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EMPIRICAL ANALYSIS OF TRAFFIC CONGESTION AND DELAY AT INTERSECTIONS IN URBAN AREAS, A CASE STUDY OF FEDERAL CAPITAL TERRITORY, ABUJA, NIGERIA.

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Abstract:

Congestion and delays are serious issues in many cities around the world in both developed and developing countries. Road intersections are the most complex locations in a city traffic system and considerably influence vehicle safety, free flow, and movement efficiency. Conflicts do, however, frequently arise where two or more roads intersect. In order to evaluate the severity of the problems, their impacts on the road users, and the causes and severity of traffic delays at those intersections, this study was framed to identify intersections in the Federal Capital Territory (FCT), Abuja, that have traffic flow challenges. The data was gathered using an intersection delay count. Analyzing the data sets involved using a straightforward descriptive technique and data representation. Results revealed that most intersections are made of T-Junctions (69%), with those around offices and residential areas experiencing more traffic congestion and delays, which is attributed mostly to illegal parking at those locations, especially during peak hours. The delay at various intersections rose to 42% of the vehicle within the selected intersection, about half of the total vehicles considered in the study area. This is attributed to the mixed land use. During peak hours, office buildings, with 41.5% traffic generators, cause chaotic flow and illegal parking. Crash trends indicate decreasing pattern from 2011 through 2015. These show that intersections create significant traffic problems impeding travel time and economic activities within the study area.

Keywords: Traffic Flow, Vehicular Conflict, Delay Analysis, Road Intersections, T-Junctions, Traffic Congestion,

Introduction

The road network is an important part of urban development because it provides the accessibility that varied land users require. As a result, the correct operation of metropolitan regions depends on an efficient transportation network, which serves as the backbone of their existence. With the increased economic expansion, increased urbanization, and underinvestment in infrastructure comes the concentration of economic potential and population in metropolitan cities. Because of this, there are a lot of mobility needs that must be satisfied in a small space, which causes congestion and delays. (Kozlak, 2018).

Put simply, traffic congestion means more vehicles are trying to use a given road facility than it can handle- without exceeding acceptable levels of delay or inconvenience (Kumarage, 2004). In FCT and other major cities, this occurs mostly during certain times of the day- called peak periods or rush hours. Congestion results from the balance between the supply and demand for road space, which is two distinct parameters in the same equation (Kumarage, 2004). A disparity between travel demand and the capacity of the transportation system leads to congestion. The concentration of travel in both space and time leads to the demand. The supply is constrained by the infrastructure's historical shape, investment level, transport management, and operating practices (Falcocchio et al., 2015).

Urban traffic congestion needs to be viewed in the broader perspective of city dynamics and the advantages of concentration. Successful urban economic development, employment, housing, and cultural policies that encourage people to live and work close to one another and draw businesses to take advantage of the productivity benefits generated frequently result in traffic congestion in metropolitan regions (OECD, 2007).

There are many indications that, even though they may not be thrilled by the prospect, urban road users are prepared to live with crowded roads so long as they derive other benefits from living and working in their cities.

Traffic delay is the time lost due to traffic congestion or, more simply, unwanted journey time. In other words, traffic delay is the inability to reach a destination in or at a satisfactory time due to slow or unpredictable travel speeds. Urban road intersections easily become the worst hit of traffic delays. This is because, at intersections, vehicular flows from several different approaches (link/edge), making either left-turn, through, or right-turn movements seek to occupy the same physical space at the same time. In addition to these vehicular flows, pedestrians seek to use this space to cross the streets, thereby worsening the already bad traffic situation. Thus, the intersections are the most critical points for an urban road network operation from capacity, congestion, and safety viewpoints.

Road intersections (where traffic flows in different directions converge) play an important role in the road network. They are the most complex locations in a traffic system, and they considerably influence vehicle safety and movement efficiency. This area allows vehicles to turn in different directions to reach their destinations. Its main function is to guide vehicles in their respective directions. A major characteristic of the urban road network is that it contains many intersections. As a result, the traffic situation in urban areas is characterized by many small disturbances, compared to highways that generally show fewer disturbances.

