Remote Sensing and Geographical Information System Application in Assessing Urban Sprawl of potiskum Town, Yobe State, Nigeria.

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Abstract
The Urban Sprawl is a global phenomenon associated with population increase which is characterized by an un-planned and uneven pattern of growth, driven by a multitude of process and leading to inefficient resources utilization. This paper assesses the effect of expansion of potiskum Metropolis and appraise the changes that occurred in the landscape from 2000 to 2020. The study made up of information extracted from Enhanced Thematic Mapper (ETM+ 2000, 2010 and 2020) satellite images, the spatial location of some notable points within and around the study area as well as attribute data obtained of the study area through Questionnaire. The images were used to increase a False Color Composite (FCC) where the training polygon were chosen and classified based on their spectral signatures. The spatial locations were overlaid on the Topographical Map and on imageries for appraisal. The Questionnaires distributed and retrieved were administered for attribute information. The results revealed from the classification that from 2000 to 2010, the built-up area increased from 270.09 to 307.80hectas which is 1.91 and 2.17% of the total area covered and from 2010 to 2020, the built-up area increase from 307.80 to 1270.52hectres that is 2.17 to 10% of the total area which is more than triple to the increase between 2000 to 2010. The system revealed in the results that the area will in the next 20 years increase by 70.253700km^2 which is 51% of the total area. The questionnaire administered revealed that majority of the increase in population are predominantly youths between the age 26 to 46 which covers 69% of the increase and are mostly Nigerians from different places which might be probably due to insurgency. The system used CELLULAR AUTOMATA (CA) for the allocation of new built-up area into other land use classes. The research recommends government/stake holders to develop policies to maintain the land for future use, as the absence of any land use planning may lead to land degradation.

Keywords: Urban Sprawl, built-up areas and geographical information system.

1.0 INTRODUCTION

Urban sprawl is the rapid expansion of cities and urban areas into surrounding rural or natural areas, often characterized by low-density development, fragmented landscapes, and inadequate public transportation. The significance of urban sprawl can be from various perspectives such us Economic Significance like increased infrastructure costs: Urban sprawl leads to higher costs for infrastructure development, such as roads, utilities, and public services. Loss of agricultural land: The conversion of rural land to urban uses can result in the loss of productive agricultural land and ecosystems. Economic segregation: Urban sprawl can exacerbate economic segregation, as affluent communities often locate on the outskirts of cities, while low-income communities are concentrated in the urban core. Environmental Significance, Habitat destruction and fragmentation: Urban sprawl can lead to the destruction and fragmentation of natural habitats, resulting in biodiversity loss. Air and water pollution: The increased reliance on personal vehicles in sprawling cities contributes to air pollution, while storm water runoff from impervious surfaces can contaminate waterways. Climate change: Urban sprawl can increase greenhouse gas emissions due to the reliance on fossil fuels for transportation and energy consumption. Social Significance: Social isolation: Urban sprawl can lead to social isolation, as residents may rely on personal vehicles and have limited opportunities for social interaction, inequitable access to services: The dispersed nature of urban sprawl can make it difficult for residents to access essential services, such as healthcare, education, and public transportation. Public health concerns: Urban sprawl has been linked to various public health concerns, including obesity, respiratory problems, and mental health issues. Planning and Policy Significance: Challenges to urban planning: Urban sprawl can make it difficult for urban planners to create efficient, sustainable, and equitable cities. Need for smart growth strategies: Urban sprawl highlights the need for smart growth strategies that prioritize compact, walkable, and mixed-use development. Importance of regional coordination: Urban sprawl often requires regional coordination and cooperation to address the complex challenges associated with it.

Urban sprawl poses several problems that affect the environment, economy, and society such as Environmental Problems Loss of biodiversity, Air and water pollution, Climate change, Soil erosion and degradation, Construction and development lead to soil erosion and degradation. Economic Problems Increased infrastructure costs, Urban sprawl requires costly infrastructure development, such as roads, utilities, and public services. Economic segregation, Reduced economic efficiency: Sprawling development patterns can lead to reduced economic efficiency, as businesses and services become dispersed. Social Problems Social isolation: Urban sprawl can lead to social isolation, as residents rely on personal vehicles and have limited opportunities for social interaction, Planning and Policy Problems etc.

In this research it Use satellite or aerial imagery to analyze urban growth patterns and land use changes. The result presented on chart, maps for Identification of areas with high rates of urbanization, including the extent and direction of growth.

In Nigeria, unprecedented population growths coupled with unplanned developmental activities have led to urban centers, lacking infrastructural facilities. These also have posed serious implications on the research base of the country. Urbanization takes place either in radial direction around a well-established city, or linearly along the highways. This dispersed development along

highways, or surrounding the city and in rural countryside is often referred to as sprawl (Theobald, 2001). Some of the causes of the sprawl include population growth, economy and proximity to resources, as well as the basic amenities. Patterns of infrastructure initiatives such as the construction of roads and service facilities (such as hotels, etc.) often encourage regional development, which eventually can lead to urbanization. Many individuals prefer to live in, or near the urban areas because of the availability of different means of earning livelihood in a more, or less compact area and the availability of necessary facilities for comfortable living in a consolidated area including utilities and services, shopping, recreational and cultural facilities, educational facilities, means of communication and movement. Urban areas developed either through objectively planned areas, guided and regulated by deliberate regulation and control systems, or spontaneous growth through unplanned isolated constructions especially on the city fringes (Ogbazi J. 1992).

