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ASSESSMENT OF EFFECTS OF TRAFFIC CONGESTION ON TRAVEL TIME IN WARRI METROPOLIS USING GEOSPATIAL APPROACH

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Abstract

Economic development and high urbanization rate have caused many challenges to transportation system within Warri metropolis long travel time (delay). This study investigated the causes and effects of traffic congestion on travel time along Warri-Sapele, and Jakpa- Ekpan road within Warri Metropolis using geospatial approach. The methods used in data collection are, GPS-GIS which are powerful tools for analysis of both spatial and nonspatial data and for solving important problems of networking. In this study GPS receiver were used to acquire average speed, travel and delay time for the study corridors. Secondary data was collected from Delta State Road Transportation Management Authority (DSRTMA) and four hundred (400) copies of questionnaire were administered to drivers, passengers and commuters in which cross tabulation was used for the analysis. Generally, from the study, the social impacts of congestion on travel time are unpredictable. Like travel time along Warri-Sapele Road corridor with 61%. The economic impact revealed fuel consumption as highest with 51% along Warri Sapele Road corridor and working hour is reduced with 48%. The study recommendations among others Linking traffic information system (TIS) to the State radio by the government of Delta State to enable commuter and motorists to take rational decisions as to which route (less or non-congested or the fastest route) to take during hour travel and provides transport planners in road controlling authorities with traffic data (speed, level of service, travel and delay time)

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1.0 Introduction

According to the joint transport research Centre of the Organization for Economic Cooperation and Development (OECD) and the European Conference of Ministers of Transport (ECMT), cities and traffic developed simultaneously since the earliest large human settlements. The forces that draw inhabitants to congregate in large urban areas lead sometimes to intolerable level of traffic congestion in urban streets and thorough fares European Conference of Ministers of Transport (ECMT 2017***): (Joseph and Anderson 2012).***

Many urban cities in Nigeria are bedeviled with traffic congestion which tends to defy various remedial measures (construction of roundabout, flyover, odd and even way traffic etc) to be adopted by different government over the years. Travel times from one point to another within a town have remained unreliable and residents have continued to face disturbing inconvenience in transportation. The contribution of road transportation to environmental degradation in urban cities of Nigeria have been highlighted by Onokala (2008). The problem is no longer limited to traditional cities such as Logos, Ibadan, Benin city, Port Harcourt, Abuja, Kano and Kaduna (Ogunsanya and Ogunbode, 2012).

Although many researchers have conducted studies on traffic congestion and delays in Nigeria, most of these studies concentrate on specific cities such as Lagos (Bashiru and Waziri 2008), Ilorin (Aderamo and Atomode 2011), Akure (Ogunbodede Ogunsanya 2004), etc. All these falls under only the south-western part of Nigeria with different cultural practices and behaviours compared with other geo-political regions of the country.

Congestion is a complex and multidimensional phenomenon that is difficult to mitigate.

Many definitions have been proposed to describe traffic congestion on roadway in urban areas. However, there is no universally accepted definition of traffic congestion (Downs, 2004.). These definitions can be broadly categorized into three: (i) demand capacity related; (ii) delay-travel time related, and (iii) cost related. Based on demand capacity related; congestion may be defined as a state of traffic flow on a transportation facility characterized by high densities and low speeds, relative to some chosen reference state (with low densities and high speed) (Bovy and Salomon, 2002). In relation to delay- travel time; traffic congestion usually relates to an excess of vehicles on a portion of roadway at a particular time resulting in slower speeds (Achi Florence 2005). Cost related; This refers to the incremental costs resulting from interference among road users.

The consequences of traffic congestion extend well beyond inconveniences felt by individual travelers. Environmental quality, roadway safety, and community access are among the many quality-of-life concerns that arise in areas plagued with congestion (McNally, *et al*, 2014).

