International Journal of Advance Research, IJOAR .org
Volume 4, Issue 3, March 2017, Online: ISSN 2320-9186

ASSESSMENT OF URBAN ENCROACHMENT DYNAMICS INTO PRECINCT SEMI-ARID FOREST RESERVES IN MAIDUGURI, BORNO STATE, NIGERIA USING GIS AND REMOTE SENSING.

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ABSTRACT

This study examined the integration of Remote Sensing and Geographic Information System (RS/GIS) for assessing urbanization on the forest reserves in Maiduguri, Borno State. The 1975, 1986, 1999 and 2015 Landsat TM satellite Remote Sensing data were used to identify and classify various Forest Reserves. A GIS database of land degradation categories within 40 years (1975-2015) was generated and analyzed with the aid of GIS analytical functions. These include area calculation, and image differencing. The results showed that population growth of communities around the forests impose a lot of pressure on the forest reserves which covered a total of 2827.01A/ha in 1975 which has now been reduced to paltry 42.05A/ha by 2015. The forest reserves around Maiduguri have suffered significantly and if the present trend of deforestation and urbanization continues; it is just a matter of time when the whole reserves would be reduced to a built up area. The study therefore, suggests that authority should gazette and make a strong policy in preserving the relict of the forest reserves from total decimation and illegal encroachment by the populace. It suggests the promotion of alternative energy sources apart from fire wood and charcoal in order to eliminate the pressure on the fragile forest lands.

KeyWords: Deforestation, Urbanization, Remote Sensing, Geographic Information System, Precinct, Forest reserve, Population, Dynamics

Introduction

Urbanization is a shift of population from rural areas to cities resulting in expansion of the urban areas. This is often noticeable when resources of the cities are over stretched and are becoming scarce. The resultant effect of which is land grabbing, and land speculations. Urbanization is a complex process, its intrinsic mechanism for population increase is often augmented by the migrants' potential ability to rapidly add to the population by its own intrinsic mechanism and/or reproductive potential in addition to socio-economic drives. The rapid population increase is the feature of urban population dynamics. Consequently, the physical environment bears the brunt of the population explosion that usually results from the rural urban drifts. A country is considered to be urbanized when over 50 per cent of its population lives in the urban areas and urban areas are often characterized by construction of roads many of which result in deforestation [5] [2] Human encroachment of natural areas stems from the demand for both residential, industrial, market, schools, hospital, worship and recreation spaces It must be noted that the industrial revolution in the late 18^{th} century and early 19^{th} century resulted in massive shift in rural urban dynamics resulting in concentration of population thereby clearing vast forests and plains for agriculture, [6]. Similarly, the past 40 to 50 years has witnessed a rapid population change in Maiduguri the capital city of Borno State. The establishment of Chad Basin Development Authority by Decree 32 of 1973 which draw many migrant workers from many rural parts of Nigeria, the establishment of several educational centers and hospitals brought about a rapid shift in population which inadvertently led to unbridled encroachment into the forest reserves created at the periphery of the city of Maiduguri and adjoining Local Government Area's forest reserve such as Jere LGA. And of course several housing estates have depleted the forests reserve around the city outskirts. The imperative here is that urbanization is not characterized by agricultural settlements rather by socio-economic factors.

In order to effectively monitor and assess the extent and dynamics of deforestation and urban usurpation of the precinct forests around the city of Maiduguri, Nigeria, GIS and Remote sensing technologies were applied [9] [11]. The launching of the first-ever remote sensing satellite (TIROS-1) coincided with the birth of GIS even though the two events occurred independently of each other [8] this development has facilitated the study. A geographic information system (GIS) is a computer assisted system for handling spatial information. GIS software can be considered as a collection of software programs to acquire, store, analyze, and display information. The input data can be maps, charts, spreadsheets, or pictures [8] [9]. With the aid of these tools, this study examines the rate of forest reserve degradation or dereservation, land use and land cover changes in forest reserve areas encompassing Maiduguri the capital city of Borno State, Nigeria over a 40 year period (1975 – 2015)

