1-1-2021

Traffic Mitigation And Congestion In Ibadan, Oyo State Nigeria: Causes And Solutions

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TRAFFIC MITIGATION AND CONGESTION IN IBADAN, OYO STATE NIGERIA: CAUSES AND SOLUTIONS

by

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A dissertation

Submitted to the Graduate Faculty

of the

University of North Dakota in partial

fulfillment of the requirements

for the degree of

Doctor of Philosophy – Environmental Engineering

Grand Forks, North Dakota

December 2021

This dissertation, submitted by Adetoye O Adeniyi, P.E in partial fulfillment of the requirements for the Degree of Doctor of Philosophy from the University of North Dakota, has been read by the Faculty Advisory Committee under whom the work has been done and is hereby approved.

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Degree Doctor of Philosophy

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Table of Contents

Page

LIST OF FIGURES

LIST OF TABLES

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ACKNOWLEDGEMENTS

I would like to acknowledge the efforts of these people who contributed in one way or another towards the successful completion of my Dissertation. They are Adedayo Adeniyi; for data gathering in Nigeria, Art Baumann of Wisconsin Department of Transportation (WisDOT) for the Highway Capacity Safety (HCS7) analysis and Bhuvan Manandhar of Wisconsin DOT for the Civil3D design of the models. I would like to acknowledge the efforts of my advisor, Dr Michael Mann, for his guidance during my course career at the University of North Dakota. I would like to acknowledge the patience of my kids; Adejoke, Adetomiwa and Adedamola and my adorable wife, Folake for her prayers and support from the onset. Lastly, I would like to thank God for the blessings of wisdom, knowledge and understanding and above all good health.

ABSTRACT

This dissertation focuses on how technology has transformed road traffic congestion between road users by examining the relationship between government, businesses, and road users through the application of traffic management in many cities in four regions of the world. It analyzes the connections between political decisions of traffic management, how users are made knowledgeable and the new modes of transportation as they relate to the roles of public and private users. The dissertation examines current literatures of twenty two (23) different countries: North America (United States of America and Canada), Europe (Poland,

United Kingdom, Italy, Netherlands and Sweden), Asia (Russia, China, Singapore, Hongkong, United Arab Emirates, Israel, South Korea, Japan, India), and West Africa (Ghana, Senegal, Sierra Leone, Mali, Cote D'Ivoire, Nigeria) as they relate to trends and causes of congestion and mitigation applied in each country. Finally, this dissertation takes an in depth look at how road network can be improved through mitigation to reduce congestion in Nigeria; most specifically in Ibadan focusing on the intersection of Sango Eleyele Road and Sango Ojoo Road representing most of the major intersections in Ibadan, Oyo State Nigeria.

CHAPTER 1 **Defining Congestion and Characterizing its Causes and Effects**

According to the European Conference of Ministers of Transport "there is no single definition for congestion". In general, there is no agreed definition of traffic congestion because it is both a physical and a relative phenomenon. Congestion has been characterized as follows:

- Based on most studies carried worldwide, congestion can be defined as a situation when traffic is moving at speeds below the designed capacity of a roadway.
- Congestion can be defined as a condition of traffic delay (when the flow of traffic is slowed below reasonable speed limit) because the number of vehicles trying to use the road exceeds the traffic network capacity to handle them.
- Congestion can be perceived as an unavoidable consequence of scarce transport facilities such as road space, parking area, road signals and effective traffic management.

- Congestion can be a physical phenomenon, defined as a situation where demand for road space exceeds supply and is reflected by slower speed, longer trip times and increased motor vehicular queuing.
- Congestion can be defined as a relative phenomenon when there is a difference between road performance and road user's expectations.
- Congestion can be applied narrowly to a near-jam conditions or more broadly to describe any loss of speed due to weight of traffic [1,2,3].

1.1 Causes and Types of Congestion

Traffic congestion is a concern in most parts of the world and the primary causes of congestion listed below have been experienced by drivers worldwide.

- Congestion can be caused by a delay due to the presence of other vehicles.
- Congestion can be caused by mutual obstruction of traffic by vehicles due to the existing interrelation between the speed of moving vehicles and the volume of flows.
- Congestion can be caused when a level of vehicle traffic exceeds the capacity of a given road which results in a decrease in the speed of moving vehicles or total prevention of free movement [3].
- Congestion can be caused by an increase in demand exceeding the capacity of an infrastructure facility [3].
- Congestion can be a result of an imbalance of the travel demand and the transport system supply. The demand results from the concentration of travel in space and time.

- Traffic congestion on road networks can occur because of excessive use of road infrastructure beyond capacity, slower speeds, longer trip hours and increased vehicular queuing.
- Congestion can be analyzed as a physically measurable phenomenon or as perceived by users of the road network, residents and others, and the level of congestion in these approaches will be different [3].

Congestion in the urban transport network is common not only in large agglomerations, but also in medium-sized cities in all countries that are characterized by a high level of socioeconomic development. In cities, we are dealing with a large concentration of transport needs in time and space that occur with a specific periodicity. With heavy traffic, a dense road network is conducive to congestion at crossroads, and from there, on a chain reaction basis, it moves to sections of streets between crossroads and then to neighboring crossroads. Different types of transport congestion are distinguished in any country's traffic network depending on the degree of its escalation [2]. Multiple interactions can occur between many vehicles with high traffic volumes, even when the capacity is not reached. An additional vehicle causes more impedance to each other's vehicles, and it leads to a reduction in speed and longer journey times. Other types of congestions are:

- Bottleneck congestion which occurs on sections of the road network where the capacity is smaller than on adjacent sections, and the number of vehicles attempting to cross this section is larger than its capacity.
- Trigger-neck congestion develops when bottlenecks start to hinder traffic on other sections of the network, for example, those crossing a jammed street.

- Network and control congestion occur where traffic controls programmed for peakhour traffic inevitably delay off-peak hour traffic.
- Gridlock congestion develops when there is an increased level of motorization and the increased number of vehicles on streets, which means traffic stopping in the whole street network in a certain area. Such a situation usually occurs in the very centers of cities.

Congestion can be recurrent (regular, occurring on a daily, weekly, or annual cycle) or non-recurrent and it can be located across a network or at some points [2]. The main difference is related to the predictability of the occurrence. Recurrent congestion is predictable and exists when the traffic volume on a road exceeds its capacity at a location during repeated time of the day. Non-recurrent congestion is instead caused by random or unpredictable events that temporarily increase demand or reduce capacity of infrastructure. It can be generated by traffic accidents, disabled vehicles, road construction or maintenance, adverse weather conditions or demand fluctuation (during holiday).

A recurrent congestion is a complex phenomenon, influenced by socioeconomic, technical, and human factors. The importance of each factor varies from one city to another and across time [5,6]. Traffic congestion has been increasing in much of the world, developed or not, and everything indicates that it will continue to get worse, representing an undoubted menace to the quality of urban life.

1.2 Effects of Congestion

The main expression of traffic congestions is a progressive reduction in traffic speeds, resulting in increases in journey times, fuel consumption, other operating costs, and environmental pollution, as compared with an uninterrupted traffic flow. The situation is

further aggravated in some regions, most specifically in the Asian and West African regions, by problems of road design and maintenance in these cities, coupled with the styles of driving which shows little respect for other road users, faulty information on traffic conditions, and unsuitable management by the responsible authorities, which are often split up among a host of different bodies. The consequences of congestion are not only suffered by private owners, but also by users of public transport –generally lower-income persons– who not only take longer to travel from one place to another but also must pay higher fares on account of congestion. City-dwellers are also adversely affected, in terms of a deterioration in their quality of life through such factors as greater air and noise pollution and the negative long-term impact on the healthiness and sustainability of their cities, all of which makes it vitally necessary to keep congestion under control. Lastly, traffic congestion has a major negative effect on global warming due to pollution.

Chapter 2

Research Objectives

The primary objective of this dissertation is to determine how technology has transformed traffic congestion between road users by:

- Examining the relationship between government, businesses, and road users through the application of traffic management.
- Analyzing the connections between political decisions of traffic management, how users are made knowledgeable and the new modes of transportation as they relate to the roles of public and private users.
- Examining current literatures of different countries in North America (USA and Canada in attachment 3), Europe (Poland, UK, Italy, Netherlands and Sweden in attachment 4), Asia (Russia, China, Singapore, Hongkong, UAE, Israel, South Korea, Japan, India in attachment 5), and West Africa (Ghana, Senegal, Sierra Leone, Mali, Cote D'Ivoire, Nigeria in attachment 6) as they relate to trends and causes of congestion and mitigation applied in each country.
- Taking an in depth look at how the road networks can be improved through mitigation to reduce congestion in Nigeria; most specifically in Ibadan focusing on the intersection of Sango Eleyele and Sango Ojoo representing most of the major intersections in Ibadan, Oyo State. https://goo.gl/maps/VB4WipVxS2L2hzdDA - Intersection of Sango Eleyele Road and Sango Ojoo Road

I have provided some basic definitions and causes of traffic congestion in Chapter 1. In Chapter 3 the general relationship between population, land use, and traffic congestion is presented to provide the reader with a basis for the analyses provided in this dissertation. In

Chapter 4 I discussed traffic Congestion; Causes and Proposed Mitigation Solutions as reflected in Table 4 by comparing the major causes of traffic congestion in four continents of the world and twenty-two (23) countries to reflect the nuances of congestion most especially in developing countries. Chapter 5 presents the federal government of Nigeria eventually starting to work in collaboration with private Sectors to Improve Road Network in Nigeria. Chapter 6 provides an in depth look at how the federal government of Nigeria is investing in Multimodal Transportation to Reduce the Demands on Road Transport in Nigeria through fixing or controlling tariffs, profits, regulating market entries or exits and ensuring the maintenance of fair and competitive practices across the transport sector. Chapter 7 presents causes and solutions to Traffic Congestion in Ibadan, Oyo state as it relates to one of the major intersections (Sango Eleyele & Sango Ojoo Intersection)

In Chapter 8 a redesign of Sango Eleyele & Sango Ojoo intersection was done using Wisconsin Highway Capacity software to determine the number of lanes (2), the level of service © and the type of intersection (roundabout) to reduce congestion at this intersection. Civil3D Autocad software was used to design the roundabout. Then the engineering factors affecting the intersection of (Sango Eleyele & Sango Ojoo) were examined and proposed solutions to a redesign of the intersection provided through Table 10 including the mitigation factors, recommendation and their effectiveness when applied. Chapter 9 concludes by offering some basic recommendations to the government of Oyo state to alleviate or reduce traffic congestion in the state.

Chapter 3 Relationship between Land Use, Population and Road Mileage on Traffic Congestion

The spread of home ownership, car use and non-motorized transport has led to a deconcentrating of residences and businesses in cities. In the past, only members of the aristocracy could afford to travel in private vehicles such as carriages and private cars. No one else could live or travel more than 10 miles from a streetcar, train, or bus line for school, work, or recreation [6]. It is apparent that because of limited mobility, a lot of people concentrated in the urban cities. For instance, 1992 data from the National Institute of Statistics (NIS) show that the population density in traditional neighborhoods that were developed before the days of the car hovers around 10,000 persons per square kilometer, while in newer areas, generally located on the outskirts of the city, this figure is 2,000 to 4,000 [6]. In that same city in America, population density rose steadily from 1940 to 1980, but then it began to drop as citizens gained new freedom to travel by buying cars. Between 1950 and 1970, in the U.S. cities of Chicago, Washington, D.C. and Boston, which by then were totally car-oriented, demographic density in the city center had begun to decline as residents moved to the suburbs [7]. Meanwhile, the opposite was happening in the Asian and West African cities. With the introduction of cars, the dispersed parts of the cities are now concentrating in the centers, despite the limited train and river transport systems making it impossible to live anywhere in a broad suburban area and commute downtown every day. Suburbanization is also made easier by the fact that in the North American city centers, there were between 0.4 and 0.5 parking places for every job [8]. Unfortunately, parking spaces are very limited in the European cities because of limited land mass and the Asian and West African cities because of lack of development.

Most of the major cities were self-sustainable only temporarily as they developed, balancing between urban density and the cost of public transport per passenger-miles. The spiral effect of private dependence, deteriorating public transit and lack of different modes of public transport impact this sustainability. The time spent travelling, per person per day, fluctuates between 45 minutes and approximately one hour and 25 minutes, with a marked concentration at about one hour.[8] This is true whether the person lives in the United States or an African village [7]. The speed of the available modes of transportation varies considerably. Thus, in the villages of Ghana, people cover only 3.5 miles per day in their daily hour, whereas in the United States they cover more than 60 miles, as they can travel by car rather than on foot. A study of data compiled between 1955 and 1970 in U.S. cities concluded that "daily travel time per traveler is notably similar" [7]. If this correlation is true, a reduction in traffic speeds resulting from congestion would reduce the average distance travelled per person, unless alternative modes of transportation are found.

Suggested options will be [7]:

- A reduction in the average duration of journeys.
- A reduction in the frequency of journeys, perhaps accompanied by a greater use of various forms of telecommunication.
- A spatial shift of travel from more congested to less congested areas.
- A modal shift of travel from cars to relatively congestion-free modes, such as subways or motorcycles.
- A temporal shift of travel towards less congested times.

Some of these options have an impact on land use, but not always in the same way, so the net impact varies from one city to another. For example, reducing time available for travel

would create a greater demand to live near workplaces or pressure to create new jobs near residential neighborhoods. This would become especially apparent in cities with relatively strict land use regulations, particularly along the perimeter of the metropolitan zone, as is the case in Europe. In Asia and West Africa, where these regulations are looser, the opposite trend would occur; that is, residences and workplaces would move to outlying areas that right now are free of major congestion.

Traffic congestion can encourage the use of public transport modes that are at least partially immune to its consequences, that is, those operating on separate roadways. To the extent that their use increases, the demand for both residential and commercial property with good access would rise, as is the case near train stations. Although this trend appears to be occurring in several cities in the North American countries, the modal distribution (the way travel is spread out among different modes of transportation) seems relatively flexible in the face of changes in the prices or travel times of the various modes.

In some West African major countries, surveys of travel patterns have been carried out over a period of 40 years. Certain inferences can be drawn with respect to the influence of congestion and its possible impact on land use, though no definite conclusions can be reached. The consequence is that, despite the reduction in time spent travelling, the number of miles travelled per person per day can fluctuate. The scenario is consistent with growing congestion, however, and this encourages the movement of residential areas towards the suburbs, forcing citizens to cover ever-greater distances between home and work. The greater physical concentration and the rise in congestion, and perhaps also a greater availability of home entertainment thanks to cable television, causes people to make fewer trips.

Heavier congestion is compatible with a higher average speed per trip if people switch from slower modes of transportation, such as ordinary buses, to other less slow modes, such as buses on segregated lanes, subways, or cars. Studies show in North America and Europe in the last 30 years, the proportion of trips made by train (including the subway) climbed relative to that of car trips. The creation of separate bus lanes or streets in the most heavily travelled corridors in North America and Europe during this time may have benefited more bus passengers.

Road pricing and land use road pricing has been proposed as a means of improving the flow of traffic, cutting car use, and promoting public transportation, and in general making some of the major cities a more enjoyable and sustainable place. The long-term effects of this measure, however, may be diametrically opposed. Several analysts have studied, usually with mathematical models, the effect of road pricing aimed at controlling congestion on the physical boundaries of the cities. The effects were inconclusive depending on each city, particularly in the West African countries where they were not employed at all. There were signs in the other three regions that point to the conclusion that road pricing would cause greater urban sprawl. Road pricing raises the relative price of driving a car in more congested areas, that is, in areas of greater residential or commercial density, which normally tend to be in the city center. In view of this increase, in the short-term motorists tend to choose among three options, none of which is to their liking:

- Switching to public transit
- Continuing to travel by car but drive during toll-free times, either by getting up early or by arriving at work later
- Continuing to drive as usual, paying the corresponding fee.

In the more distant future, drivers would have the option of moving away from the toll zone looking for cheaper places in which to drive. Regrettably, it appears that there is a very low tendency to switch to public transportation in West African and some of the Asian countries because of no road pricing. In other words, improvements in public transportation would not attract many of the motorists, and their riders would generally remain persons of lower incomes and skill levels.

Especially in West African countries, business decisions regarding the location of offices consider the preference of the most specialized employees, who are critical to success. It should be noted that most of the Asian and West African countries have ample parking outside their city centers but lack proper and effective planning. In other words, road pricing would have the perverse effect of decreasing the sustainability of the city in environmental terms, and probably in economic and social terms as well.

Although most land use factors have modest individual impacts, typically affecting just a few percent of total travel, they are cumulative and synergistic. Per studies, Integrated Smart Growth programs like complete streets where all forms of transportation modes are employed in a corridor can reduce vehicle ownership and travel to roughly 25%, and significantly increase walking, cycling and public transit and more efficient transport pricing. When evaluating the impacts of specific land use factors as they effect congestion there are factors like geographical locations, government policies, density and politics and area demographics. Density tends to receive the greatest attention, although alone its travel impacts are modest. Density is usually associated with other factors (regional accessibility, mix, transport system diversity, parking management) that together have large travel impacts.

A key question is the degree of consumer demand for more accessible, multi-modal development. Demographic and economic trends (aging population, rising fuel prices, increasing health and environmental concerns, changing consumer location preferences, etc.) tend to increase demand for more accessible, multi-modal locations. This suggests that Smart Growth policies are likely to have greater impacts and benefits in the future [9].

3.1 Strategies for Reducing Traffic Congestion

Congestion reduction strategies that reduce congestion intensity vary depending on the specific conditions in each country and can include:

- Reducing per capita vehicle travel which will reduce total regional congestion costs.
- Land use management can reduce the amount of congestion experienced for a given density.
- Improve and maintain roads & parking which results in ultimate savings.
- Increase lane roads and parking facilities and increase parking costs.
- Create more transport modes so people can have transport choices.
- Improve road safety traffic density by reducing crash frequency, severities, and fatalities.
- Improve environmental protection per capita energy consumption, pollution emissions, and land consumption.
- Encourage physical fitness by significantly increasing walking and cycling activity by designing for complete streets.

3.2 Comparison Between Land Use, Population and Road Mileage among Regions

Figure 1 and Table 1 show the comparison between the four study regions as they relate to land use, population, and road mileage. From this comparison, it is obvious that the highest percentage of population is in the Asian world, but development of road network is low compared to North America. Russia has the highest percentage of land area, but very low road network development compared to other industrialized nations. Despite the big land mass and population in Nigeria, her road network is still developing relatively in West Africa. Most European countries show close relations between land mass, population, and percentage of road network because of limited land mass, development, and industrialization.

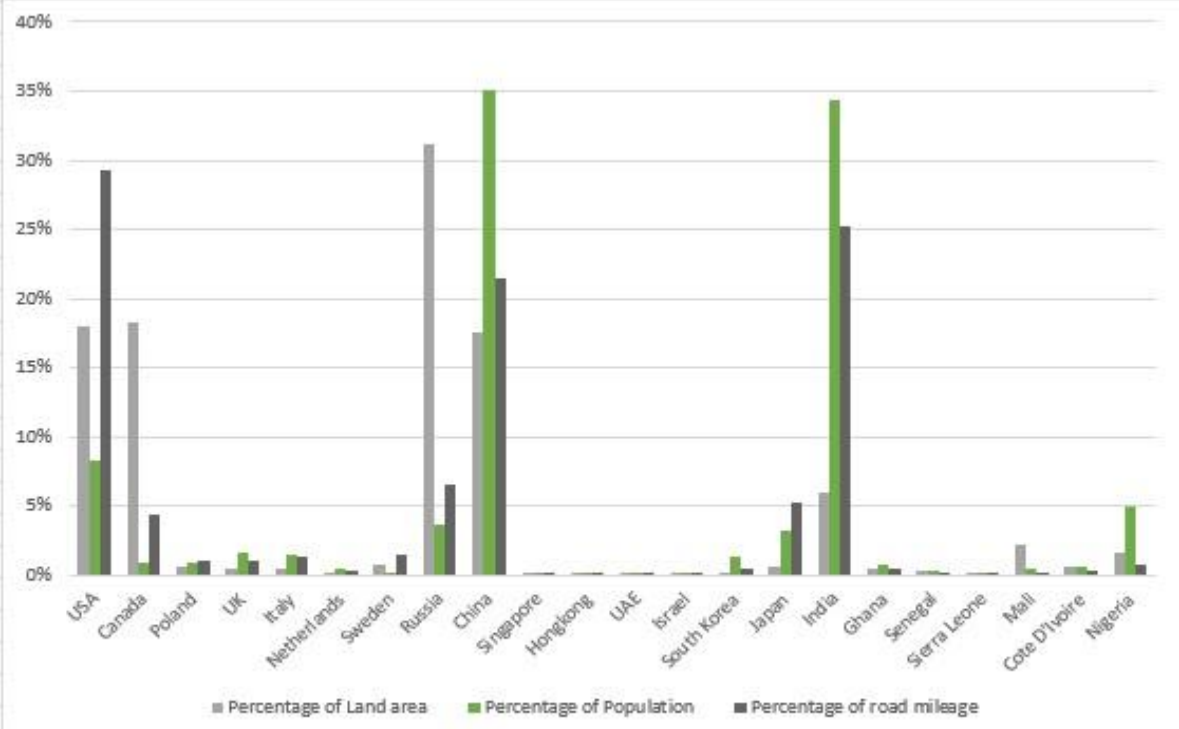

Fig 1 Relationship between Land use, Population and Road Mileage among the Regions

Relationship between Land Use, Population and Road Mileage by region – TABLE 1

	Countries	Percentage of Land area	Percentage of Population	Percentage of road mileage
NORTH AMERICA	USA	17.97%	8.24%	29.31%
	Canada	18.26%	0.94%	4.46%
EUROPE	Poland	0.57%	0.95%	1.13%
	UK	0.44%	1.67%	1.06%
	Italy	0.55%	1.52%	1.30%
	Netherlands	0.08%	0.43%	0.37%
	Sweden	0.82%	0.26%	1.54%
ASIA	Russia	31.22%	3.63%	6.54%
	China	17.55%	35.11%	21.44%
	Singapore	0.00%	0.14%	0.01%
	Hongkong	0.00%	0.19%	0.01%
	UAE	0.15%	0.25%	0.02%
	Israel	0.04%	0.23%	0.08%
	South Korea	0.18%	1.30%	0.45%
	Japan	0.69%	3.17%	5.20%
	India	6.01%	34.41%	25.25%
WEST AFRICA	Ghana	0.44%	0.76%	0.47%
	Senegal	0.36%	0.41%	0.06%
	Sierra Leone	0.13%	0.20%	0.05%
	Mali	2.26%	0.49%	0.10%
	Cote D'Ivoire	0.59%	0.65%	0.35%
	Nigeria	1.69%	5.05%	0.83%

In the developed countries the road mileages increase most especially in industrialized countries, unfortunately a lot of the countries in Europe have limited land mass. What is surprising is that Russia has a very low road mileage despite the large land mass and despite their industrialization.

