



## **Changing Land Uses and Traffic Congestion in Calabar Municipality, Cross River State, Nigeria**

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**Abstract:** *The aim of this study was to assess the relationship between changing land uses and traffic congestion in Calabar Municipality. The study employed the survey design. Field survey was undertaken using the road network map and the land use map of the study area. Traffic survey was also undertaken to obtain data on the volume of traffic. The land use maps of 2010 and 2014 were used in order to examine the changing patterns in the land use of the study area. The annual rate of land use change was obtained by dividing the difference in area covered by each land use between 2010 and 2014 by five years. In order to examine the relationship between changing land uses and traffic congestion, the multiple linear regression statistically technique was adopted. The result of the analysis indicated a coefficient of determination of 0.537 which implies that that 53.7% of the variation in traffic volume can be explained by the changes in the predictor variables - residential, commercial and public land uses. The result showed that changing land uses had significant relationship with traffic congestion in the study area. Findings also revealed that there has been significant effect in changes in the use of land along roads and these changes have created problems along transportation routes such as traffic congestion, parking problems, accidents, haphazard/indiscriminate display of signpost/billboards, over stretching of the road infrastructures and noise pollution. Based on these findings, it has been recommended from the study amongst others; equitable redistribution of land uses particularly those uses that trigger and generate high volumes of traffic, regular studies should be carried out to progressively examine the rate and pattern of changing land use, strict enforcement and implementation of development control measures, monitoring of the changes in the land use of the area from time-to-time by the Calabar Municipality Planning Authority and restriction of unnecessary change in use of land.*

**Keywords:** Land use, traffic volume, traffic congestion, change, roads and transportation.

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## **1. Introduction**

Over the years, changing land use has been a major concern for major stakeholders in the environment. Wu and Cho (2007) observed that in the United States, major land use changes have occurred in the past twenty five years, in spite of the efforts made by the government to impose strict land use control. The location of land uses with respect to the spread of residential and commercial areas when not properly considered in town planning and development of master plans for major cities can cause serious congestion problem. In most urban areas in developing countries, traffic congestion has continued to challenge the efforts of land use experts as well as transportation planners, in terms of longer travel time and delays over time and space.

Traffic congestion along roads in Nigeria is in a severe situation. According to Popoola, Abiola and Adeniji (2013), traffic congestion is as a result of the increasing growth in motor vehicles without a corresponding improvement in transport facilities such as road network, traffic management techniques. Momoh (2011) argued that poor planning of transportation system in Nigeria has led to over-dependence in motor vehicles resulting in too many vehicles with its accompanied problems including traffic congestion. More so, Popoola, Abiola and Adeniji (2013) noted that many highways in Nigeria are bedeviled with traffic congestion which tends to defy various remedial measures adopted by different governments over the years. Journey times from one point to another, have remained unreliable and travelers have continued to face disturbing inconveniences in transportation. These are accompanied by noise and air pollution and the high costs associated with burning of fuels from stationary vehicles.

One of the most important factors responsible for shaping land use patterns in urban centres is the transportation system. According to Balchin, Kieve and Bull (1991), urban road system acts as a basic component of urban areas and also plays an essential role in the determination of the scale, nature and form of the urban areas. Transportation systems have the potential to affect development and the location pattern of land uses. Indirectly, transportation systems have the potential to affect land development by either inducing new development or changing the pattern of development. According to Inyang (2000), the historic and most popular view of the role of transportation in the development process is a prerequisite for economic growth. However, the interconnections that exist among the various functional parts of cities depend upon efficient systems of transportation. The transportation system of any given city generates different land uses and also provides connections among the different land uses in that city. For instance, the transport routes in Calabar Municipality exhibits a number of nodes and linkages to form networks of both major and minor roads along which land uses such as residential, commercial, public, industrial, institutional and open spaces are located.

Increase in economic activities and good road networks are making changes in land use very challenging. In the study area, the provision of good road networks in some parts of the city, profitable and productive land uses have been attracted to some of these roads which have witnessed changes in the use of land. One of the driving forces behind changes along transportation routes in the study area is change in the use of land, these changes can be noticed along roads such as Calabar Road, Old Odukpani Road, IBB Way, Mary Slessor Avenue, MCC Road, Marian Road and Eta Agbor Road. Change in the use of land along these roads have created problems such as traffic congestion, parking problems, accidents, haphazard/indiscriminate display of signpost/billboards, over stretching of road infrastructures and noise pollution. This paper therefore intends to examine land use distribution and the rate of change in the study area. It will also examine the relationship between changing land uses and traffic volumes in the study area.