Travel time is the time that it takes an individual vehicle to traverse a unit length of roadway includes the running time and stopped delay time (Turner *et al*.1998). Usually, people judge transportation network quality using the length of time times takes to travel from point A to point B

Warri metropolis has had a fair share of traffic congestion, which is said to be attributed to the fact that most of the government offices and private organizations are located within the Central Business District (CBD), while the persons that work in these establishments are residents within or outside the city. This implies that workers in these establishments are residents outside the city and they have to travel to the CBD daily in the morning and return in the evening resulting to morning and evening peak, periods within the metropolis (Achi, 2012).

2.0 Material and Method

2.1 Description of the study area

Warri metropolis lies between Latitudes 5°44'0"N and 5- 31- 0" N of the Equator and Longitudes 5°44'0"E -5 48 0 E of the Greenwich Meridian. It comprises Warri- South, Warri South-West, some parts of Okpe local government areas. The city formerly occupied a land area of $46km^2$ in 1960 which increased significantly to $1100km^2$ in 2022 due to spatial expansion *(Victor and John 2020).*

Warri metropolis located in the Southern part of Delta State of Nigeria. It is natural oil and gas producing city in southern Nigeria. Apart from presently being the Annex of Delta State Government house; it has experienced a high concentration of Federal Parastatals and industries with projected population of 987,000 people in 2023.The study corridors are Jakpa road and Warri-Sapele Road of total length 4.84km and 4.61km, with operating speed of 60km/hr and 45km/hr respectively.

