SPATIO-TEMPORAL PATTERN OF ROAD TRAFFIC ACCIDENTS IN KADUNA STATE, NIGERIA

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DECLARATION

I declare that the work in this dissertation entitled **"Spatio-Temporal Pattern of Road Traffic Accidents in Kaduna State, Nigeria"** was carried out by me in the Department of Geography and Environmental Management. The information derived from the literature has been duly acknowledged in the text and list of references provided. No part of this dissertation was previously presented for another degree or diploma in any other Institution.

Abdulnajeem Mohammed LAWAL ____________________ ________________

Signature Date

CERTIFICATION

This dissertation entitled **"SPATIO-TEMPORAL PATTERN OF ROAD TRAFFIC ACCIDENTS IN KADUNA STATE, NIGERIA"** by ABDULNAJEEM Mohammed Lawal meets the regulations governing the award of the degree of Master of Science Degree in Remote Sensing and Geographic Information System of the Ahmadu Bello University, and is approved for its contribution to knowledge and literary presentation.

Dr. B. Akpu Chairman, Supervisory Committee	____________ (Signature)	____________ Date
Dr. J.O. Adefila Member, Supervisory Committee	____________ (Signature)	____________ Date
Dr A.K. Usman Head of Department	____________ (Signature)	____________ Date
Prof. S.Z. Abubakar Dean, School of Postgraduate Studies	____________ (Signature)	____________ Date

DEDICATION

This dissertation is dedicated to the Almighty Allah; the all knowing, who has given me the strength, wisdom and inspiration to carry out this work I say Alhamdulilah, and to my late parents and my lovely family.

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ABSTRACT

Road traffic accidents (RTAs) are often found to follow some spatial and temporal patterns as the factors that influence them vary over space and time. This study analyzed road traffic accidents in time and space, using Remote Sensing and GIS technique. The study area involves two major highways in Kaduna state; Kaduna to Birnin Gwari (single carriage way) popularly known as Lagos Road and Kaduna to Tarfa (dual carriage way) linking Abuja,covers an approximate distance of 121km and 138km respectively. Road traffic accidents data were collected from the Federal Road Safety Commission (FRSC) from year 2010 to 2014. Field survey was also carried out through which the geographical coordinates of road traffic accident locations were captured using GPS receiver, traffic count, as well as on the spot field observation. Data were analysed using the Kernel Density Estimation method and Nearest Neighbour Ratio in ArcGIS 10.1 environment to determine the road accidents hotspots and pattern; while frequency distribution tables and charts were used to depict the accidents distribution. The findings revealed that the Kaduna-Abuja road had more vehicular traffic than Kaduna-Birnin Gwari road with similar gradual increase of traffic volume between 7am-8am along the two routes till they hit their various morning peaks. The composition of vehicular traffic flow shows that private cars accounted for the most along Kaduna-Abuja (29.2%) and Kaduna-Birnin Gwari (22.6%) roads respectively. Kaduna-Abuja road had 66% of the total number of recorded accidents with over-speeding and tyre-burst been the major causes of road traffic accidents. About 69.3% of persons involved in road accidents were along Kaduna-Abuja road and 79.6% of them were males. The findings revealed that the highest number of road traffic accidents were recorded in the year 2011, accounting for 37.8% of the total number of recorded accidents along Kaduna-Abuja road; whereas for same period it was 47.4% along Kaduna-Birnin Gwari road. On road traffic accident severity index, Kaduna-Birnin Gwari road had the highest (127,2%) in the study area. The clustering pattern of Road Traffic Accident shows that the Kaduna-Abuja road had 0.135346 of nearest neighbour index while the Kaduna-Birnin Gwari road got 0.229775,with a z-score of -23.970816 and -15.170547 respectively. Eight different hotspots were identified along Kaduna-Abuja road, while Kaduna-Birnin Gwari road had only six hotspots. The only accident high risk area identified along the routes was Toll Gate hotspot, located along the Kaduna-Abuja road The study therefore recommends among others, the use of speed limit devices by drivers, public education programme by FRSC on road safety, expansion of narrow bridges, road repairs and realignment of sharp bends on the roads.

CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND TO THE STUDY

The role of transport in our daily activities cannot be overemphasized and without it, the necessities of life would be difficult to achieve. As wonderful as the role of transport may be in our daily activities, it has been noted to possess myriads of negative effects (Abdul and Ansa, 2012). Ogunsanya (1991) posited that despite the undisputed roles and impact of road transport in the efficient functioning of a society, one of the unavoidable negative consequences is accident occurrence. The high incidence of road accident tends to easily erode the positive effect of road transport in the nation's economy. This is why transport is described as the "maker and breaker" of the cities. Ogunsanya (2002) confirmed how transport has built cities over the year in some urban areas in Nigeria and how it has gradually destroyed them. Road traffic accidents have become common in everyday urban life.

According to Rune and Truls (2004) road traffic accident is any vehicular accident occurring on a public highway which includes collisions between vehicles and vehicles, vehicles and animals, vehicles and pedestrians or vehicle and fixed obstacles. Similarly, Astrom, Kent and Jovi (2006) posited that road traffic accident is a collision or similar incident involving a moving vehicle, resulting in property damage, personal injury or death. Agbonkhese, *et al*. (2013) were of the view that road traffic injuries are the leading cause of death among young people aged 15–29 years and that 91% of the world's fatalities on the roads occur in low-income and middle-income countries. Accidents may be fatal, resulting in deaths of the road users, passengers, drivers or pedestrians, or minor when it is not severe enough as to cause substantial hardship (Sarin, 1998).

Among all accidents, road traffic accidents claim the largest toll of human life and tend to be the most serious problem world over (Kual *et al*., 2005). Worldwide, the number of people killed in Road Traffic Accidents (RTA) each year is estimated at almost 1.2 million while the number of people injured could be as high as 50 million (WHO, 2004). Kopits (2005) posited that currently motor vehicle accidents rank 9th in order of disease burden and are projected to rank 3rd in the year 2020. In Africa, it has been estimated that 59,000 people lost their lives in road crashes in 1990 and this figure will be 144,000 people by 2020 (Kopits, 2005). According to data from the Nigerian Federal Road Safety Commission (FRSC), Nigeria has the highest rate of death from motor accidents in Africa; leading 43 other nations in the number of deaths per 10,000 vehicles crashes (Obinna, 2007). The number of reported cases of fatal road traffic accidents in Nigeria has shown an increasing trend from 12,212 cases of accidents in 1995 to 13,913 in 1996 and 15,418 in 2004, indicating an increase of 13.9% in fatal road accidents from 1995 to 1996 (Central Bank of Nigeria, 1997). According to the FRSC Annual Abstract of Statistics (2008), between 2003 and 2007, a total of 225,891 accident cases were reported by the Nigeria Police Force, out of which 29,490 were fatal, 39,065 were severe cases, and 23,380 were minor cases. This trend of road traffic accident is however on the increase due to rapid increase in vehicular movement on Nigeria roads.

Despite integrated efforts towards reducing fatal road accidents, Nigeria still remains one of the worst hit countries. With a human population of about 167 million, a high level of vehicular population estimated at over 7.6 million, a total road length of about 194,000 km (Sumaila, 2013,) the country has suffered severe losses to fatal accidents. Road traffic accidents occurrence varies over space and time. The study of Eke, Etebu and Nwosu (2000) revealed that 70% of fatal accidents in Port Harcourt occur during the weekends. This finding corroborates an FRSC Report (2011) on road traffic crashes involving buses on Nigerian roads which states that 16% of road accidents between 2007 and 2010 occurred on Sundays; 15% on Saturdays while other days of the week were 13% on the average. People who travel back on Sundays to resume official duties on Mondays increase traffic volume and fatal road accidents. As for commercial drivers, they often try to recoup weekend expenses when they overload passengers and over-speed to complete more trips.

Causes of motor vehicle crashes are so many and involve the interaction of a number of pre-crash factors that include people, vehicles and the road condition (Haddon, 1980; AMA, 1983; Stansfield, Smith and McGreevey, 1992; Robertson, 1992). Human error is estimated to account for between 64 and 95% of all causes of road traffic accident in developing countries (TRL, 1999; Atubi, 2009c). A high prevalence of old vehicles that often carry many people (overloading) than they are designed to carry, failure to use safety belt and helmet by motor cyclists, poor design and maintenance and the traffic mix up by one way default drivers on roads are other factors that contribute to the high rate of crashes in less developed countries (Atubi, 2012). Atubi (2009a) found out that road accidents appear to occur regularly at some flash points such as where there are sharp bends, potholes and at bad sections of the highways.

Reshma and Sheikh (2012) pointed out that the locations that have abnormal high number of crashes are described as 'crash concentrated', 'high hazard', 'hazardous', 'hot spot or black spot'. Gregory and Jarrett (1994) opined that hotspot or a 'high risk site' is the number of personal injury accidents occurring in a 100m grid square or 100m length in a three year period on a particular class of road. Therefore, if 12 accidents are recorded over a period of three years on a 100m length of road, then the area is deemed a high-risk site. Accident black spot denote those places or spots that are prone to road accidents or where road accidents are more concentrated on a road network. This often contributes to worsen the severity of a road accident (Reshma and Sheikh, 2012).

Road traffic accidents pattern is believed to be the form accidents takes over time and space. Aderamo (2012a) posited that Kaduna State had 2,335.74 road accident injuries per 100,000 populations. This suggests a pattern of very high distribution of road traffic accidents fatality in the State. Kaduna State serves as a link to other cities of the North and Southern parts of the country, as a result several inner and outer movements especially during the festive periods of Salah and Yuletide. This peak period movement is one of the factors that inundate the traffic landscape with Road Traffic Accidents (RTAs) along the major highways in Kaduna State (Balogun, 2013). Kaduna-Birnin Gwari (single carriage way) popularly known as Lagos Road and Kaduna-Tafa (dual carriage way) linking Abuja, cover an approximate distance of 121km and 138km respectively. Due to the rapid growth of human population, the numbers of vehicles on these roads have led to increased traffic flow. Bala (2014) stated that increasing number of traffic flows might also increase the number of road traffic accidents on Nigerian roads.

However, cursory observation shows that the Kaduna-Birnin Gwari road is in poor condition, with presence of sharp bends and narrow bridges. On the other hand, the Kaduna-Abuja road is relatively in good condition, which encourages over speeding that might have contributed to increased number of road traffic accidents along the study routes.

Li (2006) was of the view that accident is spatially distributed in nature, hence the use of Geographic Information System (GIS) which provides the capability to store, update, retrieve, compare and spatially display data. The advancements in GIS and Remote Sensing can be put to effective use in accident analysis. In the same vein, Deepthi and Ganeshkumar (2010) posited that GIS is useful in promoting linkage between various types of data and maps as well as able to visually display the results of analyses, thus enabling sophisticated analysis and quick decision making. This necessitated the need to apply GIS and Remote Sensing in analyzing the spatio-temporal pattern of road traffic accidents in Kaduna State.

1.2 STATEMENT OF THE RESEARCH PROBLEM

Road traffic accidents are a major public health problem all over the world. In Nigeria, road traffic accident situation over the last three decades has been particularly disturbing. In 1976, there were 53,897 road traffic accidents cases in Nigeria, resulting in 7,717 deaths (Atubi, 2010). Although in 1981, the magnitude reduced to 5,114 accidents but the fatality increased to 10,236 which mean that there was an average of 96 accidents per year and the situation in subsequent years has not been any better. The number of people killed in road accidents between 1990 and 2005 rose to 28,253 and the fatality rate remains consistently high (Atubi, 2009).

FRSC (2011) record on road traffic crashes involving buses on Nigerian roads between 2007 and 2010 revealed that Kaduna state recorded the highest cases, amounting to 543 (9.4%). The report further showed that out of 5,583 persons killed in road traffic crashes, Kaduna state also had the highest number of deaths (495 persons); while out of 27,791 persons injured in all the states in Nigeria, 3,264 persons were from Kaduna state. This situation has become worrisome and a source of concern to everyone, especially its negative effects on socio-economic development of the state.

From a public health perspective, road traffic fatalities have become increasingly more significant among overall fatalities and are affecting mainly the most vulnerable users. Actual figures are certainly higher than those reported due to under reporting, failure in relating reported deaths to traffic causes and failure in registering post accident deaths (Eduardo, 2005).

Several studies have been conducted on road traffic accidents. Aworemi and Abdul-Azeez (2010) examined the causal factors of road traffic crashes in some selected states in South Western part of Nigeria using regression analysis, the study revealed that human, vehicle, roadway and environmental factors had significant contributions of about 79.4% on road traffic crashes in the study area. Atubi (2010c) examined variation in the pattern of road traffic accidents in Lagos State. The study revealed that private cars, buses and taxes were more prone to accidents and that more than 90% of road traffic accidents in the state could be attributed to recklessness on the part of drivers, ignorance of high-way codes and over-speeding.

Another study by Mamman and Jediel (2014) examined the spatio-temporal nature of Road accidents along Kaduna-Zaria express way, using Remote Sensing and GIS techniques. The study revealed that road accidents were not evenly distributed along the route, as the frequency of occurrence appeared to be higher around some flash points, such as where there are sharp bends, sagging, U-turns and bad sections of the expressway. It further identified the nature of the road in terms of its longitudinal profile, gradients and sharp curves as factors responsible for fatal road accidents at hot spots along the road.

The previous studies on road traffic crashes concentrated on the trends, nature of road traffic accidents and at best the determination of hot spots. Kaduna-Abuja (dual carriage way) and Kaduna-Birnin Gwari (single carriage way) are among the roads in Nigeria where road traffic accidents occur more frequently. None of the previous reviewed studies examined the spatio-temporal pattern of road traffic accidents along these routes for the said period that this study considered. This is the gap this study attempts to fill. The study attempted to answer the following questions;

1. What is the nature and volume of road traffic in the study area?

2. Where are the locations of road traffic accidents in the study area?

3. What are the characteristics of road traffic accidents along the study route?

4. How does road traffic accident vary over time along the routes?

5. What is the spatial pattern of road traffic accidents in the study area?

6. Where are the road traffic accidents hot spots in the study area?

1.3 AIM AND OBJECTIVES OF THE STUDY

The aim of this study is to analyze the spatio-temporal pattern of road traffic accidents in Kaduna state. However, the specific objectives are to;

i. characterize the nature and analyze the volume of road traffic in the study routes

ii. locate and map road traffic accidents along the study routes

iii. examine the characteristics of road traffic accidents along the study routes

iv. examine the temporal variation of road traffic accident

v. determine the spatial pattern of road traffic accident along the study routes

vi. determine the road traffic accidents hotspots on the study routes.

1.4 SIGNIFICANCE OF THE STUDY

In Nigeria, road traffic accidents have become one of the leading causes of death in older children and economically active adults between the ages of 30 and 49 years (Jacobs, Aeron-Thomas and Astrop, 2000). Gbadamosi (2002) stated that road traffic accidents' statistics in Nigeria revealed a serious and growing problem with absolute fatality rate and casualty figure rising rapidly. The probability of occurrence of road accident, and its severity, can often be reduced by the application of proper traffic control devices, and sound roadway design practice (Sarin, 1998). The success or failure of such control devices and design specifications however, depend extensively upon the analysis of traffic accident records at specific locations. It has long been recognized that one of effective means towards accident reduction lies in a systematic and scientific approach that is based on the use of accurate and reliable traffic accident data (Saxena, Babu, Bajpai and Sarin, 2000).

However, in developing countries, the data required for such analysis is not always available. Most of the accident information available in police records is incomplete and therefore, may not be utilized to the fullest extent (Sarin, 1998). The findings of this study will reveal the pattern of road traffic accidents as well as determine and map out the accident hot spots locations which are a prerequisite in road maintenance and safety management. It will assist the government agencies responsible for road safety which among them include: Federal Road Safety Commission (FRSC), Nigerian Police Force (NPF), Federal Road Maintenance Agency (FERMA), Vehicle Inspection Office (VIO) and the general road users to note the areas for urgent attention, caution when driving as well as in safety decision making.

1.5 SCOPE OF THE STUDY

The spatial scope of this research work covered road traffic accidents along Kaduna-Birnin Gwari single carriage way and Kaduna-Abuja (Tafa) dual carriage way, while the content scope was on the analysis of spatio-temporal pattern of road traffic accidents. It also covered the specific location of road accidents, nature of the accidents, time of accidents, causes of accidents, as well as the characteristics of road traffic accidents hot spots. The temporal scope of the study covered road accident data between years 2010-2014 which is the available record obtained from FRSC.

CHAPTER TWO

CONCEPTUAL/THEORETICAL FRAMEWORK AND LITERATURE REVIEW

2.1 INTRODUCTION

This chapter discusses the concept of road accident and applies various bodies of theories in social and behavioural science, predominantly emphasizing on system theory and risk theory. Empirical works were also reviewed.

2.2 CONCEPTUAL FRAMEWORK

2.2.1 Road Traffic Accident

The definition of road traffic accident (RTA) is not universal according to Organization for Economic Cooperation and Development (OECD) (1998). An accident is occurrence in a sequence of events which usually produces unintended injury, death or property damage (Sharma, Singh and Mukherjee, 2011). Agbonkhese *et al.* (2013) stated that road traffic accident is an unexpected phenomenon that occurs as a result of the operation of vehicles including bicycles and handcarts on the public highways and roads. Accidents may be fatal, resulting in deaths of the road users (passengers, drivers or pedestrians), or minor when it is not severe enough as to cause substantial hardship. Accidents represent a major epidemic of non-communicable disease in the present century (Sharma, Singh and Mukherjee, 2011).

