THE EFFECTS OF TRAFFIC CONGESTION ON TRAVEL TIME IN KADUNA METROPOLIS, NIGERIA

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AN M.SC DISSERTATION SUBMITTED TO THE SCHOOL OF POSTGRADUATE STUDIES, AHMADU BELLO UNIVERSITY ZARIA IN PARTIAL FULFILLMENT OF THE REQUIREMENT FOR THE AWARD OF A MASTERS OF SCIENCE DEGREE IN REMOTE SENSING AND GEOGRAPHICAL INFORMATION SYSTEM

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DECLARATION

I certify that this research work titled **"The effect of Traffic Congestion on Travel Time in Kaduna Metropolis, Nigeria''** was conducted by me in the Department of Geography Ahmadu Bello University Zaria, under the supervision of Dr. I.J. Musa and Dr. B. Apku. Where materials have been used from previous literature it has been properly acknowledged/ referred. This research has not been presented elsewhere for assessment and award of any degree.

FLORENCE TUMAN ACHI ---------- ----------
(Signature) **(Date)**

CERTIFICATION

This thesis titled **The Effect of Traffic Congestion on Travel Time in Kaduna Metropolis, Nigeria**, meets the regulations governing the award of the degree of MASTERS of Ahmadu Bello University Zaria, and is approved for its contribution to knowledge and literary presentation.

Prof. I.J. Musa Chairman, Supervisory Committee	_____ (Signature)	_____ Date
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DEDICATION

This dissertation is dedicated to my parents Mr. and Mrs. P.M. Achi, for their wonderful encouragement and tireless support towards my academic pursuit.

Nothing, therefore, happen unless the Omnipotent wills it to happen. He either permits it to happen, or he brings it about Himself (St. Augustine of Hippo).

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ABSTRACT

This study investigates the effects of traffic congestion on travel time along Station-Stadium, Kawo-Mando and Yakubu-Gowon way within Kaduna Metropolis using GPS and GIS technique. Among the objectives were mapping the congested corridors, determining the speed, travel and delay time for each segment of the corridors, determining the difference between car travel time in the different segment and car and bus in the same segment of the corridors and also examining the causes and impact of traffic congestion on travel time. The methods used in data collection are, GIS was used in mapping the congested corridors and the variations in speed were also mapped. Descriptive statics was used to acquire average speed, travel and delay time for the corridors. T-Test analysis was used to determine the difference between car travel time in the different segment and car and bus travel time in the same segment of the corridor. Four hundred (400) copies of questionnaire were administered to drivers and passengers of (cars and buses), in which Cross-Tabulation was used for the analysis. The speed, travel and delay time for Station-Stadium and Kawo-Mando corridors revealed low speed and increases in travel and delay time during the morning and evening peak periods while Yakubu-Gowon Way gave a different partner during the afternoon period. The study also revealed the main causes of traffic congestion for the three (3) corridors are inadequate road capacity. The social impacts of congestion on travel time are unpredictable travel time along Station- Stadium corridor with 61% and Kawo-Mando with 54.5% and extra time with 46.6% was the highest along Yakubu-Gowon way. Economic impact revealed fuel consumption as highest with 51% along Station-Stadium corridor and working hour is reduced were the highest along Kawo-Mando with 50% and Yakubu-Gowon way with 51.7%. Delay experienced due to traffic congestion showed that 98% of the respondents acknowledge that traffic congestion brings about delay. Extent of delay showed Station-Stadium and Kawo-Mando has 15mins, while Yakubu gowon way has 10mins. Time of the

day congestion is experienced has 7-9am and 3-6pm for Station-Stadium and Kawo-Mando while Yakubu Gowon has 7-9am and 11-2pm. Congestion during the week shows weekdays as having the highest and weekends having the lowest for the three corridors. The study recommendations among others, include expansion of Yakubu-Gowon Way, construction of flyover around Stadium-Station roundabout and also decentralization of government offices to reduce influx of worker into the metropolis. Provision of an affordable and functional mass transit vehicles to provide alternative use of private vehicles, will help in reducing the number of vehicles on the corridors by the state government. Linking traffic information system (TIS) to the State radio by the government of Kaduna state, this would relay to commuter corridors that are congested and to provide alternate corridors, which are less congested. The use of Geographic Information System in traffic monitoring is highly relevant for solving issues relating to traffic congestion. Building of fuel station along major corridors should be discouraged because they contribute to traffic congestion.

CHAPTER ONE

INTRODUCTION

1.1 Background to the Study

Cities with one million people and above, according to the United Nations forecasts increased to over 300 by the year 2000 in the developing world, this trend will continue because of the rapid growth in population, resulting from improvement in health services and the multifarious functions performed by cities, which have been another major attractive force. The situation as described above has its impact on traffic in the cities of developing world. Thus, the activities make them generators and attractors of traffic, which of course has implications on mobility (Ogunbodede, 2003).

Urbanization is an index of transformation from traditional rural economies to modern industrial one. It is a progressive concentration of population in an urban centre. Urbanization has become not only a principal manifestation but also an engine of change, and the 21th century has become the centre of urban transition for human society. In a way, urbanization is desirable for human development; however, uncontrolled urbanization has been responsible for many of the problems cities experience today, resulting in substandard living environment, acute problems of drinking water, noise and air pollution, disposal of waste and traffic congestion (Verma, Kumari and Tiwary, 2008). The level of urbanization in developing world indicates that more people live in cities than before. This pattern induces pressure on traffic flow and makes living in urban area difficult (Ogunbodede, 2003).

It is now widely recognized that urban transport plays a crucial role for growth and development of societies all over the world. However, recent urbanization and population growth have posed serious challenges for urban transport. Thus, recent efforts have focused

on tools and techniques scientists and practitioners could employ to address these challenges and to aid planning and decision-making (Agyemang, 2013).

Traffic congestion is a phenomenon associated with urban environment all over the world; this is because people need transport to move from one place to another, especially when trekking becomes inefficient. The forecast of Global Traffic Volume (GTV) shows that traffic congestion would double between 1990 and 2020 and again by 2050 (Engwitch, 1992). This type of growth pattern, as envisaged by the end of year 2020 and 2050, is an indication of what the future congestion portends for people living in urban environment (Ogunbodede, 2003). Congestion does not occur everywhere all-at-once. Instead, congestion occurs in specific locations and propagates through network over time as congested conditions on a link spread to nearby links (Riad, El-Mikkawy and Shabana, 2012).

Congestion is a complex and multidimensional phenomenon that is difficult to mitigate. Researchers and network managers have experienced difficulty in breaking the phenomenon down into a set of discrete causal factors. The proximate causes of congestion are numerous examples too many vehicles for a given roadway's design, dynamic changes in roadway capacity caused by lane-switching and car-following behavior, etc... and are invariably linked to other factors such as land-use patterns, employment patterns, car ownership trends, road infrastructure investment and regional economic dynamics, Organization for Economic Cooperation and Development/European Conference of Ministers of Transport (2007).

Many definitions have been proposed to describe traffic congestion on roadways in urban areas. However, there is no universally accepted definition of traffic congestion (Downs, 2004). These definitions can be broadly categorized into three: (i) demand capacity related, (ii) delay-travel time related, and (iii) cost related. Based on demand Capacity related; Congestion may be defined as a state of traffic flow on a transportation facility characterized

by high densities and low speeds, relative to some chosen reference state (with low densities and high speeds) (Bovy and Salomon, 2002). In relation to delay- travel time; traffic congestion usually relates to an excess of vehicles on a portion of roadway at a particular time resulting in slower speeds (Cambridge Systematic and Texas Transportation Institution, 2005). Congestion is also the presence of delays along a physical pathway due to presence of other users (Kockelman, 2004). In relation to cost; traffic congestion refers to the incremental costs resulting from interference among road users (Victoria Transport Policy Institute, 2005). According to the engineering theory of traffic congestion, the natural explanation of congestion is a lack of road capacity, that is, a shortage of supply (Thomson, 1998).

Traffic congestion is one of many serious global problems in both developed and developing countries. It exerts a negative externality upon the society, causing severe threat to the economy as well as the environment (Meenar, 2000). In the United States, road congestion now causes commuters to spend an average of a full work week each year sitting in traffic (Texas Transportation Institute, 2005). Still in the United States, factors which include rapid population, job growth in metropolitan areas and more intensive use of automobiles which are deeply embedded in American culture have led to traffic congestion (Downs, 1992).

The consequences of traffic congestion extend well beyond the personal inconveniences felt by individual travelers. Environmental quality, roadway safety, and community access are among the many quality-of-life concerns that arise in areas plagued with congestion (McNally, Marca, Rindt, and Koos, 2002).

Travel time is the time that it takes an individual vehicle to traverse a unit length of roadway. Travel time is composed of running time, or time in which the means of transport is in motion, and stopped delay time, or time in which the means of transport is stopped (or moving sufficiently slow as to be stopped, typically less than 8 kph, or 5 mph) (Turner,

Eisele, Benz and Holdener,1998). People usually judge transportation network quality under the aspect of travel times, for example how long does it take to travel from point A to point B or how many cities are accessible in a given time period? Therefore travel time is broadly defined as the time necessary to traverse a route between any two points of interest; it can be directly measured by traversing the route(s) that connects any two or more points of interest, or by using a GPS (Global Positioning System) in a moving vehicle.

Kaduna metropolis has had its fair share of traffic congestion, which is said to be attributed to the fact that most of the government offices and private organizations are located within the central business district, while the persons that work in these establishments are residents within the peripheries. This implies that they have to travel to the CBD daily in the morning and return in the evening resulting to morning and evening peak periods within the metropolis (Achi, 2012).

1.2 Statement of the Research Problem

Traffic congestion is a major urban transportation problem (Downs, 1992; Litman, 2004). The issue of traffic congestion has affected both the developing and developed economies at different degrees irrespective of the measures taken to curb it. Traffic congestion can be seen to have substantial negative effects on urban residents and organizations. Congestion impacts include loss of productivity and restricted accessibility in the urban environment. At first glance, it would seem that urban traffic congestion would have less impact on travelers and organizations outside the metropolitan area, but congestion on roads has resulted in massive delays, increased fuel wastage and monetary losses (Jain, Sharma and Subramanian, 2012).

In the study conducted by the Texas Transport Institute (2004), congestion was said to have caused the United State of America's economy 3.7 billion hours of travel delay and 8.7 billion liters of wasted fuel. In the United Kingdom, the Commission for Integrated

Transport notes that while drivers in Central London spend up to about 50 % of their time crawling in jammed traffic, businesses in the city are also losing about £2 million a week. According to Tom Tom European Congestion Index (2013), the Europe congestion level was rated at $24^0/_0$, with cities like London having $27^0/_0$ level of congestion and delay per hour driven in peak periods of 33mins. Tom Tom North America Congestion Index (2013) also stated that the North American congestion level was also rated at $18^0/_{0,}$ with cities like Los Angeles and New York having $33^0/_0$ and $22^0/_0$ levels of congestion, with per hour driven in peak periods of 39mins and 26mins of delay respectively.

African cities particularly Nairobi (Kenya), Kampala (Uganda), Lagos (Nigeria), are noted for notorious traffic congestion; heavy traffic jam, while motorists and commuters contend with extreme heat, air and noise pollution (Olayiwola, Olaseni and Fashina, 2014).

Nigeria's traffic congestion in major cities has remained part of the operating transportation system especially during the morning, afternoon and evening peak periods. As noted by, Ogunsanya (2002). The problem of traffic congestion is no longer limited to traditional cities such as Lagos, Ibadan, Benin-City, Port Harcourt, Abuja, Kano and Kaduna (Popoola, Abiola and Adeniji, 2013).

Traffic congestion has been one of major issues that most metropolises are facing and thus, many measures have been taken in order to mitigate it. It is believed that identification of congestion characteristics is the first step for such efforts since it is an essential guidance for selecting appropriate measures (Rao and Rao, 2012).

The problem of traffic congestion in Kaduna metropolis has been persistent with every administration making efforts to tackle it. Kawo flyover was constructed in the year 2006 in order to reduce congestion along Kawo – Zaria route; the intercity railway network was introduced in 2008 to assist in the movement of people from one end of the state capital to the

other in order to reduce the effects of congestion on road users. The construction of the fourth bridge along Yakowa road was also to alleviate the problem of motorists in spending hours to commute from the southern part of the metropolis to the northern part where many of the government offices are located. Yet the problem of traffic congestion still persists within the city. Studies on the effects traffic congestion on travel time using Global positioning System and Geographic Information System have not been conducted within Kaduna metropolis.

The effects of traffic congestion on travel time in Kaduna metropolis seeks to answer the following research questions.

1. Where are the congested corridors in Kaduna metropolis?
2. What is the speed, travel and delay time for each segment of the corridors?
3. What is the extent of variation in car and bus vehicle travel time for each segment of the corridor?
4. What are the causes and impacts of traffic congestion on travel time?

1.3 Aim and Objectives

The aim of this research is to assess the effects of traffic congestion on travel time within Kaduna metropolis, Nigeria. The objectives are to:

i. map the congested corridors in the study area
ii. determine the speed, travel and delay time for each segment of the corridors
iii. determine the difference between car travel time in the different segment and car and bus in the same segment of the corridors.
iv. examine the causes and impact of traffic congestion on travel time.

1.4 Hypotheses

The following hypothesis is tested at 0.05 level of significance.

H_1: There is no significant difference between car travel time in different segment of the corridor.

H_1: There is no significant difference between car and bus travel time in the same segment of the corridor.

1.5 Scope of the Study

The spatial scope of the study covered Kaduna metropolis specifically Station roundabout to Stadium roundabout, Kawo beneath the flyover towards Mando junction first roundabout and Yakubu Gowon way which are considered as corridors. The content scope involved mapping the congested corridors, determining the speed, travel and delay time for each segment of the corridors, determining the difference between car and bus vehicles travel time for each segment of the corridor, socio-demographic characteristics of respondents and the causes and impacts of traffic congestion on travel time using statistical package for social sciences. The temporal scope covered a period of one week (Monday- Sunday) for each corridor; data was collected for, morning peak period (7am- 9am), evening peak hours (3pm- 6pm) and (11am- 2pm) afternoon off peak period. The peak hour traffic study was particularly useful in that it provides the most important information concerning the traffic congestion along the road network. Information about travel environment such as vehicle volume was not put into consideration while the travel time takes care of the vehicles taking off from the same origin.

1.6 Justification of the Study

Traffic congestion affects nearly everyone in the world due to the environmental damage and the transportation delay it causes (Hunter, Herring, Abbeel and Bayan, 2009). In Nigeria traffic congestion in the major cities has remained part of the operating transportation system, attempts made by governments to ensure that congestion is managed through various traffic management techniques have not yielded the desired result (Onasanya and Akanumu, 2002).

Traffic congestion is a regular occurrence on road networks in Kaduna metropolis which are recurrent and non-recurrent. Recurrent congestion which is recurring at specific times of the day seems to be dominant along the certain segments of the corridors.

Among the effects of congestion is environment pollution, pollution generated by vehicles in the form of CO2 has become a serious impediment to the quality of life and even the health of urban populations. Energy wastage during congestion usually brings about increase in transportation fare as in the case of public vehicles while traffic delays as a result of longer commuting time brings stress, anger etc.

Travel time and delay studies are mostly used to document congestion and to monitor congestion. It is believed that the output of this study is expected to add to the existing academic knowledge on traffic congestion. Those to benefit from this research include Kaduna State Government, transportation planners and administrators, commuters and drivers.

CHAPTER TWO

CONCEPTUAL FRAMEWORK AND LITERATURE REVIEW

2.1 Introduction

This chapter reviews concepts that are relevant to this study and also reviewed related literatures. The concepts considered are causes of traffic congestion (Non recurring and recurring), travel time, delay time, travel time reliability, global positioning system and Geographic information system.

2.2 Conceptual Framework

Many conceptual frameworks explain the effect of vehicle traffic congestion on travel time in different ways. However, for the aim of this study, the following conceptual framework is adopted.

2.2.1 Traffic Congestion

Joint Transport Research Centre (2007) of the Organization for Economic Cooperation and Development (OECD) and the European Conference of Ministers of Transport (ECMT) (2007), provided the following definitions of traffic congestion to reflect the different broad perspectives:

1. Congestion is a situation in which demand for road space exceeds supply.
2. Congestion is the impedance vehicles impose on each other, due to the speed-flow relationship, in conditions where the use of a transport system approaches capacity.
3. Congestion is essentially a relative phenomenon that is linked to the difference between the roadway system performance that users expect and how the system actually performs.

Road traffic congestion is an ever growing problem and global phenomenon of major cities throughout the world. Traffic congestion is a negative output of a transportation system

which has many detrimental effects on the performance of the road network, the traffic flow, the society, the national economy and the environment. Congestion occurs in specific locations and propagates through network over time as congested conditions on a link spread to nearby links.

Many highways in Nigeria are bedeviled with traffic congestion which tends to defy various remedial measures adopted by different governments over the years. Journey times from one point to another, have remained unreliable and travelers have continued to face disturbing inconveniences in transportation (Popoola, Abiola and Adeniji, 2013).

2.2.1.1 Causes of Traffic Congestion

Different researches and reports have identified many interrelated factors that cause traffic congestion in developed and developing countries where the road network and road users behaviour are different (Cambridge Systematics, 2005; Kwon, Mauch and Varaiya, 2006) (Ukpata and Etika, 2012) also identified the main causes of traffic congestion in Nigeria as poor driving habits, poor road network, inadequate road capacity, and lack of parking facilities.

Bashiru and Waziri (2008) listed the causes of traffic congestion in Lagos to include the following: Presence of pot holes/bad road, trading activities along major roads, on-street parking, loading and discharging of passengers along major roads, illegal bus stops, flooding/poor drainage, vehicle breakdown, narrow road sections, religious activities, high volume of traffic, lack of parking space and lack of traffic light at some road intersections.

According to the European Conference of Ministers of Transport (ECMT) (2007), causes of congestion are numerous such as; too many vehicles, land use patterns, employment patterns, income levels, car ownership trend, infrastructure investment and regional economic

dynamics. Chibuzor (2011), also identified the factors affecting vehicular traffic congestion based on five categories which are;

1. Societal / Public Causes

   This is one of the subjectively classified problems that have to do with the society/public. Society/public induced problems identified under this category are wrong parking on traffic pavement, hawking on road pavement, dumping of refuse on road pavement, reckless driving, parking of heavy trucks on the roadway, vehicle breakdown, inexperienced drivers, illegal motor parks, too many vehicles sharing a road space, use of roadway for social activities, use of infrared emitter, improper turning, use of one carriage way, procession or demonstration, bumps, peak period congestion, and accidents.

2. Construction Causes

   They are factors as a result of ill-construction managements, the factors identified under construction causes are; Lack of shoulder and lay-by, excess conflict points at intersections, inadequate channelization at intersection, use of long barrier median, lack of skid resistance surface, failed pavement, and closure of one lane during rehabilitation.

3. Design Causes

   These are factors resulting from design incapability or inaccuracies and are identified as follows; small width of roadway, use of wrong curves, lack of well-defined traffic routes at intersections, lack of auxiliary lanes towards intersection, increase in volume of traffic etc. Sadi (1987).

4. Governmental Causes

   These are problems emanating from careless governmental practices and administrations, some of these are police checkpoints, construction of one lane instead

of two, lack of traffic signs and signals, badly located fuel stations, centralization of cities population, unplanned and uncoordinated development in metropolis, concentration of industrial establishment, absence of integrated traffic unit, lack of alterative travel route, indiscriminate use of siren, lack of street light, and too many schools along the road.

5. Natural Causes

These result from natural occurrences and climatic factors thus; Excessive rainfall, erosion, poor visibility due to bad weather, and potholes.

2.2.2 Travel Time

Travel time is the time it takes for vehicles to travel between two points. Both travel time and average travel speed are good measures for specific trips or within a corridor (Cambridge Systematic Incorporation, 2005). Travel time is composed of time in which the means of transport is in motion, and time in which the mode of transport is stopped (or moving sufficiently slow as to be stopped. Travel time is an important quantitative indicator representing traffic condition. Congestion causes increase in travel time which may eventually become increasingly variable and unpredictable as congestion increases. Travel time is a simple concept understood and communicated by a wide variety of stakeholders, including transportation engineers and planners, business persons, commuters, media representatives, administrators, and commuters. Engineers and planners have used travel time and delay studies since the late 1920s to evaluate transportation facilities and plan improvements. Commuters use a "travel time budget," theorized to be between 20 and 30 minutes per one-way commute, to locate their housing relative to work locations (Turner, Eisele, Benz and Holdener, 1998). Travel time is among the most important factors that affects attractiveness of transport modes and consequent commuter travel decisions in urban areas (Makin, Healey and Dowers, 1997). Accurate estimates and comparisons of travel paths

and the duration of trips are basic requirements for planners, transportation industries, marketing businesses and social scientists.