1.2 Aim and Objective

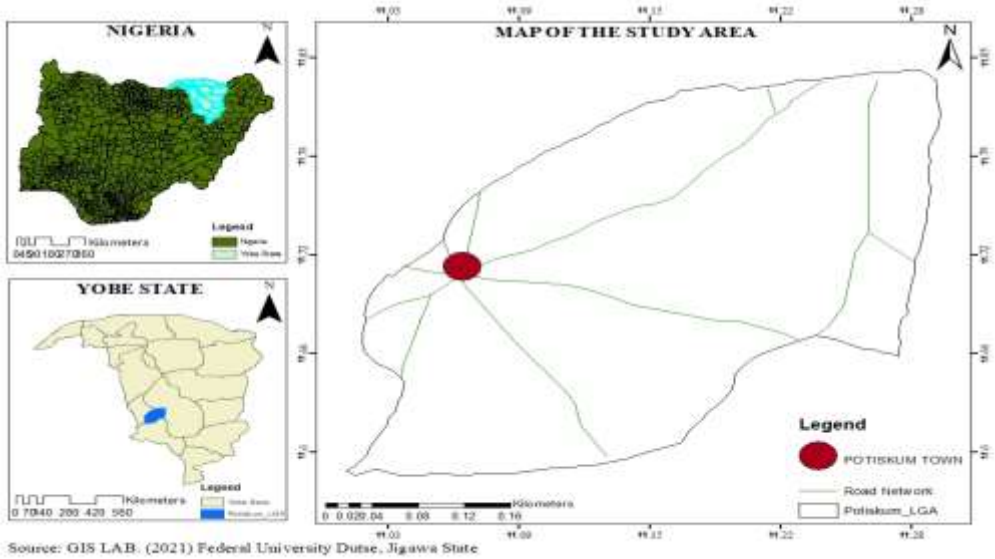
The aim of this study is to assess the urban sprawl occurring in Potiskum Metropolis using remote sensing and geographic information technique.
the study aim was be achieve through the following objectives:

1) To produce the land cover map of the study area;
2) To design and administer the questionnaire
3) To analyze the urban sprawl pattern for the study area, between the year 2000 to 2020, through the Map produced and the administered questionnaires by Remote Sensing and the GIS technique;
4) To model the future pattern of the sprawl using the raster approach.

2.0 Materials and Methods

The Study Area

The study limited itself to Potiskum Metropolis with the geographical location lying between the latitude 11º 4'N and 11º 44'N, and between the longitude 11º 04'E and 11º 08'E. The selection of Potiskum Metropolis alone was based on time constraint and also on the fact that, the town is growing at an alarming rate due to change and also mass number of immigrant (refugees) from various local governments and neighboring states due to Boko Haram insurgency, thereby facilitating increasing the influx of people into the state capital that put a high demand on the land and other social amenities.



Source: GIS LAB. (2021) Federal University Dutse, Jigawa State

3.1. Data types and Sources

The sources of the data for this study were basically the primary and the secondary data.

3.1.1 **Primary Data**

The primary data source used includes the researcher's physical observations, Global positioning system (GPS) coordinates and oral interviews as well as administration of scheduled questionnaire copies to generate information from the respondents.

3.1.2 **Secondary Data**

The secondary data source used were the existing designed land use map (hard copy) of the study area. This serves as a working diagram to the execution of the Study. The secondary sources also included published and unpublished documents, topographical maps, government records, and documented statistics, etc., that were obtained from the relevant organizations. LandSat satellite images of the 2000 and the 2010 were obtained from the Global Land Cover Facility (GLCF) an Earth Science Data Interface, while that of the 2020, was obtained from the National Space Research and Development Agency (NASRDA), Abuja, respectively, as shown in Table 3.1;

Table 3.1; Data Source

S/N	DATA TYPE	DATE	SCALE RESOLUTION	SOURCE
1.	LandSat ETM+ Image	2020	30m	NASRDA
2.	LandSat ETM+ Image	2010	30m	GLCF(ESDI)
3.	LandSat TM Image	2000	30m	GLCF(ESDI)
4	Potiskum image map	2022	0.6m (1:3000)	

5.	Census data (2006)	2009	30m	INFO TERRA,courtesy NPC
6.	Potiskum Landuse plan	2022	1:50,000	NPC Planning department Planning Potiskum
7.	Topographical map(Potiskum sheet 87 NE)	1990	1:100,000	
8.	Ground Control coordinates (GPS of some selected points)	2023	---	Survey department Potiskum Field Work

3.2 Sampling Techniques

In line with Ader and Mellerbergh's (2008) suggestion that sample size should be small in order to improve the quality and the accuracy of research work, only 120 copies of the questionnaire were administered to the respondents drawn from the sampled wards in Potiskum, using the following techniques in the table 3.2. Potiskum was first stratified into three areas as classified by the Ministry of land and survey in Potiskum, Yobe State. The questionnaire copies were distributed based on the population densities in the Study area as shown in Table 3.2.