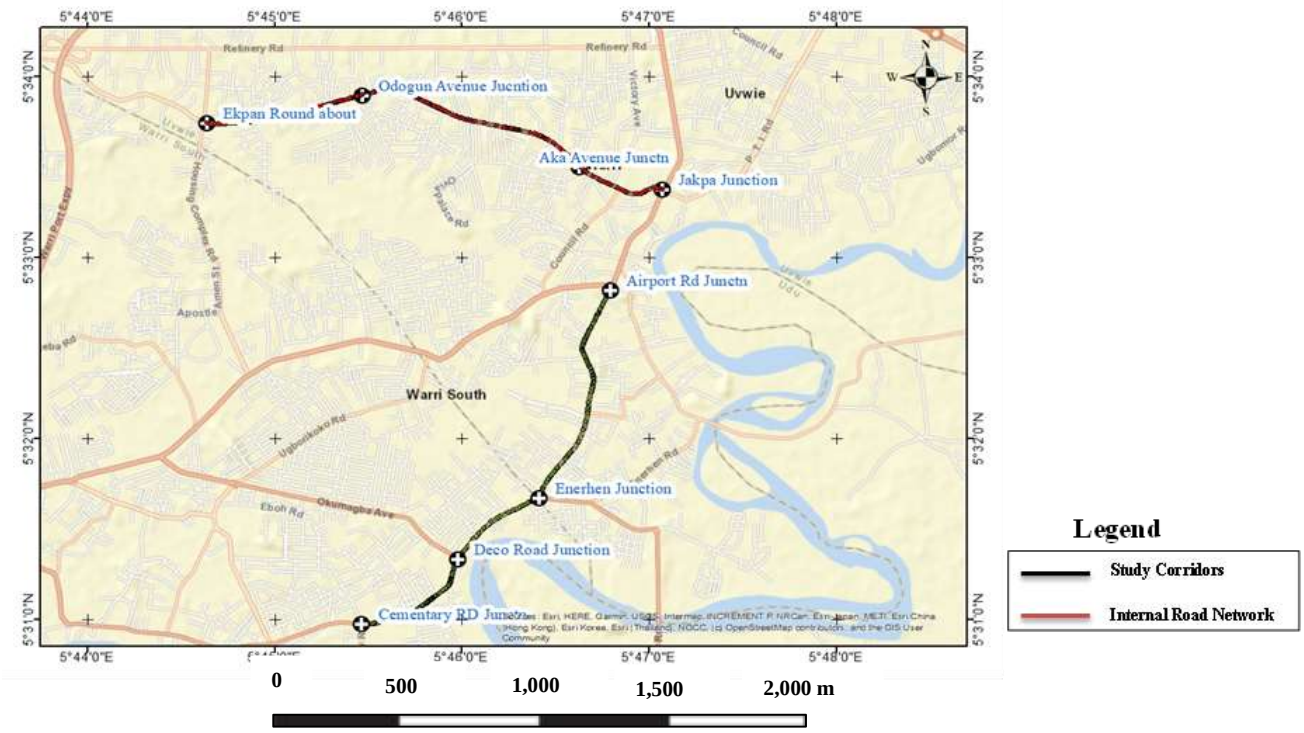

Fig1; Map of Warri Metropolis Showing the Study Corridors

2.2 Measurements of traffic density with GPS Receiver.

A vehicle was mounted with a GPSmap76Cx (GARMIN) that is capable of logging in positional and time data and later downloaded to a computer. The system was used for the determination of traffic condition (congestion data) in a pilot project covering the two study corridors (Jakpa to Ekpan Junction and Airport Junction to cemetery junction). The vehicle was driven floating in the traffic stream following the general traffic flow, so as to capture the expected traffic conditions in the morning as well as in the evening.

2.3 Generation of geospatial data

ArcGIS 9.3 by ERSI was used for all data extraction, editing, management, and analysis. All raster and vector data types were converted into a common coordinate system a vector format acceptable by the software.

2.4 Level of Service (LOS)

The LOS were used to determine or evaluate the performance of roadways and transportation elements along the study corridors

Level of Service LOS criteria

a. Level of Service A: Percent Time Delay ranges from 35% - 40%
b. Level of Service B: Percent Time Delay ranges from 40% - 55%
c. Level of Service C: Percent Time Delay ranges from 55% - 65%
d. Level of Service D: Percent Time Delay ranges from 65% - 80%
e. Level of Service E: Percent Time Delay ranges from 80% - 85%
f. Level of Service F: Percent Time Delay ranges from 85% - 100%

(Garber and Lester, 2010)

1-Total Peak Delay = [((Mean Peak Running Speed) - (Mean Peak Travel Speed))/Mean Peak Running Speed] mean Peak Travel Time

2- Percentage Time Delay (%) = (Total Peak Delay/Mean Peak Travel Time

3.0 Results and Discussion

3.1 *Information and Deduction from Measurement with GPS Receiver*

The traffic situation assessment carried out includes measurement of traffic density (using GPS receiver) and traffic volume count. The figure below presents the information and deduction from traffic assessment situation on the Warri-Sapele Road and Airport Road within the Warri metropolis, Delta state, Nigeria.

