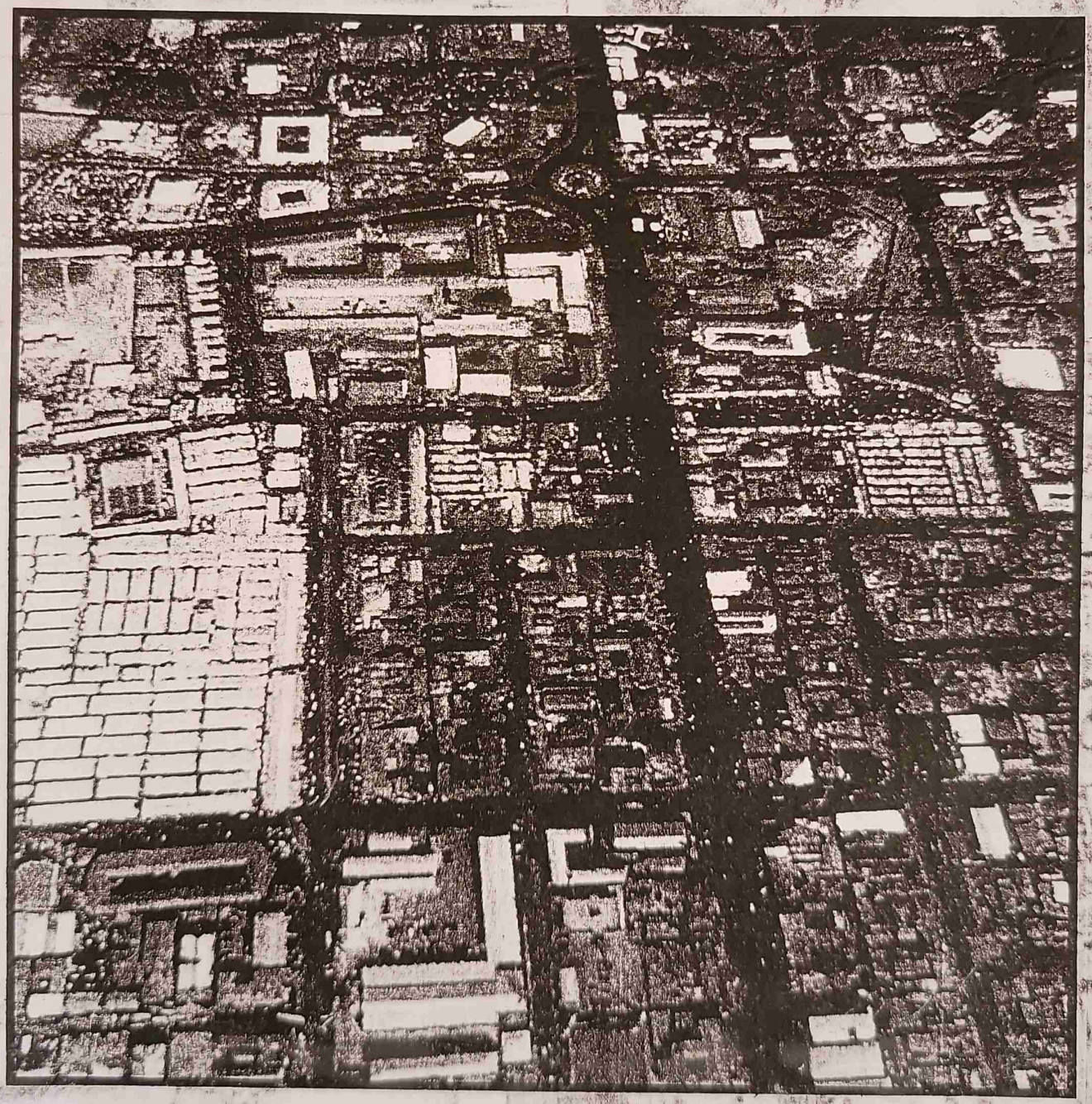
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ASSESSMENT OF URBAN SPRAWL IN MUTUM-BIYU TOWN OF TARABA STATE, NIGERIA USING GIS AND REMOTE SENSING TECHNIQUES.

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Abstract

Urban sprawl situation in Mutm-biyu town between 1983 and 2011 was assessed using GIS and remote sensing techniques. This was carried out in other to monitor the rate of urban development process especially at the peripheral areas of the city and to prevent possible environmental and social problems that can emanate from uncoordinated urban physical development. Data used were collected from both primary and secondary sources. The primary data relate to GPS coordinates of some features that were taken and a set of questionnaire administered on Heads of Departments of Land and Development Control at both Mutum-Biyu LGA and State headquarters. The questionnaire which was meant to back-up the data base assisted in providing information on factors or urban sprawling and problems of its management in the study area. Secondary data used includes topographical map, aerial photographs and Landsat TM 1993, Landsat ETM 2003 and QuickBird and Landsat ETM 2011. Both hardware and software computer components were used in processing the data while geospatial techniques of overlay, querying and statistical methods were used in analyzing the data. Result obtained indicates that early sprawl pattern in the study area depict the ribbon type of sprawling while leap frogging pattern manifested thereafter. A number of reasons were identified as factors of urban sprawl in the investigation while problems confronting of sprawl management in the study area were discussed. The study concludes by putting up a number of recommendations towards making the study area conducive for living.

Keywords: Urban Sprawl, GIS Remote Sensing, Peripheral Areas, and Development.

Introduction

Cities are the hub of most human activities; hence they are attractive to human population. This attraction which has resulted in the ever-growing size of cities is decreasing the size of open spaces available within such an area, an action which also exerts pressure on civic amenities and agricultural lands. The extraordinary growth of population and the consequent effect of pressure on amenities are the most dramatic phenomena associated with urbanization. It is also a fact that the pressure of the continuously growing city centre is gradually changing the neighborhoods. It is this process of extension of urban areas and merging of fringe areas into main city that is referred to as urban sprawl (Adegboyega 2008).

