Traffic congestion and demand management measures in Port Harcourt metropolis

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Abstract: **Traffic congestion has been a hard bone to chew in our major cities in Nigeria today. Port Harcourt metropolis has its own share of traffic congestion. This study investigated traffic congestion and demand management measures in Port Harcourt metropolis. Data were collected using both primary and secondary sources. 400 structured questionnaires were distributed among all road users comprising driver (private and commercial) passengers, pedestrians, traffic officers in the six traffic zones in Port Harcourt, Rivers State, Nigeria. A traffic count at peak periods of the day was employed to obtain estimated population figures for all road users in the selected route for the study. The sample size of 400 was distributed in four selected route traffic zone 1, 4. 5 and 6, while 66 were distributed among the remaining delineated route traffic 2 and 3. Descriptive and inferential statistics were used for the study. All statistical analysis was performed using SPSS version 24.0. The result from the study showed that 36.8% of the respondents made very early trips between 6-7am. Also, 53.7% of the respondents usually engage in private trips, while the remaining 46.3% uses public vehicles. The major causes of traffic congestion were non-functional traffic light (35.5%), vehicle accidents - especially trailer accidents that impedes traffic flow (15%), overcrowding- use of too many cars on the road (14.7%), road capacity (11.3%), bad roads (1.3%), drivers' attitude (3.2%) and lack of alternative route (18.9%). Major challenges of transport management in Port Harcourt were poor town planning (58.7%), inefficient enforcement of planning policies (70.8%), inefficient transport management system (62.9%), lack of maintenance of traffic light (69.5%), poor training of drivers (52.6%) and poorly built roads (46.6%). It is therefore recommended that measures to avert or ameliorate the constraints are provision of adequate feeder routes, improved traffic light system, training of prospective drivers, extension of roads and putting in place adequate transport management measures.**

***Keywords*: Traffic congestion, demand management, Port Harcourt, metropolis**

I. INTRODUCTION

Traffic congestion generally is a big facing major city of the world today. According to Emenike and Ibezi (2017), traffic congestion in Port Harcourt is worse with multivarious problems of overpopulation, reckless driving habits, street parking, high vehicle ownership rates, narrow roads, rapids industrialization and urbanization, proliferation of educational centers, land-use densities with different trip generating abilities (Chibuzor, 2011). This was supported by the report of Amiegbebhor (2018) where he explained the most significant causes of traffic congestion in Port Harcourt metropolis. Traffic congestion has been posing formidable challenges to state government, local government councils, and particularly the city residents. It is not uncommon for commuters to spend than two-three hours on their way to work, school, market, hospital etc or back home even when to and fro distance is not much. There is increase in crime rate in areas where there is traffic congestion (bags, phones, jewelries and other valuables are seeing snatched by social miscreants popularly known as 'Area boys' in Port Harcourt (Obinna, 2016). The importance of the human factor is underlined by psychological impact of driving behaviour which is felt directly on the roads (Emenike and Ibezi (2017). Other effects of traffic are pressure on road, infrastructure, global warming and health challenges as a result from emissions from motorized vehicles i.e. carbon monoxide on human and animals. Owolabi and Ojuri (2004) raised the same concerns in their analysis of traffic volume and parking in the Central Area of Akure, Ondo State, Nigeria. Road traffic violations have become a serious problem on our roads, as users of the roads are most times exposed to traffic violence and road rage (Aderanmo and Atomo, 2011; Aderanmo, 2012)). With the above problems of traffic congestion in Port Harcourt, this research intends to evaluate and proffer solutions to identifying demand management measures of traffic congestion in Port Harcourt city.

II. METHODOLOGY

Study location

Port Harcourt is located geographically within latitude 4^0 $47^{'}$ $30^{"}$ N and 4^0 $54^{'}$ $30^{"}$ N and longitude 6^0 $54^{'}$ $00^{"}$ E and 7^0 $04^{'}$ $30^{"}$ E. It is located in the tropical rain forest zone of Nigeria. Port Harcourt metropolis is divided into two Local Government Areas – Port Harcourt Local Government Area (PHALGA) and Obio-Akpor Local Government Area (OBALGA). The metropolitan area falls within the coastal belt which is structurally belongs to sedimentary formations of the recent Port Harcourt in Niger Delta, Hence, the study area is found in the low lying topography which is influenced by tidal fluctuation.