## **2. Literature Review**

The arrangement, distribution and organisation of land uses in an area in terms of socio-economic functions of residential, commercial, recreational, industrial and institutional usually determine the land use pattern of that area. Land use pattern summarises the distribution of urban activities in a city. The conflicts that arise between the different land uses have added dimension to land use patterns that is why, the structure of a city is as a result of growth over a period of time of various land uses. The problem with urban land use is not only in its classification but also in its distribution. In a study along Lagos-Badagry corridor, Adekunle, Oduwaye and Alade (2011) noted that the major challenge of land use distribution along the corridor was both in terms of planning standard and layout. In most cities, the conflict that arise between the different land uses have added dimension to land use patterns. This is why the structure of a city is as a result of growth over a period of time of various land uses. Etuk (2008) stated that urban land use and its transport system have aggravated the environmental impact of cities while the spatial location of activities or structures like houses, workshops, roads, railways, production and consumption are proportionally increasing. Increase in population and urbanisation have also led to the severity of these problems.

One of the driving forces behind changes along transportation routes is change in the use of land. Changing land uses have been influenced by human actions throughout the years and this has taken place without an appreciation of the effect these changes have on roads. Oruonye (2014) stated that transportation's most significant impact on land improvement occurs when access is provided to land. Changes in the location, type and density of land uses invariably changes transportation patterns. Hillier (1996), one of the proponents of the transportation and land use linkage, noted that socio-economic forces shape the city primarily through the relations between movement and the structure of the urban grid. In

recent times, frontier expansion and population growth have primarily accelerated land use change (Adger and Brown, 1994; Richards, 1990). Changing land use can occur from either direct or indirect decisions to alter the current use of land. A number of factors account for the changing pattern of land use in any given location. These factors have been summarised by some researchers to include social, economic and institutional while others include personal choice, legislation, government policies and plans, decision of developers or transportation entrepreneurs, the nature of the land itself and the availability of technology to develop the land. Moreso, land uses within the urban areas are subject to changes as roads are improved upon and made more accessible through transportation projects. However, these changes are usually associated with attendant problems which manifest in various dimensions along transport routes such as noise pollution, parking problems, accidents and congestion.

Land use and transportation are two vital subjects that are central in the understanding of the internal structures of cities. These two subjects (land use and transportation) are interdependent and findings of earlier studies have indicated the corresponding connections amongst them. For instance, land uses shape transportation by physically arranging different activities along transport routes and transportation shapes land use by providing the means or access to these land uses. Moreover, a reciprocal relationship exists between transportation and land use. Land uses by virtue of their occupancy generate interaction needs and these interaction needs are directed to specific targets by specific transportation facilities. For example, at any point in a city's development process, its activity patterns determine the transportation needs. Similarly, the land use pattern and intensity of use generates demand which can eventually lead to the development and improvement of transportation systems. When this happens, the land use becomes more attractive and developed for urban use. Land uses do not only influence transportation but transportation also influences land use. For instance, large scale transportation projects tend to precede and trigger land use changes while small scale transportation projects tend to complement existing land use pattern. Similarly, a corresponding relationship between land use and transportation also leads to a corresponding increase in vehicle ownership, this further increases the demand for provision of transport facilities as well as exacerbate the flow of traffic. It is in view of this that Sule (2004) opined that urban motor vehicle ownership and usage is growing even faster than the population and also much faster than the ability of cities to provide road space, among others. Nevertheless, an interrelationship between land use and transportation does exist as there is little doubt that land use does change in response to changes in transportation infrastructure, thereby causing secondary effects on travel demand in addition to the direct effect caused by route and mode switching.

Egbu and Kalu (2006) stated that past and recent transportation studies have shown that different land uses have their trip generation characteristics. The rate of trip making in an urban area is a function of the existing land uses in the area. Thus, each land use has its peculiar characteristics in its trip generation. For example, in a residential land use, the trip making activities of a high income household will be more than that of low income household. The ability of a land use type to attract traffic will decline as the land use type becomes more distant or remote from the people or materials it is meant to attract. Akpan (2008) in a study carried out in Ikot Ekpene urban observed that the location of certain activities (parks, banks, schools and commercial shops) along the major roads attracted and generated high traffic due to the concentration of activities on these roads.