Urban sprawl is a spread-out development that consumes significant amount of natural and man-made resources, including land and public works infrastructure of various types. It is a continuous process. Urban sprawl adds to the overall travel costs due to increasing use of automobiles to access work places and residential locations. According to Angel and Civco (2007) urban sprawl results in excessive encroachment on agricultural land, loss of aesthetic benefits from the presence of open space and high air pollution rate resulting from traffic congestion. Though the phenomenon of urban sprawl comes with a number of problems, its development also offers a number of benefits. It allows access to less-expensive housing and opportunities for home

ownership at the periphery of urban areas. Phenomena of urban sprawl appear to decongest the centers by detracting the multiplicity of purpose that neighborhoods once depended upon. Urban sprawl is a global phenomenon. This is because; almost all cities and towns in the world are undergoing the process due to technological advancement, rapid population increase and high economic growth (Adegboyega and Aguda, 2010).

Ever since the creation of Gassol Local Government Area in Taraba State with Mutum-Biyu as the headquarter in 1996, the town has been undergoing rapid urbanization. The town which had a population of 61,782 in 1991 rose to a population figure of 93, 521 in 2003. This increase represents a growth rate of almost 52 percent in just a period of twelve years (Saidu and Gadiga, 2004). This growth rate principally resulted from the change in status of the settlement from an ordinary town to a local government headquarters. However, because Mutum-biyu was unprepared for such sudden change in status, the concomitant demand for housing and other infrastructures which resulted from influx of people has led to rapid physical expansion of the settlement with little or no re–course to planning regulations. This haphazard physical expansion of the settlement is now posing serious impact on the environmental resources and livelihood of surrounding rural areas. Not only that, the enormity of this physical growth is also posing serious challenges for urban planners and managers. This is in terms of monitoring such physical growth, including infrastructural development. According to Ahris (2005), Okewole (2002) and USEPA (2001), uncontrolled and unmanageable development induced by urban sprawl usually impacts negatively on the physical, environmental and socio economic aspects of such a settlement. Attempt to address the aforementioned problems induced by rapid physical growth calls for a study of this nature which seeks to use GIS and Remote Sensing techniques to develop a data base for monitoring the growth pattern of Mutum-biyu GIS and Remote Sensing.

Study area

Mutum-biyu is located in Gassol Local Government Area of Taraba State, Nigeria. The settlement which lies between latitude 8° 37^{1} and 8° 38^{1} north of the equator and between longitude 10°45^{1} and 10°47^{1} east of Greenwich Meridian (Figure 1) is about 72km away from Jalingo, the state capital. The town which covers an area of about 33.7Sq km has a population of 97,375 (NPC, 2006). Mutum-Biyu has a tropical wet and dry climate, and it is coded as *Aw* in Koppen's climatic classification. Temperature regime in the area between March and October is warm to hot while low temperatures are usually experienced during the harmattan season which span between the months of November and February. Wet season in the area is usually observed between the months of April and November. The settlement which is located on lowland with elevation ranging between 121 and 300 meters above mean sea level has a mean annual rainfall of about 1100mm (Bulus, 2009). Urbanization process is fast taking place in the city with consequent effect on deforestation.

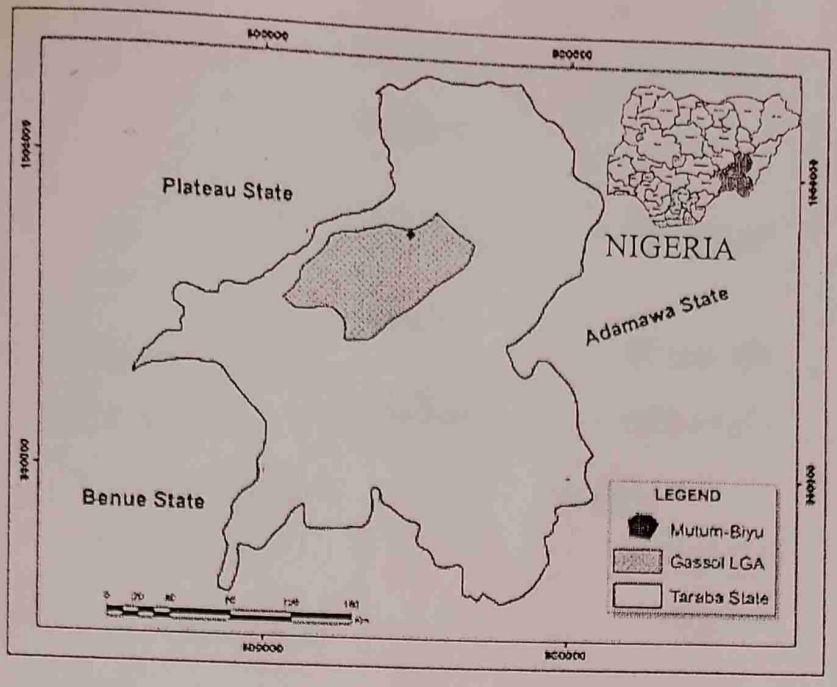


Figure 1: Map of Taraba State Showing the Study Area with Nigeria as Inset
Source: Taraba State Town Planning Authority 2006

Research Methods

Both primary and secondary data were used in this investigation. The primary dataset include GPS coordinates of some features that were taken by the researchers and a set of questionnaire administered on heads of departments of land administration and development control at both the state headquarters and Mutum-biyu LGA. The questionnaire assisted in backing up the database of the study. Information such as factors of sprawling and problems of its management were sourced using this instrument. Secondary data used include topographical map, aerial photographs and three high resolution satellite imageries for the year 1993, 2003 and 2011. Both the topographical map and aerial photographs were obtained from Taraba State Town Planning Authority while the satellite imageries were obtained from Regional Centre for Training in Aerospace Survey (RECTAS), OAU Ile-Ife. Both hardware and software computer components such as hp 530 laptop, A4 flatbed scanner, A4 colour printer, ArcMap GIS 9.3, ILWIS 3.3 Academics were used in processing the data. Database design was carried out at three levels of conceptual, logical and physical designs. Figure 2 presents the entity relationship diagram.