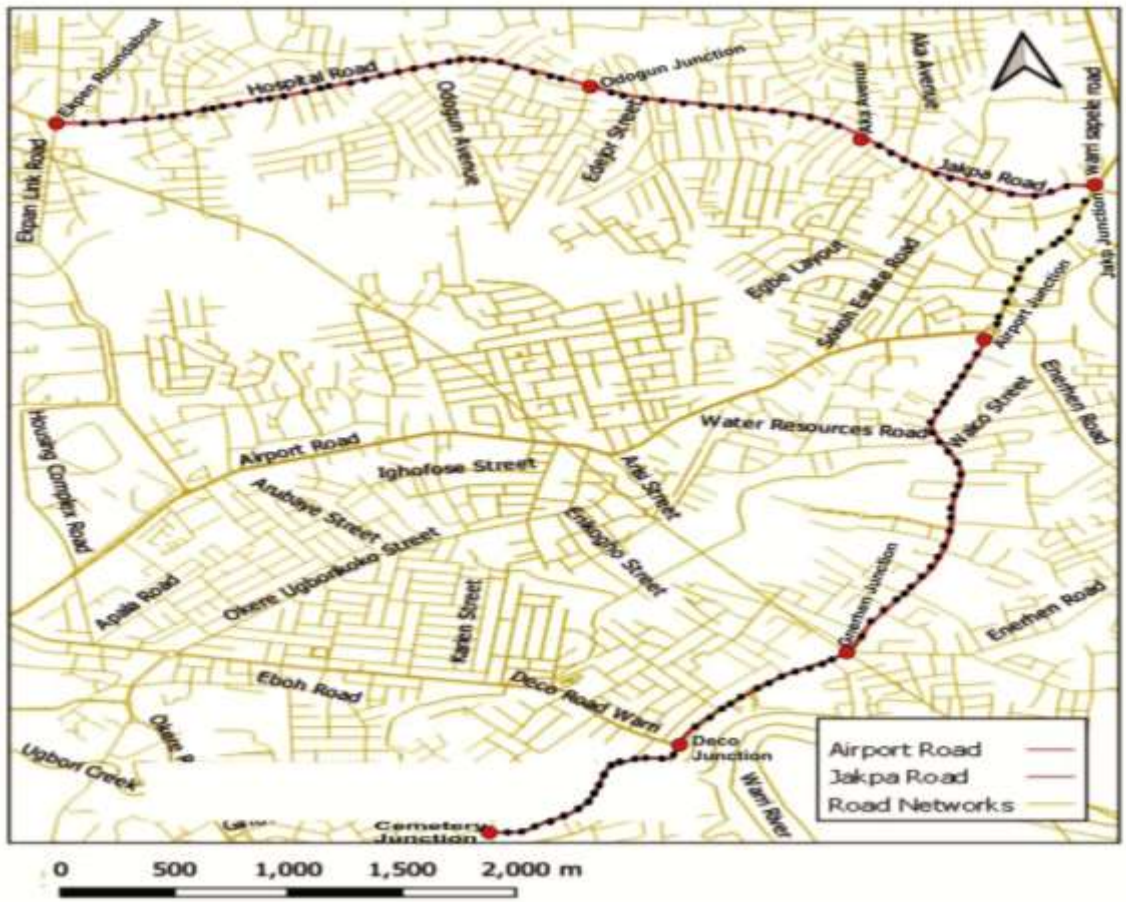

Figure 2.1: Jakpa-Ekpan and Airport Road junction-cementary junction corridor speed distribution on GPS map sources

Table 1: Data of traffic situation along Jakpa Road and Warri -Sapele Road Peak Period

ROUTE	SEGMENT	PEAK PERIODS	MON		WED		FRI		AVG MEAN PEAK TRAVELING SPEED (km/h)	AVG MEAN TIME (sec)
			MEAN PEAK TRAVELING SPEED (km/h)	TIME (sec)	MEAN PEAK TRAVELING SPEED (km/h)	TIME (sec)	MEAN PEAK TRAVELLING SPEED (km/h)	TIME (sec)		
Jakpa To Ekpan round about	Jakpa Juction To Aka Avenue	AM	14.6	224	15	218	16.7	195	15.4	212.3
		PM	13.3	245	12.9	255	11.2	292	12.5	264
	Aka Avenue To Odogun Avenue	AM	19.15	441	19.33	438	18.54	456	19.0	445
		PM	16.98	498	16.77	507	16.91	500	16.9	502
	Odogun Avenue To Ekpan Roundabout	AM	15.5	367	16.0	356	16.7	341	16.1	355
		PM	13.5	421	14.1	403	13.9	409	13.8	411
Warri Sapele road (Airport Road)	Airport Road To Enerhen Junction	AM	24.6	344	20.9	405	22.8	371	22.8	373
		PM	19.3	438	16.7	507	17.8	475	17.9	473
	Enerhen Junction to Deco Road Junction	AM	15.6	231	14.9	242	15.2	237	15.2	237
		PM	14.9	242	13.8	261	14.3	252	14.3	252
	DecoRoadJunction toCemeter Road Junction	AM	19.7	230	18.9	240	19.5	233	19.4	234
		PM	13.4	339	14.1	322	13.9	326	13.8	329

TABLE 2: Data of traffic situation on the Jakpa Road and Warri -Sapele Road Off Peak Period