3.3 Comparison between Developed and Developing Countries

Figure 2 and Table 2 reflect the comparison between the developed and developing countries. When identifying the need for road network,

- The industrialized countries have a need for road transportation for goods to move from one sector to the other, most especially in the industrialized countries: USA, Russia, China, and India.
- There is a need for improved road network development in the developing countries.

- One can equivocally state that the developing countries have a need for industrialization for development.

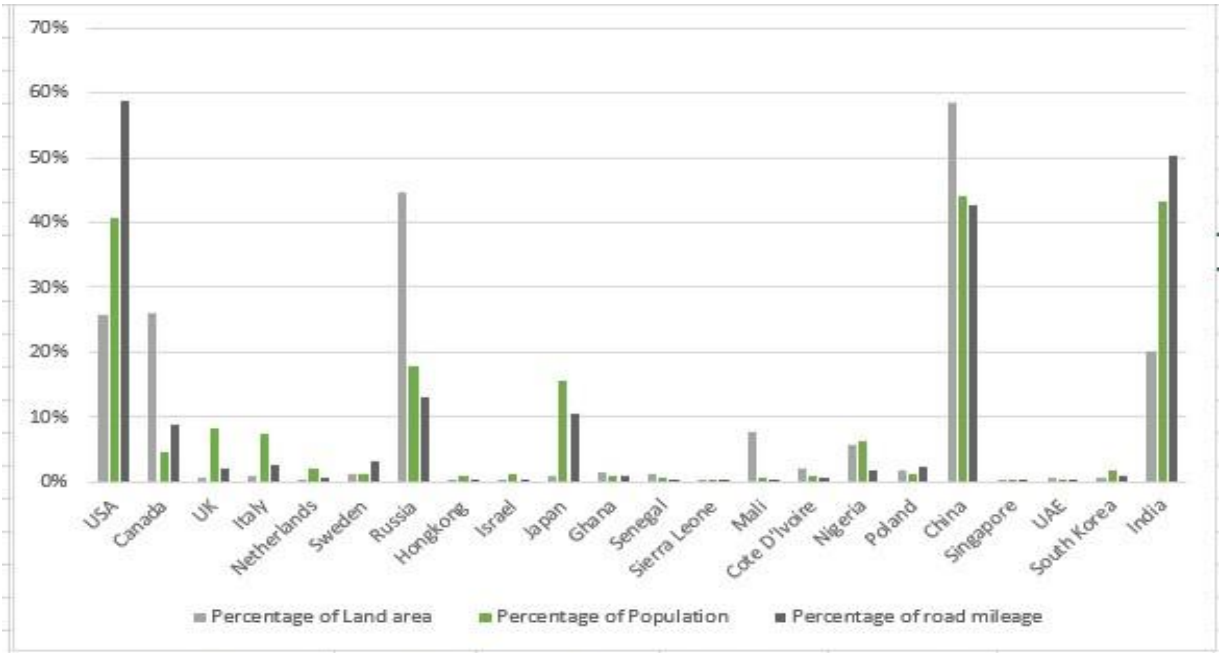

Fig 2 Relationship between Developed and Developing countries

Relationship between Land Use, Population and Road Mileage (Developed and Developing countries – TABLE 2

	Countries	Percentage of Land area	Percentage of Population	Percentage of road mileage
DEVELOPED COUNTRIES	USA	25.65%	40.64%	58.79%
	Canada	26.06%	4.65%	8.94%
	UK	0.63%	8.25%	2.12%
	Italy	0.79%	7.47%	2.60%
	Netherlands	0.11%	2.14%	0.74%
	Sweden	1.17%	1.27%	3.09%
	Russia	44.55%	17.88%	13.12%
	Hongkong	0.00%	0.93%	0.02%
	Israel	0.06%	1.12%	0.16%
	Japan	0.98%	15.64%	10.42%
DEVELOPING COUNTRIES	Ghana	1.46%	0.96%	0.93%
	Senegal	1.20%	0.51%	0.12%
	Sierra Leone	0.44%	0.25%	0.10%
	Mali	7.57%	0.62%	0.19%
	Cote D'Ivoire	1.97%	0.81%	0.70%
	Nigeria	5.64%	6.33%	1.65%
	Poland	1.91%	1.20%	2.25%
	China	58.63%	44.04%	42.76%
	Singapore	0.00%	0.18%	0.03%
	UAE	0.51%	0.31%	0.03%
	South Korea	0.61%	1.63%	0.89%
	India	20.07%	43.16%	50.35%

3.4 Comparison between West African Countries

- The West African countries shown in Figure 3 and Table 3 are reflective of all West African countries.
- Mali has the largest land mass area in West Africa, it is obvious in the figure that they have not developed their road network to its capacity due to lack of industrialization and the fact that they have deserts.
- It is also obvious that Mali, despite a large land mass compared to other West African countries has a very low population density due to lack of infrastructure development.
- Nigeria has the highest population and road network but most of the roads are not paved [Table 5].

The three charts reveal a correlation between industrialization and road mileage because of a need to transport goods within and outside the country and to the wharfs. These data reveal that with land mass, people and industrialization, there is opportunity for development. It reflects the need for development in the West African countries. Of course, with people (cars) and industrialization, there will be an accompanying increase in road mileage and eventually congestion.

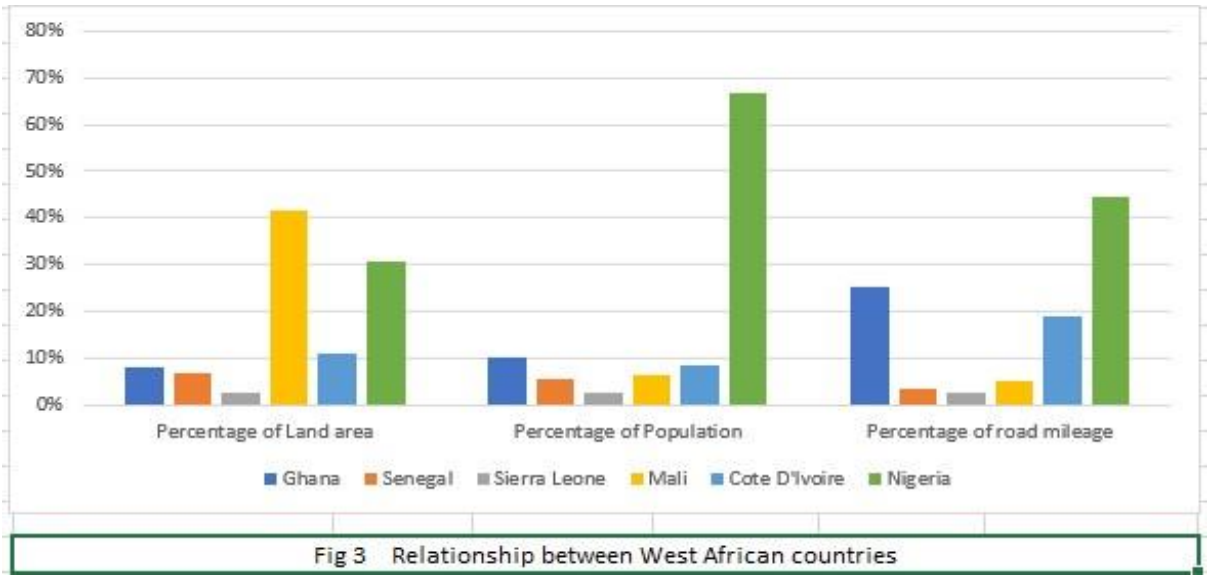

Fig 3 Relationship between West African countries

Relationship between Land Use, Population and Road Mileage West African countries

TABLE 3

	Countries	Percentage of Land area	Percentage of Population	Percentage of road mileage
WEST AFRICA	Ghana	7.97%	10.11%	25.32%
	Senegal	6.57%	5.42%	3.24%
	Sierra Leone	2.40%	2.60%	2.61%
	Mali	41.43%	6.53%	5.20%
	Cote D'Ivoire	10.77%	8.55%	18.96%
	Nigeria	30.86%	66.80%	44.67%

Chapter 4

Traffic Congestion: Causes and Proposed Mitigation Solutions.

Table 4 reflects a comparison of major causes of traffic congestion in four regions of the world; North America, Europe, Asia, and West Africa based upon research that was performed on the twenty-two (22) countries within these regions. Table 4 reflects the:

- Five major and two minor causes of traffic congestion in North America.
- Nine major and six minor causes in Europe.
- Fifteen major and six minor causes in both Asia and West Africa respectively.
- The top five major congestion factors are common in all the four regions identified.

Comparison of Major Causes of Traffic Congestion in Four Study Regions – Table 4

	CAUSES OF TRAFFIC CONGESTION							
1	USA	Impact	EUROPE	Impact	ASIA	Impact	WEST AFRICA	Impact
2	Bottlenecks (traffic demand exceeds roadway capacity)	MAJOR	Bottlenecks (traffic demand exceeds roadway capacity)	MAJOR	Bottlenecks (traffic demand exceeds	MAJOR	Bottlenecks (traffic demand exceeds roadway capacity)	MAJOR
3	Traffic incidents	MAJOR	Traffic incidents	MAJOR	Traffic incidents	MAJOR	Traffic incidents	MAJOR
4	Work zones	MAJOR	Work zones	MAJOR	Work zones	MAJOR	Work zones	MAJOR
5	Bad weather	MAJOR	Bad weather	MAJOR	Bad weather	MAJOR	Bad weather	MAJOR
6	Poor signal timing	MINOR	Poor signal timing	MAJOR	Poor signal timing	MAJOR	Poor signal timing	MAJOR
7	Special Event Gatherings	MINOR	Special Event Gatherings	MAJOR	Special Event Gatherings	MAJOR	Special Event Gatherings	MAJOR
8			Lack of balanced spatial development	MINOR	Lack of balanced spatial development	MAJOR	Lack of balanced spatial development	MAJOR
9			Shortage of Street Parking	MAJOR	Shortage of Street Parking	MAJOR	Shortage of Street Parking	MAJOR
10			Integrated Urban Transport Planning	MINOR	Integrated Urban Transport Planning	MAJOR	Integrated Urban Transport Planning	MAJOR
11			Economic Factors/Growth	MINOR	Economic Factors/Growth	MAJOR	Economic Factors/Growth	MAJOR
12			Demand/Traffic Management	MINOR	Demand/Traffic Managem	MAJOR	Demand/Traffic Management	MAJOR
13			Poor Quality of Transportation Modes and Low Capacity of Transport Infrastructure	MINOR	Poor Quality of Transportation Modes and Low Capacity of	MAJOR	Poor Quality of Transportation Modes and Low Capacity of Transport	MAJOR
14			Unreliability of Queue locations, location and	MINOR	Unreliability of Queue locations, location and	MINOR	Unreliability of Queue locations, location and	MINOR
15			Rapid Increase in Urban Population	MAJOR	Rapid Increase in Urban Population	MAJOR	Rapid Increase in Urban Population	MAJOR
16					Non-Motorized Transport	MINOR	Non-Motorized Transport	MINOR
17					Driver behavior and Drver's License	MINOR	Driver behavior and Drver's License	MINOR
18					Lack of Education	MINOR	Lack of Education	MINOR
19					Non Adherence to Traffic	MINOR	Non Adherence to Traffic	MINOR
20					Institutional Problem	MAJOR	Institutional Problem	MAJOR
21					Environmental Pollution	MINOR	Environmental Pollution	MINOR

It is apparent from Table 4 that North America is doing a lot to fix traffic congestion as compared to other parts of the world. However, one should not assume that US is not currently experiencing minor congestion causes that can result in temporary major causes, like major causes that other parts of the world are experiencing. Unfortunately, the traffic congestion situation has worsened for developing countries due to the following reasons: unplanned cities, poor discipline, alternate traffic means, archaic management, and improper lane management. The intensity of these major factors varies depending upon each country in the world. This dissertation discusses the major and minor causes and solutions embarked on by many of the cities in the countries identified.

4.1 Traffic Bottleneck

A traffic bottleneck is a localized constriction of vehicular traffic flow on streets, roads, or highways. They can be caused by a specific physical condition, often the design of the road, badly timed traffic lights, or sharp curves. They can also be caused by temporary situations, such as vehicular accidents or by construction zones where one or more existing lanes become unavailable. They lead to a localized section of highway that experiences reduced speeds and inherent delays due to a recurring operational influence or a nonrecurring impacting event.[19] Some of the solutions to bottlenecks include:

- Bring supply and demand in alignment through Congestion Pricing, assessing road users during peak periods.
- Provide alternatives as to how, when, where, and if to travel by promoting alternative commute options and driver incentive programs like ride sharing.
-

Invest in new highway capacity - Add new construction on new alignments to preserve or improve system performance.

- Improve the management and operation of the system. Improve the day-to-day operation of the system by retiming traffic signals, applying access management techniques, removing operational deficiencies, and improving response time and management of traffic disrupting events like work zones, accidents, and special events.[19]

4.2 Traffic Incidents

Traffic incidents are non-accident causes of delay. The ability to monitor traffic conditions in real-time and act to reduce accident prone conditions before they can fully develop is the goal, with models being critical tools to obtain a predictive understanding of accident risk. A comprehensive review of the following is necessary to provide solutions to congestion:

- Real-time crash prediction models.
- Performance increases in models and causative factors.
- Provide real-time predictions of the likelihood of incidents, where surveillance sensors would be used to measure traffic and environmental variables.
- Use of standard deviation of speed as an indicator to identify the difference between disruptive (potentially leading to an accident) and normal (not leading to an accident) traffic conditions.

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- The use of electronically controlled road signs, broadcasting advisory radio messages, or displaying information on in-vehicle navigation systems could be taken to alleviate the dangerous conditions.

  Use of Bluetooth sensors to collect road segment travel time.

These approaches could be categorized as components of traffic management systems, which are found to reduce the frequency of traffic congestion.

4.3 Construction Work Zones and Road Maintenance Work

Construction work zones and road maintenance work are areas where roadwork takes place and may involve lane closures, detours, reduction in the number or width of travel lanes, lane "shifts," lane diversions, reduction, or elimination of shoulders, and even temporary roadway closures and moving equipment. Highway work zones are set up according to the type of road and the work to be done on the road. The work zone can be long or short term and can exist at any time of the year. Faulty design and maintenance of road systems in work zones are causes of unnecessary congestion. In many Asian and West African cities there are frequent cases of failure to mark traffic lanes, unexpected changes in the number of lanes, bus stops located precisely where the road width becomes narrower, and other shortcomings which disturb a smooth traffic flow. Likewise, road surfaces in bad condition, and especially the presence of potholes, give rise to increasing constraints on road capacity and increase congestion. In many West African cities, the accumulation of rainwater on roads reduces their traffic capacity and hence increases congestion. According to OSHA these are recommended solutions to reduce traffic congestion on roadways during construction or maintenance of roadways:

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- Traffic Control Plans are needed for the movement of vehicles in areas where there are also workers conducting other tasks. Drivers, workers on foot, and pedestrians must be able to see and understand the routes they are to follow. Standard highway signs are to be installed for information to assist drivers in identifying the designated traffic paths.

-

- Standard Traffic Control Devices such as signals, and message boards will instruct drivers to follow a path away from where work is being done.
- Flagger stations should be illuminated - Lighting for workers on foot and equipment operators are to be designated.
- Flaggers should be trained/certified and use the signaling methods required by the authority in charge. Flaggers and others providing temporary traffic control should wear high visibility clothing with a background of fluorescent orange-red or yellowgreen and retroreflective.
- Work Zone Protections such as various styles of concrete, water, sand, collapsible barriers, crash cushions, and truck mounted attenuators are to be made available to limit motorist intrusions into the construction work zone.
- Drivers are to keep their eyes on the road and avoid changing the radio station, eating, or drinking, or using a cellphone.
- Drivers are to keep your headlights on, stay alert, slow down, be mindful when changing lanes, pay attention to flaggers and prepare for the unexpected.

4.4 Bad Weather

Weather acts through visibility impairments, precipitation, high winds, and temperature extremes to affect driver capabilities, vehicle performance (i.e., traction, stability, and maneuverability), pavement friction, roadway infrastructure, crash risk, traffic flow, and agency productivity [21]. Environmental conditions can lead to changes in driver behavior that affect traffic flow. Due to reduced visibility, drivers will usually lower their speeds and increase their headways when precipitation, bright sunlight on the horizon, fog, or smoke are present. Wet, snowy, or icy roadway surface conditions will also lead to the same effect even

after precipitation has ended. In North America and Europe, snow is the prevalent bad weather while in Asia and West Africa heavy rain is the prevalent bad weather coupled with bad roads. The following are suggested solutions to reduce traffic congestion during bad weather:

- Weather-responsive signal plans.
- Tweaking the timing of traffic lights to take road conditions into account by using video cameras and artificial intelligence (AI) software.
- Implement development of software that signal controls are so smart that they change themselves in real time based on what is happening in the road network for any reason.
- Develop effective intelligent transportation system (ITS) strategies to mitigate the negative effects of different types of adverse weather related to reduced visibility by investigating the effect of rain and fog on traffic parameters using traffic simulation and weather data.
- Engage the use of active systems by mainly including driver warning systems through the Lane Departure Warning system and variable speed limit signs. [25]
- Engage the use of passive systems comprising of various pavement markings and signs which are helpful to warn and delineate traffic. [25]
- In addition to the fixed roadside sensors, in-vehicle sensors can be considered as another data source to explore the impact of adverse weather on traffic operations. Real-time measurements of traffic parameters and weather can help in warning drivers when there is reduced visibility below certain acceptable levels or certain unsafe levels.

4.5 Poor Signal Timing and Equipment Failure

Signal timing is the technique which traffic engineers use to distribute right-ofway at a signalized intersection. The process includes selecting appropriate values for timing which is implemented in specialized traffic signal controllers. Signal timing involves deciding how much green time the traffic signal provides to an intersection by movement or approach (depending on the lane configuration), how long the pedestrian walk signal should be, whether trains or buses should be prioritized, and numerous other factors. A poorly coordinated signal system can decrease traffic flow, increase traffic delay thereby causing traffic congestion, and maximize pollution. Traffic signal timing is a very complex topic. For example timing a walk signal for a wide pedestrian crossing and slower pedestrians (for example the elderly) could result in very long waits for vehicles, and thus increases the likelihood of cars running the light, which could potentially cause accidents. In a lot of the countries in Asia and West Africa, they are yet to utilize traffic lights because of poor or underrated electric systems. Optimizing the safety of intersections involves multiple factors like:

- Widening street width or lane width.
- Reducing the number of intersecting streets.
- Providing available electricity for all signals
- Reducing number of cars per unit of time and even/uneven nature of flow,
- Determining number and type of pedestrians.
- Program to have different signal timing plans, depending on the time of day.
- Adapting signal timings depending on measured traffic conditions.
- Adapting an effective traffic signal management

4.6 Special Event Gatherings

A planned special event creates an increase in travel demand and may require road closures to stage the event. Planned special events generate trips, thus affecting overall transportation system operations. This includes freeway operations, arterial and other street operations, transit operations, and pedestrian flow. Unplanned special events which are common occurrences in West Africa and Asian countries, like closing the roads for parties without approval by government are major causes of traffic congestion. Road uses are forced to divert to another road which will increase the traffic volume on other roads leading to congestion. Solution to unplanned special events is enforcement by government to stop closing of roads by private individuals. There is a need to Manage Travel for Planned Special Events, it addresses the unique and diverse set of challenges to stakeholders charged with maintaining transportation system safety, mobility, and reliability. Some of the main challenges identified in the plans event planning include the need to:

- Manage intense travel demand.
- Mitigate potential capacity constraints.
- Influence the personal economic utility associated with various travel choices.
- Accommodate heavy pedestrian flow.