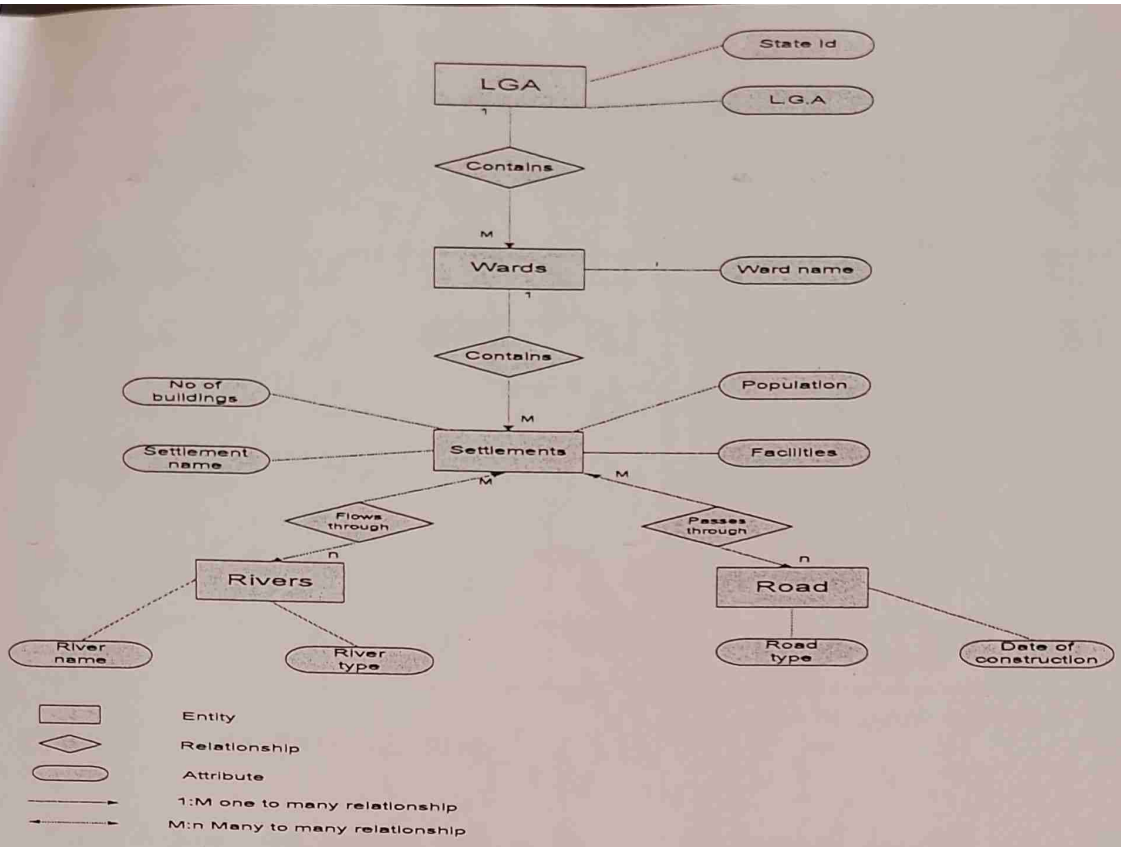


Figure 2: Entity Relationship Diagram
Source: Authors' Design, 2014

The available topographical map was converted into digital format and processed alongside Landsat TM 1993, Landsat ETM 2003 and QuickBird and Landsat ETM 2011 satellite imageries using ILWIS software. Sub-map of the study area was created and necessary imageries were extracted. Ground truthing was carried out to confirm classification and ascertain the location of major landmarks such as boundaries of roads, facilities and rivers amongst others as found in the images. On-screen digitization using ILWIS and ArcMap softwares was carried out followed by editing to have quality control. Image classification in this study was carried out using the stored selected bands in the map list. However, before classification, training of pixels was first carried out in the sample set window. Each band was filtered using median (3x3) so as to be able to identify the various land uses in the study area. This task was carried out because of the fragmented nature of the land use in the study area. Land use in this study was classified into five (5) classes of built-up areas, open spaces, water bodies, forest and bare-land/cultivated land. Maximum likelihood algorithm was used for the classification, an operation which was performed on the three satellites imageries used in the investigation. Geospatial techniques of overlay, querying and statistical methods were used in data analysis.

Discussion of Findings

Landuse Changes in the Study Area Between 1983 and 2011.

Table 1 presents the data on landuse changes in Mutum-Biyu between 1983 and 2011.