### 3. The study area

Calabar Municipality is one of the Local Government Areas in Cross River State. It is located in the South South geo-political zone of Nigeria. It lies between Latitudes 4°57' and 5°04' North of the Equator and Longitudes 8°18' and 8°24' East of the Greenwich Meridian.

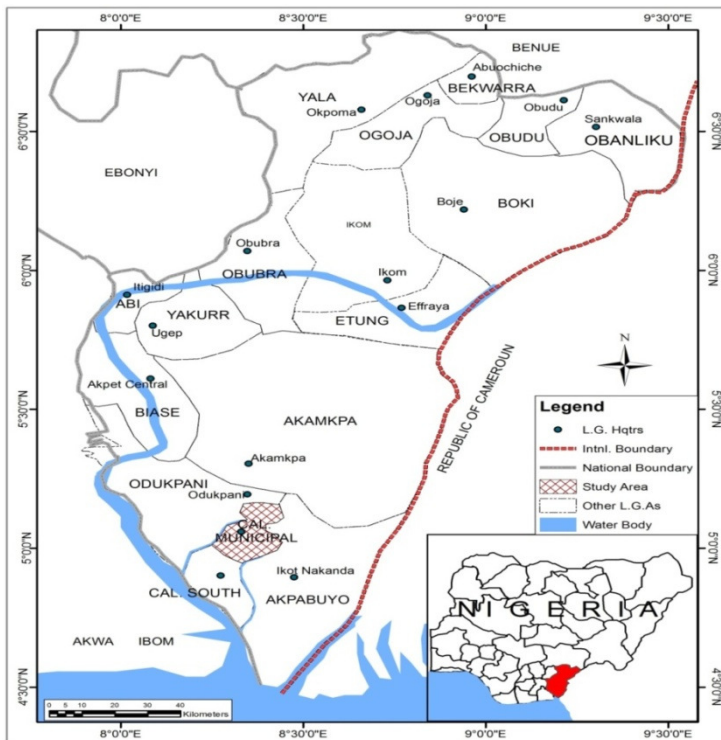


Figure 1: Calabar Municipality on the map of Cross River State

Source: GIS Department, Ministry of Lands and Town Planning, Calabar, Cross River State

Calabar Municipality is bounded in the North West by Odukpani Local Government Area and Calabar River, in the East by Akpabuyo Local Government Area and the Southern shores are bounded by the Calabar South Local Government Area (see Figure 1).

#### **4. Material and Methods**

The study utilised land use maps of the study area to obtain data on the coverage area of land uses (Figures 2 and 3). The land use map of the study area were obtained from the Geographic Information Department, Ministry of Lands and Town Planning, Cross River State. The satellite image was directly imported into the ArcMap environment. The images in the ArcMap environment were geo-referenced. The geo-referenced images were digitized on the computer system. Based on previous knowledge of the study area, a reconnaissance survey using the road network and land use maps of the study area and additional information about the study area was gathered. A classification scheme was developed for the study area. The classification scheme developed gave a general classification of five different classes of land use were. The area covered by the various land use classes which are residential, commercial, green area/open space, public and industrial land uses were calculated using the calculated geometry in the ArcGIS 10.1 environment.

The study employed the survey design method. The survey design approach was considered appropriate for the study because surveys are efficient tools for measuring the frequency with which an event occurs. The survey was used to observe and describe events as they exist without influencing the result. Primary data were obtained from the field survey; observation, measurement and recording. Data on roads were collected through field survey. Traffic volume was obtained from the traffic count. Secondary data were derived from the land use map of the study area. The annual rate of land use change was obtained by dividing the difference in area each land use covered between 2010 and 2014 by five years. The source of secondary data was the GIS Department, Ministry of Lands and Town Planning, Calabar, Cross River State. Purposive sampling technique was adopted in the selection of roads. 26 roads out of a total of 256 roads were purposively selected on the basis that most of the changes that occur in the land uses under study were observed along these 26 roads which also constitute the major roads in the study area. This number (26 roads) represents 10% of the total number of roads which is statistically accepted as the minimum sample size for a study.