MATERIALS AND METHOD:

Location of the Study Area

The study was conducted in Maiduguri the capital city of Borno State, Nigeria with a population of 722,664 according to [7] It is the most populated and fastest growing city in the North Eastern region of Nigeria; Maiduguri serves as a commercial nerves center of the sub-region with 3% annual growth rate [7] census report. Maiduguri is located between latitude $11^0$46'N to $11^0$55'N and longitude $13^0$02'30"E to $13^0$15'30"E. It shares borders with two Local Government Areas (LGA) namely: Jere and Konduga LGA located in Borno Central, (Figure 1). The major materials used for this research are the historical landsat satellite images for 1975 master plan/base map, 1986, 1999, 2015 satellite images and Ilwis 3.3 software for assessment of vegetal change detection.

Data collection

The Data for the study were acquired from a number of sources. For land cover monitoring, this requires images of different time periods, while change detection analysis was carried out with not less than three images of the study area namely: (1) Landsat TM (1986), (2) Landsat ETM – (1999) and (3) Landsat 8 (2015) satellite images of Maiduguri forest reserves.

Methodology

Image Registration and Classification

The images were imported into ILWIS 3.3 via the Geogateway format for registration and classification. Classification entails the process of regrouping similar digital numbers and assign an appropriate class name. Each cluster of observation is a class. The entire images were sub-mapped or clipped to the square size of the study area. The images were georeferenced using GPS with high accuracy (sub-meter). Some key positions identified on the images and on ground were recorded in the field and used in ILWIS 3.3 to georeference the images of classes identified. Fieldwork carried out as Training Site (TS) on all the classes. The TS were used to generate clusters of different classes, where forested class was analyzed.

Data Analysis and Discussions

Two main methods of data analysis were adopted for the study.

i. Calculation of the area in hectares of the resulting forest reserves for each year of study and subsequently comparing the results
ii. Image differencing (to provide for change analysis through differencing of images pairs).

The methods were used to identify changes in the forest reserves. The comparison of the changes observed assisted in determine the percentage change, trend and rate of change between 1975 and 2015. These are presented in Tables 1 to 4 showing the area in hectares and the percentage change for each year 1975, 1986, 1999 and 2015 measured against each spatial distribution of the forest reserves. The 1975 base map Figure 2, forms the basis by which the extraction of the study sites was carried out using the ILWIS 3.3 software. The coordinates were registered. This process was carried out for the remaining LANDSAT images for 1986, 1999 and 2015 respectively as shown in Fig. 3 using the coordinates (X_282557.06, 314739.28 and Y_1300619.39, 1317114.80)

Figure 3 shows the various Landsat images of the study area before been sub-mapped and carved out based on the established coordinates in Figure 2 to further produce a georeferenced image of the study area in Figure 4

Figure 4 shows that the forest reserves in Maiduguri are spatially distributed from 1975. In order to obtain the area extent (in hectares) of the forest reserve for each study year and for subsequent comparison, the GIS analysis in database query (AREA) of ILWIS 3.3 was carried out. Tabulations and area calculations provided a comprehensive data set in terms of the overall landscape, the type and the amount of changes that have occurred. Tables 1 to 4 show the spatial extent of the forest reserves in hectares and in percentages for the 40 year study period namely: 1975, 1986, 1999 and 2015.

Table 1 shows the total area (in hectares) of the various forest reserves identified in Figure 4, with Mafoni Forest reserve having the largest land area. Eight forest reserves were identified from the base map (Figure 2) they include; Pompomari , Mafoni, Farm

Center, Jere, Gamboru, Gwange I, Gwange II and Hausari Forest Reserves, (Figure 4) having a total forest reserve area of 2,827.01ha. Although, Mafoni and Pompomari Forest Reserves had the highest forest reserve areas covering 946.28ha (33.4%) and 909.55ha (32.1%) respectively.