Table 1: Changes in Land use Pattern between 1983 and 2011

Land Use Types	1983		1993		2003		2011	
	%	Area km^2	%	Area km^2	%	Area km^2	%	Area km^2
Built up area	1.3	0.80	5.3	2.09	25.7	8.92	30.3	9.69
Cultivation	64.3	20.7	60.8	18.5	53.5	16.98	40.7	12.96
Open Space	1.1	0.70	2.9	1.71	1.6	0.89	1.2	0.63
Water bodies	10.9	3.3	10.4	3.77	2.8	1.4	0	0
Forest	22.4	8.2	20.6	7.28	16.3	5.51	33.5	10.42
Total	100	33.7	100	33.7	100	33.7	100	33.7

Source: Authors' Fieldwork, 2014

Table 1 shows that built-up area in the study area occupied 0.8 km^2 in 1983; this represents 1.3% of total land area in the settlement. Cultivated area, open space, water bodies and areas occupied by vegetation in the same year occupied 20.7, 0.70, 3.3 and 8.2 sq km respectively. This shows that substantial area of the town (64.3%) was under cultivation in the settlement by 1983. By 1993, land area under cultivation and forest have decreased to 18.5 and 7.28 sq km respectively while built-up area, open space and area occupied by water bodies have increased to 2.09, 1.71 and 3.77 sq km respectively. By 2003, which was just a period of two decades from 1983, built-up area in the settlement had increased by over 68.6% at the expense of other land use surfaces which had decrease by between 3.71% (water) and 90.1% (cultivated area). As at the time, the areas classed under vegetation and open space have reduced from 7.28 and 1.71 sq km in 1993 to 5.51 and 0.89 sq km respectively. While the decrease in water bodies may be linked to urbanization process in the city which negatively affects infiltration process, the high percentage decrease in cultivated area poses a great threat to food security in the region. In 2011, land use pattern in Mutum-Biyu has significantly changed. The built-up area which formerly occupied 0.80 sq km in 1983 had occupied 9.69 sq km accounting for 30.3% of the land area. This physical expansion of the settlement represents over a thousand percent growth rate. Though cultivation area and open space recorded some percentage decrease in 2011 when compared with 1983 (37.4 and 10% respectively), area occupied by vegetation increased by 27.1% while land area covered by water bodies has completely dried up. Figure 3 shows the changes in land use pattern in the study area during the period under investigation.

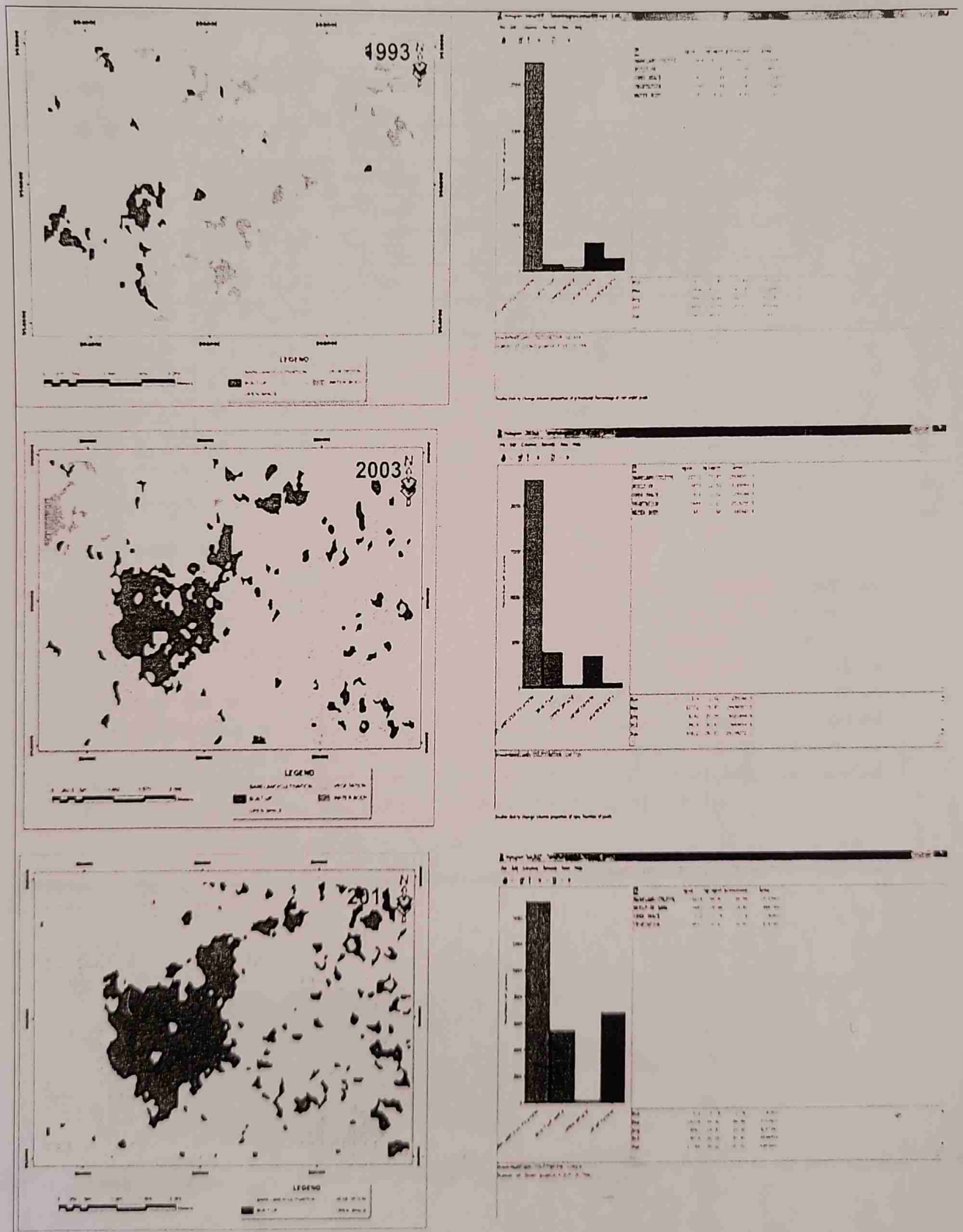


Fig 4: Land Use Changes in Mutum-biyu

Sprawl Pattern in the Study Area:

