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An Assessment of Urban Sprawl in Nasarawa Town, Nasarawa State, Nigeria

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Abstract: ***Urban sprawl is a global phenomenon that affect most of the cities and towns in the world, due to rapid population growth, technological advancement and high economic growth. An Assessment of urban sprawl in Nasarawa town using geo-spatial techniques is the theme of the present study. Remote sensing imageries of landsat TM 1999, 2009 and Landsat 8, 2019 were used to measure the extent of growth and to show the impact of this growth on other land use types. The multi-temporal approach was used to detect the changes over three Landsat images of the same scene but recorded on different time frames. Results of individual techniques were assessed and a conclusion drawn on the extent of sprawl due to change occurring over time on the selected area over the earth's surface. The supervised classification method was undertaken in order to classify the Landsat images of 1999, 2009 and 2019, while the post classification was used to determine the pixels with a change in classification between the dates. Hence, change maps accompanied with statistics that expresses the type and nature of change occurring between the Landsat image dates were generated. The same was done for the classified Landsat images of 1999 and 2019 and a change map generated. The results showed the growth of Nasarawa town and its impact on other land use classes as identified. This study has provided information on urban sprawl for effective land use planning, policy and decision making for a more sustainable development of Nasarawa town and evirons.***
Keywords: Urban, Sprawl, Assessment, Classification, Geospatial,

I. INTRODUCTION

The assessment of urban sprawl is a critical endeavor for sustainable urban planning and involves a multi-faceted approach leveraging advanced geospatial technologies and analytical metrics [1],[2]. Urban sprawl is characterized by disorganized, irregular development at the periphery of cities, threatening natural resources and ecological balance [3],[2]. Methodologies often integrate remote sensing (RS) data, Geographic Information Systems (GIS), and spatial metrics to quantify its magnitude, direction, and patterns [4],[5]. Key metrics utilized include fractal dimension, Shannon's entropy, and landscape metrics, which help describe urban form in terms of composition, shape, and fragmentation [6],[3],[7] . For instance, Shannon's entropy index is widely applied to measure urban sprawl, with its spatial context becoming increasingly recognized [8],[9].

Studies have shown that urban sprawl can be analyzed dynamically over several decades, using historical satellite imagery to track land use and land cover (LULC) changes[4],[10].[11],[12. This comprehensive assessment considers factors like population growth, economic activities, and infrastructure development, which drive urban expansion, and evaluates their impacts on urban safety resilience and energy consumption [13],[14],[15]. By understanding these spatial dynamics and their complex interplay with environmental and socioeconomic factors, researchers and planners can develop more effective strategies to manage urban growth and promote sustainable development goals [2],[16],[17].

II. MATERIALS AND METHODS

A. The Study Area

The study area covers part of Nassarawa Local Government Area of Nassarawa State. It is located between latitude $8^0$32'N, 80 18'E and longitude 8^0 32'N, 8^0 18'E. It is bounded in the North by Karu Local Government Area in the west by Toto, in the east by Doma and in the south by Kogi State (figure 1).The town lies just north of a fork in the Okwa River, which is a tributary of the Benue River. The dense forests are few, far apart and found in low land areas, particularly where population pressure is less on the land. Vegetation with little human interference consisting of canopied trees, thick foliage and natural reserves. The data used in this research include the three Landsat TM image of 1999, 2009, and Landsat 8 image of 2019.These Landsat imageries were obtained from the earth explorer website (USGS) United State Geological Survey (http//www.usgs.gov)

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B. Image Classification

Remote sensing data and Geographic Information System (GIS) techniques were used for mapping to understand the urban pattern, urban process, urban growth, land use and land cover change and sprawl. Subset of the study area was created for the images to delineate the Study area and used in the classification of land use feature classes. The imageries were then classified using selected training sites and the characteristics of various land use types were identified in the Study area.