Multiple linear regression was used to examine the relationship between changing land uses and traffic volume and also to determine if changing land uses have any significant effect on roads. According to Udofia (2005), the multiple linear regression is a parametric statistical technique which enables a researcher to carry out the following:

- (i) Investigate the causal relationships between variables.
- (ii) Measure the effect of one variable on another.
- (iii) Predict values of the dependent variable given values of the independent variable.

Moreso, in multiple regression, the effect of numerous independent variables ( $X_1, X_2, X_3, \dots, X_n$ ) is measured on a single dependent variable  $Y$ . The formula for Multiple linear regression is given as:  $Y = f(X_1, X_2, X_3, \dots, X_n)$

$$Y = a + b_1X_1 + b_2 X_2 + b_3 X_3 \dots + b_nX_n + e \quad (1)$$

where

$a = Y$  intercept

$b_1, b_2, b_3 \dots b_n =$  the regression plane of the three independent variables

$X_1, X_2, X_3 \dots X_n =$  the independent variables.

Two sets of variables were required for the study; the dependent ( $Y$ ) variable and the independent ( $X$ ) variables. The dependent variable was the volume of traffic, while the independent variables were the land uses; residential, commercial and public land uses.

## 5. Results and Findings

The land use map of the study area shows the distribution of land uses in the study area. These land uses include; residential, public, commercial and other land uses which comprise of recreational/green area, circulation and industrial (Figures 2 and 3). These land uses as well as the area covered by these land uses in 2010 and 2014 are presented in Table 1 which shows the sum total of the residential, public, commercial and other land uses along the sampled roads in the study area. The residential land use which was the dominant land use covered a total of 184.05 hectares of land in 2010 while in 2014 it covered a total of 128.78 hectares of land. This indicated a reduction in the land use coverage with about 55.27 hectares and 29% reduction as compared to the land coverage in 2010. Commercial land use covered a total of 63.31 hectares of land in 2010 and in 2014 it covered a total of 104.11 hectares of land. This indicated an increase in the commercial land use of about 40.8 hectares of land with about 23% increase from 2010. Public land use in 2010 covered a total of 88.57 and in 2014 it covered a total of 99.54 hectares of land, indicating an increase of about 10.97 hectares of land with about 22% increase from 2010. Circulation land use covered a total of 70.04 in 2010 and in 2014, the green areas covered a total of 26.08 hectares of land in 2010 and 2014 while industrial land use in 2010 covered a total of 14.44 hectares and in 2014 it covered a total of 17.94 hectares of land. This indicated an increase of 3.5 hectares of land with 4% increase from the year 2010. The circulation and the green area in 2010 respectively had 70.04 and 26.08 hectares of land which remained unchanged. This was because these land uses could not be easily encroached upon since they have been earmarked for this purpose.