Road intersections within cities do result in traffic delays that often lead to traffic congestion. A junction at grade, or on the same level, where two or more roads meet or cross, is referred to as an intersection. An intersection can have three ways (a T junction or Y junction; the latter is frequently referred to as a fork if accessed from the stem of the Y), four ways (usually in the shape of a crossroads), five ways (a 5-points), or even more than five legs. Busy intersections are often controlled by traffic lights and/or a roundabout.

However, the intersection of two or more roads can produce vehicle conflict since vehicles traveling in opposite directions wish to simultaneously occupy the same space. At a junction, drivers must make split-second decisions based on their route, intersection shape, and the speed and direction of other vehicles, among other factors. A slight lapse in judgment can result in catastrophic accidents. Additionally, depending on the ytpe, geometry, and type of control, it creates delay. Overall, how well the intersections function determines how smoothly traffic moves. It also has an impact on the road's capacity. Consequently, from the perspectives of accidents and capacity, the study of intersections is crucial for traffic engineers, especially in metropolitan settings (Tom, 2009).

In order to move both vehicle traffic and pedestrians safely and efficiently, it is essential to settle these conflicts at the intersection. There are two approaches to controlling intersections: time-sharing and space-sharing. The sort of junction control that must be used depends on the volume of traffic, the geometry of the road, the associated costs, the significance of the route, etc. (Tom, 2009)

Although a lot of research has been conducted on traffic management in FCT Abuja, in this investigation, our goal is to pinpoint the intersections with traffic flow challenges within the FCT, to examine the magnitude of the challenges and the effects on the road users within the intersections, to examine the causes and magnitude of traffic delays at the intersections, to analyze the crash trends at the intersections within FCT between 2011 to 2015, to assess the type of traffic control measures in place at the intersections with traffic flow challenges within FCT which will ultimately help us comprehend the problems of urban congestion. This study identifies the intersections with the chaotic flow and the extent to which the delay affects the travel time of the commuters. It also provides the relevant agencies with the extent of delay at the study areas in order to curb the issue and provide decisive measures in reducing the magnitude of congestion within the study areas. This study will be of great benefit to the general traffic management in urban cities like FCT Abuja, as relates to traffic congestion and traffic delay, and the followings categories of people: The FCT Transportation Secretariat Authority, Directorate of Road Traffic Services (DRTS), Abuja, and other Traffic Law Enforcements Agencies in FCT, the Motorist in FCT, the academia and general public.

Study Area

The Federal Capital Territory (FCT) Abuja is located in the North-Central geo-political zone of Nigeria. It lies between the latitude 9°3'28.26"N and longitude 7°29'42.29"E East of the Greenwich meridian in the Guinea Savannah region of Nigeria's middle belt. It is bordered on the west and north by Niger State, on the northeast by Kaduna State, on the east and south by Nasarawa State, and on the southwest by Kogi State. The overall land area is about 7,315 square kilometers, which is more than double the size of Lagos State (3,535 sq. km) (Adeoye, 2016).

The Federal Capital Territory (FCT) is divided into six (6) Area Councils: Abaji, Bwari, Gwagwalada, Kuje, Kwali, an d Abuja Municipal, having a 1,405,201 population as per the 2006
Census. Central Area, Garki, Wuse, Maitama, and Asokor o are the city's five (5) districts. Nyanya, Karu, Gwagwalad a, and Kubwa are the districts in the suburbs. The main study area is shown below:

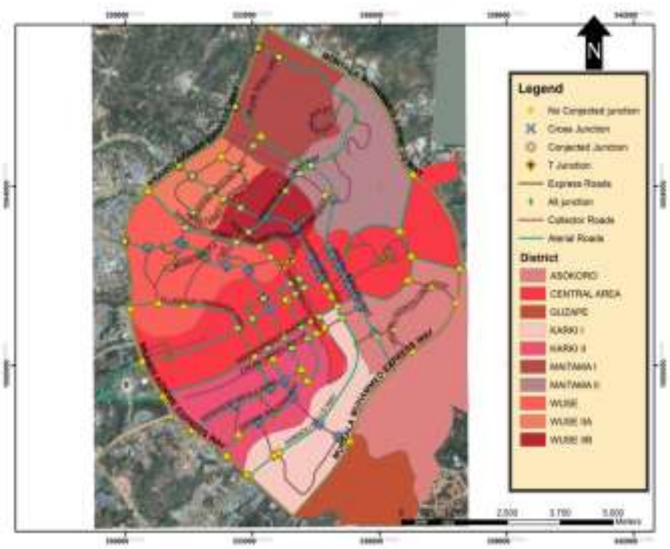

Figure 1: FCT Phase One Map Showing Road Networks (FCDA, AGIS 2016)