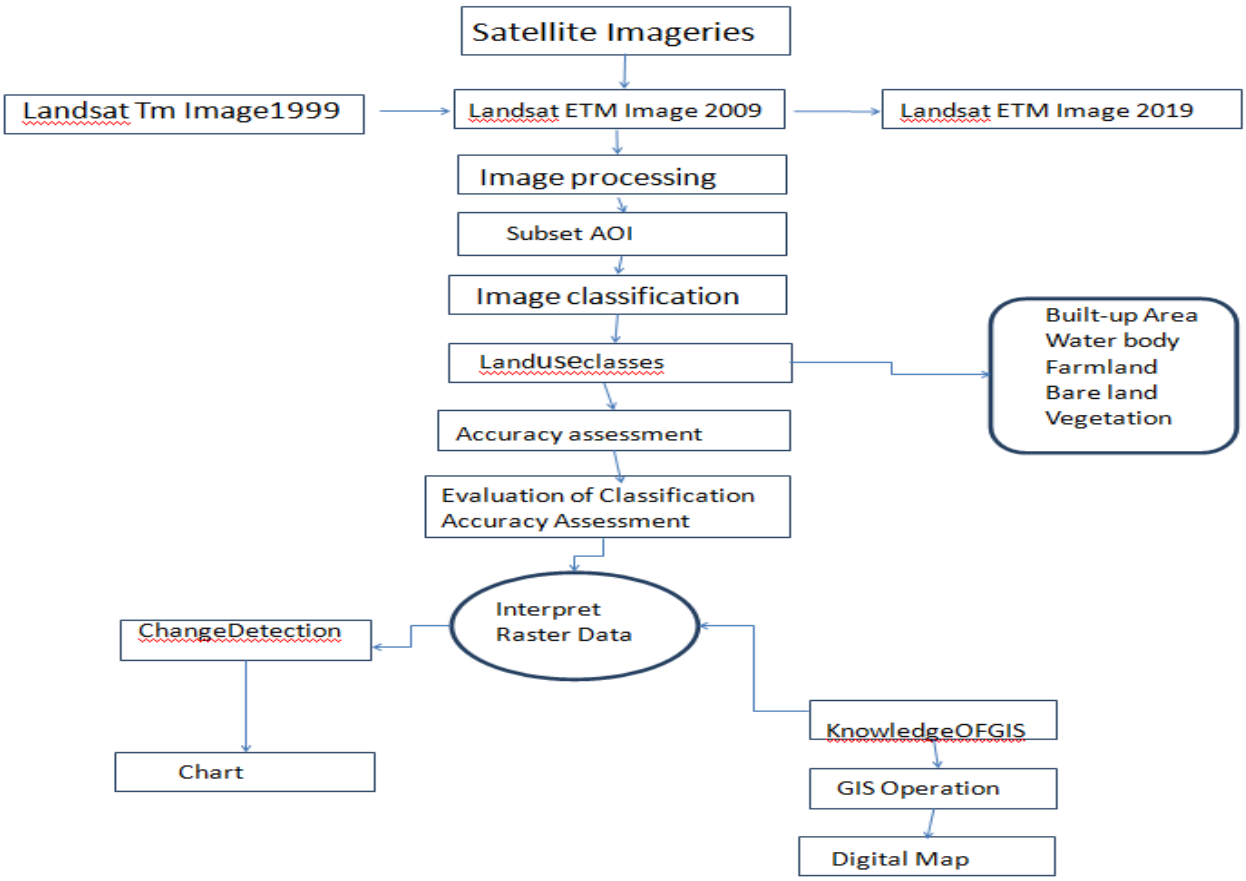


Figure1.Flowchart Summarizing the Research methodology

C. Data Interpretation

The procedure utilized supervised classification with land use-cover classification scheme based on data analyses and interpretation of available remote sensing data. This was done to determine the area covered by the different land use classes for the three periods and to assess the changes in land use classes between these periods. After this, statistical data such as, maximum likelihood classifier and accuracy assessment of the land use land cover was generated and analyzed. Statistics of the feature classes were converted to percentages and presented in tables and histogram.