2.2.1.1 Causes of road traffic accidents

According to Agbonkhese *et al*., (2013) causes of road traffic accidents depend on a list of factors which can be broadly divided into vehicle operator or human factors, vehicle factors, road pavement condition factors and environmental factors.

a.Human Factors:

Driver factors in road traffic accidents are all factors related to drivers and other road users. However, unlike the findings of Traffic Accident Causation in Europe (TRACE) in Nigeria cited in Agbonkhese *et al*., (2013), studies and road traffic accident records have clearly shown that the attitude of the Nigerian driver to driving code and etiquette is the single most important contributing factor as driver factors solely contributes to about 57% of road traffic accidents and 93% either alone or in combination with other factors. Driver-related issues include:

i. Speed and Indiscriminate Use of Sirens: An increase in average speed is directly related both to the likelihood of a crash occurring and to the severity of the consequences of the crash. Travelling too fast for prevailing conditions or above the speed limit contributes to road traffic accidents. The risk of being injured increases exponentially with speed much faster than the average speed. The severity of accident depends on the vehicle speed change at impact and transfer of kinetic energy. Though vehicles travelling slower than average speed are also at increased risk of road traffic accidents, most involved speed too fast for the conditions.

ii. Drunk-driving and Use of Drugs: Drinking and driving increases both the risk of a traffic accident and the likelihood that death or serious injury will result. The risk of being involved in a traffic accident increases significantly above a Blood Alcohol Concentration (BAC) of 0.04 g/dl. Doctors often advise patients to abstain from driving vehicles or operation of machineries while under certain drugs as these drugs are known to cause side effects of sleepiness and fatigue thus leading to possible occurrence of accident.

iii. Distracted Driving: There are many types of distractions that can lead to impaired driving, but recently there has been a marked increase around the world in the use of mobile phones by drivers that is becoming a growing concern for road safety. The distraction caused by mobile phones can impair driving performance in a number of ways, e.g. longer reaction times (notably braking reaction time, but also reaction to traffic signals), impaired ability to keep in the correct lane, and shorter following distances. Text messaging also results in considerably reduced driving performance, with young drivers at particular risk of the effects of distraction resulting from this use. Drivers using a mobile phone are approximately four times more likely to be involved in a traffic accident than when a driver does not use a phone. Hands-free phones are not much safer than hand-held phone sets as they too have been recorded to result in traffic accidents when shocking news is received while driving.

iv. Inexperienced and Unqualified Drivers: Majority of Nigerian drivers do not possess the right authorization from government authorized agencies like the Federal Road Safety Commission, FRSC and are unqualified before driving cars on road pavements. This is the major reason most Nigerian drivers are ignorant of highway codes or traffic orders. They put their lives and those of other road users at the risk of traffic accidents. As a result of their inexperience, since they were never given any tutorial or taught how to use their vehicles on highways by government accredited driving schools, their decision making ability and reaction speed to traffic is bad.

v. Non-use of safety device and negligence of duty by government established agencies: Seat belts are safety device provided to safeguard a driver in the course of an accident. The use of vehicle seat belts also helps to ensure that the driver is in an upright and comfortable position thus enabling him/her to proper operate the vehicle. However, this provided safety device has been grossly abused thus increasing the risk of fatality among front-seat and of rear-seat passengers. Also majority of motorcyclists or their passenger do not wear helmets while plying the road thus exposing themselves and indeed other road users to road traffic accident.

b.Vehicle Factors:

The vehicle itself is a key factor when analyzing the remote causes of a traffic accident and it is incorporated with gadgets like, the horn, side mirrors, wipers, braking system, trafficators, headlights and break-lights (to mention just a few) so as to avoid road accident. Malfunction of any vehicle parts such as tyres, engines, braking systems, light systems can cause road traffic accidents. The reliability of the vehicle is itself a function of the condition of vehicle at every given time. Vehicle components and vehicle maintenance are the two main conditions which affect vehicle factors as it relates to causes of road traffic accidents.

i. Vehicle Components: The assembled components of a vehicle working effectively uniformly or abnormally as a unit will determine the occurrence of a traffic accident.

ii. Vehicle Design: The specific maximum load designed for a vehicle in its entire ramification goes a long way towards determining its stability on the road surface. When vehicles are subjected to stress over and above the provisions of the design specifications as is the case of a lot of vehicles plying the Nigerian roads, deterioration for the condition of the vehicle in accelerated wear and tear sets in. Design defects affect the subsequent condition of the vehicle once it is put on the road and operated either normally or otherwise which may result to possible road traffic accidents.

iii. Vehicle Brake System: Brakes are generally applied to rotating axles or wheels. Vehicles use a combination of braking mechanisms which works jointly with the accelerator as the main synchronizer of the speeds of vehicles. Any malfunctioning of the brake sub-system should be taken very seriously as a potential source of unavoidable accident.

iv. Vehicle Body and Tyres: The firmness of the structure of a vehicle though less prominent attributes to some measure in causing road traffic accidents. One of the dominant factor in determining the stability and safety of vehicles on the road is the tyres. Tyres designed and specified for cold regions are not those specified for temperate regions like Nigeria. However, this is not the case of most tyres used in Nigeria as vehicle owners do not take the specification of tyres into consideration when buying and fixing tyres onto their vehicles and this has been known to cause tyre ruptures thus leading to traffic accidents. Some other tyre related causes of road accidents could be due to one or a combination of over-inflated tyres, under-inflated tyres or thread of tyres are thoroughly worn out.

v. Vehicle Lights: The failure of vehicle light is a major factor in road traffic accident. Failure of vehicle lights has a tendency to misinform and mislead other road users thereby providing a good opportunity for an accident to occur. Vehicle lights are very useful at all times during the daylight, in darkness and in poor/bad weather. For example, a failed trafficators light of a vehicle ahead will not normally provide the usual warning to other vehicles behind that it is about to undertake a turning manoeuvre and if for instance the driver of the vehicle behind has not allowed for a sufficient stopping sight distance or the vehicle has a faulty brake sub-system, this could result in an accident occurring.

vi. Vehicle Engine: The power house and heart of the vehicle is the engine sub-system which is responsible for bringing other parts of the vehicle into motion and one whose sudden failure on a highway is more likely to cause an accident if the volume of traffic is sufficiently high at that point in time. Even when the traffic is reasonably low, mismanagement of the failure by an experienced driver could cause road traffic accident.

vii. Vehicle Maintenance: Acquiring a well-designed vehicle and putting it onto road use is not enough to prevent the vehicle from causing road traffic accident. Actually not performing routine maintenance and checks on the vehicle can lead to deterioration of the vehicle sub-systems and thus expose the vehicle to causing road traffic accident as a well maintained vehicle is less likely to be involved in accidents. For example, if the brakes and tires are good and the suspension well-adjusted, the vehicle is more controllable in an emergency and thus, better equipped to avoid accidents.

c.Road Pavement Condition Factors:

Nigerian highways are arguably one of the worst and most dangerous in the world as they are often poorly designed, necessary important road facilities like drains are not adequately provided for and to top it up, they are rarely rehabilitated and are in dilapidated states. The deplorable states of the Nigerian highways create a scenario that makes vehicles and other road users susceptible to road traffic accidents. This further confirms that road traffic accidents are not just caused by human error or drivers' negligence.

d.Environmental Factors:

Environmental related conditions such as fog, sunrays, mist and rain in no small measure contributes greatly to the rate of road traffic accident in Nigeria today. Having stated earlier that most vehicles on Nigerian roads are poorly maintained, a poorly maintained vehicle for example on a rainy day is most likely to cause road traffic accident if the wipers are faulty and not functioning as the driver will be unable to see ahead.

2.2.2 Road Traffic Accident Hotspots

Road accidents are considered as random, rare and independent events. It is impossible to predict under which circumstances a single accident will occur (Brijs *et al*., 2007) and their occurrence in a specific location does not influence the occurrence of other accidents in other places or moments. However, the concentration of accidents in the same site might indicate a spatial relation between accidents and the environment and/or road conditions (Levine *et al*., 1995a; Elsenaar and Abouraad, 2005; Geurts *et al*., 2005a; Elvik, 2006) hence the development of road traffic accident hotspots.

The road accident literature provides no universally accepted definition of a road accident 'hotspot' (Brimicombe 2004). Although Hauer (1995) describes how some researchers rank locations according to accident rate (accidents per driven vehicle kilometre), while other researchers use accident frequencies (accident per road kilometre). Hotspots," "Black spots," or high crash locations are sites on a section of a roads that have an accident frequency significantly higher than expected at some threshold level of significance (Raut, Nalawade and Kale, 2016).

2.2.3 The Kernel Density Estimation

Road accident hotspot analysis has traditionally centred on road segments or specific junctions (Cook *et al*., 2001, Thomas 1996) while area wide hotspots are often neglected (Anderson, 2007). Hotspots, which are defined as relatively high-risk locations, are commonly identified on the basis of some specific selection criteria (Thakali, Kwon and Fu, 2015). One of the most commonly used selection criteria is defined by the expected collision frequencies at the sites of interest which emphasizes on maximizing the system-wide benefits of safety intervention targeted to the hotspots (Tarko and Kanodia, 2004). There are a variety of spatial tools developed to assist the understanding of the changing geographies of point patterns. The Kernel Density Estimation (KDE) is one of the most common and well-established methods in identifying spatial patterns (Blazquez and Celis, 2013).

The Kernel Method divides the entire study area to a pre-determined number of cells and applies a circular neighbourhood around each crash. Density Estimation measures cell densities in a raster by using a sample of known points. Kernel Density Estimation associates each known point with a Kernel function. This can be expressed as a bivariate probability density function, a kernel function looks like a "bump", centering at a known point and tapering off to over a defined bandwidth or window area (Sabel, 2006). KDE includes placing a symmetrical surface over each point and then measuring the distance from the point to a reference location based on a mathematical function and then summing the value for all the surfaces for that reference location. This procedure is repeated for successive points. This therefore allows us to place a Kernel over each observation, and summing these individual Kernels gives us the density estimate for the distribution of accident points (Fotheringham, Brunsdon, and Charlton, 2000; Anderson, 2009).

KDE calculates the density of events in a neighbourhood around those events. KDE allows some events to weigh more heavily than others, depending on their meaning, or to allow one event to represent several observations (Asgary, Ghaffari, and Levy, 2010). The main benefit of this approach lies in recognizing the risk spread of an accident (Anderson, 2009). The spread of risk can be defined as the area around a defined cluster in which there is an increased probability for an accident to happen based on spatial dependency. Secondly by using this density measure, an arbitrary spatial unit of analysis can be defined and be homogenous for the whole area which makes comparison and ultimately a taxonomy possible

(Anderson, 2009). One of the attractive parts of the KDE method as compared to other variants of clustering methods is that it takes into consideration of spatial autocorrelation of crashes and it is believed to be simple as well as easy to implement. This could be one of the reasons that KDE method is being widely used in road safety (Thakali, Kwon and Fu, 2015). KDE in ArcGIS version 10.1 environment was therefore used in the determination of road traffic accident hotspots in this study.

2.2.4 Geographic Information System (GIS)

According to Earth Science Research Institute (ESRI), Geographic Information System (GIS) is a computer system for capturing, storing, querying, analyzing and displaying geographic data. GIS represents a new paradigm for the organization of the information and the design of information system, the essential aspect of which is the use of concept of location as the basis of structuring of information systems. GIS can easily represent accident and road accident based results using various tools like linear referencing, dynamic segmentation, and spatial analyst (Deepthi and Ganeshkumar 2010). Moreover query can be easily performed, enhanced by graphical representation. According to Liang, Masoem, and Hua (2005), GIS provide a common link between two or more previously unrelated databases. The most useful aspect of GIS as a management tool is its ability to associate spatial objects (street names, milepost, route number, etc.) with attribute information (accidents, cause, etc.).

GIS as a valuable tool that combines the spatial information with other data has been widely used in road accident analysis procedure to visualize accident data and analyze hotspots in highways (Erdogan *et al.*, 2007). Similarly Liang *et al.* (2005) opined that using GIS, analysts can merge accident and highway data, geo-code the accident data and locations, calculate frequency and rate of accidents, select a variable for stratification to calculate mean and standard deviation of accident rates. Using this system, the user can identify high risk accident locations, obtain the accident location's ranking, visualize the road accident and location information, input and retrieve the accident database, perform statistical analysis on the selected accident locations and so on within a short period of time (Erdogan *et al*., 2008). Road traffic accident hotspot analysis is therefore a prerequisite for the management of road traffic safety and it involves the systematic collection of data on traffic accidents that will enable the identification and determination of the place where there are high concentrations of road accidents.

2.3 THEORIES OF ROAD TRAFFIC ACCIDENTS

Several theories have been used to explain road traffic accidents and road safety management, among which are system and risk theories as well as Jørgensen and Abane Model for traffic accidents. These theories were considered relevant to this study and were discussed below.

2.3.1 System Theory

Explanations of the systems theory are based on man-environment adjustments and maladjustments (Muhlrad *et al*., 2005). The components of the theory are the environment, the means of transport (vehicles) and the behaviour of man (Krug *et al*., 2000). The environment component comprises of the natural and the built environments and transport networks. The means of transport component comprises of the volume and quality of vehicles on the modes of transport. The behaviour of man component comprises of demographic characteristic of road users (age, sex, education, socio-economic status, stage in life cycle), people's perceptions of risk and people's general behaviour on the streets. Integrated in the systems theory is a system of highway codes and enforcement mechanisms designed to ensure that road users adhere to the controls and regulations of traffic flow for maintaining road traffic safety. Comprehensive traffic management should be sufficient to maintain road traffic safety (Hauer, 1995).

Thus, the relevance of systems theory in understanding the topic under consideration can be seen at three different levels**.** First, the theory helps to identify the system of traffic laws, regulations and mode of enforcement designed to ensure traffic safety in Kaduna State. Second the theory help to identify the multiple causes' interplay of risk factors and prevention of traffic accidents that occur in the study area. Third, the theory assist in identifying/understanding the three major contributory factors of road traffic accident including human, mechanical (vehicle) and road environment factors.

2.3.2 Risk Theory

Risk theory has also been used in the description of accident causation. Risk can be defined as the effect of uncertainty on objectives whether positive or negative. Its management is followed by coordinated economical application of resources to minimize, monitor, and control the probability and impact of unfortunate events (Hubbard, 2009) or to maximize the realization of opportunities. Risks can come from uncertainty in financial markets, project failure, legal liabilities, credit risk, accidents, natural causes and disasters as well as deliberate attacks from an adversary. Road traffic accidents risk, according to Dejoy (1989) is a function of four elements.

The first is the exposure or amount of movement or travel within the system by different users or a given population density. The second is the underlying probability of crash, given a particular exposure. The third is the probability of injury given a crash. The fourth element is the outcome of injury. Risk can also be explained by human error (Reason, 2000; Rasmussen, 1999); kinetic energy, tolerance of human body and post-crash care (Bastide *et al*., 1989). Lupton (1999) also asserts that Risks can be seen from four perspectives. These are the rationalist, realist, constructionist and middle positions. The rationalist sees risks as real world phenomena to be measured and estimated by statistics, prioritized by normative decision theory and controlled by scientific management. The realist sees risks as objective hazards or threats that exist and can be estimated independently of social and cultural processes but that may be distorted or biased through social and cultural frameworks of interpretation. The constructionist sees nothing as a risk in itself. Rather, what we understand to be a risk, the constructionist sees risk as the product of historically, socially and politically contingent ways of seeing. Proponents of the middle positions between realist and constructionist theory see risk as an objective hazard or threats that is inevitably mediated through social and cultural processes and can never be known in isolating from these processes (Jaeger *et al*., 2001; Horden, 2004).

2.3.3 Jørgensen and Abane Model for Traffic Accidents

Traffic accidents bear strong elements of man-environment adjustments and maladjustment, a well-known approach in geography (Muhlrad *et al.,* 2005). Based on the logic of a modified human ecological model of a disease the approach can be transferred to studies of road traffic accident. A model for traffic accident as inspired by the ecological model of a disease was developed by Jørgensen and Abane (1999) who made a heuristic adjustment of this basic model to suit road traffic accident analysis. The model is characterized by three main components:

i. The vehicle (corresponding to the vector in disease ecology) which describes vehicles into its composition, age, technical conditions and safety equipment like seat belts in a car.

ii. The environment comprises the road system and the wider physical and built up environment. The physical environment splits further into different aspects such as;

Daylight and climate (weather conditions and road conditions), Spatial conditions (arrangements and Macro structures), Settlement pattern (Urban or rural/sparse or populated area), situation of areas of residence and working areas, Principle of traffic separation, topography and road constructions qualities.

iii. The behaviour of the population, including its characteristics such as age and sex ratio as well as attitudes and general traffic behaviour. And it goes further into driving behaviour, driving experience, driving style, risk compensation and risk driving (influence of alcohol and drugs).

Superimposed on this model is a system of traffic laws, regulations and mode of enforcement designed to ensure that the population adheres to the controls and regulations so as to maintain some level of road safety i.e. traffic rules (speed restrictions, road signs), speed controls and convictions for various road traffic offences (Jørgensen and Abane, 1999). Available literature identifies traffic accidents in a place as been caused either by physical factors in the road system (environment), the vehicle or behaviour factors, and how they interact with enforcement regulations in unique settings.

2.4 LITERATURE REVIEW

This section discussed the empirical studies conducted on road traffic accidents and hotspot determination according the set objectives of this study.

2.4.1 Characteristics of Road Traffic Accidents

Sharma, Singh and Mukherjee (2011) analyzed road traffic accidents in Anand-Gujarat. It was a retrospective record based study and data was collected using questionnaire method (for collecting relevant information). A total of 423 RTA cases were studied from the case records of the medical records section of Shree Krishna Hospital, Pramukhswami Medical College during the period: 1st October 2007 to 31st March 2008.

All the road traffic accident cases coming in the particular specified time period were taken. The results revealed that out of total 423 RTA cases, 327 (77.3%) of the victims were males and the rest 96 (22.7%) were females. The highest number of victims 122 (28.8%) were from 21-30 years of age group. In males the maximum numbers of cases were seen in the age group 21-30 years (31.8%); whereas in case of females the highest numbers of cases were seen in the age group 31-40(21.9%). 55.79 % of the RTA victims were drivers and riders followed by the occupants and passengers (30.26%).