ROUTE	SEGMENT	Mon		Wed		Fri		Avg Mean Off-Peak Traveling Speed	Avg Mean Time (Sec)
		Mean Off-Peak Traveling Speed (Km/H)	Time (Sec)	Mean Off-Peak Traveling Speed (Km/H)	Time (Sec)	Mean Off-Peak Traveling Speed (Km/H)	Time (Sec)		
Jakpa To Ekpan round about	Jakpa Juction To Aka Avenue	55	63.7	52.6	61.5	51.8	59.9	53.1	61.70
	Aka Avenue To Odogun Avenue	46.7	180.1	43.1	176.8	51	184.3	46.9	180.4
	Odogun Avenue To Ekpan Roundabout	41.5	131.7	44.6	136.3	41.7	132.5	42.6	133.5
Warri Sapele road (Airport Road)	Airport Road To Enerhen Junction	47.4	159.7	55.5	165.1	53.4	162.4	52.1	162.4
	Enerhen Junction to Deco Road Junction	51.9	69.7	54.7	72.3	48.7	66.5	51.8	69.5
	Deco Road Junction to Cemetery Road Junction	46	96.1	47.5	98.6	46.3	97.2	46.6	97.3

Table 3: Peak Period Analysis for Jakpa to Ekpan Roundabout

ROUTE	SEGMENTS	AM/ PM	DISTANCE (Km)	Mean Peak Travel Time (Sec)	Mean Peak Travel Speed (Km/hr)	Total Peak Delay (Sec)	Peak Delay Source	Mean Peak Running Speed (Km/hr)	Percent Time Delay (%)	Los
Jakpa To Ekpan round about	Jakpa Juction To Aka Avenue	AM	0.91	212.3	15.4	120	Congestion	35.6	57	C
		PM	0.91	264	12.5	158		31.2	60	C
	Aka Avenue To Odogun Avenue	AM	2.35	445	19	205	Congestion	35.2	46	B
		PM	2.35	502	16.9	226		30.7	45	B
	Odogun Avenue To Ekpan Roundabout	AM	1.58	355	16.1	195	Congestion	35.8	55	C
		PM	1.58	411	13.8	247		34.6	60	C

In the table 3 above, Congestion was determined through LOS criteria by Gasber and Lester (2010)

Table 4: Off Peak Period Analysis for Jakpa to Ekpan Roundabout

ROUTE	SEGMENTS	DISTANCE (Km)	Mean Peak Travel Time (Sec)	Mean Peak Travel Speed (Km/H)	Total Peak Delay (Sec)	Off-Peak Delay Source	Mean Peak Running Speed (Km/H)	Percent Time Delay (%)
Jakpa To Ekpan round about	Jakpa Juction To Aka Avenue	0.91	61.7	53.1	10	Junction	53.1	16
	Aka Avenue To Odogun Avenue	2.35	180.4	46.9	29	Junction	55.9	16.1
	Odogun Avenue To Ekpan Roundabout	1.58	133.5	42.6	28.8	Junction	54.7	22

Table 5: Traffic Data on Jakpa Junction to Aka Avenue

Traffic Data	Morning Period	Evening Period	Off-Peak
Distance (km)	0.91	0.91	0.91
Travel Time (sec)	212.3	264	61.7
Mean Speed (km/h)	15.4	12.5	53.1
Delay Time (sec)	120	158	10
Running Speed (km/h)	35.6	31.2	61.2
% Time Delay	57	60	16