"Event-Specific Travel Management" issues require the following types of responses:

- Program planning that encompasses both advanced planning activities completed months prior to a single, target event and activities related to a series of future planned special events.
- Event operations planning that involves advance planning and resource coordination activities conducted for a specific planned special event.

- Implementation activities that concern strategizing traffic management plan deployment in addition to conducting necessary equipment testing and personnel training activities.
- Day-of-event activities that refer to the daily implementation of the traffic management plan in addition to traffic monitoring.
- Post-event activities that cover the evaluation of local and regional transportation operations based on stakeholder debriefings and an analysis of traffic data collected during the day-of-event.

4.7 Shortage of Street Parking

Parking spaces are very important to cities. A city must have enough parking space to provide their residents and their visitors a place to park their cars. Since vehicles are a main factor in transportation, a city must meet the needs of the drivers. Parking your vehicle on the street, anywhere on or along the curb of streets, in contrast to parking it in a parking garage are important to traffic congestion. There are also on-street parking situations where you need a parking permit to park. To make sure people follow these rules and restrictions, cities hire enforcement officers. The influence and value of parking in planning for livable communities is often underestimated and not well understood. As one of the largest single land uses in municipalities' "footprints," parking deserves more attention than it typically gets, due to its influence on the character, form, function, and flow of our communities. Many places in the European cities face a shortage of available, convenient parking close to businesses, especially in traditional downtowns due to limited land mass. The design and management of parking supply affects the livability and walkability of any downtown. Building additional parking without managing the existing supply can induce

driving and increase the demand for even more parking. Conversely, managing the existing supply can be a cost-effective way to reduce demand and increase the attractiveness of underutilized parking spaces. One of any municipality's most pressing challenges for parking is to find the right balance between supply and demand. To better manage scarce public resources, municipalities can seek a more thorough understanding of their parking supply and demand by developing a financial plan prior to incurring significant debt to finance parking garages. The design and management of parking supply affects the livability and walkability of any downtown.

The following are the preferred solutions to street parking:

- Pricing of parking allows a municipality to limit and centralize the amount of offstreet parking while also incentivizing alternative modes of transportation.
- Municipalities can design a "park-once" district that allows employees, visitors, and customers to park once and walk short distances between locations, thereby reducing overall parking demand.
- Another potential solution is to create a transportation demand management program with strategies that increase transportation efficiency by changing travel behavior and parking demand.
- Real-time information can help drivers locate spaces efficiently.
- The ability to add time to a meter remotely would be preferable to getting a parking ticket, and it is more customer friendly.

4.8 Lack of Balanced Spatial Development and Integrated Urban Transport Planning

Spatial Development can be identified as changes in the distribution of activities in space and the linkages between them through the conversion of land and property. Spatial planning

systems refer to the methods and approaches used by the public and private sector to influence the distribution of people and activities in spaces of various scales. Spatial planning can be defined as the coordination of practices and policies affecting spatial organization. Spatial planning is synonymous with the practices of urban planning in the

United States but at larger scales and the term is often used about planning efforts in European countries.[28] Discrete professional disciplines which involve spatial planning include land use, urban, regional, transport and environmental planning. Other related areas are also important, including economic and community planning, as well as maritime spatial planning. Spatial planning takes place on local, regional, national, and inter-national levels and often results in the creation of a spatial plan.[28] This is one of the prominent factors affecting congestion in Asia and West Africa. When there is lack of balanced spatial development it leads to people traveling too far from where they live, there are some social costs associated with using personal transportation. We know for each mile that we drive, society incurs a cost of three or four cents — maybe slightly more — associated with two different forms of pollution. One is greenhouse gas emissions — i.e., carbon that fosters climate change, global warming, and all of that. And the second one is much more localized: small particulates, which could affect people's health.[28]

The preferred solutions are:

- Implement a tax for congestion, where there is concentration of traffic in some areas of a city, make drivers pay for that. Tax carbon emissions by installing toll gates.
- Finding a more effective method and model to localize jobs could be a cornerstone to more sustainable communities. Identifying the aggregate geographic hiring patterns and locating major work centers in optimal locations could alter

transportation patterns, a technique called alternate destination management. A distributed design would engage a greater number of employees in a more familiar office design environment. [28]

- Improving the transportation modes in the country

4.9 Economic Factors/Growth

Economic growth is an increase in the production of economic goods and services, compared from one period to another. It can be measured in nominal or real (adjusted for inflation) terms. Traditionally, aggregate economic growth is measured in terms of gross national product (GNP) or gross domestic product (GDP), although alternative metrics are sometimes used.[30] There are suggestions that higher levels of congestion are initially associated with faster economic growth. But, above a certain threshold, congestion starts to become a drag on growth. Specifically, congestion seems to slow job growth when it gets to be worse than about 35 to 37 hours of delay per commuter per year (or about four-and-a-half minutes per one-way trip, relative to free-flowing traffic). A similar threshold exists when the entire road network gets too saturated throughout the course of the day.[30] Unfortunately, as more people flock to cities, congested roads, expensive commutes, and a lack of reliable transport options are disrupting urban economies and affecting quality of life in Asia and West African cities. Studies suggest that traffic congestion reduces regional competitiveness and redistributes economic activity by slowing growth in country's gross output or slowing metropolitan area employment growth.[30] Traffic congestion and long travel times are undesirable because they affect the economy in these ways:

- Discourage and slow future metropolitan economic growth,
- Increase vehicular emissions,

- Increase fuel expenses,
- Increase operating costs for both private and freight vehicles,
- Decrease economies of agglomeration,
- Shape economic geographies.
- Affect quality of life of people making those commutes which starts to decline.

The solutions to increasing the economy are:

- Reducing traffic congestion through very effective urban/spatial planning.
- Employing effective transport modes.
- Improving the standard of transit buses

4.10 Demand/Traffic Management

Demand/traffic management is the organization, arrangement, guidance, and control of both stationary and moving traffic, including pedestrians, bicyclists, and all types of vehicles. Therefore, it is necessary to have traffic management signals that help in organizing the flow of traffic on the roads. Additionally, they also help in guiding and managing the traffic on various roads which is crucial to prevent accidents and get people where they need to be.

Lack of an effective traffic management causes traffic congestion and a lot of accidents which are prevalent in Asian and West African countries. These result from demand-supply imbalance in the transportation network. Traffic flow slows down when the number of vehicles travel on the road increases, or the roadway capacity decreases due to various reasons.

The solution to reducing congestion is an effective traffic management plan. An effective traffic management plan must include the five pillars of traffic management:

- Traffic Engineering
- Traffic Education
- Traffic Enforcement
- Traffic Ecology/Environment
- Traffic Economy

4.11 Poor Quality of Transportation Modes and Low Capacity of Transport Infrastructure

The first and most important is when the demand for mobility exceeds the capacity of the transport system. Second, when random but predictable events bring about a temporary service disruption, such as an accident or a natural hazard such as flooding. The expected growth of mobility demands is likely to have major impacts on the nature and form of the future transport industry. In the short term, road transport is expected to continue its dominance. There are two primary reasons for this assertion. In the developed world, automobiles and trucks already dominate the market, and the spatial patterns of economic activities are interdependent to the demands of these modes [31]. Such low density, space extensive patterns are pushing the traffic congestion ever further out and make it very difficult for other higher-capacity modes to compete. At the same time, the demand for mobility is growing because of the rapid industrialization in developing economies such as China and India [31]. The economic and social impacts of congestion remain a salient issue, particularly in developing economies where it can impede economic growth and in developed economies where they mainly impair performance and reliability [31]. There are various forms of transportation, but when it comes to freight shipping and transportation of people there are a few main transportation methods: by water, air, rail, and road. Road

transportation is the most popular, the most frequently used, and the most in-demand mode of transportation: it works for everyone. Some of the solutions may include:

- Employing the services of an efficient transportation mode in a city like the following: Public Transit buses, Bus Rapid Transit, Rails, Bicycles, Taxis and Limos.
- Maximizing the use of public transport system – Public transport systems can carry a significant number of trips during congested hours, improving overall transportation capacity, and can release the burden of excess demand on congested road networks.
- Public transport is a cheaper and less stressful option to use to commute from one place to another. Many people shifting to using public transport will help reduce the number of vehicles on the road which will help in reducing traffic congestion.
- The solutions can also be mitigating the effects; an attractive solution is to increase capacity by depending heavily on engineering solutions to design and construct infrastructure.
- Reassess the priorities in the use of infrastructures and provide incentives (or disincentives) particularly in urban areas.
- Provide substantial capital investment required to upgrade the system and maintain its operability most especially in Asia and West African countries.
- Another approach that is gaining momentum is charging for the use of transport infrastructure. For China, the last two decades have seen an impressive level of highway construction with the setting of a national highway network, the longest in the world. Comparatively, the American Interstate highway system is nearing a phase

in its life cycle. While most of the Interstate is publicly funded, almost all Chinese highways were funded by private interests that are using tolls to recover their investments [31].

- Get involved in Public-private partnerships -For many developing economies, this the main option since public finances are usually insufficient for the high level of capital investment required by modern transport infrastructure. Thus, private involvement in the provision of transport infrastructure is to be expected. Several models have already been implemented: BOT (Build-Operate-Transfer), where the private sector builds and operates a facility or system and then transfers it back to the government after an agreed period; BLT (Build-Lease-Transfer), where after building a facility, it is leased for a fixed period and finally transferred back; ROT (Rehabilitate-Operate-Transfer) where the private party refurbishes an existing facility to be operated for a term before being turned back to the state [31].
- Engage in the Reactive, Preventive and Proactive Maintenance model as they apply [32].

4.12 Unreliability of Queue Location and Moments

Another factor which increases congestion is ignorance of the prevailing traffic conditions. If a motorist with a few possible routes for reaching his destination knew that traffic condition was bad on the route he intended to use, he would use alternate route, where his own contribution to congestion would be less. A study of a hypothetical city made in the University of Texas in the United States indicates that the fact of being well informed about traffic conditions in different parts of the road network can reduce congestion much more than such drastic measures as levying charges for using congested streets [32]. Basic

unfamiliarity with the road system can also increase the average distance of each journey and thereby contribute to congestion.

Possible solution to improving road conditions and decreasing congestion is the implementation of Intelligent Transportation System (ITS)

4.13 Rapid Increase in Urban Population

As the size of population grows 1%, the congestion level experienced by drivers will increase from 0.338% to 0.424%. This research found that a 1% increase in population density would increase traffic density by 0.216 to 0.227% among these smaller cities [32]. According to reports the annual cost of traffic congestion in the U.S. was estimated at $121 billion, equivalent to slightly more than 1 percent of all annual US personal consumption. The average American spends about 34 hours every year sitting in traffic.[32] This cost could grow to $186 billion by 2030. The annual cost of traffic congestion in the European Union was estimated to be even higher at 1% of the GDP [32] If you include extra cost of gasoline, air pollution, or even lost property value near roadways, the total cost of congestion would multiply ever further.

Congestion is usually associated with large metropolitan areas, where the land is a highly valuable and scarce resource due to the high concentration of people, activities, and services. Therefore, cities usually demand that road networks consume the minimum but necessary land for cities to function properly with acceptable traffic congestion. One of the important unresolved questions in the analysis of congestion deals with scaling relationship between traffic congestion versus population sizes of cities. For example, do larger cities experience disproportionately greater traffic congestion creating longer delay hours? If the answer is in the affirmative, congestion follows urban congestion penalty. On the other hand, the negative

answer indicates that congestion follows urban congestion advantage. If, however, larger cities experience proportionately longer total traffic delay hours or constant traffic delay hours per person, then, the situation may be designated as linear or neutral urban congestion. Findings supported the idea of urban congestion penalty for the 101 U.S. cities.[32] In other words, among the largest populated cities, traffic congestion experienced per person remains the same, regardless of population size of cities whereas among the smaller cities, traffic congestion per person increases rapidly as the size of population increases.

The answer to the urban congestion scaling relationship may vary by subgroups of cities with different population sizes. Intensive urban growth can lead to greater poverty, with local governments unable to provide services for all people. The trends that exacerbate congestion show no signs of weakening, and most cities have not yet fully articulated the steps they'll need to take to improve. Suggested solutions include:

- These large cities will need to mobilize many of the congestion reduction strategies such as more effective use of public transit, ridesharing, congestion pricing, cycling, walking and many others.
- Comparing the progress of traffic congestion and projecting future congestion targets and strategies, individual cities need to define its peer group of cities carefully by considering population size as well as density and income per capita.
- Involve local community and local government to reduce air pollution using alternative transport systems.

A proactive approach to congestion can be taken by shifting the trajectory of mobility and making cities far more livable, with convenient, clean, and cost-effective mobility solutions.

Public–private collaboration — with a focus on citizen-centered mobility — is an ecosystem-oriented approach that can lead us to a future where we want to live [34].

4.14 Non-Motorized Transportation

Non-motorized transportation (also known as Active Transportation and Human Powered Transportation) includes walking and bicycling, and variants such as smallwheeled transport (skates, skateboards, push scooters and hand carts) and wheelchair travel [35]. Nonmotorized vehicles-bicycles, cycle-rickshaws, and carts play a vital role in urban transportation in much of Asia. Nonmotorized vehicles account for 25 to 80 percent of vehicle trips in many West African and Asian cities [35]. Ownership of all vehicles, including nonmotorized vehicles, is growing rapidly throughout West Africa and Asia as incomes increase. However, the future of nonmotorized vehicles in many Asian cities is threatened by growing motorization, loss of street space for safe nonmotorized vehicle use, and changes in urban form prompted by motorization. Transportation planning and investment in most of Asia has focused on the motorized transportation sector and has often ignored nonmotorized transportation. Without changes in policy, nonmotorized vehicles use may decline precipitously in the coming decade, with major negative effects on air pollution, traffic congestion, global warning, energy use, urban sprawl, and the employment and mobility of low-income people. As cities in North America, Japan, the Netherlands, Sweden, and several other European nations demonstrate, modernizing urban transportation requires not total motorization, but the appropriate integration of walking, nonmotorized transportation, and motorized transportation. As in European and Japanese cities, in which a major share of trips is made by walking and cycling, nonmotorized vehicles have an important role to play in urban transportation systems throughout Asia in coming decades.

Transportation investment and policy are the primary factors that influence nonmotorized vehicle use and can influence the pace and level of motorization. Japan, Sweden, Denmark, and the Netherlands have witnessed the major growth of bicycle use despite increased motorization, through policies providing extensive bicycle paths, bicycle parking at or several decades offered employee commuter subsidies for cyclists, cultivated a domestic bicycle manufacturing industry, and allocated extensive urban street space to nonmotorized vehicle traffic. This strategy reduced the growth of public transportation subsidies while meeting most mobility needs.

Today, 50 to 80 percent of urban vehicle trips in China are by bicycle, and average journey times in China's cities appear to be comparable to those of many other more motorized Asian cities, with favorable consequences for the environment, petroleum dependency, transportation system costs, and traffic safety [35]. Bicycles are the predominant type of private vehicle in many West African and Asian cities. Bicycle ownership in Asia is now more than 400 million and growing rapidly. Bicycle ownership in

China and West African countries increased more than 50-fold in the last twenty (20) years. In many Chinese cities, bicycle ownership rates are one bicycle per household or more. In India there are roughly 25 times as many bicycles as motor vehicles, and urban bicycle ownership is growing at a fast pace. Most of the world's 3.3 million cycle-rickshaws and goods tricycles are· found in Asia in West Africa. Tricycles are used majorly in West Africa and Asia for public transport system to meet transportation need. Although, nonmotorized vehicles form the foundation for a large informal sector providing goods or services on the street or transporting people and goods on a for-hire basis they constitute nuisance or traffic congestion when not properly managed. Solutions employed by various cities include:

- Develop modal separation in corridors of high traffic flow.
- Engage in complete street design.
- Employ proper and constant maintenance of the sidewalks, trails, and bike routes.
- Institute comprehensive networks of bicycle-safe roads and paths needed to attract less-skilled cyclists to use the bicycle for a significant share of their short daily trips in motor vehicle-dependent cities and to avoid the diversion of cyclists to motorized modes in mixed-traffic and nonmotorized transportation-dependent cities.
- Consider the important factors in nonmotorized vehicle facility planning which includes continuity, facility standard and function, degree of separation of modes, anticipated traffic flows by mode, and available rights-of-way.
- Classify highways and evaluate their spacing which is equally useful in planning and designing cycle networks as part of the concept of network functional hierarchy

4.15 Driver Behavior, Lack of Education, Non-Adherence to Traffic Regulation, Lack of Driver's License.

The behavior of those who use the public roadways, be they drivers or pedestrians, has varying degrees of influence on congestion and safety. The steady growth of roadway use led to the establishment of rules of play, traffic regulations or standards, with a view to defining rights and restrictions on the use of streets and thus improving the flow of traffic as well as preventing accidents.[35] Unfortunately, many people are unaware of these rules or choose to ignore them. A lack of driving discipline or consideration for others in fact reduces the capacity of the road network to a fraction of its potential. Trying to gain a few seconds by violating the rules governing traffic at intersections or on streets seriously disrupts other

vehicles' movement, translating into heavier congestion and, unfortunately, a greater risk of accidents.

Pedestrians must also obey the rules of the road, crossing streets only at the times and places designated for that purpose. Driver and pedestrian behavior absolutely must improve. There are drivers who show little respect for other road users. In big cities especially in Asia and West Africa, many drivers try to cut a few seconds off their journey times by forcing their way into intersections and blocking the passage of other motorists, thus causing economic losses to others which are much greater than their own gains. In other countries such as US, it is a tradition for buses to stop immediately before an intersection, thereby causing congestion (and accidents).

In big cities in Asia and West Africa, as in others that have an excessive number of taxis that do not habitually operate from fixed taxi stops, these vehicles crawl along looking for passengers, and this also gives rise to congestion. In addition to these practices, the traffic flows also often include old and poorly maintained vehicles, as well as some drawn by animals most, especially in Asia. One assumes, when the traffic flow resumes after being stopped at a traffic light, a form of congestion ensues because vehicles with a normal rate of acceleration are held up by slower vehicles located in front of them. Obviously, a vehicle which is stopped or moving sluggishly seriously affects the smooth flow of traffic, since in effect it blocks a traffic lane.

Another major cause of traffic congestion is road safety which is critical to the socioeconomic agenda of nations across the world. Concerns about road traffic collision have been on the front burner of many countries, particularly developing countries, where road safety issues are compounded not only by an increase in population but also by inadequate

road infrastructure and ineffective safety policies and transportation systems [35]. It is estimated that about 1.35 million people around the world are killed by road collision annually, with an additional 50 million people sustaining various degrees of injury or disability [36]. The socioeconomic effect of road traffic collision (RTC) is enormous. Road traffic crashes account for 1%, 1.5%, and 2% of gross national products in developing countries, transition economies, and highly motorized countries, respectively [36]. The world-wide cost of road traffic collision is estimated to be US$ 518 billion annually, and RTC and injuries globally are projected to rise by 65% between the year 2000 and 2020 [36]. However, in low- and middle-income economies, deaths resulting from RTC are projected to rise by 83% [36]. Road traffic collision is generally classified as a human-induced disaster, which is on a very rapid increase, complex, and influenced by multidimensional factors [36]. Amongst all identified determinants and factors of RTC, human behaviors or actions appear to be the predominant factors [35].

About 90% of RTC cases and injuries occur in developing countries, and 12 countries in sub-Saharan Africa are listed in the top 20 RTC-prone countries for cases and casualties [37]. Increasing populations and booming socioeconomic growth activities coupled with a rise in the number of vehicle ownership in several West African nations account for the alarming rates of RTC [34]. The rate of death through RTC per every 100,000 people is highest in Africa with 24.1 deaths per a 100,000 population [34]. These alarming statistics advances the topic of adequate and effective road safety policies and transport systems, which have both social and economic implications for national and regional concerns.

Ghana, one of the most populous countries in the Western Africa region after Nigeria, has an estimated population of over 28.83 million [15]. Statistics indicate that six people die

daily on Ghanaian roads due to road traffic collision, and over 230 million dollars are lost yearly due to collision pertaining to road, leading to approximately 1,600 deaths [32]. In 2001, Ghana recorded 73 deaths per 1000 collision, making it the second highest road traffic collision-prone nation among six West African countries [18]. Statistics from the National Road Safety Commission (NRTC) shows that Ghana loses about 1.7 per cent of its Gross Domestic Product every year to road collision in addition to the loss of lives [32].

Solutions include:

- There must be driver education in school curricula, educational campaigns in radio and television spots or advertisements directed towards the public at large, driving schools, the requirement that a certain number of hours of supervised driving practice be carried out before obtaining a license, and more stringent driving exams.
- Some noteworthy initiatives have been launched in Brazil, such as using mimes to teach people how to cross the street at designated locations and playing folk or popular songs that teach the rules of the road at places where crowds congregate.
- Another interesting innovation in Chile involves setting up uniformed student patrols to show classmates how to travel properly on the streets when going to and from school.
- Improving the safety standards of roads such as the designing junctions, installing guardrails, marking spaces and crossings for pedestrians, and road lighting.
- Road construction and maintenance are to be improved.
- There must data collection on collision for purposes of future improvement, research, and implementation of various policies.