Table 3.2 Land use Classes and Ranking

S/N	LAND USE	NO. OF QUESTIONAIRES	PERCENTAGE (%)
1.	Low Density Areas	40	33.33 %
2.	Medium Density Areas	40	33.33 %
3.	High Density Areas	40	33.33 %
	Total	**120**	**100 %**

Both stratified and systematic random sampling methods were used in administering the questionnaires. One questionnaire for the first household of the first street and one for the last household of that same street making two questionnaire copies in one street, and the next two streets were skimped. This was the techniques that were used during the administration of the questionnaire copies as a primary source of data collection. Owing to the absence of some of the members of the household, in some of the streets that fell within the sample frame; the second, the third or the fourth household of the street were selected and the second, the third or the fourth to last were selected. Two houses were selected in each street.

3.4 Image processing

In remote sensing, digital image processing, historically is important owing to two principle areas of application. Firstly, the improvement of the spectral information for visual interpretation and secondly, the processing of image data for computer assisted classification. The whole task

of digital image processing revolves around increasing spectral separability of the object features in the image.

3.4.1 Geo referencing of the map

Landsat images acquired were already geo referenced, it was confirm by selecting and applying the ground control points (GCPs). Nearest-neighbor re-sampling technique was used. The root mean square (RMS) error of georeferencing is approximate 0.5 pixels. Subsets of the study area were selected but the topographical maps, image map and the Land use plan of the Town Planning Department were scanned and geo referenced for use as base map for image extraction as, well as working diagrams as well as for checking and confirmation of the already geo referenced Landsat images. All images were checked and ascertained.

3.4.2 Colour composite

The main aim of this method was to get around the limitations of relatively broad spectral bands in Landsat images for the years 2000, 2010 and the 2020 by using the bands to determine the relative spectral between the bands and to identify the different land cover types in the images. The combination of the bands 4, 3 and 2 for Red, Green and Blue (RGB), respectively, was used in the study as shown in the figures (3.1, 3.2 and 3.3), respectively.

3.5 Measuring Urban Sprawl

To understand the complexity of a dynamic phenomenon such as the urban sprawl; land use change analyses, the urban sprawl pattern and computation of sprawl indicator indices were determined. In carrying out this study, remotely sensed satellites imagery (data) supported with the required ground truth exercise was done for checking. Apart from the fact that remote sensing is an effective and efficient tool for urban studies; it is considered to be highly economical, easy to acquire and flexible to use in rapid detection of land use changes. Field survey was first done to identify the land cover and the land use types. The use of hand-held GARMIN 76 H GPS receiver facilitated navigation and identifications of locations on the ground.

3.6 Methods of Data Processing

Five main methods of the data processes were adopted in this study.

3.6.1 Supervised Classification with Maximum Likelihood algorithms

The images were displayed in False Colour Composite (FCC) for a better visualization and identification of the built-up lands, forest lands, Water bodies, vegetation/Agriculture and Other lands.

Training sample sets were collected based on the ground truth data during field the hecks. Statistical data were then extracted from the classified sample set.

3.6.2 Calculation of the Area in hectares of the resulting land use/land cover types for each study year and subsequent comparison of the results

The comparison of the land use / land cover statistics assisted in identifying the percentage change, trend and the rate of change in the Land use sprawl.

In achieving this, the first task was to develop a table showing the area in hectares and the percentage change for each year measured against each land use land cover type. Percentage change to determine the trend of change was then calculated by dividing the observed change by the sum of changes multiplied by 100

$$\text{(Trend) percentage change} = \frac{\text{observed change}}{} * 100$$

Sum of change

To obtain annual rate of change, the percentage change was divided by 100 and multiplied by the number of the study year.

The research work adopted stepwise procedure from the problem identification to the final output. The methodology of the research procedures is given in the following work flow.