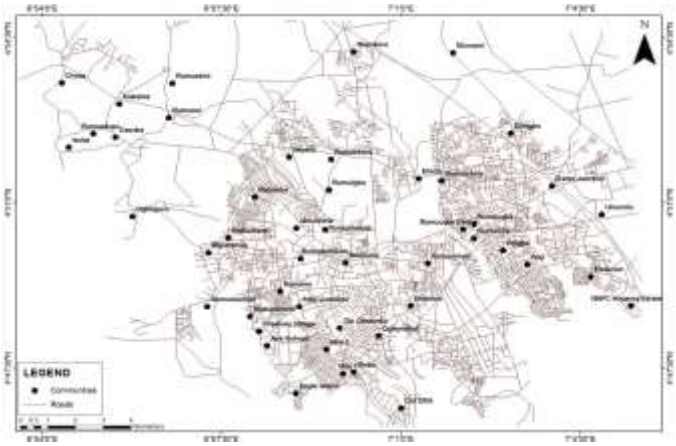

Figure 1.: Port Harcourt Metropolis showing the road network structure

Research Design

The study adopted the cross sectional survey research design. Cross sectional research design aim to provide data on the entire population under study. Cross-sectional studies involve information obtained at a specific time. It may also describe the characteristics of a particular population under study, like the frequency of a particular case study, or it might be based on outcomes of a relationship between phenomenon (Schmidt and Kohlmann, 2008). A reconnaissance survey was carried out in order to get acquainted with the study area. Thus, areas and location of interest for the research was delineated for the study. This survey exercise was also embarked on to obtain the respondents needed for the study. Similarly, since data on the total number of road users may not be feasible, a traffic count of road users within the study area was employed on the delineated traffic routes in Port Harcourt to enable the study obtain a sample size for the research.

Sources of Data and Population of study

This study made utilize both primary and secondary data. The primary data was acquired from field surveys through the distribution of questionnaires. The reconnaissance survey involved the collection of data concerning the population of road users through traffic counts on the six traffic zones in Port Harcourt. The field survey included the distribution of copies of questionnaire in the selected traffic zones in the study area among road users, operators and traffic managers. The population of study includes all road users found along the selected traffic routes in the six traffic zones on Port Harcourt roads. Traffic counts at peak periods of the day 6 am - 8 am and evening; 4 pm - 6 pm was employed to obtain an estimated population figure for all road users in the selected routes for the study (details of six traffic zones and the total traffic count is displayed on Table 1). The selected times of the day were in accordance with the peak periods of traffic activities on Port Harcourt roads.

Table 1: Details of Six Traffic Zones and their Routes

Traffic Zones	Traffic Routes and total vehicle flow	Total Traffic counts
1	Borokiri - Eastern Bye Pass Round about a. Borokiri - Lagos Bus stop = 889* b. Lagos bus stop - Old GRA c. Old GRA - Eastern Bye Pass d. Waterlines - Garrisson e. Garrisson - Ogbunabali f. Ogbunabali - Eastern Bye pass round about = 352*	1241
2	Abuloma - Elelenwo a. Abuloma - FGGC b. FGGC - Mothercat c. Mothercat - Trans-Amadi d. Trans-Amadi - Odili road = 118* e. Odili - Nwaan junction f. Nwaan junction - YKC/Slaughter g. Slaughter - Woji h. Woji - Elelenwo = 514*	632
3	UTC junction - Ogbogoro a. UTC - Mile 1 b. Mile 3 - Mile 1 = 379* c. Mile 1 - Elechi beach d. Elechi beach - UST axis e. UST - Agip round about = 741* f. Agip - Mgboshimini g. Mgboshimini - Ada George h. Ada George - Elioparanwo/Iwofe/Wimpey i. Wimpey - Ogbogoro	1120
4	Rumukurushi - Onne Trailer Park a. Rumukurushi - Shell b. Shell - Rumuomasi c. Rumuomasi - Stadium road d. Stadium road - Rumuola = 991* e. Eleme junction - Oyigbo f. Oyigbo - Rumukwangwo g. Rumukwangwo - Rumuakuru h. Oil Mill - Eleme junction= 1044 i. Eleme junction - East-West road/Tank/Rumuodara= 1132* j. Rumuodara - Eneka = 301 k. Eneka - Eliozu/ Rumuokoro = 535 l. Eleme - Akpajo = 513 m. Akpajo - Refinery junction = 311 n. Refinery junction - Onne Trailer park = 201	2123
5	Ikoku junction - Rumuigbo junction a. Ikoku junction - D/line axis b. D/Line - GRA c. GRA - Presidential/ Rumuola = 559* d. Rumuola - Orazi e. Orazi - Rumuokwuta f. Rumuokwuta - Rumuigbo junction/Mgbuoba = 686*	1245
6	Rumuokoro - Isiokpo a. Rumuokoro - Rumuaholu b. Rumuaholu - Rumuosi c. Rumuosi - Alakahia d. Alakahia - Uniport/Choba = 1330 e. Choba - Aluu f. Rumuokoro – Rumuodumaya = 1098 g. Rumuodumaya - Rukpoku/Igwuruta h. Rukpoku/Igwuruta - Umuogwu/Isiokpo	2428
Total		8789

Source: Port Harcourt Traffic Routes (Rivers State, 2014)