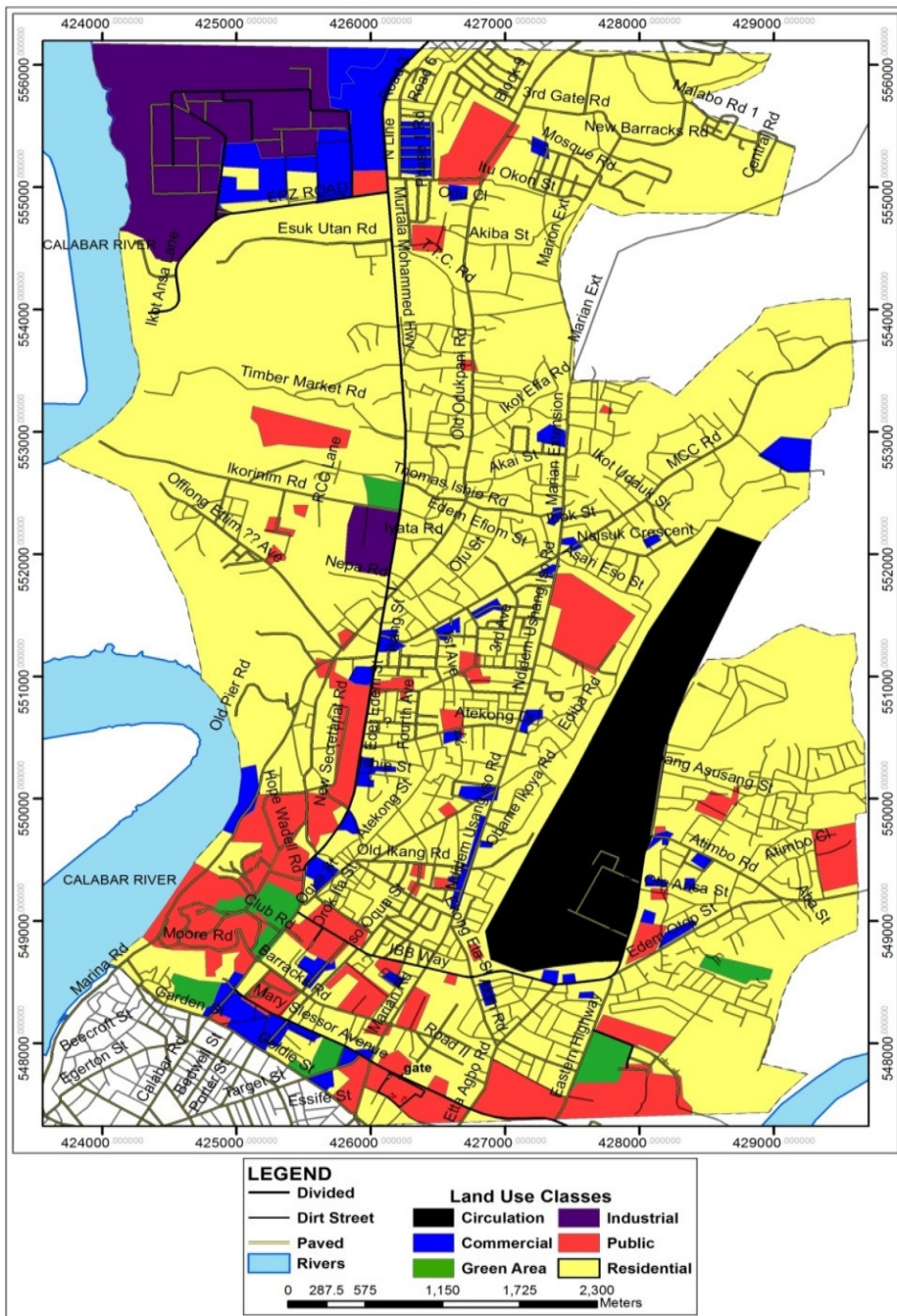


Figure 2: Land use classes of 2010 on the map of Calabar Municipality

Source: GIS Department, Ministry of Lands and Town Planning, Calabar, Cross River State