4.16 Institutional Problem

In almost all Asian and West African cities, the deterioration in traffic conditions has been significantly worse than it could and should have been, partly because of inappropriate actions by the corresponding authorities. It is obvious that the problem has clearly overtaken the institutional capacity to deal with the situation. So far, the reaction of the authorities has only been of a "I don't care" nature, because in virtually the two regions the responsibility for urban transport planning and management is split up among a host of bodies, including various national ministries, regional governments, municipalities, suburban train or metro companies, the traffic police, etc.[39] Each of these does what it considers to be most appropriate, without taking much account of the repercussions on the interests of the other institutions. There are buildings constructed with no regards for other authorities and no planning for traffic detour. There are consequences of decisions taken without coordination and without considering their broader repercussions. There is lack of coordination between street parking and private parking which encourages people to come downtown in their cars. This set of measures fosters increased congestion. Furthermore, strong pressures are exerted by organized groups, such as transport interests, as well as by politicians, who put forward their own points of view and sometimes take up arms on behalf of interests, which complicates the situation still further.

Solutions include:

- Urban transport should be handled in an integral, technical manner, instead of measures being taken separately by each institution or in favor of sectoral interests.
- Make it mandatory for a nation like Nigeria to construct, built, and invest in roads and to ensure their proper utilization and maintenance.

4.17 Environmental Pollution

Vehicular congestion and atmospheric pollution are two major problems that plague modern cities, especially in developing countries. The two have causes in common - Congestion is produced by the operation of motor vehicles on streets and avenues of limited capacity. Pollution is produced because contaminant emissions, of which vehicles account for a large percentage, exceed the absorption and dilution capacity of the basin in which the city is located. Pollution has an impact on public health, harm to vegetation and ecosystems, damage to materials and reduced visibility which leads to congestion. Motor vehicles that operate on internal combustion engines produce three types of contaminant emissions, in general: exhaust pipe emissions, evaporative emissions, and dust raised from the street.

Potential solutions include:

- There should be transport policies and measures designed to reduce congestion in a city that will also influence air pollution.
- Design speed limits are important to each relative area.
- Design of vehicles to reduce emission.

Chapter 5

Government Working in Collaboration with Private Sectors to Improve Road Network in Nigeria.

The Nigerian government in the past was not involved in collaboration with private partnership due lack of vision by previous leaders. This led to transport infrastructures lacking many functions. This dissertation discusses the role Nigeria is currently playing in the Public-private-partnership sector.

5.1 Lack of Adequate Transport Infrastructure Due to Government Mismanagement and Effects on the Country

Public-private partnership (PPP) is a tool that helps governments leverage the expertise and efficiency of the private sector, raise capital, and spur development. They also help allocate risk across the public and private sectors to where it can best be managed and ensure that resources are widely distributed in addressing the most urgent development needs [40]. This dissertation strongly advocates for a strategic public-private partnership relationship at ensuring a sustainable urban transportation in Nigeria.

The state of transportation in Nigeria can be classified into five major modes – Roads, Rail, Water, Air and Pipelines. Financing Nigeria's infrastructure gap presents a formidable challenge. The World Bank estimates it will require approximately US$110bn, approximately $20bn for power, $16bn for rail, $14bn for roads, and $60bn for oil and gas. Even considering this optimistically, Nigeria will not have adequate resources and public savings to meet these needs [39]. However, channeling private capital through publicprivate

partnerships (PPPs) can help to bridge this shortfall, as well as improving project delivery and operation by applying private sector discipline [39].

The relevance of an integrated approach for achieving long-lasting relationship in urban transport management and controls is extremely important. With strong political commitment and clear objectives and priorities; the appropriate mix desired for attaining efficient mobility in Nigeria's urban system would be ensured. However, there is a strong recommendation that Government should concentrate on legislation, regulation and creating conducive environment. Government should forge partnerships with the private sector and other stakeholders in policy formulation, reform, and implementation.

The contribution of the transport sector to the economy of Nigeria, if considered by the GDP, tends to have stagnated or declined at about 3% of GDP in the last twenty years due to poor maintenance, bad designs, lack of experience by government officials, bad policies etc. [38]. The road transport sub-sector accounts for more than 90 percent of internal passenger and freight movement in Nigeria. It was estimated that the nation's road network has an asset nominal replacement value of one trillion, eight hundred and fifty billion Naira (N1,850 billion) in 1995 [38]. Unfortunately, it has declined over the course of the years due to majorly poor government management, unfavorable exchange rate and relative prices of imported used vehicles and lack of road rehabilitation and routine maintenance which has led to a lot of road accidents and high fatalities. In addition, funding provided by entities escalated the prices of new vehicles and their spare parts, resulted in mobility crisis in rural areas where commercial motorcycling has become rampant despite their poor safety records. Rural access roads throughout the country are in very deplorable condition; they are owned

and managed by the local government who are at least financially incapable of maintaining them.

All these problems coupled with others caused a need to provide and manage transport to help in maintaining the continuous survival of the country's transport infrastructure. These issues call for functional management objectives and policies that could yield a public-private partnership framework in Nigeria's urban transport system.

Nigeria's road network falls into three categories, the trunks A, B & C owned and managed by Federal, State and Local Governments, respectively. The state of road transportation in Nigeria is beyond deplorable. It will take a lot of PPP to get Nigeria's transport infrastructure to an acceptable level. The total length of public roads in the nation's network is about 200,000 kilometers with local roads at 75% poor state of paved road. Details of the distribution and their conditions are given in [Table 5].

During road construction, provision was unfortunately hardly made for its maintenance needs due to lack of funding or funding source. Developing the capacity for planned program maintenance and a stable maintenance framework remained largely unchanged from the pro-independence period with continuing reliance on government funding even in the face of its dwindling financial resources and competing demands from the other sectors of the economy.[38]

Table 5 - Pavement Conditions in Nigeria

Type of Pavement	Federal	State	Local Govts.	Total
Paved Trunk Roads	26,500	10,400	-	36,900
Unpaved Trunk Roads	5,600	20,100	-	25,700
Urban Roads	-	-	2 1,900	21,900
Main Rural Roads	-	-	72,800	72,800
Village Access Roads	-	-	35,900	35,900
Total: Kms	32,100	30,500	130,600	193,200
Percentage	17	16	67	100

Paved Roads			
	Good	Fair	Poor
Federal Roads	50%	20%	30%
State Roads	30%	30%	40%
Local Govt. Roads	5%	20%	75%

Unpaved Roads			
	Good	Fair	Poor
Federal Roads	6.0%	56.6%	37.4%
State Roads	7.0%	49.5%	43.5%
Local Govt. Roads	4.2%	38.4%	57.4%

Source: Road Vision 2000 Steering Committee Information Brochure, Pp. 4 Transport in Nigeria in 2020.

The failure to reform the existing system to meet the present-day realities and challenges has put this country's considered investments in roads in jeopardy to the point where less than 50% of the national road network today is in good or fair condition and the road assets are estimated to be suffering an annual loss of value of about $80 billion per year due to lack of maintenance. Road users suffer an additional vehicle operating cost of $53 billion per year due to poor condition of the roads [38].

The above total annual financial loss of $200 billion per annum represents about 5.5% of Nigeria's Gross Domestic Product (GDP) since 1994. When these losses are added to the economic costs from road accidents, loss of productive man-hours etc., arising from poor condition of the road network, it becomes clear that the situation needs urgent attention.

It is very clear that government alone cannot adequately undertake the funding of transport services. Therefore, the need for policies aimed at improving the performance of the country's road sector is evident [38]. A critical assessment of the current mobility status, transport, and communication policies in Africa in general and Nigeria in particular shows high level of undesirable results. The following deficiencies are inherent in the existing policy and its implementation:

- Weak implementation and enforcement procedure
- Lack of multi-modality, integration, coordination, and optimum utilization of all existing modes, with less transport – induced environmental degradation
- Corruption and indiscipline
- Environmental deficiencies and conflicting responsibility among different levels of government over land-use controls
- Lack of data and management information
- Obsolete transport rules, regulations, and laws
- Energy crisis – fuel scarcity
- Lack of professionalism - manpower, human and institutional capacity building, and utilization in mobility
- Poor macro-economic climate
- Less consideration of socio-cultural, economic and citizens' participation.
- Lack of measurement of transport impacts on the environment
- Less involvement of the private sector in transport and communication project financing and management
- Inadequate and unstable sources of funding/of financing

- Inadequate institutional and legal framework for transport and communication management
- Technological constraints – research and technology
- Government sponsored transport activities have been beset by these vices' corruption, mismanagement, dependence on treasury funding, poor services, arrogance, and insensitivity, parasitism, and inequities
- Very low standard of social infrastructure in most African countries.[39] The general economic downturn or recession globally has made it difficult if not impossible to make significant investment endlessly without management and control consciousness on the transport sector. In another dimension, the urban mobility situation in Nigeria can be described as near immobile not because there are no vehicles, rather due to traffic congestion and traffic hold-ups vis-à-vis street trading and general absence of offstreet parking infrastructure and facilities [39]. In addition, intermodal transport development is weak. In the case of Nigeria, vehicles for urban movement cannot be described as available. Many vehicles and buses in use are in complete state of disrepair, rickety and unduly overloaded with passengers [39] In addition, the numbers of vehicles available in the country are even too low to cope with passenger demand. Again, the globalization of the world through information technological changes, and improved management information systems, pose serious treats and problems for Nigeria to cope with especially when considering the pace at which the entire world is responding to the technological and information dynamics.

There is need to establish a transport policy through which five (5) sustainable transport modes could be pursued and achieved. The National Transport Policy for Nigeria summarized the Nigeria transport system functioning in a crisis. There exists abundant evidence that the nation's transport system and the transport management, approaches, procedure have not been able to achieve the policy objectives set out in the National transport policy.[38] Public sector provision of goods and services has been almost a total disaster in many parts of Nigeria, due to the culture of poor management that has become the hallmark of such activity. This poor management culture has been exhibited in the following key areas of public sector economic management:

- Inadequate or conflicting objectives,
- Poor human resources management,
- Lack of strategic planning,
- Lack of expertise in technical management,
- Weak capital structures of public enterprises,
- Poor and inadequate systems and procedure,
- Poor debt management,
- Persistent loss making, Inappropriate tariff (or pricing) policies
- Absence of the audit culture, accountability, and transparency [39]

5.2 Privatization

Various options exist for privatizing or for private sector participation in the transportation sector. A long-term vision is to achieve transport infrastructure, which is sustainable for health and the environment, which meets the needs of the present without endangering the

ability of future generations which can be referred to as sustainable mobility.[39] The following listed strategies must be promoted and advocated for:

- Create livable cities sensitive to disadvantaged groups – aged, disabled, children and women.
- Increase public and non-motorized transport infrastructures.
- Employ the use of alternative fuels such as the hydrogen fuel cells for the propulsion of buses and trains.
- Information Technology (IT) systems giving buses and trams priority at traffic lights should be deployed.
- Maintain fair prices on automobile.
- Encourage the use of public transport, walking and cycling; to reinvent safe, attractive streets for walking and cycling.
- Political will and public acceptability democratization.
- Encourage the support of major African financial institutions in the development of the private sector in Nigeria.
- Stabilize African economies in the context of the current liberalization and globalization of trade and commerce that are sweeping across the globe.

A legal framework should be put in place to ensure policy continuity for private sector participation in transport. This framework should include the following components:

- Creation of a National Roads Board and Road Fund Board to manage transport infrastructure.
- Introduction of user charges as a sustainable funding source.

- Appropriate monitoring, control, and evaluation mechanisms, as well as checks and balances to ensure that corrective measures can be taken quickly to keep the project on track before resources are wasted.
- Modernization of the roads and road rehabilitation, railways, and waterways.
- Encourage development policies towards local fabrication of parts and subsequent development of a Nigerian car in the nearest future.
- Human resource development must be accorded prime position especially in engineering and management discipline.
- Restructuring of the railway organization and ensuring adequate resource allocation.
- Revisit Air services operation with a view to encouraging private Nigerians and foreign participation in air transport business as there are enough airports and passengers to warrant investment in this area.
- Establish a Technical Committee representing major stakeholders in the industry to assist in policy making for the transport section.

The Lekki-Epe Toll Road Concession Project (see figure 4) which was the first-ever PPP Toll Road Project in Nigeria commenced in 2000 for a cost of $430million. The project was financially closed in 2008 and handed over back to Lagos state government in 2017 [41]. The concession agreement involved:

Figure 4 PPP Lekki-Epe Toll Road Concession Project https://goo.gl/maps/UTGwyUhCTVQ2Z5Pm8

- To design, rehabilitate, construct, operate, maintain, and toll the existing 49.5km Epe

  Expressway (which widened and rehabilitated as Phase 1 of the project)

- The introduction of three toll plazas (with a maximum 22 lanes/plaza)
- To build a 20km coastal road which will be an expressway running parallel to the existing road (as Phase 2 of the Project; and
- To build the Southern Bypass [41].

Although, traffic congestion was reduced along this corridor there are congestion at the concession booths which defeats the purpose of constructing the expressway. There are possible alternative choices to reduce congestion at this tool booth as follows:

- Mode Choices - Carpool/Vanpool, Transit, Non-Motorized Departure
- Time Choices – Choose time of Day or Day of Week that there is not heavily traffic.
- Route Choices - Alt. Roadway Routes, Alt. Mode Routes Trip Reduction Choices and Telework.
- Provide toll incentives to users.
- Provide I Pass for people to buy toll fees on the internet.

- Separate Truck from Car lanes at concession booths.
- Lastly, if the options are not possible, Lagos State government should consider demolishing the concession booths to create a free flow of traffic to address the original intent.

Recently, in 2019 the present federal government of Nigeria in furtherance of its commitment to infrastructure development, being a key growth driver and economic development enabler, Issued the "Companies Income Tax (Road Infrastructure Development and Refurbishment Investment Tax Credit Scheme)". This will enable

- Private companies to finance construction or refurbishment of federal roads designated as "Eligible Roads" under the Scheme and recoup their investments by utilizing the approved total costs expended on the Eligible Roads
- Use as a tax credit against the annual Companies Income Tax payable by such private companies in the corresponding year of assessment. With the introduction of the tax credit, the Federal government recently commenced the procurement process of 12 highways to the private sector under the Public Private Partnership, PPP, scheme.

The concessions arrangement attracted investments of over N1.134 trillion ($2.2billion). Hopefully this helped mitigate the challenges in the transport section.

The 12 highways selected for the pilot scheme include the Benin-Asaba, Abuja-Lokoja, Kano –Katsina, Onitsha-Owerri-Aba, Shagamu-Benin, Abuja-Keffi-Akwanga, Kano-Shuari, Potiskum-Damaturu, Lokoja-Benin, Enugu-Port Harcourt, Ilorin-Jebba, Lagos-OtaAbeokuta, and Lagos-Badagry-Seme. The Highway Development and Management

Initiative (HDMI) was created in March 2021 by federal ministry to develop and manage the federal road network through sustainable private-sector investment. Their goals are to:

- Maximize the use of assets along the right of way.
- Facilitate further development of Nigeria's federal highway network
- Bring in investment to improve efficiency, accountability, and profitable entrepreneurship to the operation, management, and maintenance of all assets within the Right of Way on the highways.

These new PPP will help hopefully mitigate the challenges in the transport section.

Government's Investment in Multimodal Transportation that will Reduce the Demands on Road Transport in Nigeria.

Multimodal Transport Systems (MMTS) are developed to explore and coordinate the use of two or more modes of transport for speedy, safe, pleasant, and comfortable movement of passengers in urban areas. Transportation plays a key role in the economic and social development of any nation. A well-functioning transport system stimulates national development, allows unhindered movement of goods and services, and allows vital links with facilities among others. Multi– modal transportation framework includes the mass transport modes of travel primarily classified as follows:

- Rail based Modes (Metro Rail Corridor, Light Rail Transit, Monorail, and Integrated Rail cum Bus Transit, etc.)
- Road based Modes (Regular Buses, Minibuses, Double Decker Buses, Articulated Buses, Express Buses, Trolley Buses, etc.)
- Marine Services (ferry service) • Inter modalism more important than multiple modalism.
- Airways services
- Pipelines

The Presence of MMTS in metro cities like Lagos, Ibadan, Enugu, Port Harcourt, Kaduna, and Kano would greatly enhance accessibility, economic growth, public health, environmental protection, security and safety, social cohesion, etc. It is desirable for these State governments to establish a single authority for planning, development, implementation, and enforcement of the policies regarding development and operations of MMTS. The growth of any nation's economy is tied implicitly to the level and efficiency of its public

infrastructure, principal amongst which is transportation. It is therefore imperative for every progressive nation to have a functional and efficient transport system, which is available and accessible to all despite age, tribe, geographic location, or financial capacity. In a bid to achieve this, many countries develop regulatory frameworks to intervene in the operation of the transport sector. This intervention is carried out by fixing or controlling tariffs, profits, regulating market entries or exits and ensuring the maintenance of fair and competitive practices across the transport sector.

Prior to now, the regulation of the Nigerian transport sector had been at sub-sectoral levels with multiple regulatory agencies controlling different constituents within the market. The absence of an economic regulator has therefore encouraged anti-competitive behavior such as exercise of dominant power leading to disproportionate tariffs. The different transport modes rail, road, water, and air have specific advantages and uses hence the overall efficiency of the transport system depends on the development of these modes. There has been an evolution of a modern transport system in Nigeria; the networks of road, rail and water were built to meet the exportation of agricultural produce and the post-colonial era where with the discovery of petroleum, it became an instrument of unification and an important tool of social and economic development [42]. In Nigeria today goods and passenger movement are performed by road while water, rail and air played a significant but less important roles. Recent developments including a national transport policy shows that the Federal government plans to establish an integrated transport system that will ensure effective connection between ports, rails, roads, inland waterways, and air thereby making use of the advantages of different modes to ensure seamless movement of goods. The idea of restructuring the ports which is also in tandem with the economic policy of the Nigerian

government is to grow an economy that is robust, private sector- driven, locally, and globally competitive and efficient.

The federal government is promoting stronger private sector involvement in search of a solution. A major aspect of the transport system is the fulfilment of the presidential initiative project which is essentially geared towards linking all the six geopolitical zones on dual carriage way. Also, a lot of work has been done in the aviation sector as evidenced in absence of air accidents. The Railway Amendment Bill that is presently before the National Assembly was passed into law five years ago.[42] The prompt passage of the bill opened the rail transport sub sector for the participation of the private sector. Financial resources of the Federal Government have been invested in the rehabilitation of the railway. Progress and success are recorded which includes contract award of Lagos-Jebba track rehabilitation, daily arrival of heavy-duty civil engineering equipment and immediate mobilization to sites of the contractor, China Civil Engineering construction (CCEC).

The Nigerian Ports Authority is committed to being the hub of West and Central Africa and every effort has been channeled to connecting the Ports to the Railways. This will permanently improve speedy clearance of cargo and free the burden on one mode of transport, roads [42]. As an interim measure of freeing the roads pending the establishment of an integrated transport system and completion of major rail works that are in the pipeline, the Federal Government has in various occasions and each successive year set up committees to decongest the port [42]. While these efforts yielded results in the interim a much more enduring solution is being sought because while cargo traffic is increasing in Nigerian Ports only road transportation is in existent and the bad roads are not helping matters [42]. These are efforts to ensure speedy delivery of cargo, including:

- Remedial works for Tin Can Island Service Lane has been completed while the Rehabilitation of Access Road to Kirikiri Phase 1 Apapa is ongoing.
- The rehabilitation of access roads to the Lilypond container terminal –remedial works on the existing carriageway and Rehabilitation of Port Harcourt Road are in progress.
- Very recently after about six years of delay, the Nigerian Ports Authority (NPA) has finally commenced construction of the all-important 1.6 kilometers port access road at the Apapa wharf.
- The Capital Dredging of Lower River Niger has been completed while maintenance dredging is on-going.
- The Onitsha Port was also commissioned to assist inland waterways [43].

The Nigerian Ports Authority recognizing the role of effective intermodals also initiated several road projects within the port areas. These are additional efforts by the Nigerian Ports Authority to complement the numerous road projects being undertaken by the Federal Government in building a virile transport system.

6.1 Summary of Challenges and Solutions

The future of transport infrastructure in Nigeria can be efficient and effective if the following challenges can be addressed:

- Lack of adherence to city master plans which sometimes results in encroachment into existing and future right-of-way especially for roads and railways.
- Absence of basic transport infrastructure/hubs where road, railway and marine systems are interconnected to ease movement of passengers.
- Multiple Agencies that coordinate and supervise transport service operations.

- Multiple Jurisdictions (overlap of sub-national and national transport operation laws).
- Multiple modes (motorized and non-motorized competing for usually unplanned transport corridors)
- Multiple transportation professional disciplines being responsible for various aspects and creating confusion / disorderliness.
- Growing transport demand due to rapid urbanization – Inadequate public transport and increasing use of personalized vehicles.
- Lack of institutional co-ordination among agencies belonging to different levels of Government.
- Inter modal integration.
- Increased trip lengths/travel time
- Lack of integration of land use and transport planning
- Lack of financing
- High and increasing number (in many cities) of road fatalities.
- Poor air quality
- Network inadequacies
- Largely unorganized urban transport industry.
- Increasing level of congestion and pollution (rising levels of carbon emission) affecting the environment [42].