Atubi (2010) examined the variation patterns of road traffic accident in Lagos State. The study used mostly secondary data; accident records and vehicular situation were obtained from the Nigeria police force and Federal Road Safety Commission. The data were obtained for a period of thirty two (32) years from 1970-2001. The analysis of the number and type of vehicles involved in road traffic accidents revealed that private cars, buses and taxis were more prone to accidents in Lagos State. The 16 harmonics for the selected LGAs considered contribute above 90% of the total variance in the time series. This means that more than 90% of road traffic accident in Lagos State could be attributed to recklessness on the part of drivers, ignorance of high way codes, over speeding etc. Also, the dominant cycles of road traffic accidents observed in the study area have periodicities of 32.00 and 16.00 years with the most dominant being 32 years.

2.4.2 Road Traffic Accidents and Traffic Flow

A number of studies have been conducted to relate traffic flow with road crash propensity. Jean-Louis (2002) showed that damage-only and injury-involved incident rates are higher in light traffic than in heavy traffic conditions. The author also compared the incident rates on the basis of time of the day and found that these rates do not depend on day time or night-time traffic. Hasan *et al.* (2011) have found that road accident probability on the freeway depends significantly on the traffic flow. They developed a regression tree by using traffic flow and speed at accident location, nearest upstream and downstream and concluded that road accidents depend more on traffic parameters: traffic flow and vehicle speed rather than weather condition.

On the contrary, Lord *et al.* (2005) showed that the crash risk cannot be predicted perfectly only by traffic flow but adding traffic density so improves the prediction performance. Furthermore, they also described the comparative difference of crash density relationship between urban and rural freeways. For the same flow and density, it has been found that crash rates are much higher on urban freeways than the rural ones. Dickerson *et al.* (1998) revealed significant differences in accident - traffic flow relationship by road class and geography. Their outcomes are based on all types of accidents regardless of severity level. Accident probability also depends on type of vehicles (Ayati and Abbasi, 2011). Non-passenger car vehicles are found to cause more accidents on urban highways than other vehicle types. Interestingly, it was shown that heavy vehicles cause less accident than non-passenger cars including taxis and motorcycles.

2.4.3 Pattern of Road Traffic Accidents

The world road accident problem dates back to 1863 when Lenoir built the first car in Paris, France. But, it was not until after 1896 that the first motoring facility was experienced. Indeed the first recorded death due to mechanical vehicle in the United States of America was in 1899 (Haddon, 1968). Nigeria recorded her first traffic accident in Lagos in 1906 (Oluduro, 1999). For more than half a century thereafter, accident rates in the country remained low due largely to low vehicular population (Ogunsanya, 2004). But from the 1970s following remarkable improvements in the economic prosperity in the country arising from the oil boom, the magnitude of the accident problem increased.

Road traffic accidents occur worldwide but the incidence is more in developing countries. Annually, about 1.24 million people die each year as a result of road traffic crashes. Road traffic injuries are the leading cause of death among young people, aged 15–29 years. 91% of the world's fatalities on the roads occur in low-income and middle-income countries, even though these countries have approximately half of the world's vehicles. Half of those dying on the world’s roads are “vulnerable road users”: pedestrians, cyclists and motorcyclists. Without action, road traffic crashes are predicted to result in the deaths of around 1.9 million people annually by 2020. Only 28 countries, representing 416 million people (7% of the world’s population) have adequate laws that address all five risk factors: speed, drink-driving, helmets, seat-belts and child restraints (WHO Road traffic injuries; fact sheet N° 358, 2013).

Sadly, the character of Road Traffic Accidents in terms of frequency of occurrence and fatality rate has not changed over the years in Nigeria. Within the period, an annual average of 8,153 crashes was recorded with 5,084 annual deaths and an average fatality rate of 5 per 100,000 populations (FRSC, 2012). The highest number of 11,341 cases was recorded in 2008 as against the figure of 8,477 cases in the preceding year. Since 2008 however the trend has been a declining one. Perhaps one can safely conclude that this may be attributed to the activities of the Federal Road Safety Corps which assumed full road safety responsibilities in 2007. In terms of spatial spread, the FRSC has shown that about 50% of the total accidents and fatalities were recorded in most of the states that constitute the North Central and North-Western zones. They are therefore ranked respectively as the first and second high risk zones in the country in which Zaria, Kano and Sokoto are among the states in the North-West zone.

Olajuyigbe, Ogan, Adegboyega and Fabiyi (2014) carried out spatio-temporal analysis of Road Accidents in Abuja, Federal Capital Territory (FCT) Nigeria using Geographical Information System (GIS) techniques. They acquired their data from Federal Road Safety Corps (FRSC) and structured questionnaire. Also, topographical map, QuickBird imagery, accident records between 2009 and 2011 were also obtained. These data were integrated and analyzed using spatial analysis tools of AcrGIS 9.3. Overlay function and query operations were performed to determine the accident hotspots based on the frequency of road accidents and their spatio-temporal trend. The results of their study showed that Wuse maintained the highest accident black spots while Asokoro experienced the least accident. It was observed that accidents are caused by road, vehicle, driver and environmental factors.

Jibril and Wabundani (2014) analyzed the spread of RTA frequencies based on the period of occurrences. The classification was based on two distinctive seasons of wet and dry. Effects of religious festive seasons on road traffic accident occurrence were also considered. A record on Road Traffic Accidents (RTAs) frequency on the study route was analyzed under temporal variable of festivals and seasons against the total cases of accidents covered by the study. To estimate the effects of each of the temporal variables on accidents, one way analysis of variance ANOVA was used at 0.05 level of significance at 95% confident intervals. The result revealed amongst others that road traffic accident is high during wet season throughout the four years of study spanning 2007 to 2010.

2.4.4 Determination of Road Traffic Accident

Erdogan, Yilmaz, Baybura and Gullu (2008) studied accidents hot spots and detected safety deficient areas on the highways in the city of Afyon, Turkey. KDE and repeatability analysis were conducted to identify accident black spots. Result from both analyses, shows that black spots where mostly located at cross roads, access roads, junction points to the towns and villages. They also showed that accident density increase in summer and winter especially in December and August. Also weekends have higher frequencies of accidents. Moreover, they found that Heavy accidents mostly occurred in midnight.

Umar (2009 as cited in Jobin 2015) mapped Road Traffic Crashes (RTC) along Kano-Zaria Road using Remote Sensing and GIS. The top five black-spots in the study area were highlighted. The results of the study showed that over speeding was the factor most responsible for Road Traffic Crashes along the road with 37.5%. Also, Jibril and Wabundani (2014) examined the spatial distribution of RTA frequencies along Kaduna-Zaria Expressway. The study segmented into three namely; Kaduna-Katabu (km18.41), Katabu-Jaji (km17.02) and Jaji-Zaria (Km 38.51). Spatial data were generated from the field, satellite imagery and road accidents data from the Federal Road Safety Corps (FRSC) and Nigeria Police Force (NPF) along Kaduna–Zaria expressway of Kaduna State. The result partly revealed that Rigachuku, National Teachers Institute (NTI), Tollgate and Maraban Jos (Katabu) recorded high frequency of Road Traffic Accidents (RTA) along Kaduna-Katabu especially in 2009 and 2010.

Jobin (2015) applied Remote Sensing and Geographic Information Systems (GIS) to analyze road traffic accident hotspots along Zaria-Kaduna Expressway, Kaduna State, Nigeria. The accident data used for the study were obtained from Federal Road Safety Commission of Nigeria. Global Positioning System (GPS) was used to collect the coordinates of the accident locations. The accident data were evaluated in ArcGIS version 10.1 environment. Queries and Kernel Density Estimation (KDE) were used to determine the accident hotspots, Analytical Hierarchy Process (AHP) and Accident Point Weightage (APW) formula was used to the rank the accident hotspots. Image interpretation was also carried out to identify the characteristics of the road. The results of the study showed that over-speeding (27.7%), tyre burst (17.6%), loss of control (15.5%) and dangerous driving (13.6%) were the major causes of accidents along the route. The study also discovered that Jaji, Birnin Yero, Foundation and Konar Farakwai are the most dangerous locations along the study route. Finally, characteristics of the road such as Bridges (24.9%), built-up areas (24.9%) were the cause of accident while sharp bend (21.9%), U-turn/intersection (13.8%), stationary vehicles (6.2%), slope (4.2%), market (2.7%), potholes (1.4%) also contributes significantly to accidents along Zaria-Kaduna Expressway.

In summary, many literatures materials have discussed the road traffic accidents and its several causative factors although traditional methods often times are used in determining road traffic accidents patterns in space and time. However, the spatio-temporal GIS analysis has been proven to work well examining road traffic accidents pattern hence the need to apply Geographic Information System (GIS) in analyzing the spatio-temporal pattern of road traffic accidents along Kaduna-Abuja and Kaduna-Birin Gwari Expressway.

CHAPTER THREE

STUDY AREA AND METHODOLOGY

3.1 INTRODUCTION

This chapter discusses the study area in terms of the location, extent, relief, drainage, climate, soil, vegetation, population, people, economic activities and transportation. It also describes the data sources, method of data collection and the techniques used for data analysis.

3.2 THE STUDY AREA

3.2.1 Location and Size

Kaduna-Abuja road is located from Latitudes 9º 20' N - 10° 29' N and Longitudes 7° 14' E - 7° 25' E while Kaduna-Birnin Gwari road is located between Latitudes 10º 35' N – 10º 40' N and Longitudes 6º 17' E – 7º 26' E of the Greenwich meridian. Kaduna-Abuja road has a distance of about 139km from the overhead bridge at Abuja junction Kaduna to Tafa while Kaduna-Birnin Gwari road covers an appropriate distance of 121km from Mando Roundabout (Kaduna). Kaduna state is bounded in the north by Kano, Katsina, Zamfara States in the west by Niger State, to the east by Bauchi State and in the south by Nasarawa and Plateau State (OSGOF, 2011). The State occupies a land mass of about 48, 473.2km^2 (See Figure 3.1).

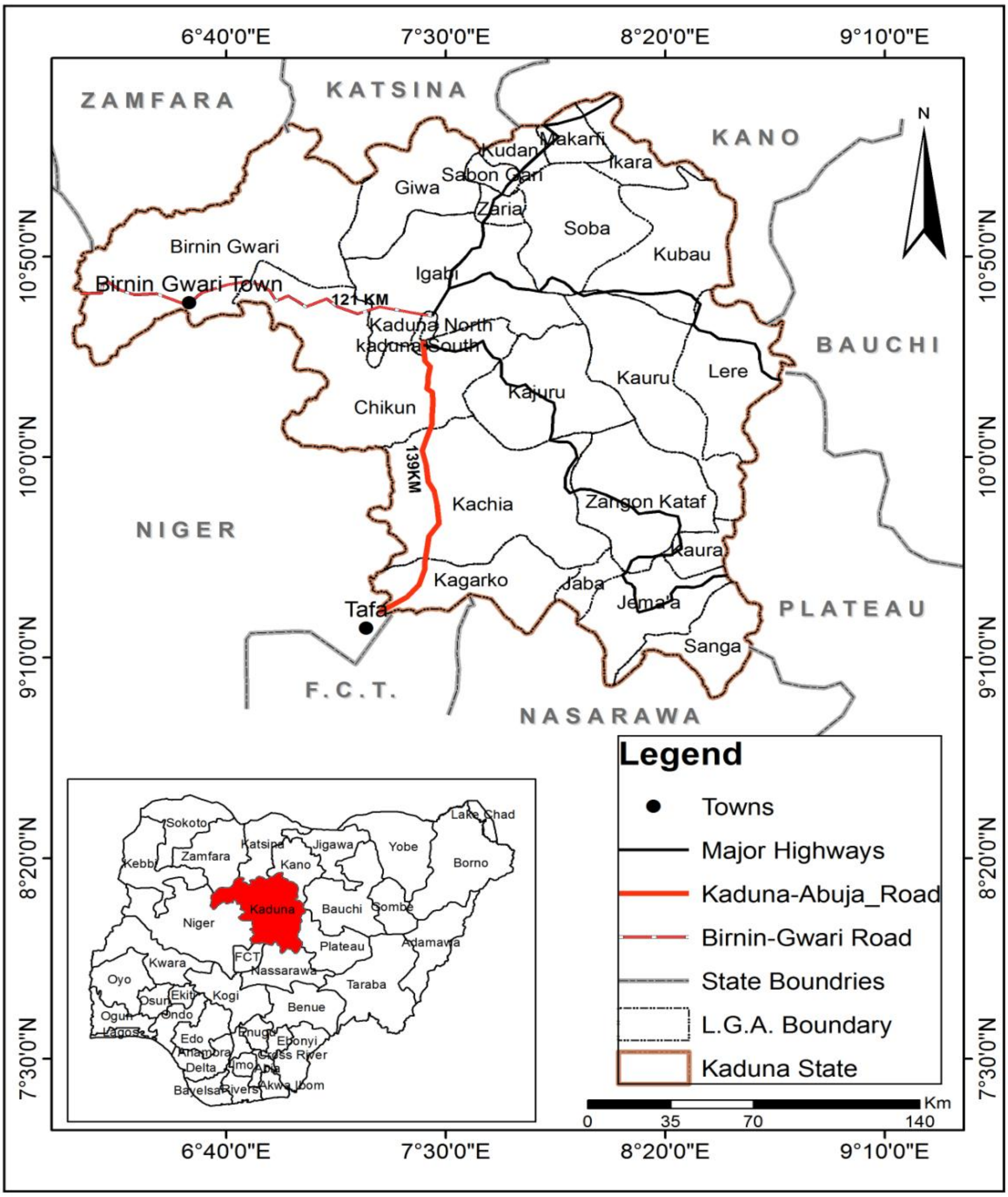

Figure 3.1: **Kaduna State Showing the Study Route**
Source: Adapted from the Administrative Map of Kaduna State

3.2.2 Relief and Drainage

The relief of the state consist mainly of the Precambrian rocks of the basement complex (Barbour, 1982) The topography constitutes a rolling low land plain generally below 610 meters above sea level. This comes about by the prolonged denudation of the basement complex rocks which underlie the area. The area consists of biotic gneisses and older granites. In the southern corner younger granites and batholiths are evident. The weathered profile is rich in red clay which are mined for construction purpose, while granite is commonly quarried (Thorp, 1971). Kaduna state is mainly drained by two rivers namely; River Kaduna and river Gurara, which is sourced at Kwal on the north central Jos plateau and is one of the largest tributaries of river Niger.

3.2.3 Climate and Weather

Kaduna state experiences a tropical continental climate with distinct seasonal variation (Adejuwon, 1998). The climate changes from cool to hot dry and humid to wet. These two seasons reflect the influence of tropical continental and maritime air masses, which blow over the entire country (Gbuyiro 1998 cited in Joseph, 2013). It is characterized by two distinct alternating wet and dry seasons. The rainy season usually begins from March/April and runs through September/October. The rainfall amounts falls between 1100-1300 mm. The rainfall type is convectional with a single regime of maximum peak usually occurs in August/September at a stretch (Parkman International Association, 1997).

3.2.4 Soil and Vegetation

The soil in most parts of Kaduna state fall under the ferruginous tropical soils. Most of the soils contain between 30-40 percent clay at a reasonable depth, because of intensive leaching. Experts have noted that the nutrients holding capacity of this soil is not known to support intensive agriculture for long periods without the application of fertilizers and or manure. Some areas have permanently waterlogged soils (Fadama). The plains in Kaduna State have undergone considerable changes over the years due to combined actions of both physical and chemical weathering (Laah, 2003).

The natural vegetation of the study area is that of the Northern Guinea Savannah with grass dominating and scattered trees hardly higher than 15ft with broad leaves.

Meanwhile, the seasonal character of rainfall in the study area has influenced the vegetation which turns evergreen during the wet season and pale brown in the dry season respectively. Thus, the dominant true species are *Isoberlina Doka*, *Dodoneaspp,* and grass communities consist of Hyperhenia and Andropgon species. In the city proper the vegetation is characterized by Silk cotton, Baobab and other protected trees. However, man have greatly affected the vegetation formation in the area, through his activities like; bush burning, cultivation of crops, grazing, lumbering, urbanization and industrial activities among others. The vegetation formation varies and associated with distinct ecological site with particular regard to the nature of the soil (Oguntoyinbo, 1983). The effect of the vegetation on the road cannot be over emphasized, as uninterrupted vegetation along the major road impaired a clear view from a distance by the road users (motorists) especially, on the bends.

3.2.5 Population and People

Kaduna state is one of the most densely populated states in Nigeria. This is as a result of the liberal nature of the state that it accommodates all kinds of people. In year 2006 according to National population census, Kaduna state has a population of 3,090,438 males and 3,023,065 females totaling 6,066,562 and is 3rd after Kano and Lagos state, translating to 4.333% of the total Nigerian population (National Population Commission, 2009). Some of the major ethnic groups in the state includes: Hausa, Fulani, Baju, Ham, Gbagyi, Koro Kaninko, Gure, Kurama, Atyap, Ikulu, Aegorok Adara, Atakad, Chawai, Kagoma, Kahugu Nimzo and Numana (Tourist Guide, 2009).

3.2.6 Economic Activities and Transportation

There are many economic activities going on in the state. Kaduna is the second largest commercial town after Kano in the north. There are economic activities going on in the state for example industrial, educational, hospitality. There are a lot of trading activities in Kaduna state. The present of various markets such as Abubakar Gumi, Central market, Kasuwa mata and general market Kafanchan all help in boasting the trading activities in the state. Transportation is especially not left behind in helping economics activities. A lot of Government and private transport companies are found in Kaduna state some of these transports goods and people within and outside the state. Road transport has been one of the most prominent transport systems in Kaduna state especially in recent times. It has served as a catalyst for economic development all over the state. The state has a network of local, state and federal roads.

3.3 METHODOLOGY

This section discussed the various methods employed in generating data for the study; it also explained the reconnaissance survey, types and sources of data, method of data collection, data processing and data analysis.

3.3.1 Reconnaissance Survey

A reconnaissance survey was carried out to get acquainted with the study area. During the survey, the road traffic accident report was got from Federal Road Safety Commission which assisted the researcher in identifying the various locations of accidents along the study routes.

3.3.2 Types of Data Used

In accordance with the stated objectives, the data types collected were specified in Table 3.1.