After 11 years of progressive urbanization and concomitant deforestation between1975 and 1986 the results in Table 2 indicate that a significant percentage of the forest reserves were lost whereas others were completely decimated such as the Hausari forest reserve. Figure 6 shows a graphical deterioration of the forest reserves over the period under consideration. This has highlighted the importance of the use of GIS and Remote Sensing technology in monitoring the dynamics of our precinct forests

Table 3 shows a continuation in the trend of deforestation and urbanization in the forest reserves after 13 years (1986 – 1999) when it was first identified. The continuous quest for urban expansion in Maiduguri has led to a further depletion of the reserve by the year 1999, as only five forest reserves (including two sub units; Gamboru and Gwange) were left, with 232.52ha. This has led to the loss of 93.1% of the total area of the forest reserves in Maiduguri (Table 3). The rate at which this depletion occur is a clear indication that if nothing is done, the whole reserves with time will be gradually transformed into town and city centers.

Table 4 further gives insight into the rapid rate of depletion of these reserves in 16 years (1999 – 2015), with only about 42.05ha left for the remaining forest reserves. It is shown here that clearly urban encroachment is a factor militating forest conservation.

The consequence of urban expansion on forest development in this area require that regular stock taking of the forest estates to determine the direction of management in order to avoid total depletion. Where necessary that would demand creation of new reserved. In Figure 5 the graphical extent of loses of forest reserves are presented, as well as the percentage left of the previous forest reserves over time. By the year 2015, 98.76% of the total forest reserves have been lost to urban encroachment and/or development without adequate provision for new forest reserves.

The Mafoni and Pompomari forest reserves which occupy the largest land area among the forest reserves (Table 1) were depleted to only 27.91area/ha and 7.47area/ha respectively (Table 4). However, following the trend of forest reserve depletion in the results above (Table 2, 3, and 4), it is estimated that the remaining 1.23% (Fig. 4) of the total forest reserve left will be completely depleted by the year 2025 if no action is taken.

Table 1 Forest Reserves around Maiduguri, Percentage Area Cover in 1975

Polygon	*Area (ha)*	*% Area*	*Forest Reserve*
1.	909.55	32.17	Pompomari
2.	946.28	33.47	Mafoni
3.	275.96	9.76	Farm Center
4.	368.66	13.04	Jere
5.	193.5	6.84	Gamboru
6.	59.45	2.10	Gwange I
7.	49.92	1.76	Gwange II
8.	23.69	0.83	Hausari
Total	2,827.01	100	

Source: ILWIS 3.3, Fieldwork 2015

Table 2 Forest Reserves around Maiduguri, Percentage Area Cover in 1986

Polygon	*Area (ha)*	*% Area*	*Forest Reserve*
1.	39.03	12.63	Pompomari
2.	37.91	12.27	Mafoni
3.	104.64	33.87	Farm Center
4.	49.12	15.89	Jere
5.	20.64	6.68	Gamboru
6.	46.55	15.06	Gwange I
7.	11.04	3.57	Gwange II
8.	-	-	Hausari
TOTAL	308.93	100	

Source: ILWIS 3.3, Fieldwork 2015

Table 3 Forest Reserves around Maiduguri, Percentage Area Cover in 1999

Polygon	*Area (ha)*	*% Area*	*Forest Reserve*
1.	73.6	31.65	Pompomari
2.	26.16	11.25	Mafoni
3.	79.57	34.22	Farm Center
4.	-	-	Jere
5.	20.97	9.01	Gamboru
6.	32.22	13.85	Gwange I
7.	-	-	Gwange II
8.	-	-	Hausari
TOTAL	232.52	100	

Source: ILWIS 3.3, Fieldwork 2015

Table 4 Forest Reserves around Maiduguri, Percentage Area Cover in 2015

Polygon	*Area (ha)*	*% Area*	*Name*
Pol 1	7.47	17.76	Pompomari
Pol 2	27.91	66.37	Mafoni
Pol 3	6.67	15.86	Farm Center
Pol 4	-	-	Jere
Pol 5	-	-	Gamboru
Pol 6	-	-	Gwange I
Pol 7	-	-	Gwange II
Pol 8	-	-	Hausari
TOTAL	42.05	100	