The following solutions can bring immediate relief to traffic congestion in big cities:

- Implement an Urban Transport Policy – Focusing on the mobility of people rather than of vehicles).

- Reduce travel demand by encouraging integration of land use and transport planning and sustainable transport solutions.
- Encourage investment in public transport systems and provide facilities for nonmotorized modes, capacity building and greater involvement of the private sector
- Set up a city level metropolitan transport Authority and a dedicated urban transport fund at the state level.
- Change in bye laws and master plan of cities to integrate land use and transport by densification along with stations and setting up of a regulatory mechanism to periodically revise fares for all public transport systems.
- Provide human resources and capacity enhancement.

Chapter 7

Traffic Congestion in Ibadan – Causes and Solutions

(Sango Eleyele- Sango Ojoo Intersection)

The city of Ibadan is in the South-western part of Nigeria, it has a population of over 3 million people and ranked as the third largest city in Africa. Ibadan is the capital of Oyo state. The city of Ibadan is a major transport hub with freeways liking it. Regional commercial vehicles connect Ibadan to all major towns in Southwestern Nigeria, including Abeokuta, Ife, and Oyo. Commercial buses also connect the city to the northern and eastern part of the country. Ibadan has an airport which operates daily flights from some parts of the country including Lagos and Abuja (Capital), it is served by domestic carriers only. The city used to be a major terminus railway station linking Lagos in the south with Kano in the North of the country.

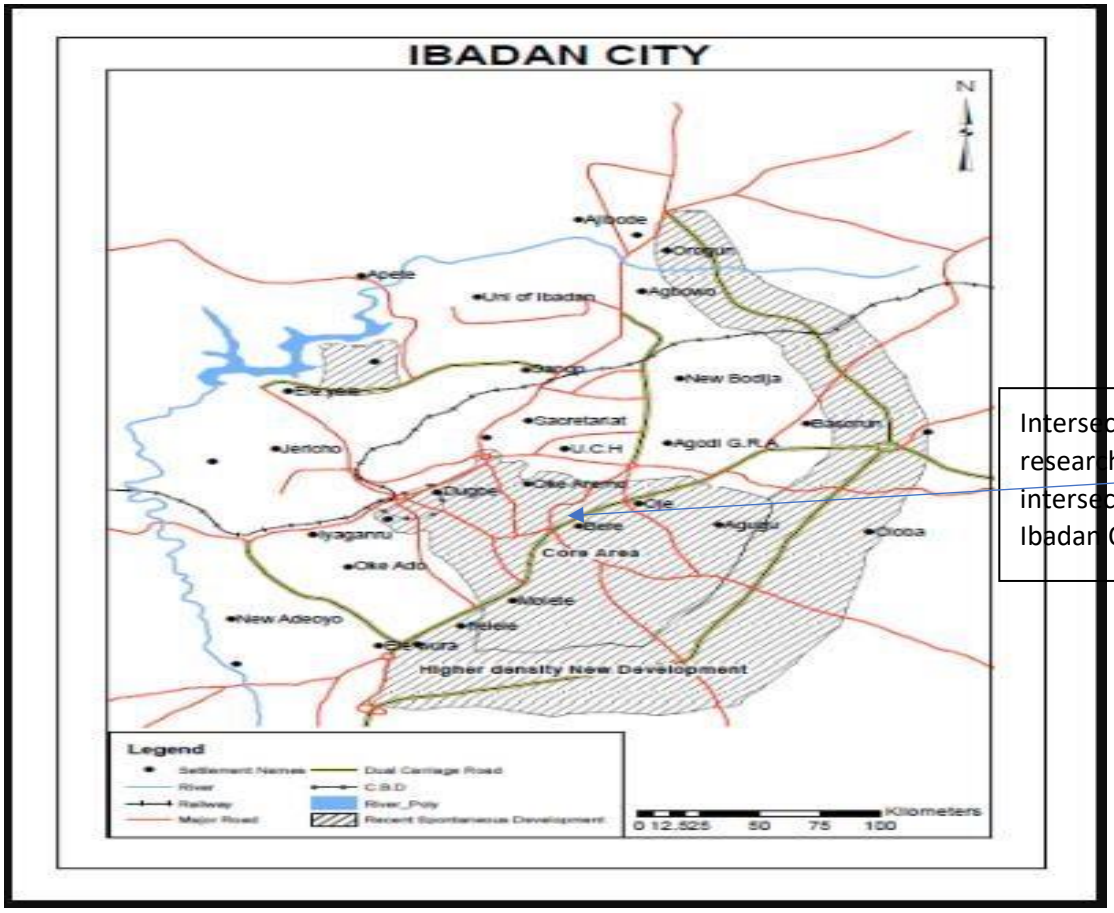
Modes of transport include, cabs & taxis, taxi-vans commonly called *Danfos*, and in more recent times mass transit buses have commenced operations to reduce the hardship of students and workers commuting from

various suburban areas to the city center. There are other modes of transportation like private, personal, family cars, and scooters commonly known as *Okadas*, coach (bus) services, more commonly known locally as "luxurious busses" such as *Alakowe Bus*, which operate services linking Ibadan and all other major destinations in the country and beyond,

as well as the common pedestrian walking. The intersection under research is one of the major intersections in Ibadan. It conveys a major arterial for over thirty miles within the city from where it enters the city from the south to leaving the city in the north to the expressway towards the northern part of the country. Figure 5 depicts location of Ibadan in Nigeria. Figure 6 reflects the route from the south to the north passing the intersection

under research and showing the transport modes. Figure 7 depicts how Ibadan is regionalized.

Fig 5 Location of Ibadan in Nigeria



Intersection under research – Polytechnic intersection, Sango Ibadan Oyo State.

Figure 6. Location of Intersection under research

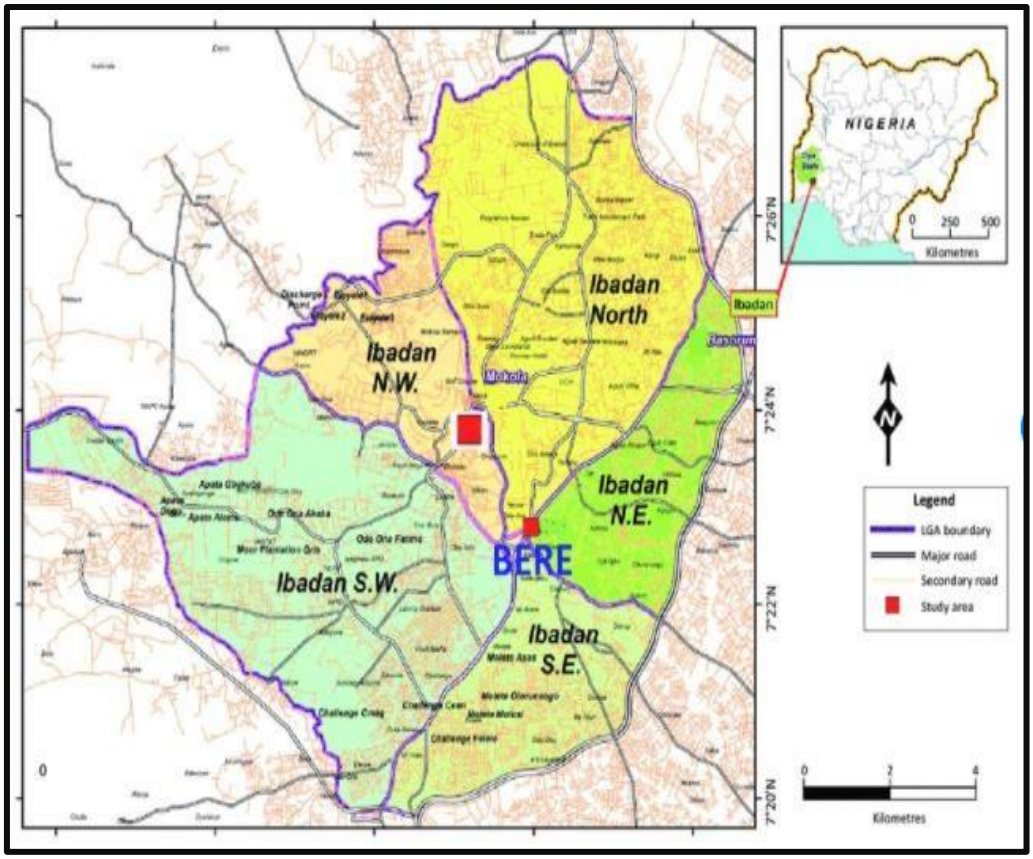


Figure 7. Regional Areas of Ibadan

Traffic congestion is one of the major problems facing Ibadan City in Nigeria. It is attributed to a lot of factors including rapid population increase, inadequate and poor road infrastructure, city structure, rapid increase in number of cars and lack of infrastructure plan and a controlling city development. The government is already implementing strategies to minimize traffic congestion. However, many of the strategies are focusing on improving the capacity of roads in terms of increasing number of lanes, proposing new overpasses and underpasses at the main road intersections and improving public transport. These strategies cannot fully overcome the congestion problems in Ibadan on their own unless efforts are made to redistribute services and community infrastructure. The latter can be achieved through physical planning, which has the potential of influencing trip generation and travel

patterns and traffic volume in specific roads. Therefore, to minimize traffic congestion in Ibadan both strategies for improving road capacity, public transport and physical planning solutions ought to be applied together. This dissertation attempts to determine causes of traffic congestion at the intersection of Sango Ojoo and Sango-Eleyele Intersection in Ibadan, Oyo State Nigeria and recommending mitigation solutions to the traffic congestion. The inadequacies of the intersection are reflected in the pictures in Figures [8-15] depicting the normal operation of the intersection daily, including weekends. The pictures below reflect the factors affecting the intersection; bad roads, reckless driving, U-turns, hustlers and touts, peddlers or lack of traffic signs, parking on public access, gas station, nonenvironmental appealing roads, sidewalk encroachments, lack of design etc.

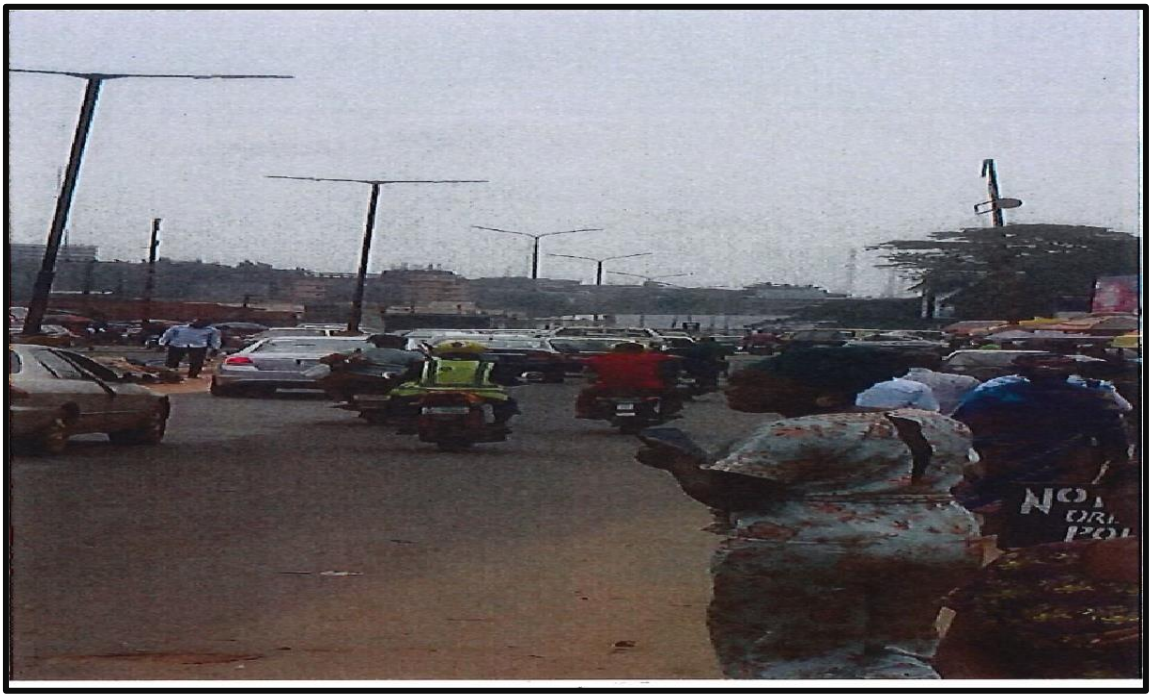


FIG 8 Lack of pavement Markings and Hawking on the street

FIG 9 Garbage on the Median fallen on the street and the Railway Crossing

FIG 10 Garbage all over the Median, Railway Crossing

FIG 11 Pedestrians Crossing the road, Dug out Median

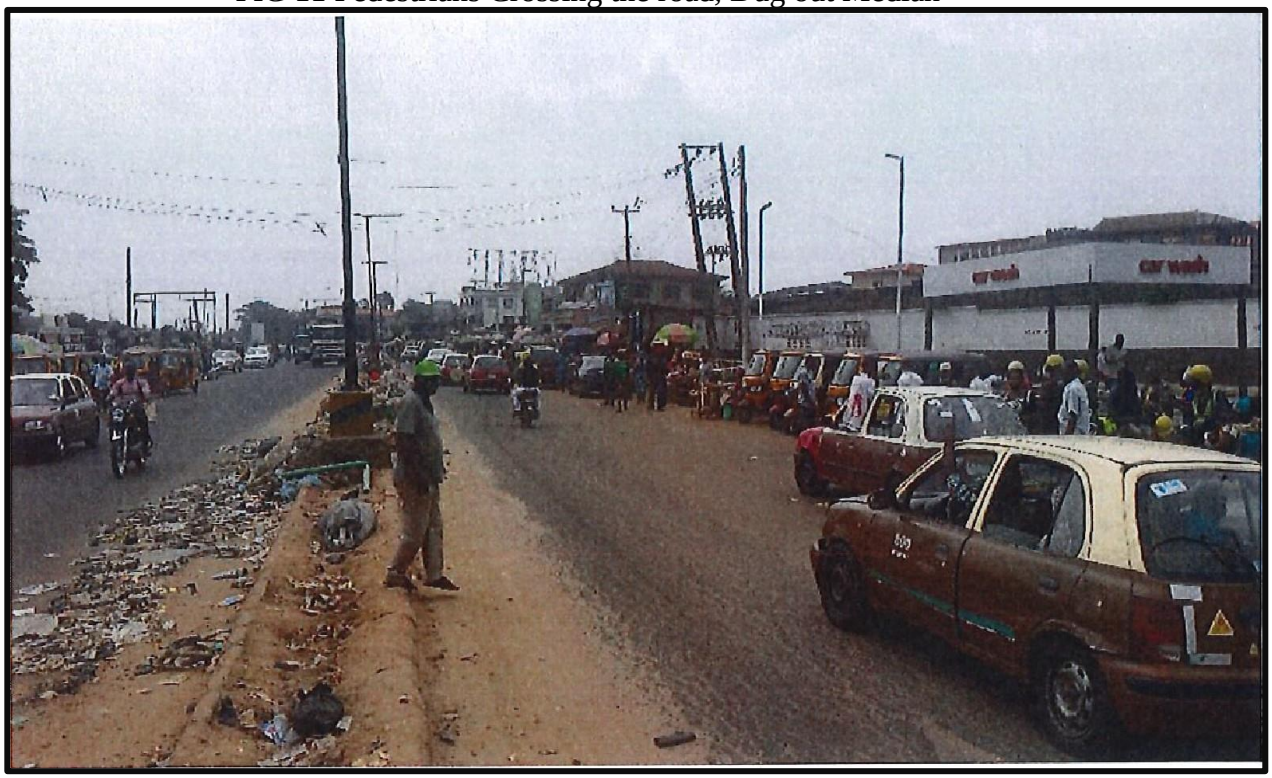


FIG 12 Garbage all over the road and Pedestrian Crossing

FIG 13 Motorcyclists occupying the third lane, Gas station with no Demarcated Entry, Electric Poles all over the intersection

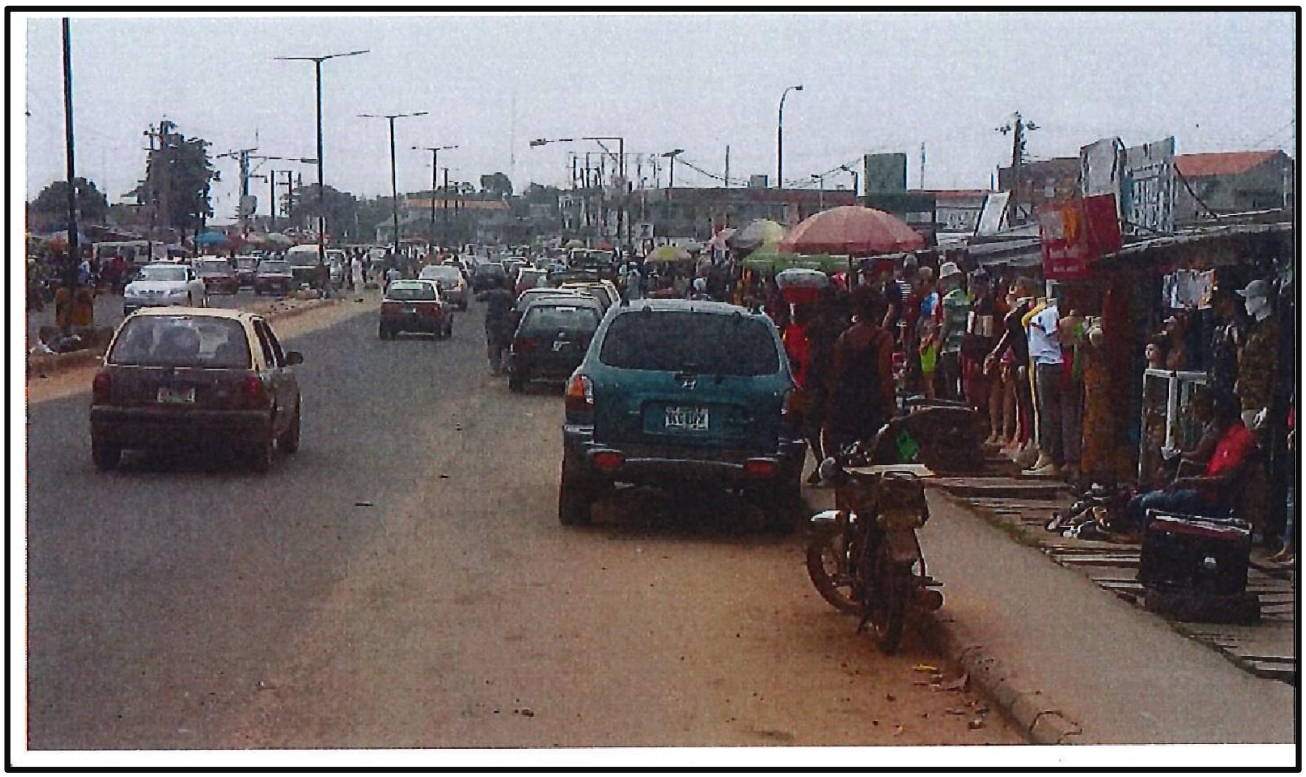


FIG 14 Third lane used as Parking Lane, Narrow Sidewalk

FIG 15 Street Hawkers, damaged sidewalk

The pictures above reflect the factors affecting the intersection; bad roads, reckless driving, U-turns, hustlers and touts, peddlers or street trading, railroad, lack of traffic signs, parking on public access, gas station, non-environmental appealing roads, encroaching on sidewalks, lack of design etc. A survey was conducted to develop quantitative data, evaluating the major problems causing congestion in this intersection. A survey of 150 road users was used to determine factors affecting the intersection and a survey of 200 road users to provide input into the ranking of the important factors. Survey results are presented in Table 6 and a ranking of the factors collected given in Table 7.

Table 6A – Factors Affecting the Intersection

	FACTORS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Total	Ranking
1	Bad Roads	1		1		1		1						1					1			6	
2	Over Population					1			1										1			3	
3	Too many car owners								1													1	
4	Indiscipline and reckless driving/U-Turns	1	1	1		1	1	1	1	1	1	1	1		1	1	1	1	1	1		17	4
5	Hustlers and Touts	1	1	1	1		1		1	1	1	1		1	1	1	1	1		1	1	16	5
6	Street Trading or Peddling	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	20	1
7	Market Proximity	1		1	1	1		1	1			1										7	
8	Railroad					1																1	
9	School Proximity			1																		1	
10	Road Rage		1		1		1			1	1	1	1	1	1	1	1	1	1	1	1	15	6
11	Accidents	1	1		1	1	1	1		1	1	1	1	1	1	1	1	1		1	1	17	4
12	Avoidance of Robbery																					0	
13	Lack of road signs	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	20	1
14	Road Expansion – Narrow roads		1	1		1	1		1	1	1		1	1			1		1	1	1	13	7
15	Vehicle Failure – Maintenance	1	1		1	1	1	1		1	1	1	1	1	1	1	1	1		1	1	17	4
16	Unauthorized parking in Public	1	1	1	1		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	19	2
17	Limited transportation Modes				1								1		1	1		1	1		1	7	
18	Non-Licensed Drivers	1	1		1		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	18	3
19	Gas Station at Intersection			1				1														2	
		10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	200	

Table 6B – Top ten most important factors affecting the intersection

	MAJOR FACTORS
1	Lack of road signs
2	Street Trading or Peddling
3	Unauthorized parking in Public Access
4	Non Licensed drivers
5	Indiscipline and reckless driving/U-Turns
6	Accidents
7	Vehicle Failure – Maintenance
8	Hustlers and Touts
9	Road Rage
10	Road Expansion – Narrow roads

The survey conducted on this intersection reflected some of the problems causing congestion. The following are the causes and the mitigation solutions:

7.1 Street Trading or Peddling, Hustlers & Touts

Street trading is a form of squatting that involves perpetual movement that may occur within established marketplaces or around road intersections which results in several negative impacts on physical environment such as traffic congestion, environmental pollution, and on aesthetically unpleasing environment [48]. The trading and peddling of goods on these streets, as reflected in the pictures, disrupts the normal flow of traffic, usually by physical impedance in the travel lanes. In addition to blocking travel lanes physically, drivers and passengers tend to buy goods from peddlers thereby slowing down traffic and causing congestion. The selling of goods on the shoulders, sidewalks or roadsides also influences traffic flow by distracting drivers, leading to changes in driver behavior and

ultimately degrading the quality of traffic flow.

