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Factors Influencing Land Modification in Central Nigeria: a Case Study of Central Area of Kaduna State

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Abstract

Information on factors influencing land modification and the consequences are important for effective land suitability and urban planning in order to satisfy man's insatiable quest for social- economic development and its impacts. The rapid development in the Central Area of Kaduna State has led to increase in the uncontrolled utilization and modification of land; however, little attempt was made to analyze and model what is causing the change. Therefore, this research filled this gap by assessing and providing information on factors underlying the change in the study area between 1975 and 2014. Land use/cover was mapped using Landsat images, while statistical modelling was used to model as well as to understand the relationship between land use change patterns, the socio-economic characteristics of residents and the occurrence of conflicts in the study area. Result revealed a great transformation in all the land use/cover types e.g. built-up areas increased from 0.48% in 1975 to 3.04% in 2014 due to the expansion of villages into towns; bare ground increased from 12.05% in 1975 to 27.19% in 2014 because of the demands for firewood and construction materials by the increased population. Statistical modelling shows that the socio-economic status of residents has a weak influence on land modification decision- making while intensity of conflict has a strong influence on the spatial dimensions of land modification. The region should pursue the management of the increasing population to reduce the rate of land modification and the elimination of insecurity to control the spatial dimension of land modification.

Background to the Study

Over half of the lands cape is modified by humans in a non-linear pattern and this modification is referred to as land use change (Tayyebi and Pijanowski, 2014). At global scale, human beings are changing the use of land at an accelerating pace in consideration of many factors which include urban growth, increasing population, available economic opportunities, government policies, food security, technological advancement, geographic location, etc. (Marcucci, 2000; Lambin *et al*. 2003; Twumasi and Merem, 2006; Ishaya *et al*. 2008; Fikir *et al*. 2009; Ellis, 2010; Ndabula et *al*. 2013). According to Chaudhary *et al*. (2008), urban growth and increasing population are common events world over and that they have the most significant impacts on the functioning and structure of the environment particularly in the developing countries since the last century. Some Scholars observed that, industrialization and modernization are responsible for the large migration from the rural areas to the cities (Mabogunje, 1968; Fabiyi, 2006; Putra and Bairer, 2008; Balogun *et al*. 2011; Chegg, 2013). As land is becoming a scarce resource, information about the factors of land modification is essential for the selection, planning and implementation of land use schemes to meet the increasing demands for basic human needs and welfare activities (Abubakar *et al*. 2002; Bahrain, 2003; Kesgin and Nurlu, 2008; Singh and Khanduri, 2011).

The Central Area of Kaduna State is one of the most important regions in Central Nigeria that has witnessed urbanization and rapid population growth through the influx of immigrants to Kaduna metropolis, particularly in the 1970's to 1990's because of Nigeria's oil boom and other factors (Olaleye, 2006; Abdullahi *et al*. 2009; Obansa, 2012; Skivington, 2012). This led to a remarkable growth and development in terms of building, road construction, etc. which resulted in uncontrolled utilization and modification of land cover. Some researchers have studied the dynamics of land use pattern in Central Area of Kaduna State. For instance Olaleye (2006), Ishaya *et al*. (2008) and Ndabula *et al*. (2013) but little attempt was made to analyze and model the land use change in relation to the factors associated with the modification. This study seeks to model the causative factors of land modification in the Central Area of Kaduna State over the last 39 years in order to provide information on them for sustainable land use management.

Objective of the Study

The objectives of the study are to characterize the land use/cover pattern of the Central Area of Kaduna State between 1975 and 2014, analyze the transitions of land use/cover in the study area and model the factors that influenced the utilization and modification of land in the study area during the study period.

The hypotheses formulated and verified in the study are:

1. There is no relationship between land use change pattern and socio-economic characteristics of residents in the Central Area of Kaduna State.
2. There is no relationship between land use change pattern and occurrence of conflict in the Central Area of Kaduna State.