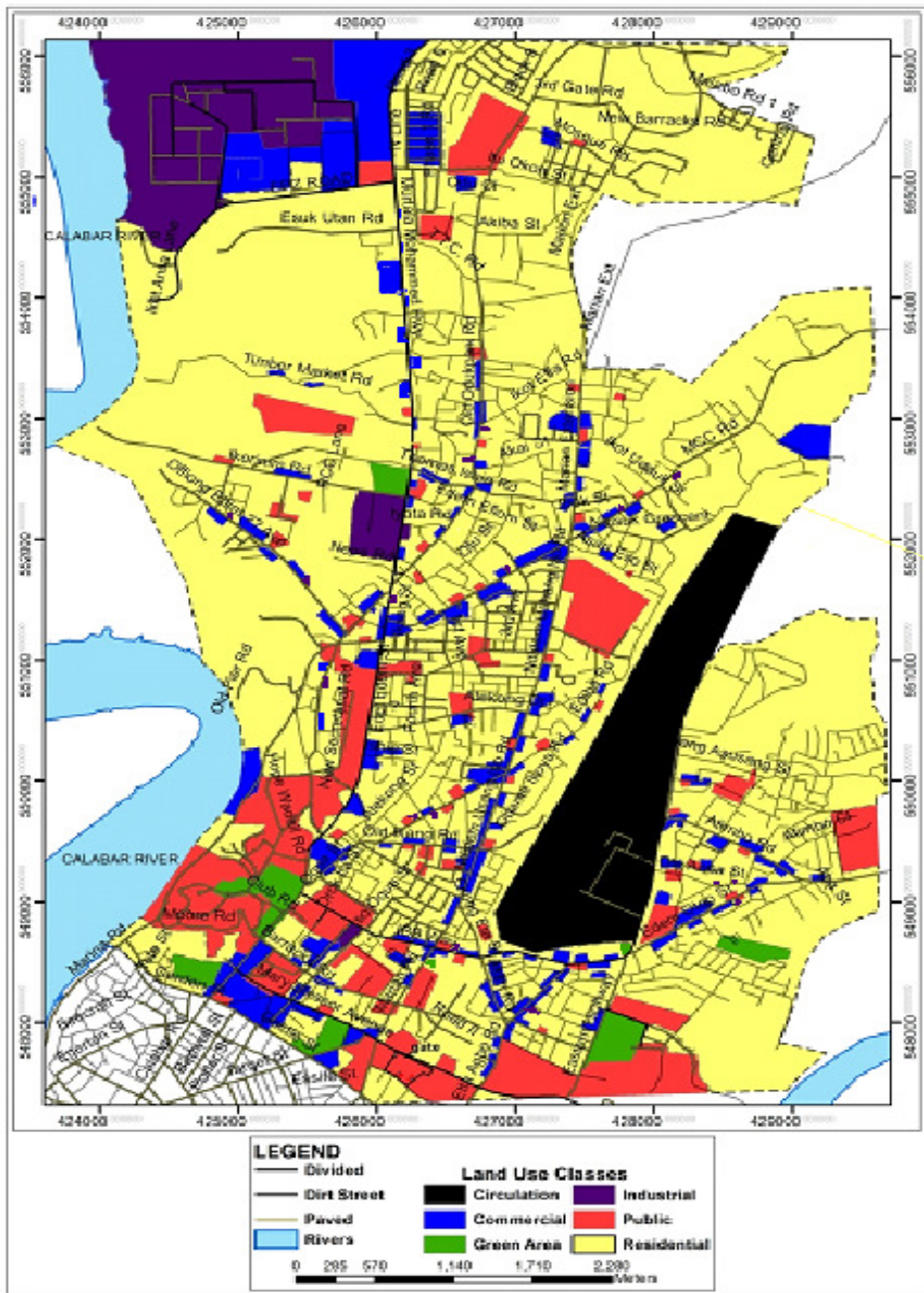


Figure 3: Land use classes of 2014 on the map of Calabar Municipality

Source: GIS Department, Ministry of Lands and Town Planning, Calabar, Cross River State

**Table 1: Land use distribution in the study area.**

S/N	Land Use Classes	Area (Hectares) covered in 2010	Area (Hectares) covered in 2014	Change (Difference in Hectares)	%
1	Residential	184.05	128.78	*55.27	29
2	Commercial	63.31	104.11	**40.80	23
3	Public	88.57	99.54	**10.97	22
4	Circulation	70.04	70.04	0	16
5	Green Area	26.08	26.08	0	6
6	Industrial	14.44	17.94	*3.50	4
Total		446.49	446.49		100

**Source:** *Authors’ Data Analysis (2014)* \*Decrease hectares covered \*\*Increase in hectares covered

**6. Analysis of Land Use and Rate of Change in the Study Area.**

Table 1 indicates the distribution of land uses in the study area. In order to determine the rate and nature of change of land use in the study area, the 2010 and 2014 land use maps were juxtaposed and their data analysed. Table 2 indicates that there has been a substantial increase and change in commercial, public and industrial land uses while there has been a decrease in the residential land use. The result showed that commercial land use increased by 40.80 hectares at the rate of 8.2 hectares, public land use increased by 10.97 hectares at the rate of 2.2 hectares, industrial land use increased by 3.50 hectares at the rate of 0.7 hectares while the residential land use decreased by 55.27 hectares at the rate of 11.1 hectares. The residential land use decreased due to conversion and infiltration of residential land uses by commercial as well as public and industrial land uses. Commercial public and industrial land uses witnessed positive changes while residential land uses witnessed negative change. The green area and circulation land uses did not witness changes as new green areas were not developed and the existing roads were not expanded within this period.

In examining the relationship between changing land uses and traffic volumes in the study area, null hypothesis was formulated which states “that there is no relationship between changing land uses and traffic volumes in the study area.” The hypothesis was tested using multiple regression analysis. Table 3 shows the results of the multiple regression analysis that was adopted to determine if changing land uses had any significant relationship on traffic volume. It showed that the value  $R = 0.733$  and  $R^2 = 0.537$ . The coefficient of determination  $R^2 = 0.537$  implied that 53.7% of the variation in traffic volume in the study area could be explained by the changes in the predictor variables (Residential, commercial and public land uses). It also meant that this effect was

statistically significant implying that the extent to which changing land uses affect traffic volume was 54%.