Table 2: Sprawls Locations, Elevation and Extent

S/NO	Latitude	Longitude	Elevation height	Location	No of building
1	10°16′30.6″	8° 14′ 09.2″	153m	Sabon-Gari2	118
2	10°15′52.7″	8° 14′28.5″	141m	Tudun-Haske	61
3	10°16′38.3″	8°15′ 05.9″	139m	Badeja	45
4	10°14′51.8″	8°15′ 23.8″	147m	Badeja2	56
5	10°15′28.1″	8°16′ 29.6″	159m	Sabon-Gari	64
6	10°15′11.8″	8°16′ 58.7″	145m	Jigawa	103
7	10°15′56.1″	8°17′44.3″	144m	Garin-Magaji	136
8	10°16′21.0″	8° 17′ 44.5″	150m	Lomodu	63
9	10°16′21.0″	8°.17′ 44.4″	152m	Garin-Atiku	89
10	10°17′08.4″	8°.15′ 56.8″	146m	Garin-Tudu	112
	TOTAL				847

Source: Field work 2014

Table 2 shows that much of the sprawling took place in areas such as Sabon-Gari2, Garin- Magaji, Grin-Tudu, Jigawa and Garin-Atiku. Figure 5 to 9 depict the sprawl pattern in the study area for the study period. While Figure 4 shows the initial built-up of Mutum-biyu as at 1983, Figure 5 depicts the extents of sprawl as at 1993. The sprawl pattern as at 1993 closely follows the concentric land use theory of Burgess (1925). However, by 2003, Figure 6 shows that the town had manifested Ribbon form of sprawl which encourages the expansion of the town around road networks and infrastructural facilities. This sprawl pattern follows the sector theory of urban land use earlier described by Hoyt (1939).