Materials and Methods

The Study Area

The Central Area of Kaduna State covers four Local Government Areas of Kaduna State namely, Kaduna North, Kaduna South, Igabi and Chikun Local Government Areas (LGAs). The study area (Figure 1) lies within latitudes 10º 05′ and 11º 02′ North of Equator and longitudes 06º 42′ and 07º 58′ East of Greenwich Meridian, on the southern fringe of northern Nigeria. It covers an area of 8,531.05 Km². It is bounded to the north by Giwa, Zaria and Soba LGAs, to the south by Niger State and Kachia LGA, to the east by Kajuru and Kauru LGAs and to the west by BirninGwari and Giwa LGAs. The study area has a total population of 1,570,331(NPC, 2006). This figure comprises the population figures for the four LGAs of the study area as follows: Chikun LGA with 193,373; Igabi LGA with 144,124; Kaduna North LGA with 583,041 and Kaduna South LGA with 649,793.

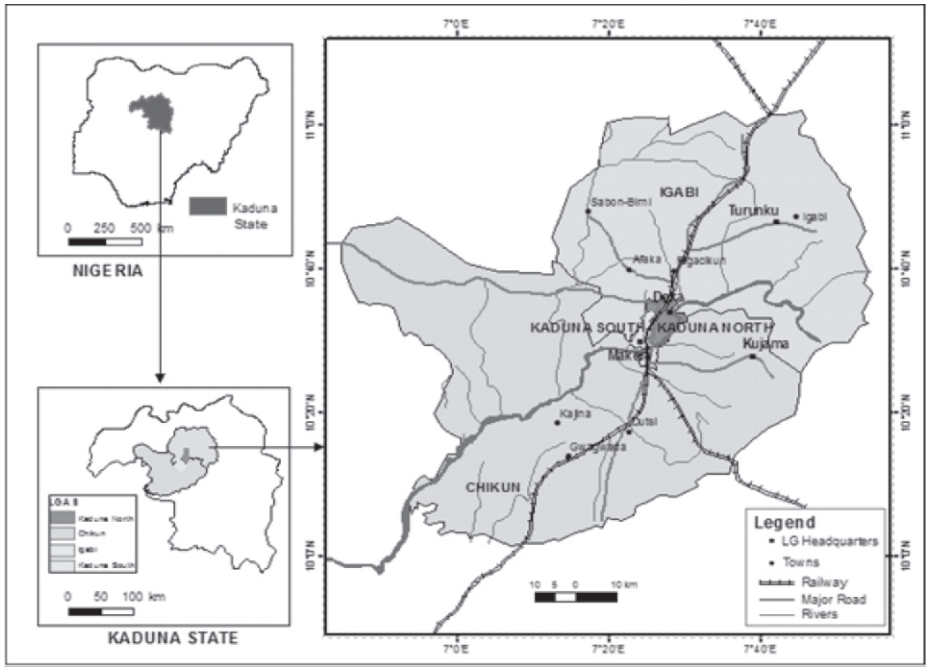

Figure : Location of Central Area of Kaduna State
Source: Modified from Kaduna State Ministry of Lands and Surveys (2006)

Data

The Landsat images of four epochs; 1975, 1986, 1999 and 2014 assisted in detecting the trend of land use change from the past to the present. These Landsat images are MSS of 30th January 1975, TM of 26th December 1986, ETM+ of 28th January 1999 and OLI-TIRS of 5th January 2014; all of Landsat world reference systems path189 and row 52 covering the study area and were obtained from the United States Geological Surveys website on earth resources observation and science centre. Topographic maps on scales 1:100,000 and 1: 250,000 of 1967 obtained from Federal Surveys Department, Abuja, Nigeria and topographic map on scale 1: 100,000 obtained from Kaduna State Ministry of Lands and Surveys, Nigeria covering the study area were used for the identification of location

names as well as selection of training samples and accuracy assessment for land use/cover classification. Administrative map, ESRI shape files obtained from the Office of the Surveyor General of the Federation (OSGOF), Nigeria was used for the delimitation of the study area boundary and identification of place names. Household survey was conducted using 420 copies of questionnaire administered to respondents as well as interviews conducted on institutions drawn from the fields related to land utilization and modification to seek valuable information on issues that have influenced land modification. Historical data and reports on occurrence of conflict indicating the number of deaths and properties destroyed during religious crises between 1975 and 2014 in the study area were used for the study as well. These data were provided by the Nigeria Police Force (NPF), Kaduna State Command; Christian Association of Nigeria (CAN), Kaduna State Chapter as well as the Jama'atu Nasril Islam (JNI), Kaduna State Chapter. The data was used to calculate the Intensity of conflict used to regress against change in proportion of area of 1975 and 2014 for research hypothesis two.