3.7 Methods of data analysis

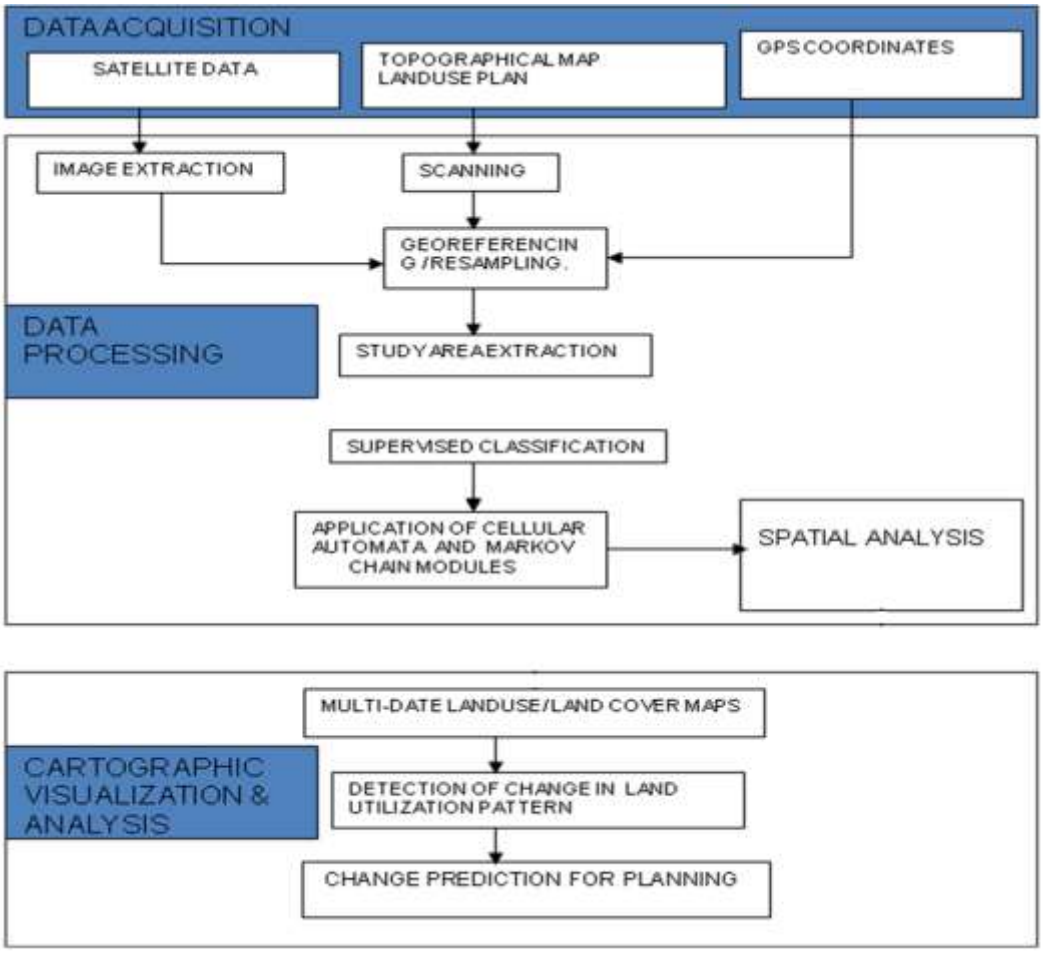


Figure 3.5: Methodology work Flow
Source: Author's Laboratory work, 2023

4.0 RESULT AND ANALYSIS

4.1 Identification of urban sprawl

4.1.1 Image Analysis and Interpretation

The standard image processing techniques such as the image extraction, rectification, restoration and classification, were applied in the current study. The image obtained from the NASRDA and the GLCF, were used to create a False Colour Composite (FCC). Training polygons were chosen from the composite image and the corresponding attribute data were obtained in the field using the GPS. Based on these signatures, corresponding to various land features, image

classification was done using the Gaussian Maximum Likelihood Classifier.

The images were classified with an average reliability and average overall accuracy of 74 and 60 percent (as in the appendix 1,2 and 3) into four (4) broader categories as built-up lands, other lands, vegetation - agriculture and water bodies as shown in Figures 4.1, 4.2 and 4.3.

From the classified images, the area under the built-up lands, other lands, vegetation – agriculture, and the water bodies were computed and tabulated accordingly, for further analyses.

Table 4.1; Land Use Land Cover Distribution (2000, 2010, and 2020)

LANDUSE/LAND COVER CATEGORIES	2000		2010		2020	
	AREA (Ha.)	**AREA (%)**	**AREA (Ha.)**	**AREA (%)**	**AREA (Ha.)**	**AREA (%)**
BUILT-UP LANDS	270.09	1.91	307.80	2.17	1370.52	10
OTHER LANDS	9475.47	67.01	11169.81	78.99	5340.15	38
VEG. & AGRICULTURE	4307.49	30.46	2553.21	18.06	7173.63	50
WATER BODY	87.75	0.62	109.98	0.78	256.50	2
TOTAL	**14140.80**	**100**	**14140.80**	**100**	**14140.80**	**100**

4.2 Analysis of the urban sprawl pattern

4.2.1 Trend, Rate and Magnitude of the Land Use Land Cover Change

The results of the satellite image classification (in Fig. 4.1 above) suggest that the metropolitan area has experienced significant land conversions mainly due to urban expansion. The general trends in land cover changes were identified at the metropolitan level, as summarized in the Table 4.2, which also shows that, the built-up land cover increased over the past two decades ranges from 2% of the total land (study) area in 2000, to 10% of the same land area in 2020, and the vegetation-Agricultural land cover and the other lands as classified bore the major burden of the urbanization. The water body class, which was the smallest land cover among the four detected classes, doubled its extent, as major the man-made reservoirs were created over the study period.

Studying the spatial and temporal heterogeneity of the land cover changes allowed us to identify fast and the slow sprawling areas. From the annual rate of change in the Table 4.2 below it suggests that the Potiskum Metropolis experienced fast built-up land cover over the past two decades.

Table 4.2 Land use land cover change of Potiskum and its environs (2000, 2010 and 2020)

LANDUSE/LAND COVER CATEGORIES	2000 – 2010		2010 – 2020		ANNUAL RATE OF CHANGE	
	AREA (Ha.)	**PERCE TAGE CHANGE**	**AREA (Ha.)**	**PERCENT AGE CHA NGE**	**2000 - 2010**	**2010 – 2020**
BUILT-UP LAND					0.13	0.54

OTHER LANDS	37.71	1	1062.72	9	6.24	-3
VEG.& AGRIC	1694.34	48	-5829.66	-50	-6.5	2.4
WATER BODY	-1754.28	-50	4620.42	40	0.13	0.06
	22.23	1	146.52	1		

The percentage change in the built-up lands between the year 2000, and the 2020 (9% as from the Table above) was found to be very much higher than that of between the year 2000, and the 2010 (1%). This may suggest that the rate at which the new lands were acquired for development after the state creation is high and this may also be the trend between the year 2020, and the 2040, as there seems to be development expanding towards the outskirts of the city in the form of sprawl. The following Figure 4.4 shows the gains and the losses in the built-up lands between the year 2000, and the 2020 (9%) that indicate some significant differences.

