Land Resources Management and Sustainable Agricultural Land use around Bauchi Metropolis, Bauchi State, Nigeria

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Abstract

The study analyzed the nature of land use/land cover change around Bauchi metropolis between 1985 to 2015. The study analyzed the pattern of agricultural land, loss of urban growth around Bauchi metropolis and assess the socioeconomic implications of agricultural land conversion to other purposes in the study area. Analysis of land use/land cover change was achieved through the analysis of multi spectral satellite images of 1985, 2000 and 2015 using ArcGIS 9.2 Academic Image Classification Software. A questionnaire was administered to 300 respondents randomly selected to evaluate the socioeconomic implications of agricultural land conversion. The results of the study have shown that there is an unprecedented growth of built up area of 1985 when built up area constituted 11.6% to 2015 when it constituted 83.1% of land use/land cover within the study period. The expansion in built up area translates to loss of agricultural land with a marked decline in land holdings such that the majority of farmers (60.20%) depends on farm lands that are 1-5 ha in 2015 as against 56.8% that were relying on 6-10 ha in 1985 which led to decline in per capita productivity. Based on the findings of this study, it is recommended that urban farmers should be adequately sensitized and equipped with modern methods and implements to enhance and sustain their productivity in spite of the smaller parcels of land they rely on.

Keywords: Agricultural land use, Bauchi Metropolis, Built-up area, Resource Management and Sustainable agriculture.

Introduction

Urban expansion is one of the major ways through which man exert his influence on the natural landscape. Urban expansion or urbanization is defined as the horizontal or vertical outward extension of urban area over the neighbouring agricultural land. It's a natural process that consumes many hectares of most agricultural land in the peri-urban locations (Manish, Aruna and Virek, 2012). Urban Population growth and escalating demand for housing among other urban needs have combined to impact on land within the urban periphery. This impact is through the alteration of non-urban land to accommodate the expansion of urban land uses such as the construction of roads, houses and commercial

areas (Kavitha, Somashekar and Nagaraja, 2015; Kaifang, Yun, Bailang, Tingbao and Linyi, 2016 and Kalu, Alozie, Oti and Onyenorah, 2017). Urban growth has resulted in changes in land cover in the urban periphery. Land use/land cover pattern of a region is an outcome of either one or a combination of natural and socioeconomic factors and their utilization by man in time and space (Adam, 2015). Land use refers to man's activities and the varied uses which are carried out on the land. On the other hand, land cover refers to natural vegetation, water bodies, rock/soil, artificial cover and other noticed features of the land.

The methods of land-change science include remote sensing and geospatial analysis and modeling, together with the interdisciplinary assortment of natural and social scientific methods needed to investigate the causes and consequences of Land Use Land Cover Change (LULCC) across a range of spatial and temporal scales (Robert Pontius, 2013; Uma Maheswari, Rajkumar, Surendran and Krishnamoorthy, 2015). Thus, the application of Remote Sensing (RS) and Geographic Information System (GIS) enables the tracking of the pattern of land use/land cover change and obtaining the socioeconomic data that enables the understanding of the implications of these changes on the socioeconomic activities. Remote Sensing (RS) and Geographic Information System (GIS) according to Ray and Dadhwal, 2001; Jiang, Chun and Olson, 2004; Kato and Yamaguchi (2007), have been recognized as powerful and effective tools and widely applied in detecting the spatio-temporal dynamics of land use and land cover. Bauchi metropolis, the Bauchi State capital, have witnessed a remarkable expansion, growth and developmental activities such as the construction of buildings and infrastructure as well as many other anthropogenic activities since 1976. This has therefore, resulted in a substantial increase in urban land usage, modification and alterations of Bauchi Metropolis and its environs over time. Although, studies relating to changes in land use have been carried out within and around Bauchi Metropolis (Okali, Okpara and Olawole, 2001), the problem however, is that there have been very limited detailed and comprehensive attempts to evaluate this status as it changes over time with a view to detecting the rate of agricultural land loss. The specific objectives of the study are to:

i.   analyze the nature of land use/land cover change around Bauchi metropolis from 1985 to 2015.
ii. analyze the nature of land lost to various urban uses around Bauchi metropolis in 2015.
iii. examine the trends and the extent of land use and land cover changes around Bauchi metropolis between 1985 and 2015.
iv. assess the socio-economic implications of agricultural land conversion into other uses in the study area.

Materials and Methods

Description of Study Area

Bauchi Metropolis the study area is located between latitude 10^0 17^1 to 10^0 18^1N and longitude 9^0 48^1 to 9^0 49^1E. The Metropolis is the headquarters of the Bauchi Local Government, which has a population of 493,810 (a large proportion of the population resides in Bauchi Metropolis as it is the most developed part of the Local Government Area). The study area has undergone various transformations in its administrative status as Provincial Capital, Local Government Headquarters and State Capital at various times in the course of its development.