Source: ILWIS 3.3, Fieldwork 2015

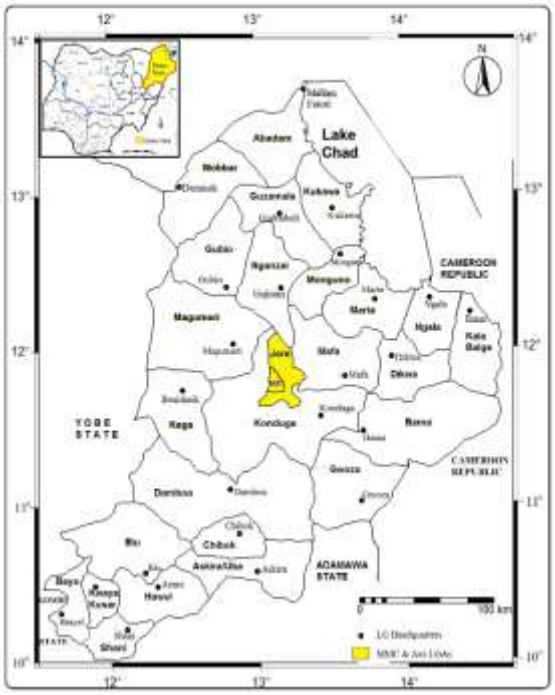


Figure 1. Map of Borno State, inset the map of Nigeria

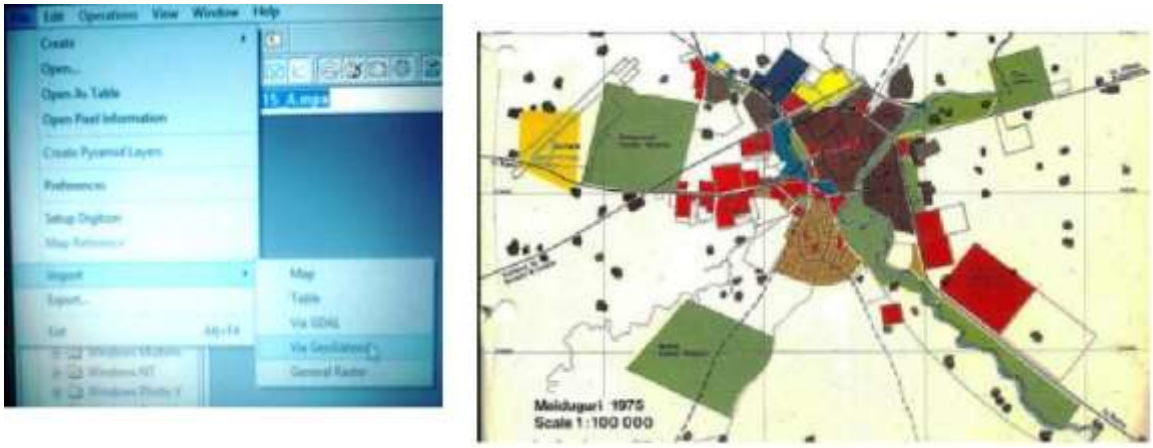
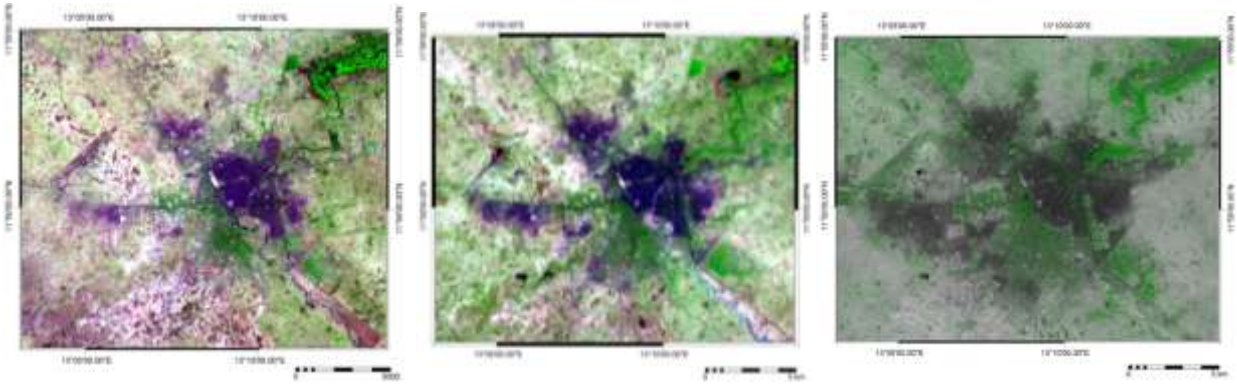