D. Post Classification

Post classification comparison broadly involves two steps in the change detection procedure. Firstly, a classification (for the Study, supervised classification has been selected) and was done on the three independent temporal images. The three dates of the Landsat imagery are independently classified and registered. Then a comparison is done to determine the pixels with a change in classification between the three Landsat images. Hence, change maps accompanied with statistics that expresses the type and nature of change occurring between the image dates were generated. Furthermore, the classes that were used in the classification routine for each of the Landsat images were decided mainly on the basis prior knowledge of change taking place between the three scenes. Based on the previous knowledge as well as the visual interpretation of imageries, it was decided to classify all the Landsat images into five classes, which are Built-up area, Water body, Farmland, Vegetation, and Bare land.

III. RESULTS AND DISCUSSION

A. Supervised Classification of Landsat Image of NassarawaTown for the year 2009

The result for 2009 showed that, Built-up area was 43.73km^2, representing 23.82% of the total area. Water body was 4.82km^2, representing 3.2%, Farmland was 41.33km^2, representing 28%, vegetation was 34.36km^2, representing 23% and Bare land was 32.21km^2, representing 22%. However, the rate of expansion in Nassarawa appears more gradual compared to some other African cities. [18] reported that Awka metropolis, Nigeria, experienced built-up area growth from 3,444.48 km² in 1986 to 11,452.46 km² in 2016, a substantially larger absolute increase. Similarly, [19] found that Morogoro urban municipality in Tanzania recorded built-up area expansion from 22.40 km² (4.3%) in 2011 to 48.89 km² (8.7%) in 2017, representing a faster proportional growth rate than Nassarawa. These variations suggest that the intensity of urban sprawl is influenced by factors such as city size, economic opportunities, and planning frameworks of an area.

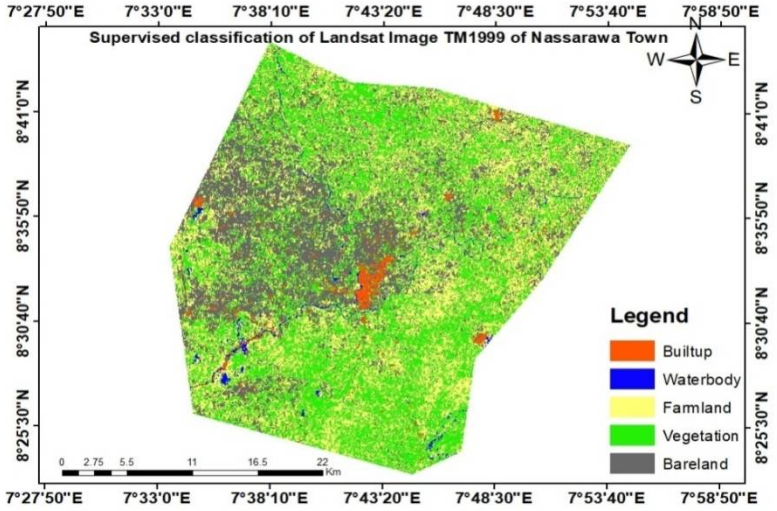


Figure2. Supervised Classification of Landsat Image of Nassarawa Town for the year 1999

B. Supervised Classification of Landsat ETM image of Nassarawa Town for the year 2019

In 2019, figure8 and Table5 showed that, Built-up area was 59.40km2, representing 32.36% of the total area. Water body was16.80km2, representing 9.14%, Farmland was 37.23km2, representing 20.28%, Vegetation was 31.42km2, representing 17.12%, and Bare land was 38.71km2, representing 21.09%. The results derived from classifications of Landsat imageries, in figure6,7 and figure 8 enable land cover to be measured and the extent of built-up area to be highlighted on the three dates.(1999, 2009 and 2019). The surface of the Study area is approximately 183.56km2. Figures 6, 7 and 8, showed that urban sprawl is increasing in Nasarawa and environs at a very rapid rate. The five land use/land cover classes studied revealed that there is continuous change in each cover over the years of study. Of particular interest were the dynamic change shown in built-up area in different period of years.