The climate of the area is tropical in nature with distinct rainy and dry seasons. The study area receives an average annual rainfall of 1097mm^3 with the highest rainfall received in August. The soil in the study area is mainly laterite with productive clay, loam occurring along the flood plains providing fertile soil for farming. The relief is one of the important factors that affect the soil characteristics and suitability of the land for various uses in the area. Bauchi metropolis spans two broad relief zones, a high plain area of hill range, which is part of the crystalline rock area of the Northern Nigeria and central high plain with isolated hills punctuating the high plain in several places such as Dutsen Taushi, Guru, Kofar Wambai and Gudume. This plain is favourable for agricultural production and settlement development.

The status of Bauchi Metropolis as state capital attracts the development of a cocktail of land uses and socioeconomic services, thus attracting a larger proportion of the population to the urban center, hence the change of its population in terms of size and composition. Figure 1 and 2 shows the location of the study area and different landuse/landcover.
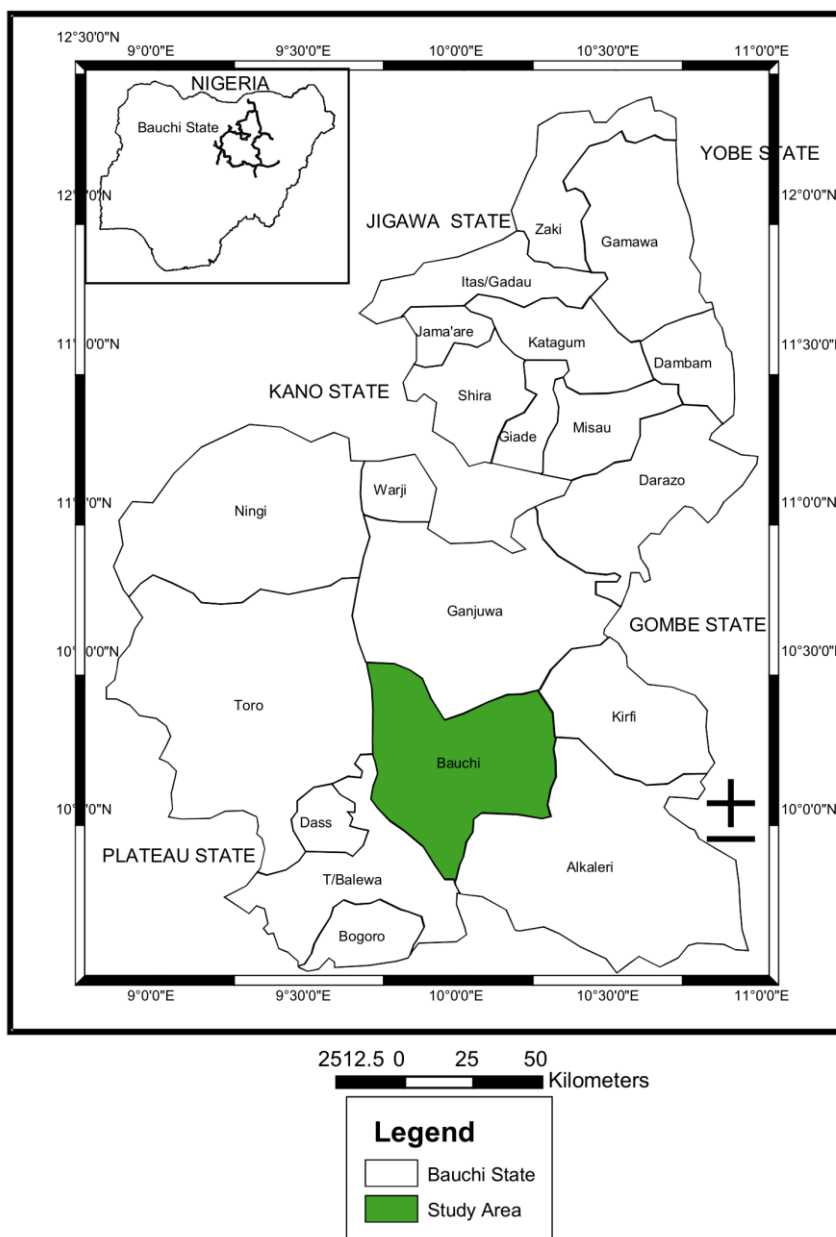
Figure 1 :Bauchi State Showing the Location of the Study Area
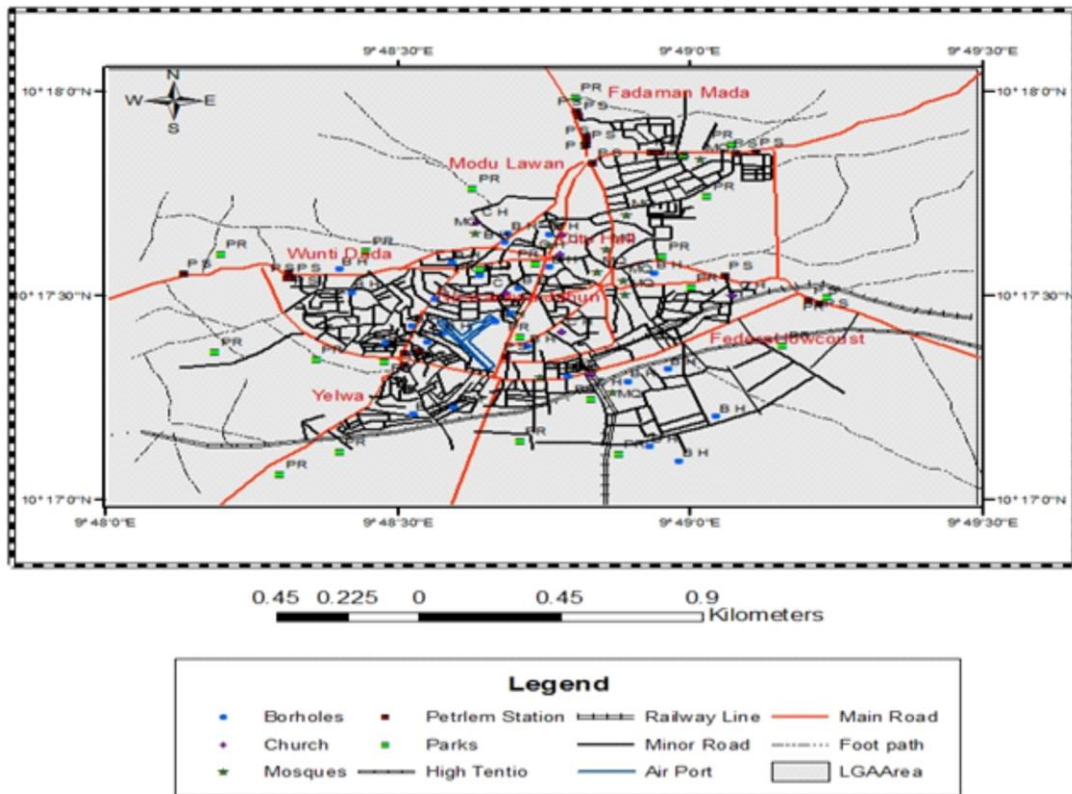(Source : Department of Geography, MAUTECH Yola)