Table 3.1: Types and Sources of Data Required

S/No	Data Type	Source
1	Traffic count	Field Survey
2	Route network map	Google Earth Imagery 2014
3	Geographic coordinates of all the different road traffic accident locations.	Field survey (Using GPS receiver)
4	Date of the accident, Number of accident, Nature of the accident (fatal, severe or minor), and Persons involved in the accident.	FRSC Road Accidents Records
5	Condition of the road at accident point, human activities, and road width	Non-participatory, observation and measurement

3.3.3 Sources of Data

Sources of data for this study included both primary and secondary sources.

3.3.3.1 Primary sources of data

Traffic count was conducted for three days along the two study routes. Absolute location of road traffic accident along the study area was acquired using handheld GPS. The geographic coordinates was used to create map showing accident locations. Non-participatory observation was also used to identify the road conditions at various accident locations.

3.3.3.2 Secondary sources of data

Secondary source of data was acquired from road traffic accident record of Federal Road Safety Commission. Literature materials were obtained from textbooks, journal, both published and unpublished projects and FRSC bulletin, some of which was used for literature review.

3.3.4 Data Processing

The Google Earth interface covering the study area was imported in the ArcGIS 10.1 environment using the Arc2Earth extension tool. The Google Earth imagery was geo-referenced, digitized and integrated with the road traffic accident records in the ArcGIS 10.1 environment for analysis and querying.

All vector data (i.e. line and point features) was arranged in separate attribute tables where the roads were labeled with their names. The coordinates and their attributes were entered in Microsoft excel and then saved as Comma Separated Values CSV (comma delimited) format and imported into the ArcGIS 10.1 environment. The x and y coordinates define the position of an accident location on the map as a point feature with each point having its own attributes.

3.3.5 Data Analysis

Objective i: Characterization of vehicular traffic volume in the study routes

This was achieved through the use of descriptive statistic in the form of frequency tables to summarize the characteristics of road traffic volume in the study routes according to the data collected during the traffic volume count survey. After the hourly traffic volume count for the three days, its daily average was calculated for the different vehicular types across the two study routes.

Objective ii: Locate and map road traffic accidents

This was achieved through importing the geographic coordinates of road traffic accidents locations from the excel file into ArcGIS 10.1 environment, which was overlaid on the geo-referenced and digitized Google Earth imagery of the study routes. Road traffic accident map was therefore created.

Objective iii: Characterization of road traffic accidents

This was achieved through the use of descriptive statistics in the form of frequency tables and charts where necessary to summarize the nature (type of accidents, persons involved and severity) of road traffic accidents obained from the road traffic accidents record.

Objective iv: Temporal variation of road traffic accidents

Simple descriptive statistics using tables mean, and standard deviation was employed to examine the time/periods of road traffic accidents as extracted from the FRSC road traffic accidents record.

Objective v: Determine the spatial pattern of road traffic accidents

The pattern of distribution of road traffic accidents locations was determined using Average Nearest Neighbor statistical tool in ArcGIS 10.1. The tool measures the distance between each feature and its nearest neighbor's location. It then averages all these nearest neighbor distances. The Average Nearest Neighbor Ratio is given by Clark and Evans (1954);

$$\frac{\text{Observed Mean Distance}}{\text{Expected Mean Distance}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(i)}$$

Objective v: Determination of road traffic accidents black spots

This was achieved through the use of Kernel Density Estimation in ArcGIS 10.1 which was utilized in mapping the accident black spots along the route. It works by first overlaying an area of interest with a fine rectangular grid. It then calculates an estimate of the density of accidents in each grid cell, which is based on a weight function-the kernel. The kernel is a function of specified shape and bandwidth (or search radius). The Kernel Density Estimation is given by Deepthi and Ganeshkumar (2010):

$$f(x,y) = \frac{1}{nh^2}\sum_{i=1} K\left(\frac{d_i}{h}\right) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(ii)}$$

Where $f(x,y)$ is the density estimate at location *(x,y)*, h is the search radius (bandwidth or kernel size), n is numbers of observations (total number of accidents), K is the kernel function and di, is the distance between the location (event point) *(x,y)* and location of the ith observation. The mean and standard deviation of the Kernel Density Estimation was used to determine the pattern and also a raster map generated, where the intensity of traffic accidents is represented by continuous surfaces. Lighter shades were used to represent locations with a lower traffic accident density, while darker shades represented locations characterized by the highest traffic accident density.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 INTRODUCTION

This chapter presents the results and discussion of data collected on spatio-temporal pattern of road traffic accidents along Kaduna-Abuja and Kaduna-Birnin Gwari roads. This was done in subsections, with a view to achieving the aim and objectives of the research.

4.2 VEHICULAR TRAFFIC CHARACTERISTICS IN THE STUDY ROUTES

Tables 4.1 and 4.2, show the hourly traffic pattern of the two study roads in the study area. Kaduna-Abuja road had more vehicular traffic than Kaduna-Birnin Gwari road. This could be attributed to the fact that Abuja being the Federal Capital Territory and people from different parts of the country tend to travel to the city for job opportunities and businesses. The results reveal a similar gradual increase of traffic volume between 7am-8am for Kaduna-Abuja (8.4%) and Kaduna-Birnin Gwari (7.8%) roads respectively till they hit their various morning peaks. Kaduna-Abuja road recorded its highest morning peak between 10am and 11am (10.8%) whereas along Kaduna-Birnin Gwari it was between 9am-10am (11.0%) while 3pm-4pm and 5pm-6pm represents the evening peaks for the two roads respectively. The result shows that the composition of the vehicular traffic flow is dominated by private car which makes up 29.2% and 22.6% along Kaduna-Abuja and Kaduna-Birnin Gwari roads respectively. This shows high rate in private vehicle ownership in the study area as a result increased tendency of road traffic accidents occurrence is expected given much number of vehicles on the road.

Table 4.1: Average Daily Traffic Volume along Kaduna-Birnin Gwari Route

Time class	Motorcycle		Tricycle		Private car		Pickup		Minibus		Luxbus		Lorry/Truck		Tanker		Trailer		Total	
	No.	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**
7-8am	25	5.1	22	6.6	82	7.2	99	9.5	51	7.1	5	16.7	45	8.7	29	8.0	37	9.3	395	7.8
8-9am	48	9.7	34	10.2	112	9.8	107	10.2	80	11.1	5	16.7	59	11.5	37	10.2	43	10.8	525	10.4
9-10am	55	11.1	40	12.0	120	10.5	111	10.6	80	11.1	3	10.0	57	11.1	39	10.7	49	12.3	554	11.0
10-11am	61	12.3	37	11.1	126	11.0	103	9.9	75	10.4	2	6.7	49	9.5	42	11.5	35	8.8	530	10.5
11-12noon	54	10.9	36	10.8	126	11.0	108	10.3	74	10.2	2	6.7	49	9.5	34	9.3	36	9.0	519	10.3
1-2pm	39	7.9	28	8.4	72	6.3	77	7.3	67	9.3	1	3.3	54	10.5	32	8.8	39	9.8	409	8.0
2-3pm	49	9.9	31	9.3	128	11.2	96	9.1	67	9.3	2	6.7	50	9.7	40	11.0	36	9.0	499	9.9
3-4pm	61	12.3	36	10.8	120	10.5	124	11.8	70	9.7	2	6.7	50	9.7	34	9.3	41	10.3	538	10.7
4-5pm	51	10.3	34	10.2	127	11.1	109	10.4	79	10.9	4	13.3	48	9.3	35	9.6	37	9.3	524	10.4
5-6pm	52	10.5	35	10.5	129	11.3	116	11.0	79	10.9	4	13.3	54	10.5	42	11.5	47	11.8	558	11.0
Total	**495**	**100**	**333**	**100**	**1142**	**100**	**1050**	**100**	**722**	**100**	**30**	**100**	**515**	**100**	**364**	**100**	**400**	**100**	**5051**	**100**
% Total	**9.8**		**6.6**		**22.6**		**20.8**		**14.3**		**0.6**		**10.2**		**7.2**		**7.9**		**100**	

Source: Field Survey, 2016

Table 4.2: Average Daily Traffic Volume along Kaduna-Abuja Route

Time class	Motorcycle		Tricycle		Private car		Pickup		Minibus		Lux-bus		Lorry/Truck		Tanker		Trailer		Total	
	No.	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**
7-8am	45	7.7	32	9.6	130	7.9	81	7.7	64	8.7	3	12.5	47	10.5	38	9.3	33	8.2	473	8.4
8-9am	57	9.8	33	9.9	141	8.6	88	8.4	72	9.8	4	16.7	49	11.0	46	11.3	38	9.5	528	9.4
9-10am	64	11.0	33	9.9	156	9.5	103	9.8	71	9.6	3	12.5	48	10.7	42	10.3	45	11.2	565	10.0
10-11am	66	11.3	36	10.7	173	10.5	125	11.9	80	10.8	2	8.3	44	9.8	36	8.8	47	11.7	609	10.8
11-12noon	66	11.3	32	9.6	165	10.0	134	12.8	72	9.8	2	8.3	44	9.8	37	9.1	41	10.2	593	10.5
1-2pm	51	8.7	30	9.0	141	8.6	102	9.7	70	9.5	1	4.2	45	10.1	34	8.3	36	9.0	510	9.2
2-3pm	64	11.0	32	9.6	182	11.1	108	10.3	73	9.9	2	8.3	39	8.7	44	10.8	40	10.0	584	10.4
3-4pm	62	10.6	36	10.7	206	12.5	119	11.3	80	10.8	3	12.5	43	9.6	49	12.0	40	10.0	638	11.3
4-5pm	56	9.6	36	10.7	180	11.0	105	10.0	85	11.5	2	8.3	42	9.4	39	9.6	42	10.5	587	10.4
5-6pm	52	8.9	35	10.4	169	10.3	84	8.0	71	9.6	2	8.3	46	10.3	43	10.5	39	9.7	541	9.6
Total	**583**	**100**	**335**	**100**	**1643**	**100**	**1049**	**100**	**738**	**100**	**24**	**100**	**447**	**100**	**408**	**100**	**401**	**100**	**5628**	**100**
% Total	**10.4**		**6.0**		**29.2**		**18.6**		**13.1**		**0.4**		**7.9**		**7.2**		**7.1**		**100**	

Source: Field Survey, 2016

It further shows that vans(pickups) accounts for about 18.6% of the traffic composition along Kaduna-Abuja as against 20.8% along Kaduna-Birnin Gwari (Table 4.1 and 4.2). This is often used in the movement of goods. The least vehicle constituting traffic in the study area is luxurious-bus with 0.4% and 0.6% of the total traffic composition along Kaduna-Abuja and Kaduna-Birnin Gwari roads respectively. This might be due to the practice that most luxurious-buses travel at night which was not captured during the traffic count survey.

4.3 ROAD TRAFFIC ACCIDENTS MAPPING ALONG THE STUDY ROUTES

The total number of road traffic accidents recorded along the study routes was used to map the distribution of accidents in the study area.

4.3.1 Distribution of Accidents along Kaduna-Abuja and Kaduna Birnin Gwari Road

Information on the spatial distribution of road traffic accidents along the study routes was obtained from the Federal Road Safety Commission (FRSC) record, while the geographic coordinates of the accident locations were obtained from field survey, with the aid of Global Positioning System (GPS) receiver. The coordinates of the accident scenes was overlaid on the road map of the study routes in ArcGIS environment to produce the road traffic accident map of the area. Table 4.3 shows the frequency of accidents on Kaduna-Abuja Road and Kaduna-Birnin Gwari road for the year 2010 to 2014.

Table 4.3: Frequency of Accidents on Kaduna-Abuja and Kaduna-Birnin Gwari Road for the Year 2010 to 2014

Route	Frequency	%
Kaduna-Abuja Road	222	66
Kaduna-Birnin Gwari Road	114	34
Total	336	100

Source: Field Survey, 2016

The table shows that a total of 336 accidents were recorded on both routes with the majority (66%) recorded along Kaduna-Abuja road, while 34% occurred on Kaduna-Birnin Gwari Road. Figure 4.1 and 4.2 further shows the distribution of road traffic accidents along the routes.

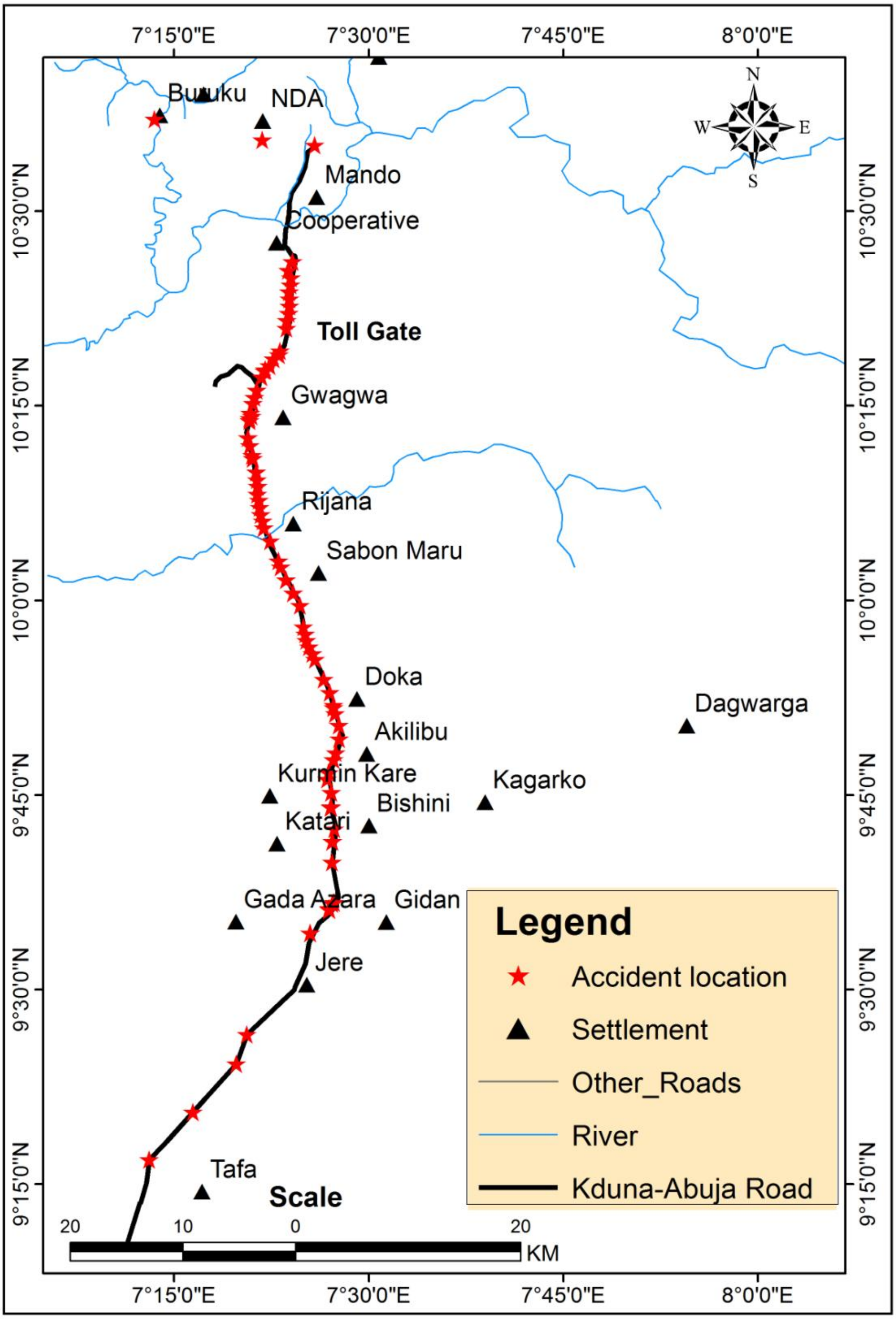

Figure 4.1: **Distribution of Road Traffic Accidents along Kaduna-Abuja Road for the Year 2010 to 2014**

Source: Field Survey, 2016

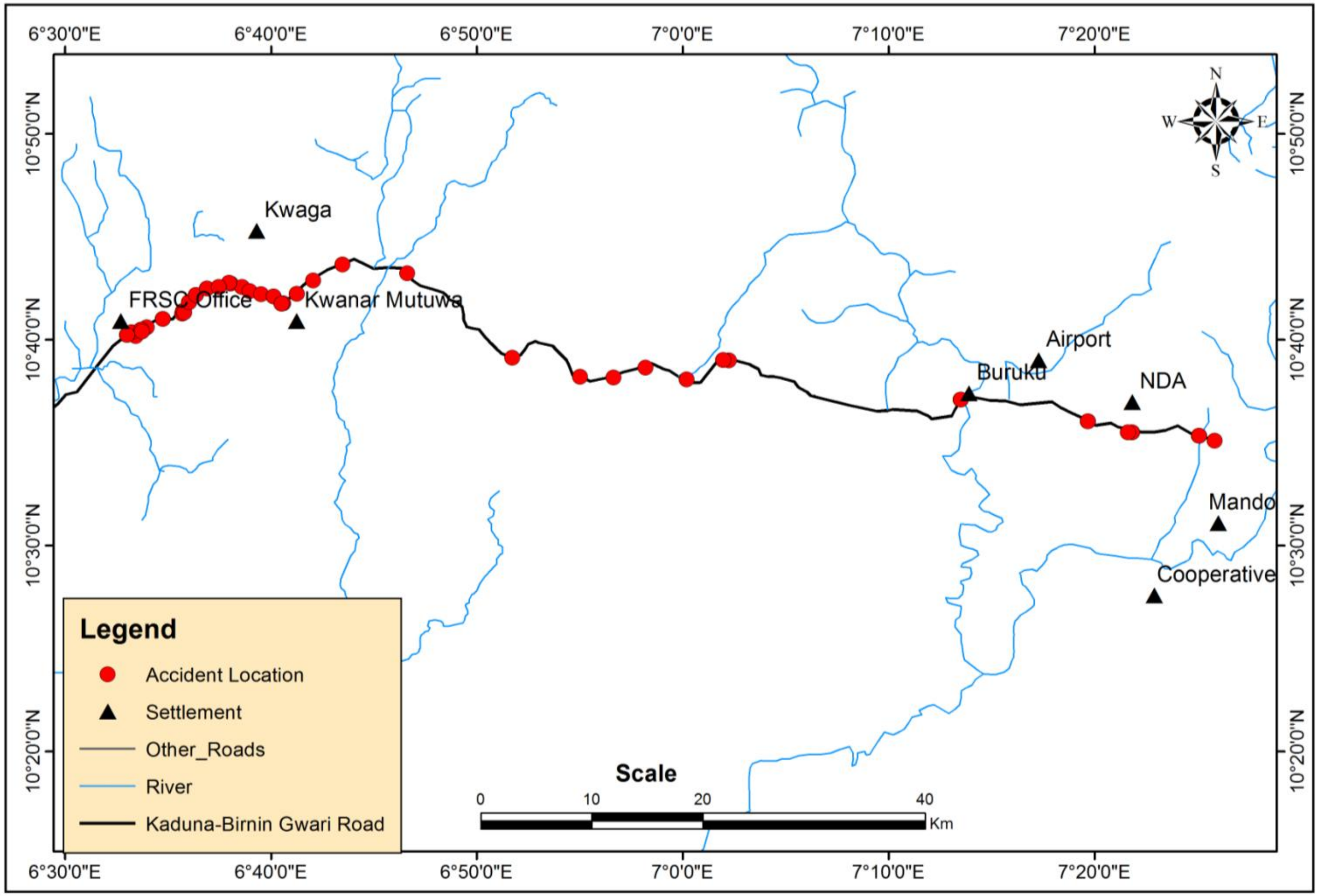

Figure 4.2: **Distribution of Road Traffic Accidents along Kaduna-Birnin Gwari Road for the Year 2010 to 2014**
Source: Field Survey, 2016

This finding is similar to that of Rukewe, Taiwo, Fatiregun, Afuwape and Alonge (2014) found that road crashes significantly differed between dual and non-dual carriage roads within Ibadan metropolis. This result implies that there was more occurrence of road traffic accident on the dual carriage way (Kaduna-Abuja) than on the single lane road (Kaduna-Birnin Gwari). Higher frequency of vehicular movement along Kaduna-Abuja road as established in Table 4.2 could be the possible explanation for difference in road traffic accidents occurrence in the study area.