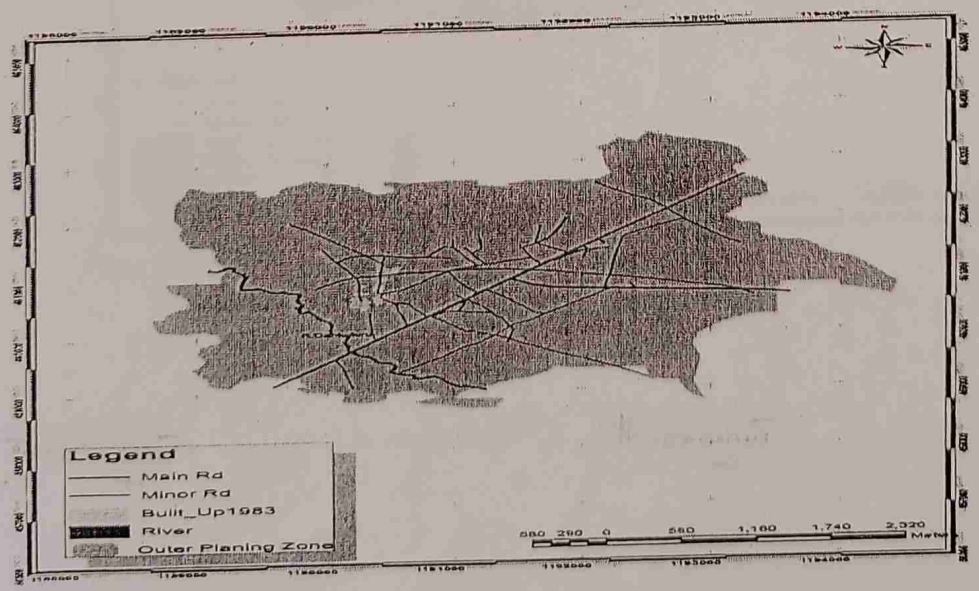


Figure 4: Land Use of Mutum-Biyu, 1983

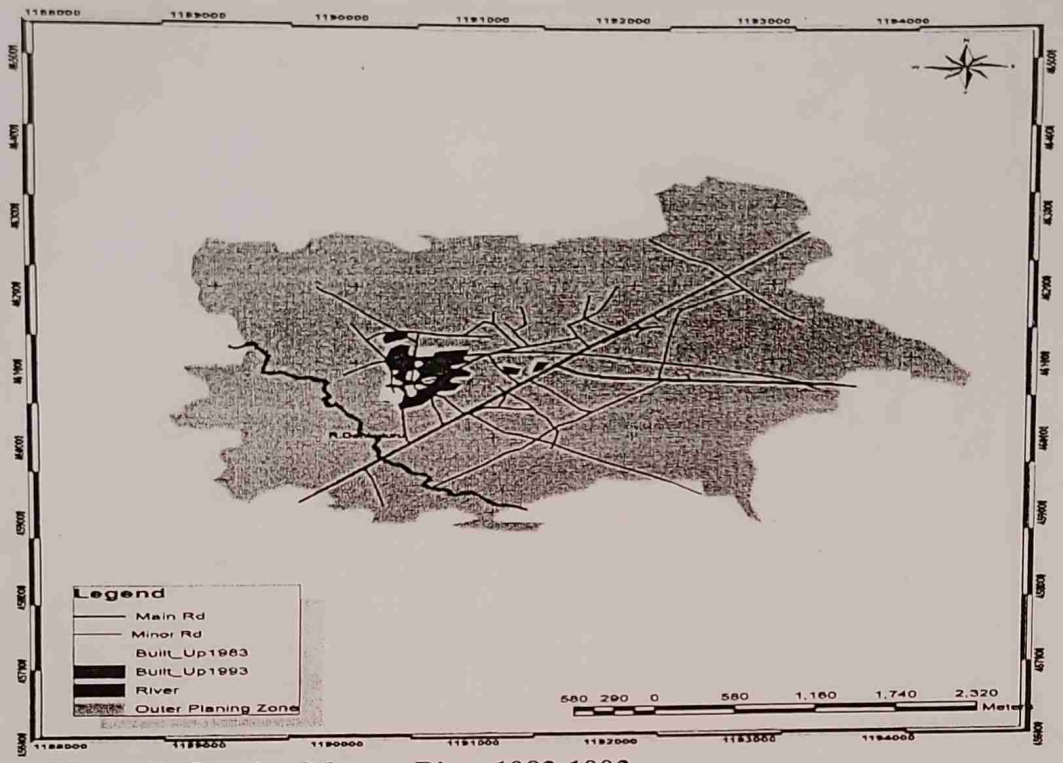


Figure 5: Overlay Mutum-Biyu, 1983-1993

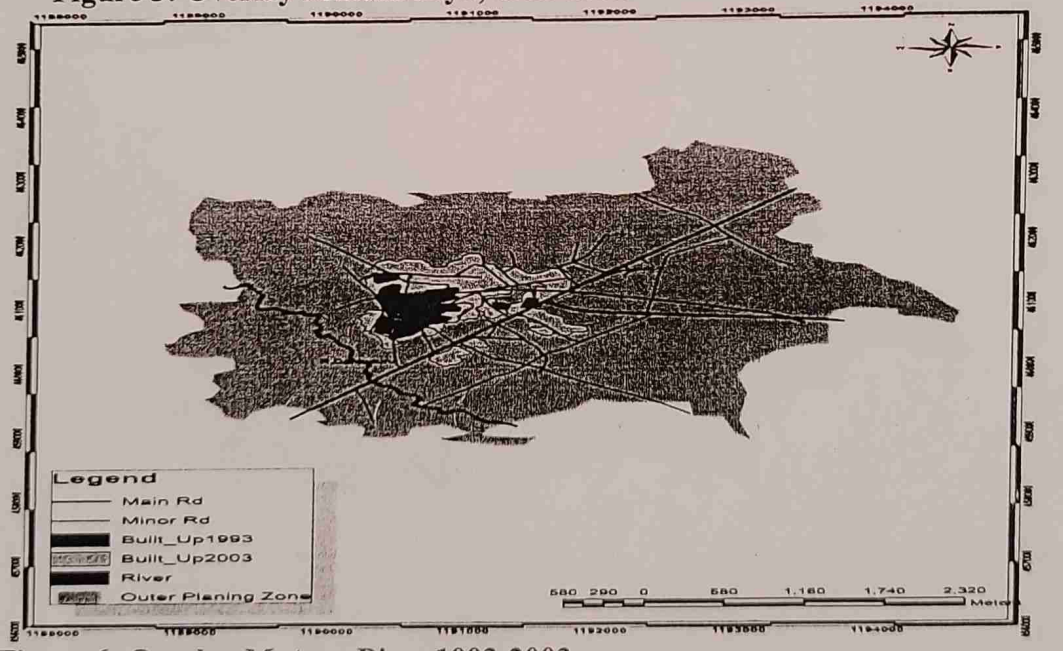


Figure 6: Overlay Mutum-Biyu, 1993-2003

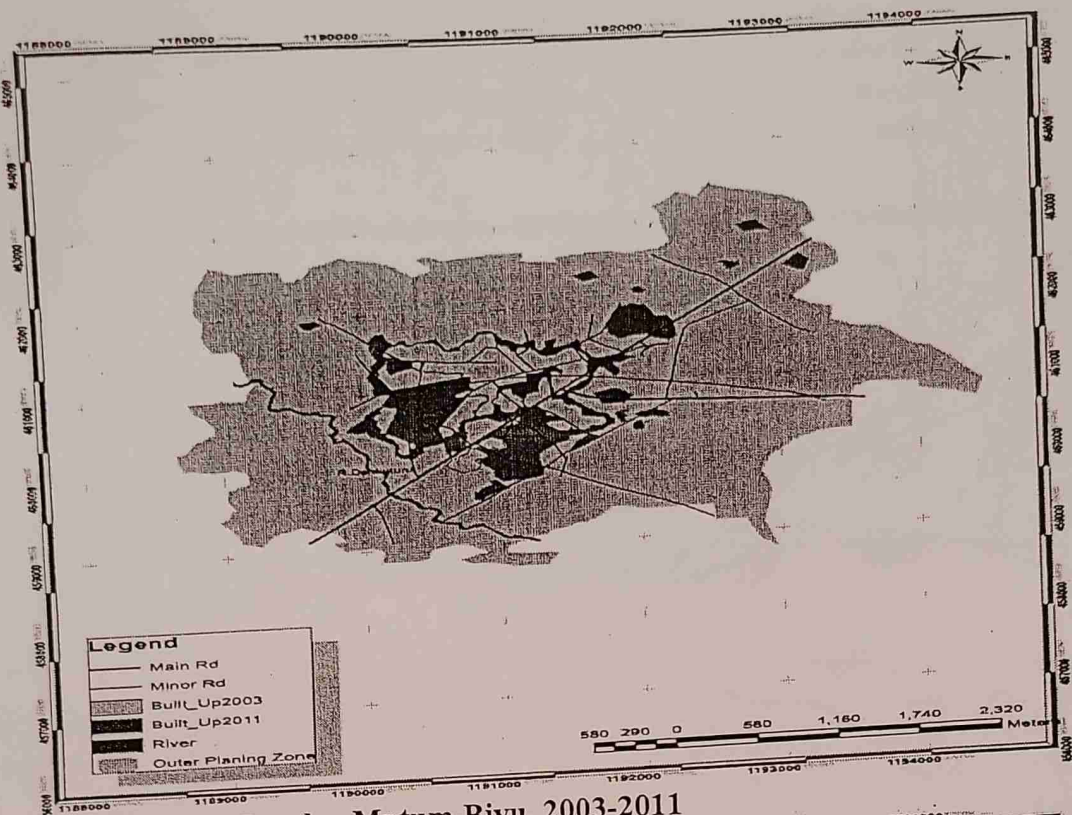


Figure 7: Overlay Mutum-Biyu, 2003-2011

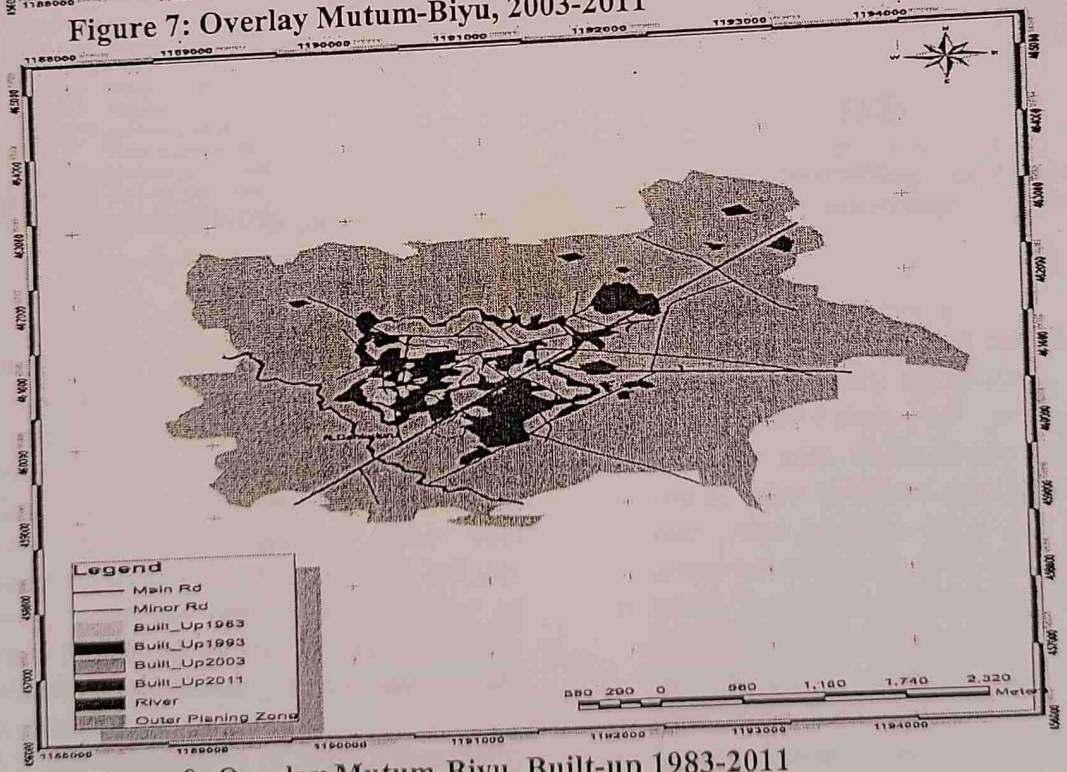


Figure 8: Overlay Mutum-Biyu, Built-up 1983-2011

After 2003, there was manifestation of Leap frogging type of sprawling in 10 locations as can be seen on Figure 7. This sprawl pattern can be ascribed to the institutional land use demand in the study area. Land area acquire for institutional use usually occupy large expanse of land which do not always allow private developments to be carried out around such an area. The expansion during this period engulfed some of the adjacent settlements and villages such as, Tudun-

Haske, Sabon-Gari, Badeja, Lomodu, Garin-Atiku, Sabon-Gari2, Jigawa and Garin-Magaji. The engulfed settlements created new CBDs, while their population also increased tremendously as a result of rapid urbanization of Mutum-biyu. Figure 9 depict the locational pattern of sprawling during the study period.