Fig 2: Map of Bauchi Town showing different landuse/landcover

Source: Bauchi State Department of Urban and Regional Planning, Ministry of Lands and Survey

Data Collection

Both primary and secondary types of data were used. The main secondary data used in this study were land use maps and satellite images of three different periods (as shown in Table 1), sourced from the National Space Research and Development Agency (NASRDA) and Global Land Cover Facility (GLCF) website. The remote sensing data obtained was corrected for radiometric and geometric errors. The Arc GIS 9.2 Academic Software was used in classifying the land use map of the study area, generated from the classified images; the statistics were used as the basis for producing the graphs in the work.

Table: 1 Multi-Spectral Satellite Images

S/N	Satellite Type	Resolution	Path/Row	Date of observation	Source

1	Nigeria Sat-1	32	Zone/Scene	16/2/2015	NASRDA
2	Land Sat TM	30	189/54	29/12/2000	GLCF
3	Land Sat -5	30	189/54	23/12/1985	GLCF

Source: NASRDA, 2019

The primary data used was collected using questionnaires, visual observations, institutional surveys and key informant interviews. The institutional surveys covered the Bauchi State Urban Development Board, Bauchi State Ministry of Lands and Survey and Ministry of Agriculture. The questionnaires were administered to obtain information on the types and nature of land use changes, implications of land use conversion into housing and other developmental projects.

Sample, Sampling Technique and Questionnaire administration

The random sampling technique was used. Six (6) wards were randomly selected from the ten (10) wards in the Metropolis. The estimated population of these six (6) wards is about 53% of the population of the ten wards of the Metropolis. 300 respondents were randomly selected from the six selected wards. A questionnaire was administered to the 300 randomly selected respondents to elicit information on their land holdings and per capita productivity with the view of evaluating the socioeconomic implications of agricultural land use conversion in the study area. The distribution of the questionnaire is shown in Table 2.