2.2.3 Delay Time

Delay is the time spent in traffic beyond what would normally be spent if travel could be done at the ideal speed (Cambridge Systematic Incorporation, 2005). Delay (time loss) due to traffic congestion is determined, in general, by comparing the average trip time on congested road with the trip time under free-flow conditions corresponding to the design speed of the road(Hansen, 2000). Delay rises as speed falls; delay is a quantity that indicates where the problems are.

2.2.4 Global Positioning System

Global Positioning Systems (GPS) provide a real-time spatial and time measurement of a location. GPS is the only system today able to show you your exact position on the Earth anytime, in any weather, anywhere. GPS satellites, 24 in all, orbit at 11,000 nautical miles above the Earth. They are continuously monitored by ground stations located worldwide. The satellites transmit signals that can be detected by anyone with a GPS receiver. Using the receiver, people can determine their location with great precision (Owusu, Afukaar and Prah, 2006).

GPS technology offers a low capital cost, a low installation cost, and a low data collection cost combined with high location accuracy. GPS has been increasingly used in conducting transportation studies (Quiroga and Bullock 1998; D'Este *et al*. 1999; Li *et al*. 2002). As part of an effort for obtaining traffic data using remote sensing techniques integrated with GIS (Geographic Information System) (Roper 2003, Sivaram and Kulkarni 2001), investigates the use of GPS probe vehicle data as a part of the traffic data collection system. The advantage in using Global Positioning System (GPS) is that mapping of the relevant parameters can easily be done in a GIS environment. This makes it possible to make a pre-evaluation of various

measures related to the local targets and which usually proves to be conclusive. In this study coordinates were taken at each segments of the corridor, the changes in speed limit are shown at different distances using GIS analysis.

2.2.5 Geographic Information System (GIS)

Geographical Information System (GIS) was first introduced and used in the 1960s and since then, the technique has developed into a useful means of gathering and analyzing different kinds of spatial data related to unique geographical locations (Longley *et al*, 2005).

GIS is defined by (Murayama and Estoque, 2010) as an organized collection of computer hardware, software, geographic data, procedures, and personnel designed to handle all phases of geographic data capture, storage, analysis, query, display, and output. GIS is also a computerized tool for performing operations on geographic data with a view to reveal what is otherwise invisible (Longley *et al*, 2005). GIS draws concepts and ideas from many different disciplines which include cartography, computer science, engineering, environmental sciences, geodesy, landscape architecture, public policy, photogrammetry, remote sensing and surveying (Heywood, Cornelius, & Caver, 2006).

Transportation authority's need to plan routes and schedules, to keep track of vehicles and to deal with incidents that delay them, and to provide information on the system to the traveling public. All of these employ GIS, in a mixture of operational, tactical, and strategic applications. In operational systems, GIS is used:

1. To monitor the movement of mass transit vehicles, in order to improve performance and to provide improved information to system users.
2. To route and schedule delivery and service vehicles on a daily basis to improve efficiency and reduce costs.

In tactical systems

1. To design and evaluate routes and schedules for public bus systems, school bus systems, garbage collection, and mail collection and delivery.
2. To monitor and inventory the condition of highway pavement, railroad track, and highway signage, and to analyze traffic accidents.

In strategic systems:

1. To plan locations for new highways and pipelines, and associated facilities.
2. To select locations for intermodal transfer points, and airline hub (Longley *et al*, 2005).

2.3 Literature Review

2.3.1 Effects of Traffic Congestion

Aderamo (2012), examined traffic congestion problems and their causes at selected road intersections, in Ilorin, Nigeria. Traffic volume and delay were estimated and the causes of delay were identified. The result revealed that space and time variations exist in traffic flow and delays at the intersections. Traffic wardens and parking problems were found to be the greatest cause of delays. The study recommended that the road intersections be signalized and vehicle parking be strictly prohibited to reduce congestion and delays.

Ukpata and Etika, (2012), investigated traffic congestion which has become a common sight in most urban centres of Nigeria. A survey was conducted during the Annual National Conference of the Nigerian Society of Engineers (NSE) which held in December 2011 at the Calabar Tinapa Business and Leisure Resort. Three hundred (300) copies of questionnaires were distributed among participants and 196 returns were made and these were analyzed. The results showed that poor driving habits, poor road network, inadequate road capacity, and

lack of parking facilities constitute the greatest causes of traffic congestion in Nigeria. Also, Lagos, Port Harcourt and Abuja were identified as cities most affected by traffic congestion.

Popoola, Abiola and Adeniji (2013) investigated the causes, effects and remedies of traffic congestion in Mowe/Ibafo section of the Lagos-Ibadan expressway. The result from the study showed the causes of traffic congestion as inadequate road capacity, poor road pavement, poor traffic management, poor drainage system poor driving habit, poor parking habit, poor design junctions/round-about, presence of heavy trucks, lack of pedestrian facilities, lack of road furniture, lack of parking facilities and others. Effects of road congestion from the study were waste of time, delay movement, stress, accident, and inability to forecast travel of time, fuel consumption, road rage, relocation, night driving, and environmental pollution. To drastically reduce these negative effects the following were proposed; there must be provision for adequate parking space, construction of proper drainage, enlarging the width of the road, rehabilitate all roads needing attention, public enlightenment, traffic education, hack down all illegal buildings/shops built on the right of way (ROW), creating a separate/alternative root for trucks and heavy vehicles, provision of pedestrian facilities, In-depth training of transport/traffic personnel, ban all form of road trading/hawking, and reduce the number of bus-stop are necessary.

Fadairo (2013) investigated traffic congestion in Akure, along Federal University of Technology Akure Road / Oja-Oba Road. The data collected from both primary and secondary sources were analyzed and these include using of camera to capture traffic-congested zones; information on traffic-congested junctions; the roads and the land use areas; and traffic census for some selected road junctions in the study area. The results showed that poor driving habits, weather condition, absence of traffic light and/warden, work zones, road side parking, special events, lack of public mass transit, reluctance to use parking facilities

and bus stops constitute the greatest causes of traffic congestion in the study area. The recommendations were that both Federal and State governments should initiate plans for the introduction of other forms of urban transportation such as metros and trains which support mass movement of people as done in major cities globally

2.3.2 Traffic Congestion and Travel Time.

Marius (1999) presented a modeling and simulation procedure to evaluate optimal routes and to compute travel times for each individual trip of an OD survey database. Using TransCAD GIS software, the procedure finds the best routes through a topological road network. Each road is characterized by a maximal speed related to the functional class of the road, to its location in rural or urban areas, and to the distance from the nearest school. Turn and transfer penalties govern movements at the intersections. Moreover, the procedure calculated the number of persons traveling on every road to estimate traffic congestion. Through the study it was concluded that it is possible to combine GIS and transportation modeling to estimate travel time of urban commuters which can help in measuring temporal constraints of households in planning their daily activities.

Faghri and Hamad (2002) applied GIS/GPS in collecting travel time, speed, and delay information on sixty four (64) major roads throughout the State of Delaware. The primary objective of travel-data collection was to monitor traffic congestion and to compare the information over four (4) years of data collection (1997–2000) to identify the road that had either an increase or a decrease in traffic measures, i.e., travel time, peak speed, and percentage of time in delay. A comparative statistical analysis was performed on data collected by GPS method, with data collected simultaneously by the conventional method. The GPS data proved to be at least as accurate as the data collected by conventional methods

and was 50% more efficient in terms of manpower which can be used for daily congestion measurements with data being collected on a daily basis.

Ogunbodede (2003) used Geographic Information System to investigate traffic congestion patterns in Akure and determine the management techniques suitable for their reduction. Topographical map of Akure as at 1966, Landsat images of Akure as at 1986 and 2002 were acquired and processed to produce the base map on which the major analyses were based. Major entities influencing traffic congestions were identified and modeled. The result showed two major ways by which GIS can provide solutions to traffic congestion in the area. The first way is the provision of traffic information that enables commuters and motorists to take rational decisions as to which route to take during peak hour travel. The second is the determination of appropriate queries that can evoke graphical response, which could be used to manage traffic congestions. The study also revealed that GIS is a veritable tool that can be used to sustain an endurable flow of traffic in urban environment, provided it is built on a properly designed database, which must also be amenable to constant updating. The study recommended that a GIS structure in addition to existing traffic management techniques should be put in place to monitor traffic congestions in the city.

Bashiru and Waziri (2008) studied the problems of intra-urban traffic in Lagos Nigeria and found that 57% of commuters and motorists spend between 30 to 60 minutes on the road due to traffic congestion. Their results also showed that the worst traffic congestion occurs on Mondays. They listed traffic congestion in Lagos to include, presence of pot holes/bad road, trading activities, on-street parking, loading and discharging of passengers, illegal bus stops, flooding/poor drainage, vehicle breakdown, narrow road sections, religious activities, high volume of traffic, lack of parking space and lack of traffic light at some road intersections.

Yusuf, Akpu, Arigbede and Abbas (2011), studied attitudinal factors of road users and increase commuting time in Zaria, Kaduna state. The data were collected from Zaria city-Danmagaji – Tudun Wada axis and Sabon-Gari, Kwangila-Samaru axis. The findings revealed that about 97 % of commuters attributed increased commuting time to the attitude of drivers among which are impatience and waiting for passengers, another 87% attributed it to passenger attitude. The study also showed that Zaria city-axis recorded longer commuting time than Samaru-axis. About 93% of respondents believed that commuting time is extended by 10-15 minutes, depending on the vehicles. The study revealed that delays in commuting time can be reduced through attitudinal change and sustained policy intervention.

Thwala *et al*, (2012), examined the effects and causes of traffic congestion in Ibadan city, Nigeria. The study was carried out in three neighborhoods (Agbowo, Bodija and Agodi Gate) in Ibadan North Local Government Area. Survey approach through questionnaire was used for data collection. Fifty (50) respondents were sampled in each of the three neighborhoods making a total of 150. Descriptive statistics such as means, simple percentages and graphics were employed in analyzing the data collected. Results show that 51.3% of the respondents spend between 21 minutes and above on congestion daily while 20.7% spend between 5-15 minutes and1.3% less 5 minutes. It was equally observed that residents in the city spend almost twice the time they would use on their trip from home to office due to traffic congestion. On the temporal and spatial pattern of traffic congestion in the three neighborhoods, the results revealed that Agbowo (65.3%) recorded the highest traffic congestion in the evening and morning period followed by Bodija (48 %) and Agodi Gate (31. 4%).On ranking of some major routes in the study area on traffic congestion by respondents, Agodi – Iwo Road route ranked highest with a mean value of 1.45 followed by University of Ibadan(U.I) – Bodija- Agodi Gate route with mean value of 1.27 and Sango-

Iwo Road 1.03.The authors recommended the banning of street trading and provision of functional mass transit buses.

Ibrahim and Salisu (2012) studied the effects of road development on travel time and cost in Kaduna state, Nigeria. The research determined the travel time as it relates to road connectivity and accessibility among some selected major settlements. Questionnaire administration was carried out in major motor parks in the selected settlements. The results of the study showed that there was significant decrease in travel time between different locations in Kaduna State which can be attributed to the huge investments in road development in the State. The reduction in travel time has brought about greater spatial integration in the State. It also revealed road development translated to improved accessibility and connectivity and decrease in travel time.

Although many researchers have carried out works on traffic congestion and delays in Nigeria, the effects of traffic congestion on travel time in Kaduna metropolis using GPS/GIS is essential in order to gain real time traffic conditions and in the process address transportation issues.

CHAPTER THREE

STUDY AREA AND RESEARCH METHODOLOGY

3.1 Introduction

This Chapter describes the method used in attaining the stated aim and objectives of the study. The research approach in this dissertation involves the use of GPS to acquire the coordinates and stop watch for travel and delay time for the study, Arc map to show the analysis of the coordinates at which the various speed and travel time were collected on the field. The use of questionnaire was also to determine the causes and impacts of traffic congestion on travel time.

3.2 Study Area

Kaduna metropolis lies between Latitudes 10^0 $26^{'}$- 10^0 $36^{'}$ N of the Equator and Longitudes 7^0 $22^{'}$-7^0 $30^{'}$ E of the Greenwich Meridian. It is made up of Kaduna north and Kaduna south, as well as parts of Igabi and Chikun local government areas. The city formerly occupied a land area of 21.10km^2 in 1960 which increased significantly to 181.01km^2 in 2009 due to spatial expansion (Ndabule *et al*, 2012).

3.2.1 Location of Study Area

Kaduna State occupies part of the central area of the Northern part of Nigeria (with Kaduna as its capital). As the capital of the former Northern Nigeria it was and remains a focal point of Northern politics and economy. Kaduna metropolis was founded in 1917 as an administrative Headquarters of northern Nigeria. Apart from presently being the administrative Headquarter of Kaduna state; it has experienced a high concentration of Federal parastatals and industries (Okunola, Uzairu and Ndukwe, 2007). Figure 3.1 shows the corridors in which data was collected, which are Station-Stadium Way, Kawo-Mando Way and Yakubu-Gowon Way.

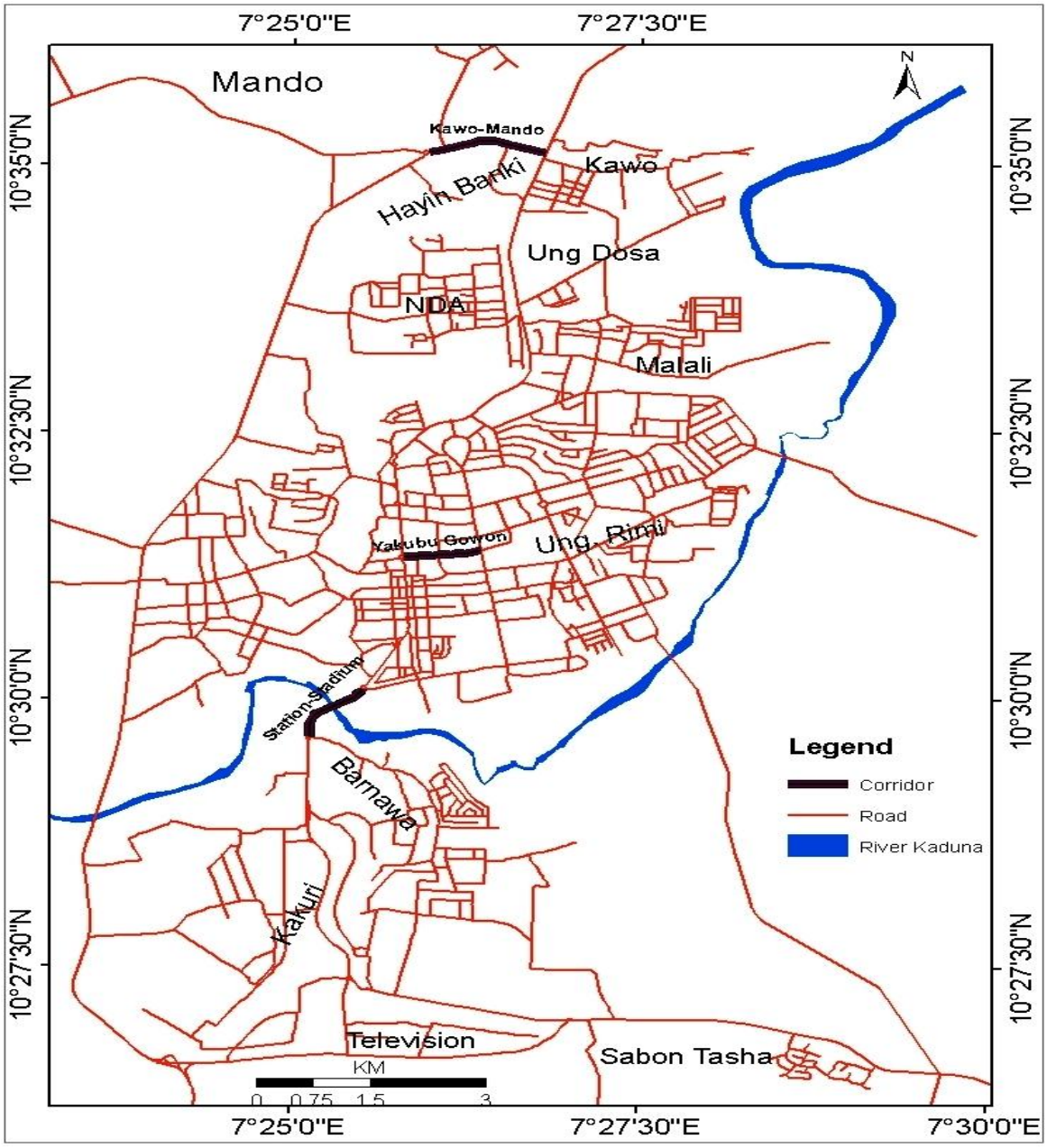


Figure 3.1: Kaduna Metropolis showing the study corridor
Source: Adapted from the Google map of the study area (2015)

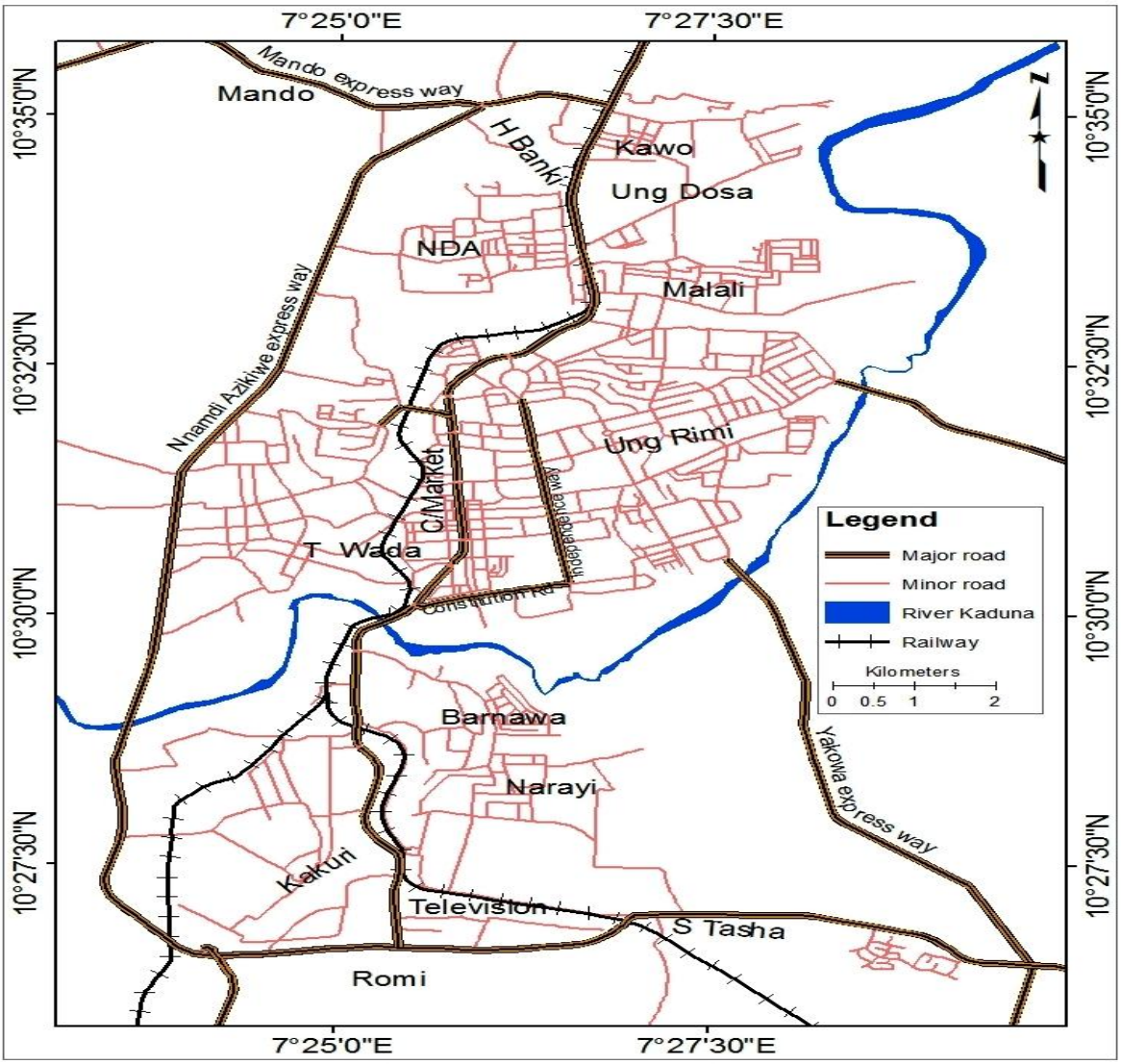


Figure 3.2: Kaduna Metropolis showing roads within metropolis

3.2.2 People and Socioeconomic Characteristics

Kaduna metropolis has undergone structural changes in its physical form, population, economic and social composition over the last century due to urban growth (Saleh *et al*, 2014). The population of Kaduna metropolis has shown steady and rapid increase as follows: 10,653 in 1931, 44,540 in 1952, 149,910 in 1963, and 800,000 in 1991. The exponential method of population projection has been recommended by the National Population Commission. The population for Kaduna metropolis is estimated as 2,068,568 for the year 2015.