**Table 2: Land use status and rate of change in land use in the study area**

S/N	Land Use Classes	Area (Hectares) covered in 2010	Area (Hectares) covered in 2014	Change (Difference) between 2010 and 2014	Annual Rate of land use change (Hectares) between 2010 and 2014	Nature of change
1	Residential	184.05	128.78	55.27	11.1	Decreased
2	Commercial	63.31	104.11	40.80	8.2	Increased
3	Public	88.57	99.54	10.97	2.2	Increased
4	Circulation	70.04	70.04	0	0	No Change
5	Green Area	26.08	26.08	0	0	No Change
6	Industrial	14.44	17.94	3.50	0.7	Increased
Total		446.49	446.49			

*Source: Authors' Data Analysis (2014)*

**Table 3: Multiple regression analysis for traffic volume and changing land uses.**

Model	R	R Square	Adjusted R Square
1	.733 <sup>a</sup>	.537	.474

a. Predictors: (Constant), Commercial, Public, Residential b. Dependent Variable: Traffic Volume

## 7. Conclusion and Recommendations

The study on changing land use and traffic congestion in Calabar Municipality, Cross River State revealed that significant changes have taken place in the land use structure of the area over the past five years, particularly; the public and commercial land uses have witnessed significant changes. The study also revealed the relationship between changing land use and traffic congestion in Calabar Municipality. Thus, as land uses change, traffic volume increases. However, in order to address the challenges posed by changing land use on roads, there is need for adequate land use planning so as to mitigate the effects posed by changing land use on roads.

In addition to this, there is a need for municipal planning authority to monitor the process of change in the area in order to prevent the negative effect these changes may unleash on the environment. Since some of the changes or conversion of land uses are done without

the consent of the Municipal Planning Authority, development control measures should be strictly implemented by the Municipal Planning Authority so as to curb the rapid and unauthorised conversion of land uses. In order to curb traffic noise, accidents and traffic volume in the area, there is need for equitable redistribution of land uses particularly those uses that trigger and generate high volumes of traffic. Also, development control laws should be strictly enforced by the planning authority, the Calabar Municipality Planning Authority should enact bye-laws that restrict change of use of land either by 10 or 20 years.

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## 9. Appendix

**Table 4: Distribution of Land uses and their Areas in 2010**

S/N	Roads/ Streets	Resi- dential	Public	Comm- ercial	Circu- lation	Green Area	Indus -trial	Total
1	Eta Agbor Road	5.13	17.18	2.66	1.85	0	0	26.82
2	IBB Way	10.34	9.72	3.74	5.64	2.04	0.29	31.77
3	Atimbo Road	7.11	1.41	1.85	2.56	0	0.45	13.38
4	EdimOtop Road	7.02	1.38	2.24	1.11	0	0.34	12.09
5	Akim Road	2.04	0.25	2.47	0.74	0	0	5.50
6	Marian Extension	8.95	1.25	2.13	4.12	0	0.41	16.86
7	Murtala Mohammed Highway	23.09	9.44	6.58	13.3	8.45	8.10	68.96
8	MCC Road	10.73	1.81	3.65	2.88	0	0.51	19.58
9	Calabar Road	1.30	2.04	4.82	1.55	14.46	0	24.17
10	Old Odukpani Road	12.02	2.28	2.89	8.01	0	0.45	25.65
11	Old Ikang Road	5.63	1.35	1.20	1.60	0	0.37	10.15
12	Essien Etim Offiong Road	8.89	1.51	1.10	1.55	0	0.35	13.40
13	Ediba Road	7.85	1.24	2.85	1.19	0	0.40	13.53
14	Ndidem Usang Iso Road	14.01	2.55	7.20	6.51	0	0.46	30.73
15	Big Qua Road	4.51	1.41	1.60	1.04	0	0.33	8.89
16	Essien Town Road	5.22	1.48	1.14	1.56	0	0.46	9.86
17	Diamond Hill	8.25	1.86	2.01	1.40	0	0.39	13.91
18	Marian Road	9.35	3.15	4.62	3.24	1.13	0.34	21.83
19	Bogobiri Road	0.72	0.40	0.51	0.38	0	0	2.01
20	Mary Slessor Avenue	3.03	15.51	2.42	4.40	0	0	25.36
21	Eyo Etta Street	4.27	1.12	0.87	0.47	0	0	6.73
22	OtuAnsa Street	5.78	1.81	1.31	0.81	0	0.42	10.13
23	Archibong Eso Road	6.03	1.53	1.18	0.92	0	0	9.66
24	Thomas Ishie Road	3.56	4.58	0.40	0.87	0	0	9.41

