and practice. Buildings & Cities, 4(1), 124–138. https://doi.org/10.5334/bc.348

Auwalu, F. K., & Bello, M. (2023). Exploring the contemporary challenges of urbanization and the role of sustainable urban development: a study of Lagos City, Nigeria. Journal of Contemporary Urban Affairs, 7(1), 175-188.

Collier, P., & Venables, A. J. (2017). Urbanization in developing economies: The assessment. Oxford Review of Economic Policy, 33(3), 355-372. https://doi.org/10.1093/oxrep/grx035

Dahiru, A., Abdullahi, A. H., Bello, N., & Abubakar, M. L. (2026). Assessment of the influence of climate change on desertification in Katsina State, Nigeria. Discover Geoscience, 4, 29. https://doi.org/10.1007/s44288-026-00403-x

Forman, R. T. (1995). Land mosaics: the ecology of landscapes and regions. Cambridge university press.

Khan, H., & Khan, I. (2023). The effect of technological innovations, urbanization and economic growth on environmental quality: Does governance matter? Frontiers in Environmental Science, 11, 1239288. https://doi.org/10.3389/fenvs.2023.1239288

Koko, A. F., Bello, M., & Sadiq, M. A. (2023). Understanding the Challenges of 21st Century Urbanization in Northern Nigeria's Largest City, Kano. In Integrative Approaches in Urban Sustainability-Architectural Design, Technological Innovations and Social Dynamics in Global Contexts. IntechOpen.

Mendez, P., Atienza, M., & Modrego, F. (2023). Urbanization and productivity at a global level: New empirical evidence for the services sector. Regional Science Policy & Practice, 15(9), 1981-1998. https://doi.org/10.1111/rsp3.12620

Mmaduabuchi, A. S., Bello, Y., & Yaro, A. (2020). Determination of Factors Responsible for the Change in Vegetal Cover in Katsina Town. FUDMA Journal of Sciences, 4(3), 636-644. https://doi.org/10.33003/fjs-2020-0403-427

Musa, K., & Abubakar, M. L. (2024). Monitoring urban growth and landscape fragmentation in Kaduna, Nigeria, using remote sensing approach. Journal of Degraded and Mining Lands Management, 12(1), 6757–6769. https://doi.org/10.15243/jdmlm.2024.121.6757

Ofoezie, E. I., Eludoyin, A. O., Udeh, E. B., Onanuga, M. Y., Salami, O. O., & Adebayo, A. A. (2021). Climate, Urbanization and Environmental Pollution in West Africa. Sustainability, 14(23), 15602. https://doi.org/10.3390/su142315602

Oluborode, J. O., Soumah, M., Dieng, M. A. (2004). "Development of Administrative Map and Mapping/ Monitoring of Urban Growth of Some Cities in Osun State Using Nigeirasat-1 Data". National Space Research and Development Agency, Vol. 1, Issue 3.

Rouhana, S., & Bruce, I. (2016). Urbanisation in Nigeria: Planning for the unplanned. World Bank Group. https://blogs.worldbank.org/en/africacan/urbanization-in-nigeria-planning-for-the-unplanned

Salisu, M., Mustapha, A., Gambo, B., Peter, I. T., Muhammed, M. A., Lawal, H., & Salisu, M. (2021). Assessment of Post-Harvest Losses of Tomato in Zobe Irrigation Project, Dutsin-Ma Local Government Area of Katsina State. ASIO Journal of Humanities, Management & Social Sciences Invention (ASIO-JHMSSI), 7(2), 2021: 12-20

Samaila, I., Abubakar, K., Abdulkadir, U., Isa, Z., & Tadama, M. A. H. (2024). Influence of land use and land cover changes on flood susceptibility in Karadua River Basin, Katsina State, Nigeria. Science World Journal, 19(4), 1023-1029.

Tacoli, C., McGranahan, G., & Satterthwaite, D. (2015). Urbanisation, rural-urban migration and urban poverty (Vol. 1). London: Human Settlements Group, International Institute for Environment and Development.

Tanimu, I. (2014). Monitoring Change of Urban Growth Using Remote Sensing and GIS Techniques: A Case Study of Kano City, Northern Nigeria. Unpublished MSc. Project of the Department of the Faculty of Computing. Engineering and Science. University of South Wales, Prifysgol, De Cymru.

Takuro, F, Krishna, P., and Ryutaro, O. (2002). Changing Characteristics of Landuse as Commons in Roviana, Western province and Solomon Island. In: Proceedings of 23rd Asia Conference on Remote Sensing.

United Nations. (2018). 68% of the world population is projected to live in urban areas by 2050. United Nations, February 15, 2020. https://www.un.org/uk/desa/68-world-population-projected-live-urban-areas-2050-says-un

Yang, X and Lo. C.P. (2002). Modeling Urban Growth and Landscape Changes in the Atlanta Metropolitan Area. International Journal of Geographic Information Science, Vol. 17, No. 5 pp 463-488.