Table 2: Distribution of Questionnaire to Selected Respondents

Selected Ward	Population	No. of Respondents Selected	% of the sample
Yelwa	52,064	60	20
Fadama Mada	42,444	50	17
Wuntin Dada	47,365	55	18
Fed. Low Cost	32,156	35	11.7
Muda Lawan	33,897	40	13.3
Nassarawa Jahun	51,886	60	20
Total	**259,812**	**300**	**100**

Source: Computed from 2015 Voters' Register, INEC and 1991 Census, NPC.

Data Analysis

Arc GIS 9.2 software was used to characterize land cover types in the study area. The land use/land cover in this study were grouped and classified into five. These were: built-up area, vegetation, farmland, rock outcrop and open-space. Image Accuracy

assessment was also carried out in order to correct errors and obtain quality images for comparison and change detection. The results of the analyzed data were presented using a frequency distribution table, histogram, and percentages.

Analysis of Satellite imagery

In order to analyze the land use/land cover classes in Bauchi Metropolis, the multi-spectral images were processed and five (5) land cover types were identified. These are; built-up area, vegetation, farmland, rock outcrop and open-space. Supervised classification was carried out using the Maximum Likelihood and a composition of band 1, 2 and 3 by applying the false colour composite to select Region of Interest (ROI) for features like open-space and shrubs/grass, while the true colour composite was applied in choosing the ROI of built up area, farm land and other lands. The spectral signature of each class was obtained from the images using ENVI. This was done through the selection of ROI for each of the LULC categories. This classification yielded a good result after subjecting the classified maps to a confusion matrix. An overall accuracy of 93.50*%* and a Kappa coefficient of 0.92 were obtained from the 1985 map, while for the 2015 map, the overall accuracy was found to be 89.66*%* and a Kappa coefficient of 0.848**.**

Post classification.

The three independently classified images were then run for post classification, comparison in order to produce a change map. By using the change detection, statistical tool of the post classification, the matrix table of ''from – to'' change class was obtained. Finally, this classification proved to be effective because it presents the advantage of indicating the nature and magnitude of change that has taken place through pixel by pixel comparison.

Result of the Findings

The Nature of Existing Land Use/Land Cover Around Bauchi Metropolis

The pattern of land use/land cover around Bauchi Metropolis is a reflection of the changing structure and political status of Bauchi over the study period. The pattern of land use/land cover in the study area is a cocktail of land uses that confers the urban status on Bauchi Metropolis; the land uses are mostly non-agricultural, and as the urban area expands it encroach on the surrounding agricultural lands there by displacing the urban farmers.

Five classes of land uses/land cover were identified in the study area. Built-up area constituted 83.1% of the land use in the study area, vegetation constituted 4.3%, farm land constituted 11.3%, rock outcrop constituted 0.2% and open space constituted 1.1% of the land use within Bauchi Metropolis. The predominance of built up area is as a result of the upsurge in population of Bauchi Metropolis. Thus the population of Bauchi rose from 38,014 persons in 1973 to 283,638 in 1991. The 2006 census gave the population of Bauchi Local Government as 493,810 (the 2006 census results weren't disaggregated into towns

and villages, however, a large proportion of the population resides in Bauchi Metropolis which is the most urbanized). At national growth rate of 2.79%, the population of Bauchi Metropolis is expected to be about 633,580 in 2015(Modibbo *et al,* 2017). The trend in land use/land cover changes in the study area is presented in Table 3.

Table 3: Land use and Land Cover Changes around Bauchi Metropolis From 1985-2015

Land use/ land cover type	1985 Area cover in square kilometer (km^2)	2000 Area cover in square kilometer (km^2)	2015 Area cover in square kilometer (km^2)
Built-up area (settlement)	11.68 km^2 (10.9%)	39.06km^2(36.4%)	89.23 km^2(83.1%)
Vegetation	43.75km^2(40.7%)	12.26km^2(11.4%)	4.64km^2(4.3%)
Farmland	36.68km^2(34.2%)	40.1 km^2 (37.3%)	12.16km^2(11.3%)
Rock outcrop	8. 10km^2(7.5%)	2.98 km^2 (2.8%)	0.19km^2(0.2%)
Open-space (bare surface)	7.18km^2(6.7%)	12.99 km^2 (12.1%)	1.17km^2(1.1%)
Total	107.39km^2 (100%)	107.39km^2 (100%)	107.39km^2 (100%)

Trend and extent of Land use and Land Cover Changes Around Bauchi Town between 1985 and 2015