Until the coming of the British, the local population of Kaduna metropolis was widely scattered and sparse. The establishment of a base for the West Africa Frontier Force (WAFF) in Kaduna was an important landmark that led to immigration into Kaduna metropolis and the subsequent growth of adjourning towns. This growing migration stimulated a spate of individual migration into the city by relations and friends of these workers.

The concentration of government employment opportunities and infrastructure also prompted most of the people migrating in from other parts of the country, the changing economic activities from agriculture to a modern and technology developed one and the commerce status of the town also attracts investors and other professionals and this has brought about increase in population and high economic activities within the metropolis.

3.2.3 Road Network System

Nigeria ranks tops compared with other countries in Sub-Saharan Africa in terms of road network. The country has the largest road network in West Africa and the second largest, south of the Sahara with an estimated 200,000km of road network connecting villages to cities, the distant with the near and the inter-land with the urban market (Compendium Report on Road Infrastructure and Related Development in Nigeria- An Investor's Manual, 2013).

The types of road network identified in Kaduna metropolis; are inter-urban, intra-urban and urban minor road. The network in Kaduna metropolis has seen a contrary plan to the proposed master plan by Max Lock 1967 and also coupled with its economic dynamics and vibrancy, this consequences are now seen all over Kaduna metropolis in traffic congestion and large extension areas with no logical internal road and no direct linkages with each other.

3.3 Methodology

3.3.1 Reconnaissance Survey

A reconnaissance survey of the study area helped in identifying the congested corridors, which guided in (i) defining the corridors to be studied; (ii) defining the time period during which data will be collected; (iii) determining the number of travel time runs that are necessary; and (iv) training of test vehicle drivers along the corridors with one hour performing sample runs.

3.3.2 Primary Materials used

Questionnaire and travel time data which include the speed and travel time.

3.3.3 Secondary Materials used

Journals, thesis, internet, newsletter and other published and unpublished materials were used as reference materials for the study.

3.3.4 Data Types

The data required include:

i. Corridors length/width

ii. Coordinates of each corridor

iii. Travel and delay time for each of the corridors

iv. Speed for each of the corridors

v. Distance for each of the corridors

vi. Socio-demographic characteristics of respondents

vii. Impact of traffic congestion on travel time within the corridors

3.3.5 Data Sources

Questionnaire survey was used in collecting data on the socio-demographic characteristics of respondents, causes and impacts of traffic congestion on travel time. Also Global Positioning

System (GPS) was used to acquire coordinates for the travel time and a stop watch for taking the travel time. Speed was recorded using a speedometer while the width and distance and of the congested corridors was measured using a measuring tape.

3.3.6 Sample Size and Sampling Technique

The sampling size used to determine the sample size is based on Yamene (1967) formula.

that is Sample size = $\frac{N}{1+ N(e)^2}$

Where N= total number of population = 2,068,568

e = error margin = 0.05

Sample size = 399.8

A total of 400 copies of the questionnaire were administered. There are a number of corridors within the metropolis with their respective levels of congestion; the researcher purposively selected the three corridors as a result of their socio-economic importance as a by-pass leading to the west and north, as a major road leading to both government and private administrative headquarters within the metropolis and also an administrative corridor.

Copies of the questionnaire were distributed purposively to road users (bus and car drivers as well as passengers both of bus and car) for each week because of the lack of pre-determined consistent population and passengers and drivers chances of not being selected. Kawo-Mando was giving 133, Station-Stadium was giving 133, and Yakubu-Gowon way was giving 134. For each corridor the bus and car drivers were administered 20 copies questionnaire each while the passengers were administered 47 for bus and 46 for car, based on the fact that, the travel data collected is on transit mode.

3.3.6.1 Materials and Software Used

i Global positioning system (GPS)

ii Measuring tape

iii Stopwatch

iv Speedometer

v Arc GIS 10.1

3.3.6.2 Questionnaire Administration

The questionnaire was prepared in order to gather additional information on the causes of delay along the corridors, social and economic impact of delay, how much delay is experienced when there is congestion, time delay is experienced and day of the week in which delay is experienced, for the congestion analysis. As congestion is a function of people's perception toward the time and trip purpose, it was necessary to obtain data on how the road users in the corridors selected perceive the current traffic congestion and how much delay they experience.

3.3.7 Data Collection Techniques

3.3.7.1 Travel Time Data

Travel time data were the most important data for the congestion analysis, because it reveals the true congestion situation of the corridors. Travel time data gathered for the three corridors which are Station- Stadium Roundabout towards the central business district CBD, Kawo towards Mando junction and Yakubu-Gowon way within seven days from Monday to Sunday, Saturday and Sunday were included to have a proper travel time journey pattern. Morning and evening peak periods and also afternoon off-peak periods were considered. Turner, Eisele, Benz and Holdener (1998), in their final report on travel time data handbook suggested that the maximum number of test vehicle runs for a particular corridor can be 3 to 6 runs per corridor (Whenever possible, it is recommended that at least 2 test runs be completed for each corridor to yield observed speed ranges, therefore the number of runs that were considered for each segment of the corridors was 2 for each period. Time of survey was

classified under Am peak (7am – 9am), (11am-2pm) afternoon off-peak period and evening peak-period (3pm to 6pm). The mode of transportation was car and bus.

Data collection personnel in a test vehicle control the speed of the vehicle. In this study, a GPS receiver was held in a vehicle to record coordinates while the travel time, delay time, speed, distance and date was recorded manually using a stop watch, speedometer and measuring tape respectively. The data for each corridor was collected at the beginning of each segment.

The vehicle (car and bus) had a driver and two personnel; one takes the speed and coordinates while the other takes the travel time. A number of three points were taken in which there were variations in speed for each run/segment and this was based on the fact that the data were to be imputed into ARCGIS for analysis, in which the point where well mapped out.

3.3.7.2 Data Processing and Analysis

Descriptive statistics were used to calculate the average travel speed, average travel and average delay time, for the questionnaire responses pie chart and cross tabulation using SPSS statistical package. Hypothesis testing T-Test was also used in SPSS (Statistical Package for Social Science) environment for the analysis.

In order to calculate the actual travel time of the 3 corridors, the following formula was used.

The actual travel-time was calculated using $S = d/t$

Where S = Speed
d = distance
t = time

Google Earth image of the study area was geo-referenced and digitized in ArcGIS 10.1 to extract the road network in the study area. The coordinates captured were put in Microsoft excel sheet and saved as CSV (comma delimited) format, and then put into the ARCMAP after which the speed variations and coordinates were displayed geographically using the

‘Add data’ tool. This overlaid the coordinates on the geo-referenced road network of the selected congested corridors. Graduated color ramp was used to locate the position of each coordinates according to speed and travel time of the Car/Bus, spatial analysis tools were used, the map showing the congested corridor is shown with the boundary and corridors was digitized in polyline respectively. Different colors were used to represent the different speed and the corridors.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Introduction

The results and discussion are contained in this Chapter. Analysis was done on mapping the congested corridors, determining the speed, travel and delay time for each segment of the corridors using GIS and the average speed and average travel and delay time were determined using inferential analysis. T-test analysis was done on the differences between car travel time in the different segments of the corridor and also between car and bus in the same segment. Finally the causes and impact of traffic congestion on travel time was analyzed using descriptive statistics.

4.2 Mapping the Congested Corridors

The three congested corridors considered in this study were mapped and presented in Figures 4.1, 4.2 and 4.3.

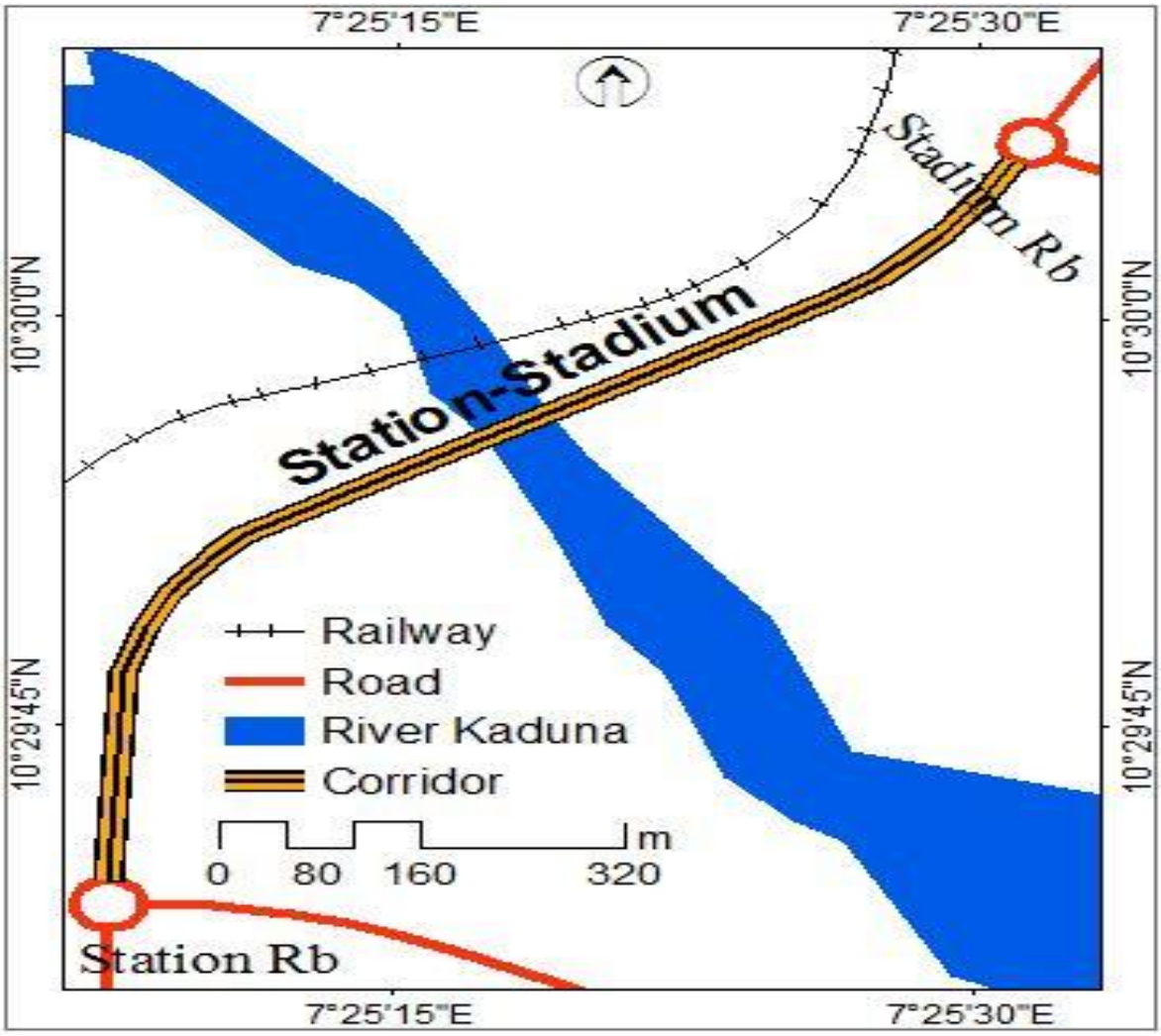


Figure 4.1: Station-Stadium congested corridors
Source: Author's GIS Analysis (2015)

Figure 4.1 shows Station-Stadium corridor with a shoulder of 3m, width of 9.5m and length of 1178m. The corridor is two-lane and the major road that connects places like Barnawa, Kakuri, Television, etc, with the Central Business District (CBD) of the metropolis. It is also the shortest link between southern and northern parts of the metropolis.

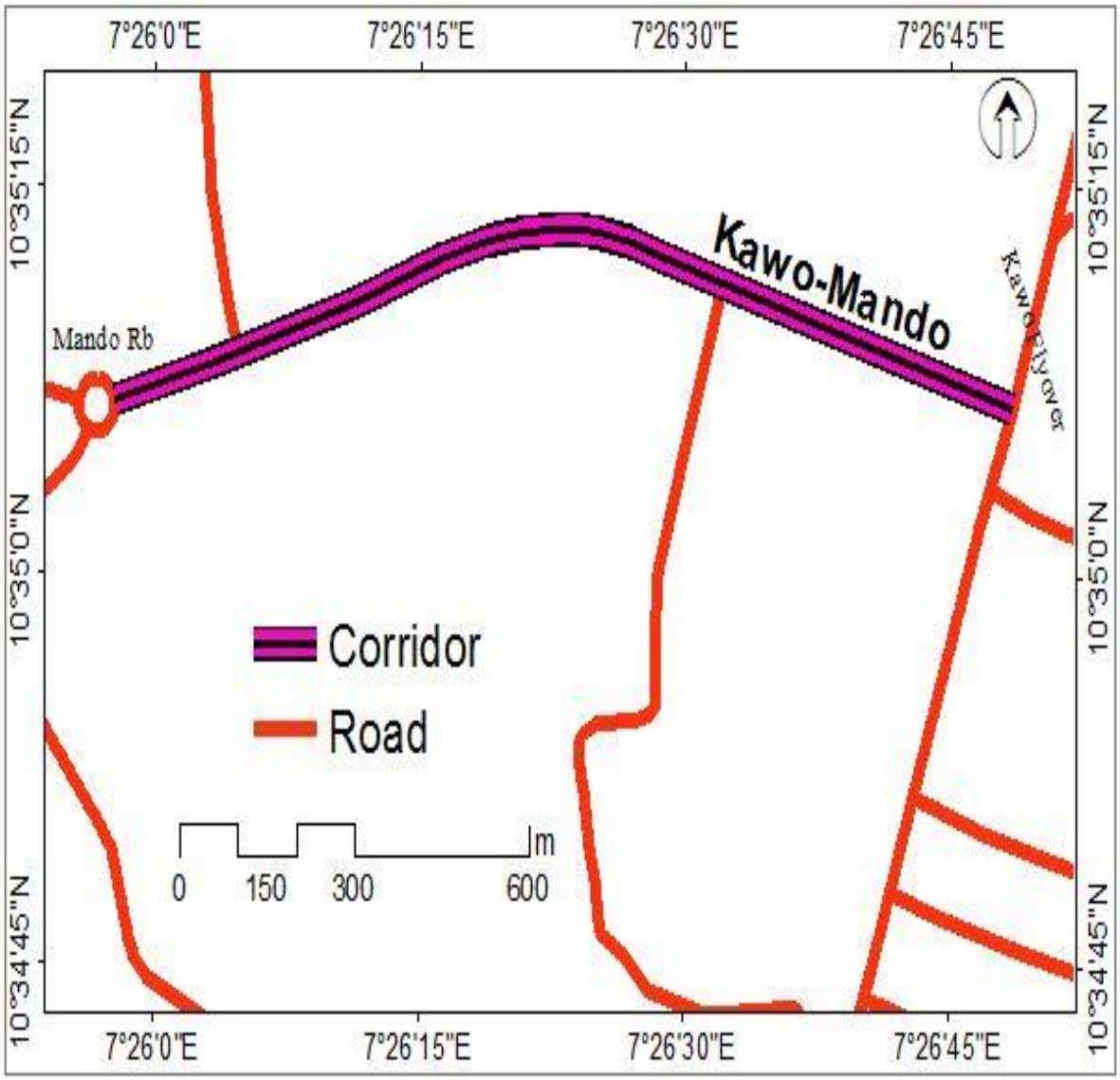


Figure 4.2: Kawo-Mando congested corridor
Source: Author's GIS Analysis (2015)

Figure 4.2 shows Kawo-Mando corridor with shoulder length of 2m, width of 7.3m, length of 1601.6m. This corridor is also two-lane and it is the only bypass for road users travelling from Kano, Maiduguri, Yobe, Katsina, Sokoto, etc, to the southern part of Nigeria. It is also the major road between Mando and Kawo.

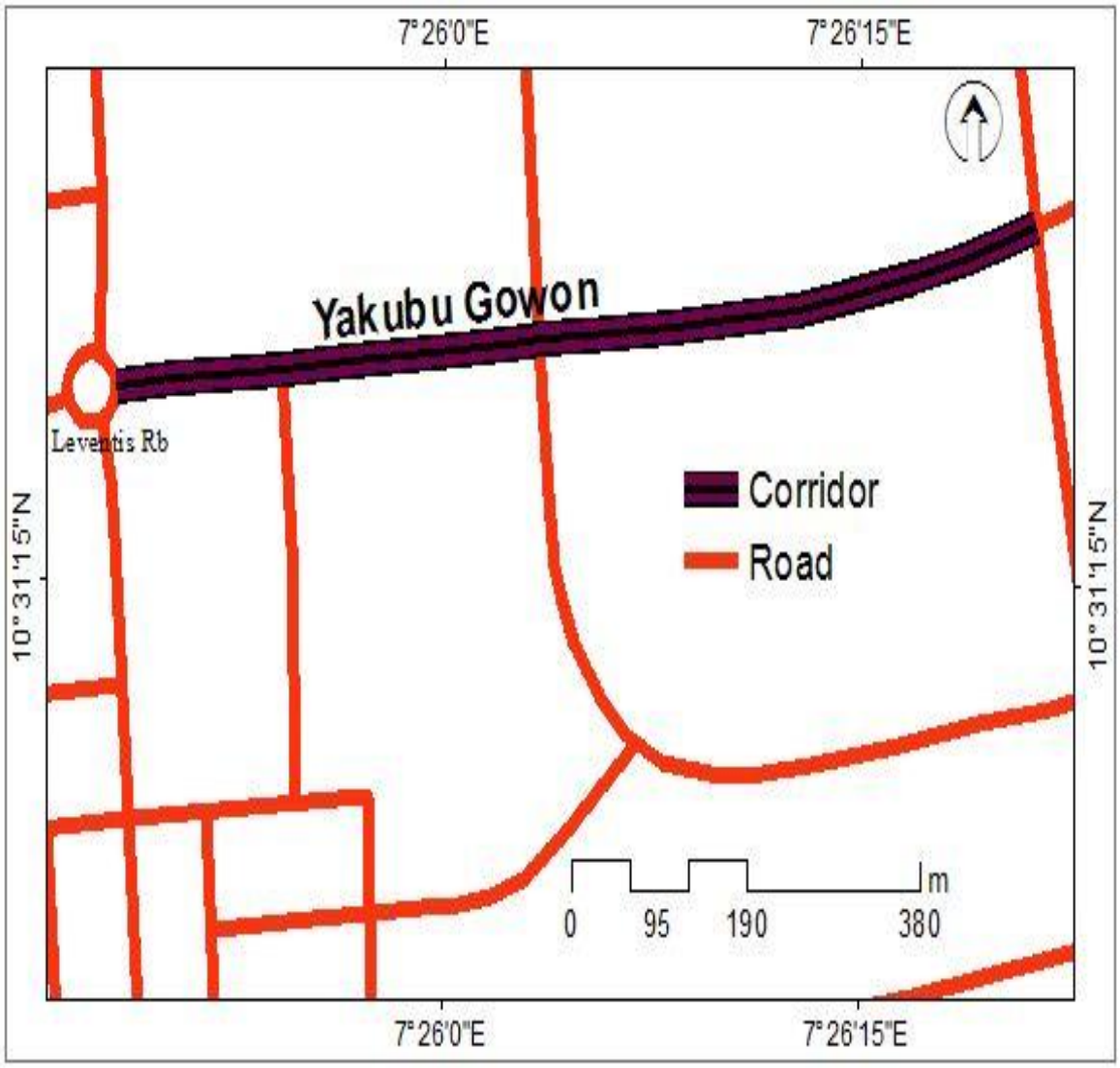


Figure 4.3: Yakubu Gowon way congested corridor
Source: Author's GIS Analysis (2015)

Figure 4.3 shows Yakubu Gowon way corridor with shoulder length of 1.6m, width of 6.4m, length of 1019.9m. The road is one-lane and most of the ministries in Kaduna state, banking regional offices and telecommunication regional offices are situated along the corridor.