Figure 2 Importation of image in ILWIS (Maiduguri forest reserves in 1975 base map)



Landsat 1986 Landsat 1999 Landsat 2015

Figure 3. Landsat Images of the study area at different time periods

Source: GEONETCAST Station, Department of Geography, University of Maiduguri.

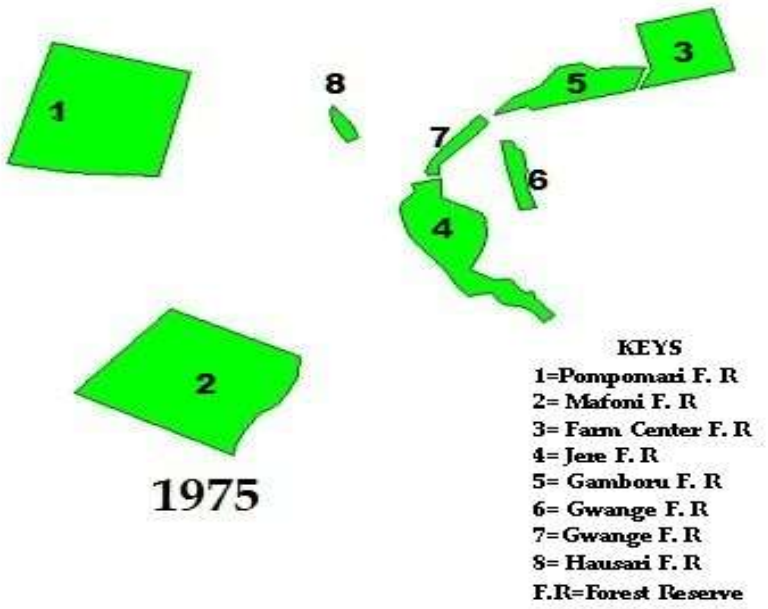


Figure 4 Base map (1975) Identifying the Forest Reserves

(Source: Max Lock Maiduguri 1975*).*

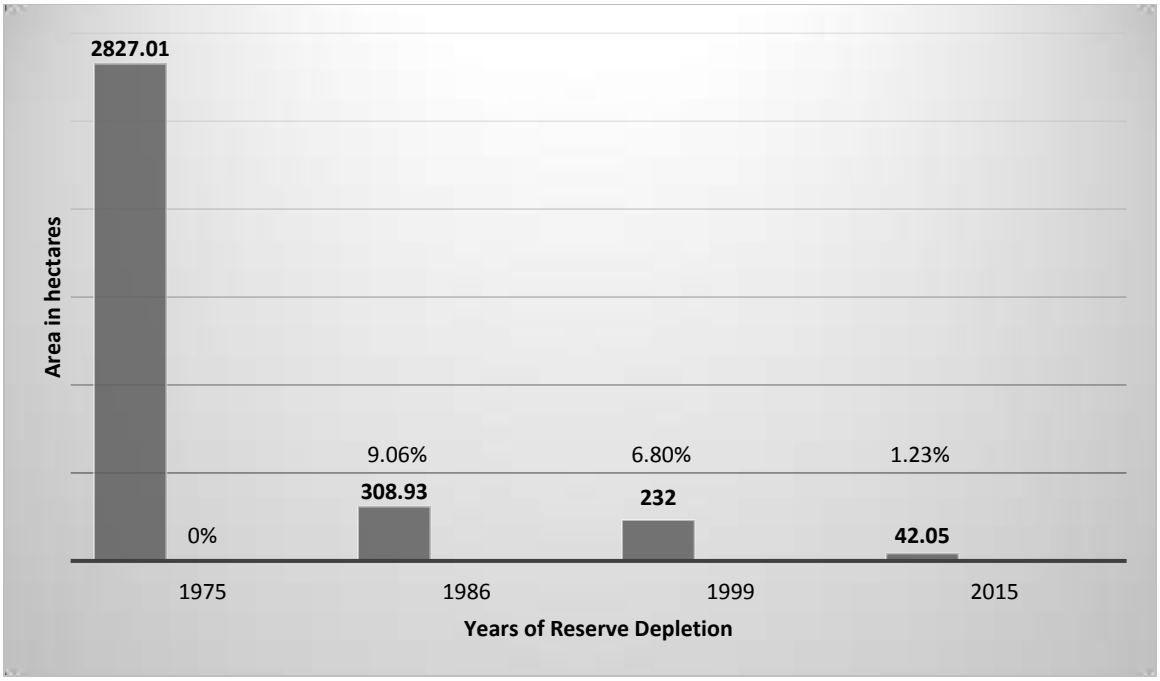


Figure 5 Magnitude of Maiduguri Forest Reserve Depletion (1975 - 2015)