Research Methodology

Two sources of data were used for this study; primary and secondary. The primary data source includes raw data collected through the physical survey, traffic count, and questionnaire administered on the field. The secondary data sources were gathered from research reports, conference papers, and stakeholders that include: Federal Road Safety Commission (FRSC), Nigerian Police, Land Office, etc. The population of the study was centered on the motorist, traffic enforcement officers, the road intersection, and other road users.

The intersection delay study counts the vehicles that stopped at the intersection approach in successive intervals, whereas the field survey takes inventory of the intersections and categorizes them. The average duration of these intervals is between 10 and 20 seconds; however, we used a 15-second interval in this investigation. When conducting this research at a stop sign-controlled intersection, the number of cars halted is limited to those that came to a complete stop. Vehicles that "roll" through the stop are classified as "Not Stopped".

Data Presentation And Analysis

The data acquired in the field was evaluated and presented using simple descriptive techniques and representations such as tables, percentages, and graphs to summarize findings and ensure the ordered documentation expected of a research and design capacity usage analysis. Equation 1 was used to calculate the time spent in a queue and is expressed as;

$$\mathrm{TIDQ} = \left(\mathrm{I_s} \times \frac{\Sigma \mathrm{V_{iq}}}{\Sigma \mathrm{V_{tot}}}\right) \times 0.9 \qquad (1)$$

Where:

TIDQ = Time in Queue Delay

I_s =Time Interval between Queue Counts (sec)

ΣV_{iq} = Sum of all Vehicles in Queue Counts (vehicles)

ΣV_{tot} = Total number of vehicles during the study period (vehicles)

0.9 is the Empirical adjustment factor.

Other delay parameters include;

Total delay = Total Number Stopped X Sampling Interval/3660 = Veh/hr.

Average Delay per Stopped Vehicle = Total Delay/Number of Stopped Vehicles

Average Delay per Approach Vehicle = Total Delay/Approach Volume

Percent of Vehicles Stopped = Number of Stopped Vehicles / Approach Volume

The Magnitude of Traffic Flow Situation within the Federal Capital City

This section identifies intersections with chaotic traffic flow and their magnitude in the study area

Intersection Inventory and Locations in the Study Area

Table 1*: Intersection Inventory and Locations in the Study Area*

S/N	Type of Intersection	Number	%	Location
1	T-Junction	9	69.2	• B6/N13 (Constitutional Avenue/Shehu Shagari Way) Federal Secretariat • N13/RR1 (Shehu Shagari Way/Nnamdi Azikwe Way) NICON Junction • Mpape Junction • NITEL Junction • TafawaBalewa/RR1 (Area 3 Junction) • Nyanya/Karu Junction • Old CBN Junction • Central Mosque Junction • S20/Airport
2	Roundabout	1	7.7	• Maitama Roundabout
3	Crossroad	3	23.1	• Aminu Kano Crescent/Ahmadu Bello Way (Bannex Junction) • OSEX/ShehuSagari Way Deeper Life Junction • S20/ISEX (Games Village Junction)
		13	100	

There are 13 main intersections in the research region as shown in Table 1. According to the field survey, T-junctions make up 69 percent of the intersections in the study region, cross-junctions make up 23 percent, and roundabouts make up 1% of the intersections. Thus, T-junctions are dominant in the research area.

Analysis of Delay at Intersections

This section evaluates the performance of intersections in allowing traffic to enter and pass through or to enter and turn onto another route. This study effectively provided a detailed evaluation of delays at some of the intersections in the study area. These include Time-in-Queue Delay (TIQD), Average Total Vehicle in Queue, Total Delay, etc.