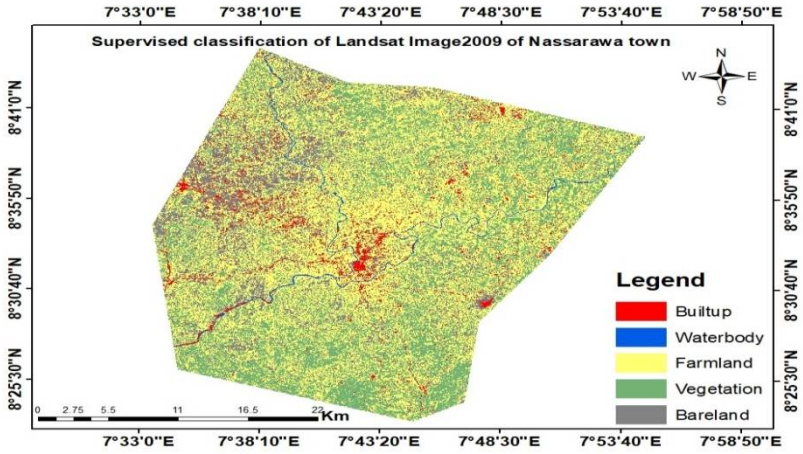


Figure3.Supervised Classification of Landsat Image of NassarawaTown for the year 2009

C. Land use areas for the period 1999 to 2019

The results showed the classified images and the area of coverage of each class and the extent of expansion of Nassarawa town over time was examined (Figure4) and the annual farm land loss to built-up area was 6km^2. Representing 4%, vegetation loss annually was 5.9km^2, representing 3.7%. The environmental implications of vegetation loss in Nassarawa town aligns with the concerns raised by [20] in their study of Prishtina, Kosovo, where vegetation cover decreased from 410.57 km² (75.92%) in 2000 to 390.63 km² (72.40%) in 2020. Both studies highlight the negative impact on ecosystem services, including carbon sequestration, biodiversity support, and climate regulation. [19] further contextualized these environmental concerns within the framework of Sustainable Development Goals (SDGs), particularly SDG 11 (sustainable cities) and SDG 15 (terrestrial ecosystems protection), arguing that uncontrolled urban sprawl directly threatens the achievement of these global targets by 2030.

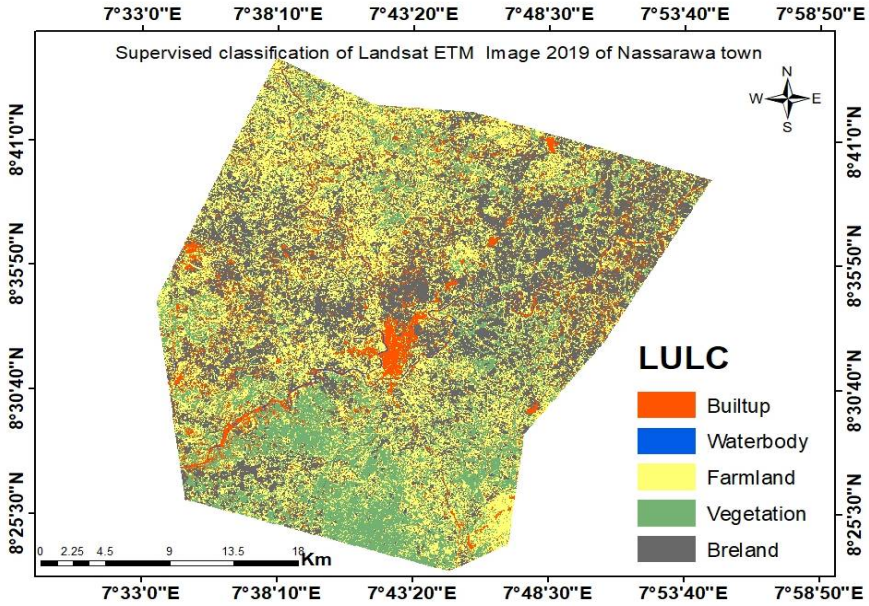


Figure4.Supervised classification of Landsat ETM image of Nassarawa Town for the year 2019