Analysis

The land use/cover classes used for this study are cultivated lands and tempered vegetation, bare lands, built-up area, water bodies and secondary vegetation selected based on Anderson *et al.* (1976) classification scheme. The cultivated lands and tempered vegetation refer to farmlands, crop fields, golf courses, and football field. Bare lands are bare rock outcrop and bare fields. Built-up areas include residential, commercial, industrial and rural built-up areas; transportation and communication. Water bodies are single/double rivers and reservoirs while secondary vegetation refer to savannah and wet land vegetations, deciduous forest land, mixed forest land, orchards and nurseries. The pre-processing of the Landsat images were carried out in three stages: image composition, rectification and enhancement. The Colour Infra-red (CIR) composite (432/543) was used because it is the standard "false color" composite and gives results similar to traditional colour infrared aerial photography (Quinn, 2001).The supervised maximum likelihood classification was employed for this study due to the prior knowledge of the study area by the researchers in order to characterize the land use pattern of the study area.

Post classification accuracy assessment namely quantity and allocation disagreements of Pontius and Millones (2011) was used for the study since the main purpose of the work was focused on the quantification of cover of a particular class computed using a classification of remote sensing data. The land cover classification accuracy assessment was based on 200 stratified random sample points. After accuracy assessment, filtering and boundary cleaning were carried out to eliminate “bad” pixels, i.e. isolated pixels to aid classification accuracy assessment. In order to determine the extent and rate of change in the land cover dynamics in the Region; total area, changed area, change extent and annual rate of change were developed and computed to produce thematic maps and statistical tables of the land cover present in the images. The cartographic presentation of the maps was carried out using Arc GIS 10.0. A multiple-date post classification change detection algorithm, *cross tabulation* was carried out to locate those areas that have changed in land cover in time intervals (1975-1986, 1986-1999 and 1999-2014) and hence

give information on the spatio-temporal pattern of land use change in the study area within the study period. The cross tabulation approach has the advantage of "from-to" change information.

Statistical data analysis was carried out for summarizing, characterization and presentation of the field data collected as well as the testing of the hypotheses formulated for this study using Statistical Package for the Social Sciences (SPSS). To verify the hypotheses, analysis of variance (ANOVA) at 5% significant level was utilized because it permits examination of several samples at the same time for the purpose of determining whether a significant relationship exists between them and secondly because of change over time. Two multiple regression analyses were carried out on the two hypotheses. One was tested on the socio-economic characteristics of respondents from the questionnaire data while the other was tested on intensity of conflict in the four LGAs of the study area. To be able to carry out these tests, two statistical models were employed which are:

Model 1: LAUSC = $_{o}$ +$_{1}$Gender + $_{2}$Father + $_{3}$Son - $_{4}$Secondary -$_{5}$Post secondary - $_{6}$Age + $_{7}$ Civil servant……..... (3.1)
Model 2: LAUSC = $_{0}$ - $_{1}$ Intensity of Conflict…… (3.2)

Prior to the analysis, the responses from the questionnaire were coded and entered into the "SPSS" data sheet in preparation for regression against land use change statistics (that is, change in the area of 1975 and 2014). This is for the first hypothesis. For the second hypothesis, it was the intensity of conflict in the four LGAs of the study area that was regressed against change in proportion of the area of 1975 and 2014.

Results and Discussion
Post classification accuracy assessment revealed an overall disagreement of 24%, 24%, 18% and 22% for 1975, 1986, 1999 and 2014 respectively. Also it revealed the overall allocation disagreement for the years as 19%, 19%, 13% and 16%; a suggestion of low classification errors that allowed us some degree of confidence in proceeding with the analysis in the study after generalizations (majority filtering) was carried out.