***Table 2**: Nitel Junction Average Time in Queue Delay Study*

	Number of Lanes: 2		Total Vehicle Arriving, V_{tot}: 614	
	Survey Count Interval (I_s): 15		Stopped Vehicle Count, V_{stop}: 242	
		Total Number of Vehicles Stopped In Approach at Time:			
	Starting Time	0 SEC+	15 SEC +	30 SEC+	45 SEC+
1	10:00am	3	4	8	15
2		4	13	18	17
3		7	10	15	21
4		4	8	10	14
5		6	12	13	18
6		3	6	15	16
7		5	9	11	19
Sub Total		32	62	90	120
Total Vehicle in Queue		304			

Table 2 shows the Average Time in Queue at the NITEL junction. Results indicated a total number of vehicles stopped at this intersection approach in the time interval. The number of vehicles stopped during this time interval was 242, while 614 vehicles arrived at this point during the survey. Result also shows a total of 304 vehicles in the queue within the study period. This indicates that within 45 seconds of 7 cycles, the average total vehicle in the queue at NITEL Junction per lane is about 304 vehicles.

The other junctions considered for the Average Time in Queue Delay Study are Bannex Junction, Federal Secretariat Junction, Life Camp Junction, and Nyanya-Karu Junction.

At the BANEX junction, a total of 702 vehicles arrived in the area during the survey. The number of stopped vehicles counts to 331, while a total of 425 vehicles were in the queue within this study period. This shows that within 45 seconds of 7 cycles, the average total number of vehicles in the queue at the BANEX junction per lane is about 425 vehicles.

Federal Secretariat Junction recorded a total number of 228 vehicles arriving during the survey, with 191 vehicles stopping at this point. Result also shows a total of 287 vehicles in the queue within the study period. This shows that within 45 seconds of 7 cycles, the average total number of vehicles in the queue at Federal Secretariat Junction per lane is about 287 vehicles.

The Average Time in Queue study results at Life Camp Junction revealed a total number of 674 vehicles arriving during the survey. The stopped vehicles counted to 311, while a total of 393 vehicles were in the queue during this study period. This indicates a total average number of vehicles of 393 in queue per lane at Life Camp Junction within 45 seconds of 7 cycles.

The last junction considered for the Average Time in Queue study was Nyanya-Karu Junction. A total of 471 vehicles arrived at this point during the survey. The stopped vehicles counts to 216 in number. Also, a total of 291 vehicles were in the queue within the study period. This shows that within 45 seconds of 7 cycles, the average total vehicles in the queue at Nyanya/Karu Junction per lane is about 291.

Table 3 shows the delay analysis in the study area's five (5) selected intersections. The table is based on the results/information from the junctions considered above and methods as described in data analysis.

***Table 3**: Analysis of Delay at The Selected Intersections*

	NITEL	**BANEX**	**FED. SEC**	**LIFE CAMP**	**Nyanya/ Gwarinpa**
Average Total Vehicle in Queue	304	425	287	393	291
Time in queue per vehicle	6.7 Sec/Veh	6.4 Sec/Veh	9.8 sec/vehicle	7.9 Sec/Veh	8.3 Sec/Veh
Total Delay (Veh-Hr.)	1.3	1.7	1.2	2.0	1.2
Average Delay per Stopped Vehicle (Sec)	18 Sec	19 Sec	47 sec	19 sec	20 sec

Average Delay per Approach Vehicle	7.4 Sec	9.1 Sec	16 sec	9 sec	9 sec
Percent of Vehicle Stopped	40%	47%	33%	46%	45%

As seen in table 3, the first row is a result that reveals the total number of vehicles in the queue. Banex junction has the highest severity, with 425 vehicles per lane during the study period. This is due to the highest volume of vehicles at the intersection and the complexity of the intersection, while Federal Secretariat Junction has the least average vehicles in queue. The results show that Federal Secretariat Junction has the highest Time in Queue per vehicle with 9.8 sec/vehicle; this is because the intersection is a T-Junction with manual traffic control, and preference is given to motorists taking a left turn in and out of the secretariat link.

Results also indicated the percentages of the vehicles stopped at the crossline of the intersections, with almost 50% of vehicles stopping at Banex, Life Camp, and Nyanya/Gwarinpa Junctions. This might be attributed to the mixed land use of these three (3) intersections. Table 3.3 shows the detailed information of this analysis.