Sampling Procedure and Technique

The sampling procedure employed for the study was simple random sampling. The study ensured that all delineated traffic zones were selected for sampling whereby two major traffic routes were selected in order to ensure the representation of each traffic zone in the data collection. The two (2) traffic routes selected were based on their high level of traffic congestion on Port Harcourt roads which makes it a total of 12 sampled traffic routes for the study. The simple random sampling ensured that respondents for the study were randomly selected within the six traffic zones, in order to ensure that each delineated route is being sampled and to also give all respondents equal chance of being selected. The sample size of 400 was divided among the six delineated traffic zones, whereby a total of 67 copies of the questionnaire were distributed in four selected route (traffic zone 1,4,5 and 6) while 66 copies were distributed among the remaining delineated routes (traffic routes 2 and 3) as proportional samples based on volume of traffic flow count in each delineated zones; sampling a total of 12 selected traffic routes from the overall total of 51 traffic routes belonging to the six delineated traffic zones. A total of 400 copies of the questionnaire were distributed among selected study routes, while 380 copies of the questionnaire were retrieved for analysis. The study routes from the delineated ones were: Zone 1 (traffic route - Borokiri – Lagos Bus stop and Ogbunabali to eastern Bypass; Zone 2 (traffic route - Trans Amadi to Odili road and Woji to Elelenwo axis; Zone 3 (traffic route – Mile 3 to Mle 1 and UST to Agip roundabout; Zone 4 (traffic route – Stadium road to Rumuola and Eleme junction to East West road/Tank/Rumuodara; Zone 5 (traffic routes – GRA to Rumuola and Rumuokuta to Rumuigbo junction; Zone 6 (traffic routes – Alakahia to Choba and Rumuokoro to Rumuodumaya. Thereafter, random sampling was employed for questionnaire distribution among selected traffic routes within each traffic zones.

Data Analysis

Descriptive and inferential statistics were used for the study. Descriptive statistics was used to explain the information obtained from the data collected on traffic count, and questionnaire distribution. All statistical analyses were performed using the Statistical Package for Social Scientist (SPSS) version 24.0

III. RESULTS

The socio-economic characteristics of sampled respondents for the study were displayed on Table 2. The respondents' socio-economic data and the distribution showed that 56.1% respondents were males, while the remaining 43.9% respondents were females. The age group of respondents showed 52.1% for between 18-30 years, 33.7% for between ages of 31-45, 11.1% for between 46-60 years, and 3.2% respondents with above 55 years. The occupational status of respondents showed that 32.6% of the respondents were civil servants, 50.5% are into one form of business or the other, 14.5% respondents were students, while the remaining category of respondents are 2.4%. The education status, showed that respondents with at least primary school level were 13.2%, secondary level belong to 28.9% of the respondents, tertiary level were 57.4% of the total respondents, while the respondents that belong to other education status were 0.5%. The marital status showed that 31.8% of the sampled respondents were single, 55.8% of the respondents were married, and 8.2% of the respondents are divorced, while the remaining 4.2% of the sampled respondents are widow. Furthermore, the information regarding the monthly income of sampled respondents revealed that 16.1% of the respondents earn about #20,000, 23.2% of the respondents earn between #21,000 and #50,000, 22.6% of the respondents earn between #51,000 and #80,000, 22.4% of the respondents earn between #81,000 and #100,000 while the remaining 15.7% of the respondents earn above #100,000.

Table 2: Respondents Socio-economic Characteristics

Gender	Traffic Zones						Total (%)
	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	
Male	37	37	30	45	34	30	213(56.1)
Female	26	27	31	19	31	33	167(43.9)
Age(years)							
18-30	30	28	26	41	47	26	198(52.1)
31-45	25	23	26	15	16	23	128(33.7)
46-60	8	9	8	7	0	10	42(11.1)
Above 60	0	4	1	1	2	4	12(3.2)
Occupation							
Civil servant	20	12	20	30	13	29	124(32.6)
Business	32	36	37	31	34	22	192(50.5)
Student	7	13	3	2	18	12	55(14.5)
Others	4	3	1	1	0	0	9(2.4)
Education status							
Primary	2	7	16	10	4	11	50(13.2)
Secondary	13	23	18	13	22	21	110(28.9)
Tertiary	48	33	27	40	39	31	218(57.4)
Others	0	1	0	1	0	0	2(0.5)
Marital Status							
Single	10	14	16	23	25	33	121(31.8)
Married	40	39	43	31	40	19	212(55.8)
Divorced	10	6	2	6	0	7	31(8.2)
Widowed	3	5	0	4	0	4	16(4.2)
Monthly income							
≤ #20,000	19	3	15	6	3	15	61(16.1)

#21000-#50000	16	10	18	12	15	17	88(23.2)
#51000-#80000	9	18	12	21	15	11	86(22.6)
#81000-#100000	10	15	15	15	20	10	85(22.4)
Above #100000	9	18	1	10	12	10	60(15.7)