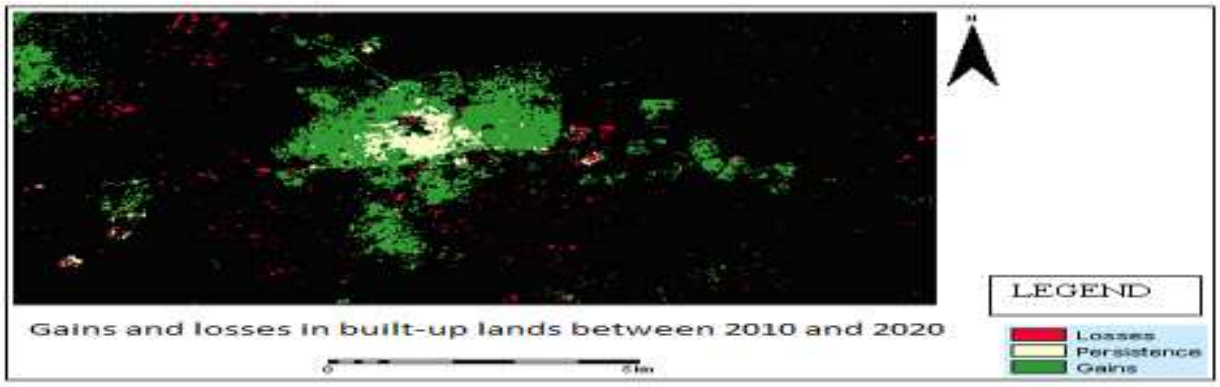


Figure 4.4: gains and the losses in the built-up lands between the year 2000, and the 2020 (9%) that indicate some significant differences.
Source: author's Laboratory work, 2022

4.3 Analysis of the factors underlying the urban sprawl

4.3.1 Questionnaire survey

Findings from the questionnaire survey deduced from the forms as shown in the appendices revealed that more than half of the people in Potiskum metropolis constituting 70 % as shown in Table 4.3.1.1 are young men and women between 26 and 45 years, because they are in the productive age. About 15 % of the respondents are between the ages of 15 and 25years, and only 12.5% and 2.5% are between the ages of 46 and 55 years, and between 56 years and, above, respectively, as shown in Table 4.3.1.1.

Table 4.3.1.1: Age of Respondents

S/N	AGE	FREQUENCY	PERCENTAGE
1.	15 – 25 yrs	19	15 %
2.	26 – 45 yrs	84	70 %
3.	46 – 55 yrs	14	12.0 %
4	56 yrs and Above	3	3.0 %
	Total	**120**	**100 %**

The age distribution table did not record the responses from the age groups less than 15years, because they are classified as dependants. The relatively low percentage of the people of the age between 56 years and above as illustrated in Table 4.3.1.1, shows that a significant number of the people in Potiskum Metropolis are youth.

Evidence from the field observation indicate that the population of Potiskum is not only from the rural areas around, or within the Yobe state only, but also from different states in Nigeria and outside Nigeria as shown in Table 4.3.1.2 below.

Table 4.3.1.2: Nationality

S/N	ORIGIN	FREQUENCY	PERCENTAGE	CUMMULATIVE PERCENTAGE
1.	Non Nigerians	22	18.3 %	18.3 %
2.	Nigerians but from different places	47	39.2 %	57.5 %
3.	Indigenes of Potiskum	51	42.5 %	100 %
	Total	**120**	**100 %**	

Although about 57.5 % of the respondents are non-indigenes of Potiskum and 42.5 % are indigenes as represented in Table 4.3.1.2 above, Non-Nigerians constitute 18.3 % and the majority of them are from the Niger Republic Chad Republic and the Cameroun Republic due their proximity to Potiskum.

Findings from the questionnaire survey in Table 4.3.1.3 below shows how long have the people been in Potiskum. This revealed that more than half of the people in Potiskum constituting 57.50 % as shown in Table 4.3.1.3, are non-indigenes of the study area, though some are from Yobe state.

Table 4.3.1.3: The length of time of the people living in Potiskum

S/N	TIME OF MIGRATION	FREQUENCY	PERCENTAGE	CUMMULATIVE PERCENTAGE
1.	Indigenes	51	42.50 %	42.50 %
2.			10.83 %	53.33 %
3.	< 5 yrs	13	18.33 %	71.66 %
4.			15.83 %	87.49 %
5.	6 – 10 yrs	22	7.5 %	94.99 %
6			5.01 %	**100 %**
	11 – 15 yrs	19	**100 %**	
	16 – 20 yrs	9		
	21 yrs and Above	6		
	Total	**120**		

The following Table 4.3.1.4 shows the role of economy the movement with about 14.17 % of the respondents being motivated to migrate for economic reasons. Next to it is migration for academic purposes with 9.17 % respondents, while 5.0 % and 29.16 % respondents migrated to settle with their families and for civil service, respectively. The consequence of these is urban growth which has positive and negative impacts on the Potiskum metropolis.