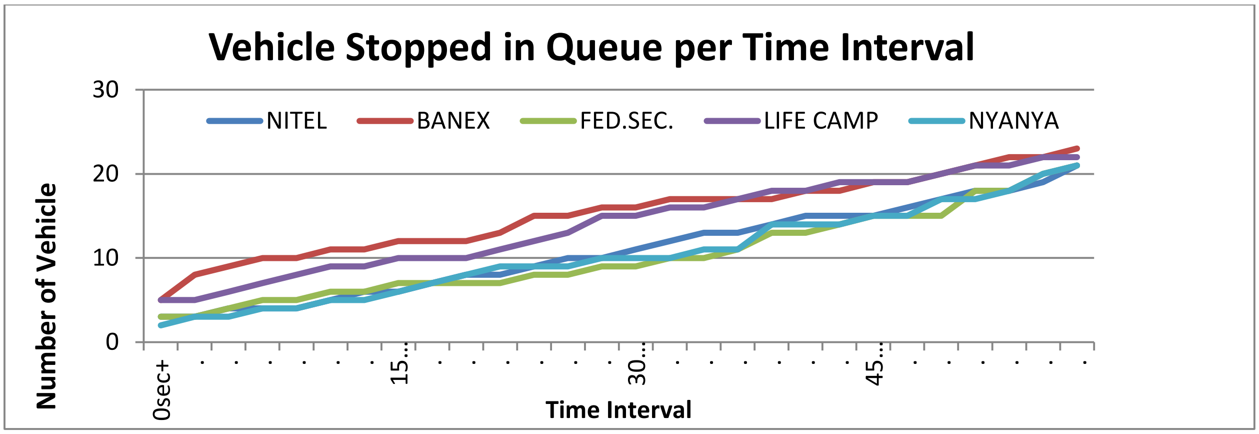

Figure 2: Distribution of vehicle stopped in queue per time interval

From figure 2 which shows the distribution of the vehicles stopped in queue per time interval in the study area, it is noticeable that the range of cars is 3 to 25, respectively.The results show an all-increasing distribution.

Table 4: Traffic Delay at Identified Intersections During Free Flow Travel Time and Peak Periods

Location		**Free Flow Travel Time**	**Chaotic Travel Time**	**Delay**
1	FED. SEC JUNCTION	9Seconds	72 Seconds	63 Seconds
2	AREA III JUNCTION	8Seconds	63 Seconds	55 Seconds
3	NITEL JUNCTION	9Seconds	112 Seconds	103 Seconds
4	NICON JUNCTION	11Seconds	184 Seconds	173 Seconds
5	NYANYA/KARU JUNCTION	9Seconds	96 Seconds	87 Seconds
6	LIFE CAMP GWARINPA JUNCTION	7 Seconds	53 Seconds	46 Seconds
7	AIRPORT ROAD	10 Seconds	163 Seconds	153 Seconds
8	BANEX JUNCTION	10Seconds	122 Seconds	112 Seconds
9	MAITAMA ROUNDABOUT	9 Seconds	82 Seconds	73 Seconds
10	CENTRAL MOSQUE	8Seconds	63 Seconds	55 Seconds
11	GAME VILLAGE	7 Seconds	82 Seconds	75 Seconds
12	MPAPE JUNCTION	8Seconds	55 Seconds	47 Seconds
13	OLD CBN JUNCTION	7Seconds	77Seconds	70 Seconds

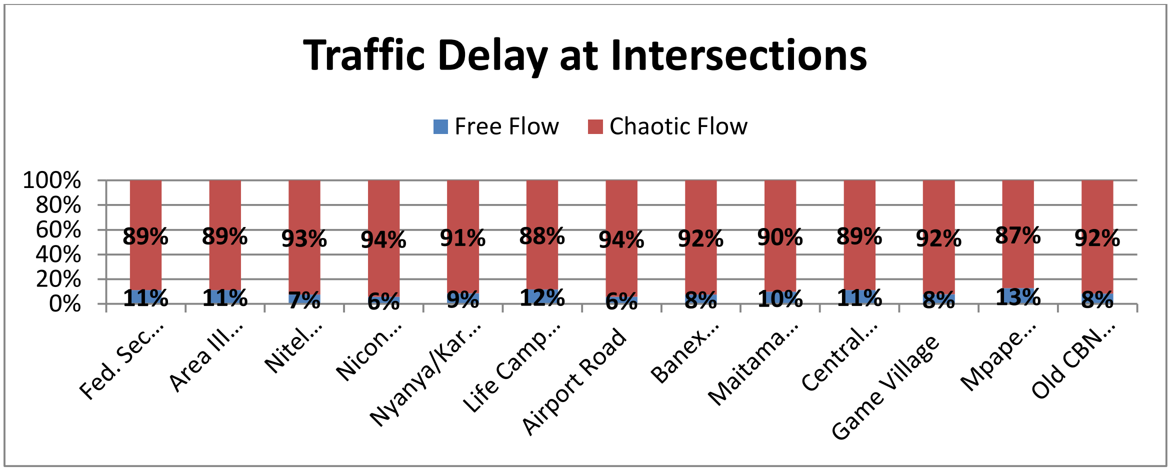

Figure 3: Traffic delay at intersections.