. Mitigation - The recommendation is to provide trained traffic wardens who will fine people encroaching the driving lanes and install barricades along the shoulders to prevent peddlers from entering the streets to ensure better traffic flow. These arears should also be developed to enhance trading off the roads and build cheaper shopping complexes and lastly

provide better waste management at this intersection.

7.2 Unauthorized parking in Public Access

Illegal on-street parking is one of the primary reasons why major city centers like Ibadan face progressively worsening traffic conditions. This intersection has a major problem with illegal parking by taxis, motorcycles, tricycles, and market customers. Most drivers remain blissfully ignorant of parking rules and regulations and have no qualms blocking access of other vehicles with haphazard parking. Inadequate and poorly managed

parking facilities often force vehicle owners to illegally park on the streets. When such parking encroachments spill over to sidewalks, they wreak havoc on pedestrians' lives too.

The oncoming traffic is obstructed by the parked vehicles, resulting in a traffic hold ups. Often this road experiences heavier traffic than the road' s capacity. The absence of lawmakers and enforcers make situations worse in that they not only cause traffic congestions, but they often lead to vehicle accidents at this intersection.

Mitigation - Even though government aims to exercise foresight while planning and developing the city, they often overlook facilities such as paid parking. In addition, they also underestimate the vehicular density on this corridor. The lapse in consideration of such vital elements contributes towards traffic jams. A parking structure can effectively curb" the problem with affordable parking cost. Ibadan city government must educate vehicle owners of the importance of responsible and paid parking. Parking is not a right but a privilege one needs to pay for. There is also a need for expansion of roads of this intersection to handle the volume of traffic from the south.

7.3 Non- Licensed Drivers

In the last few decades, developing countries such as Nigeria has experienced a rapid increase in population and number of vehicles which led to an increase in the number of accidents and traffic congestion caused by people lacking driver's license. This situation is no different in Ibadan where drivers typically have had no instructions on how to drive and have not studied traffic rules. It is apparent to the travelling public that lack of driver's license/training is prominent among both private and public vehicle drivers in Ibadan. There continues to be lack of lane discipline, disregard to traffic laws, frequent traffic violations,

increase crashes and of course traffic congestion which is prominent in this intersection. Although the data didn't capture the percentage of drivers without a driver's license, the poor driving skills of the drivers is evidence of lack of driver's license. It is rather unfortunate

that the requirements to get a driver's license are at a minimum and drivers still refused to get a driver's license. Unfortunately, law enforcement officers are bribed by drivers and allowed to drive on these streets.

Mitigation - The benefits of driving instruction is no longer just to impart knowledge and techniques, but also to put across the social and ethical values, in other words to inculcate

behavioral patterns and attitudes which are no less significant in reducing accident risks than the actual driving- skills themselves [49]. Improved driver skills can be ensured through better driving education, driver training and licensing procedures along traffic enforcement by hiring traffic wardens. The hiring of traffic wardens will also be an aid to reducing some of the unemployment problems in the city.

7.4 Indiscipline, Reckless Driving, and Illegal Turns

The basic goal of any transportation system is to provide safe mobility. It becomes apparent that the concept of road safety be seen in a more serious light in Ibadan. The lack of disciplined drivers, reckless driving and illegal U-turns contributed immensely to traffic safety and congestion in. this intersection. Due to lack of segregation with pavement marking; the same road space is used by motorized and nonmotorized traffic, thus creating

unsafe conditions for the road users and eventually leading to traffic congestion.

Mitigation - Road safety depends on the drivers' good judgment and a reduced willingness to take risks, which, like most habits, develop over time. Anything that improves road safety for all drivers improves safety for young drivers. Some strategies are designed specifically for young drivers to limit exposure to risk while they are developing good judgment and safe driving habits. Since these habits are mostly exhibited by young drivers it will be prudent for the government to engage in driver's education training, learner's permit that are extended for a period, allowing adults to be passengers in these vehicles, a requirement of a minimum of a suggested 100 hours of supervised driving and prevention of phone texting during driving. The enforcement of traffic laws will also bring about the reduction of road congestion and increased traffic safety.

7.5 Accidents and Vehicle Failure

Although some progress has been made over the past several years on improving safety on some of Ibadan's major arterials highways, the frequency and severity of crashes continue to be of concern. Identification of the factors associated with crashes has also continued to be of major interest to government officials. A better understanding of the factors associated with crashes enables engineers to identify and implement effective countermeasures to reduce crash occurrences. Studies suggest that variations of crash rates as they relate to hourly traffic volumes, geometric characteristics, average speed, and standard deviation estimate changes in crash characteristics because of the combined effects of changes in speed, and geometric characteristics. According to Table 8, the monthly Road Safety report

from Federal Road Safety Corps (FRSC) on Ibadan major roads, some of the factors contributing to accidents that lead to traffic congestion along this corridor include driver behavior, driving under influence, over speeding, distraction, bad roads, and lack of vehicle maintenance etc.

Table 7 – FRSC Monthly Safety Data Report

S/N	DATE	TIME (HRS)		ROUTE	VEHICLE	PROBABLE	NUMBER INJURED					NUMBER KILLED					PEOPLE INVOLVED				
		CRASH	RESPONSE		CATEGORY	CAUSE(S)	ADULT		CHILD		TOTA	ADULT		CHILD		TOT	ADULT		CHILD		TOTAL
		TIME	TIME			OF RTC	M	F	M	F		M	F	M	F		M	F	M	F	
a	c	d	g	h	l	s	t	u	v	w	x	y	z	aa	ab	ac	ad	ae	af	ag	ah
1	1/1/2020	0432HR	0003HRS	IBD-IFE	CAR/M-CYCLE	WOV/LOC	1	0	0	0	1	0	0	0	0	0	2	0	0	0	2
2	1/1/2020	0545HR	0011HRS	IFE-IBD	TRUCK/BUS	ROB/SPV	3	1	0	0	4	2	1	0	0	3	5	2	0	0	7
3	1/1/2020	1320HR	0012HRS	OYO-IBD	CAR/M-CYCLE/M	DGD	2	1	0	1	4	1	1	0	0	2	4	2	0	1	7
4	1/1/2020	1655HR	0001HRS	ELE-IWO RD	BUS/CAR	DUI	1	0	0	0	1	0	0	0	0	0	1	0	0	0	1
5	1/2/2020	1030HR	0003HRS	IBD-OYO	BUS	TBT	3	2	0	0	5	0	0	0	0	0	9	5	0	0	14
6	1/2/2020	1210HR	0003HRS	IFE-IBD	M-CYCLE	SPV/LOC	1	0	0	0	1	0	0	0	0	0	1	0	0	0	1
7	1/2/2020	1732HR	0010HRS	IFE-IBD	TRUCK	SPV,LOC	0	0	0	0	0	1	0	0	0	1	2	0	0	0	2
8	1/3/2020	1709HR	0011HRS	OYO-IBD	BUS	MDV	1	2	0	0	3	0	0	0	0	0	10	8	0	0	18
9	1/3/2020	1400HR	0007HRS	OGB-IKOYI	TANKER	BFL,LOC	0	0	0	0	0	0	0	0	0	0	3	0	0	0	3
10	1/4/2020	1000HR	0005HRS	IBD-LAG	BUS/TRUCK	DGD (HIT & RU	0	2	0	0	2	0	0	0	0	0	6	3	0	0	9
11	1/4/2020	1420HR	0006HRS	IBD-IFE	M-CYCLE/CAR	SPV/TBT	7	6	0	0	13	0	0	0	0	0	10	5	0	0	15
12	1/5/2020	1630hrs	0004HRS	OGB-ILR	CAR	MDV	2	1	0	0	3	0	0	0	0	0	4	2	0	0	6
13	1/6/2020	1010HR	0015HRS	IBD-OYO	BUS	MDV	3	3	0	0	6	0	0	0	0	0	10	8	0	0	18
14	1/6/2020	2320HR	0005HRS	OYO-IBD	TRUCK	SPV/LOC	1	0	0	0	1	1	0	0	0	1	1	0	0	0	1
15	1/10/2020	1210HR	0006HRS	LAG-IBD	CAR	SPV,LOC	2	2	0	1	5	0	0	1	1	2	2	2	2	1	7
16	1/11/2020	1110HR	0009HRS	IBD-LAG	TRUCK	SPV,LOC	1	0	0	0	1	0	0	0	0	0	2	0	0	0	2
17	1/12/2020	1109HR	0008HRS	LAG-IBD	TRUCK/M-CYCLE	RTV	0	0	0	0	0	1	0	0	0	1	4	2	1	1	8
18	1/13/2020	0920HR	0010HRS	IBD-ABK	M-CYCLE	WOV	1	1	0	0	2	0	0	0	0	0	1	1	0	0	2
19	1/13/2020	1700HR	0005HRS	IFE-IBD	BUS	SPV,LOC	0	2	0	0	2	0	0	0	0	0	8	5	0	3	16
	1/13/2020	1201HR	0016HRS	OYO-IBD	TRUCK/BUS/BUS/	BFL,LOC	7	3	1	1	12	1	0	0	0	1	20	8	4	3	35
20	1/14/2020	0835HR	0007HRS	OYO-OGB	TANKER/TRUCK	TBT	0	0	0	0	0	0	0	0	0	0	4	0	0	0	4
21	1/15/2020	0800HR	0000HRS	OYO-OGB	TRUCK	SPV,LOC	1	0	0	0	1	0	0	0	0	0	1	0	0	0	1
22	15/1/2020	1000HR	0005HRS	IBD-LAG	TRUCK	DGD	9	0	0	0	9	1	0	0	0	1	10	0	0	0	10
23	16/1/2020	1205HR	0001HRS	OYO-IBD	CAR/BUS	DGD,SOS	1	0	0	0	1	0	0	0	0	0	6	13	0	0	19
24	16/1/2020	1445HR	0015HRS	OYO-IGB	BUS/BUS	RTV,LOC	4	0	0	0	4	0	0	0	0	0	36	0	0	0	36
25	16/1/2020	1935HR	0011HRS	OGB-OSH	TRUCK/TRUCK	SPV,LOC	2	0	0	0	2	1	0	0	0	1	2	0	0	0	2
26	17/1/2020	1900HR	0005HRS	IBD-LAG	BUS	SPV,LOC	5	7	2	2	16	2	1	0	0	3	7	8	2	2	19

COMM– Commercial PVT – Private
GOVT – Government M-CYCLE – Motorcycle
DGD – Dangerous Driving SPV – Over speeding
LOC – Loss of Control RTV – Route violation
TBT – Tire Burst OVL – Overloading
WOV – Wrongful Overtaking DUI – Driving under influence
MDV – Mechanically Deficient Vehicle BRD – Bad Road

Mitigation - Accidents and vehicle failures are correlated as they relate to traffic congestion in Ibadan, its environs and most especially at this intersection. This intersection can witness an average of ten vehicle inferences per hour between accidents and vehicle failures. The delay

caused while waiting for the right towing vehicles to clear the problem vehicle(s) and the resultant traffic detours amount to a staggering billions of Naira loss each year. The government is encouraged to set up some towing vehicles along this route and maintain awareness of traffic wardens at this intersection.

7.6 Road Rage

This is an aggressive or angry behavior by a driver of an automobile or other motor vehicle. Such behavior might include rude gestures, verbal insults, deliberately driving in an unsafe or threatening manner, or making threats. Road rage can lead to altercations, assaults, and collisions which result in injuries and even deaths. It can be thought of as an extreme case of aggressive driving [49]. Road rage crosses all levels of drivers irrespective of gender in Ibadan and most especially at this intersection. However, it is predominant among commercial drivers that depend on driving as their source of income. Some start altercations that lead to getting out of vehicles and start physical fights. These aggressive behaviors lead in many ways to traffic congestion because the two drivers are in the middle of the driving lane and care less about the vehicles behind them. These aggressive behaviors often lead to some drivers and passengers going to emergency hospitals when the altercations are between a vehicular driver and a motorcyclist. They eventually leave their vehicles in the middle of the roads thereby causing traffic congestion for a period until they are towed or moved.

Mitigation - The enforcement of traffic laws will also bring about the reduction of road congestion and increased traffic safety. The Government should start to fine drivers when they engage in aggressive driving and coming out of cars to start brawling coupled with towing of vehicles for fees to return the vehicles to the owners. The other

recommendations are defensive driving courses, insurance reduction/incentive courses and suspended license courses.

Mitigation recommendations on major causes also captures most of the minor problems affecting the intersection or the corridor. However; the combination of other minor factors; bad roads, over population, too many car owners, school proximity and avoidance of robbery can also be a major problem at this intersection if not addressed along with the major ones. It is very difficult to ignore the fact that this major intersection as well as a few other ones have major problems that must be addressed as soon as possible.

Chapter 8

Design of Poly Intersection

It has been established through several surveys that this intersection is subgrade due to several human factors. In addition, engineering factors that are lacking include among many, pavement marking, type of intersection, safety, pedestrian crossing, railway crossing, traffic lights, curb and gutter, sidewalk encroachment, access control. The Level of Service (LOS) along this corridor is F during peak hours according to sample Figures 16a & b.

FIG 16a – Typical Level of Service

Levels of service	Vehicle flow states	Average vehicle speed	V/C
Level A	Driving smoothly	>48km/h	0≦V/C<60%
Level B	Stable vehicle flow	>40km/h	60≦V/C<70%
Level C	Stable vehicle flow	>32km/h	70≦V/C<80%
Level D	Less stable vehicle flow	>24km/h	80≦V/C<90%
Level E	Unstable vehicle flow	≈24km/h	90≦V/C<100%
Level F	Traffic congestion	<24km/h	≧100%

FIG 16b – Level of Service (Volume/Capacity numbers)

Figure 17 reflects the current design of the corridor: unfortunately, the third lanes along the corridor has been turned to parking lanes.

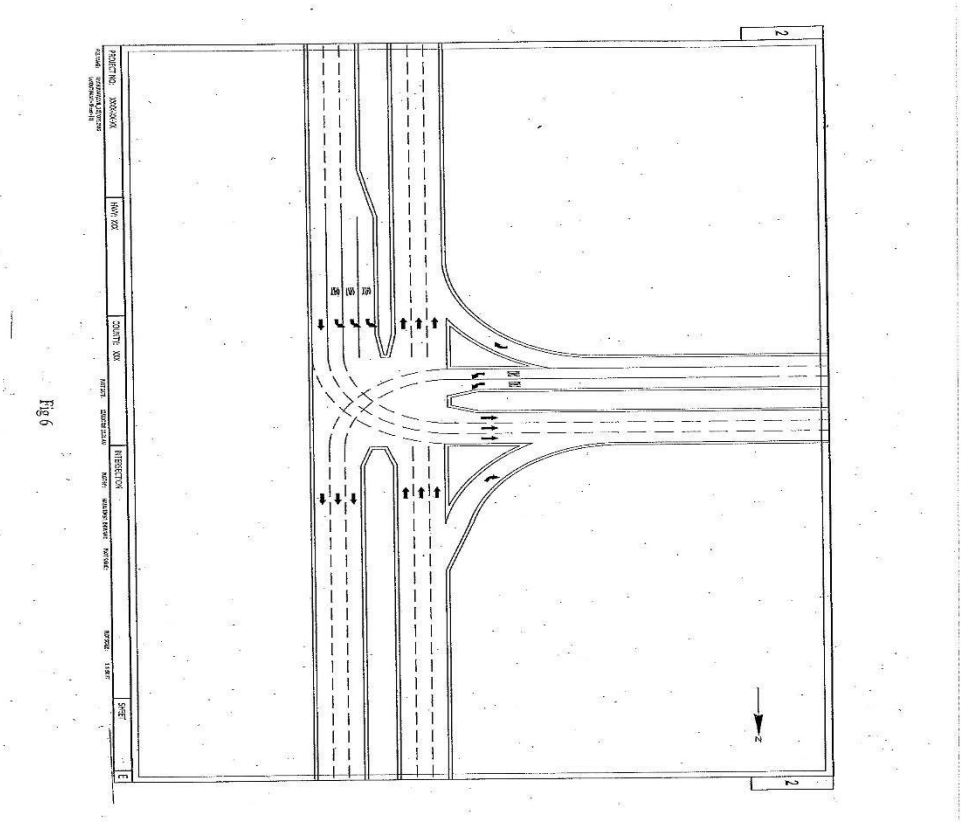


Fig 17 – Current Design of Sango Ojoo and Sango Eleyele Intersection

Traffic counts were done by six men at all six corners of the intersection at the same time. Results are shown in Table 8. These traffic counts were done for two weeks consecutively between the peak hours of 7:00 am to 10:00 am and 3:00 pm – 7:00 pm from Tuesday to Thursday when the corridor had the highest traffic volume. The results of the traffic count were analyzed, using the Wisconsin highway traffic control manual. In Table 9, the result of the traffic count was used to determine Level of service (LOS) through volume capacity ratio (V/C) and peak hour factor (PHF) method in the Wisconsin Highway Capacity Manual (HCM). The equation used that was computed is as follows:

$$vi = Vi/PHF$$

Where vi = demand flow rate of movement i (veh/h)

Vi = demand volume for movement i (veh/h)

PHF = Peak Hour Factor

The level of service is typically used to determine congestion in a corridor; level A is usually an expressway/highway with free flow of traffic and no congestion, while level F depicts flow of traffic is restricted and congestion is very high. The recommended LOS for this intersection is C.