Table 4.3.1.4: Reasons for migration to Potiskum

S/N	REASONS	FREQUENCY	PERCENTAGE	CUMMULATIVE PERCENTAGE
1.	Job	17	14.17 %	14.17 %
2.	for academic purposes	11	9.17 %	23.34 %
3.		35	29.16 %	52.50 %
4.	civil service	6	5.00 %	57.50 %
	Settlement with family			**100 %**
5.	and doing business	51	42.50 %	
	Indigenes	**120**	**100 %**	
	Total			

The growth of Potiskum metropolis in the past 20 years is obvious as 63.33% of the respondents viewed it as rapid manifesting in increasing economic activities and expansion of the residential areas. 36.67% of the respondents believing that the growth is normal as shown in the following Table 4.3.1.5.

Table 4.3.1.5: The Growth of Potiskum over the past 20 years

S/N	COMMENTS	FREQUENCY	PERCENTAGE	CUMMULATIVE PERCENTAGE
1.	There is rapid increase	76	63.33 %	63.33 %
2.	The growth is normal	44	36.67 %	100 %
	Total	**120**	**100 %**	

Findings from the questionnaire survey as summarized in Table 4.3.1.6 below shows the factors underlying the spatial urban sprawl. This shows that field observations revealed that 43.33 % of the respondents felt that the factors underlying the spatial urban sprawl was owing to migration, while 39.17 % respondents, and 17.50 % respondents support that it was due to population growth and poverty, respectively, (Table 4.3.1.6).

Table 4.3.1.6: Factors underlying the spatial urban sprawl

S/N	COMMENTS	FREQUENCY	PERCENTAGE	CUMMULATIVEPERCENTAGE
1.	Migrations	52	43.33 %	43.33 %
2	Population growth	47	39.17 %	82.50 %
3..	Poverty	21	17.50 %	100 %
	Total	**120**	**100 %**	

Findings based on the questionnaire survey revealed that 68.33 % of the respondents revealed that the effects of the spatial urban sprawl on the environment includes loss of agricultural land, while 11.67 %, and 20 % of the respondents indicate loss of open spaces and distorted master plan, respectively.

Table 4.3.1.7: Effects of the spatial urban sprawl on the Environment

S/N	COMMENTS	FREQUENCY	PERCENTAGE	CUMMULATIVE PERCENTAGE
1.	Loss of agricultural Lands	82	68.33 %	68.33 %
2		14	11.67 %	80.00 %

3..	Loss of open spaces Destroyed master plan **Total**	24 **120**	20.00 % **100 %**	100 %

4.3.2 Built-up area as an indicator of urban sprawl

The percentage of the area covered by the impervious surfaces such as the asphalt and the concrete is a straight forward measure of development (Barnes et al, 2001). It can be safely considered that developed areas have greater proportions of the impervious surfaces that is the built-up areas as compared to the lesser-developed areas. Furthermore, the population in the region also influences the sprawl. The proportion of the total population in the Region to the total built-up of so, is a measure of quantifying the sprawl. Since the sprawl is characterized by an increase in the built-up area along the urban and the rural fringe. This attribute gives considerable information for understanding the behavior of such sprawls. This is also influenced by parameters such as, population density, and population growth rate, etc.

4.3.3 Population Growth and Built-up Area

The rate of development of land in Potiskum metropolis is far outstripping the rate the population growth (Table 4.3.3 below). This implies that the land is consumed at excessive rates and probably in an unnecessary amount as well. Between the year 2000 and the 2020, population in the Region grew by 19%, while the amount of developed land grew by 56%, or nearly three times the rate of the population growth (Table 4.3.2). This means that the per capita consumption of the land has increased markedly over two decades (Table 4.3.3). The per capita land consumption refers to the utilization of all the land development initiatives such as the commercial, the industrial, the educational, and recreational establishments along with the residential establishments per person. Since most of the initiative's paves way for creation of jobs and subsequently help in earning livelihood, development of the land is seen as the direct consequence of this, hence it can be concluded that the per capita land consumption is inclusive of all the associated land developments.

Table 4.3.3.1: Population Data of Potiskum between 2000 and 2020.

YEAR	**POPULATION (inhabitant)**	**SOURCE**
2000	32,427	RESEARCHER'S ESTIMATE
2004	38,053	NPC (1992)
2010	49,155	RESEARCHER'S ESTIMATE
2020	59,560	RESEARCHER'S ESTIMATE
2021	87,706	NPC(2009)

Table 4.3.3.2: Population and built-up lands growth of Potiskum between 2000 and 2020.

YEAR	POPULATION	BUILT-UP LANDS (AREAS IN ha)
2000	32,427	270.09
2010	49,155	307.80
2020	59,560	1370.52

Table 4.3.3.3: Land consumption rate and Absorption coefficient

YEAR	LAND CONSUMPTION RATE	PERIOD	LAND ABSORPTION COEFFICIENT
2000	0.008	2000-2010	0.002
2010	0.006	2000-2010	0.002
2020	0.023		

4.4 Modelling urban sprawl

The land use analysis of the Region and the preliminary analysis on the population growth for the same period as discussed in the previous sections indicated some significant relationships between the change in the built-up area to the population growth, and the population-built-up density. Population has been for long accepted as a key factor of urban sprawl.

The Cellular Automata (CA) transitions are defined for the allocation of the new built-up areas into other land use classes. Furthermore, the allocation is also based on the suitability of the cells whose area ranked after the multi-criteria evaluation for the suitability of the land. In twenty-iteration (i.e. from year 2020 to 2040) of the CA model, the simulation time is set to twenty (20) years and so the model allocated the land use into the urban for the amount determined by the prediction model for demand also established for fifteen-years simulation time.