25	Barracks Road	3.81	1.04	1.35	1.50	0	0.37	8.07
26	Atekong Drive	5.41	1.27	0.52	0.84	0	0	8.04
Total		184.05	88.57	63.31	70.04	26.08	14.44	446.49

*Source: Authors' Data Analysis (2014)*

Table 5: Distribution of Land uses and their Areas in 2014

S/N	Roads/Streets	Resi- dential	Public	Comm- ercial	Circu- lation	Green Area	Indus- trial	Total
1	Eta Agbor Road	2.63	17.18	4.78	1.85	0	0.38	26.82
2	IBB Way	7.99	10.92	5.59	5.64	2.04	0.59	31.77
3	Atimbo Road	4.81	2.01	3.55	2.56	0	0.45	13.38
4	Edim Otop Road	3.91	1.88	4.85	1.11	0	0.34	12.09
5	Akim Road	1.24	0.25	3.27	0.74	0	0	5.50
6	Marian Extension	5.35	2.05	4.93	4.12	0	0.41	16.86
7	Murtala Mohammed Highway	15.07	12.34	10.18	13.3	8.45	9.62	68.96
8	MCC Road	7.42	2.53	6.24	2.88	0	0.51	19.58
9	Calabar Road	1.30	2.04	4.82	1.55	14.46	0	24.17
10	Old Odukpani Road	7.19	3.49	5.91	8.01	0	1.05	25.65
11	Old Ikang Road	3.95	1.35	2.88	1.60	0	0.37	10.15
12	Essien Etim Offiong Road	6.38	1.51	3.61	1.55	0	0.35	13.40
13	Ediba Road	3.59	2.05	6.30	1.19	0	0.40	13.53
14	Ndidem UsangIso Road	9.42	3.05	10.89	6.51	0	0.86	30.73
15	Big Qua Road	4.21	1.41	1.90	1.04	0	0.33	8.89
16	Essien Town Road	4.57	1.48	1.79	1.56	0	0.46	9.86
17	Diamond Hill	7.01	2.24	2.87	1.40	0	0.39	13.91
18	Marian Road	8.11	3.15	5.56	3.24	1.13	0.64	21.83
19	Bogobiri Road	0.60	0.40	0.63	0.38	0	0	2.01
20	Mary Slessor Avenue	2.71	15.51	2.74	4.40	0	0	25.36
21	Eyo Etta Street	3.21	1.43	1.62	0.47	0	0	6.73
22	OtuAnsa Street	3.96	2.12	2.82	0.81	0	0.42	10.13
23	Archibong Eso Road	5.01	2.01	1.72	0.92	0	0	9.66
24	Barracks Road	2.50	1.29	2.41	0.87	0	0	9.41
25	Thomas Ishie Road	2.66	4.58	1.30	1.50	0	0.37	8.07
26	Atekong Drive	4.98	1.27	0.95	0.84	0	0	8.04
Total		128.78	99.54	104.11	70.04	26.08	17.94	446.49

*Source: Authors' Data Analysis (2014)*

Table 6: Data on Traffic Volume (Dependent Variable)

S/N	Roads/Streets	Traffic Volume(Frequency)
1	Eta Agbor Road	5951
2	IBB Way	4852
3	Atimbo Road	4807
4	EdimOtop Road	2684
5	Akim Road	3805
6	Marian Extension	5076
7	Murtala Mohammed Highway	6108
8	MCC Road	4904
9	Calabar Road	5107
10	Old Odukpani Road	4601
11	Old Ikang Road	2691
12	Essien Etim Offiong Road	1586
13	Ediba Road	1170
14	Ndidem Usang Iso Road	4891
15	Big Qua Road	2804
16	Essien Town Road	2492
17	Diamond Hill	2041
18	Marian Road	5608
19	Bogobiri Road	651
20	Mary Slessor Avenue	2854
21	Eyo Etta Street	421
22	Out Ansa Street	795
23	Archibong Eso Road	875
24	Thomas Ishie Road	1842
25	Barracks Road	2216
26	Atekong Drive	1703

*Source: Authors' Field Survey*