4.3.2 Spatial Variation of Road Traffic Accidents

Tables 4.4 and 4.5 show the number of road traffic accidents recorded at the various spots along the routes.

Table 4.4: Spatial Variation of Road Traffic Accidents along Kaduna-Birnin Gwari Road for the Year 2010 to 2014

Location	No. of Accidents	Percentage (%)
Mando	25	21.9
NDA	12	10.5
Airport Junction	12	10.5
Buruku	8	7.0
Kwanar Mutuwa	8	7.0
Kwaga	15	13.2
FRSC Office (Birnin Gwari)	8	7.0
Kuriga	12	10.5
Birini Gwari (Girls Sec. Sch.)	14	12.4
Total	**114**	**100**

Source: Field Survey, 2016

Table 4.4 shows that of the nine (9) different road traffic accident locations along Kaduna-Birnin Gwari road, Mando (21.9%) recorded the highest number of accident, followed by Kwaga (13.2%) and Birini Gwari (12.4%).

Plate 4.1: Road Traffic Accident Location at Birnin Gwari (opposite Girls Sec. Sch.)
Source: Field Survey, 2016

The result also reveal that Buruku, Kwanar Mutuwa and FRSC Office accounts for the locations with the least frequency of road traffic accidents along Kaduna-Birnin Gwari road, having 7.0% each. Plate 4.1 shows one of the accidents locations.

Table 4.5: Spatial Variation of Road Traffic Accidents on Kaduna-Abuja Road for the Year 2010-2014

Location	No. of Accidents	Percentage (%)
Goingora	15	6.7
Toll Gate (Near Sabon Gayan)	46	20.7
Sabon Gayan	23	10.4
NYSC	13	5.9
Dutse Village	8	3.6
Zhipe Village	11	5.0
Konar Bature	15	6.7
Audu Jogon	8	3.6
Rijana	8	3.6
Sabon Maro	8	3.6
Akilibu	15	6.7
Gidan Busa	23	10.4
Katari	18	8.1
Total	**222**	**100**

Source: Field Survey, 2016

Table 4.5 shows that the highest frequency was recorded at Toll gate (20.7%) followed by Sabon Gayan (10.4%) and Gidan Busa (10.4%) along Kaduna-Abuja road, while the least were at Dutse village, Audu Jogon, Rijana and Sabon Maro, with 3.6% each. Plate 4.2 shows one of the locations of road traffic accidents along Kaduna-Abuja road.

Plate 4.2: Road Traffic Accident Location at Sabon Gayan (Kaduna-Abuja Road)
Source: Field Survey, 2016

4.3.3 Causes of Road Traffic Accidents

Tables 4.6 and 4.7 show the various causes of road traffic accidents in the study area as extracted from FRSC road traffic accident record.

Table 4.6: Causes of Road Traffic along Kaduna-Abuja Road

S/No	Cause	No. of Accidents	Percentage (%)
1	Dangerous Driving	22	9.9
2	Dangerous Overtaking	16	7.2
3	Loss of Control	24	10.8
4	Mechanically Deficient Vehicle	13	5.9
5	Road Obstruction Violation/Stationary Vehicle	15	6.8
6	Overloading	6	2.7
7	Route Violation	7	3.2
8	Traffic Light Violation	2	0.9
9	Sleeping on Steering	7	3.2
10	Over Speeding	58	26.1
11	Tyre Burst	33	14.7
12	Others	12	5.4
13	Nil	7	3.2
	Total	**222**	**100.0**

Source: Field Survey, 2016

Table 4.6 reveals that out of the total number of accidents that occurred along Kaduna-Abuja road, over-speeding was the major cause, constituting 26.1%, followed by tyre burst (14.7%) and loss of control (10.8%). This result indicates that drivers and vehicular factors were the major causes of road traffic accidents along the route. Other causes of road traffic accidents include dangerous driving, dangerous overtaking, road obstruction, traffic light violation and others (rainfall and presence of potholes) of which the least was sign light violation. The insignificance of sign light violation as a cause of road traffic accidents could be attributed to absence of traffic light along the route.

Table 4.7: Causes of Road Traffic along Kaduna-Birnin Gwari Road

S/No	Cause	No. of Accidents	Percentage (%)
1	Bad Road	4	3.5
2	Dangerous Driving	13	11.4
3	Dangerous Overtaking	5	4.4
4	Loss of Control	16	14.1
5	Mechanically Deficient Vehicle	2	1.8
6	Route Violation	2	1.8
7	Traffic Light Violation	14	12.3
8	Sleeping on Steering	4	3.5
9	Over Speeding	27	23.6
10	Tyre Burst	25	21.8
11	Wrongful Overtaking	2	1.8
	Total	114	100.0

Source: Field Survey, 2016

Table 4.7 reveals that over speeding (23.6%) was the highest cause of road traffic along Kaduna Birnin Gwari road, followed closely by tyre burst (21.8%) while loss of control, sign light violation and dangerous driving accounted for 14.1%, 12.3% and 11.45 respectively. This result agrees with the view of Atubi (2010) that more than 90% of road traffic accidents in Lagos State could be attributed to recklessness on the part of drivers, ignorance of high way codes and over speeding. Mechanically deficient vehicles, route violation and wrongful overtaking are the least causes of road traffic accidents represented with 1.8% each. Wrongful overtaking and route violation as the least causes of road traffic accidents might be attributed to single carriage width of the road which drivers often tend to be more careful while driving especially when overtaking than in a dual carriage width road minimizing the frequency of accident occurrence.

4.4 CHARACTERIZATION OF ROAD TRAFFIC ACCIDENTS

The characteristics of road traffic accidents such as reported number of accident victims, number of persons injured, lives lost to accidents and severity as extracted from FRSC accident record in the area were discussed.

4.4.1 Reported Victims of Road Traffic Accidents

Table 4.8 indicates the sex variation in the number of persons involved in road traffic accidents in the study area.

Table 4.8: Distribution of Number of Persons Involved in Road Traffic Accidents

Sex	**Kaduna-Abuja**		**Kaduna-Birnin Gwari**		**Total**	
	Frequency	%	Frequency	%	Frequency	%
Male	1458	79.4	653	80.2	2111	79.6
Female	379	20.6	161	19.8	540	20.4
Total	**1837**	**100.0**	**814**	**100.0**	**2651**	**100.0**

Source: Field Survey, 2016

Table 4.8 reveals that of the 2,651 persons involved in road traffic accidents along the study routes, males were the most involved, as they accounted for 79.6% while 20.4% were females. This corroborates the finding of Sharma, Singh and Mukherjee (2011) that 77.3% of the victims of road traffic accidents were males and the rest (22.7%) were females. It was observed that males involvement in road traffic accidents was more along Kaduna-Birnin Gwari road (80.2%) as against 79.4% along Kaduna-Abuja road.This might be due to Kaduna-Birnin Gwari road linking rural areas where male passengers travel more than the female.

4.4.2 Injury Due to Road Traffic Accidents

Table 4.9 shows the number of persons injured in road traffic accidents according to their sex in the study area.

Table 4.9: Number of Person Injured in Road Traffic Accidents

Sex	Kaduna-Abuja		Kaduna-Birnin Gwari		Total	
	Frequency	%	Frequency	%	Frequency	%
Male	795	81.1	362	93.5	1157	84.6
Female	185	18.9	25	6.5	210	15.4
Total	**980**	**100.0**	**387**	**100.0**	**1367**	**100.0**

Source: Field Survey, 2016

Table 4.9 reveals that of 1,367 persons injured as a result of road accidents along the study routes, mostly were males (84.6%) with only 15.4% representing the females. The injuring of males was more along Kaduna-Birnin Gwari road (93.5%) than Kaduna-Abuja road (81.1%) whereas regarding the females, the reverse was the case as 18.9% and 6.5% accounts for Kaduna-Abuja and Kaduna-Birnin Gwari roads respectively.

4.4.3 Life Lost in Road Traffic Accidents

Table 4.10 indicates the sex variation in the number lives lost in road traffic accidents in the study area.

Table 4.10: Number of Lives Lost in Road Traffic Accidents

Sex	Kaduna-Abuja		Kaduna-Birini Gwari		Total	
	Frequency	%	Frequency	%	Frequency	%
Male	182	82.7	118	81.4	300	82.2
Female	38	17.3	27	18.6	65	17.8
Total	**220**	**100.0**	**145**	**100.0**	**365**	**100.0**

Source: Field Survey, 2016

The result as shown in Table 4.10 reveals that out of 365 lives lost along the two routes, Kaduna-Abuja road recorded the highest number of lives lost. It was observed that along Kaduna-Abuja 82.7% of the males lost their lives due to road traffic accident as against 81.4% along Kaduna-Birnin Gwari road while the reverse was the case regarding the females who lost their lives along the routes.

4.4.4 Road Traffic Accident Severity Index

The accident severity index (ASI) measures the seriousness of an accident. It is defined as the number of person death per 100 accidents. Table 4.11 presents accident severity index for the study routes during the period under study.

Table 4.11: Road Traffic Accident Severity Index along the Routes

Route	Number of Death	Number of Accidents	Accident Severity Index (%)
Kaduna-Abuja	220	222	99.1
Kaduna-Birini Gwari	145	114	127.2
Total	365	336	108.6

Source: Field Survey, 2016

Table 4.11 reveals that although Kaduna-Abuja recorded the highest number of road traffic accidents, Kaduna-Birini Gwari (127.2) have the highest road traffic accident severity index in the study area. The possible explanation of this could be the poor condition of Kaduna-Birini Gwari road. This result is an indication of high road traffic accident fatality rate in single carriage way than in a dual carriage way.

4.5 TEMPORAL VARIATION OF ROAD TRAFFIC ACCIDENTS

The occurrence of road traffic accidents has been found to vary over time and space, as a result the yearly and monthly variation of road traffic accidents in the study area.

4.5.1 Yearly Variation in Road Traffic Accidents

Road traffic accidents are believed to occur at different times/period even in same location. Table 4.12 shows the number of road traffic accidents recorded across the years along the routes.

Table 4.12: Road Traffic Accident Yearly Variation along the Routes

Route	Year	No of Accidents	Percent (%)
Kaduna-Abuja	2010	24	10.8
	2011	84	37.8
	2012	57	25.7
	2014	57	25.7
	Total	222	100.0
Kaduna- Birnin Gwari	2010	18	15.8
	2011	54	47.4
	2012	27	23.7
	2014	15	13.1
	Total	114	100.0

Source: Field Survey, 2016

Table 4.12 reveals that the highest road traffic accidents cases was recorded in the year 2011, which accounted for 37.8% and 47.4% in Kaduna-Abuja road and Kaduna-Birnin Gwari road respectively. This indicates high occurrence of road traffic accidents in year 2011 across the two study roads. The possible explanation to this could be the fact that it was an election year which several journeys were made on the roads which might have increased the number of road traffic accidents. Also the year 2010 in Kaduna-Abuja road (10.8%) and year 2014 for Kaduna-Birnin Gwari road (13.1%) accounted for the least.

4.5.2 Monthly Variation in Road Traffic Accidents

Figure 4.3 and 4.4 indicates the monthly/seasonal variation in the number of road traffic accidents recorded across the years along the routes.

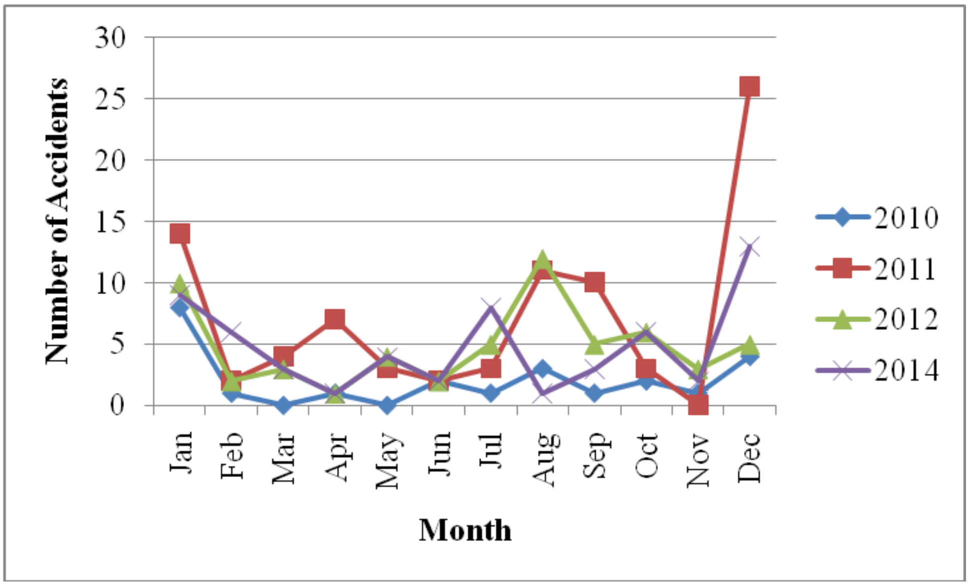

Figure 4.3: Monthly Variation in Road Traffic Accident along Kaduna-Abuja Road
Source: Field Survey, 2016

Figure 4.3 reveals that the highest number of accidents for the year 2010 along Kaduna-Abuja road was recorded in the month of January and followed by December, while the least was recorded in March and May. In 2011, the month of December, January and August had the highest. This is similar to year 2014, where the months of December and January had the highest number of cases of road traffic accidents, with November being the least. This no doubt suggests that January and December are very critical to road safety in the area, given the high frequency of road traffic accidents. This partly agrees with the findings of Erdogan, Yilmaz, Baybura and Gullu (2008) which showed that accidents' density increase in summer and winter, especially in December and August on the highways in the city of Afyon, Turkey but contradicts Atubi's (2012) finding that the month of July recorded the highest number of accidents in Lagos State.

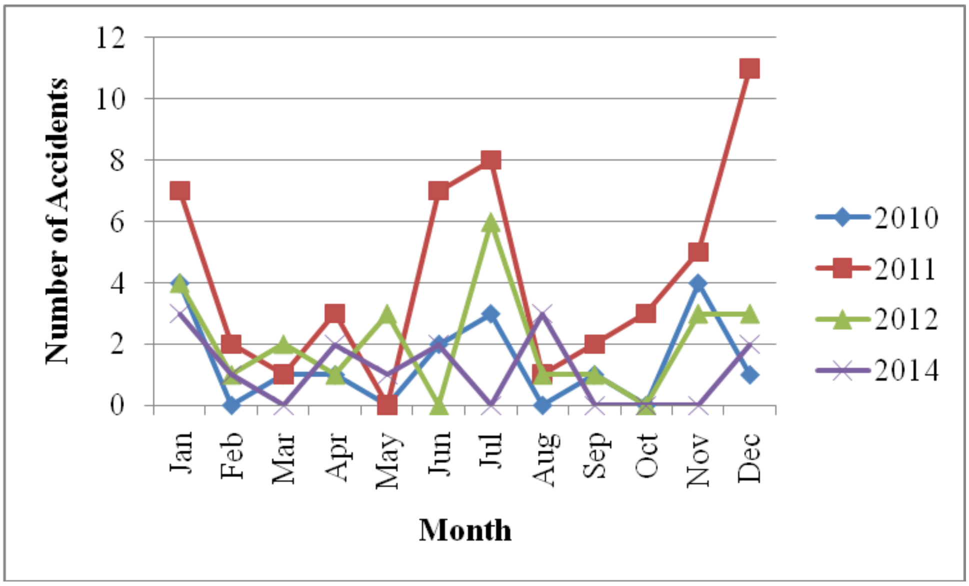

Figure 4.4: Monthly Variation in Road Traffic Accident along Kaduna-Birnin Gwari Road

Source: Field Survey, 2016

Figure 4.4 reveals that the highest number of acccidents cases were recorded in the months of January and November for the year 2010 along Kaduna-Birnin Gwari and followed by July, while the least were recorded in the months of February and August as against December, July and January respectively for the year 2011. It was revealed that in the year 2012, the months of July and January recorded the highest number of accidents, with the least recoded in June and October respectively; whereas the months of January and August recorded the highest in the year 2014 with months of March, July, September, October and November having the least respectively. Consequently, the months of January, July, August, November and December recorded relatively high number of road traffic accidents and thus rate among the most unsafe months. The reason for these months being unsafe could be that they represent the festive periods when most people travel and as a result increased tendency of road traffic accident occurrence.