Table 4 and Figure 3 show a traffic delay at identified intersections during free-flow travel time and peak periods in the study area. The results show a huge difference in delay time during peak and off-peak periods in the study area. From the results, it can be seen that NICON Junction, with (173 sec) has the highest delay time, followed by Air-port Road Junction, with (153 sec), and then Banex Junction, which has a total of (112 sec) delay time. A considerably lower delay time of (46sec) was observed at Life camp/Gwarinpa and (47sec) at Mpape Junction. The results in figure 3.2 above show the proportion of the free travel time to the congested travel time and reveal that the travel time in the study area during the congested period is more than eight (8) times the travel time during free travel time.

Cause of Traffic Delay at Problematic Intersections within the FCC

For the various intersections considered, many factors are responsible for generating traffic congestion, leading to delays. Some of these include but are not limited to location, type of intersection, etc. Table 5 summarizes the different traffic challenges that cause traffic delays.

***Table 5**: Traffic Generators at Intersections in the Study Area*

		Traffic Generators					
Intersections		Offices	Shopping Complex	Hotels	Market	Home/ residence	Dominant Generator
1	B6/N13 (Constitutional Avenue/Shehu Shagari-Way) Federal Secretariat	88%	0	1	0%	0	Office
2	N13/RR1 (Shehu Shagari Way/Nnamdi Azikiwe Way) NICON Junction	5%	7%	5%	%3	70%	Home/ residence
3	Mpape Junction	15%	50%	0	5%	20%	Shopping Complex
4	NITEL Junction	45%	25%	5%	5%	20%	Office
5	Tafawa Balewa/RR1 (Area 3 Junction)	55%	20%	5%	5%	15%	Office
6	Nyanya/Karu Junction	5%	20%	15%	0	60	Home/ residence
7	Old CBN Junction	70%	10%	5%	0%	15%	Office
8	Central Mosque Junction	90%	0%	10%	0	0	Office
9	S20/Airport	60	5%	5%	0%	30%	Office
10	Maitama Roundabout	60%	0%	0%	0%	40%	Office
11	Aminu Kano Crescent/ Ahmadu Bello Way (Bannex Junction)	30%	60%	5%	0%	5%	Shopping Complex
12	OSEX/ Shehu Shagari Way Life Camp Junction	10%	20%	5%	5%	50%	Home/ residence
13	S20/ISEX (Games Village Junction)	5%	10%	5%	5%	75%	Home/ residence
		41.5%	**17.5%**	**6.9%**	**2.5%**	**31.5%**	

Table 5 shows the various and dominant traffic generators within the selected intersections in the study area. The result indicates that within the study area, the prevailing traffic generators at the selected intersections are office complexes with 41.5%, followed by residential areas with 31.5%, while hotels and markets generate the least traffic at the intersection within the study area with 6.9% and 2.5% respectively.

It was found that intersections dominated by offices are most prone to high traffic delays, especially during peak hours, while shopping complexes exhibited the least traffic delays. Hence, showing that office areas experienced chaotic traffic congestion within the study area.

As evaluated, illegal parking within the study area is one of the causative agents of traffic delays. It was found that most of the intersections experienced a very severe and severe level of illegal parking, and hence plays a critical role in the condition of traffic at the selected intersections

Crash Trends at the intersections within the Federal Capital City between 2011 and 2015

The secondary data source was obtained from various road authorities, containing records of the accident and crashes at the selected intersection within the study area. Table 6 gives a complete summary of the data records.