Source: ILWIS 3.3, Fieldwork 2015

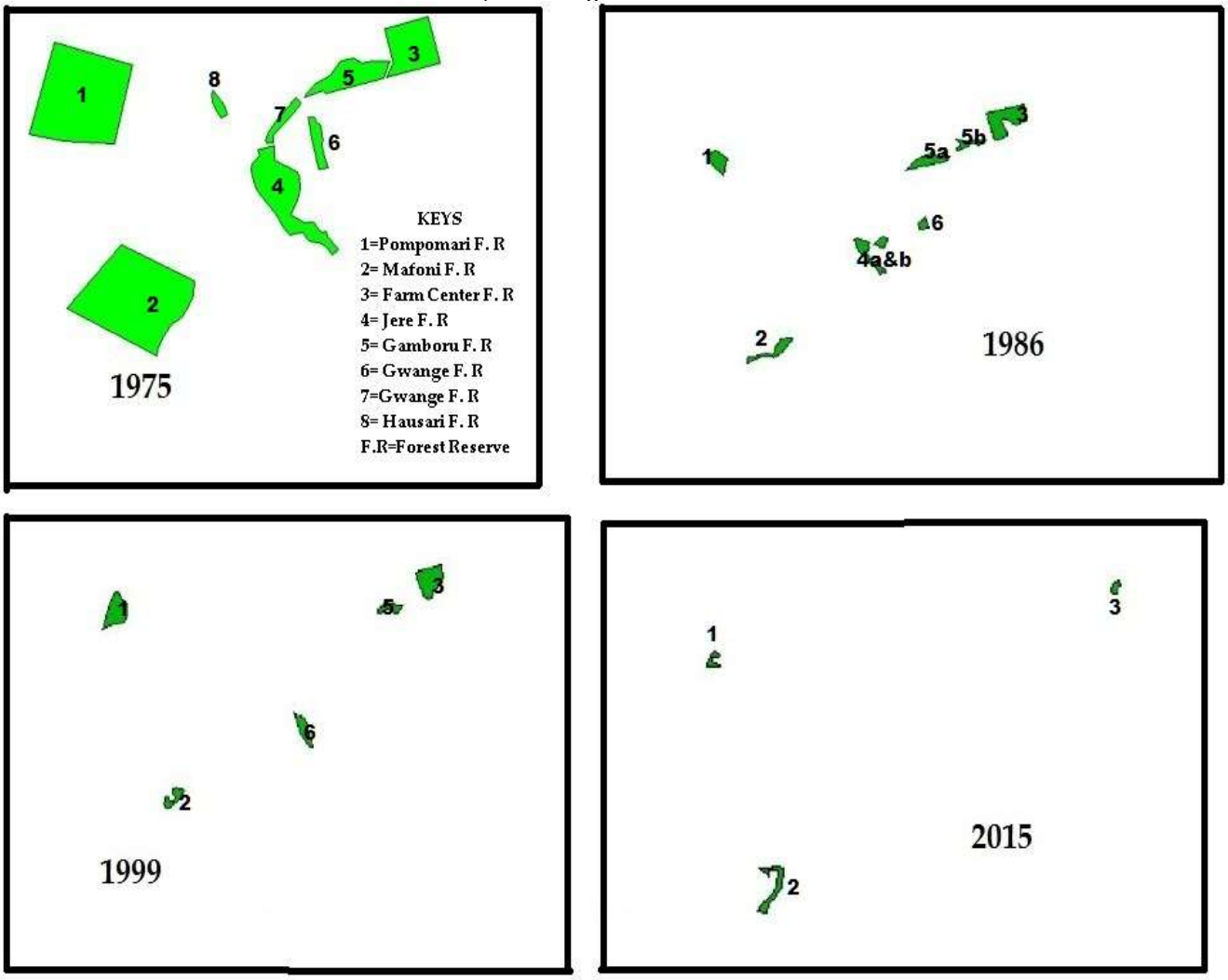


Figure 6. Map showing the relict of forest reserves in Maiduguri *(Source: ILWIS 3.3, 2015 Field work)*

Discussion

The result shows that Gwange I & II, Jere, Gamboru and Hausari Forest reserves have been decimated or completely encroached by the communities (Table 4). This result is similar to the findings of [1] maintaining that deforestation and land degradation as a result of anthropogenic factors due to urban encroachment is severe and demands attention. Due to the increasing rate of urbanization of Maiduguri city, a significant portion of the reserves have been encroached through dynamic urbanization. In 1986 up to 90.9% of the reserve had been encroached, it became 93.2% in 1999 and nearly all the reserved had gone (98.8%) in 2015, Fig. 4. Evidently, forest establishment is a soft target of urbanization. The rate of loss of forest land is faster than the rate of creating new forest estates. This perhaps is the reason why there is dwindling forest resources in Nigeria particularly in the semi-arid zones. While it may be almost impossible to sacrifice urban growth on the altar of forest conservation, it is wise to develop a synergy between land use and urban development. Pockets of trees may be allowed in city development or the creation of green areas without stifling thirst for urban development and city expansion. Nigeria since independence has become an increasingly urbanized and urban-oriented society [8].

Most of the competition for space between man and other species is demonstrated by the conversion of land to agriculture, aquaculture, infrastructure, urban development, industry and unsustainable forestry. Hence, population pressure is clearly a force of some considerable importance [4]