From the characterization, the pattern and processes of land use/cover in the study area vary spatially and temporally as can be observed with the land cover maps generated for all the four years (Figures 2 to 5). Individual land area and percentage coverage for the four years are presented in Table 1 while the trend of land use (total area, changed area, change extent and annual rate of change are presented in Table 2. From Table 1, the result indicated a great transformation in all the land use/cover types. Built-up areas increased from 0.48% in 1975 to 3.04% in 2014 due to the expansion of villages into towns; an aspect of rural-urban migration spurred by the oil boom prosperity of the 1970s. Cultivated lands and tempered vegetation was 41.4% in 1975, decreased slightly to 39.66% in 1986 due to misclassification of it as bare lands because of drought incidence in 1986. Drought stress resulting in drop in the total annual rainfall was evident on maize output as there was a reduction of 40-90% in 1986 (Ammani *et al*. 2012). The demand for food and other resources by the growing population made cultivated lands and tempered vegetation

increase to 58.09% in 2014. 0.22% of water was present in the study area in 1975, increased to 0.53% in 1986 but decreased in 2014 to 0.42%. The reduction in the water body in 2014 is due to climate change in Kaduna state. This is evident in the total annual rainfall drop. The huge change in the area extent of the water surfaces between 1975 and 1986 is believed to be related to the huge expansion of the Kaduna State Water Board dams to support the growing demand for water for both domestic and industrial uses. Also, percentage of the land surface that is impermeable due to its exposure caused by the rapid urbanization in that period influenced the volume of water that ran into drainage systems. Bare ground increased from 12.05% in 1975 to 27.19% in 2014 because of the demands for firewood and construction materials by the increased population therefore more lands are being excavated, more trees are being fell and as such more lands are being exposed. For secondary vegetation, the total coverage was 45.86% but in 1975 decreased rapidly to 11.16% in 2014. Increased settlements mean higher population of people which amounts to more activities that lead to the degradation of the forest in the study area. This is in agreement with FAO (2005) *that t*he activities of man has been known to be one of the major threats to the forest because, man always want to make himself more comfortable and hence tries to use whatever is available to him within his environment.

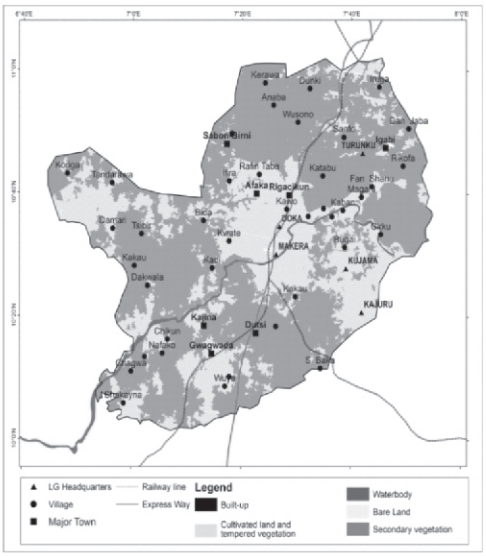

Figure 2: Land cover of Central Area of Kaduna State, 1975
Source: Authors' Analysis (January, 2014

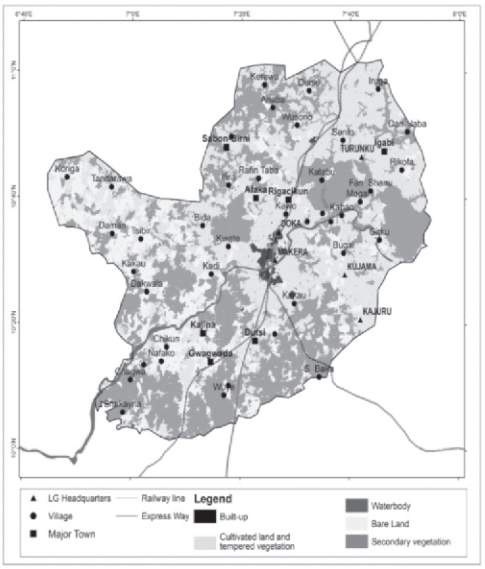

Figure 3: Land cover of Central Area of Kaduna State, 1986
Source: Authors' Analysis (January, 2014)