Source: Researcher's Fieldwork, 2018

Table 3 presents information about the route network structure of Port Harcourt Metropolis. The road network structure is delineated into six (6) major zones according to the Rivers State government, in order to effectively create road transport route, for proper accessibility, distribution and management of traffic in Port Harcourt. Thus, Zone 1 features Borokiri, Lagos, Old G.R.A, Eastern Bypass, Waterlines, Garrisson, Ogbunabali axis; Zone 2 features Abuloma, NLNG, Mothercat, Trans-Amadi, Odili road, Woji, Slaughter and Elelenwo axis; Zone 3 extends from UTC junction to Mile 1 and Mile 3, RSUST (Rivers State University of Science and Technology), Agip round about, Mgboshimini, Ada George, Elioparanwo, Wimpy down to Ogbogoro; Zone 4 which features the longest Trunk A and B roads, starts from Rumukurushi to Shell, then reaches Rumuomasi which extends to Stadium road and ends at Rumuola axis, while Eleme junction axis 1 which features Oyigbo, Rumukalango, Igbo Etche and Rumuakuru; axis 2 features Akpajo, refinery junction and Onne Trailer park. The Zone 5 axis starts from Ikoku junction, to D/Line, Rumuola by Presidential (through G.R.A axis), Orazi to Rumuokwuta, Psychiatric road and Mgbuoba. However, the last Zone 6 features traffic routes that extends along the East-West road (Trunk A road), Rumuokoro axis features: Rumuodumaya, Rukpoku, Igwurita, and Isiokpo, while extending westwards to Alakahia, Choba (Uniport), and extend northwards to Aluu.

Table 3: Details of Traffic Routes Network in Port Harcourt Metropolis

Traffic Zones	Traffic Routes/ Public/Private Transportation Routes
1	-Borokiri - Eastern Bye Pass Roundabout- Lagos Bus stop -Old GRA- Waterlines - Garrisson - Ogbunabali-Eastern Bye pass round about
2	-Abuloma - Elelenwo - FGGC - Mothercat - Trans-Amadi - - Odili road - Nwaan junction - YKC/Slaughter - Woji - Elelenwo
3	-UTC junction - Mile 1 - Mile 3 - Mile 1 - UST axis - Elechi beach axis - Agip round about -Agip - Mgboshimini - Ada George Elioparanwo/Iwofe/Wimpey - Wimpey - Ogbogoro = 354
4	-Rumukurushi - Shell - Rumuomasi - Stadium road - Eleme junction - Oyigbo - Rumuebulu - Rumukalango - Igbo Etche - Rumuakuru -Oil Mill junction - Eleme junction - East-West road - Rumuodara - Tank - Eneka - Eliozu - Rumuokoro -Eleme junction - Refinery junction - Onne/Trailer Park
5	-Ikoku junction - D/Line - G.R.A. axis - Presidential Rumuola - Orazi - Rumuokwuta - Psychiatric - (Checking point) Mgbuoba - Rumuigbo junction
6	-Rumuokoro - Rumuaholu - Rumuosi - Alakahia - Uniport - Aluu - Choba - Rumuigbo - Rumuokoro - Rumuodumaya - Rukpoku - Igwuruta - Umuogwu - Isiokpo

Source: Rivers State Government (RSG), (2014); Researcher's Field analysis, 2018

Table 4 revealed the distribution of the zone of trips in selected traffic routes among sampled respondents for the study. The information revealed that 36.8% of the respondents make very early trips between 6-7am, 22.4% of the respondents makes early trips between 7am and 8am, 8.2% of the respondents usually make trips between 8am and 9am, 13.7% of the respondents were making trips between 9am and 10am, 6.1% of the respondents make their trips between 10am and 11am, while the remaining 12.9% of the respondents moves about their business trips between the hours of 11am and 12pm. The study revealed the level of movement as regards the morning trips made by sampled respondents. This information has several implications on the volume of traffic and its movement along sampled transport routes in Port Harcourt. Thus, the study discovered that the early time of day between 6am and 9am on the selected traffic routes are usually busy because of the heavy traffic flow as observed by the time of trip from the delineated zones of study. The study also discovered that between 11am and 12pm traffic congestion are experienced on delineated zone in traffic routes like Mile 1 to Mile 3, UST to Agip round about, and Eleme to East-West road/Tank/Rumuodara. This is due to high commercial activities which are trip generating within selected traffic routes. Thus, the road will be less congested between 10m and 11am. In the same vein, the information on the traffic congestion in the afternoon and evening periods was displayed on Table 5. The distribution showed that 41.8% of the respondents makes their daily trips between 4pm and 5pm, 10.3% of the respondents usually moves along transport route between 5pm and 6pm, 10.3% of the respondents makes trips along transport route between 6pm and 7pm, 13.7% of the respondents usually makes evening trips between 7pm and 8pm, 15.3% of the respondents moves between 8pm and 9pm, while the remaining 8.7% of the respondents moves between 9pm and 10pm. The distribution of trips among selected transport route are based on respondents nature of work and business which are the determining factor responsible for distributing and redistributing of trips among selected transport routes. Thus all transport zones are heavily congested between 4pm to 8pm daily because this period are trip generating and usually constitute to high traffic movement on Port Harcourt roads.