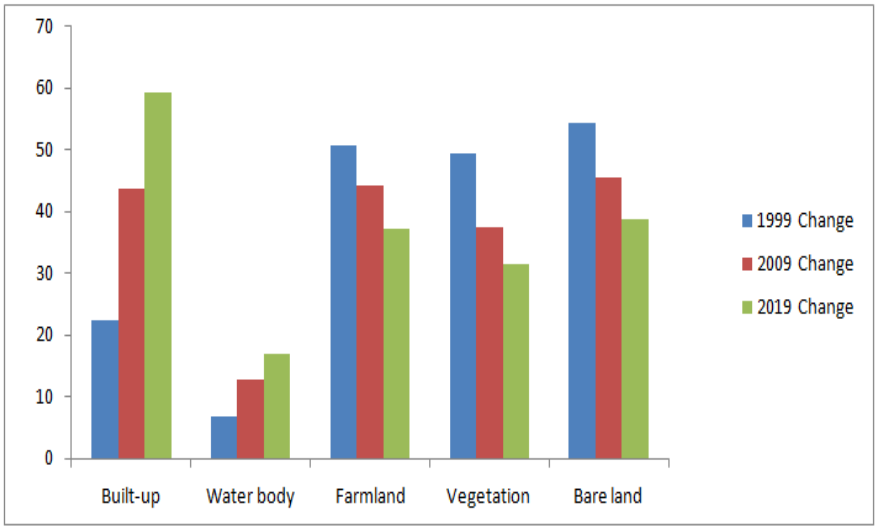


Figure5. Histogram showing land use and land cover classes from 1999-2019

Table1. Land use areas and percentages for the period 1999 to 2019

Classes	1999 Area (Km^2)	% Cover	2009 Area (Km^2)	% Cover	2019 Area (Km^2)	% Cover
Built-up	22.28	12.14	43.73	23.82	59.40	32.36
Waterbody	6.73	3.67	12.72	6.93	16.80	9.15
Farmland	50.74	27.64	44.34	24.16	37.23	20.28
Vegetation	49.32	26.87	37.36	20.35	31.42	17.12
Bare land	54.49	29.68	45.41	24.74	38.71	21.09
Total	183.56	100	183.56	100	183.56	100

D. Dynamic of Land use Change from 1999-2019

The results derived from classifications of Landsat imageries enable land cover to be measured and the extent of built-up area to be highlighted on the three dates (1999, 2009 and 2019). The surface of the Study area is approximately 183.56km^2. The result showed that urban sprawl is increasing in Nasarawa and environs at a very rapid rate. The five land use and land cover classes revealed that there is continuous change in each cover over the years of study. Of particular interest were the dynamic change shown in built-up area in different period of years. .

Table 2 showing the Dynamic of Land use Change from 1999-2019

Classes	Area in Km^2			1999- 2009	2009-2019	1999-2019
	1999	2009	2019			
Built-up	22.28	43.73	59.40	-21.45	-15.67	-37.12
Water body	6.73	12.72	16.80	-5.99	-4.08	-10.07
Farmland	50.74	44.34	37.23	6.40	7.11	13.51
Vegetation	49.32	37.36	31.42	14.96	11.96	5.94
Bare land	54.49	45.41	38.71	9.08	6.70	9.04
Total	183.56	183.56	183.56	3.00	6.02	-18.70

E. Spatial Growth of Nasarawa Town between 1999 and 2019

From Table 3, Annual Growth rate of Nassarawa Town from 1999 to 2019 was 5.02km^2, representing 3.5%. The reasons for the growth of the area are: (1) thenatural increase in the population of the area, (2) migration of people to the area because of its proximity to Abuja, theFederal Capital Territory (FCT) and (3)the establishment of the Federal Polytechnic Nassarawa in 1984. (4) Town expansion into surrounding rural areas without planning. (5) Nassarawa is the Headquarter of Nassarawa Local Government Area, people move to the area for economic opportunity. (6) Health is another major reason. People, especially the elderly are often forced to move to Nassarawa Town where there are doctors and hospitals that can cater for their health needs; the Nassarawa General Hospital and other privates Hospital are situated in Nassarawa Town. These processes explain urban population growth.