4.6 SPATIAL PATTERN OF ROAD TRAFFIC ACCIDENTS

The distribution pattern of road traffic accidents was determined using the average nearest neighbour in spatial statistic toolbox of ArcGIS version 10.1 environment. The average nearest neighbour analyses calculates the nearest neighbour index (which is a measure of the distance between each accident centroid and its nearest neighbour's centroid location). It then averages all these nearest neighbour distances. These parameters were used as basis for determining whether the distribution is clustered, dispersed or random. Table 4.13 shows the Nearest Neighbor Ratio, z-score and p-value.

Table 4.13: Pattern of Road Traffic Accidents

	Kaduna-Abuja	**Kaduna-Birnin Gwari**
Observed Mean Distance	134.55 Meters	313.53 Meters
Expected Mean Distance	994.11 Meters	1364.51 Meters
Nearest Neighbor Ratio	0.135346	0.229775
z-score	-23.970816	-15.170547
p-value	0.0000000	0.0000000

Source: Field Survey, 2016

Table 4.13 shows that nearest neighbour index for Kaduna-Abuja is 0.135346 and for Kaduna-Birnin Gwari route is 0.229775 with z-score of -23.970816 and -15.170547 respectively.

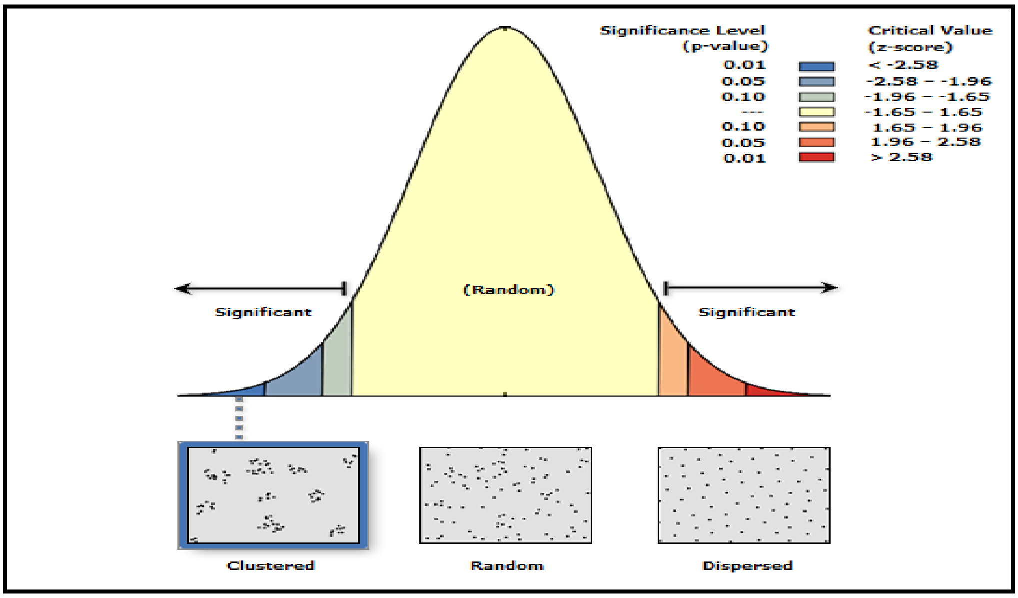

Figure 4.5: Pattern of Distribution of Accidents in the Study Areas
Source: Field Survey, 2016

According to Clark and Evans (1954), if the index (average nearest neighbor ratio) is less than 1, the pattern exhibits clustering. If the index is greater than 1, the pattern is toward dispersion. Based on this assertion, the result shows clustering in the pattern of distribution of accidents on both routes and this is further shown in Figure 4.5. This clustered pattern indicated that there were locations that recorded more road traffic accidents than others for the two different routes. This result agrees with the findings of Rukewe, Taiwo, Fatiregun, Afuwape and Alonge (2014) that the pattern of road traffic crashes in Ibadan Metropolis were generally clustered in space and localized in the metropolis.

4.7 ROAD TRAFFIC ACCIDENTS HOTSPOTS ON THE STUDY ROUTES

The Hot-spot analysis was carried out for the routes to show the sections of the road or locations where there is concentration of accidents. Kernel Density Estimation method in ArcGIS 10.1 environment was used to calculate the density of accidents and in accordance with Gregory and Jarret (1994), locations with 12 road traffic accidents and above was mapped as hotspots. A search radius of 500m was further used to calculate the density of accidents selected based on the hotspots identification criteria for highways given by Xie and Yan (2008).

4.7.1 Road Traffic Accident Hotspots along Kaduna-Birini Gwari Road

The result of the Kernel Density Estimation method for accident hotspots for Kaduna-Birnin Gwari road is presented in Figure 4.6.

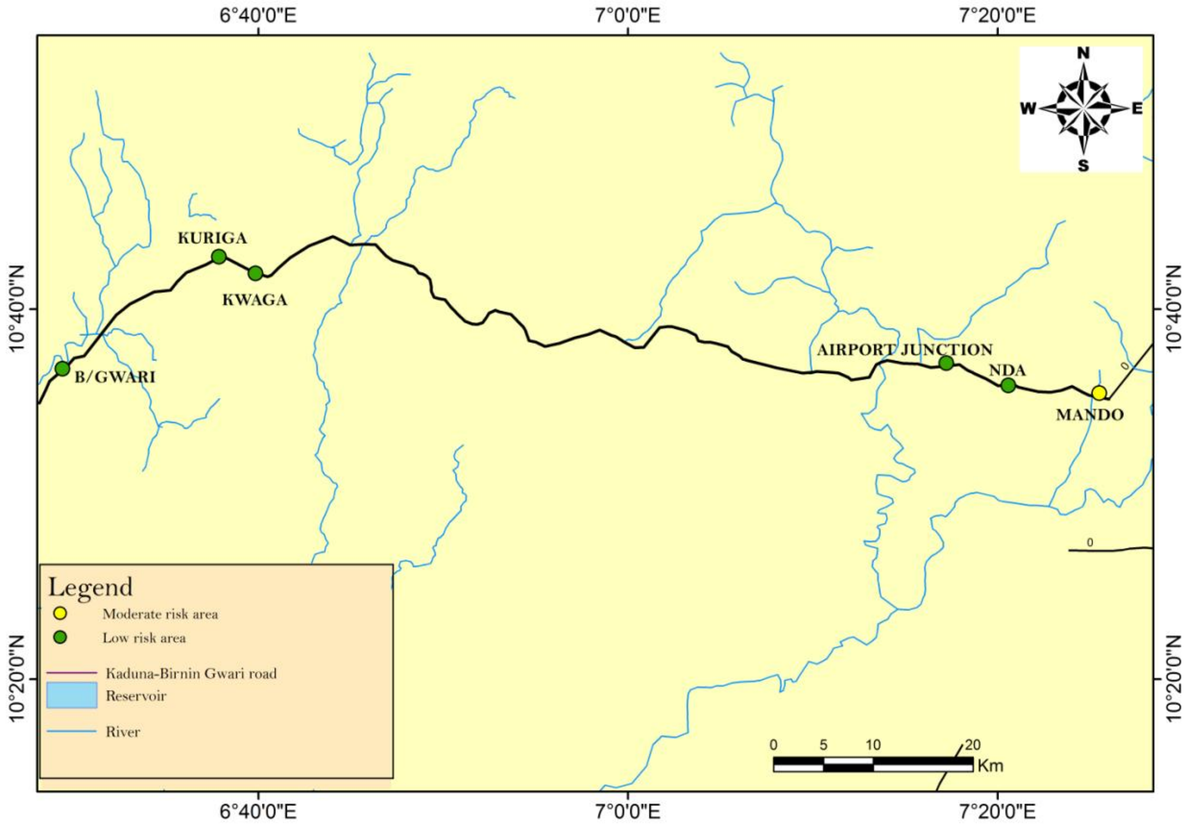

Figure 4.6: Road Traffic Accident Hotspot Locations along Kaduna-Birinin Gwari Road
Source: Field Survey, 2016

As shown in Figure 4.6, six (6) road traffic accident hotspot locations were identified along Kaduna-Birinin Gwari road. These locations include Mando, Nigerian Defense Academy (NDA) junction, Airport junction, Kwaga, Kuriga and Birnin-Gwari. Plate 4.3 shows a hotspot location at Birnin-Gwari.

Plate 4.3: Hotspot Location with Potholes/Eroded Shoulder along Birinin Gwari Road
Source: Field Survey, 2016

Ranking of the hotspot locations indicated that Mando was the only moderate hotspot risk location along the route. The development of hotspot along Birinin-Gwari road could be attributed to the presence of pot-holes and eroded road shoulders, which careless driving might cause road traffic accidents. More over the population density within the township viz a viz pedestrians either doing petty businesses by the road or crossing might be a contributing factor to high road traffic accident occurrence in this location. This result is in line with the findings of Jobin (2015) that bridges, built-up areas, sharp bend and potholes were the characteristics of the road at Jaji, Birnin Yero, Foundation and Konar Farakwai found to be hotspots along Zaria-Kaduna Expressway.

4.7.2 Road Traffic Accident Hotspots along Kaduna-Abuja Road

Figure 4.7 shows the result of Kernel Density Estimation method of ArcGIS 10.1 for determining accident hotspots location for Kaduna-Abuja road.

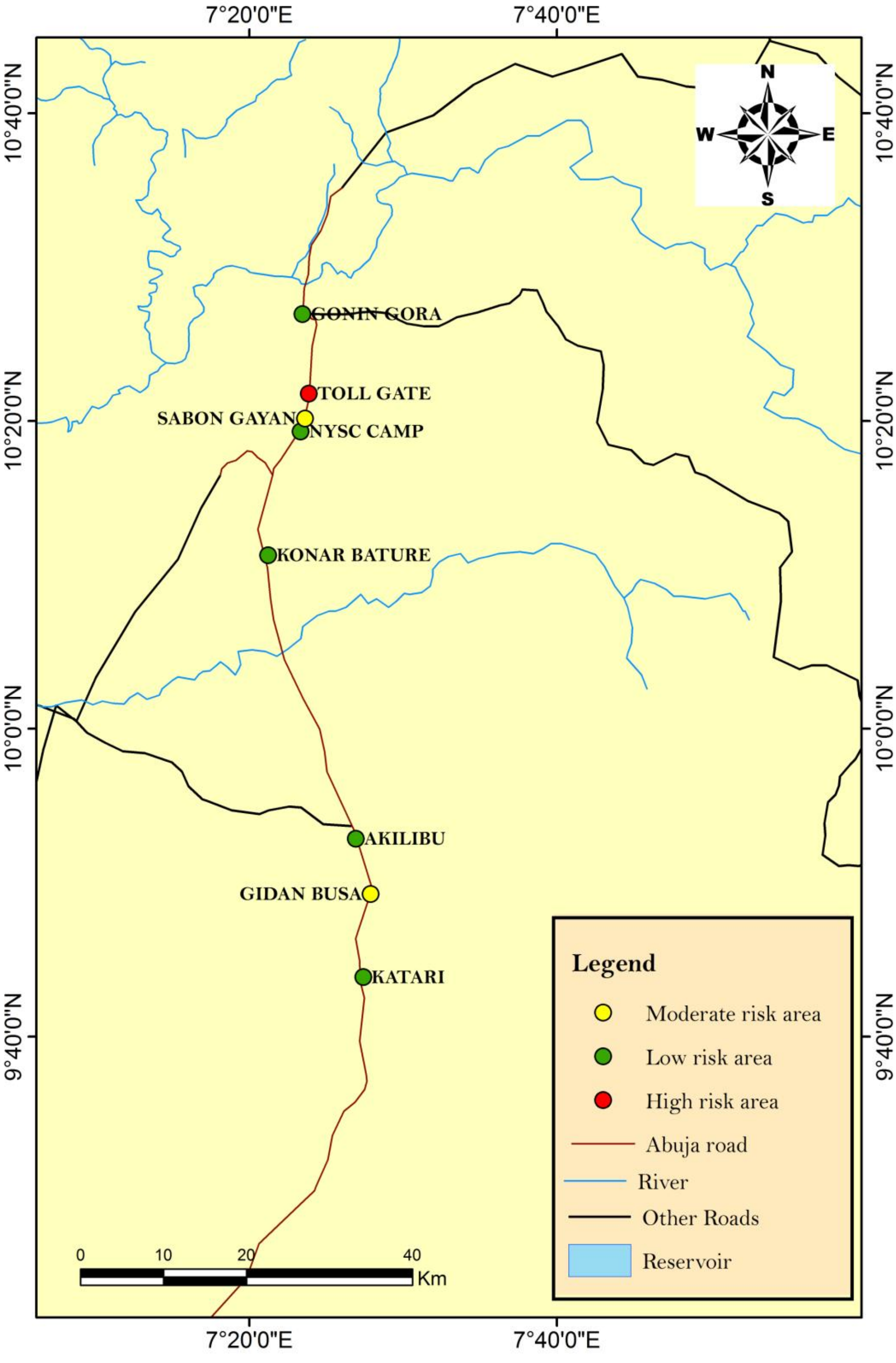

Figure 4.7: Road Traffic Accident Hotspot Locations along Kaduna-Abuja Road
Source: Field Survey, 2016

The distribution of the accident hotspots as shown in Figure 4.7 revealed that there were eight (8) hotspots along Kaduna-Abuja road among which were Goningora, Toll Gate, Sabon Gayan and Gidan Busa. This result corroborated Mamman and Jediel (2014) study which revealed that the concentration of road accidents were not evenly distributed along Kaduna- Zaria road as more of the occurrences appear to be regular at some flashpoints. Plate 4.4 and 4.5 shows hotspot locations at Toll Gate and Goningora along Kaduna-Abuja road.

Plate 4.4: Hotspot Location at Toll Gate along Kaduna-Abuja Road
Source: Field Survey, 2016

Plate 4.5: Hotspot Location at Goningora along Kaduna-Abuja Road
Source: Field Survey, 2016

Toll Gate hotspot location was the only identified high risk area along the route. The mounting of military check point at this location and presence of U-turn might be the possible reason for the high frequency of road traffic accidents at the hotspot location. Absence of bridge safety rail, narrow bridge and road washout accounted for the high concentration of road traffic accidents at Goningora and Gidan Busa while Sabon Gayan and Konar Bature were characterized by sharp bends, potholes and eroded shoulder. This agrees with Lee and Fred (1999) that roadway characteristics like pot-holes, road-side characteristics like; market, settlement and road design (sharp bends, narrow bridges and U-turns) among others are the principal causes of road accidents in some developing and developed countries of the world.

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 INTRODUCTION

This chapter presents the summary of findings of the study. The findings of the study have specifically described the road traffic accidents, its causes and determination of hotspot locations of traffic accidents along the study routes with conclusion and recommendations made as well.

5.2 SUMMARY OF FINDINGS

The findings revealed that Kaduna-Abuja road had more vehicular traffic than Kaduna-Birnin Gwari road. There was a similar gradual increase of traffic volume between 7am-8am along the two routes respectively till they hit their various morning peaks. Kaduna-Abuja had its highest morning peak between 10am-11am whereas along Kaduna-Birnin Gwari road, it was between 9am-10am while 3pm-4pm and 5pm-6pm represents the evening peaks for the two roads respectively. The composition of the vehicular traffic flow pattern was dominated by private cars which constituted 29.2% and 22.6% along Kaduna-Abuja and Kaduna-Birnin Gwari roads respectively.

The study also shows that a higher proportion (66%) of the accidents was recorded along Kaduna-Abuja road. Over speeding and tyre burst were the major causes of road traffic accidents along both routes. About 69.3% of the persons involved in road traffic accident were along Kaduna-Abuja. Males were majorly involved as it accounted for 79.6% of persons involved in road traffic accidents along the routes. Kaduna-Abuja road (60.3%) recorded the highest numbers of persons killed by road traffic accident

The temporal variation revealed that the highest road traffic accidents cases were recorded in the year 2011. Road traffic accidents were found to occur mostly in the months of

January, July, August, November and December. The nearest neighbour index shows the clustering pattern of road traffic accidents distribution along the routes. Eight (8) different hotspots were identified along Kaduna-Abuja road of which Toll Gate was the most dangerous location, while six (6) different hotspots were for Kaduna-Birnin Gwari.

5.3 CONCLUSION

Road traffic accident is identified as one of the leading causes of deaths along Kaduna-Abuja and Kaduna-Birnin Gwari roads in Kaduna state, Nigeria. The study has shown the existence of spatial and temporal variations of road traffic accidents in the study area. Moreover, GIS in this study has proven useful in the determination of road traffic accidents hotspots and its pattern in Kaduna State as well as assisted our understanding of contributory factors in the development of road traffic accident hotspots. The information obtained is necessary in the development of strategies to reduce road traffic accidents and the development of hotspots.

5.4 RECOMMENDATIONS

Based on the outcome of this research, the following are recommended:

i. Drivers' use of speed limit devices inside vehicles should be enforced by the Federal Road Safety Corps (FRSC) and Police on the highways.

ii. The importation and use of fairly used tyres by the motorists should be ban by the government.

iii. Public education programme on speed by FRSC should be mounted and adopted especially in the months of January, July, August, November and December which were found to be prone to road traffic accidents

iv. FERMA should repair the bad sectiosn, realign the sharp bends, expansion of narrow bridges, construction of bridge safety rail in all the identified hotspot locations along

Kaduna-Abuja and Kaduna-Birnin Gwari roads. This will ensure reduction in the rate of road accidents on the highways as well as the severity level

v. Drunk driving test should be conducted randomly especially on commercial drivers plighting the highways to prevent accident.

vi. Radar should be installed on the highways by FRSC in collaboration with other government agencies to monitor drivers who flaunt traffic laws and regulations.