Table 4: Trip Generating Zones and Traffic Congestion (Morning Trips)

Zones		Morning Time to Noon Time						Total
		6-7am	7-8am	8-9am	9-10am	10-11am	11-12pm	
Zone 1		33	11	3	10	1	5	63
		52.4%	17.5%	4.8%	15.9%	1.6%	7.9%	
Zone 2		21	17	11	4	4	7	64
		32.8%	26.6%	17.2%	6.2%	6.2%	10.9%	
Zone 3		12	17	3	9	4	16	61
		19.7%	27.9%	4.9%	14.8%	6.6%	26.2%	
Zone 4		20	12	2	13	5	12	64
		31.2%	18.8%	3.1%	20.3%	7.8%	18.8%	
Zone 5		36	12	8	8	0	1	65
		55.4%	18.5%	12.3%	12.3%	0.0%	1.5%	
Zone 6		18	16	4	8	9	8	63
		28.6%	25.4%	6.3%	12.7%	14.3%	12.7%	
Total		140	85	31	52	23	49	380
		36.8%	22.4%	8.2%	13.7%	6.1%	12.9%	100%

Source: Researcher's Fieldwork, 2018

Table 5: Trip Generating Zones and Traffic Congestion (Afternoon/Evening Time Periods)

Zones		Afternoon Time/ Evening Time of the day						Total
		4-5pm	5-6pm	6-7pm	7-8pm	8-9pm	9-10p	
Zone 1		38	3	3	6	12	1	63
		60.3%	4.8%	4.8%	9.5%	19.0%	1.6%	100.0%
Zone 2		22	9	7	11	12	3	64
		34.4%	14.1%	10.9%	17.2%	18.8%	4.7%	100.0%
Zone 3		13	8	4	11	11	14	61
		21.3%	13.1%	6.6%	18.0%	18.0%	23.0%	100.0%
Zone 4		44	5	5	3	4	3	64
		68.8%	7.8%	7.8%	4.7%	6.2%	4.7%	100.0%
Zone 5		21	7	12	12	8	5	65
		32.3%	10.8%	18.5%	18.5%	12.3%	7.7%	100.0%
Zone 6		21	7	8	9	11	7	63
		33.3%	11.1%	12.7%	14.3%	17.5%	11.1%	100.0%
Total		159	39	39	52	58	33	380
		41.8%	10.3%	10.3%	13.7%	15.3%	8.7%	100.0%

Source: Researcher's Fieldwork, 2018

Table 6 presents information on the time the day trips were made by respondents in the study area. The distribution showed information for two categories of respondents; those that make single time trips once in a day and those that normally make double trips. Therefore, going by majority (highest % rate) the information shows that the first category of respondents for single trips revealed that 88.5% of the majority of sampled respondents usually makes morning trips, 12.7% of the respondents make afternoon trips, and another 45.3% respondents make evening trips. The second category of respondents for double trips revealed that 18.5% of this category of respondents make both morning and evening trips, 25 % of the respondents usually make morning and afternoon trips, while the remaining 41% of the respondents engage in afternoon and evening trips. Thus, time of the day these trips were made have implications on the nature of traffic on the selected routes in the study area. The time of day can contribute to heavy traffic along transport routes because of

the heavy traffic flow based on the nature of activities in Port Harcourt as people respond to different purposeful trips. Thus, trip generating time of the day like morning periods can cause traffic congestion on Port Harcourt roads along transport routes.

Table 6: Trip Generating Periods

Zones		Period of the day					
		Morning	Afternoon	Evening	Morning and Evening	Morning and Afternoon	Afternoon and Evening
Zone 1		31	8	3	6	2	17
		49.2%	12.7%	4.8%	9.5%	3.2%	27.0%
Zone 2		24	5	29	11	2	17
		37.5%	7.8%	45.3%	17.2%	3.1%	26.6%
Zone 3		54	0	7	11	5	25
		88.5%	0.0%	11.5%	18.0%	8.2%	41.0%
Zone 4		20	3	23	3	16	21
		31.2%	4.7%	35.9%	4.7%	25.0%	32.8%
Zone 5		40	4	18	12	6	4
		61.5%	6.2%	27.7%	18.5%	9.2%	6.2%
Zone 6		63	0	0	9	16	21
		82.3%	0.0%	0.0%	14.3%	25.4%	33.3%

Source: Researcher's Fieldwork, 2018

The cross sectional distribution of the causes of traffic congestion as displayed on Table 7. The distribution showed that 53.7% of the respondents usually engage in private trips, while the remaining 46.3% of the respondents normally uses public vehicles. The distribution also revealed that amongst the major causes of traffic congestion on selected rote networks were: non-functional traffic light (35.5%), vehicle accidents - especially trailer accidents that impedes traffic flow (15%), overcrowding- use of too many cars on the road (14.7%), road capacity (11.3%), bad roads (1.3%), drivers' attitude (3.2%) and lack of alternative route (18.9%). The identified causes of traffic congestion may be numerous but these are the most common types identified along selected transport route on Port Harcourt roads.