4.3 Speed, Travel and Delay Time for Each Segment of the Corridors

The speed, travel and delay time for the study area are discussed here. Whenever segment 1 and 2 are mentioned under Station-Stadium corridor, it is simply referring to (1) movement from Station roundabout to Stadium roundabout, (2) movement from Stadium roundabout to Station roundabout. Segment 1 and 2 for Kawo-Mando corridor refers to (1) movement from under the flyover to Mando-Kawo, (2) movement from express roundabout to Kawo flyover. Yakubu Gowon way corridor, moving from Leventis roundabout to Independence way junction is segment (1) and movement from Independence way junction to Leventis roundabout way is segment (2).

4.3.1 Car Speed at Station-Stadium Corridor

Car speed along Station-Stadium corridor during morning, afternoon and evening periods from Monday to Sunday are presented in Table 4.1, 4.2 and 4.3.

Table 4.1 which shows time of the day from Monday to Friday, shows segment (1) morning period and segment (2) evening period as having the lowest average speed. The highest average speeds were experienced during the afternoon along segment (1) and (2). Friday shows low speed along segment (1) during the morning and segment (2) during the afternoon.

Table 4.1: Time of the Day Average Speed of Car at Station-Stadium Corridor (Weekdays)

Day	Time of the day	Speed (Kmph)		Average for both Segments (Kmph)
		Segment 1	Segment 2	
Monday	Morning	19	28	
	Afternoon	31	48	31
	Evening	38	19	
Tuesday	Morning	19	58	
	Afternoon	47	52	39
	Evening	39	20	
Wednesday	Morning	16	24	
	Afternoon	39	41	28
	Evening	38	11	
Thursday	Morning	24	45	
	Afternoon	46	35	35
	Evening	36	24	
Friday	Morning	20	35	
	Afternoon	35	12	29
	Evening	35	24	

Source: Author's Field Survey (2015)

Congestion occurs during the morning because of the large number of vehicles transporting commuters to the central business district for work, businesses, school and early morning market. The evenings also experience congestion because the same passengers return through the same corridor.

Friday reveal afternoon congestion because workers in the state return from work during the afternoon and during this time Jumat prayers takes place at railway station roundabout Jumat mosque along Station roundabout.

The result reveals that during the morning and evening the corridor suffers traffic congestion which reduces the car speed. The speed pattern agrees with that of Olusina and Samson

(2014), who studied the determination of predictive models for traffic congestion in Lagos metropolis, there finding revealed more routes are congested between 7.00 – 8.00hrs in the morning peak period and between 16.00 – 17.00hrs and 18.00 – 19.00hrs in the evening peak period, while the low speed that reflects congestion in the afternoon on Friday disagrees with their findings. The average for both segments reveals Wednesday as having the lowest speed, followed by Friday while Tuesday shows the highest speed during the weekdays.

Table 4.2: Time of the Day Average Speed of Car at Station-Stadium Corridor (Weekend)

Day	Time of the day	Speed (Kmph)		Average for both Segments (Kmph)
		Segment 1	Segment 2	
Saturday	Morning	42	45	
	Afternoon	32	38	38
	Evening	38	33	
Sunday	Morning	42	43	
	Afternoon	42	42	43
	Evening	46	43	

Source: Author's Field Survey (2015)

Table 4.2 which is time of the day for Saturday to Sunday, show high speed on both segments for morning, afternoon and evening periods.

The findings reveals that Saturday and Sunday are weekends and most individuals stay indoors to rest, thereby making the corridor non-congested. This study disagrees with the findings of Osoba (2012), who studied intra-urban traffic congestion in some selected Local Government Areas of Lagos metropolis and found out that 10% of the respondents agreed to the fact that traffic congestion occurs mostly on Sunday and 7% of the respondents said traffic congestion occurs mainly on Saturday.

Table 4.3: Average Weekly Car Speed at Station-Stadium Corridor

Day of the week	Speed(kmph)	
	Segment 1	Segment 2
Monday	29	32
Tuesday	35	43
Wednesday	31	25
Thursday	35	35
Friday	30	24
Saturday	37	39
Sunday	43	40

Source: Author's Field Survey (2015)

Table 4.3 shows that speed along segment (1) is generally low which could be due to the fact that this segment leads to the Central Business District in which individuals travel to work, businesses, school and for other activities daily. The lowest speed was experienced on Monday, which could be that during this day the volume of vehicles that ply the corridor are usually high in number because of travel to work, school, business and other personal activities.

The presences of filling station along both segments of the corridor where cars are park along the roadside in order to fuel their cars also contribute to congestion which in turn reduces vehicular speed.

Friday has the lowest average speed along segment (2), which is due to Jumat prayer which is performed at railway station roundabout along that segment. The highest average speed was experienced on Saturday and Sunday on both segments, which could also be due to the fact that these days are weekend, implying that most individuals travel mostly for visitation,

shopping, recreation and other personal activities at different times and this keeps the corridor less congested.

4.3.2 Car Travel and Delay Time at Station-Stadium Corridor

Car travel and delay time along Station-Stadium corridor during morning, afternoon and evening periods for the week.

Table 4.4: Time of the Day Average Travel and Delay Time of Car at Station-Stadium Corridor

Time of the Day	Travel-time (sec)		Delay-time (sec)	
	Segment 1	Segment 2	Segment 1	Segment 2
Morning	350	99	283	47
Afternoon	107	178	35	106
Evening	120	306	49	216

Source: Author's Field Survey (2015)

Table 4.4 shows that the highest average travel and delay time was experienced during the morning period along segment (1) and evening along segment (2). This indicates that the location of major government offices with respect to the spread of residential areas, is not properly considered in town planning and development of master plans for Kaduna city, this is causing serious congestion problem due to mass movement of commuters within the same period as in the case of civil servants, students, business men and women moving, to and from work around the same period of time.

Increased in vehicular ownership and the convenient to commute for work, business and other personal activities alone by car increases volume of vehicles, which increases traffic congestion which in turn increases travel and delay time.

The result agrees with that of Thwala *et al*, 2012 who studied traffic congestion, causes and effect on residents of cities in Nigeria, their result indicated that traffic congestion is very high along Agbowo, Bodija and Agodi in the morning and evening period as compared to the afternoon.

Table 4.5: Weekly Average Car Travel and Delay Time at Station-Stadium Corridor

Day of the week	Travel-time(sec)		Delay-time(sec)	
	Segment 1	Segment 2	Segment 1	Segment 2
Monday	282	221	211	150
Tuesday	183	206	112	135
Wednesday	259	236	188	165
Thursday	232	159	161	88
Friday	196	293	125	222
Saturday	110	143	39	72
Sunday	84	85	13	14

Source: Author's Field Survey (2015)

Table 4.5 reveals that both segments have high average travel and delay time during the weekdays and lower average travel and delay time during the weekends. Segment (1) revealed Monday had the highest travel and delay time, the situation on Wednesday is an occasional one, which could be due to the fact that the filling station along the segment had fuel (petrol) and vehicles were parked along the segments corridor thereby increasing the level of congestion.

Segment (2) shows Friday as having the highest average travel and delay time, which could be as a result of commuters coming back from work, businesses and being a Friday in which Jumat prayers is performed in and around railway station roundabout Jumat mosque along the segment, during these period vehicles are usually packed along the corridor causing increase in congestion level.

Travel time and delay is high during the weekdays as compared with the weekends along the entire corridor, which is because the weekend's trips are mostly for leisure. This study agrees with the study of Olaogbebikan, Ikpechukwu, Akinsulire and Enosko (2013), in Alaba International Market, Ojo, Lagos State, Nigeria, their study revealed high congestion on Monday, which they deduced because it is the first day of the new week and it also disagrees that congestion occurs on weekends along the corridor.

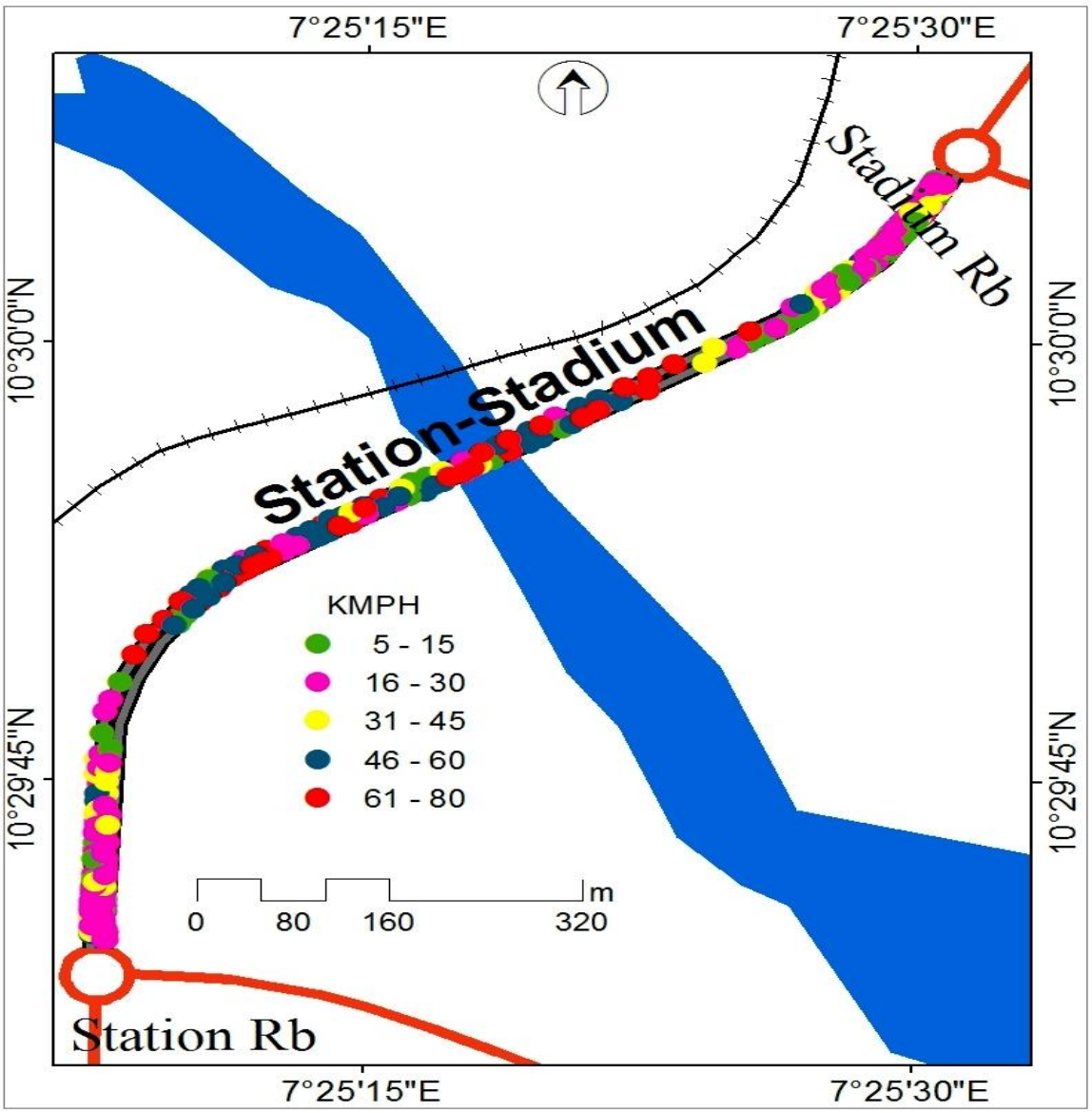


Figure 4.4: Station-Stadium observed car speed distribution for the week
Source: Author's GIS Analysis (2015)

The figure 4.4 has free flow travel time of 71secs, nodes of different colors are used to show changes in speed limit and movement from both edges of the segments reveals that the speed is low and gradually increases towards the middle.

4.3.3 Bus Speed at Station-Stadium Corridor

Bus Speed along Station-Stadium corridor during morning, afternoon and evening periods from Monday to Sunday is discussed in Tables 4.6 to 4.8

Table 4.6: Time of the Day Average Speed of Bus at Station-Stadium Corridor (weekdays)

Day	Time of the day	Speed (Kmph)		Average for both Segments (Kmph)
		Segment 1	Segment 2	
Monday	Morning	13	31	
	Afternoon	30	40	27
	Evening	30	17	
Tuesday	Morning	20	58	
	Afternoon	45	50	39
	Evening	41	20	
Wednesday	Morning	13	25	
	Afternoon	35	40	26
	Evening	33	11	
Thursday	Morning	29	43	
	Afternoon	43	42	38
	Evening	45	22	
Friday	Morning	25	40	
	Afternoon	43	11	30
	Evening	41	20	

Source: Author's Field Survey (2015)

Table 4.6 shows that Segments (1) has low average speed during the morning peak-period, while segment (2) has low average speed during the evening peak-period. Segments (1) revealed high average speed during the afternoon and evening periods while segment (2)

reveals high speed during the morning and afternoon period. This agrees with the study of Olaogbebikan, Ikpechukwu, Akinsulire and Enosko, (2013) in Alaba international Market, Ojo, Lagos State, Nigeria. There discovery reveals that majority of the trips generated in the area are for working purposes and congestion may be evident during the morning rush hour (people commuting to work) and also during the evening period when they close from work.

The bus average speed pattern is the same with that of car average speed in Table 4.1, the only differences is seen in the average speed figures, which shows that car is higher than bus; this is because no matter the congestion bus drivers maneuver their way through the corridor faster than car drivers. The average speed for the entire corridor shows that Wednesday has the lowest speed.

Table 4.7: Time of the Day Average Speed of Bus at Station-Stadium Corridor (Weekend)

Day	Time of the day	Speed (Kmph)		Average for both Segments (Kmph)
		Segment 1	Segment 2	
Saturday	Morning	35	40	
	Afternoon	46	46	41
	Evening	40	36	
Sunday	Morning	48	50	
	Afternoon	49	42	48
	Evening	47	52	

Source: Author's Field Survey (2015)

Table 4.7 Time of the day speed for Saturday and Sunday, shows high speed on both segments for morning, afternoon and evening periods. The finding is the same as that of car which revealed that individuals mostly stay indoors to rest during the weekends, thereby making the corridor non-congested.

Table 4.8: Weekly Average Bus Speed at Station-Stadium Corridor

Day of the week	Speed(kmph)	
	Segment 1	Segment 2
Monday	24	29
Tuesday	35	43
Wednesday	27	25
Thursday	39	37
Friday	36	24
Saturday	40	41
Sunday	48	48

Source: Author's Field Survey (2015)

Table 4.8 shows that Monday has the lowest average speed on segment (1) while Saturday and Sunday has the highest average speed. The results along segment (2) shows Friday as having the lowest average speed while Saturday and Sunday also reveals highest along the same segment.

The result revealed that speed flow is related to the travel pattern in which most of resident from the suburb (Barnawa, Sabo-tasha, Romi, Kakuri, Gonin-gora and Narayi) travel daily to the metropolis through segment (1) and return through segment (2). The experience in bus speed pattern is the same as that discussed in car in Table 4.3, with only difference in the figures.

4.3.4 Bus Travel and Delay Time at Station-Stadium Corridor

Bus travel and delay time along Station-Stadium corridor during morning, afternoon and evening periods from Monday to Sunday is discussed in Tables 4.9- 4.10

Table 4.9: Time of the Day Average Travel and Delay Time of Bus at Station-Stadium Corridor

Time of the Day	Travel-time (sec)		Delay-time (sec)	
	Segment 1	Segment 2	Segment 1	Segment 2
Morning	316	99	250	39
Afternoon	89	166	22	97
Evening	124	270	53	200

Source: Author's Field Survey (2015)

Table 4.9 shows the morning, afternoon and evening periods travel and delay time for Station-Stadium corridor. The highest average travel-time were experienced during the morning period along segment (1) and in the evening along segment (2), this is due to the fact that individuals travel for work, school and business during the morning periods along segment (1) and return from work, market and businesses through segment (2) of the corridor during the evening period. The delay in the morning and evening is higher, because the higher the travel time the higher the delay.

The afternoon and evening period along segment (1) and the morning and afternoon period along segment (2) experience low travel an delay time which could be because during this period commuters travel for their personal activities such as shopping and visiting.

Traffic congestion flows to areas where people move to earn their living in the morning and return after the work day is completed in the early evening. This findings is however in line with the study of Osoba (2012), who reported that traffic congestion is at its peak between 7 to 9 am (morning) and 5 to 7 pm (evening). The pattern is also similar to that of car in Table 4.4, the difference is in the travel and delay time figures with car having the highest.

Table 4.10: Weekly Average Bus Travel and Delay Time at Station-Stadium Corridor

Day of the week	Travel-time(sec)		Delay-time(sec)	
	Segment 1	Segment 2	Segment 1	Segment 2
Monday	241	226	170	155
Tuesday	202	230	131	159
Wednesday	239	206	168	135
Thursday	226	127	158	56
Friday	162	286	91	215
Saturday	102	99	31	28
Sunday	92	89	22	18

Source: Author's Field Survey (2015)

Table 4.10 shows Monday as having the highest average travel and delay time along segment (1) and Friday along segment (2). The result generally shows that the weekdays on both segments have high travel and delay time than the weekends.

Generally travel and delay time is higher during the weekdays and lower during the weekends, which clearly shows that during working days more people move towards the city centers for work, school, banking and business purpose through this corridor than during the weekends.

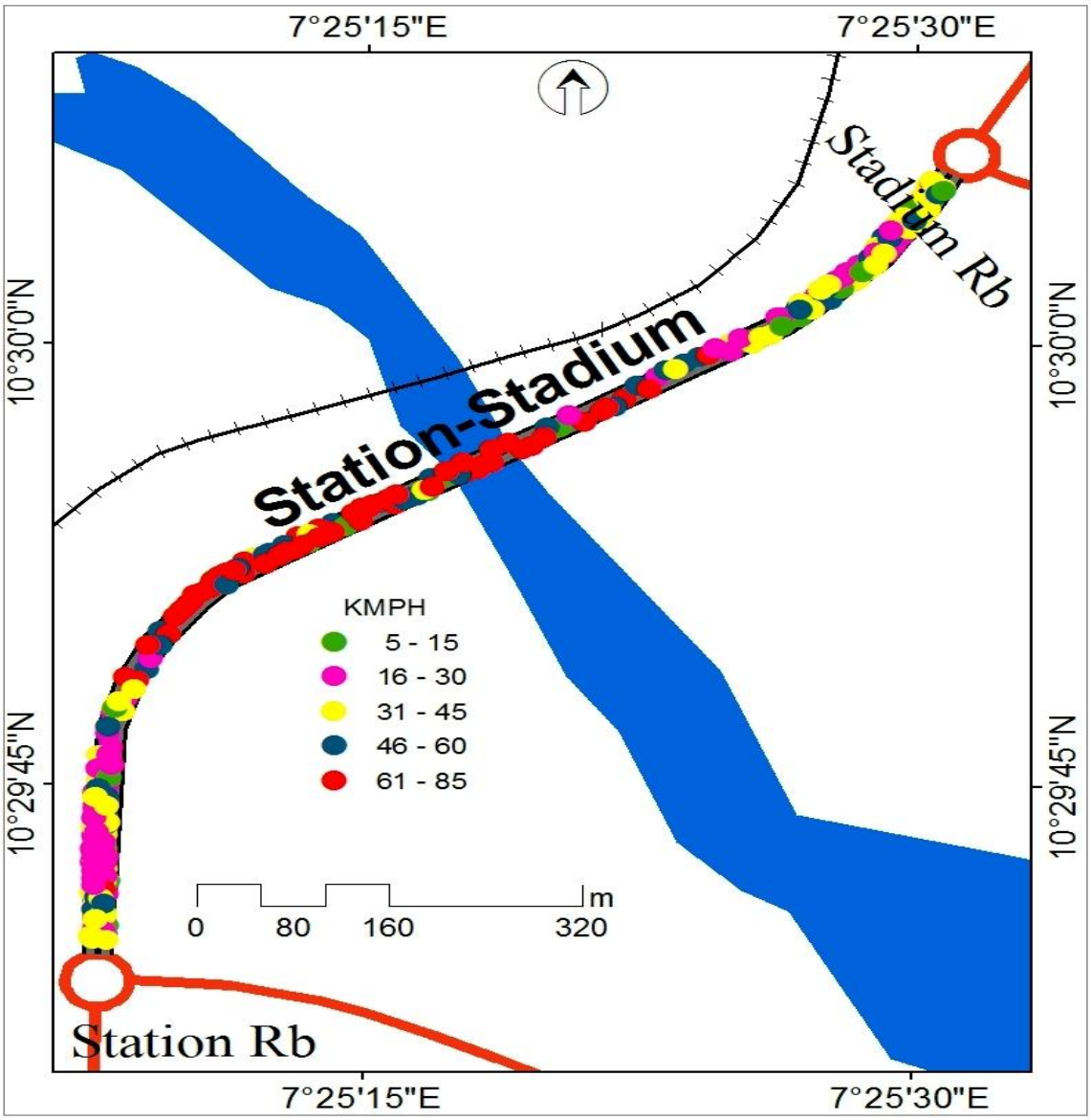


Figure 4.5: Station-Stadium observed Bus speed distribution for the week
Source: Author's GIS Analysis (2015)

Figure 4.5 has a free flow travel time of 71secs; nodes of different colors are used to show changes in speed limit, movement from both edges of the segments reveals that the speed is low and gradually increases towards the middle.