Table 3. Spatial Growth of Nasarawa Town between 1999 and 2019

Year	Built-up area in km^2	Percentage growth(%)
1999	22.28	16.3
2009	43.73	22.5
2019	59.40	30.6

F. Overlay of the extent of study Are from 1999 to 2019

From figure 6, the extent of the town keep growing largely toward North-east, North-west, South-West, South-East and compact at the Centre of the town. The expansion toward the north-west is along Nasarawa-Keffi road, the expansion toward south-west is along Nasarawa-Abaji road and the expansion toward South-East is along Loko-Nasarawa road. This aligns with the findings in the research carried out by [21] where growth was largely attributed to the movement of the capital and subsequent influx of migrants.Sprawl development can be divided into three basic spatial forms, namely, low-density continuous sprawl, ribbon sprawl and leap frog development sprawl. The spatial form of sprawl in Nasarawa town is ribbon sprawl, because the expansion of built-up was along the major roads of the area.

The rapid expansion of development and increased in land use changes as shown in figure 10was due to population and economic growth of the area. This make it very important to measure and monitor these land use changes to understand land use and land cover changes over different spatial and temporal time scales for effective land use management. The finding of this research corroborate with findings from [21], who attributed Abuja's rapid expansion to the relocation of the Federal Capital Territory in 1991, resulting in both internal and international migration alongside natural population increase. Similarly, [22] identified population expansion as the primary driver of urban sprawl in Tehran Metropolis, Iran, where the city's social and economic attractiveness accelerated growth rates. However, [22] also emphasized the role of land ownership restitution policies in facilitating sprawl, a factor not explicitly mentioned in the Nassarawa study but potentially relevant given Nigeria's complex land tenure systems