The study findings revealed that land use and land cover around Bauchi town has undergone transformation over the study period with a resultant increase in urban land use and significant decrease in vegetation cover, rock outcrop and farmland. The increase in urban land area is more pronounced between 2000 and 2015 compared with that of between 1985 and 2000 as depicted in figures 3, 4, 5 and 6.
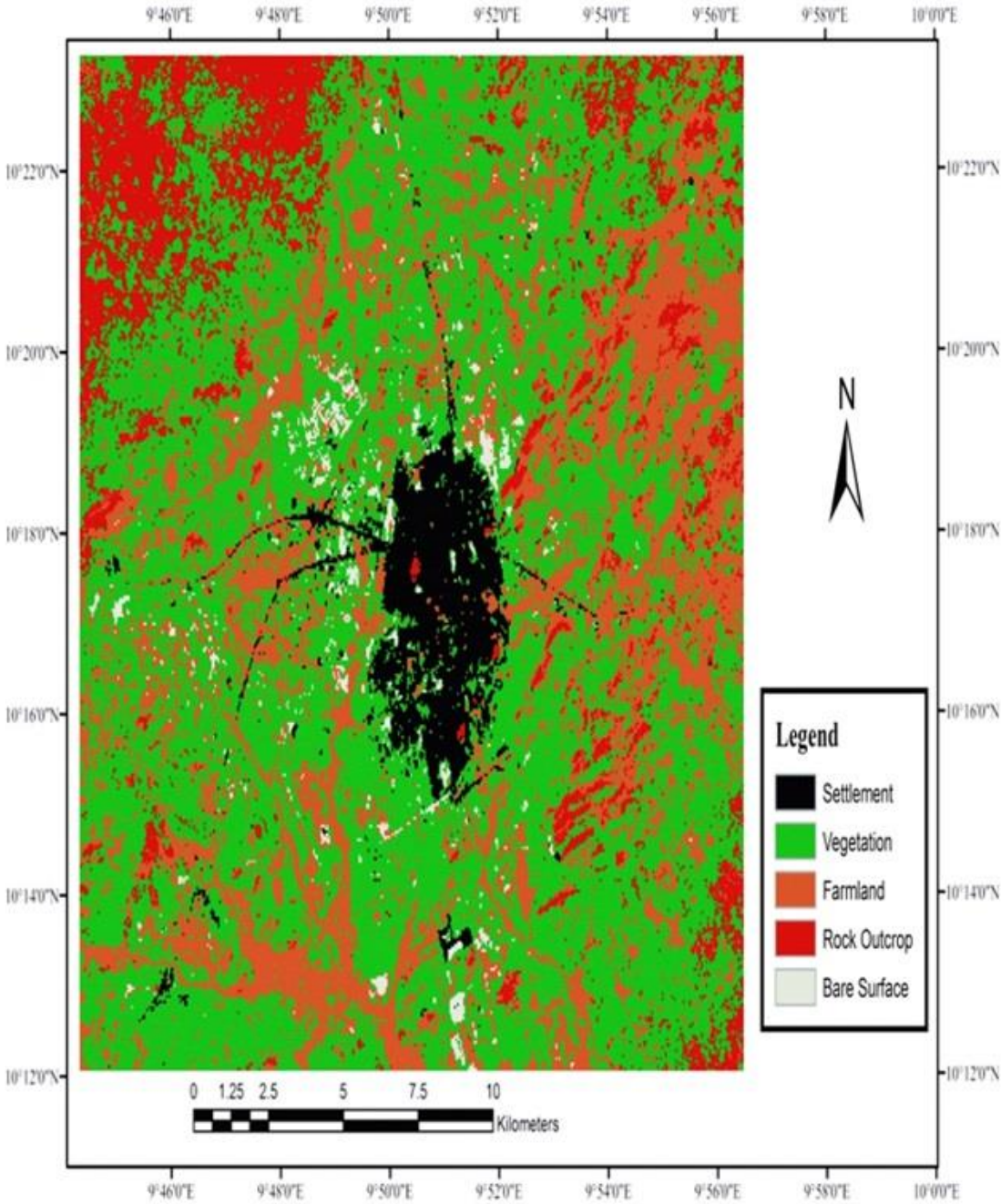
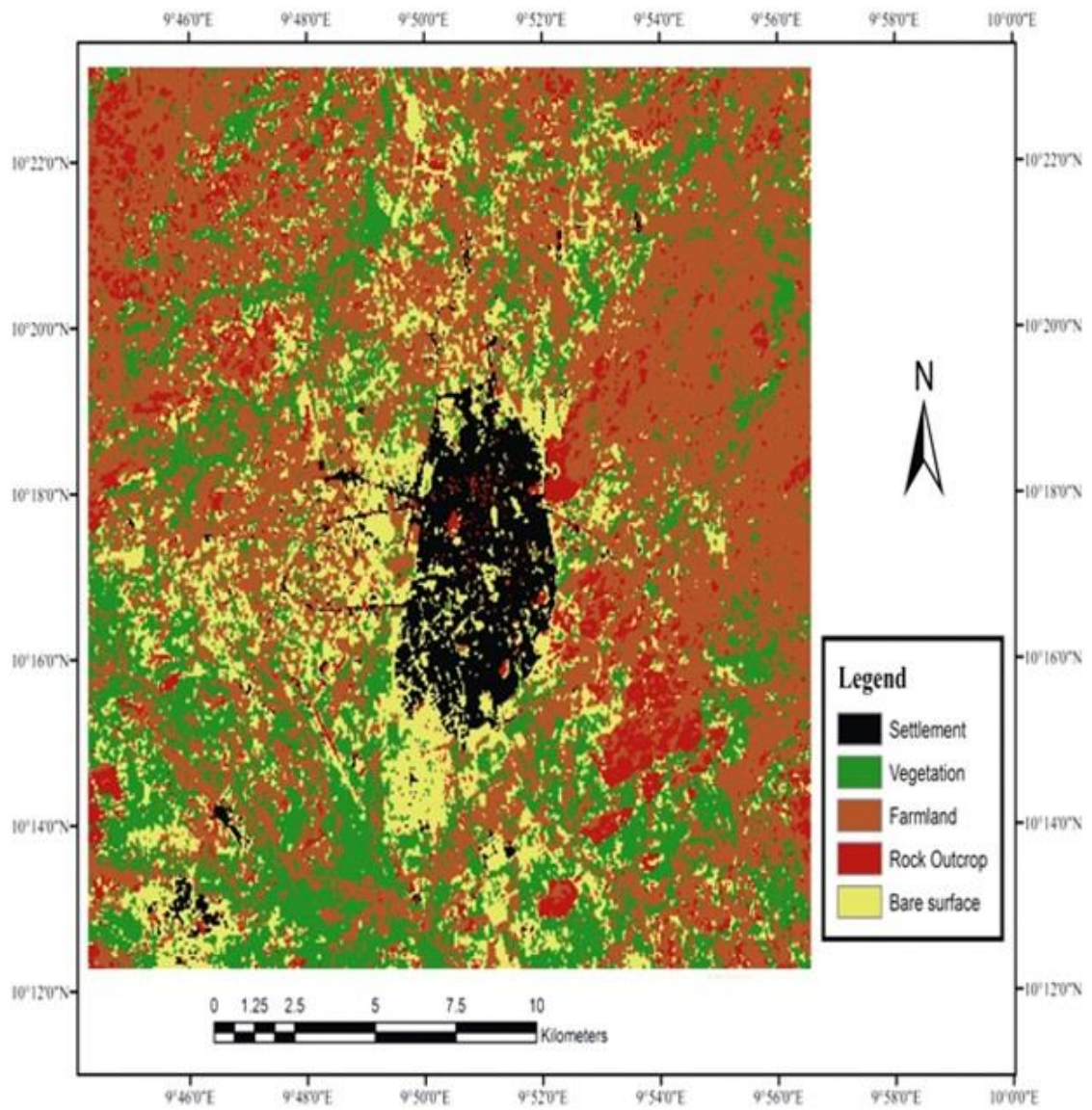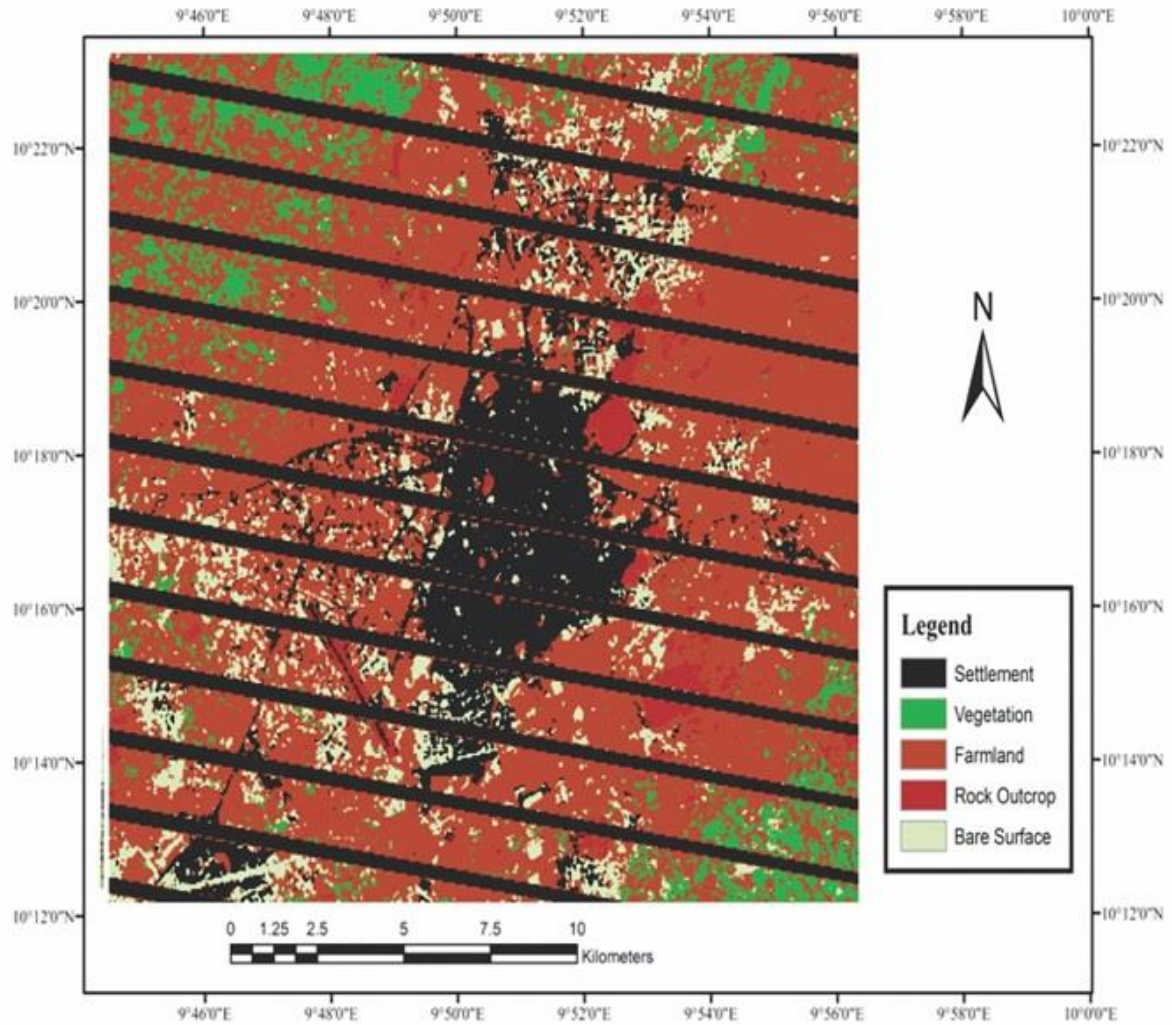**Figure 3: Classified Image of the Study Area in 1985**