4.3.5 Car Speed at Kawo-Mando Corridor

Car Speed along Kawo-Mando corridor during morning, afternoon and evening periods from Monday to Sunday is discussed in Tables 4.11 to 4.13

Table 4.11: Time of the Day Average Speed of Car at Kawo-Mando Corridor (Weekdays)

Day	Time of the day	Speed (Kmph)		Average for both Segments (Kmph)
		Segment 1	Segment 2	
Monday	Morning	13	31	
	Afternoon	30	20	26
	Evening	40	20	
Tuesday	Morning	23	50	
	Afternoon	52	52	40
	Evening	41	20	
Wednesday	Morning	13	42	
	Afternoon	42	46	34
	Evening	45	15	
Thursday	Morning	29	43	
	Afternoon	43	42	37
	Evening	45	22	
Friday	Morning	25	46	
	Afternoon	43	21	34
	Evening	41	28	

Source: Author's Field Survey (2015)

Table 4.11 shows that the average speed for the morning period in segment (1) and evening period in segments (2) is low which is due the fact that commuters travelling into and out of the State and also individuals going and returning to work during the morning and evening using both segments. The bypass is used by commuters travelling out to the Western part, Southern part of the country and also commuters travelling to the North West from the West and South.

The afternoon period is high for both segments which is because of the few number of travelers commuting the corridor during this period and their travels are mostly for leisure.

Congestion affects speed and smooth traffic flow and this affects a wide range of activities, such as work trip, school trip and business trip opportunities in the metropolis which can best be delivered through road transportation.

The findings along Kawo-Mando corridor agrees with that of Olusani and Samson (2014), in their study on determination of predictive models for traffic congestion in Lagos metropolis, which revealed that more routes are congested between 7.00 – 8.00hrs in the morning peak period and between 16.00 – 17.00hrs and 18.00 – 19.00hrs in the evening peak period.

The average for the entire corridor revealed that Monday has the lowest speed, which could be due to the fact that Monday is the first working day of the week and individuals use the corridor for different purposes.

Table 4.12: Time of the Day Average Speed of Car at Kawo-Mando Corridor (Weekend)

Day	Time of the day	Speed (Kmph)		Average for both Segments (Kmph)
		Segment 1	Segment 2	
Saturday	Morning	35	40	
	Afternoon	46	46	41
	Evening	40	36	
Sunday	Morning	48	50	
	Afternoon	49	42	48
	Evening	47	52	

Source: Author's Field Survey (2015)

Table 4.12 shows high average speed during the morning, afternoon and evening periods for both segments. This indicates that weekend is not usually congested along the corridor, which is because the travels during these days are mostly long distance journeys and trip to work, school, businesses and recreation are fewer.

Table 4.13: Average Weekly Car Speed at Kawo-Mando Corridor

Day of the week	Speed(kmph)	
	Segment 1	Segment 2
Monday	28	24
Tuesday	37	41
Wednesday	33	34
Thursday	39	37
Friday	36	32
Saturday	40	41
Sunday	48	48

Source: Author's Field Survey (2015)

Table 4.13 shows that both segments have low average speed on Monday which could be because the corridor is a bypass and the movement includes travel for work, school, businesses and recreation. Commuters travelling from and out to the West and South use this corridor and also commuters travelling through to other State of the North-West , while the weekend shows slight increase in speed which could be because travels are usually for personal reasons during the weekends.

4.3.6 Car Travel and Delay Time at Kawo-Mando Corridor

Car travel and delay time along Kawo-Mando corridor during morning, afternoon and evening periods for the week.

Table 4.14: Time of the Day Average Travel and Delay Time of Car at Kawo-Mando Corridor

Time of the Day	Travel-time (sec)		Delay-time (sec)	
	Segment 1	Segment 2	Segment 1	Segment 2
Morning	203	138	106	43
Afternoon	157	212	64	126
Evening	162	270	65	173

Source: Author's Field Survey (2015)

Table 4.14 shows that the highest average travel delay time is experienced during the evening period along segment (2), while the lowest is felt during the morning period along the same segment. Segment (1) shows highest travel and delay time during the morning period and the lowest during the afternoon.

The study reveals that the morning period is usually congested along segment (1) this is because commuters travel through this corridor during the morning to other states in the west and south of the country and is also used by travelers moving to work, school and business activities which are located along the corridor.

The evening periods along segment (2) experience commuters returning from their work places, schools business and long journey from the western and southern into the states thereby causing congestion which in turn increases travel and delay time.

Table 4.15: Day of the Week Car Average Travel and Delay Time at Kawo-Mando Corridor

Day of the week	Travel-time (sec)		Delay-time(sec)	
	Segment 1	Segment 2	Segment 1	Segment 2
Monday	234	312	138	216
Tuesday	167	201	71	105
Wednesday	213	229	117	133
Thursday	137	203	41	107
Friday	208	243	112	147
Saturday	150	151	54	55
Sunday	108	107	12	11

Source: Author's Field Survey (2015)

Table 4.15 shows that the travel and delay time for Kawo-Mando car for Monday has the highest, followed by Wednesday, Friday and Tuesday along segment (1). Segment (2) shows Monday as the highest, followed by Friday, Wednesday and Thursday.

The study reveals that weekdays generally have high travel and delay time on both segments of the corridor; these can be justified by the fact that commuters travel in and out of the state using these corridor which is a bypass and also travel to work, school, businesses and other daily activities, this however leads to the clogging of the corridor, which in turn leads to terrible traffic congestion bringing about increase in travel and delay time.

The study of Osoba (2012), on the geographical analysis of intra-urban traffic congestion in Lagos metropolis, does not agree with this study. His study revealed that traffic congestion occurs mostly on Monday which was justified by the fact that Monday is the first day of a new week in which work, school and business activities begins for the week and commuters travel for such purpose, while these study revealed that congestion occurs throughout the weekdays.

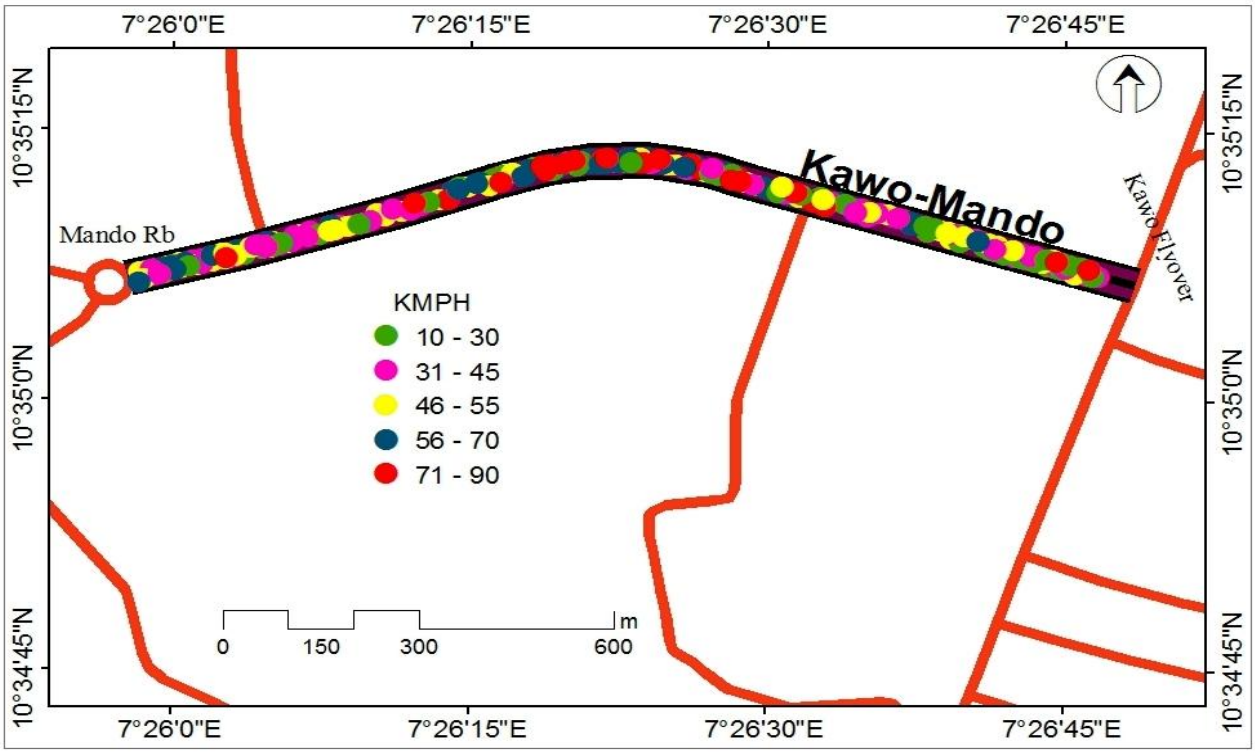


Figure 4.6: Kawo-Mando observed car speed distribution for the week
Source: Author's GIS Analysis (2015)

The figure above has a free flow travel time of 96secs; nodes of different colors are used to show changes in speed limit, movement from both edges of the segments reveals that the speed is changing throughout the corridor.

4.3.7 Bus Speed at Kawo-Mando Corridor

Bus Speed along Kawo-Mando corridor during morning, afternoon and evening periods for the week from Monday to Friday is discussed in Tables 4.16 to 4.18

Table 4.16: Time of the Day Average Speed of Bus at Kawo-Mando Corridor

Day	Time of the day	Speed (Kmph)		Average for both Segments (Kmph)
		Segment 1	Segment 2	
Monday	Morning	13	31	
	Afternoon	30	20	26
	Evening	40	20	
Tuesday	Morning	23	50	
	Afternoon	48	47	40
	Evening	38	20	
Wednesday	Morning	13	42	
	Afternoon	42	46	34
	Evening	45	15	
Thursday	Morning	29	43	
	Afternoon	43	42	37
	Evening	45	22	
Friday	Morning	25	46	
	Afternoon	43	21	34
	Evening	41	28	

Source: Author's Field Survey (2015)

Table 4.16 shows that segment (1) has the lowest average travel speed during the morning period and the evening period along segment (2). The afternoon and evening period along segment (1) and the morning and afternoon along segment (2) show high average speed along both segments. The result is same as that of car, with difference only in the speed figure in Tables 4.11.

Table 4.17: Time of the Day Average Speed of Bus at Kawo- Mando Corridor (Weekend)

Day	Time of the day	Speed (Kmph)		Average for both Segments (Kmph)
		Segment 1	Segment 2	
Saturday	Morning	35	40	
	Afternoon	46	46	41
	Evening	40	36	
Sunday	Morning	48	50	
	Afternoon	49	42	48
	Evening	47	52	

Source: Author's Field Survey (2015)

Table 4.17 also reveals the same pattern of speed flow as that of car in Table 4.12, which reveals weekends as having high travel speed.

Table 4.18: Weekly Bus Average speed at Kawo-Mando Corridor

Day of the week	Speed(kmph)	
	Segment 1	Segment 2
Monday	27	24
Tuesday	36	39
Wednesday	33	34
Thursday	39	36
Friday	36	32
Saturday	40	41
Sunday	48	48

Source: Author's Field Survey (2015)

Table 4.18 shows that both segments have lowest average travel speed on Monday and highest during the weekend. The pattern of the weekly bus average speed is the same as that of car in Table 4.13.

4.3.8 Bus Travel and Delay Time at Kawo-Mando Corridor

Car travel and delay time along Kawo-Mando corridor during morning, afternoon and evening periods from Monday to Sunday is discussed in Table 4.19 to 4.20.

Table 4.19: Time of the Day Average Travel and Delay Time of Bus at Kawo-Mando

Time of the Day	Travel-time (s)		Delay-time (s)	
	Segment 1	Segment 2	Segment 1	Segment 2
Morning	192	136	111	50
Afternoon	155	199	62	62
Evening	149	274	62	118

Source: Author's Field Survey (2015)

Table 4.19 shows that the highest travel and delay time is experienced during the morning and the lowest is felt during the evening along segment (1). The highest travel and delay time is experienced during the evening periods and the lowest is felt during the morning along segment (2). This result is due to the fact that individuals travel to work, school, business and personal activities and also travel into and out of the state through the corridor especially during the morning and evening periods.

The results revealed the same pattern of speed as that of car in Table 4.14; the differences can be seen in the travel and delay figures, with bus having less value during the morning and evening.

Table 4.20: Weekly Bus Average Travel and Delay Time at Kawo-Mando

Day of the week	Travel-time(s)		Delay-time(s)	
	Segment 1	Segment 2	Segment 1	Segment 2
Monday	226	300	130	204
Tuesday	167	194	71	98
Wednesday	202	247	106	151
Thursday	152	205	56	109
Friday	194	286	98	193
Saturday	133	131	37	35
Sunday	103	106	7	10

Source: Author's Field Survey (2015)

Table 4.20 shows that the travel and delay time for Kawo-Mando bus is highest on Monday, followed by Wednesday, Friday along segment (1). Segment (2) shows Monday as the

highest, followed by Friday, Wednesday and Thursday. Generally weekdays experience more congestion because of the number of commuters plying the corridor for longer journeys, work, school, business and also leisure trips which brings about increases in travel and delay time.

The pattern is similar to that of car travel and delay time for the week in Table 4.15; the difference is seen in the figures.

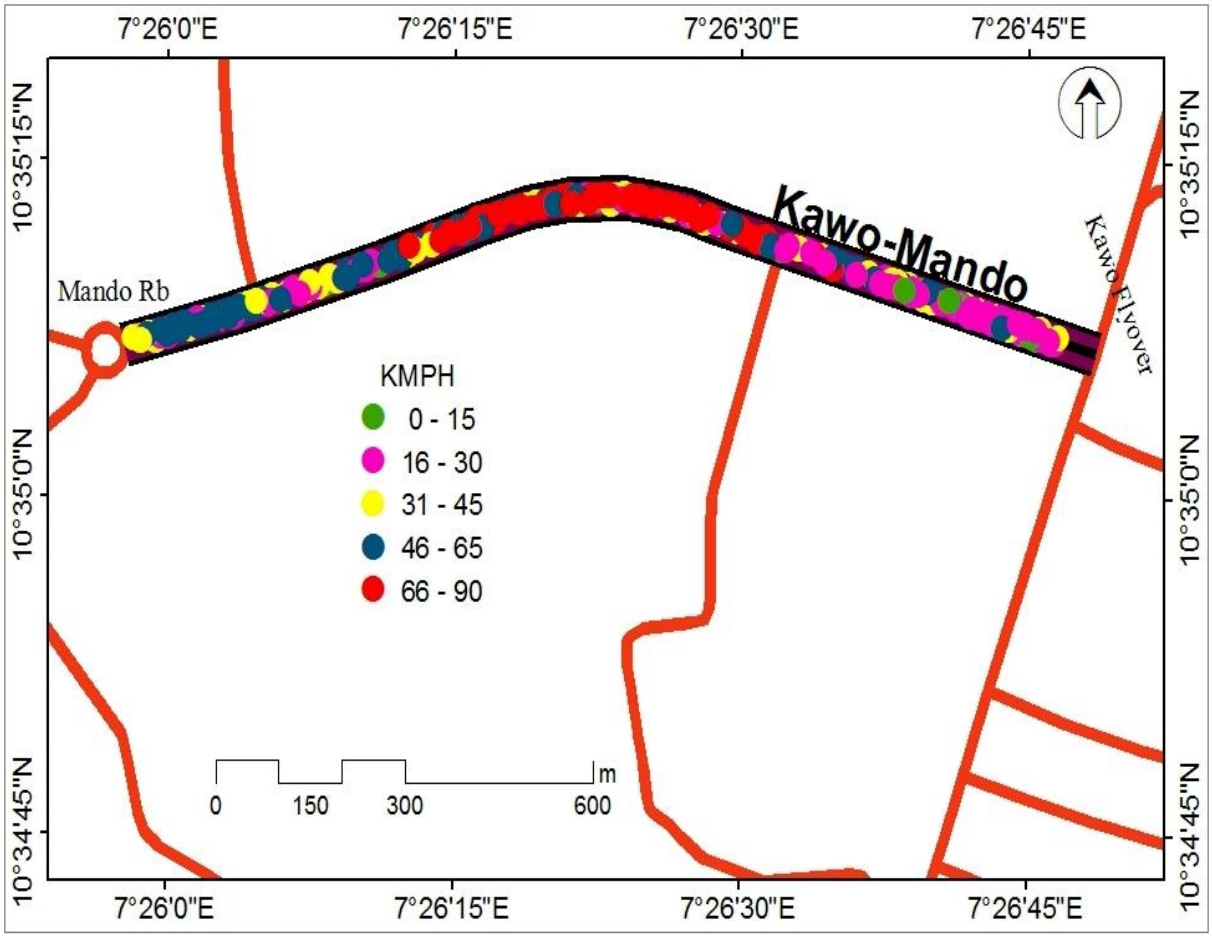


Figure 4.7: Kawo-Mando observed bus speed distribution for the week
Source: Author's GIS Analysis (2015)

The figure above has a free flow travel time of 96secs, with speed of 60kmph. Nodes of different colors are used to show changes in speed limit, movement from Kawo flyover shows lower speed. The speed increases towards the middle and also gradually reduces as one move towards the express roundabout.

4.3.9 Car Speed at Yakubu-Gowon Way Corridor

Car Speed along Yakubu-Gowon way corridor for morning, afternoon and evening periods from Monday to Sunday is discussed in Table 4.21 to 4.23

Table 4.21: Time of the Day Average Speed of Car at Yakubu-Gowon Way Corridor (Weekday)

Day	Time of the day	Speed (Kmph)		Average for both Segments (Kmph)
		Segment 1	Segment 2	
Monday	Morning	23	20	
	Afternoon	13	18	21
	Evening	30	23	
Tuesday	Morning	25	30	
	Afternoon	13	18	21
	Evening	22	18	
Wednesday	Morning	32	43	
	Afternoon	26	24	32
	Evening	31	35	
Thursday	Morning	33	33	
	Afternoon	24	24	32
	Evening	42	38	
Friday	Morning	40	40	
	Afternoon	22	23	32
	Evening	33	32	

Source: Author's Field Survey (2015)

Table 4.21 shows that the lowest average speed along both segments is experienced during the afternoon off period, this type of result is expected, as the corridor referred to, is located within the Central Business District. The influx of commuters into the corridor for various activities such as banking services, telecommunication services, civil service and other businesses and also coupled with the fact that it is a single lane makes it congested during the afternoon.

Table 4.22: Time of the Day Bus Average Speed at Yakubu-Gowon Way Corridor (Weekend)

Day	Time of the day	Speed (Kmph)		Average for both Segments (Kmph)
		Segment 1	Segment 2	
Saturday	Morning	33	42	
	Afternoon	43	47	41
	Evening	45	47	
Sunday	Morning	47	50	
	Afternoon	47	43	48
	Evening	48	50	

Source: Author's Field Survey (2015)

Table 4.22 revealed that average speed is high at the corridor on both segments throughout the morning, afternoon and evening periods. The weekends have higher average travel speed, which is because the corridor has more of offices than residential buildings and during the weekends the offices are closed, thereby making drivers and commuters to travel faster.

Table 4.23: Day of the Week Car Average speed at Yakubu-Gowon Way Corridor

Day of the week	Speed (kmph)	
	Segment 1	Segment 2
Monday	22	20
Tuesday	20	22
Wednesday	30	34
Thursday	33	32
Friday	32	32
Saturday	40	45
Sunday	47	48

Source: Author's Field Survey (2015)

Table 4.23 shows that the average speed on weekdays is lower, with Monday and Tuesday having the lowest for both segments, this is because they are the beginning of the week after the weekends and individuals travel to these corridor for work, banking services, telecommunication services and business activities. The weekends experience few vehicles

which cause average speed to be high and this is due to the fact that the offices are closed for the week.