Table 7: Cross Sectional Distribution of Causes of Traffic Congestion among Road Users

User		Causes of Traffic Congestion							Total
		Non-functional Traffic light	Vehicle Accidents	Over crowding	Road Capacity	Bad roads	Drivers Attitude	Lack of Alternative Route	
Private		68	26	26	31	4	7	42	204
		50.4%	45.6%	46.4%	72.1%	80.0%	58.3%	58.3%	53.7%
Public (taxis and buses)		67	31	30	12	1	5	30	176
		49.6%	54.4%	53.6%	27.9%	20.0%	41.7%	41.7%	46.3%
Total		135	57	56	43	5	12	72	380
		35.5%	15.0%	14.7%	11.3%	1.3%	3.2%	18.9%	100.0%
		100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Source: Researcher's Fieldwork, 2018

Table 8 presents information concerning the average time spent by respondents on the road during trips as a result of traffic congestion. The distribution revealed that 32.9% of the respondents spent averagely less than 30 minutes on a 10 minutes to 15 minutes trip, 35.5% of the respondents spent above 30 minutes but less than 1 hour (with majority of respondents from zone 1, 4, 5 and 6), 14.7% of the respondents' spent 1hour to 1 hour 30 minutes (majority of respondents from zone 2, 4 and 6), while the remaining 16.8% respondents usually spend above 1 hour 30 minutes (majority of sampled respondents from delineated zones 1, 3, 4 and 6). The implication of these findings is attributed to the level of traffic congestion on the selected traffic routes in the study area. Thus, zones 1, 2, 3, 4 and 6 are mostly heavily congested during peak periods of the day. Similarly, the other major impacts identified on selected traffic routes were displayed on

Table 9; and these are: time wasting (35.3%), inability of the users to forecast travel time (30%), wear and tear of vehicles due to idling (14.7%), and spill-over effects, which usually affect alternative routes and congest main arteries (20%). The study discovered that the average time spent on trips have been doubled because of the high traffic congestion along sampled transport routes. The issue of waste of time is a major factor leading to the inability of the users to forecast their travel time, speeding up wear and tear of their vehicles and leaving them with no alternative routes because of the spill-over effects.

Table 8: Average Time spent during Trips

Zones	Average Time				Total
	Less than 30mins	30min - Less than 1hr	1hr - 1hr30mins	Above 1hr30mins	
Zone 1	23	24	5	11	63
	36.5%	38.1%	7.9%	17.5%	
Zone 2	29	13	13	9	64
	45.3%	20.4%	20.3%	14.1%	
Zone 3	18	21	9	13	61
	29.5%	34.5%	14.8%	21.3%	
Zone 4	14	24	12	14	64
	21.9%	37.5%	18.8%	21.9%	
Zone 5	31	27	4	3	65
	47.7%	41.5%	6.2%	4.6%	
Zone 6	10	26	13	14	63
	15.9%	41.3%	20.6%	22.2%	100.0%
Total	125	135	56	64	380
	32.9%	35.5%	14.7%	16.8%	100.0%

Source: Researcher's Fieldwork, 2018

Table 9: Impacts of Traffic Congestion

Zones	Impacts				Total
	Time wasting	Inability to forecast travel time	Wear and Tear on Vehicles	Spillover effects	
Zone1	27	12	10	14	63
	42.9%	19.0%	15.9%	22.2%	100.0%
Zone 2	15	9	15	25	64
	23.4%	14.1%	23.4%	39.1%	100.0%
Zone 3	19	22	7	13	61
	31.1%	36.1%	11.5%	21.3%	100.0%
Zone 4	22	27	7	8	64
	34.4%	42.2%	10.9%	12.5%	100.0%
Zone 5	22	23	13	7	65
	33.8%	35.4%	20.0%	10.8%	100.0%
Zone 6	29	21	4	9	63
	46.0%	33.3%	6.3%	14.3%	100.0%
Total	134	114	56	76	380
	35.3%	30.0%	14.7%	20.0%	100.0%

Source: Researcher's Fieldwork, 2018

The information about the traffic management measures in Port Harcourt was displayed on Table 10. The distribution revealed 51.3% for provision of checkpoints by road safety officials; provision of traffic signs and signals was 57.6%; penalty for driving with expired license had 51.8%; driving against traffic was 51.1%; while driving without functioning

trafficators had 51.8%. Thus, the identified traffic management measures implemented on Port Harcourt roads amongst others are: the provision of checkpoints, provision of traffic signs and signals, penalty for driving with expired license, penalty for driving against traffic and penalty for driving without functioning turn-signal lights. However, the level of effectiveness of the traffic management measures on Port Harcourt roads was assessed among sampled respondents in the study area and the information obtained was displayed on Table 4.10. The ratings showed that the level of effectiveness was rated by 15.5% of the sampled respondents as very effective, 15.3% of the respondents rated it effective, 29.7% of the respondents were of the opinion that it is somewhat effective, while 39.5% of the respondents who are the majority were of the opinion that it is not effective. Thus, employed traffic management measures on Port Harcourt roads are not effective as perceived by sampled respondents in selected traffic routes of study.