Figure 4: Classified Image of the Study Area in 2000

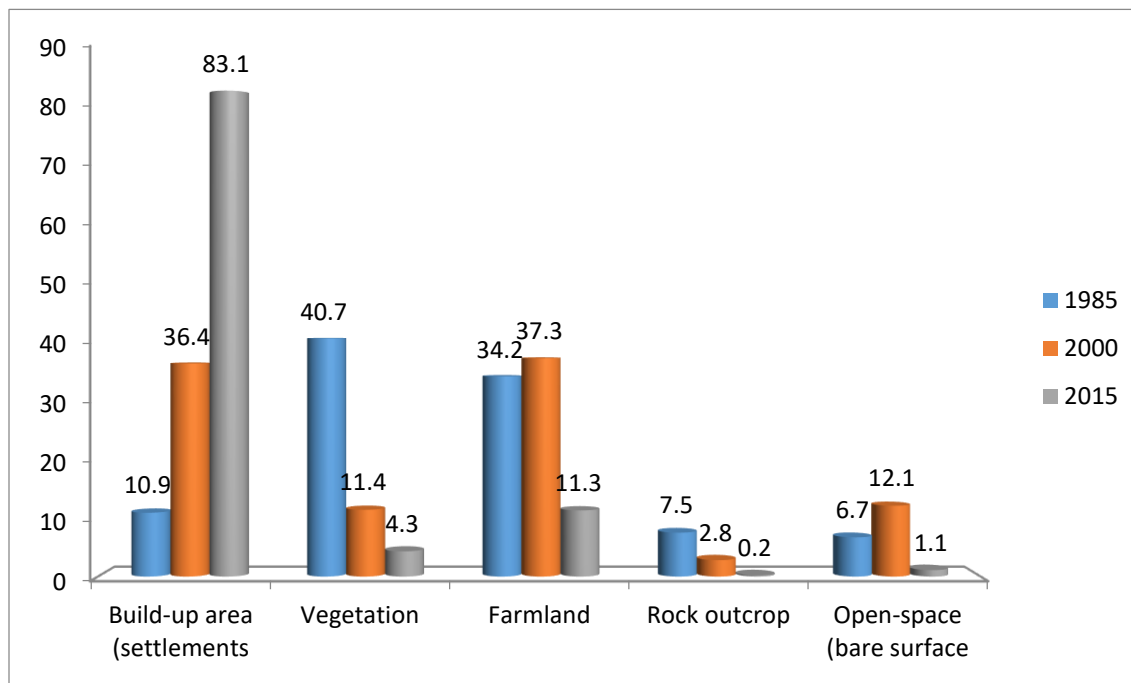**Figure 5: Classified Image of the Study Area in 2015**

Fig. 6: Extent of changes in Land use and Land cover types around Bauchi Metropolis from 1985 to 2015

They strive for limited land, population dynamics and unprecedented urbanization have combined to cause changes in the land use pattern within the study area in the 30 year study period. Thus, within the period of study built up area expanded by 500% and farmland witness shrinkage of about 180% from 2000 to 2015 when urbanization was at its peak.