4.3.10 Bus Travel and Delay Time at Yakubu-Gowon way Corridor

Car travel and delay time along Yakubu-Gowon Way corridor during morning, afternoon and evening periods from Monday to Sunday is discussed in Tables 4.24 to 4.25.

Table 4.24: Time of the Day Average Travel and Delay Time for Car at Yakubu-Gowon Way Corridor

Time of the Day	Travel-time (s)		Delay-time (s)	
	Segment 1	Segment 2	Segment 1	Segment 2
Morning	105	97	43	50
Afternoon	262	264	201	205
Evening	102	98	38	40

Source: Author's Field Survey (2015)

Table 4.24 shows that the highest travel and delay time is experienced during the afternoon period on both segments. While the morning and evening periods low average travel time on both segments also. This is due to the fact that the corridor is situated were most of the government headquarters, banking regional offices, telecommunication regional offices and other business activities are located, which makes individuals to travel through it for different activities during the afternoon causing increase in travel and delay time.

Yakubu-Gowon Way corridor is also a single lane, in which the numbers of vehicles travelling into it are higher more than its carrying capacity. The morning and evening periods show lower average travel time and these can be attributed to the fact that most of the commuters during these periods are worker in these offices moving in for work during the morning or out of work during the evening period.

This agrees with the findings of Aderamo (2012) who studied traffic congestion at road intersections in llorin, Nigeria. The result showed that in terms of distribution of peak-hour

delay time the junctions show delay, during the morning peak-periods. During afternoon off-peak, delay times were also recorded at the junctions. The delay times were associated with the traffic volumes at the various junctions which ultimately translate to traffic congestion.

Table 4.25: Weekly Average Travel and Delay Time of Car at Yakubu-Gowon Way Corridor

Day of the week	Travel-time(s)		Delay-time(s)	
	Segment 1	Segment 2	Segment 1	Segment 2
Monday	227	193	166	163
Tuesday	187	176	136	113
Wednesday	192	188	132	133
Thursday	186	185	125	124
Friday	173	172	112	111
Saturday	65	66	4	4
Sunday	60	61	1	2

Source: Author's Field Survey (2015)

During the weekdays along both segments of the corridor reveals increase in travel and delay time which is due to traffic congestion. The result of the findings is due to the fact that most of the government offices, banking service headquarters and other businesses are located along this corridor and also coupled with the fact that the corridor is a single carriage way, with large number of commuters moving in and out for different activities along both segments, this cause traffic congestion resulting in increase in travel and delay time.

The recent prohibition of operation of commercial cyclist (Okada) within Kaduna metropolis, has brought about a shifted to operation of tricycles called 'Keke-Napep'. The traffic nuisance meant to be eradicated by banning motorcycle in the metropolis is still being perpetrated by Keke-Napep along these corridor thereby causing congestion and increase in travel and delay time.

The findings agrees with that of Olayiwola, Olaseni and Fashina (2014), there study revealed that Ikeja CBD is dominated by institutional land use mixed with other land uses hence it generates significant vehicular traffic, which led to conflict, friction of movement, and traffic congestion in the area.

The study with Osoba (2012), also agrees with these finding, in his research he deduced from the survey that traffic congestion occurs mostly on Mondays in some selected local government areas of Lagos State and which was justified by the fact that Mondays is the first working day of the week and this, however leads to the clogging of the roads, which in turn leads to traffic congestion.

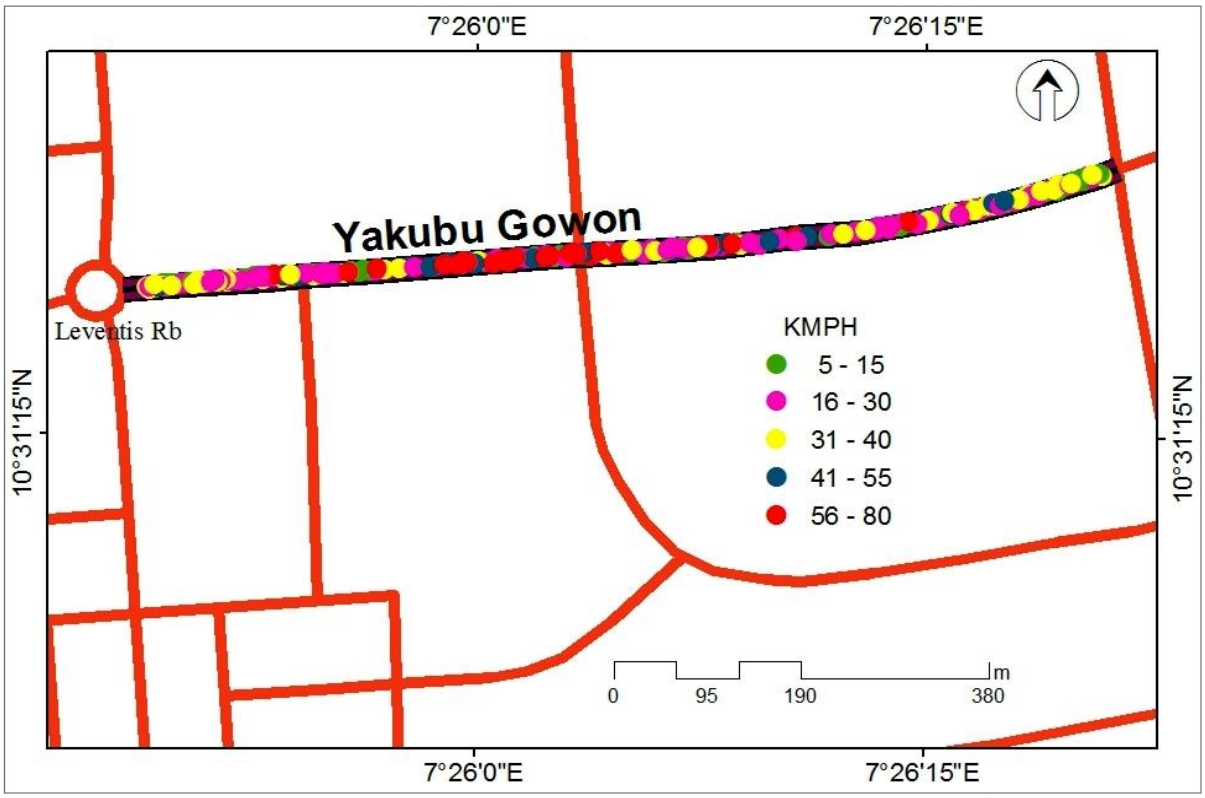


Figure 4.8: Yakubu-Gowon way observed car speed distribution for the week
Source: Authors GIS Analysis (2015)

Figure 4.8 has a free flow travel time of 61secs; nodes of different colors are used to show changes in speed limit, movement from both edges of the segments reveals varying speed throughout the corridor.

4.4 Hypothesis Testing

Table 4.26: T-test for Travel Time of Car in Segment (1) and (2) of Station-Stadium Corridor

Variables	Mean	SD	N	df	tcal	significances	decision
Car TT1	192.26	214.654					
Car TT2	194.38	226.948	42	41	-.043	0.966	accept

CarTT1 = car travel time segment (1) CarTT2 = car travel time segment (2)
Source: Author's Field Survey (2015)

The results of the T-Test are:

The null hypothesis is accepted that there is no significant difference in the travel time of car along the different segments of the corridor. These is because both segments experience almost the same number of commuters daily who use segment (1) during the morning period for their trips to work, school, businesses and other personal activities and also return through segment (2) during the evening period to their homes.

Table 4.27: T-test of Travel Time of Car and Bus in the same segment (1) and (2) of Station-Stadium Corridor

Variables	Mean	SD	N	df	tcal	significances	decision
Car TT2	194.38	226.948					
Bus TT2	181.21	209.801	42	41	.276	0.794	accept
Car TT1	193.55	216.257					
Bus TT1	176.40	187.578	42	41	1.852	0.037	rejected

CarTT1=car travel time for segment (1) BusTT1=bus travel for segment (1)
CarTT2=car travel time for segment (2) BusTT2=bus travel for segment (2)
Source: Authors Field's Survey

The null hypothesis is rejected, there is a significant difference between car and bus travel time in the same segment (1) of the corridor. The result could be as a result of the fact that both vehicles are plying the segment at the same time and the same pattern of travel flow is maintained but the car drivers are not able to maneuver their way as the bus driver in order to avoid traffic.

The null hypothesis is accepted, there is no significant difference between car and bus travel time in the same segment (2) of the corridor. These result shows that both vehicles are plying the same segment at the same time and the same pattern of travel flow is maintained.

Table 4.28: T-test for Travel Time of Car in Segment (1) and (2) of the Kawo-Mando Corridor

Variables	Mean	SD	N	df	tcal	significances	decision
Car TT1	174.02	112.70					
Car TT2	206.40	172.89	42	41	-1.011	0.318	accept

CarTT1 = car travel time segment (1) CarTT2 = car travel time segment (2)
Source: Author's Field Survey (2015)

The null hypothesis is accepted that there is no significant difference in the travel time of car along the different segments of the corridor. These is because both segments experience almost the same number of commuters daily who use segment (1) during the morning period for their trips to work, school, businesses and other personal activities and also return through segment (2) during the evening period from the school, business, other personal activities and travelers moving into and outside of the State through this corridor.

Table 4.29 shows that the null hypothesis is accepted, there is no significant difference between car and bus travel time in segment (1) and (2), which is because it is the same

corridor with only difference in mode of transportation and the same activities taking place along the corridor.

Table 4.29: T-test of Travel Time of Car and Bus in the same segment (1) and (2) of Kawo-Mando Corridor

Variables	Mean	SD	N	df	tcal	significances	decision
Car TT2	206.40	172.89					
Bus TT2	209.81	188.10	42	41	-.472	0.639	accept
Car TT1	174.02	112.70					
Bus TT1	169.67	106.80	42	41	.568	0.573	accept

CarTT1=car travel time for segment (1) BusTT1=bus travel for segment (1)
CarTT2=car travel time for segment (2) BusTT2=bus travel for segment (2)
Source: Authors Field's Survey (2015)

4.5 Causes of Traffic Congestion

The causes of traffic congestion for this study include traffic warden, accident, roadside-hawking, vehicle-breakdown, roadside-packing, inadequate road capacity and others. Table 4.30 shows that inadequate road capacity had the highest percentage along Station-Stadium, Kawo-Mando and Yakubu-gowon way corridors, with 68.4%, 57.5% and 63.9% respectively.

The findings show that congestion along the three (3) corridors occurs mainly due to inadequate road capacity, which could be as a result of the fact that during the morning and evening peak periods there is higher volume of vehicles that ply the corridors and are moving in the same direction at the same time.

Table 4.30: Causes of traffic congestion along the corridors

	Station-Stadium	Kawo-Mando	Yakubu-Gowon way	Total
Traffic warden	10(7.5%)	2(1.5%)	0(0.0%)	12(3.0%)
Accident	0(0.0%)	0(0.0%)	1(0.8%)	1(0.3%)
Roadside-hawking	0(0.0%)	1(0.7%)	2(1.5%)	3(0.8%)
Vehicle-breakdown	0(0.0%)	6(4.5%)	0(0.0%)	6(1.5%)
Roadside-parking	1(0.8%)	5(3.7%)	45(3.3%)	51(12.8%)
Inadequate road-capacity	91(68.4%)	77(57.5%)	85(63.9%)	253(63.3%)
Others	31(23.3%)	43(32.1%)	0(0.0%)	74(8.5%)
Total	133	134	133	400

Source: Author's Field Survey (2015)

The corridors were constructed during 1980's, these corridors were wide enough considering the population at that time and the numbers of vehicles that ply them, but with the rate of urbanization, improvement in level of living and the high level of commercial activities going on in the city presently, the effects would be that the corridor's capacity has now become inadequate for the increased vehicular flow.

The findings from a number of studies, including Eluwa, Ajagbe, Umaru, Ojo, and Yusuf (2012), who saw narrow road network in the city of Ibadan as one of the causes of traffic congestion, agrees with this study, their study identified too many vehicles plying the corridors as a cause of traffic congestion, which also agrees with the findings of Transport Advisory Committee (2014) in Hong Kong, according to their findings of public opinion survey, the general public and drivers considered too many vehicles on the road as one of the major causes of road traffic congestion.

4.6 Impact of Traffic Congestion

Traffic impact includes the social and economic impact.

4.6.1 Social Impact

Social impacts include stress-anger, late-missed appointment of trip, extra-travel time having to travel at another time, unpredictable travel time and others as the options.Table 4.31 shows that unpredictable travel time has the highest percentage along Station-Stadium and Kawo-Mando corridors with 61.7% and 54.5% respectively.

These results are expected; along the corridors because once there is congestion it tends to affect vehicle travel speed, which makes travel time to become unpredictable. Yakubu-Gowon way had extra-travel time as the highest social impact with 46.6%. The findings agrees with that of Popoola, Abiola and Adeniji (2013) who revealed waste of time as the most significant effect of traffic congestion on Lagos-Ibadan express way.

Table 4.31: Social Impact of Delay

	Station-Stadium	**Kawo-Mando**	**Yakubu-Gowon way**	**Total**
Stress or anger	4(3.0%)	6(4.5%)	8(6.0%)	18(4.5%)
Late or missed appointment	3(2.3%)	10(7.5%)	6(4.5%)	19(4.5%)
Extra-travel time	43(32.3%)	45(33.6%)	62(46.6%)	150(37.5%)
Postponement of trip	0(0.0%)	0(0.0%)	2(1.5%)	2(0.5%)
Unpredictable travel-time	82(61.7%)	73(54.5%)	55(41.4%)	210(52.5%)
Others	1(0.8%)	0(0.0%)	0(0.0%)	1(0.3%)
Total	133	134	133	400

Source: Author's Field Survey (2015)

4.6.2 Economic Impact

The economic impacts has high fuel consumption, paying extra fees, working hours reduced, productivity is reduced and others as the options enumerated. Table 4.32 shows high fuel consumption with 51%, as the highest economic impact along Station-Stadium.

The Kawo-Mando and Yakubu-Gowon way corridor revealed working hour is reduced as the highest economic impact with 50.0% and 51.9% respectively. Kawo-Mando corridor been an express-by pass experience and Yakubu-Gowon experience traffic congestion and this leads to increase in travel and delay time thereby reducing the number of hours spend on their jobs.

Table 4.32: Economic Impact of Delay

	Economic impact of delay					
Corridor	High fuel consumption	Paying extra fee	Working hour is reduced	Productivity is reduced	Others	Total
Station-Stadium	68(51.1%)	0(0.0%)	64(48.1%)	1(0.8%)	0(0.0%)	133
Kawo-Mando	59(44.0%)	1(0.7%)	67(50.0%)	6(4.5%)	1(0.7%)	134
Yakubu Gowon way	59(44.4%)	0(0.0%)	69(51.9%)	5(3.8%)	0(0.0%)	133
Total	186(46.5%)	1(0.3%)	200(50.0%)	12(3.0%)	1(0.3%)	400

Source: Author's Field Survey (2015)

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

from work, which has gradually reduced the output of workers and consequently a distortion in the developmental process and prospect of the state.

4.6.3 Delay Experienced

The delay experienced options from the questionnaire are "yes" and "no". This is revealed in the questionnaire. Figure 4.9 shows that 98% of the respondents affirm that traffic congestion brings about delay in travel time while 2% do not affirm to it. This indicates that the pattern of travel along the three corridors brings about congestion, so at one time commuters have experienced congestion along the corridors.

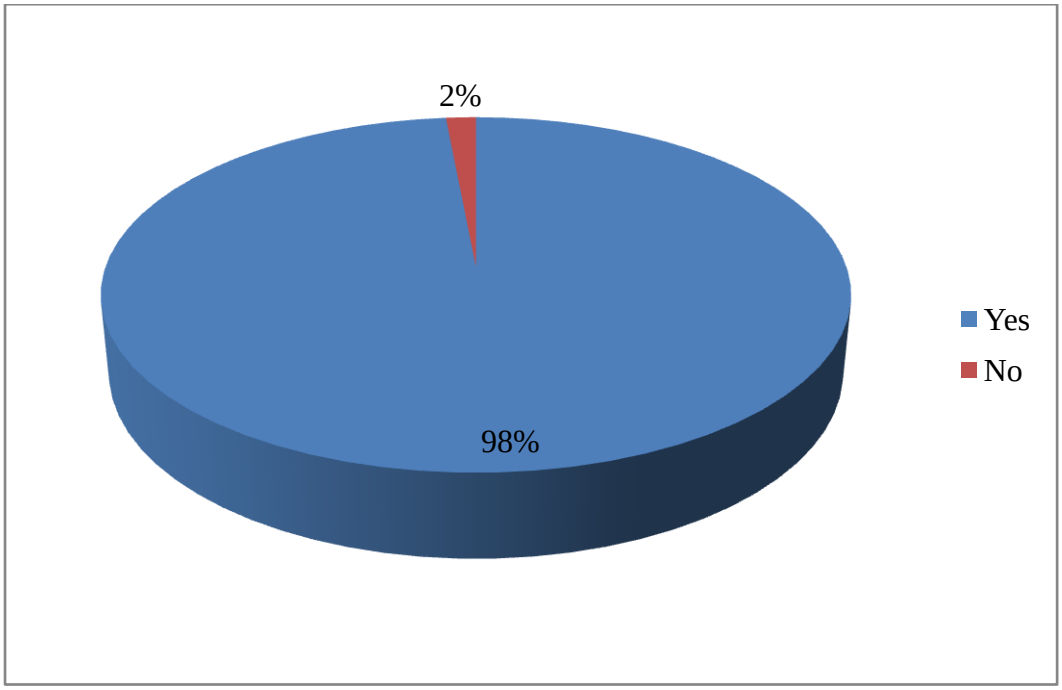


Figure 4.9: Experience of delay due to traffic congestion

Source: Author's Field Survey (2015)

This could be due to the fact that most of the respondents have travelled through the different corridors to work, school, business and leisure and they have experienced traffic congestion which had resulted in decrease in vehicular speed resulting in increase in travel time causing delay. The findings agrees with the study of Fadairo (2013) who studied traffic congestion along Federal University of Technology Akure to Oja-Oba road, in Akure, in which 94% of

the respondents agree that they experienced congestion while 6% disagree that there are traffic congestions along the road

4.6.4 Delay experienced during Congestion

Delay experience includes 5min, 10min, 15min, 20min and 30min as the possible additional time when delay is experienced along the corridors. This is shown in Table 4.33.

Table 4.33: Minutes in which delay is experience when there is congestion

	Delay experienced when there is traffic congestion					
Corridor	5min	10min	15min	20min	30min	Total
Station-Stadium	0(0.0%)	21(15.8%)	53(43.6%)	50(37.6%)	4(3.0%)	133
Kawo-Mando	4(3.0%)	27(20.1%)	53(39.6%)	43(32.1%)	7(5.2%)	134
Yakubu Gowon way	12(9.0%)	67(50.4%)	39(29.3%)	15(11.3%)	0(0.0%)	133
Total	16(4.0%)	115(28.8%)	150(37.5%)	108(27.0%)	11(2.8%)	400

Source: Author's Field Survey (2015)

Table 4.33 shows 15min as the highest delay experienced along Station-Stadium and Kawo-Mando at 43.6% and 39.6% respectively, while delay experienced along Yakubu-Gowon way corridor revealed 10min as the highest with 50.4%. The study revealed that commuters spend at least 15min due to congestion along the corridors, which could be because of high vehicular volume especially during the morning and evening peak periods along the corridors as a result of travel to work, school, business activities which cause congestion.

The findings from this study is not only peculiar to Kaduna metropolis alone, in Nigeria; as most cities are facing a similar problem, this result is similar to the findings of Yusuf, Akpu, Arigbede and Abbas, (2011) who revealed that commuting time in Zaria is extended by 10-15 minutes, depending on the vehicles.

4.6.5 Time of the Day in which Congestion is experience

Time of the day in which congestion is experience has 7-9am, 11am-2pm, 3-4pm and always as the options spotted out.

Table 4.34: Time of the day traffic congestion is experience along the corridors

Corridor	Time of day traffic congestion				Total
	7-9am	11am-2pm	3-6pm	Always	
Station-Stadium	76 (57.1%)	35(16.3%)	22(26.5%)	0(0.0%)	133
Kawo-Mando	70(52.2%)	23(17.2%)	39(29.1%)	2(1.5%)	134
Yakubu-gowon way	53(29.8%)	79(59.4%)	0(10.8%)	1(0.0%)	133
Total	199(49.8%)	153(38.3%)	45(11.5%)	3(0.8%)	400

Source: Author's Field Survey (2015)

Table 4.34 shows that traffic congestion is highest along Station-Stadium and Kawo-Mando corridor from7-9am while Yakubu-Gowon way revealed 11am-2pm. The reasons for the time of congestion along Station-Stadium and Kawo-Mando could be because workers, students and business men and women usually ply the corridors at this time causing increase in volume of vehicles thereby causing congestion.