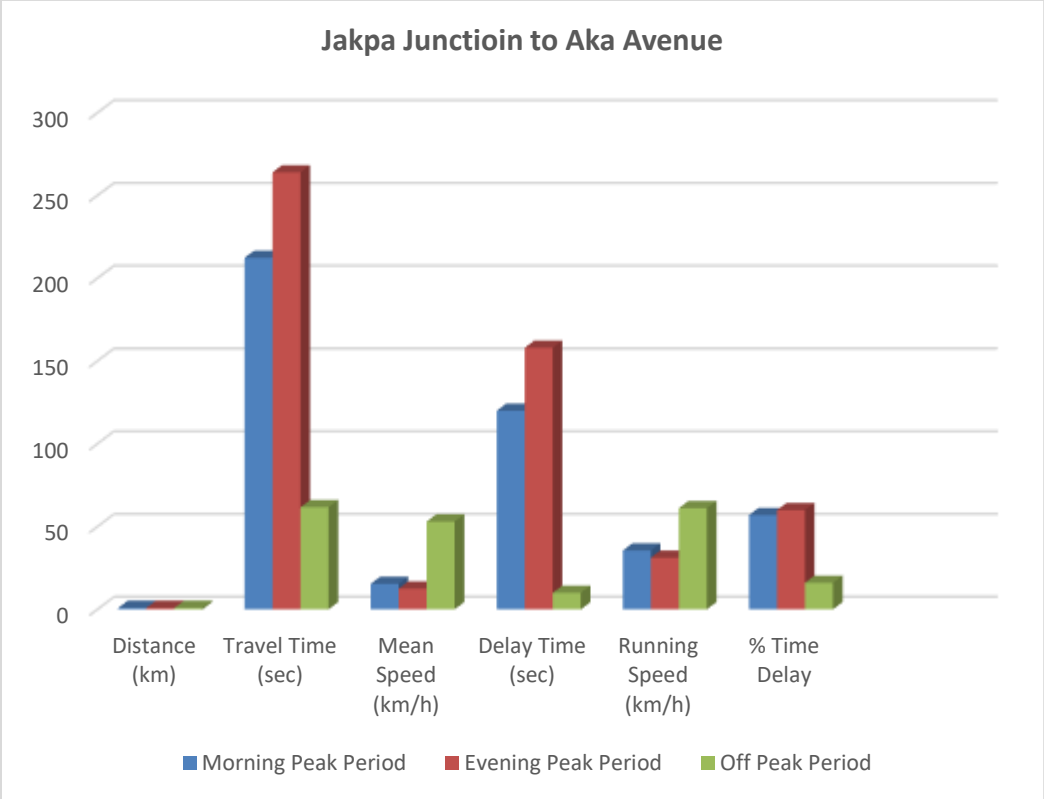

Figure 3: Graphical representation of traffic data on Jakpa Junction to Aka Avenue

3.3 Causes of traffic congestion

The cause of traffic congestion for this study includes traffic warden, accident, roadside hawking, vehicle breakdown, roadside-packing, inadequate road capacity and others. Table 6 shows that inadequate road capacity had the highest percentage along Warri-Sapele Road, Jakpa-Ekpan Road corridors, with 68.4% and 57.5%. The findings show that congestion along the two (2) corridors

occurs mainly due to in inadequate road capacity, which could be as a result of the fact that during the morning and evening peak periods there is higher volume of vehicles that ply the corridors and are moving in the same direction at the same time.

Table 6: Causes of traffic congestion along the corridors

	Warri-sapele	**Jakpa-Ekpan Road**	**Total**
Traffic warden	10(7.5%)	2(1.5%)	12(3.0%)
Accident	0(0.0%)	0(0.0%)	1(0.3%)
Roadside-hawking	2(0.0%)	1(0.7%)	3(0.8%)
Roadside-parking	1(0.8%)	6(3.7%)	7(12.8%)
Inadequate road-capacity	91(68.4%)	77(57.5%)	168(63.3%)
Others	31(23.3%)	43(32.1%)	74(8.5%)
Total	135	135	270

Source: (DSRTMA, 2020)

The corridors were constructed during 1970's, these corridors were wide enough considering the population at that time and the numbers of vehicles that ply them, but with the rate of urbanization, improvement in level of living and the high level of commercial activities going on the city presently the effects would be that the corridor's capacity has now become inadequate for the increased vehicular flow.

3.4 Impact of Traffic Congestion

Traffic impact includes the social and economic impact. In this study 400 copies of questionnaire were administered to commuters to assess the current traffic status of the city and its impacts. The respondents are composed from three individual groups of the society who use the road for different purposes. Government and private employees, self-employed or business persons, drivers of various vehicles and traffic police who manage the traffic on the road. For simplicity, results are presented in tabular format.