5.5 SUGGESTION FOR FURTHER STUDIES

i. Road Traffic Accidents Reduction Strategies at the hotspots along the study routes

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Appendix I: Casualty Information and Geographical Coordinates of Accident Locations on Kaduna-Abuja Road

S/N	YEAR	ROUTE	LOCATION	LAT	LONG	CAUSE	INJURED		NUMBER KILLED		PEOPLE INVOLVED	
							M	F	M	F	M	F
1	2010	ABJ-KD	1 KM	10.43519	7.40247	SPV	1	0	0	0	1	0
2	2010	ABJ-KD	1 KM	10.43519	7.40247	SPV, DOT	2	0	0	0	2	0
3	2010	ABJ-KD	13 KM	10.32062	7.3861	DOT	1	0	0	0	1	0
4	2010	ABJ-KD	138KM	9.323	7.257	SPV	3	0	1	0	4	0
5	2010	ABJ-KD	138KM	9.323	7.257	SPV	2	0	0	0	2	0
6	2010	ABJ-KD	14 KM	10.3156	7.38491	ROV	1	0	0	0	7	0
7	2010	ABJ-KD	15 KM	10.3106	7.37813	RTV	0	0	0	0	7	0
8	2010	ABJ-KD	16 KM	10.3018	7.37277	DGD	21	0	0	0	21	0
9	2010	ABJ-KD	17 KM	10.2948	7.36671	MDV	30	7	4	0	23	7
10	2010	ABJ-KD	18KM	10.2871	7.36248	SPV	0	0	0	0	10	3
11	2010	ABJ-KD	20KM	10.2703	7.35625	TBT, LOC	0	0	0	0	5	0
12	2010	ABJ-KD	21KM	10.2608	7.35321	RTV	0	0	0	0	3	0

13	2010	ABJ-KD	28KM	10.1991	7.34775	SPV,MDV	0	0	0	0	4	2
14	2010	ABJ-KD	29 KM	10.1863	7.35048	SPV, DGD	0	0	0	0	3	1
15	2010	ABJ-KD	34 KM	10.1468	7.35769	TBT, SPV	0	0	0	0	0	0
16	2010	ABJ-KD	45 KM	10.0508	7.38417	SPV	0	0	0	0	7	2
17	2010	ABJ-KD	45KM	10.0508	7.38417	LCV	0	0	0	0	3	0
18	2010	ABJ-KD	5KM	10.3966	7.39781	DGD	0	0	0	0	12	5
19	2010	ABJ-KD	6KM	10.3875	7.39862	SPV, LOC	0	0	0	0	6	0
20	2010	ABJ-KD	7 KM	10.3784	7.39822	T BT	0	0	0	0	6	1
21	2010	ABJ-KD	7 KM	10.3784	7.39822	SPV	1	0	0	0	0	0
22	2010	ABJ-KD	8KM	10.3689	7.39741	SPV, DOT	2	0	0	0	2	0
23	2010	ABJ-KD	GWAGWA	10.2369	7.34983	DOT	1	0	0	0	1	0
24	2010	ABJ-KD	TITKANIYA	10.5852	7.4307	SPV	3	0	1	0	4	0
25	2011	ABJ-KD	1 KM	10.43519	7.40247	SPV	2	0	1	0	2	0
26	2011	ABJ-KD	1 KM	10.43519	7.40247	WOV	3	0	0	0	12	0
27	2011	ABJ-KD	1 KM	10.43519	7.40247	OVS	2	0	0	0	4	0
28	2011	ABJ-KD	11 KM	10.34989	7.394666	OVS	6	1	0	0	6	1

29	2011	ABJ-KD	12 KM	10.334	7.395	OLV	0	0	2	0	3	0
30	2011	ABJ-KD	12 KM	10.334	7.395	SPV	0	2	0	0	2	0
31	2011	ABJ-KD	12 KM	10.334	7.395	TBT	2	0	2	0	9	0
32	2011	ABJ-KD	12 KM	10.334	7.395	TBT	2	0	4	0	14	6
33	2011	ABJ-KD	12 KM	10.334	7.395	SPV	2	0	0	0	2	0
34	2011	ABJ-KD	12 KM	10.334	7.395	OBS	4	0	0	0	8	2
35	2011	ABJ-KD	12 KM	10.334	7.395	LOC	10	1	0	0	16	4
36	2011	ABJ-KD	12 KM	10.334	7.395	DGD	6	0	0	0	6	0
37	2011	ABJ-KD	12 KM	10.334	7.395	OVS	0	0	0	0	4	0
38	2011	ABJ-KD	12 KM	10.334	7.395	DGD	4	8	3	0	10	5
39	2011	ABJ-KD	12 KM	10.334	7.395	DGD	0	0	1	2	2	3
40	2011	ABJ-KD	12 KM	10.334	7.395	SPV	3	0	0	0	12	6
41	2011	ABJ-KD	129 KM	10.29635	7.36754	DGD	2	2	0	1	5	3
42	2011	ABJ-KD	12KM	10.334	7.395	LOC	7	2	0	0	10	8
43	2011	ABJ-KD	14 KM	10.3156	7.38491	TBT	2	0	0	0	3	3
44	2011	ABJ-KD	14 KM	10.3156	7.38491	OTHERS	1	0	1	0	1	0

45	2011	ABJ-KD	14 KM	10.3156	7.38491	NIL	1	0	0	0	9	3
46	2011	ABJ-KD	15 KM	10.3106	7.37813	NIL	2	2	0	0	2	2
47	2011	ABJ-KD	15 KM	10.3106	7.37813	SPV	1	0	2	0	5	0
48	2011	ABJ-KD	16 KM	10.3018	7.37277	TBT	4	1	0	0	4	1
49	2011	ABJ-KD	16 KM	10.3018	7.37277	TBT	6	0	0	0	6	0
50	2011	ABJ-KD	16 KM	10.3018	7.37277	SPV	1	2	0	0	3	3
51	2011	ABJ-KD	16 KM	10.3018	7.37277	DGD	0	0	0	0	3	0
54	2011	ABJ-KD	18 KM	10.2871	7.36248	DOT	2	0	0	0	2	0
55	2011	ABJ-KD	2 KM	10.4241	7.39698	OVS	1	1	0	0	1	1
56	2011	ABJ-KD	2 KM	10.4241	7.39698	WOV	1	0	0	0	4	1
57	2011	ABJ-KD	2 KM	10.4241	7.39698	OVS	7	0	0	0	7	0
58	2011	ABJ-KD	2 KM	10.4241	7.39698	DOT	0	0	1	0	6	0
59	2011	ABJ-KD	20 KM	10.2703	7.35625	TBT	3	3	0	0	12	6
60	2011	ABJ-KD	20 KM	10.2703	7.35625	SOS	0	2	0	0	0	2
61	2011	ABJ-KD	21 KM	10.2608	7.35321	SOS	3	3	0	1	3	3
62	2011	ABJ-KD	22 KM	10.2532	7.35136	LOC	1	0	1	0	1	0

63	2011	ABJ-KD	22 KM	10.2532	7.35136	OLV	1	0	0	0	2	0
64	2011	ABJ-KD	23 KM	10.2405	7.34792	SPV	0	0	0	0	2	0
65	2011	ABJ-KD	23 KM	10.2405	7.34792	SPV	4	0	0	0	5	4
66	2011	ABJ-KD	24 KM	10.234	7.34687	DOT	3	0	0	0	6	3
67	2011	ABJ-KD	27 KM	10.2091	7.34502	LOC	1	0	0	0	1	0
68	2011	ABJ-KD	27 KM	10.2091	7.34502	SPV	1	0	0	0	3	0
69	2011	ABJ-KD	29 KM	10.1863	7.35048	SPV	1	0	0	0	1	0
70	2011	ABJ-KD	3 KM	10.4144	7.40054	SPV	2	0	0	0	6	0
71	2011	ABJ-KD	3 KM	10.4144	7.40054	TBT	2	2	2	2	3	3
72	2011	ABJ-KD	30 KM	10.1826	7.3515	DOT	7	4	0	0	8	6
73	2011	ABJ-KD	30 KM	10.1826	7.3515	DGD	6	6	0	0	10	7
74	2011	ABJ-KD	30 KM	10.1826	7.3515	LOC	1	0	0	0	6	0
75	2011	ABJ-KD	30 KM	10.1826	7.3515	NIL	4	0	0	0	4	0
76	2011	ABJ-KD	32 KM	10.165	7.35593	DOT	1	1	0	0	1	1
77	2011	ABJ-KD	32 KM	10.165	7.35593	SPV	1	2	0	0	3	3
78	2011	ABJ-KD	34 KM	10.1468	7.35769	SOS	1	0	0	0	1	0

79	2011	ABJ-KD	34 KM	10.1468	7.35769	SPV	3	0	0	0	3	0
80	2011	ABJ-KD	34 KM	10.1468	7.35769	NIL	1	1	0	2	1	3
81	2011	ABJ-KD	35 KM	10.1364	7.35736	NIL	2	4	0	0	5	6
82	2011	ABJ-KD	35 KM	10.1364	7.35736	SPV	0	0	2	0	2	0
83	2011	ABJ-KD	36 KM	10.1288	7.35901	LOC	4	0	1	0	7	0
84	2011	ABJ-KD	37 KM	10.1194	7.36034	LOC	1	0	0	0	1	0
85	2011	ABJ-KD	38 KM	10.1106	7.36166	SPV	6	2	1	1	7	3
86	2011	ABJ-KD	38 KM	10.1106	7.36166	MDV	1	0	0	0	3	0
87	2011	ABJ-KD	39 KM	10.1022	7.36396	RTV	3	1	2	0	5	3
88	2011	ABJ-KD	4 KM	10.4052	7.39975	SPV	5	0	0	0	6	0
89	2011	ABJ-KD	4 KM	10.4052	7.39975	MDV	1	0	1	0	3	0
90	2011	ABJ-KD	42 KM	10.0764	7.37366	TBT	1	1	0	0	2	1
91	2011	ABJ-KD	45 KM	10.0508	7.38417	LOC	6	0	2	1	7	2
92	2011	ABJ-KD	46 KM	10.0429	7.38739	LOC	2	0	0	0	5	0
93	2011	ABJ-KD	48 KM	10.0265	7.39423	MDV	1	0	0	0	5	0
94	2011	ABJ-KD	48 KM	10.0265	7.39423	LOC	0	0	1	0	4	0

95	2011	ABJ-KD	5 KM	10.3966	7.39781	BFL	1	0	0	0	3	0
96	2011	ABJ-KD	5 KM	10.3966	7.39781	LOC	0	0	0	0	3	0
97	2011	ABJ-KD	56 KM	9.95707	7.41875	OVS	0	0	0	0	6	4
98	2011	ABJ-KD	57 KM	9.94841	7.42037	SOS	7	0	1	1	10	2
99	2011	ABJ-KD	58 KM	9.94034	7.42365	DGD	0	0	0	0	3	0
100	2011	ABJ-KD	6 KM	10.3875	7.39862	BFL	0	0	0	0	4	2
101	2011	ABJ-KD	60 KM	9.9242	7.43151	OVS	2	0	0	0	6	0
102	2011	ABJ-KD	67 KM	9.86522	7.45493	DGD	0	1	0	0	0	1
103	2011	ABJ-KD	72 KM	9.82196	7.46231	DGD	2	1	1	0	5	3
104	2011	ABJ-KD	78KM	9.77017	7.44689	DGD	1	0	0	0	7	0
105	2011	ABJ-KD	8 KM	10.3689	7.39741	DOT	0	0	0	1	0	3
106	2011	ABJ-KD	80 KM	10.43519	7.40247	DGD	1	0	0	0	2	0
107	2011	ABJ-KD	82 KM	9.73486	7.45162	DGD	0	0	0	0	6	0
108	2011	ABJ-KD	82 KM	9.73486	7.45162	TBT	6	0	2	2	8	2
109	2011	ABJ-KD	9 KM	10.3598	7.395	NIL	1	0	0	0	3	0
110	2012	ABJ-KD	1 KM	10.43519	7.40247	SPV	2	0	0	0	4	0

111	2012	ABJ-KD	12 KM	10.334	7.395	TBT	1	0	0	0	3	0
112	2012	ABJ-KD	12 KM	10.334	7.395	TBT	1	0	0	0	3	0
113	2012	ABJ-KD	12 KM	10.334	7.395	DOT	8	0	0	0	11	0
114	2012	ABJ-KD	12KM	10.334	7.395	DOT	5	0	2	0	20	0
115	2012	ABJ-KD	12KM	10.334	7.395	PWR	12	1	1	0	12	5
116	2012	ABJ-KD	12KM	10.334	7.395	SPV	4	0	0	0	4	0
117	2012	ABJ-KD	12KM	10.334	7.395	SPV	1	0	1	0	4	0
118	2012	ABJ-KD	12KM	10.334	7.395	TBT	3	0	0	0	3	0
119	2012	ABJ-KD	12KM	10.334	7.395	SPV	2	0	4	0	7	0
120	2012	ABJ-KD	14KM	10.3106	7.37813	DGD	3	0	0	0	3	0
121	2012	ABJ-KD	15 KM	10.3106	7.37813	TBT	5	0	0	0	5	0
122	2012	ABJ-KD	15KM	10.3018	7.37277	SPV	9	2	0	0	12	8
123	2012	ABJ-KD	16KM	10.3018	7.37277	SPV	2	1	0	0	6	2
124	2012	ABJ-KD	1KM	10.43519	7.40247	LOC	10	2	2	2	11	5
125	2012	ABJ-KD	20 KM	10.2703	7.35625	SPV	2	0	0	0	2	0
126	2012	ABJ-KD	22KM	10.2532	7.35625	DOT	2	0	0	0	3	0

127	2012	ABJ-KD	24KM	10.234	7.34687	SPV	3	0	2	1	5	1
128	2012	ABJ-KD	27KM	10.2091	7.34502	SPV	3	0	0	0	6	3
129	2012	ABJ-KD	30 KM	10.165	7.35593	DOT	4	5	0	0	13	0
130	2012	ABJ-KD	32 KM	10.165	7.35593	OVS	0	0	3	0	5	0
131	2012	ABJ-KD	32 KM	10.165	7.35593	DGD	1	0	0	0	1	0
132	2012	ABJ-KD	32KM	10.165	7.35593	MDV	3	0	0	0	3	0
133	2012	ABJ-KD	32KM	10.165	7.35593	WOV	1	0	0	0	1	0
134	2012	ABJ-KD	32KM	10.155	7.35702	TLV	3	0	0	0	4	1
135	2012	ABJ-KD	33 KM	10.1364	7.35736	OVL	1	0	0	0	3	0
136	2012	ABJ-KD	35 KM	10.1288	7.35901	TLV	6	3	0	0	8	4
137	2012	ABJ-KD	36KM	10.1194	7.36034	TLV	4	3	2	2	8	4
138	2012	ABJ-KD	3KM	9.57256	7.42522	TBT	1	0	0	0	4	1
139	2012	ABJ-KD	40KM	10.0934	7.3656	TBT	4	2	1	0	5	2
140	2012	ABJ-KD	40KM	10.0429	7.38739	ROBBERY ATTACK	3	1	0	0	6	1
141	2012	ABJ-KD	46KM	10.0265	7.39423	TBT	5	0	1	0	6	0
142	2012	ABJ-KD	48KM	10.0265	7.39423	LOC	6	0	0	0	6	0

143	2012	ABJ-KD	5 KM	10.3966	7.39781	SPV	2	0	0	0	5	1
144	2012	ABJ-KD	50KM	10.0098	7.40306	MDV	1	1	0	0	4	3
145	2012	ABJ-KD	50KM	9.99387	7.41214	DGD	0	1	0	0	0	2
146	2012	ABJ-KD	52KM	9.96627	7.41655	MDV	3	1	0	0	5	3
147	2012	ABJ-KD	55 KM	9.93181	7.42787	SPV	1	0	0	0	3	0
148	2012	ABJ-KD	59KM	9.9242	7.43151	MDV	5	1	0	0	15	4
149	2012	ABJ-KD	60KM	9.89888	7.44242	DGD	0	0	0	0	3	0
150	2012	ABJ-KD	63KM	9.89888	7.44242	SPV	3	0	0	0	5	3
151	2012	ABJ-KD	63KM	9.88166	7.45008	TBT	0	0	0	0	3	0
152	2012	ABJ-KD	65KM	9.876	7.451	LOC	5	0	0	0	5	0
153	2012	ABJ-KD	6KM	10.3875	7.39862	DOT	6	0	6	0	6	0
154	2012	ABJ-KD	70KM	9.80407	7.45787	TBT	7	0	0	0	15	0
155	2012	ABJ-KD	74KM	9.79571	7.45497	TBT	1	1	1	1	1	1
156	2012	ABJ-KD	75KM	9.79571	7.45497	SPV	3	0	0	0	3	0
157	2012	ABJ-KD	75KM	9.79571	7.45497	TBT	3	0	6	0	9	0
158	2012	ABJ-KD	75KM	9.79571	7.45497	SPV	10	0	0	0	27	4