According to [3] Land cover change is emerging as a central issue within the community concerned with global environmental change. This position is not different in the Nigerian situation of Borno State, this is a veritable cause of deforestation in Borno State. However, it must be emphasized that there is need for a balance between urban expansion and forest depletion.

Recommendations

The following recommendations are *sine qua non* to sustainable management of forest on the trajectory of urban growth and expansion

i. Government should formulate policies aimed at preserving forest reserves from illegal activities.
ii. Development of the green areas and avoidance of large scale development that consume entire forest estates.
iii. Development and promotion of trade in non-timber forest produce to reduce the pressure on timber resources and to enhance rural livelihood.
iv. Lastly, the use of remote sensing and GIS technology should be highly employed for studies such as this in order to enlighten the populace on the rate and trend at which such activities (such as deforestation) contribute to threats in the society.

Conclusion

The study has shown that urbanization is a threat to precinct forests particularly in the fast growing economy. The Maiduguri city just like in any other nations has the propensity to grow according to demographic expansion that is unstoppable. Therefore, the need to conserved precinct forest around developing cities for the overall benefit of the populace in terms of climate and/or weather mitigation. Making use of GIS and Remote Sensing techniques would enable real time monitoring of the possible urban encroachment into any precinct forest estates and of course to adequately plan ahead of any significant depletion of the forest reserve.

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