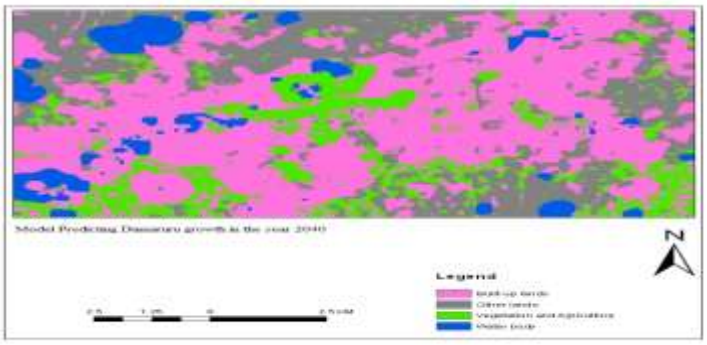


Fig. 4.5; Model predicting Potiskum growth in the year, 2040
Source: Author's Laboratory work, 2022

In the above analysis and the projection, the underlying assumption is that only those land use classes other than the urban, buld be considered for the new urban areas, implying that the urban growth could increase and would never recede. Thus, when the simulation is executed, a set of output for the respective years would be depicting the future urban growth. Thus, the CA model for simulating the urban growth is configured for the area under study by considering some of the drivers.

4.5 Transition Probability Matrix

The transition probability matrix records the probability that, each land cover category will change to the other category. This matrix is produced by the multiplication of each column in the transition probability matrix with the number of cells of the corresponding land use in the later image.

For the 4 by 4 matrix Table presented below, the rows represent the older land cover categories, and the column represents the newer categories. Although, this matrix can be used as a direct input for specification of the prior probabilities in the maximum likelihood classification of the remotely sensed imagery, it was, however, used in predicting the land use land cover of in year 2040.

Table 4.5.1: Transitional Probability derived from (From Idrissi Andes Software) the land use land cover map of the year, 2000 and the 2020.

"Class_Name"	Built-up lands"	Other lands	Vegetation and Agriculture	Water body"
"Built-up lands"	0.0000	0.8243	0.0479	0.1278
"Other lands"	0.5894	0.0000	0.0643	0.3463
"Vegetation and Agriculture"	0.5430	0.0000	0.0798	0.3772
"Water body"	0.2429	0.2644	0.1020	0.3907

Row categories represent the land use land cover classes in the year 2020 while the column categories represent that of the year, 2040 classes.

Table 4.5.2.: Projected Land use land cover for 2040 (Derived from ArcGIS Software)

"Class_Name"	Area_sqKM	Area sqKM (%)
"Built-up lands"	73.253700	52
"Other lands"	35.743499	25
"Vegetation and Agriculture"	22.434299	16
"Water body"	9.976499	7
Total	**141.407997**	**100**

The Table above shows the statistics the of land use land cover projection for the 2040. This may tend to suggest a change in the land use classes between 2020 and 2040. Thus, in Table 4.6, built-up lands have the highest proportion in the classes, while the water body retains its least position.

This shows that there is likely to be compactness in Potiskum by 2040 which signifies crowdedness and more urban sprawl as also shown in th

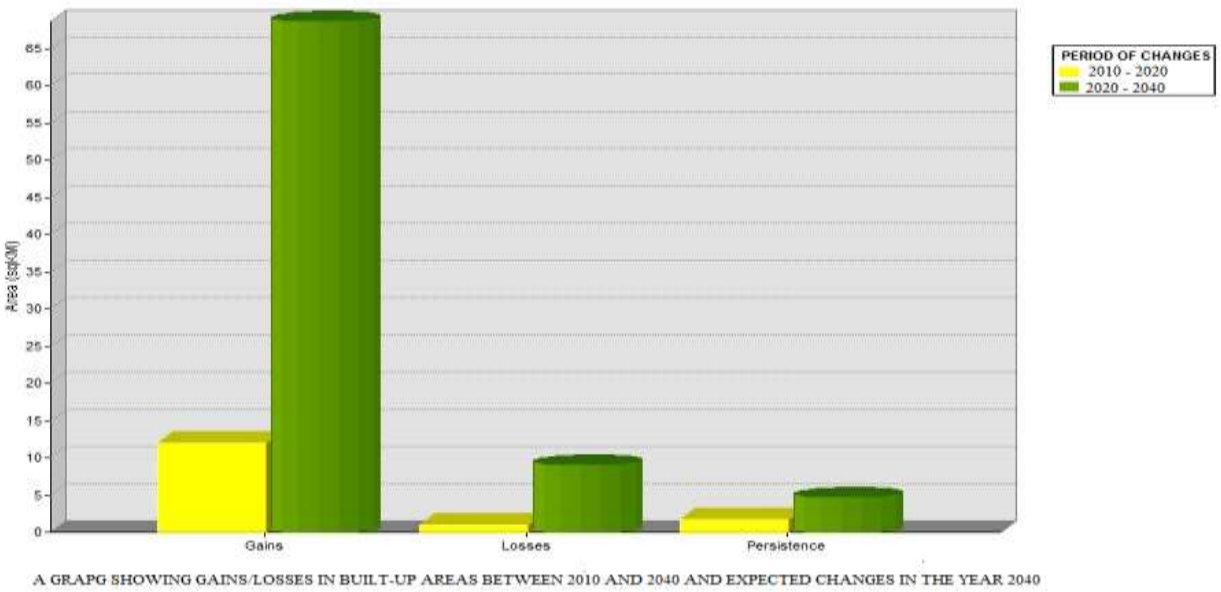


Figure 4.5: Graph showing the expected Gains and losses by the year 2040
Source: Author's Laboratory work, 2022