***Table 6**: Crashes Trends at the Intersections*

		2011	**2012**	**2013**	**2014**	**2015**	**Total**
1	B6/N13 (Constitutional Avenue/Shehu Shagari -Way) Federal Secretariat	98	85	110	92	90	**475**
2	N13/RR1 (Shehu Shagari Way/Nnamdi Azikiwe Way) NICON Junction	145	115	110	107	96	**573**
3	Mpape Junction	94	70	92	90	85	**431**
4	NITEL Junction	130	110	98	67	65	**470**
5	Tafawa Balewa/RR1 (Area 3 Junction)	97	58	82	80	78	**395**
6	Nyanya/Karu Junction	73	65	100	97	65	**400**
7	Old CBN Junction	90	82	115	102	98	**487**
8	Central Mosque Junction	122	100	82	46	45	**395**
9	S20/Airport	132	113	99	95	91	**530**
10	Maitama Roundabout	86	33	90	89	81	**379**
11	Aminu Kano Crescent/ Ahmadu Bello Way (Bannex Junction)	118	70	90	87	85	**450**
12	OSEX/ Shehu Shagari Way Deeper Life Junction	60	72	80	85	70	**367**
13	S20/ISEX (Games Village Junction)	78	69	72	68	69	**356**
	TOTAL	**1323**	**1042**	**1220**	**1105**	**1018**	**5708**

As seen from the results in table 6, there were 5,708 crashes at the selected intersections in the study area within five (5) years. The highest recorded was 1,323 crashes in the year 2011 and the lowest recorded was 1,018 crashes in the year 2015, indicating a severe to a very severe level of accidents within the study area, although the trend is reducing in arithmetic progression annually.

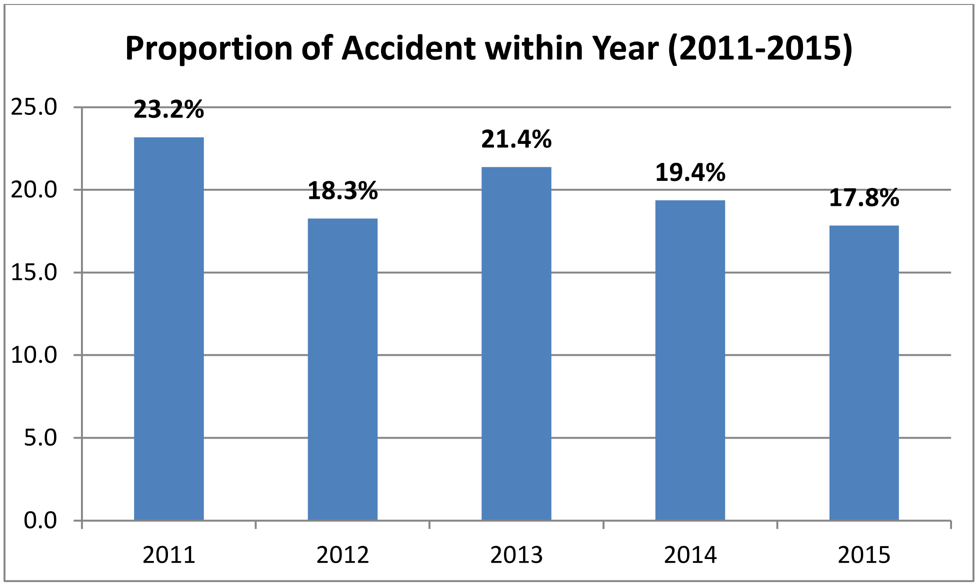

***Figure 4**: Proportion of Accidents in Year (2011-2015) within the Study Area.*

From the chart in figure 4, the results revealed most crashes occurred in 2011, accounting for 23.2% of the total occurrence of accidents within the study area, followed by the year 2013, accounting for 21.4% of the total road crashes. The year 2015 has the lowest record of road crashes, with a total of 17.8% of the total occurrence within the study area. It could be observed that there was a gradual decrease in crashes between the years 2013 to 2015 in the study area.