Table 8 Sample Traffic Counts on the intersection

Traffic Count at Poly Junction - Ibadan				
Thursday 11/28/19	Cars/SUVs	Total	Trailers or Vans	Total
7.00-7.15		106		2
7.15-7.30		164		1
7.30-7.45		216		2
7.45-8.00		203		1
8.00-8.15		218		1
8.15-8.30		208		0
8.30-8.45		170		1
8.45-9.00		186		3
9.00-9.15		169		1
9.15-9.30		158		0
9.30-9.45		156		1
9.45-10.00		162		3
3.00-3.15		160		3
3.15-3.30		146		4
3.30-3.45		168		6
3.45-4.00		165		7
4.00-4.15		140		8
4.15-4.30		141		10
4.30-4.45		139		6

4.45-5.00		162		7
5.00-5.15		158		9
5.15-5.30		139		8
5.30-5.45		165		7
5.45-6.00		143		6
6.00-6.15		132		7
6.15-6.30		146		6
6.30-6.45		97		4
6.45-7.00		72		3

Table 9 – Highway Capacity Safety Analysis

HCS7 Roundabouts Report

General Information		Site Information	
Analyst		Intersection	
Agency or Co.		E/W Street Name	Sango Eleyele Road
Date Performed	12/18/2019	N/S Street Name	Oyo Road
Analysis Year	2019	Analysis Time Period (hrs)	0.25
Time Analyzed	PM Peak Hour 3:00-4:00	Peak Hour Factor	0.94
Project Description	Tuesday	Jurisdiction	

Volume Adjustments and Site Characteristics

Approach	EB				WB				NB				SB			
Movement	U	L	T	R	U	L	T	R	U	L	T	R	U	L	T	R
Number of Lanes (N)	0	1	0	1	0	0	0	0	0	1	1	0	0	0	2	0
Lane Assignment	L		R						L		LT		T		TR	
Volume (V), veh/h	0	824		408					0	1133	408		0		408	213
Percent Heavy Vehicles, %	5	5		5					5	5	5		5		5	5
Flow Rate (v_{ro}), pc/h	0	920		456					0	1266	456		0		456	238
Right-Turn Bypass	None				None				None				None			
Conflicting Lanes	2				None				2				2			
Pedestrians Crossing, p/h	100								150				120			

Critical and Follow-Up Headway Adjustment

Approach	EB			WB			NB			SB		
Lane	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass
Critical Headway (s)	4.6453	4.0000					4.0000	4.0000		4.6453	4.0000	
Follow-Up Headway (s)	2.6667	2.8000					2.8000	2.8000		2.6667	2.8000	

Flow Computations, Capacity and v/c Ratios

Approach	EB			WB			NB			SB		
Lane	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass
Entry Flow (v_e), pc/h	920.00	456.00					912.66	809.34		326.18	367.82	
Entry Volume veh/h	876.19	434.29					869.20	770.80		310.65	350.30	
Circulating Flow (v_c), pc/h	456			2642			920			1266		
Exiting Flow (v_{ex}), pc/h	0			1504			1376			912		
Capacity ($c_{e,x}$), pc/h	887.43	924.95					661.58	661.58		421.22	515.29	
Capacity (c), veh/h	786.83	820.09					616.90	616.90		401.16	490.76	
v/c Ratio (x)	1.11	0.53					1.41	1.25		0.77	0.71	

Delay and Level of Service

Approach	EB			WB			NB			SB		
Lane	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass
Lane Control Delay (d), s/veh	89.4	11.9					213.2	147.2		37.6	27.2	
Lane LOS	F	B					F	F		E	D	
95% Queue, veh	24.6	3.2					39.7	29.2		6.5	5.7	
Approach Delay, s/veh	63.7						182.1			32.1		
Approach LOS	F						F			D		
Intersection Delay, s/veh | LOS	111.7						F					

The intersection was analyzed using the Highway Capacity Safety Calculation software to analyze and calculate how many lanes of roundabout. Civil3D, a design graphics software

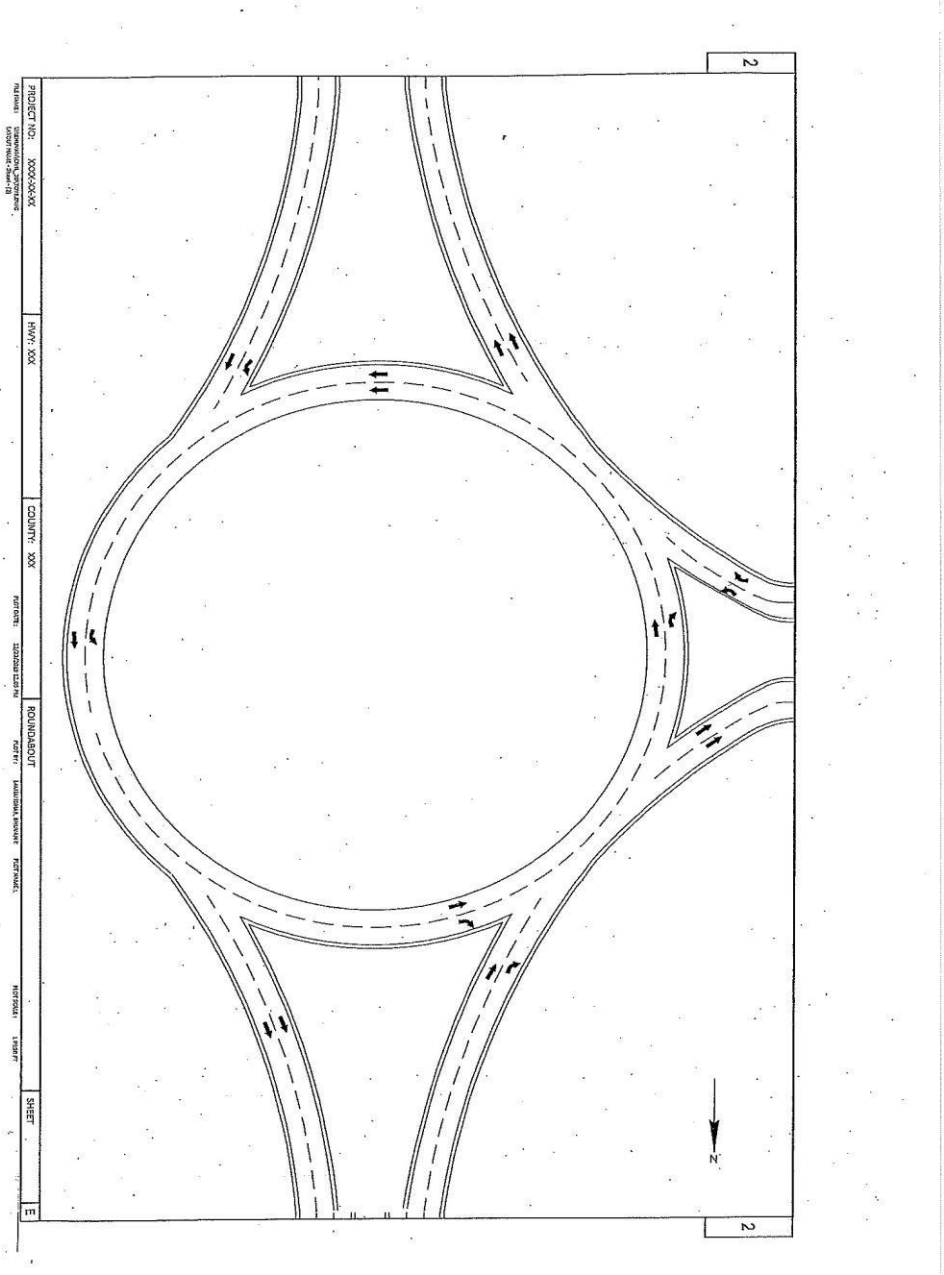


Fig 7

was used to design the roundabout as the recommended alternative for the intersection. Figure 18 depicts the recommended roundabout based on the software analysis of Table 9

FIG 18 – Recommended alternative for intersection (Roundabout)

The following are engineering improvements recommended on the intersection based on design factors on intersections:

8.1 Pavement Markings to Communicate Information to Road Users.

Pavement markers provide continuous information to road users related to the roadway alignment, vehicle positioning, and other important driving-related tasks.

Mitigation – To aid in the reduction of crashes at this intersection, pavement markings are highly recommended to reduce crashes or crash rates. In addition, enhanced pavement markings that are more retroreflective are recommended due to visual and cognitive deficiencies. Older and impaired drivers are especially susceptible to rear ended types of crashes that are common in this intersection.

8.2 Safety

Traffic safety in this intersection can be divided into two areas. The corridor experiences traffic safety concerns from pedestrians and peddlers who cross the roads without regard for the drivers/vehicles. The second safety concern is mixture of engineering and human factors: drivers fighting for right of way especially between the taxi drivers, private owners, motor cyclists and tricyclist.

Mitigation – There must be an increase in enforcement officers deployed to this intersection. Pavement marking must be done to demarcate the lanes to determine who has right of way.

8.3 Pedestrian Crossing

This problem is prominent in any major intersection in Ibadan because most major intersections have markets close to them. The peddlers come out of the markets to sell since the customers will not have access to them due to lack of parking. This has become one of the major causes of congestion in this intersection.

Mitigation – Employing the services of enforcement officers will have some impact but a major impact is installing fences along this corridor and directing pedestrians to cross at the intersection.

8.4 Railway Crossing

There is an abandoned railway crossing that is half a mile south of this intersection. The railway track is not functioning and has potholes along the roadway. This causes all vehicles to slow down.

Mitigation - The railway track should be removed, and potholes repaired.

8.5 Traffic Lights

This intersection is lacking traffic lights as the same applies to almost all the intersections in Ibadan. The city continues to deal with lack of electricity and the government is not doing that much to improve this situation.

Mitigation -This is a difficult since there is lack of electricity, making it hard to recommend traffic lights. Presently, the feasible solution is to install traffic lights that are solar enhanced. A future solution is to change the intersection to a roundabout.

8.6 Curb and Gutters as a Drainage System for Stormwater Runoff

Curb and gutters hold the pavement in place and collects runoff from paved streets, preventing the erosion of roadside shoulders and adjacent slopes. The drainage system in this area is terrible. When it rains, the intersection is flooded, and traffic congestion increases.

Mitigation – A redesign of the corridor which will accommodate water runoff and prevent flooding at the intersection will improve traffic flow during rain in the corridor. It is also recommended that the gutters along the corridor be properly maintained.

8.7 Sidewalk Encroachment

Figures 12, 14, 15 16 clearly reflect that most of the sidewalks are encroached by sellers, forcing pedestrians to walk on the streets. Most of the time, there is a mixture of pedestrians using roadsides instead of using sidewalks. Mixing pedestrians on the roadside along with motorcyclists, tricyclists and other vehicles is a disaster waiting to happen. This intersection experiences countless accidents between pedestrians and vehicles every day because of this encroachment.

Mitigation – There is a need for more effective persuasive enforcement of rules, legislation, and regulation in Ibadan most especially in this intersection. Separation of pedestrians from vehicles is a major factor that can reduce congestion in this intersection, as earlier recommended installing fences at the right places along the corridor should be the order of the day.

8.8 Access Control

Access control is generally referred to as the regulation of interchanges, intersections, driveways, and median openings to a roadway. It is also important on minor roadways for safety considerations such as driver sight distance. This intersection has very limited access control. The shops are right in the faces of drivers along the sidewalks, the commercial motorcycles and tricycles are parked on the streets waiting for riders. The gas station has too much access where drivers can drive into the gas station from any side without restrictions.

Mitigation – There must be legislations that address access control. Coupled with enforcement along this corridor to prevent people from violating these regulations.

8.9 Traffic Control

Traffic control is a critical element in the safe and efficient operation of any transportation system. Elaborate operational procedures, rules and laws, and physical devices (*e.g.*, signs, markings, and lights) are but a few of the components of any traffic control system. Traffic control signs can prevent road congestion and accidents on the roads and in parking lots. Traffic signs are designed to help improve safety on our streets and highways, making it easier for drivers to understand and follow the rules of the road and navigate to their destination. In an ideal world, regulatory and warning signs should help to improve the flow of traffic, reduce accidents, and ensure that pedestrians can safely use designated crosswalks. The failure ofgovernment to provide and maintain traffic signs to guide road users through the local roads and highways in Nigeria is the major cause of road accidents and traffic congestion in Nigeria and most especially in Ibadan. The depiction of the pictures reflects lack of traffic control in this intersection as it is in a lot of other intersections in Ibadan, Nigeria.

Mitigation - Provision and maintenance of traffic control signs present opportunity to promoting safety on the highways and achieving the sustainable development goals. The application of Manual on Uniform Traffic Control Devices (MUTCD), Intelligent Transportation System (ITS), warning systems and active speed warning signs should be deployed in the streets of Ibadan. In addition, road names and directions should be installed, and speed limits posted.

8.10 Road Expansion and Bad Roads

The sporadic expansion of Ibadan's population and limited modes of transportations has brought about the major traffic congestion in major arterial inter sections in the last thirty years. It is a frustrating experience that people at times prefer to walk a two-mile distance instead of taking a taxi or driving their cars. However, it is apparent in this intersection that

road users care less about traffic laws: they turn the intersection into parking lots, peddlers use, store fronts etc. The pictures reflect pedestrians are always at this intersection and in the vicinity of the intersection anytime. Most people don't use the intersection to cross to the other side. The traffic count reflects a maximum of 4470 Vehicles/Hour (veh/hr) and average of 2500 veh/hr during the peak period. Based on the counts, one can estimate that an average of 45,000 vehicles pass through this intersection every week. The pedestrian count was very difficult because the pedestrians were not using the intersections. The average pedestrian count along the corridor within 2000 ft of each intersection is 1100 ped/hr. The three-lane road has been turned to two lane road and a parking lane with people parking along the corridor. The potholes, though not that many, contribute to a lot of congestion as drivers try to avoid them. The abandoned railway line contributes tremendously to traffic congestion in the corridor as vehicles must slow down to around 2 miles/hour to drive over it. One should not forget that the intersection is not environmentally attracting, drivers avoid not driving on the garbage that were left in the middle of the medians and that wind blew to the middle of the street. All these contribute to accidents as drivers sway to avoid the dump. Mitigation - The only way to address congestion effectively is to manage traffic, this can be done using a range of tools, eliminating potholes along the corridor, removing the abandoned rail track, cleaning the roads more often by removing refuse and sand, removing the front stalls, and finally increasing the number of lanes.

8.11 Limited Transport Modes

Ibadan's major road network is chronically congested during peak hours and this corridor is not an exception during the peak hours. The delays from commuters: truck drivers, taxi drivers, private vehicles, pedestrians, peddlers, breakdowns, crashes, construction etc. are

insurmountable. Commutes that used to take fifteen minutes now routinely take one hour and sometimes over. To address the problem, the present government has increased the number of tricycles and motorcycles by easing commercial licenses, but they are now nuisances on the roads. Due to congestion, valuable hours are lost, which ultimately drains the economy on top of causing stress, which can translate into deeper health hazards. While expanding the highway network to ease congestion is not an option and while diverting drivers to public transportation is worthwhile, it is difficult, as taking the bus is rarely faster than driving, and rail infrastructure is not available. Due to limited and raggedy public transport, private owners prefer to drive their cars.

Mitigation - Transportation service should start with improving bus service to most people especially low- income people to reduce traffic congestion in Ibadan and along this corridor. The cost for public transportation should be reduced, a lot of the taxis should be abandoned with government incentive to buy new vehicles. There should be incorporation of commuter rail service from downtown (Dugbe) to the ends of Agbowo, Moor Plantation, Iwo Road and Challenge. There should be proper, efficient, and effective management of commercial transportation. Unfortunately, since the regulations are relaxed, a lot of these commercial vehicles do not deserve to be on the road talk less of picking up passengers. The recommended mitigating measures, the ease of implementation, the relative cost and time to implementation, and priority are summarized in Table 10.

Table 10. Summary of Recommended Mitigating Measures, Ease of Implementation, Relative Cost and Time to Implement, and Priority for the Study Corridor in Ibadan

	Causes	Mitigation Measures	Ease of Improvement	Cost of Improvement - ($1-5million - Low), (5- 10million - Medium), ($10-20Mil-High), ($20 - above - Very High)	Relative time frame (Years)	Priority
1	Street Trading/Peddling and Hustlers & Touts	A - Provide trained traffic wardens. B - Install Barricades along the shoulders. C - Build smaller shopping complexes. D - Provide better Waste management at this corridor	Provides employment, reduces congestion, provides more spaces for parking and shopping and a clean environment	Low	5 to 10	A, B, D, C
2	Unauthorized Parking in Public Access	A - Install paid parking. B - Build Parking Structure. C - Expand Road by increasing lanes	Drivers parked at public parking lots and reduction of traffic congestion	Med	5to 10	B, C, A

3	Non- Licensed Drivers	A - Driving Education & Training. B - Increase Traffic Enforcement.	Increases safety, reduces vehicle accidents, and provides employment	Low	2 to 5	A, B
4	Indiscipline, Reckless Driving, and Illegal Turns	A - Engage in driver's education training. B - Issue learner's permit C No phone texting while driving. D - Traffic enforcement	Increases safety, reduces vehicle accidents, and provides employment	Low	2 to 5	A, D, C, B
5	Accidents and Vehicle Failure	A - Invest in buying the right tow truck and maintain them regularly. B - Encourage car owners to maintain their cars regularly. C - Do yearly vehicle inspection of public vehicles. D	Number of people riding in public vehicles will increase, safety is maintained, reduction of congestion along the corridor when towing vehicles are present.	Medium	2 to 5	B, A, C, D

		- Do emission test of vehicles biannually.				
6	Road Rage	A - Traffic enforcement. B - Issue driver's fines. C - Engage in defensive driving trainings. D - Employ insurance incentives and suspended license courses.	Safety is increased and maintained	Low	2 to 5	C, D, A, B
7	Pavement Markings	A - Provide enhanced pavement markings	Safety is increased and maintained	Low	1 to 2	A
8	Safety	A - Increase the number of enforcement officers. B -	Safety is increased and maintained	Low	2 to 3	B, A

		Provide pavement marking.				
9	Pedestrian Crossing	A - Provide enforcement officers. B - Install fences along the corridor. C - Direct pedestrians to cross at the intersection.	Provides employment, reduces congestion and safety is maintained	Low	2 to 5	B, A, C
10	Railway Crossing	A - Remove the railway track, B - Fix the potholes.	Reduces Congestion	Low	1 to 2	A, B
11	Traffic Lights	A - Install traffic lights that are solar enhanced. B - Future solution is to change the intersection to a roundabout. C - Increase law enforcement	Traffic regulations are followed, Congestion is reduced	Traffic Lights - Low, Roundabout - Very high	2 to 5	A, B

12	Curb & Gutters	A - Redesign and reconstruct the corridor. B - Properly maintain the existing Curb and gutter.	Clean environment, solves drainage problem during rain and reduces congestion	Very High	3 to 6	B, A
13	Sidewalk Encroachment	A - Increase traffic enforcement B - Installing fences along the corridor.	Reduces Congestion	Low	2 to 5	B, A
14	Access Control	A - There must be legislations that address access control. B - Traffic Enforcement.	Reduces Congestion	Low	2 to 5	A, B
15	Traffic Control	A - Provide and maintain traffic control signs. B - Employ the use of Intelligent Transportation	Reduces Congestion	Medium	2 to 5	A, B, C

		System (ITS). C -				
		Speed warning signs should be posted.				
16	Road Expansion and Bad Roads	A. Eliminate Potholes along the corridor. B - Remove abandoned train tracks. C - Keep the roads clean by not dumping garbage in the median. D - Increase the number of lanes	Clean environment and congestion reduction	High	2 to 5	B, A, C D

17	Limited Transport Modes	A - Reduce cost for public transportation. B - Encourage commercial vehicle owners to buy new vehicles by introducing incentives. C - Engage in Multimodal transportation	Number of people riding in public vehicles will increase, economy will improve, safety is maintained and reduction of congestion along the corridor	High	2 to future	A, C, B, D, E
		most especially commuter rails. D - Proper maintenance of public vehicles and inspection. E - Proper, efficient, and effective management of commercial transportation.				

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Chapter 9

Conclusion

It is almost impossible to eliminate traffic congestion from our lives. But we can take steps to reduce the impact it has on the society and the environment. Taking an initiative to implement some of the steps mentioned below will have a positive impact on the levels of traffic congestion experienced on the roads. Some of the basic measures that can be taken to reduce the amount of traffic congestion on the roads in Ibadan most especially along this corridor include:

- Encourage the use of public transportation as one of the most obvious solutions to reduce the impact of traffic congestions. This can be enhanced by replacing the old

transit systems and maintaining them. Public transport is a cheaper and a less stressful option to use to commute from one place to another.

- Carpooling is a very good option to reduce road traffic.
- Taking turns to drive to work is a great way to reduce the stress of driving in the traffic every day. This will also help in reducing the maintenance costs of vehicles while reducing the number of pollutants emitted into the environment.
- Avoiding peak hours and schedule errands outside the peak hours can help reduce contribution towards road congestion.
- Stricter implementation of some of the existing traffic rules can have a great impact on the amount of traffic on the roads.
- Encourage the use advanced traffic advisory as a system that can be used to provide real-time monitoring of traffic on the roads. This uses many subsystems like CCTVs, sensors, and other devices on roads to provide 24/7 traffic advice.
- Variable message signs can also be placed along the roadways to indicate real time information about emergencies and road closures.
- Adaptive signal technology can be used to adjust the amount of time for a green light in a particular signal based on real time traffic updates.
- There is a need for practical innovative systems, and variable lane capacity management is one such system. This system helps in improving the efficiency of congested highways. The roadways are configured with the help of movable barriers that help in changing the vehicle lanes based on traffic demand. This helps in a real time increase of the road capacity which will help in reducing the road congestion.

- Lastly, change the intersection to a roundabout. According to Ministry of Works the properties around this intersection are owned by the government. All the shops and motor parks are encroaching the Oyo State government's right of way. It will not be difficult to ask the shop owners to leave and move the motor park somewhere else.

It is obvious that traffic congestion has clearly overtaken the institutional capacity of Oyo State and unfortunately it will take a lot of Public Private Partnership to deal with the situation in Oyo state. The reactions of those in power has been nonchalant for a long time. For a better implementation of an effective and efficient transportation infrastructure or system, the government of Oyo State needs to take advantage of partnerships, plan and be ready to implement the plans. Unfortunately, because of institutional problems, the new government abandons the previous government's plans, all in the name of politics. Each government does what it considers to be most appropriate, without being accountable to the citizens of the state and because there are few repercussions to the ruling government actions. Furthermore, strong pressures are exerted by organized groups, such as transport interests, as well as by politicians, who put forward their own points of view and sometimes take up arms on behalf of interest groups, which complicates the situation still further.

Urban transport should be handled in an integrated, technical manner, instead of measures being taken separately by each institution or in favor of sectoral interests. Make it mandatory for a nation like Nigeria to construct, build, and invest in roads and to ensure their proper utilization and maintenance.

As part of the recommendation/solution to solving congestion along this corridor, Table 10 has a breakdown of the causes and mitigation measures experienced along this corridor. The suggested solutions in Table 10 are ranked based on the need of the corridor. It is apparent

in Table 10 based on the ranking that any improvement that will cause a redesign and construction will carry a high cost. For example, construction of roundabout and curb & gutter will cost the government of Oyo state millions of dollars. Table 10 also recommends that drivers need a lot of trainings and hiring of trained enforcement officers deployed to this corridor will improve congestion along this corridor. It is highly recommended that the government of Oyo state explores systems dynamics approach to model the connection between road construction, highway capacity, traffic volume, travel time and traffic congestion as a way into the future. This dissertation encourages the government of Oyo state to engage in partnership as the federal government so congestion can be seriously reduced along this corridor as well as others in Ibadan, Oyo State Nigeria.