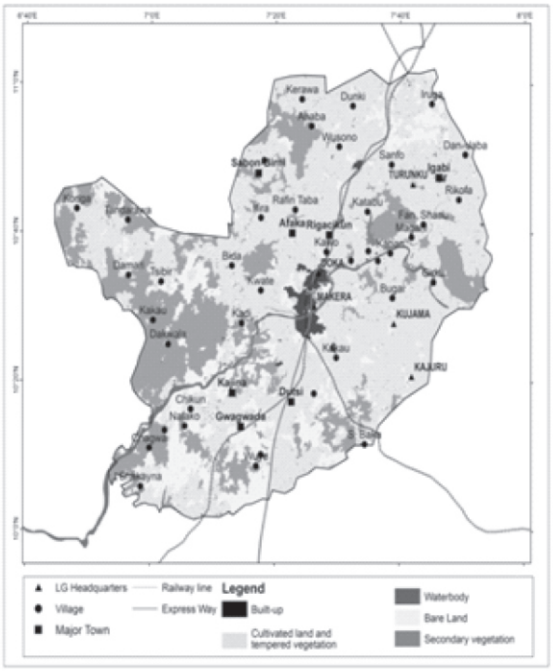

Figure 4: Land cover of Central Area of Kaduna State, 1999
Source: Authors' Analysis (January, 2014)

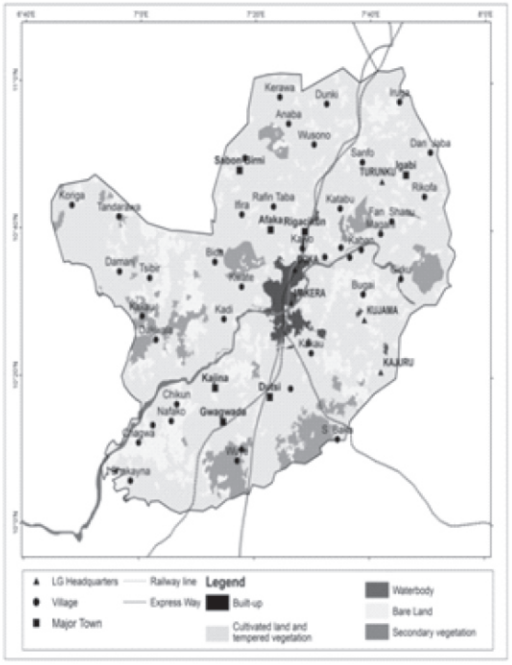

Figure 5: Land cover of Central Area of Kaduna State, 2014
Source: Authors' Analysis (January, 2014)

Table 1: Land cover area and Percentage for Individual study years

	1975		1986		1999		2014	
Land Use	**T_a**	**T_a%**	**T_a**	**T_a%**	**T_a**	**T_a%**	**T_a**	**T_a%**
Built-up	40.46 sq. Km	0.48	112.34 sq. km.	1.32	154.71 sq. km.	1.81	259.53 sq. km.	3.04
Cultivation/ tempered vegetation	3531.77 sq. Km	41.4	3383.46 sq. km.	39.66	4008.47 sq. km.	46.99	4956.02 sq. km.	58.09
Water body	18.81 sq. Km	0.22	44.84 sq. km.	0.53	45.26 sq. km.	0.53	35.66 sq. km.	0.42
Bare Ground	1027.97 sq. Km	12.05	2084.15 sq. km.	24.43	2498.25 sq. km.	29.28	2327.64 sq. km.	27.28
Secondary Vegetation	3912.04 sq. Km	45.86	2906.26 sq. km.	34.07	1824.36 sq. km.	21.38	952.20 sq. km.	11.16
Total	**8531.05**	**100**	**8531.05**	**100.00**	**8531.05**	**100.00**	**8531.05**	**100.00**

Total area (Ta)
Source: Authors' Analysis (January, 2014)