3.4.1 Social Impact

Social impacts include stress-anger, late-missed appointment of trip, extra-travel time having to travel at another time, unpredictable travel time and others as the options. Table 8 shows

that unpredictable travel time has the highest percentage along Warri-Sapele Road corridor with 61.7%.

This result is expected; along the corridor because once there is congestion intends to affect vehicle travel speed, which makes travel time to become unpredictable. Jakpa-Ekpa Road had extra-travel time as the highest social impact with 46.6%. The findings agree with that of Popoola, Abiola and Adeniji (2013) who revealed waste of time as the most significant effect of traffic congestion on Lagos-Ibadan express way.

Table 7: Social Impact of Delay

	Warri-Sapele	**Jakpa-Ekpan**	**Total**
Stress or anger	4(3.0%)	6(4.5%)	10(4.5%)
Late or missed appointment	3(2.3%)	10(7.5%)	13(4.5%)
Extra-travel time	43(32.3%)	62(46.6%)	105(37.5%)
Unpredictable travel-time	82(61.7%)	73(54.5%)	155(52.5%)
Others	1(0.8%)	0(0.0%)	1(0.3%)
Total	133	153	286

Source: Author Field Survey (2022)

3.4.2 Economic Impact

The economic impacts have high fuel consumption, paying extra fees, working hours reduced, productivity is reduced and others as the options enumerated. Table 9 shows high fuel consumption with 51%, as the highest economic impact along Warri-Sapele Road.

The Jakpa - Ekpan road corridor revealed working hour is reduced as the highest economic impact with 50.0% Jakpa road experience traffic congestion and this leads to increase in travel and delay time thereby reducing the number of hours spend on their jobs.

Table 8: Economic Impact Delay

Corridor	**High fuel Consumption**	**Paying extra fee**	**Working hour reduction**	**Productivity reduction**
Warri – Sapele Road	68(51.1%)	0(0.0%)	64(48.1%)	1(0.8%)
Jakpa – Ekpan Road	59(44.0%)	1(0.7%)	67(50.0%)	6(4.5%)
Total	127(46.5%)	1(0.3%)	131(50.0%)	7(3.0%)

The findings agree with Ojeh and Ozabor, (2013) who mentioned in their study that to make any trip within Benin metropolis, one needs to add extra hour into the projected time in order to beat traffic jams. This has a play hack effect on the people (commuters) and they take the following forms which include lateness to work and increase sensitivity towards closing early from work, which has gradually reduced the output of workers and consequently a distortion in the developmental process and prospect of the state.

4.0 Conclusion and Recommendation

4.1 Conclusion

This paper examined the effect of traffic congestion on travel time in Warri Metropolis. Over the time traffic congestion has been a problem along the study corridors with peak periods of 9-11am and 4-6pm and off-peak period of 11-3pm. In this study GPS was used to acquire coordinate from the congested corridor at the point where the speed had variation due to congestion. The average speed, travel and delay time for each corridor were analyzed as showed in table 1 and 2. More also questionnaire was administered to commuter to determine the negative impact of traffic congestion. Inadequate road capacity was the main cause of traffic congestion among others along the study corridor.

Vehicular traffic speeds and travel time in the metropolis can effectively be managed by the application of the GPS in a probe vehicle and GIS. Mapping of the situational road traffic speed brings out the desired geographic patterns and relationships which are fundamental decision-making tools for the management of traffic system.

4.2 Recommendations

1. Provision of an affordable and functional mass transit vehicles to provide alternative use of private vehicles, will help in reducing the number of vehicles on the corridors by the state government.
2. Linking traffic information system (TIS) to the State radio by the government of Delta State, this would relay to commuter corridors that are congested and to provide alternate to routes, which are less congested.
3. The use of Geographic Information System (G1S) in traffic monitoring is highly relevant for solving issues relating to traffic congestion.

Further recommendation for the use of Geographic Information System and Global Positioning System for speed, travel and delay time should be collected over a period for at least a month on the different corridors or between holiday and non-holiday periods in other to acquire adequate data.

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