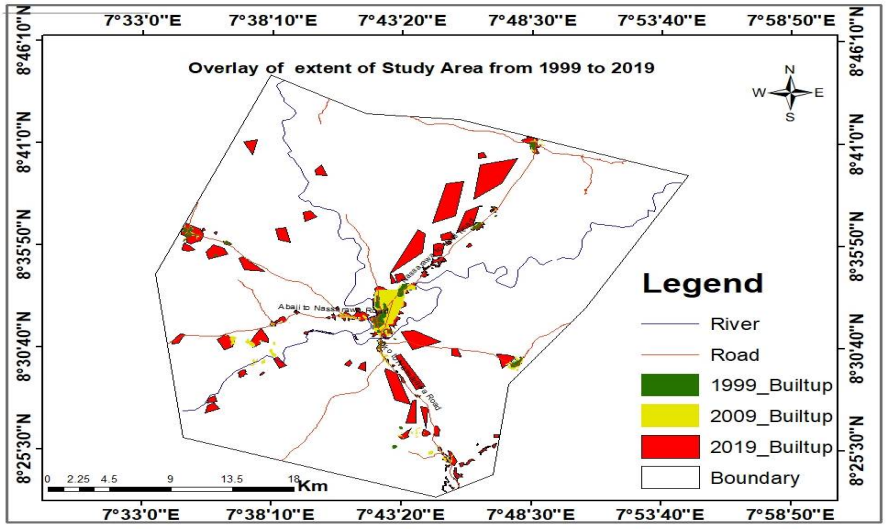


Figure6: Overlay of the extent of study Are from 1999 to 2019

IV. CONCLUSION

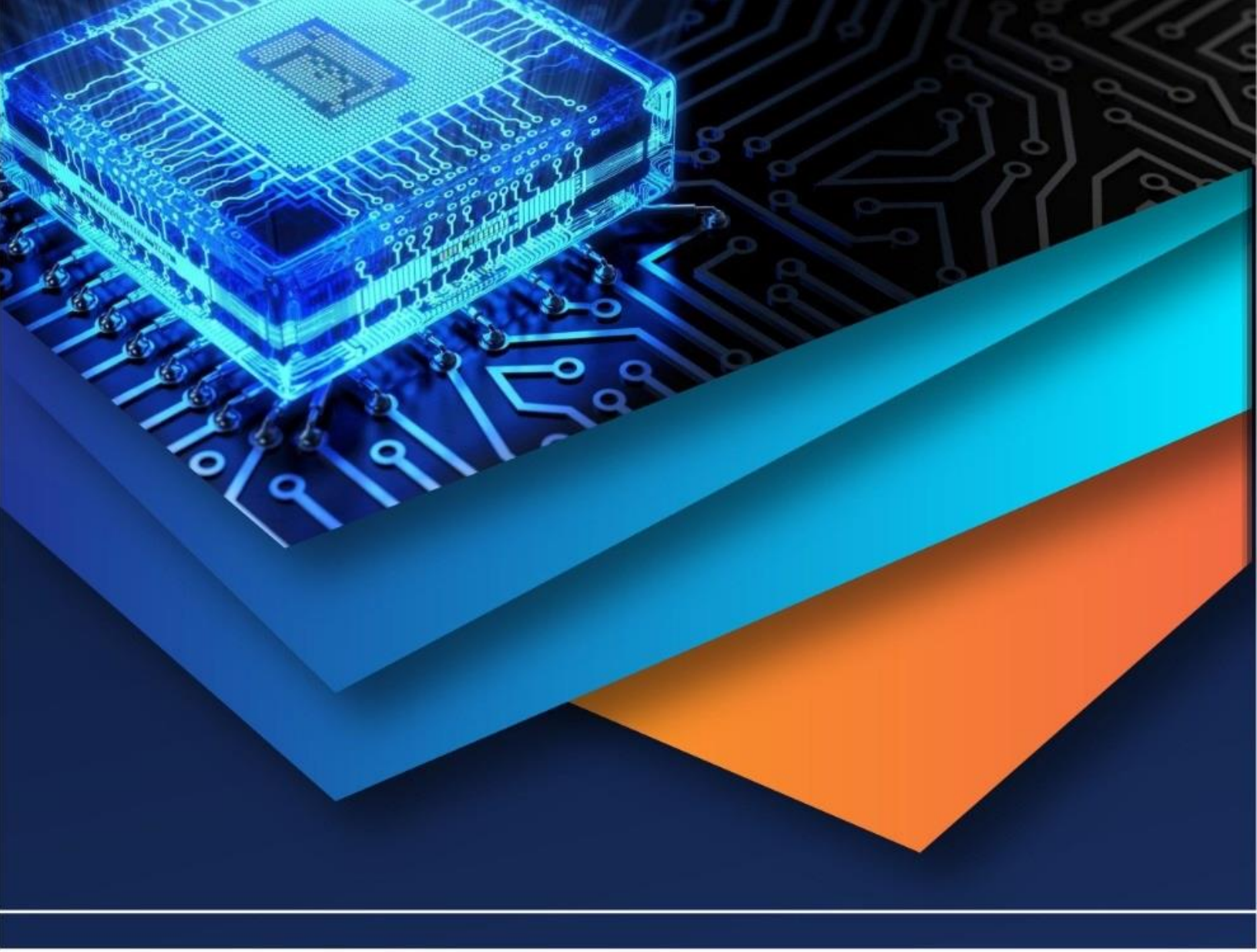
This Study aimed at the pattern of urban growth in Nasarawa Town. We used Remote Sensing (RS) and Geographic Information System (GIS) Technology to determine the rate of urban expansion with reference to land use types in Nasarawa town for the period of 1999 to 2019. The result of the study showed that Nasarawa town keep growing towards the North, along Nasarawa-Keffi road, South-East, along Nasarawa_Loko road, and South West, along NasarawaToto road and compact development at the center of the town. The type of sprawl present in Nasarawa town is ribbon sprawl.

The town has expanded rapidly within the Study period from a total of built up area of 28.28km^2 in 1999 to 39.40km^2 in 2019 at a growth rate of 5.02km^2, representing 3.5%. The land use changes in this study were due to rapid expansion of built up area. Therefore, the need for continuous monitoring of these land use and land cover changes is necessary for effective land use management. Based on the findings of this research, it was recommended that there should be formulation of master plan and with appropriate legislations backing. Urban renewal process should be initiated to redevelop the town with a view to beautify Nasarawa town. It was also recommended that there should be awareness through seminars and conferences to educate people about the importance of studies such as this. There results and findings should be adopted as instruments for subsequent development and monitoring of activities within the study area.

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