Table 2: Land Cover trends in the Study years

Year	1975-1986 (11yrs)				1986-1999 (13yrs)				1999-2014 (15yrs)			
Land Use	C_a	C_a%	C_r	C_e	C_a	C_a %	C_r	C_e	C_a	C_a %	C_r	C_e
Built-up	72 sq. km.	0.84	0.08	1.77	42 sq. km.	0.50	0.05	0.38	105sq. km.	1.23	0.11	0.68
Cultivation/ tempered vegetation	-148 sq.km	-174	-0.16	-0.04	625 sq. km.	7.33	0.67	0.18	948sq. km.	11.11	1.01	0.24
Water body	26 sq. km.	0.31	0.03	1.38	0.42sq. km.	0.00	0.00	0.01	-10sq. km.	-0.11	-0.01	-0.5
Bare Ground	1056 sq.km.	12.38	1.13	1.03	414 sq. km.	4.85	0.44	0.20	-171 sq.km.	-2.00	-0.18	-0.07
Secondary Vegetation	-1006 sq. km.	-11.79	-1.07	0.03	-1082sq.km.	-12.68	-1.15	-0.37	-872sq.km.	-10.22	-0.93	-0.48

Changed area (Ca)Ca= Ta (t2) -Ta (t1)
Change extent (Ce)
Ce=Ca/Ta (t1)
Annual rate of change (Cr)
Cr=Ce/ (t2-t1)
Source: Authors' Analysis (January, 2014)

The investigation on the spatial transitions of land use types between the study years in the study area yielded information on the overall trends of land use change on a comparative basis. The land use transitions (in percentages) in the study area in the first, second and third intervals of study (1975-1986, 1986-1999, 1999-2014) are presented in Tables 3, 4 and 5. From 1975 to 2014, increased urbanization, socio-economic factors and human activities such as construction, deforestation, and agriculture greatly contributed over the years to produce different types of land use change in the study area, thereby altering the natural environment. The effect of biophysical factors has been minimal except for an occurrence of drought in 1986.

Table 3: Land use transition in the First interval (1975-1986)

	Built-up	Cultivated lands/tempered vegetation	Water body	Bare Ground	Secondary Vegetation
Built-up	100.00	2.18	-	-	-
Cultivated lands/tempered vegetation	-	49.10	34.08	13.03	38.56
Water body	-	0.32	23.76	0.41	0.63
Bare Ground	-	24.01	19.56	79.55	10.51
Secondary Vegetation	-	24.39	22.59	7.01	50.30

Source: Authors' Analysis (January, 2014)

Table 4: Land Use Transition in the Second interval (1986-1999)

	Built-up	Cultivated lands/tempered vegetation	Water body	Bare Ground	Secondary Vegetation
Built-up	93.25	0.76	1.66	1.37	0.20
Cultivated lands/tempered vegetation	-	62.64	7.44	53.97	45.87
Water body	4.31	0.10	79.03	0.64	0.17
Bare Ground	1.82	30.50	7.12	29.32	23.59
Secondary Vegetation	0.62	6.00	4.75	14.69	30.17

Source: Authors' Analysis (January, 2014)

Table 5: Land Use Transition in the Third interval (1999-2014)

	Built-up	Cultivated lands/tempered vegetation	Water body	Bare Ground	Secondary vegetation
Built-up	88.27	1.00	14.82	2.82	0.31
Cultivated lands/tempered vegetation	2.89	66.42	20.16	56.36	47.79
Water body	2.55	0.11	60.52	0.26	0.07
Bare Ground	5.51	27.95	1.57	31.17	22.53
Secondary vegetation	0.78	4.51	2.94	9.39	29.30

Source: Authors' Analysis (January, 2014)

From the transitional matrices of tables 2 to 4, it is observed that a total of 2.18% of cultivated lands and tempered vegetation was converted to built-up in the first interval (1975-1986), while in the second (1986-1999) and third (1999-2014) intervals, it was 0.76% and 1% of it that changed to built-up respectively. There were less bare lands utilized for agriculture in the first interval (13.03%) when compared to 53.97% and 56.36% in the second and third intervals respectively. For the abandoning of cultivated lands and tempered vegetation, there has been a steady change of them to bare lands with 24.01% in the first interval, 30.50% in the second interval and 27.95% in the third interval. This is because the socio-political changes early in the 20th century resulted in a shift to modern economy and technological development instead of agricultural development. The pattern of political changes, shift in economy, and an increase in population has resulted in an increase in the built-up areas. This pattern of urban expansion affects prime agricultural farming areas and it limits the potential of farming in the study area. Thus, converting agricultural areas in the urban and peri-urban areas to an urban status continues due to the process of urbanization. This problem is more pronounced and is also being driven by government developmental activities by taking over large areas of agricultural lands for one project or the other in the study area. Generally speaking, whilst cultivated lands and tempered vegetation decreased around built-up areas due to urbanization, the demand for food by the growing population made cultivated lands to increase around the built-up areas throughout the periods.