4.6 Discussion

Potiskum metropolis has recorded a significant increase in the built-up areas, and in the fringe of the town, mainly owing to population growth and development in its formal and informal sector of the economy. One of the critical issues associated with this expansion in Potiskum metropolis over the years, has been the haphazard and unplanned development as well as distortion of the existing plans common in the southern and the northern part of the metropolis. Associated with this, is road traffic congestion, high level of crime, stream constriction, clogging of the drains, high rate of waste generation and the improper waste disposal. Despite this growth in population and the increase in the built-up areas, development in infrastructural provision and services in the areas has not been made sufficiently.

Comparing the series of the LandSat images in Figure 4.1 Potiskum metropolis is expanding in every direction, but with more concentration in the south. The important aspect in the area land use change is the large extent of increase of the built-up land from 2% to 10%.

5.1 Summary

The study focused on the application of geo-information techniques to assess the urban Sprawl through the spatial growth of Potiskum Metropolis in Yobe State, with the objectives as to produce the land use land cover map of the study area; to analyze the urban sprawl pattern for the study area between the 2000 and the 2020 through Remote Sensing and GIS. In the work, urban sprawl of the Potiskum Metropolis and its environs has been studied, covering the period of 20 years (2000–2020), to extract the information related to sprawl, area of impervious surfaces and their spatial and temporal variability. Statistical classification approaches have been used for the classification of the remotely sensed images obtained from various sensors. The primary data source includes the researcher's physical observation, Global positioning system (GPS) coordinates and oral interviews to get information

from respondents. The general trends in land cover changes have been identified and summarized. Urban sprawl and its spatial and temporal characteristics have been derived from the classified satellite images. Land use and population growth analyses as key factors of the urban sprawl for the same period were carried out. They have revealed some significant relationships with the change of built-up area to the population growth. Also, the lands consumption rate and the lands absorption coefficient as indicators of the urban sprawl have been computed in terms of spatial phenomenon, in order to quantify the urban form (impervious area). The results of the change in the built-up area, land consumption rate and land absorption coefficient were both revealed to be high between the 2000, and the 2020. These suggest that the rate at which new lands are acquired for development is high. The results also revealed that the percentage change in the built-up (56%) was found to be very much higher than the percentage change in the population growth (19%). From these, the possibility of sprawl in terms of the percentage built-up was modelled for the year, 2040. The CELLULAR AUTOMATA (CA) transitions are defined for the allocation of new built-up areas into other land use classes. Government may eventually need to develop policies to maintain the land for future use, an absence of any land use planning may lead to land degradation.

5.2 Conclusion

The urban sprawl for the period of nearly twenty years was quantified in terms of changes the in built-up areas as well as the land consumption rate. Land consumption rate was high between the 2010 and the 2020. This increase is also anticipated before the 2040. Also, land absorption coefficient, was high between the 2000, and the 2020. This therefore, suggests that the rate at which the new lands are acquired for development is high. This may also be the trend between the 2020 and the 2040 as there seems to be development, expanding towards the outskirts in the form of sprawl. The percentage change in the built-up (56%) was found to be very much higher than the percentage change in the population growth (19%). Furthermore, the thrust being on modeling studies has enable the study successfully define the sprawl phenomenon. From these, the possibility of sprawl in terms of percentage built-up, was modelled for the year 2040. The future scope of this work would further look into generating the images of further sprawl under different scenarios to understand any threat to natural resources and the ecosystem.

5.3 Recommendations

The study demonstrates the application of the GIS and the Remote Sensing techniques in studying urban sprawl and its dynamics. In the course of the urban spread, valuable land is being converted for building, industry, transport facilities, etc. The land, being inadequate, government needs to develop policies to maintain it for intensive land use and peri-urban agriculture. Absence of any land use planning can lead to land degradation. Urban sprawl increases traffic problems, depletes natural resources, and mounts pressure on infrastructure, particularly in the peripheral areas. This has translated into socio-economic and political problems, thereby imposing great challenges to urban planners, city administrators, and the general public. The implications of urban sprawl are not only on the surrounding neighborhood with the loss of agricultural lands, or ecological habitats, but on the basic amenities like, transportation, water supply and sanitation, energy, etc., within the inner core of the city. Un-planned decisions may result into misery for large segment of the local population and destruction of valuable eco-system. Techniques for the planning and management of land resources specifically

integrated and holistically will check long term quality of the land for human use, their prevention, or resolution of social conflicts related to land use, and the conversion of the ecosystem. The wisdom lies in how effectively we plan the urban growth without hampering the natural resources and disturbing the rural setup. Additionally, the planning should also focus on a dispersed economic structure and aim at the creation of balanced ecological, social, and economic system. Thus, it is, essential to review the conventional planning methods and introduce innovative measures such as geo- information technologies in this regard.

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