Yakubu-Gowon way is an administrative and commercial corridor and it experience congestion from 11am-2pm because at this time commuters move into the corridor for different activities such as banking services, civil service appointment, postal services, telecommunication services and personal businesses which also increase vehicular volume causing congestion.

Station-Stadium and Kawo-Mando, agrees with the study of Olaogbebikan, Ikpechukwu, Akinsulire and Enosko (2013) on traffic management problems in Lagos, along Alaba

international market road Ojo, which revealed that congestion occurs mostly from 8-10am and 4-6pm, which is said to be as a result of commuters travelling to work in the morning and coming back from work in the evening through the same corridor, while Yakubu-Gowon way result disagrees with their findings.

4.6.6 Day of the Week Congestion is most experience.

The study conducted covered Monday to Sunday. There is always variation on different days as presented on Table 4.35.

Table 4.35: Day of the Week Traffic Congestion is experienced along the corridors

	Stadium-Stadium	Kawo-Mando	Yakubu-Gowon way	Total
Monday	47(35.3%)	38(28.4%)	43(32.3%)	128(32.0%)
Tuesday	39(29.3%)	31(23.1%)	41(30.8%)	111(27.8%)
Wednesday	10(7.5%)	8(6.0%)	26(19.5%)	44(11.0%)
Thursday	2(1.5%)	8(6.0%)	10(7.5%)	20(5.0%)
Friday	34(25.6%)	47(35.1%)	13(9.8%)	94(23.5%)
Saturday	1(0.8%)	0(0.0%)	0(0.0%)	1(0.3%)
Sunday	0(0.0%)	2(1.5%)	0(0.0%)	2(0.5%)
Total	133	134	133	400

Source: Author's Field Survey (2015)

Table 4.35 shows that Station-Stadium and Yakubu-Gowon way has the highest traffic on Monday. The result of the findings is not far from the fact that Monday is the first working day of the week, in which both workers, traders, students and business individual's travel through these corridors at the same period to begin the week's activities after spending the weekend.

The tends to agree with Osoba (2012) who deduced from the survey that traffic congestion occurs mostly on Mondays in some selected Local Government areas of Lagos State and

which was justified by the fact that Mondays is the first day of a new week and this, however leads to the clogging of the roads, which in turn leads to traffic congestion on Mondays.

Kawo-Mando corridor reveals Friday as having the highest congestion. The findings could be attributed to the fact that as an express bypass apart from trips to work, school and other business activities, journeys made into and out of the state increase on Fridays as individuals travel for weekend which cause congestion.

4.6.7 Number of times Appointments has been cancelled

The possible numbers of times appointments have been cancelled are several times, 10 times, 4 times, twice, once and nil as the options provided. Table 4.36 presents the findings.

Table 4.36: Number of times Appointments have been cancelled

	Station-Stadium	Kawo-Mando	Yakubu-Gowon way	Total
Several times	0(0.0%)	1(0.7%)	0(0.0%)	1(0.3%)
10 times	0(0.0%)	0(0.0%)	1(0.8%)	1(0.3%)
4 times	0(0.0%)	0(0.0%)	1(0.8%)	1(0.3%)
twice	1(0.8%)	4(3.0%)	3(2.3%)	8(2.0%)
once	1(0.8%)	1(0.7%)	0(0.0%)	2(0.5%)
nil	131(98.5%)	128(95.5%)	128(96.2%)	387(96.8%)
Total	133	134	133	400

Source: Author's Field Survey (2015)

According to Table 4.36 most of the respondents did not cancel appointment due to traffic congestion on the three corridors. The result could be because people having knowledge of the corridors leave earlier to their place of appointment in order to avoid traffic congestion which in turn increases travel and delay time along the corridors.

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

Summary of findings, conclusion and recommendations are contained in this chapter. The purpose of this study is to gain insights into the effect of traffic congestion on travel time in Kaduna metropolis using reliable and accurate data sources.

5.2 Summary of Findings

GPS was used to acquire to coordinate from the congested corridor at the point where the speed had variations due to congestion. The average speed, average travel and average delay time for each corridor were analyzed using descriptive analysis. The study showed that speed limit were low during morning and evening along Station-Stadium and Kawo-Mando corridor, while Yakubu-Gowon way corridor showed afternoon period with the lowest speed. Traffic congestion affects travel and delay time along Station-Stadium and Kawo-Mando corridors during the morning and evening peak periods, while Yakubu Gowon way corridor revealed a pattern of traffic congestion during the afternoon off peak periods.

T-test analysis was used to determine the variation in travel time between car at different segments of the same corridor and also the differences between car and bus at the same segment of the same corridor. The result revealed that there is no significant difference between car in difference segment and also no different between car and bus in the same segment.

Cross-tabulation analysis was used to determine the causes and impact of congestion. Inadequate road capacity was the main cause of traffic congestion along Station-Stadium and Kawo-Mando and Yakubu-Gowon way corridor. Social impact unpredictable travel time had the highest percentage along Station-Stadium and Kawo-Mando corridor with 61.7% and

54.5% respectively, while Yakubu-Gowon Way corridor had extra time as the highest with 46.6%. The economic impact showed fuel consumption with 51%, as the highest along Station-Stadium corridor, while Kawo-Mando and Yakubu-Gowon Way corridor revealed reduced working hour as the highest with 50% and 51.9%. Delay experienced reveals yes congestion was experienced with 98% for all the corridors, while the extent of delay showed 15mins as highest for Station-Stadium and Kawo-Mando corridor, while 10mins is highest for Yakubu-Gowon Way corridor. The time of the day congestion is experienced revealed 7-9am and 3-6pm along Station-Stadium and Kawo-Mando while Yakubu Gowon way corridor revealed 11-2pm as the highest. The day of the week congestion is experienced reveals that Monday had the highest for all the corridors, while generally weekdays commuters experience more traffic congestion than the weekends.

5.3 Conclusion

Traffic congestion has been a problem in the study area with morning peak periods of 7-9am, afternoon peak period of 11am-2pm and evening peak period of 3-6pm while inadequate road capacity is a major cause. Unpredictable travel time, fuel consumption and working hours is reduced are the major impact felt.

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

5.4 Recommendations

1. Flyover should be constructed along Station-Stadium corridor within the metropolis to reduce traffic congestion

2. Decentralization of government offices, business and banking activities should also be considered to reduce the influx of individual commuters into the metropolis.
3. Government should expand Yakubu-Gowon Way and make it a dual carriage way.
4. Provision of an affordable and functional mass transit vehicles to provide alternative use of private vehicles, will help in reducing the number of vehicles on the corridors by the state government.
5. Linking traffic information system (TIS) to the State radio by the government of Kaduna State, this would relay to commuter corridors that are congested and to provide alternate routes, which are less congested.
6. The use of Geographic Information System (GIS) in traffic monitoring is highly relevant for solving issues relating to traffic congestion.

Further recommendation for the use of Geographic Information System and Global Positioning System for speed, travel and delay time should be collected over a period for at least a month on the different corridors or between holiday and non holiday periods in other to acquire adequate data. Building of fuel station along major corridors should be discouraged because; they contribute to the causes of traffic congestion.

REFERENCES

Aboh, H.O, (2009) Assessment of the Aquifers in some Selected Villages in Chikun Local Government Area of Kaduna State. *Science World Journal,* 4

Achi, F.T. (2011). *An analysis of Traffic Congestion in Kaduna Metropolis using Geographic Information System Techniques. Nigeria.* An Unpublished Post Graduate Diploma Project. Geography Department, Ahmadu Bello University, Zaria, Nigeria.

Aderamo, J. A., (2012). Traffic Congestion at Road Intersections in Ilorin, Nigeria, *Mediterranean Journal of Social Sciences* 3(2). pp201 Abstract Doi:10.5901mjss.2012.v3n2.201

Agyemang, E. (2013). A cost-effective Geographic Information Systems for Transportation (GIS-T) application for traffic congestion analyses in the Developing World. *Ghana Journal of Geography*. 5, pp 65-66 Retrieved from http://www.ugspace.ug.edu.gh/handle/ 123456789

Bashiru, A. R. and Waziri, O. O. (2008). Analysis of intra-Urban Traffic Problems in Nigeria: A study of Lagos Metropolis. *Indonesian Journal of Geography* 40 (1), pp. 31. Abstract Retrieved from http://jurnal.ugm.ac.id/ijg/article/view/2246

Bovy, P.H.L., and Salomon, I. (2002) Congestion in Europe: measurements, patterns and policies In: Stern, E, Salomon, I and Bovy, P.H.L. (Eds) *Travel behavior: spatial patterns,Congestion and modeling*. Transport, Economics, Management and Policy series. Cheltenham UK, Northampton USA: Edward Elgar, pp 7

Cambridge Systematics, Incorporation and Texas Transportation Institute (2005).*Traffic Congestion and Reliability: Trends and Advanced Strategies for Congestion Mitigation,*Washington, DC. Federal Highway Administration. pp 292 Retrieved from http://www.camsys.com

Chibuzor, O. K. (2011). Index analysis of the Causes of Vehicular Traffic Congestion in South-Eastern Nigeria. *Journal of Emerging Trends in Engineering and Applied Sciences* 2(6) pp, 926. Retrieved from http://jetas.scholarlinkresearch.ord

D/Este, G.M., Zito, R., and Taylor, M.A.P (1999). Using GPS to Measure Traffic System Performance, Computer-Aided Civil and Infrastructure Engineering, 14(4). pp 255-265

Downs, A. (1992). *Stuck in Traffic: Coping with Peak-Hour Traffic Congestion*, Washington, D.C. The Brookings Institution. pp 145.

Downs, A. (2004). *Still Stuck in Traffic*: *Coping with Peak-Hour Traffic Congestion*, Washington, D.C. The Brookings Institution. pp 455.

Elefteriadou, L. and Cui.X, (2007). *A Framework for Defining and Estimating Travel Time Reliability.*Paper presented at 86th Annual Meeting of the Transportation Research

Board,Washington, D.C.

Eluwa, S.E., Ajagbe, A. M., Umaru, T. E., Ojo, A.K., and Yusuf, G.O.(2012). Assessing intra-city Road Traffic in an Indigenous African city, Ibadan, Nigeria. *Engineering Science and Technology: An International Journal.* 2(2) pp 5

Engwitch.D. (1992). *Towards an Eco- City; Calming the Traffic*, Sydney NSW. Envirobook Publishers.

European Conference of Ministers of Transport (ECMT).(1999). *The Spread of Congestion in Europe*, In:110th Round Table Report, on Transport Economics, Paris: Organization for Economic Cooperation and Development (OECD) Publication Service. Retrieved from http://www.oecd.org/cem/

European Conference of Ministers of Transport (ECMT). (2007) *Managing urban Traffic Congestion.* Organization for Economic Cooperation and Development (OECD) pp. 64

Faghri, A. and Hamad, K.(2002). Travel Time, Speed and Delay analysis using an integrated GIS/GPS System. pp 325. Doi: 10.1139/202-014

Fadairo, G. (2013). Traffic congestion in Akure Ondo state, Nigeria. Using Federal University of Technology Akure as a case study. *International journal of Arts and Commerce.* 2(5), pp 71. Retrived from http://www.ijac.org.uk

Federal Highway Administration. (2012)."*Highway Performance Monitoring System," 1982 to 2010.* Available: http://www.fhwa.dot.gov/policyinformation/hpms.cfm

Hansen Ingo. (2000). Determination and Evaluation of Traffic Congestion Costs. *European Journal of Transportation and International Research*, 1(1), pp. 61-72

Heywood, I. Cornelius, S. & Carver, S. (2006): *An Introduction to Geographic Information Systems,* Harlow.Third Edition. Pearson Education Limited.

Hunter, T., Herring, R., Abbeel, P., and Bayan, A. (2009). *Path and Travel Time Inference from GPS Probe Vehicle Data*. Neutral Information Processing Systems Foundation (NIPS), Vancouver, Canada, pp, 1

Ibrahim,J. M., and Salisu A.(2012). Effects of Road Development on Travel Time and Cost in kaduna State, Nigeria. *Journal of Environment & Earth Sciences.* 1(1). pp 1. Abstract Retrieved from http://www.irjset.com

Jain, V., Sharma, A., and Subramanian, L. (2012). *Road Traffic Congestion in the Developing World* . Proceeding of the 2nd ACM Symposium on Computing for Development. pp11. Doi: 10.1145/2160601.2160616

Joint Transport Research Centre (2007) “Managing Urban Traffic Congestion”; Retrieved from www.cemt.org/JTRC/index.htm.

Kwon, J., Mauch, P., and Varaiya, P. (2006). Components of Congestion: Delay from Incident, Weather, Potential Ramp metering gain, and Excess demand. *Journal of Transportation Research Board* (Transportation Research record No. 1959), pp 84-91.

Kockelman. K. (2004). Traffic congestion, In: McGraw-Hill. *Handbook of Transportation Engineering*, New York: pp 2.
Retrieved from www.ce.utexas.edu/prof/**kockelman**/public

Li, S., Zhu, H., B.H.W., Van, G., Nagle.J., and Tuttle. C. (2002) Reconsideration of Sample Size Requirements for Field Traffic Data Collection Using GPS Devices. In Transportation Research Record: *Journal of the Transportation Research Board*, No. 1804. National Research Council, Washington, D.C., 2002, pp 20

Litman, T. (2004). *Congestion Costs, Transportation Cost and Benefit Analysis; Techniques Estimates and Implications*, Victoria, British Columbia: Victoria Transport Policy Institute. pp, 61, Retrieved www.vtpi.org

Longley P.A., Goodchild M.F., Maguire D.J., and Rhind, D.W. (eds) (2005) *Geographical Information Systems: Principles, Techniques, Management and Applications* (Abridged Edition). Hoboken, N.J.Wiley.

Lomax, T., Turner, S., Shunk, G., Levinson, H.S., Pratt, R.H., Bay, P.N. and Douglas, G.B. (1997). *Quantifying congestion*, volume 1and 2, National Cooperative Highway Report Program Report 398, Washington, DC: Transportation Research Board. pp Retrieved from onlinepubs.trb.org./onlinepubs/nchrp/nchrp_rpt_398 pdf

Lomax, T., Schrank, D., Turner,S. and Margiotta, R.(2007). *Selecting Travel Reliability Measures.*Texas Transportation Institute. pp, 3
Retrieved from tti.tamu.edu/documents/474360-1.pdf.

Makin, J., Healey.R.G., and Dowers.S. (1997) *Simulation Modeling with Object-Oriented GIS:* A Prototype Application to the Time Geography of Shopping Behavior. Geographic Systems 4(4), pp, 397-430.
Retrieved from http://scholar.google.com/citations

Marius, T. (1999). Modelling commuter trip length and duration within GIS: application to an O-D survey, *Journal of Geographic Information and Decision Analysis*, 3 (1) pp, 40-56

McNally,M.G., Marca, J.E., Rindt, C.R., and Koos, M.A.(2002) *GPS/GIS Technologies for Traffic Surveillance and Management:* A Test bed Implementation Study, California path program institute of transportation studies university of California, Berkeley

Meenar, A. (2000). Traffic Congestion in Dhaka City, Where is the solution. Term paper for the course PD592; Infrastructure and Transportation Planning, Department of Planning,Sunny Buffalo.

Murayama, Y., and Estoque, R.C., (2010). *Fundamentals of Geographic Information System* pp 7.

Ndabula, C., Jidauna, G.G., Oyatayo, K., Averik,P .D. and Iguisi, E.O.(2012) Analysis of Urban Flood plain Encroachment: Strategic Approach to Flood and Floodplain Management in Kaduna Metropolis, Nigeria. pp 50. Doi:10.5539/jgg.v4n1p170

NPC (1998) "1991 National Population Census of the Federal Republic of Nigeria: Analytical Report at the National Level". National Population Commission (NPC), Abuja

OECD (Organisation for Economic Cooperation and Development) and ECMT (European Conference of Ministers of Transport). Joint Transport Research Centre (2007). Managing Urban Traffic Congestion (Summary Document)

Ojeh, V. N. and Ozabor, F. (2013). Impact of Weather related Road Traffic Congestion on Transportation Cost in Benin City Nigeria. *Journal of Environment Science and Recourse Management* 5(2). pp 132. Retrieved from http://www.cenresinpub.org

Olaogbebikan, J.E., Ikpechukuw, N., Akinsulire,E.S. and Enosko, O. (2013). Traffic Management Problems in Lagos: A focus of Alaba International Market Road, Ojo, Lagos state of Nigeria. *Journal of Economics and Sustainable Development* 4(4), pp 148-150 Retrieved from http://wwwijste.org

Olayiwola, O.K., Olaseni .M . A. and Fashina, O. (2014). Traffic Congestion Problems in Central Business District (CBD) Ikeja, Lagos Metropolis, Nigeria. *Research on Humanities and Social Sciences*.(4)1, pp,24 Retrieved from http//www.iiste.org

Olusina, J.O. and Samson, A.P. (2014) Determination of Predictive Models for Traffic Congestion in Lagos Metropolis, Nigeria. *International Journal of Engineering and Applied Sciences* 5(2), pp 25. Retrieved from www.eaas-journal.org

.

Ogunbodede, E.F. (2003) Assessment of Traffic Congestions in Akure Nigerian Using GIS Approach: Lessons and Challenges for Urban Substances. *Indian journal of transport management* 27(3) pp

Ogunsanya, A.A. (2002). *Maker and Breakers of Cities.* 59th Inaugural Lecture, University of Ilorin. In Joseph. O. U. and Anderson A. E. (2012), Traffic Congestion in Major Cities of Nigeria. *International Journal of Engineering and Technology.* 2(8), pp, 1433

Onasanya, A.O. and Akanmu.J.O. (2002) "Quantitative Estimates of Traffic Congestion on Lagos –Abeokuta Road, Lagos, Nigeria. *Journal of Civil Engineering,* (2), pp 5-8.

Okunola,O.J., Uzairu, A. and Ndukwe,G. (2007). Levels of trace metals in soils and

vegetation along Major roads in metropolitan city of Kaduna State. Accepted 16 February 2007 (full length paper).

Osoba, S.B., (2013). Full length paper . A Geographical Analysis of Intra-urban Traffic Congestion in some selected Local Government Areas of Lagos Metropolis. *Journal of Geography and Regional Planning,* 5(14) pp,366. doi:10.58971JGRP11.114

Owusu, J., Afukaar, F and Prah, B.E.K. (2006). Urban Traffic Speed Management: The use of GPS/GIS.

Pison Real Estate and Infrastructure Professional Practice and Services (2013). Compendium Report on Road Infrastructure and Related Development in Nigeria- An Investor's Manual.

Popoola, M.O., Abiola S. O.and Adeniji W.A.R.(2013). Traffic Congestion on Highways in Nigeria Causes, Effects and Remedies.*International Journal of Civil, Architectural Science and Engineering 7*(11) pp, 528 Retrieved from waste.org/publications/17391

Quiroga, C.A., and Bullock, D. (1998). *Travel Time Studies with Global Positioning and Geographic Information Systems*: An Integrated Methodology In Transportation Research Part C6, pp, 101-127.

Raid, M. A., El-Mikkawy, M.E.A., and Shabana, B.T. (2012). Real Time Route for Dynamic Road Congestions. *International Journal of Computer Science Issues*, 9 (3), pp, 1694 Retrieved from www.international journal of computer science issues.organization

Rao, K.R. and Rao, A.M. (2012). Measuring Urban Traffic Congestion- A Review *Journal of Traffic and Transport Engineering*, 2(4) pp, 286 Doi: http//dxdoi.org/10.7708/ijtte20122(4).01

Roper, M.D., (2003). *GPS to GIS procedural handbook*, Version 5.2, Retrieved from http://www.fs.fed.us/database/gps/gps2gis/gps_gis_v5.pdf.