In testing the first hypothesis, the regression model of land use change and socio-economic characteristics of residents in the study area indicated that:

1. the adjusted coefficient of determination (Adjusted R Square) = 0.123 from the model summary table, meaning that the independent variables explain 12.3% of the variation in the dependent variable which implies that socio-economic characteristics of residents shows a weak relation to land use change.
2. the unstandardized regression coefficient of FATHER, SON & GENDER showed the highest positive beta values of 0.695, 0.609 and 0.492 respectively from the coefficient table, hence a strong statistical relation to land use change.

The model is significant at 5% level. Considering the significant of 0.000 from the ANOVA table, it implies that the model can be used for estimation. The p-values of the criterion variables are less than 0.05 (coefficient table); an indication that one or more of the independent variables are significant predictors of land use change therefore, the model can be used for estimation. Hence, we conclude that socio-economic characteristics of residents can predict land use change.

- **Statistical model is:** LAUSC = 1.375 + 0.492 Gender + 0.695 Father + 0.609 Son – 0.272 Secondary – 0.257 Post secondary – 0.075 Age + 0.214 Civil servant……1
- **LAUSC** = Land use change.

In verifying the second hypothesis, the result of the regression model of land use change and occurrence of conflict in the study area revealed that:

1. the Adjusted R Square = 0.946 (model summary table), meaning that the independent variable explain 94.6% of the variation in the dependent variable implying intensity of conflict show a very strong relation to land use change.
2. the unstandardized beta value = - 0.012, indicating a weak negative statistical relation to land use change.

The model is significant at 5% level. Significant value is 0 .018 (both ANOVA & Coefficient tables) hence the model can be used to predict land use change**.**

Statistical model is: LAUSC = 0.198 - 0.012 Intensity of Conflicts……..2
The conclusion from the performance of the regression model is that, the intensity of conflict in the LGA affects the spatial dimension of land use change and hence has an explanatory power over land use change i.e. it can predict land use change.

Conclusion
The potential of Landsat data and spatial-temporal analysis to understand the characteristics and modification in land use in the Central Area of Kaduna State is evident from this study. Furthermore, the study presented the explanatory models of factors responsible for land modification. It was obvious through this research that the land use characteristics of the study area evolved greatly over time and space in the transition from an undeveloped area to an urbanized area. The comparative studies of land use characteristics in different intervals indicate that land use in the Central Area of Kaduna State passed through three different patterns over the short span of 39 years; that is, the traditional land use where secondary vegetation was the majority has become majorly cultivated and tempered vegetation as a result of the urbanization of the area. This transformation was dominated by the change of secondary vegetation to cultivated lands and tempered vegetation throughout the period of study. The rapid population growth and urbanization had a strong impact on the land use pattern in the study area. The analysis with the explanatory models to identify the factors responsible for land use change revealed that socio-economic status of residents and intensity of conflict have explanatory powers on land modification. The application of remote sensing, GIS and statistical models in monitoring the environment for land use management have proved effective. Remote sensing was useful in the aspect of data collection, GIS in the area of database development and data analysis while statistical models were utilized to identify the factors influencing land modification.

Recommendations
To alleviate the dramatic change in land use, minimize environmental impacts of urban expansion in the Central Area of Kaduna State the following actions should be taken:
1. The current growth pattern needs to be managed through effective land use planning and management.
2. A review of the existing Master Plans for the major centres and the preparation of an integrated regional Master Plan for the State are essential.
3. The state must also review the existing Town Planning Laws and Regulations in accordance with the Nigerian Urban and Regional Law (Decree 88 of 1992). This

would be useful to protect the fertile cultivated lands in the region and further reduce environmental degradation.

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