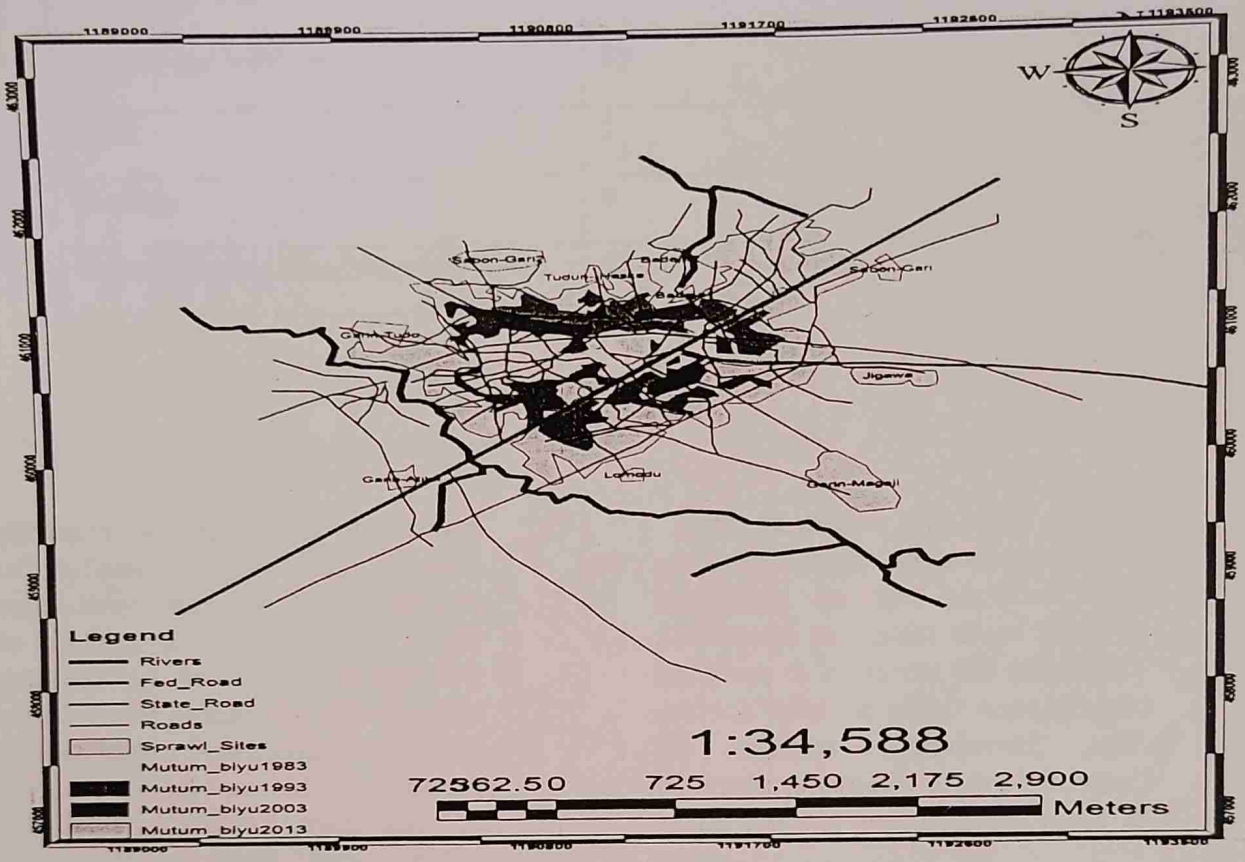


Figure 9: Pattern of Sprawling in the Study Area

Factors of Urban Sprawling and Problems of its Management

Result of interview conducted on selected heads of departments of land administration, development control and environmental management which was meant to strengthen the database of this study identified some major factors of urban sprawl in the study area. Amongst these factors according to the respondents include:

i. The establishment of local government secretariat in the study area: Mutum-Biyu became the headquarters of Gassol Local Government in 1996, and since then the town has recorded rapid growth, both in terms of population and physical development. The expansion of the town has attracted investors, both within and outside the country.
ii. The availability of infrastructural facilities such as health services, good roads, schools, electricity, water supply etc: These facilities which has attracted a number of people from different parts of the country to Mutum-Biyu. Table 3 shows the list of some of the social infrastructural facilities that can be accessed in the town.
iii. Security status of the town: This has also contributed immensely to its growth. The town is very peaceful; the two major religious groups found in the settlement are living in peaceful coexistence. Couple with this is the good traditional institution the town is endowed with.

Table 3: Factors of Urban Growth in Mutum-Biyu

Facility Name	Number
Secondary School	19
Primary schools	30
Healthcare services	12
Bank	1
Markets	4
Telecommunication Network masts	4
Car parks	5
Hotels	12

Source: Field work 2014

iv. Agricultural activity within and around the settlement: This has attracted people from near and far distance to Mutum-Biyu town. Large area of the settlement has flat and fertile land that is used in the production of both food and cash crops. Few examples of crops grown in the area include rice, beans, groundnuts, maize and vegetables. The presence of big grain market in the town is acting as a great factor of attraction of people from different part of the country into the city.

v. Good climatic condition: Mutum-Biyu is located between latitude 8^0 37^1 and 8^0 38^1 and between longitude 10^0 45^1 and 10^0 47^1. The settlement has very conducive climate; a characteristic which makes the city one of fastest growing towns in Taraba State.

On the problem of management of urban sprawling in the study area, authorities concerned at both the state and local government office who were interviewed acknowledge their limitations in capacity to monitor and control the rapid growth rate taking place in Mutum-biyu. The officers identified the following as some of the challenges confronting them in the task of carrying out their duties:

i. Lack of master plan. The officers carry out their exercise without any guide.

ii. Ignorance on the parts of land developers as almost all of them do not want to leave out the mandatory setback between plots. According to the officers interviewed, such landowners usually regard the small space left out between the plots as waste.

iii. The enforcement of planning laws, most times are not adhered to, most especially by the royal families and people in power.

iv. Lack of knowledge among the generality of staff concerned with urban planning and management in the use of GIS and Remote Sensing techniques for monitoring the rate or urban growth. According to them, research equipments in these areas are not available both at the state and at the local government office.

Recommendations

Based on the observations from this study, the following recommendations are hereby put forward towards controlling and managing the problems induced by sprawling:

i. The authorities concerned should as a matter of urgency prepare a master plan to ensure a conducive environment for the residents of the city.

ii. There should be establishment of GIS and Remote Sensing Units in the local government headquarters so that spatial data base can be created and updated either through recent imageries analysis or collection of data through field work at regular interval with a view to providing input data for decision making process. The output data should not be made too complex to enhance easy interpretation and efficient management of urban settlements.

iii. Workshops and conferences should also be regularly organized at both state and local government levels for cross fertilization of ideal among the workers.

Conclusion

GIS and remote sensing are essential and viable tools for monitoring rate of urban sprawl. The act of monitoring urban sprawl is very important for proper planning and implementation of policies for suitable development programme. Monitoring of urban sprawl will help in forecasting the rate of physical expansion of a settlement. This action will in no small way help government at various levels towards proper planning and provision of utilities such as electricity, water supply, road networks amongst others. The use of GIS for these tasks is of vital importance as information on the state of such facilities at any period of time can be collected from the field and store in a database which can be retrieved and updated any time need arises. This modern technology feature of GIS and Remote Sensing technique makes it suitable for managing urban expansion and growth in any growing settlement.

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