Table 10: Traffic Management Measure Employed on Port Harcourt roads

	Traffic Routes						Total (%)
	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	
Use of Checkpoints	37	38	18	32	55	15	195(51.3)
Traffic signs and signals	43	34	38	31	56	17	219(57.6)
Penalty for expired license	37	42	14	29	56	19	197(51.8)
Penalty for driving against traffic	39	29	29	31	51	15	194(51.1)
Penalty for ill functioning turn-signal lights	39	40	12	31	58	17	197(51.8)

Source: Researcher's Fieldwork, 2018

Table 11: Level of Effectiveness of Traffic Management Measures employed on Port Harcourt roads

Zones	Responses				Total
	Very Effective	Effective	Somewhat Effective	Not Effective	
1	8	10	18	27	63
2	26	10	20	8	64
3	2	7	30	22	61
4	3	6	11	44	64
5	13	11	21	20	65
6	7	14	13	29	63
Total	59 (15.5)	58 (15.3)	113 (29.7)	150 (39.5)	380(100)

Source: Researcher's Fieldwork, 2018
*Figures in Parentheses are percentages

The information concerning the challenges of traffic management in Port Harcourt was displayed on Table 12. The distribution revealed that the major challenges of transport management in Port Harcourt were identified as: poor town planning (58.7%), inefficient enforcement of planning policies (70.8%), inefficient transport management system (62.9%), lack of maintenance of traffic light (69.5%), poor training of drivers (52.6%) and poorly built roads (46.6%).

Table 12: Challenges of Traffic Management in Port Harcourt

Challenges	Zones						Total (%)
	1	2	3	4	5	6	
Poor Town planning	46	38	31	31	59	18	223(58.2)
Inefficient enforcement	55	42	34	40	58	40	229(70.8)
Inefficient management system	51	42	23	42	45	36	239(62.9)
Lack of Maintenance of Traffic light	52	44	35	40	57	36	264(69.5)
Poor training process for drivers	44	30	27	32	50	17	200(52.6)
Poorly built roads	35	41	29	37	13	22	177(46.6)

Source: Researcher's Fieldwork, 2018

IV. DISCUSSION

The study revealed the spatial analysis of Port Harcourt traffic route structure as delineated into six major traffic zones for proper accessibility, distribution and management of traffic in Port Harcourt. The six delineated zones feature major traffic routes: Borokiri to Eastern Bypass round about; Abuloma to Elelenwo; UTC junction to Ogbogoro; Rumukurushi to Onne Trailer park; Ikoku junction to Rumuigbo junction; and Rumuokoro to Isiokpo. Thus, findings showed that in order to spatially analyze the route network characteristics, the number of nodes (traffic points) along a traffic route with respect to the nature of socio-economic characteristics of users, level of traffic jam on transport route, time of the day, and route connections or the transport systems are important factors to be considered. These results are supported by what Emenike and Ibezi (2017) reported earlier.

Ukpata and Etika (2012) in their work on traffic congestion in major cities of Nigeria reported that poor driving habits, poor road network, inadequate road capacity, and lack of parking facilities constitute the greatest causes of traffic congestion in Nigeria. Also, Lagos, Port Harcourt and Abuja were identified as cities most affected by traffic congestion. Popoola et al. (2013) in their work on traffic congestion on highways in Nigeria, causes, effects and remedies, reported that causes of traffic congestion as inadequate road capacity, poor road pavement, poor traffic management, poor drainage system poor driving habit, poor parking habit, poor design junctions/round-about, presence of heavy trucks, lack of pedestrian facilities, lack of road furniture, lack of parking facilities and others.

Chwiałkowski and Zydro (2022) observed the corresponding determinants of factors to be considered as route usage, specific trade corridors, and the quantity of transport links for the spatial analysis of transport route characteristics. Thus, the level at which route networks have similar attributes and characteristics based on their similar paths; central functions

and complementarily between networks; and changes in one route network can affect the scale of movement and structure or pattern of individual route characteristics (Chwiałkowski and Zydro, 2022). Similarly, Amiegbebhor (2018) reported similar findings that the routes proned to traffic congestion as locations that are trip generating zones which constitute to heavy congestion along traffic routes. The information revealed that 36.8% of the respondents make very early trips between 6-7am, 22.4% of the respondents makes early trips between 7am and 8am, 8.2% of the respondents usually make trips between 8am and 9am, 13.7% of the respondents were making trips between 9am and 10am, 6.1% of the respondents make their trips between 10am and 11am, while the remaining 12.9% of the respondents moves about their business trips between the hours of 11am and 12pm. Popoola et al. (2013) reported the effects of road congestion from the study are waste of time, delay movement, stress, accident, inability to forecast travel of time, fuel consumption, road rage, relocation, night driving, and environmental pollution.