Sadi, A. (1987). "Effect of Faulty Design and Construction on Road/Building Maintenance." *Journal of Performance of Constructed Facilities,* Saudi Arabia. 2, pp,13

Saleh, Y., Badr, A, M., El banna, F. M., and Shehata, A. S. (2014). Some Aspects of Urban Transition in Nigeria. The Case of Kaduna Metropolis. *Journal of African Studies* 35(1)

Sivaram, C.M.S.L. and Kulkarni, M. N. (2001). "GPS-GIS Integrated Systems for Transportation Engineering. Retrieved from http://www.gisdevelopment.net/technology/gps/techgp0008pf.htm

Texas Transportation Institute. (2005). *The keys to Estimating Mobility in Urban areas:* Applying Definitions and Measures that everybody understands. Texas Transportation Institute. pp,5-9

Thwala, D. W., Eluwa, E. S., Ajagbe, A.M., Ojo, A.K., Duncan,E.E., Gafar,O.Y., and Abdullah,A. (2012) Traffic Congestion, Causes and Effect on Residents of Urban Cities in Nigeria. In: The Asian Conference on the Social Sciences 2012, Official Conference Proceeding. pp. 219

Thomson, J. M. (1998). Reflections on the Economics of Traffic Congestion. *Journal of Transport Economics and Policy*. pp 93- 112

Turner, S. M., Best, M. E., and Schrank, D.L. (1996). *Measuers of Effectiveness for Major Investment Studies.* Southwest Region University Transportation Center, Texas Transportation Institute, College Station, Retrieved from SWUTC/96/467106-1

Turner, S. M., Eisele, W. L., Benz, R. J. and Holdener, D.J. (1998). *Travel Time Data Collection Handbook*, Report No. FHWA-PL-98-035, pp 5.

TomTom European Congestion Index (2013) International BV, All rights reserved. pp.4, 27

TomTom American Congestion Index (2013) International BV, All rights reserved. pp, 4, 29, 38

Udo, P. O., (1982) *Physical Geography of Nigeria*. Heinemann Education publishers Ibadan. pp

Ukapa,O.J., and Etika, A. A. (2012). Traffic Congestion in Major Cities of Nigeria. *International Journal of Engineering and Technology* 2 (8) pp, 1436.

Verma R.K., Kumari S., and Tiwary R.K. (2008). Application of Remote Sensing and GIS Technique for Efficient Urban Planning in India. Retrieved from http://www.csre.iitb.ac.in/~csre/conf/wpcontent/uploads/.../OS4/OS4_13.pdf

Victoria Transport Policy Institute. (2005). Congestion Reduction Strategies: *Identifying and Evaluating Strategies to Reduce Congestion*, Canada: Retrieved from http://wwwvtpi.org/tdm/tdm96.htm

Victoria Transport Policy Institute. (2013). Transportation Cost and Benefit Analysis – Travel Time Cost. Retrieved from http:// www.vtpl.org

Yamene, T. (1967). Statistics: *An Introductory Analysis* 2nd Edition, New York. Harper and Row.

Yusuf, R. O., Akpu, B., Arigbede, Y.A. and Abbas, I.I. (2011). *Attitudinal Factors of Road Users And Increase commuting Time In Zaria Kaduna State, Nigeria*.In: Paper presented at the 53rd annual conference of association of Geographers held at the Department of Geography and Planning Lagos State university ojo. pp.1

APPENDIX I

DEPARTMENT OF GEOGRAPHY
AHMADU BELLO UNIVERSITY, ZARIA

Questionnaire on Effect of Traffic Congestion on Travel Time in Kaduna Metropolis

Dear respondent,

I am an MSc student of the department of Geography in the faculty of science Ahamadu Bello University Zaria and am currently writing my research titled effect of traffic congestion on travel time in Kaduna metropolis. Kindly complete the following questions. All information given will be treated confidentially and will be used purely for academic purpose.

SECTION A:

1. Name of Corridor ……..

2. Are you a a) Driver b) Passenger

3. Type of vehicle use a) Private b) Commercial

SECTION B: SOCIO-DEMOGRAPHIC CHARACTERISTICS

1. Sex a) Male b) Female

2. Age a) 18-23 b) 24-29 c) 30-35 d) 36-41 e) 42-47 f) 48- 53 g) 54-59 h) 60-above

3. Educational level a) Primary b)Secondary c)Tertiary d) No-formal education

4. Occupational Status a) Civil service b) Trading/Business c) Farming d) Artisan

e)Others(Specify)…….

SECTION C: IMPACT OF DELAY DUE TO TRAFFIC CONGESTION

1. What do you think are the causes of delay along the corridor a) Traffic Wardens

b) Accident c) road-side hawking d) vehicle Breakdown e) road side parking

f) road capacity g) Others (specify)……

2. What are the social impacts of delay a) stress/anger b) late/missed appointment?
   c) extra time d) having to travel at another time e) unpredictable travel time
   f)others(specify)……
3. What are the economic impacts of delay a) fuel consumption b) paying extra fee
   c) Working hours is reduced d) productivity is less e) others (specify) ……
4. Do you experience delay due to traffic congestion along these corridor. YES / NO
5. At what speed do you travel when there is congestion? .....
6. How much delay do you experience when there is congestion? a) 5min b) 10min
   c) 15min d) 20min e) 30min and above
7. What time of the day do you experience traffic congestion along this corridor? A) 7am-9am b) 11pm-2pm c) 3pm-6pm d) Always
8. Have many times have you cancelled appointments due to delay…….
9. Which day of the week do you experience traffic congestion along this corridor?
   a) Monday b) Tuesday c) Wednesday d) Thursday e) Friday f) Saturday g) Sunday

APPENDIX II

Speeds in KMPH for Each Day of a Week along Station-Stadium Car Corridor

period	Monday		Tuesday		Wednesday		Thursday		Friday		Sa
	seg1	seg2	seg1	seg2	seg1	seg2	seg1	seg2	seg1	seg2	se
Morning	10	5	5	40	20	30	10	30	40	20	30
	5	10	10	80	15	50	30	60	30	70	60
	15	5	20	40	25	40	15	50	5	30	40
	45	60	10	50	10	40	20	30	30	20	40
	10	50	20	70	5	30	30	60	5	10	60
	30	40	50	40	20	50	40	40	10	60	20
Average	19	28	19	53	16	24	24	45	20	35	42
Afternoon	20	55	40	40	30	40	40	30	30	35	20
	60	80	70	50	70	50	50	70	70	20	60
	5	25	50	60	10	35	45	25	10	25	20
	25	40	40	55	25	30	30	30	30	20	30
	60	70	50	60	60	50	65	60	60	10	50
	20	20	30	50	40	40	45	40	10	5	10
Average	31	48	47	52	39	41	46	35	35	19	32
Evening	20	15	40	20	25	10	30	30	20	25	30
	60	25	50	10	60	5	70	40	80	30	60
	40	30	30	30	20	20	10	10	10	40	10
	30	10	15	10	30	15	20	20	20	20	35
	70	30	60	30	70	10	70	30	70	40	70
	10	5	40	20	25	5	15	15	10	20	20
Average	38	19	39	20	38	11	36	24	35	29	38

Source: Author's Field Survey (2015)

SPEED IN KMPH FOR EACH DAY OF THE WEEK ALONG STATION-STADIUM

BUS CORRIDOR

period	Monday		Tuesday		Wednesday		Thursday		Friday		
	Seg1	seg2	seg1	seg2	seg1	seg2	seg1	seg2	seg1	seg2	se
Morning	10	15	20	40	10	40	40	30	30	40	30
	10	15	10	70	5	30	35	70	35	80	60
	5	10	5	40	10	20	20	40	20	30	10
	20	60	20	40	20	40	10	35	20	20	30
	5	50	20	65	10	20	40	40	15	65	65
	25	40	45	45	20	10	30	40	30	40	15
Average	13	31	20	58	13	25	29	43	25	46	35
Afternoon	20	50	40	35	30	40	35	30	30	30	25
	40	70	70	50	70	50	45	65	65	20	60
	10	25	50	55	10	30	40	20	10	20	20
	20	40	35	50	20	25	30	25	25	25	40
	50	80	80	80	80	80	70	80	80	20	80
	40	30	40	40	40	50	40	30	45	10	50
Average	30	40	45	50	35	40	43	42	43	21	46
Evening	30	20	20	10	20	20	50	40	5	30	40
	50	34	80	20	70	10	70	20	80	60	80
	30	15	40	30	25	20	30	10	25	30	10
	40	20	15	20	20	15	25	20	20	10	40
	60	10	50	30	60	10	55	30	70	30	60
	30	20	40	10	40	16	40	10	45	10	10
Average	30	17	41	20	33	11	45	22	41	28	40

Source: Author's Field Survey (2015)

SPEED IN KMPH FOR EACH DAY OF THE WEEK ALONG KAWO-MANDO CAR CORRIDOR

Period	Monday		Tuesday		Wednesday		Thursday		Friday		Saturday		Sunday	
	Seg 1	seg 2	seg 1	seg 2	seg 1	seg 2	seg 1	seg 2	seg 1	seg 2	seg 1	seg 2	seg 1	seg 2
Morning	40	30	20	35	30	15	35	20	30	10	30	50	40	60
	30	20	30	40	50	25	25	30	40	20	35	80	80	85
	20	30	10	30	30	40	20	20	20	30	40	24	50	25
	10	50	30	45	40	30	30	40	30	50	30	30	50	60
	15	20	20	40	20	20	40	20	10	20	80	85	80	90
	30	40	35	30	30	45	30	30	30	30	60	30	45	30
Average	13	31	20	50	13	42	29	43	25	46	35	40	48	50
Afternoon	25	40	30	40	50	30	50	50	50	60	50	50	30	50
	60	70	70	80	80	50	70	80	80	70	85	80	80	90
	50	40	50	50	60	30	50	40	40	30	60	30	60	40
	40	50	20	45	70	40	45	50	40	40	40	30	50	50
	45	55	80	70	65	70	80	60	20	20	70	70	90	90
	50	40	40	40	30	30	60	30	60	60	50	50	40	30
Average	45	49	52	52	42	46	43	42	43	42	46	46	49	42
Evening	30	20	20	20	40	15	40	30	30	40	30	30	30	40
	40	40	60	35	45	20	50	15	70	30	60	60	40	75
	30	30	40	30	50	30	35	30	60	40	30	20	50	30
	40	20	40	20	40	5	40	10	20	30	40	30	60	40
	30	10	50	5	55	20	60	20	80	50	50	60	80	60
	70	5	30	15	40	5	40	30	30	30	30	20	50	40
Average	40	20	41	20	45	15	45	22	37	47	40	36	47	52

Seg= Segment
Source: Author's Field Survey

SPEED IN KMPH FOR EACH DAY OF THE WEEK ALONG KAWO-MANDO BUS CORRIDOR

period	Monday		Tuesday		Wednesday		Thursday		Friday		Saturday		Sunday	
	Seg 1	seg 2	seg 1	seg 2	seg 1	seg 2	seg 1	seg 2	seg 1	seg 2	seg 1	seg 2	seg 1	seg 2
Morning	20	30	20	20	20	60	55	20	20	50	20	40	50	60
	10	50	30	40	10	50	25	50	30	15	30	80	80	70
	15	35	20	30	20	60	30	40	20	70	20	20	20	20
	10	25	25	40	15	50	20	50	30	50	30	10	50	40
	20	30	20	45	5	40	15	30	25	80	80	70	70	80
	10	20	30	20	10	20	43	25	30	5	30	20	20	30
Average	13	31	23	50	13	47	29	43	25	46	35	40	48	50
Afternoon	30	30	50	45	30	25	50	30	30	30	30	40	20	40
	40	20	30	85	70	70	75	70	70	20	50	35	80	75
	45	15	60	20	40	40	20	20	50	10	40	75	30	25
	30	10	40	50	20	30	10	30	20	35	50	20	50	50
	25	30	70	70	75	70	75	70	55	20	70	65	60	40
	35	10	35	10	30	40	30	25	30	10	40	40	50	25
Average	30	20	48	47	42	46	43	42	43	21	46	46	49	42
Evening	20	30	10	20	30	20	40	20	20	30	50	50	30	60
	50	10	60	30	50	30	60	45	60	60	20	70	65	75
	30	30	40	20	40	10	30	10	50	50	30	50	50	30
	40	20	40	10	50	5	40	15	40	40	50	50	10	40
	60	10	50	15	60	10	60	10	50	70	40	20	80	70
	40	25	30	25	40	15	45	30	25	40	50	10	50	40
Average	40	20	38	20	45	15	45	22	41	48	40	36	47	52

Seg= Segment
Source: Author's Field Survey

SPEED IN KMPH FOR EACH DAY OF THE WEEK ALONG YAKUBU-GOWON WAY CORRIDOR

period	seg 1	seg 2	seg 1	seg 2	seg 1	seg 2	seg 1	seg 2	seg 1	seg 2	seg 1	seg 2	seg 1	seg 2
Morning	40	40	40	30	10	55	40	20	50	20	40	50	40	30
	5	10	10	50	20	20	50	15	40	60	60	30	60	70
	10	30	10	20	40	60	25	30	20	50	20	60	40	40
	10	10	40	30	40	60	20	35	30	50	30	60	50	40
	20	20	20	30	50	20	40	60	60	20	40	30	70	50
	50	5	30	20	30	45	20	40	40	40	10	20	20	70
Average	23	20	25	30	32	43	33	33	40	40	33	42	47	50
Afternoon	20	15	20	30	20	10	20	35	20	10	40	40	40	40
	5	30	15	5	40	25	30	15	10	40	70	60	80	70
	10	20	5	15	15	10	25	10	30	20	20	30	20	20
	10	10	20	20	20	60	20	25	40	30	30	40	70	40
	25	20	10	30	40	30	30	40	20	20	60	70	40	60
	5	15	10	10	20	10	20	20	10	20	40	40	30	30
Average	13	18	13	18	26	24	24	24	22	23	43	47	47	43
Evening	20	20	10	20	40	50	30	30	30	30	20	40	30	40
	40	50	25	10	20	20	60	60	50	60	50	67	80	70
	30	10	10	20	20	25	40	10	20	10	70	20	40	40
	40	20	35	20	40	25	30	20	40	30	40	45	30	50
	20	30	40	10	20	40	50	50	20	50	30	60	70	60
	30	10	10	30	50	50	40	60	40	10	60	50	40	40
Average	30	23	22	18	31	35	42	38	33	32	45	47	48	50

Seg = Segment
Source: Author's Field Survey (2015)

APPENDIX III

Travel and Delay Time at Station-Stadium Car

TTS1	TTS2	DS1	DS2
Monday			
Morning			
389	78	318	7
746	198	675	127
Afternoon			
148	102	77	31
78	97	7	26
Evening			
74	456	3	385
119	399	48	328
Tuesday			
Morning			
428	127	357	56
253	61	182	
Afternoon			
70	92		21
69	89		18
Evening			
156	200	85	129
123	847	52	776
Wednesday			
Morning			
960	182	889	111
241	62	170	
Afternoon			
94	98	23	27
97	91	26	20
Evening			
146	530	75	459
152	275	81	204
Thursday			
Morning			
74	86	3	15
967	93	876	22
Afternoon			
92	141	21	70
81	78	10	7
Evening			
95	90	24	19
83	372	12	301
Friday			
Morning			
336	67	265	

180	116	109	45
Afternoon			
156	127	85	56
205	1228	134	1157
Evening			
143	127	72	56
155	191	84	120
Total			
1175	1856	749	1434
Average			
196	293	125	239
Saturday			
Morning			
82	77	11	6
80	89	10	18
Afternoon			
94	77	23	6
132	101	61	30
Evening			
132	216	61	145
141	396	70	325
Sunday			
Morning			
74	74	3	3
92	72	21	1
Afternoon			
75	100	4	29
105	72	79	1
Evening			
71	116		45
87	74	16	3

TTS= Travel Time

DTS = Delay Travel
Source: Authors Field's Survey (2015)

Travel and Delay Time at Station-Stadium Bus

TT1	TT2	DT1	DT2
Monday			
Morning			
328	95	257	24
686	114	615	43
Afternoon			
75	120	4	49
71	74		3
Evening			
143	383	72	312
131	567	60	496
Tuesday			
Morning			
313	120	242	49
419	128	348	57
Afternoon			
77	45	6	
122	47	51	
Evening			
141	184	70	113
142	856	71	785
Wednesday			
Morning			
724	133	653	62
207	145	136	74
Afternoon			
151	128	80	57
81	73	10	2
Evening			
138	493	67	422
146	259	75	188
Thursday			
morning			
81	79	10	8
910	152	839	81
afternoon			
85	136	14	65
81	80	10	10
evening			
70	128		57
128	187	57	116
Friday			
morning			
326	79	255	8
128	183	57	112

afternoon			
141	74	70	3
140	1088	69	1017
evening			
141	151	70	80
98	143	27	72
Saturday			
morning			
77	68	6	
75	72	4	1
afternoon			
117	115	44	44
66	67		
evening			
145	77	74	6
132	192	61	121
Sunday			
Morning			
72	68	77	6
75	74	4	3
Afternoon			
74	79	3	8
78	91	7	20
Evening			
105	82	34	11
76	75	5	4

TTS= Travel Time

DTS = Delay Travel
Source: Author's Field Survey (2015)

Travel and Delay Time at Kawo-Mando Car

TT1	TT2	DT1	DT2
Monday			
Morning			
173	154	77	58
159	153	63	57
Afternoon			
141	159	45	63
142	265	82	169
Evening			
122	367	62	271
267	275	87	179
Tuesday			
Morning			
101	149	41	53
140	161	44	65
Afternoon			
90	85	9	65
146	128	50	32
Evening			
204	126	108	12
141	803	45	707
Wednesday			
Morning			
81	86		
389	155	293	59
Afternoon			
147	193	51	97
507	245	411	149
Evening			
197	214	101	118
85	313		217
Thursday			
Morning			
170	133	74	37
625	167	529	71
Afternoon			
99	169	3	73
81	104		8
Evening			
147	84	51	
156	561	60	465
Friday			
Morning			
146	127	50	31
395	145	229	49
Afternoon			

145	265	49	196
129	908	33	812
Evening			
242	127	146	31
188	298	96	202
Saturday			
Morning			
136	147	40	51
93	132		36
Afternoon			
148	149	52	53
206	149	110	53
Evening			
137	186	41	90
179	145	83	49
Sunday			
Morning			
97	82	1	
137	135	41	39
Afternoon			
139	71	43	
79	80		
Evening			
84	122		26
119	152	23	56

TTS= Travel Time

DTS = Delay Travel
Source: Author's Field Survey (2015)

Travel and Delay Time at Kawo-Mando Bus

TT1	TT2	DT1	DT2
Monday			
morning			
124	143	28	47
166	165	70	69
afternoon			
139	169	43	73
181	243	85	147
evening			
152	439	56	343
148	321	52	225
Tuesday			
morning			
112	194	16	98
175	184	79	88
afternoon			
144	117	48	21
138	108	42	12
evening			
245	166	149	70
185	944	86	848
Wednesday			
morning			
184	119	88	23
240	118	144	22
afternoon			
119	166	23	70
390	191	294	95
evening			
151	228	55	132
77	410		314
Thursday			
morning			
173	61	77	61
683	207	587	147
afternoon			
73	186		126
159	99	63	39
evening			
134	123	38	63
131	488	35	428
Friday			

Table 4.9 Cont'd

morning			
154	151	58	55
425	99	329	3

afternoon			
125	188	29	92
200	906	104	810
evening			
197	131	101	35
189	328	93	232
Saturday			
morning			
147	91	51	
77	147		51
afternoon			
155	142	59	46
137	124	41	28
evening			
125	124	29	28
157	157	61	61
Sunday			
morning			
87	82		
122	138	26	42
afternoon			
128	74	32	
78	78		
evening			
79	184		88
121	79	25	

TTS= Travel Time

DTS = Delay Travel
Source: Author's Field Survey (2015)

Travel and Delay Time at Yakubu-Gowon Way Car

TT1	TT2	DT1	DT2
Monday			
morning			
81	74	20	13
152	135	91	74
afternoon			
327	326	266	265
311	313	250	252
evening			
100	89	39	28
156	119	95	58
Tuesday			
morning			
101	95	40	34
167	151	106	90
afternoon			
431	422	370	361
374	373	313	312
evening			
198	205	137	144
91	95	30	34
Wednesday			
morning			
60	65		4
87	84	26	23
afternoon			
491	499	430	438
265	234	204	204
evening			
192	188	134	131
59	60		
Thursday			
morning			
88	83	27	22
248	206	187	145
afternoon			
187	138	127	77
378	487	317	426
evening			
120	129	59	68
93	67	32	6
Friday			
morning			
76	75	15	14
141	131	80	70
afternoon			

453	449	392	388
193	200	132	139
evening			
89	101	28	40
88	73	27	12
Saturday			
morning			
61	62		1
73	69	12	8
afternoon			
63	65	2	4
73	69	12	8
evening			
58	62		1
60	66		5
Sunday			
morning			
59	67		6
56	64		3
afternoon			
62	58	1	
59	61		
evening			
64	60	3	
62	54	1	

TTS= Travel Time

DTS = Delay Travel
Source: Author's Field Survey (2015)