Socioeconomic Effects of loss of Agricultural land in Bauchi Metropolis

The socioeconomic implication of land use/land cover change is far reaching and vicious. The respondents were categorized into socioeconomic groups based on their sources of income, land holdings and per capita production. Thus, 57% of the respondents had farming as their primary occupation in 1985; about 12% of the respondents were not farmers in 1985. Amongst the respondents that had farming as their primary occupation as at 1985, farming contributed substantially to their income, however with the trend in urbanization it is only 8% of the respondent that are having substantial proportion of their income from farming. This implies that the majority of the respondents that were farmers in 1985 have abandoned large scale farming for other occupations associated with urbanization process in Bauchi Metropolis.

Landholding and per capita production are the other social, economic variables affected by the transformation of the Bauchi metropolis to a fast growing urban area. Thus,

Tables 4a and 4b show the trends in land holding and crop production within the study period.

Table 4a: Pattern of Land Holding (in Hectares) amongst Farmers in Bauchi Metropolis in 1985 and 2015 (n=300)

Wards/Years	1-5ha		6-10ha		11ha and above		Undecided	
	1985	2015	1985	2015	1985	2015	1985	2015
Yelwa	7	35	30	13	14	6	8	4
Fadaman	6	32	28	14	12	4	5	2
Mada	5	31	31	14	13	5	7	4
Wunti Dada	5	24	20	10	5	3	5	2
Fed. Low Cost	4	25	25	6	7	4	4	4
Muda Lawan	5	36	33	15	15	5	6	2
Nassarawa								
Jahun								
Total (Frequency)	32	183	167	72	66	27	35	18
Percentage (%)	10.6	61	56	24	22	9	11.7	6

Table 4b: Per Capita Productivity (in 100kg Bags) amongst Farmers in Bauchi Metropolis in 1985 and 2015 (n=300)

Wards/Years	1-5bags		6-10bags		11bags and above		Undecided	
	1985	2015	1985	2015	1985	2015	1985	2015
Yelwa	9	35	14	13	29	6	6	5
FadamanMada	7	27	11	12	28	7	4	4
Wunti Dada	5	28	10	16	32	6	9	4
Fed. Low Cost	5	22	7	9	22	5	3	2
Muda Lawan	4	24	8	10	21	4	5	3
NassarawaJahun	7	29	15	17	34	7	5	5
Total (Frequency)	37	165	65	77	166	35	32	23
Percentage (%)	12.3	55	21.6	25.7	55.3	11.7	10.7	7.7

*NB: Crops grown within this period are mainly cereals (Rice, Maize and Sorghum etc, hence the use of 100kg bag as the unit of measurement.

From the above Tables, it could be seen that there is a marked reduction in sizes of land holdings. Whereas 66% of the respondents were having farmlands of 11ha and above

in 1985, it is only 27% of the respondents that have land of this size in 2015.There is also a corresponding decline in crop production across all the wards, as shown in Table 4b, only 11.7% of the respondents produced 11 bags and above in 2015 as against 55.3% in 1985. The implication of the scenarios presented in Tables 3a and 3b is the displacement of urban farmers through large scale agricultural land conversion to non-agricultural land uses, thereby increasing threat to food security and availability.

Conclusion

The study has explored the pattern of growth of urban land use through the expansion of built up area over the period of study (1985 to 2015). The study has also linked the trend in urban expansion to population growth and the consequences of that growth, which is reduction in land holding among urban farmers and dwindling per capita productivity. The rate of loss of agricultural land as revealed by this study is alarming, and if not properly addressed, will in the long run result in displacement of urban farmers and serious threat to urban food security.

Recommendations

Based on the findings of this study the following recommendations were made;

i.   Farmers should be trained in modern farming techniques that will enable them to produce more on smaller land holdings.
ii.   Concerned agencies should fast track urban expansion from the perspective of environmental concern. This will restore and regulate land use/land cover that is as important as built up (i.e. vegetation).
iii. Government can also address the rapid urbanization of Bauchi metropolis by pursuing rural development policy that will ensure a sustainable development of rural areas which will in the long run curtail rural-urban migration.
iv.   Government should also pursue agricultural development policies that will provide improved and affordable agricultural inputs, and train farmers on modern techniques of farming that will enable them to produce more.

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