The study revealed the level of movement as regards the morning trips made by sampled respondents. This is similar to the reports of Aderanmo and Atomo (2011). This information has several implications on the volume of traffic and its movement along sampled transport routes in Port Harcourt. Thus, the study discovered that the early time of day between 6am and 9am on the selected traffic routes are usually busy because of the heavy traffic flow as observed by the time of trip from the delineated zones of study. The study also discovered that between 11am and 12pm traffic congestion are experienced on delineated zone in traffic routes like Mile 1 to Mile 3, UST to Agip round about, and Eleme to East-West road/Tank/Rumuodara. This may be attributed to high commercial activities which are trip generating within selected traffic routes. Thus, the road will be less congested between 10am and 11am. The findings of the study revealed that time of day have effect on the volume of traffic along transport routes in the study area. The study carried out by Duranton and Turner (2011) revealed that time of the day create activities that are trip generating which in turn promotes or increases the volume of traffic on affected routes. Also relative, is the level of socio-economic characteristics that surrounds the route network or combination of route networks. For instance, in the study area, the causes of traffic congestion are numerous but the major factors identified were trip generating period of the day, non-functional traffic lights, vehicle accidents, overcrowding due to increased vehicular movement, road capacity, bad roads, drivers' attitude and the lack of adequate alternative route. Fadairo (2013) have observed similar findings in relation to the study, which assessed traffic congestion in Akure using GIS. The associated impacts are time wasting which affects average time spent during trip/travel; inability of users to forecast travel time; wear and tear on vehicles and spill-over effects.

The traffic management measures employed on Port Harcourt roads is: use of checkpoints, traffic signs and signals, issue of penalty for expired license among drivers, penalty for driving against traffic and penalty for turn-signal light that is not functioning. The level of effectiveness of traffic management measures employed was rated not effective by majority of sampled respondents in the study area. Brendan (2010) discovered that traffic management measures employed by most developing countries are usually inefficient and poor and therefore contributes to most challenges and problems encountered in their transportation systems Onokala, 2008; Olagunju, 2015. Similarly, major challenges identified in the study are poor town planning, inefficient enforcement and management system, lack of maintenance of traffic light, poor training of drivers and poorly built roads. The volume of traffic experienced between the noon time period and evening time period showed that there is a significant relationship between the two time periods in selected traffic routes in the study area. The application of GIS has proved very profitable in traffic management in recent years. Riad and Shabana (2012) in their work on Real Time Route for Dynamic Road Congestions emphasized that speeds are treated by GIS tools to determine historical and real time speeds for each street segment in the road network which is being used for calculating time impedance (cost matrix) for each street segment dynamically. ORDRS uses a cost matrix of the current time slice for determining the best route to each vehicle in duty attached. Popoola *et al.* (2013) suggested that to drastically reduce these negative effects; there must be provision for adequate parking space, construction of proper drainage, enlarging the width of the road, rehabilitate all roads needing attention, public enlightenment, traffic education, hack down all illegal buildings/shops built on the right of way (ROW), create a separate/alternative root for trucks and heavy vehicles, provision of pedestrian facilities, In-depth training of transport/traffic personnel, ban all form of road trading/hawking, and reduce the number of bus-stop where necessary. It is hoped that this study will become the foundation of further research in the area of improve road traffic management on our major highway.

V. CONCLUSION

The study on traffic congestion and traffic demand and management measures on Port Harcourt roads has revealed the causes of traffic congestion as the poor nature of transport management facilities on Port Harcourt roads identified as: non- functional traffic light, vehicular accidents, road capacity, bad roads, drivers attitude and low accessibility level relating to the lack of an alternative route (arteries and feeder routes). More so, the major impacts these problems are delay in the average time of trip, time wasting, inability of users to forecast travel time, contributing to the wear and tear of their vehicles and creating spill-over effects which are affecting the available alternative routes and creating congestion within main road arteries. The employed transport management measures on Port Harcourt roads are the use of traffic checkpoints; provision of traffic signs and signals; penalty against offenders of expired driving license; penalty directed towards offenders that drive against traffic; and penalty for ill functioning signal-turn lights. Even though these measures are

in place, their level of effectiveness were rated low among sampled transport routes users who were of the opinion that the traffic management measures needs improvement and proper enforcement. Similarly, as part of the challenges identified were poor town planning; inefficient enforcement and management system; poor traffic light management; poorly constructed roads and poor assessment programs of prospective drivers. The study discovered that there exist a significant relationship in the volume of traffic flow between the morning time periods and evening time periods which were indicators of the trip generating time periods influencing traffic congestion along traffic routes on Port Harcourt roads.

VI. RECOMMENDATION

In this study the researcher recommends some measures to avert or ameliorate the constraints, such as provision of adequate feeder routes, improve traffic light system, training of prospective drivers, extension of roads and putting in place adequate transport management measures. Finally, there is need for the Government and public to accept urban planning policies on ground.

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