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Chapter 10

Acronyms

- HCS Highway Capacity Safety
- ECMT European Conference of Ministers of Transport
- UAE United Arab Emirates
- NIS National Institute of Statics
- RTC Road Traffic Collision
- NRTC National Road Safety Commission

- GDP Gross Domestic Product
- PPP Public Private Partnership
- HDMI Highway Development and Management Initiative
- MMTS Multi Modal Transport System
- CCEC Chana Civil Engineering Construction
- FRSC Federal Road Safety Corps
- MUTCD Manual of Uniform Traffic Control Devices
- ITS Intelligent Transportation Services
- CCTV Closed Caption Tables

References

1 Wikipedia
https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja
&uact=8&ved=2ahUKEwjEv8XO3qjvAhXMXM0KHbIkAIgQFjAHegQIBxAD
&url=https%3A%2F%2Fen.wikipedia.org%2Fwiki%2FMali%23%3A~%3Atext
%3DMali%2520is%2520the%2520eighth%252Dlargest%2CIts%2520capital%2520is%2520Bamako.&usg=AOvVaw3bJVYOLb58LxPDLmacqG64

2 The World Bank - The Republic of Mali for a Second Transport Sector Project.
https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja
&uact=8&ved=2ahUKEwiarrrphMHuAhVQhlwKHeDHB8sQFjAAegQIAxAC&
url=http%3A%2F%2Fdocuments.worldbank.org%2Fcurated%2Fen%2F7665814
68052446600%2Fpdf%2F39308.pdf&usg=AOvVaw3afi-kKxNXI8n3x2fMs-61

3 Transport in Mali - Wikipedia
https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja
&uact=8&ved=2ahUKEwiqj4iZmrjvAhVHOs0KHeGfCc0QFjAAegQIBRAD&u
rl=https%3A%2F%2Fen.wikipedia.org%2Fwiki%2FTransport_in_Mali&usg=AO vVaw2DFc4ExX2xj5fk1oG56pDv

4 Africa Infrastructure continental Diagnostic - Mali's Infrastructure: A Continental Perspective
https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja
&uact=8&ved=2ahUKEwiqj4iZmrjvAhVHOs0KHeGfCc0QFjANegQICxAD&ur
l=https%3A%2F%2Fppiaf.org%2Fdocuments%2F3150%2Fdownload&usg=AOv
Vaw1naqZVu7QDvRdpgwywKOdu

5 World Bank urban transport improvement project will ease Freetown's Congestion
https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja
&uact=8&ved=2ahUKEwiX05yEgcHuAhVynVwKHRAlA0cQFjAAegQIAhAC
&url=https%3A%2F%2Fwww.thesierraleonetelegraph.com%2Fworld-bank urban-transport-improvement-project-will-ease-freetowns-congestion-says president-bio%2F&usg=AOvVaw1S1Es47tFPOr6ZsaMpn4qv

6 SIERRA LEONE INTEGRATED RESILIENT URBAN MOBILITY PROJECT
https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja
&uact=8&ved=2ahUKEwiX05yEgcHuAhVynVwKHRAlA0cQFjAFegQICRAC
&url=https%3A%2F%2Fppiaf.org%2Fdocuments%2F5803%2Fdownload%3Fotp%3Db3RwIzE1ODI0MTAxMjM%3D&usg=AOvVaw0FOFhXd2FVx748mBBj7RoM

7 Highways policy – The American Road and Transportation July2020
https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=2ahUKEwiNorGK4ILwAhWRdc0KHV2TB8gQFjAAegQIAhAD&url=https%3A%2F%2Fwww.artba.org%2Fgovernment-affairs%2Fpolicy-statements%2Fhighways policy%2F&usg=AOvVaw2Xbag3-wb6knDsPvUP3Muu

8 National Funding of Road Infrastructure: England and Wales
https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=2ahUKEwjOg_vdw43wAhUaHM0KHcSYCRgQFjAQegQIBxAD&url=https%3A%2F%2Fwww.loc.gov%2Flaw%2Fhelp%2Finfrastructure funding%2Fenglandandwales.php&usg=AOvVaw3ROfxnc_K6O9ObYy-jxfk_

9 Road Rehabilitation Project in Kazakhstan
https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=2ahUKEwjHpcbJxY3wAhXQU80KHXFXBfIQFjAMegQIEhAD&url=http%3A%2F%2Fwww.oecd.org%2Fcountries%2Fkazakhstan%2F36064944.pdf&usg=AOvVaw3W18c6lxe6nVxEFTvbkCgU

10 Road Funds and Road Maintenance
https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=2ahUKEwi6qZGHzY3wAhWPGs0KHb-9B40QFjAAegQIAxAD&url=https%3A%2F%2Fwww.adb.org%2Fsites%2Fdefault%2Ffiles%2Fpublication%2F160620%2Froad-funds-and-road maintenance.pdf&usg=AOvVaw0AgXYvpSgCJ2rQepUMGLFe

11 Traffic problems in Southeast Asia featuring the case of ...
https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=

8&ved=2ahUKEwid-qCP-JTwAhWnQjABHQ18BkcQFjAKegQIFRAD&url=https%3A%2F%2Fwww.sciencedirect.com%2Fscience%2Farticle%2Fpii%2FS0386111218300748&usg=AOvVaw22q25806T0JD65q3slMwJm

12 Urban Transport
https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=2ahUKEwid-qCP-JTwAhWnQjABHQ18BkcQFjAJegQIFhAD&url=https%3A%2F%2Fwww.adb.org%2Fsectors%2Ftransport%2Fkey-priorities%2Furban transport&usg=AOvVaw19GMkK8v_ODvCFNo2OyRbZ

13 Traffic Congestion reconsidered – Europe
Matilde.Chinellato@eurocities.eu

14 European cities present solutions to traffic congestion in Amman
https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=11&cad=rja&uact=8&ved=2ahUKEwjLseepu7jnAhWaLc0KHUYXDHcQFjAKegQIAxAB&url=http%3A%2F%2Fwww.eurocities.eu%2Feurocities%2Fnews%2FEuropeancities-present-solutions-to-traffic-congestion-in-Amman-WSPO-AG5ETX&usg=AOvVaw1RZ-W0O3rOSbpkGFE166BJ

- Traffic Congestion Reconsidered - USA
https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=10&cad=rja&uact=8&ved=2ahUKEwi3hpqqxLjnAhVbXc0KHSw2BOkQFjAJegQIAxAB&url=http%3A%2F%2Ftheconversation.com%2Ftraffic-congestion-reconsidered-111921&usg=AOvVaw276W0ikfX3gsw5ybH3XecT
-

16 Mobility and Transport – European Cities
https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=13&cad=rja&uact=8&ved=2ahUKEwim-

J_3xLjnAhVRVc0KHQNHD9AQFjAMegQIBhAB&url=https%3A%2F%2Fec.europa.eu%2Ftransport%2Fthemes%2Furban%2Furban_mobility_en&usg=AOvVaw0LSkL_6hscGo-AqcLVQfQI

17 Seven Ways Cities around the world are tackling traffic https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=15&cad=rja&uact=8&ved=2ahUKEwj-9tyTxbjnAhWLPM0KHWTFCg0QFjAOegQICRAB&url=https%3A%2F%2Fwww.weforum.org%2Fagenda%2F2014%2F07%2Fseven-ways-cities-around-worldtackling-traffic%2F&usg=AOvVaw10Mnihhkbb-KE3thSoRBnK

18 Smart Cities World – Sharing Ideas to Solve Urban Challenges https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=17&cad=rja&uact=8&ved=2ahUKEwjdrdG3xbjnAhX4B50JHVhCBZEQFjAQegQICRAB&url=https%3A%2F%2Fwww.smartcitiesworld.net%2Fspecial reports%2Fspecial-reports%2Ftraffic-congestion-cutting-through-the complexity&usg=AOvVaw0UwuGH5ga28tpoUkMfloul

19 Localized Bottleneck Reduction Program - Traffic Bottlenecks https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=2ahUKEwiIuODclpXwAhXHHM0KHQveDT8QFjAAegQIAxAD&url=https%3A%2F%2Fops.fhwa.dot.gov%2Fbn%2Flbr.htm&usg=AOvVaw3dqgAjtCUGwB4MSBoKunT5

20 Work or Construction zones - NHTSA https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja

&uact=8&ved=2ahUKEwjb_sLcp5XwAhXRQc0KHXgJCb0QFjAAegQIA
hAD
&url=https%3A%2F%2Fwww.nhtsa.gov%2Fsites%2Fnhtsa.dot.gov%2Ffil
es%2F workzones.pdf&usg=AOvVaw1OFLNY9rJskZfG1xgS3GV6

21 OSHA - Work Zone traffic safety fact Sheet
https://www.osha.gov/OshDoc/data_Hurricane_Facts/work_xone_traffic_sa
fety.p
df

22 How Do Weather Events Impact Roads? - FHWA Road
https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&c
ad=rja
&uact=8&ved=2ahUKEwim1IKd8qPwAhXcRjABHTYTAf8QFjAAegQIAhAD
&url=https%3A%2F%2Fops.fhwa.dot.gov%2Fweather%2Fq1_roadimpact.htm&
usg=AOvVaw1L-WXRo6iafzPmzLHiP1oK

23 Traffic Congestion and Reliability: Linking Solutions to Problems
https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&c
ad=rja
&uact=8&ved=2ahUKEwjYhurN86PwAhWSiOAKHSjaAuoQFjAAegQIAxAD
&url=https%3A%2F%2Fops.fhwa.dot.gov%2Fcongestion_report_04%2Fexecuti
ve_summary.htm&usg=AOvVaw3RX7Gx7QoJIzDc3UWCjpko

24 Weather-responsive intersections could ease traffic congestion
https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&c
ad=rja
&uact=8&ved=2ahUKEwjYhurN86PwAhWSiOAKHSjaAuoQFjAKegQIIh
AD&

url=https%3A%2F%2Fwww.sciencedaily.com%2Freleases%2F2019%2F03%2F
190305092832.htm&usg=AOvVaw3OG9HV15XW5VKEdh9og6eS

25 Examining the effect of adverse weather on road transportation using weather and traffic sensors
https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=2ahUKEwjYhurN86PwAhWSiOAKHSjaAuoQFjAMegQIIRAD&url=https%3A%2F%2Fjournals.plos.org%2Fplosone%2Farticle%3Fid%3D10.1371%2Fjournal.pone.0205409&usg=AOvVaw0er_nE9hnfMOD_SCZDCkWo

26 Planned Special Events - Economic Role and Congestion ...
https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=2ahUKEwj8gYaomKTwAhUJVs0KHW1bDh0QFjABegQIAxAD&url=https%3A%2F%2Fops.fhwa.dot.gov%2Fpublications%2Ffhwahop08022%2Fchap_1.htm%23%3A~%3Atext%3DA%2520planned%2520special%2520event%2520creates%2Ctransit%2520operations%252C%2520and%2520pedestrian%2520flow.&usg=AOvVaw2JruupC6XKRpfDgbyHqpge

27 3 Effects of Roads on Ecological Conditions | Assessing and
https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=2ahUKEwjProTovbDwAhVFV80KHa1sBMgQFjADegQIChAD&url=https%3A%2F%2Fwww.nap.edu%2Fread%2F11535%2Fchapter%2F5&usg=AOvVaw3egkMlwC4zF16Y5OdZBh68

28 Traffic Congestion - CEPAL
https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=2ahUKEwj3q6DogLbwAhWQVc0KHayKB9kQFjAJegQIAxAD&url=https%3A%2F%2Frepositorio.cepal.org%2Fbitstream%2Fhandle%2F1136

2%2F37898%2F1%2FLCG2199P_en.pdf&usg=AOvVaw2e7tbyZhmIiqM9YFv6l5Qz

29 In a jam: how traffic slows urban economies | News | Economy https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=2ahUKEwj3q6DogLbwAhWQVc0KHayKB9kQFjANegQIEBAD&url=https%3A%2F%2Fwww.eco-business.com%2Fnews%2Fin-a-jam-how traffic-slows-urbaneconomies%2F&usg=AOvVaw1NXH2WSBYrEqjzJFtMU3Pc

30 Economic Growth - Investopedia https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=2ahUKEwi0yu3VrfwAhV6TTABHZKIAaAQFjACegQIBhAD&url=https%3A%2F%2Fwww.investopedia.com%2Fterms%2Fe%2Feconomicgrowth.asp%23%3A~%3Atext%3DEconomic%2520growth%2520is%2520an%2520increase%2Cperiod%2520of%2520time%2520to%2520another.%26text%3DTraditionally%252C%2520aggregate%2520economic%2520growth%2520is%2Calternative%2520metrics%2520are%2520sometimes%2520used.&usg=AOvVaw2faLaucNLvo1BkM8P9DtAe

31 Traffic Congestion – The Problem https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=2ahUKEwjm-ezgibjwAhW4AZ0JHXc-CpQQFjAAegQIAhAD&url=https%3A%2F%2Frepositorio.cepal.org%2Fbitstream%2Fhandle%2F11362%2F37898%2F1%2FLCG2199P_en.pdf&usg=AOvVaw2e7tbyZhmIiqM9YFv6l5Qz

32 Road Safety Challenges in Sub-Saharan Africa: The case of Ghana https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=2ahUKEwiwoeHI5LrwAhVeAZ0JHZmzCU8QFjAJegQIAxAD&url=http

s%3A
%2F%2Fwww.hindawi.com%2Fjournals%2Fjat%2F2020%2F7047189%2F&usg=
AOvV aw0VEKOPMniXP4YWNO-ySXOi

33 Improving Transport Infrastructure
https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja
&uact=
8&ved=2ahUKEwjOlIKE6brwAhXNmuAKHUlOD30QFjAAegQIAhAD&url=https%3
A%2F%2Ftransportgeography.org%2Fcontents%2Fconclusion%2Fimproving-transport
infrastructure%2F&usg=AOvVaw1MAf3Moos6rwpP4F1ONofz

34 Traffic Congestion- The Reason for Its Increase and Ways to Reduce It
https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&c
ad=rja
&uact=8&ved=2ahUKEwjwiOaq6rrwAhULG80KHTPeCKcQFjAGegQIC
xAD&
url=https%3A%2F%2Fwww.bankbazaar.com%2Finsurance%2Fmotor-
insurance guide%2Fsimple-ways-to-reduce-traffic
congestion.html&usg=AOvVaw1kK1lSg8sOplEplqGIE-4T

35 Bicycles and Cycle-Rickshaws in Asian Cities: Issues and Strategies
https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja
&uact=
8&ved=2ahUKEwiGwdTT8rrwAhWIVs0KHbwGB0MQFjAAegQIAxAD&url=http%3
A%2F%2Fonlinepubs.trb.org%2FOnlinepubs%2Ftrr%2F1992%2F1372%2F1372-
011.pdf&usg=AOvVaw3Ujh4WhEDnrDpjVS1bkjEI

36 PUBLIC-PRIVATE PARTNERSHIP RELATIONSHIPS IN URBAN
TRANSPORTATIONS IN NIGERIA S. I. ONI (PH. D) DEPARTMENT OF
GEOGRAPHY UNIVERSITY OF LAGOS, LAGOS, NIGERIA
https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=
8&ved=2ahUKEwjtkqi63_jwAhUGD8AKHSw4BlcQFjAAegQIFhAD&url=https%3A%

2F%2Fwww.codatu.org%2Fwp-content%2Fuploads%2FPublic-private-partnership relationships-in-urban-transportations-in-Nigeria-S.I.-ONI.pdf&usg=AOvVaw297KLkXoDG_7k9tHrP4cyh

37 PROJECT: Capacity Building for PPP Infrastructure (CB4PPPi) COUNTRY: Nigeria https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=2ahUKEwi8uIz64_jwAhWLiVwKHSbFCUYQFjAAegQIGBAD&url=https%3A%2F%2Fwww.afdb.org%2Ffileadmin%2Fuploads%2Fafdb%2FDocuments%2FProject and-Operations%2FNIGERIA_-_PAR__-_CB4PPPi_.pdf&usg=AOvVaw2IGP137heEZgNmc7C10ekb

38 Nigeria: Public-Private-Partnership and Road Infrastructure Development in Nigeria: Understanding the Presidential Executive Order No. 007 Of 2019 by Banwo and Ighodalo https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=2ahUKEwjW3qzn5_jwAhVylFwKHW-JCpgQFjAAegQIDBAD&url=https%3A%2F%2Fwww.mondaq.com%2Fnigeria%2Fgovernment-contracts-procurement-ppp%2F790274%2Fpublic-private partnership-and-road-infrastructure-development-in-nigeria-understanding-the presidential-executive-order-no-007-of-2019&usg=AOvVaw0uTXtJN3elZQexh3AmNZLN

39 FG delivering 19 roads projects across Nigeria via PPP — Osinbajo https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=2ahUKEwjW3qzn5_jwAhVylFwKHW-JCpgQFjABegQIChAD&url=https%3A%2F%2Fwww.pulse.ng%2Fnews%2Flocal%2Ffg-delivering-19-roads-projects-across-nigeria-via-ppp-osinbajo%2Fsyslxfq&usg=AOvVaw2VwYvdo9oJmlOTHu0hcnHU 40 FG to concession 12 highways to private sectors -1/31/21 https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=2ahUKEwjW3qzn5_jwAhVylFwKHW-

JCpgQFjACegQIFhAD&url=https%3A%2F%2Fwww.icrc.gov.ng%2Ffg-to concession-12-highways-to-private-sectors%2F&usg=AOvVaw03I-6Sa9RgiKvL fbo2uiF

41 OVERVIEW OF LEKKI-EPE WAY TOLL ROAD CONCESSION PROJECT https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd= &cad=rja &uact=8&ved=2ahUKEwjW3qzn5_jwAhVylFwKHW-JCpgQFjANegQIFxAD&url=https%3A%2F%2Fwww.theajalabug.com%2Fhome %2F20 19%2F6%2F24%2Fan-overview-of-public-private-partnership-projects and-structures&usg=AOvVaw1mHIvUEdnn76mkS9aN2Ghe

42 NPA DEVELOPMENT OF INTERMODAL TRANSPORTATION … https://shipsandports.com.ng/npa-development-of-intermodal-transportation system-in-the-nations-seaport-and-the-economy/ 43 Development of a Multi -Modal Transport System - The ... http://www.icrc.gov.ng/assets/uploads/2018/03/Devt-of-a-multi-modal-transport system-280218.pdf

44 The Impact of Proposed Legislation on the Multimodal Transportation Sector in Nigeria

https://www.detailsolicitors.com/the-impact-of-proposed-legislation-on-the multimodal-transportation-sector-in-nigeria/

45 The impact of Traffic Sign Deficit on Road Traffic accidents in Nigeria — Christian Ezeibe et al https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja &uact=8&ved=2ahUKEwjRl_WdlsXxAhWEcc0KHQQvDRQQFnoECAIQAw& url=https%3A%2F%2Fwww.tandfonline.com%2Fdoi%2Fabs%2F10.1080%2F17 457300.2018.1456470&usg=AOvVaw0El_myFlJZiELudkwdm7iI

46 Traffic Control Strategies for Congested Highways and Work Zones FHWA/TX-08/05326-2

https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja &uact=8&ved=2ahUKEwjAjqmzlsXxAhWaZM0KHc2_ALUQFnoECAUQAw& url=https%3A%2F%2Fstatic.tti.tamu.edu%2Ftti.tamu.edu%2Fdocuments%2F0-5326-2.pdf&usg=AOvVaw2j2neawnylImHEm_-nN9PE

47 Managing Traffic Congestion in the Accra Central market, Ghana Frances Agyapong
https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=2ahUKEwiOtYnFlsXxAhWQLc0KHZtgAEwQFnoECAUQAw&url=https%3A%2F%2Fwww.sciencedirect.com%2Fscience%2Farticle%2Fpii%2FS2226585617300857&usg=AOvVaw0Jf6pBMiAVczNVA7JHqRIi

48 Effect of street Trading on Urban areas in Nigeria — Bogoro Audu Gani https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=2ahUKEwj216DXlsXxAhUaK80KHZQ-DlwQFnoECAIQAw&url=http%3A%2F%2Fgarj.org%2Fgarjmbs%2F2%2F2016%2F5%2F2%2Feffects-of-street-trading-on-urban-areas-in nigeria&usg=AOvVaw2gFS1xI60zrxCZVV9r49GF

49 Recommendation for Driver's Licensing and Traffic Law Enforcement in India aiming to improve road safety.
https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=2ahUKEwiSrtvslsXxAhXWWM0KHSyZCZUQFnoECAMQAw&url=https%3A%2F%2Fwww.researchgate.net%2Fpublication%2F281195619_Recommendations_for_driver_licensing_and_traffic_law_enforcement_in_India_aiming_to_improve_road_safety&usg=AOvVaw0eFrC4z8BtVSLz0UOwow1S

50 Users' satisfaction with public transport operations in Ibadan, Nigeria https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=2ahUKEwiBo87xnbPxAhWFQs0KHcVSBsMQFnoECAIQAw&url=https%3A%2F%2Fwww.researchgate.net%2Fpublication%2F326845176_Users%27_satisfaction_with_public_transport_operations_in_Ibadan_Nigeria&usg=AOvVaw3ewCKRZciXkBGmaccFTowO