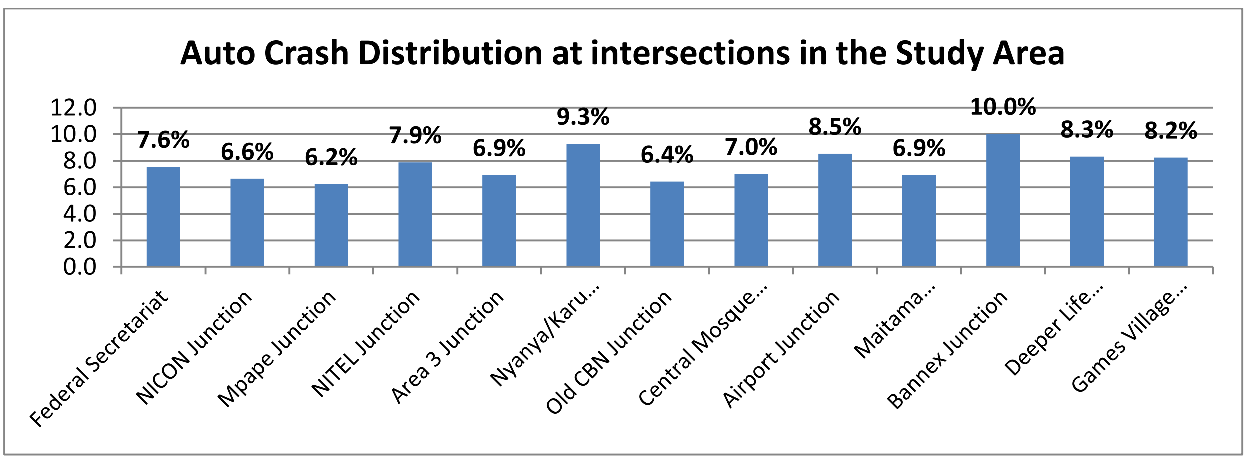

Figure 5: Auto Crash Distribution at intersections in the Study Area between 2011 and 2015

From the analysis of the field data obtained, as shown in figure 5, results show that Bannex junction has the highest record of accidents accounting for 10% of the total accidents recorded, followed by Nyanya/Karu junction, which has a total record of 9.3%. Airport Junction came next with 8.5% crashes, followed by Deeper Life Junction, which recorded 8.3% total crashes. Looking at the chart very closely, we could see that the junction that recorded the least accident occurrence during this period was the Mpape junction, which accounted for only 6.2% of the total road crashes within the study area.

Perception of the Road Users on the Effect of the Traffic Delay at the intersection.

Perception and how we feel about any situation are subjective, and as such, a field survey was carried out among the road users within the study area to know the traffic challenges and the effects on the road users within this area. Some of the problems encountered by respondents on the causes and challenges of traffic flow in the study area are shown in Table 7

Table 7: Problems Encountered by Respondents in the Course of their Journey along the Intersections

Problems Encountered	Number Of Respondents	Percentage
Traffic Congestion	91	36.4
Intersection /Turning delays	62	24.8
Bad Road	5	2.0
Frequent breakdown of bus/car	15	6.0
Inadequate/irregular car/bus services	33	13.2
Insecurity	11	4.4
None availability of designated bus stops/ Non compliance	29	11.6
No response	4	1.6
Total	250	100

Table 7 shows that traffic congestion is the most dominant problem faced by respondents in the cause of their journey along the intersections, which account for 36.4% of the total problems encountered, while bad roads contributed to only 2% of the problems faced and hence, justifying the need for this study.

The study identifies intersections with problematic challenges, which revealed that 69 percent are T-junctions having 6 conflicts. The magnitude of delay at various intersections rose to 42% of the vehicle within the selected intersection, which is about half of the total vehicles considered in the study area. This is attributed to the mixed land use. Offices complexes with 41.5% traffic generators cause problematic/chaotic flow and illegal parking during peak hours. Crash trends indicate decreasing trends from 2011 through 2015. Road users around the study area revealed that traffic congestion for vehicles intending to left/right turn, diverge, or make a U-turn at the intersection at peak hours accounted for the most cause of the accident at various intersections.

Conclusion

Considering the trend in traffic challenges discussed, it can be concluded that T-junctions were dominants having about 69% of the study area, which is expected to have traffic challenges, especially when not controlled. 42% of the vehicles were delayed at these intersections from the total sample size considered. This is significantly high, causing delays at the T-junctions. Traffic signals should be introduced to further reduce crashes to control the traffic at various intersections. The model used was empirical. Advanced models such as artificial Intelligence can be used to determine the level of challenges of the traffic flow in developing cities such as FCT Abuja to curb the issue of conflicts in a mixed traffic road network is strongly recommended.

Conflict of Interest:
The authors declare that there is no conflict of interest reported in this work.

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