159	2012	ABJ-KD	80KM	9.75332	7.45216	TBT	3	1	9	5	12	6
160	2012	ABJ-KD	80KM	9.73486	7.45162	DGD	1	0	0	0	6	0
161	2012	ABJ-KD	82 KM	9.66359	7.45331	LOC	1	1	0	0	2	0
162	2012	ABJ-KD	90KM	9.607	7.458	DGD	1	0	0	0	1	0
163	2012	ABJ-KD	94KM	9.60421	7.44939	DGD	3	0	1	0	5	0
164	2012	ABJ-KD	94KM	9.60421	7.44939	TBT	4	0	1	0	5	0
165	2012	ABJ-KD	94KM	9.60421	7.44939	TBT	4	0	0	0	7	0
166	2012	ABJ-KD	9KM	10.61843	7.225227	RTV	3	2	4	1	15	6
167	2014	ABJ-KAD	DOKA, KM68	9.85488	7.45705	TLV	3	0	1	0	10	0
168	2014	ABJ-KAD	KM 87 KATARI	9.69023	7.45363	TLV	1	0	3	0	3	0
169	2014	ABJ-KAD	KM 95, GIDAN BUSSA	9.61186	7.4554	TLV	1	1	6	2	6	3
170	2014	ABJ-KAD	KM 97 JERE	9.57256	7.42522	SPV, LOC	3	0	2	0	5	0
171	2014	ABJ-KAD	KM 97, GADA AZARA	9.603	7.44961	DAD	13	0	0	0	15	0
172	2014	ABJ-KAD	KM50, POLE WIRESARKIN PAWA	9.99387	7.41214	TLV	7	0	3	0	10	0
173	2014	ABJ-KAD	KM68 POLEWIRE	9.86244	7.45515	TLV	1	1	1	1	4	6
174	2014	ABJ-	KM75 AKILIBU	9.77854	7.44897	DOT & SPV	1	0	0	0	3	0

		KAD											
175	2014	ABJ-KAD	KM77 AKILIBU	9.77854	7.44897	SPV & BRD	1	2	0	0	1	4
176	2014	ABJ-KAD	KM82, GIDAN BUSA	9.73407	7.4517	SPV	2	0	1	0	5	0
177	2014	ABJ-KAD	KM85, BISHINI JUNCTION	9.70647	7.45594	TLV	5	0	4	0	9	0
178	2014	ABJ-KAD	KM96 NASARA VILLAGE	9.6104	7.45349	SPV	1	0	0	0	2	0
179	2014	ABJ-KAD	POLEWIRE	9.86244	7.45515	TLV	15	0	2	0	18	0
180	2014	ABJ-KD	KM 83,KUROMI KARE	9.655	7.455	LOC	16	1	2	0	37	2
181	2014	ABJ-KD	KM100,JERE	10.6698	6.55744	TBT	4	0	0	1	4	1
182	2014	KAD-ABJ	AKILBU	9.77854	7.44897	SPV & BRD	1	4	1	0	2	5
183	2014	KAD-ABJ	AKILIBU VILLAGE	9.61186	7.4554	DOV, LOC	1	1	0	0	1	1
184	2014	KAD-ABJ	GIDAN BUSA (KM89)	9.61186	7.4554	SPV, LOC	5	1	0	0	6	2
185	2014	KAD-ABJ	GIDAN BUSA (KM89)	9.61186	7.4554	HIT AND RUN	0	2	0	1	0	3
186	2014	KAD-ABJ	JERE(KM60)	9.9242	7.43151	SPV, TBT	1	0	3	0	7	0
187	2014	KAD-ABJ	KATARI (KM86)	9.69023	7.45363	SPV, LOC	2	0	0	0	2	0
188	2014	KAD-ABJ	KATARI (KM86)	9.69023	7.45363	SPV, LOC	0	8	1	0	3	15
189	2014	KAD-ABJ	KATSINA RBT	10.0934	7.3656	TBT	1	0	1	0	2	0
190	2014	KAD-	KM 104	10.0934	7.3656	TLV,LOC	3	2	0	0	8	2

		ABJ	NASARAWA DOKA									
191	2014	KAD-ABJ	KM 40 RIJANA	10.0934	7.3656	SPV	2	0	0	0	12	0
192	2014	KAD-ABJ	KM 50, MARABA ISA	9.85488	7.45705	LOC	2	0	4	0	6	0
193	2014	KAD-ABJ	KM 60, DOKA	9.9242	7.43151	SPV,LOC	0	0	5	2	10	2
194	2014	KAD-ABJ	KM 65, GADA AZARA	9.69023	7.45363	TLV	2	2	1	1	3	3
195	2014	KAD-ABJ	KM 75 KATARI	9.79571	7.45497	SPV/LOC	6	2	0	0	8	2
196	2014	KAD-ABJ	KM 82 BEFORE KATARI	9.61186	7.4554	SPV,DGD	1	1	2	0	3	1
197	2014	KAD-ABJ	KM 89 GIDAN BUSA	9.61186	7.4554	TBT, LOC	6	1	0	0	6	1
198	2014	KAD-ABJ	KM 89 GIDAN BUSA	9.61186	7.4554	TBT	5	0	0	0	5	0
199	2014	KAD-ABJ	KM115,SABO MARO	10.1288	7.35901	SPV	1	2	0	0	3	2
200	2014	KAD-ABJ	KM36	10.1288	7.35901	SPV	1	0	0	0	9	0
201	2014	KAD-ABJ	KM65 HAYIN GADA	9.603	7.44961	SPV	2	0	0	0	2	0
202	2014	KAD-ABJ	KM67,AZARA	9.603	7.44961	SPV,LOC	1	0	4	1	5	1
203	2014	KAD-ABJ	KM70, AZARA	9.77854	7.44897	SPV,LOC	2	0	0	0	6	3
204	2014	KAD-ABJ	KM73, AKILIBU	9.69023	7.45363	SPV, TBT	2	0	0	0	3	6
205	2014	KAD-ABJ	KM77, KATARI	9.778	7.451	TBT, LOC	5	0	0	0	6	0

206	2014	KAD-ABJ	KM82,KURUMI KARE	9.73486	7.45162	SPV	1	1	0	0	3	1
207	2014	KAD-ABJ	KM84,GIDAN BUSA OPPOSITE CITY FARM	9.61186	7.4554	SPV	2	0	1	0	3	0
208	2014	KAD-ABJ	KM87 KATARI	9.69023	7.45363	SPV, TBT	8	0	0	0	8	0
209	2014	KAD-ABJ	KM89, NEAR KATARI POLICE STATION	9.69023	7.45363	SPV, TBT	2	0	1	0	4	0
210	2014	KAD-ABJ	KM90, AKILIBU	9.77854	7.44897	SPV, DGD	3	9	0	1	12	13
211	2014	KAD-ABJ	MARARABA ISA KM104	9.77854	7.44897	DGD	1	0	0	0	5	1
212	2014	KAD-ABJ	YANGOYI VILLAGE(KM 75)	10.6698	6.55744	LOC	1	0	0	0	3	0
213	2014	KAD-ABJ	KM 48	10.7126	6.63398	LOC	3	0	1	0	4	0
214	2014	KAD-ABJ	KURUMI KARE	10.7126	6.63398		0	0	3	1	3	1
215	2014	KAD-ABJ	GIDAN BUSA	9.61186	7.4554		2	1	0	1	2	3
216	2014	KAD-ABJ	KATARI	9.69023	7.45363		1	0	0	0	1	0
217	2014	KAD-ABJ	KATARI	9.69023	7.45363		3	0	0	1	5	1
218	2014	KAD-ABJ	AKILIBU	9.77854	7.44897		4	1	1	0	5	1
219	2014	KAD-ABJ	AKILIBU	9.77854	7.44897		5	0	2	1	12	1
220	2010	KAD-	JERE(KM138)	9.323	7.257		1	0	1	0	2	0

		ABJ									
221	2011	KAD-ABJ	JERE(129KM)	9.376	7.303	1	0	0	0	1	0
222	2012	KAD-ABJ	JERE(98)	9.595	7.449	1	0	0	0	1	0

Appendix II: Casualty Information and Geographical Coordinates of Accident Locations on Kaduna-Birnin Gwari Road

S/N	YEAR	ROUTE	LOCATION	LAT	LONG	CAUSE	INJURED		NUMBER KILLED		PEOPLE INVOLVED	
							M	F	M	F	M	F
1	2010	KD-BGW	1.5 from BNG	10.5852	7.4307	SPV	1	0	0	0	1	0
2	2010	KD-BGW	13KM	10.677	6.56631	DGD	1	0	0	0	1	0
3	2010	KD-BGW	15KM	10.7039	6.65869	0VS	0	0	0	0	0	0
4	2010	KD-BGW	2KM from BNG	10.6964	6.67659	DGD	7	0	7	0	7	0
5	2010	KD-BGW	AFAKA	10.6736	6.5624	SPV, LOC	0	0	0	0	0	0
6	2010	KD-BGW	AIRPORT JUNCT	10.6009	7.32811	DGD	5	6	6	1	15	10
7	2010	KD-BGW	AIRPORT JUNCT	10.6009	7.32811	SPV	1	0	1	0	3	0
8	2010	KD-BGW	AIRPORT JUNCT	10.6009	7.32811	LOC	2	2	0	0	2	2
9	2010	KD-BGW	MANDO	10.58906	7.41804	TBT	2	0	2	0	3	0
10	2010	KD-BGW	MANDO	10.58906	7.41804	SPV	1	1	2	0	1	1
11	2010	KD-BGW	MANDO	10.58906	7.41804	TBT	3	0	3	0	5	0
12	2010	KD-BGW	MANDO	10.58906	7.41804	SPV	8	0	0	1	6	4

13	2010	KD-BGW	MEGA STATION	10.58906	7.41804	LOC	2	0	0	0	3	0
14	2010	KD-BGW	MEGA STATION	10.58906	7.41804	DGD	4	0	0	0	4	0
15	2010	KD-BGW	N/AZIKWE	10.58906	7.41804	SPV	0	0	0	0	3	0
16	2010	KD-BGW	NAF	10.59197	7.363716	TBT	13	0	0	0	18	0
17	2010	KD-BGW	POWER STATION	10.6504	7.03284	LOC	3	0	1	0	7	0
18	2011	KD-BGW	0.5KM	10.67292	6.554028	TBT	3	2	0	0	3	2
19	2011	KD-BGW	1 KM	10.6736	6.5624	SPV	12	2	0	1	12	4
20	2011	KD-BGW	1 KM	10.6736	6.5624	POTHOLE	0	0	0	0	6	0
21	2011	KD-BGW	1.25 KM	10.6736	6.5624	RAIN	2	0	0	0	6	0
22	2011	KD-BGW	10 KM	10.713	6.63273	POTHOLE	0	0	0	0	3	0
23	2011	KD-BGW	10 KM	10.713	6.63273	MDV	3	1	1	0	6	0
24	2011	KD-BGW	10 KM	10.713	6.63273	TBT	15	3	2	0	13	7
25	2011	KD-BGW	10 KM KWAGA	10.713	6.63273	DGD	1	1	0	0	3	0
26	2011	KD-BGW	12 KM	10.677	6.56631	TBT	1	1	0	0	2	0
27	2011	KD-BGW	16 KM	10.7042	6.68753	TBT	1	3	3	0	4	2

28	2011	KD-BGW	16KM	10.7042	6.68753	SPV	7	0	0	0	7	0
29	2011	KD-BGW	1KM	10.6751	6.56152	SPV	1	0	0	0	1	0
30	2011	KD-BGW	1KM	10.6751	6.56152	SPV	1	0	1	0	3	0
31	2011	KD-BGW	2 KM	10.6736	6.5624	SPV	0	0	0	0	0	0
32	2011	KD-BGW	2 KM	10.6736	6.5624	OVS	2	0	0	0	11	0
33	2011	KD-BGW	21 KM	10.7278	6.72479	OVS	0	0	0	0	0	0
34	2011	KD-BGW	2KM KURIGA	10.6736	6.5624	DGD	8	7	0	0	9	7
35	2011	KD-BGW	3 KM	10.6838	6.57926	LOC	8	0	0	0	8	0
36	2011	KD-BGW	3 KM	10.6838	6.57926	SPV	1	1	5	2	6	3
37	2011	KD-BGW	4 KM	10.6881	6.59478	TBT	1	0	0	0	1	0
38	2011	KD-BGW	5 KM	10.6902	6.59558	LOC	4	0	0	0	4	0
39	2011	KD-BGW	54 KM	10.6444	6.96987	TBT	1	0	2	1	3	1
40	2011	KD-BGW	5KM	10.689	6.59649	TBT	14	2	0	0	14	2
41	2011	KD-BGW	62 KM	10.6503	7.03732	SPV	4	0	2	0	6	0
42	2011	KD-BGW	7KM	10.7032	6.60606	TBT	3	0	0	0	3	0

43	2011	KD-BGW	8 KM	10.7086	6.6149	SPV	1	1	3	2	4	3
44	2011	KD-BGW	8 KM	10.7086	6.6149	DGD	1	4	3	0	4	4
45	2011	KD-BGW	9 KM	10.7098	6.62457	LOC	1	0	1	0	2	0
46	2011	KD-BGW	9 KM	10.7098	6.62457	WOV	1	0	0	0	2	0
47	2011	KD-BGW	9 KM	10.7098	6.62457	LOC	2	0	7	0	12	0
48	2011	KD-BGW	AIRPORT JUNCT	10.6009	7.32811	OVS	2	0	7	0	9	0
49	2011	KD-BGW	BURUKU	10.61843	7.225227	WRECLESS	2	0	0	0	2	0
50	2011	KD-BGW	Doda	10.61843	7.225227	POTHOLE	2	0	0	0	6	0
51	2011	KD-BGW	FRSC OFFICE	10.67084	6.550128	POTHOLE	3	0	0	0	3	0
52	2011	KD-BGW	FRSC OFFICE	10.67084	6.550128	WOV	4	0	0	0	5	0
53	2011	KD-BGW	FRSC OFFICE	10.67084	6.550128	DOV	5	0	0	0	5	2
54	2011	KD-BGW	GSS	10.67084	6.550128	SPV	2	0	2	1	5	3
55	2011	KD-BGW	GWAMNA RD	10.69613	6.675226	SPV	0	0	1	0	1	0
56	2011	KD-BGW	KURMI MASHI	10.69613	6.675226	SPV	1	0	0	0	1	0
57	2011	KD-BGW	KWANAR MUTUWA	10.69613	6.675226	DGD	1	0	0	0	5	0

58	2011	KD-BGW	MANDO		10.58906	7.41804	SPV	2	1	0	0	2	1
59	2011	KD-BGW	MANDO		10.58906	7.41804	DGD	10	0	0	0	10	0
60	2011	KD-BGW	MANDO		10.58906	7.41804	MDV	0	0	0	0	3	0
61	2011	KD-BGW	MANDO		10.58906	7.41804	DOT	2	1	0	0	4	2
62	2011	KD-BGW	NDA		10.59197	7.363716	OVS	2	0	0	0	9	5
63	2011	KD-BGW	NDA		10.59197	7.363716	SPV	0	0	1	0	4	0
64	2011	KD-BGW	OPP SECRETARIATE	ANPP	10.58906	7.41804	RTV	0	1	0	1	0	3
65	2011	KD-BGW	POLE WAYA		10.6504	7.03284	OTHERS	1	0	0	0	1	0
66	2011	KD-BGW	POLE WAYA		10.6504	7.03284	SPV	4	1	0	0	4	1
67	2011	KD-BGW	SARKIN NOMA		10.5921	7.36034	SPV	5	2	0	0	6	4
68	2011	KD-BGW	UNG. LIMAN		10.43519	7.40247	LOC	2	2	2	1	8	5
69	2012	BNG-KAD	BURUKU		10.61843	7.225227	TBT	1	0	0	0	1	0
70	2012	KD-BGW	0.5KM		10.67292	6.554028	TBT	0	0	0	0	4	0
71	2012	KD-BGW	0.5KM		10.67292	6.554028	SLV	2	0	2	0	4	0
72	2012	KD-BGW	1 KM		10.6736	6.5624	WOV	8	0	4	0	12	0

73	2012	KD-BGW	10KM	10.713	6.63273	SOS	1	5	0	0	4	10
74	2012	KD-BGW	12 KM	10.677	6.56631	SLV	2	0	2	0	4	0
75	2012	KD-BGW	14 KM	10.702	6.66896	WOV	8	0	4	0	12	0
76	2012	KD-BGW	14KM	10.702	6.66896	SOS	1	5	0	0	6	5
77	2012	KD-BGW	15KM	10.6964	6.67659	TBT	5	1	0	1	6	2
78	2012	KD-BGW	18KM	10.715	6.70082	TBT	1	1	0	0	1	1
79	2012	KD-BGW	27 KM	10.7208	6.7771	TBT	7	0	0	1	9	6
80	2012	KD-BGW	2KM KURIGA	10.6736	6.5624	DGD	1	0	0	0	3	0
81	2012	KD-BGW	3.5KM	10.6838	6.57926	SPV	1	1	0	0	2	0
82	2012	KD-BGW	51 KM	10.6362	6.94407	SPV	1	1	0	0	2	0
83	2012	KD-BGW	6 KM	10.6973	6.60032	SPV	1	0	0	0	1	0
84	2012	KD-BGW	6KM	10.6973	6.60032	SPV	3	0	1	0	4	0
85	2012	KD-BGW	6KM	10.6973	6.60032	SPV	3	0	3	0	6	0
86	2012	KD-BGW	7KM	10.7032	6.60606	TBT	1	0	0	0	4	0
87	2012	KD-BGW	AIRPORT JUNCT	10.6009	7.32811	LOC	0	0	0	0	3	0

88	2012	KD-BGW	AIRPORT JUNCT	10.6009	7.32811	SPV	3	0	0	0	5	2
89	2012	KD-BGW	BURUKU	10.61843	7.225227	DGD	4	0	9	0	13	0
90	2012	KD-BGW	KWANAR MUTUWA	10.69613	6.675226	SPV	0	0	0	0	2	0
91	2012	KD-BGW	MANDO	10.58906	7.41804	TBT	3	0	0	0	3	0
92	2012	KD-BGW	NAF	10.59197	7.363716	TBT	4	0	2	0	6	0
93	2012	KD-BGW	NAF	10.59197	7.363716	SPV	5	0	1	0	6	0
94	2014	BNG-KAD	0.4KM	10.7126	6.63398	SLV	5	0	0	0	7	0
95	2014	BNG-KAD	10.1KM	10.7126	6.63398	RTV	1	0	1	0	2	0
96	2014	BNG-KAD	10KM	10.7126	6.63398	LOC	2	0	1	0	5	0
97	2014	BNG-KAD	10KM	10.7096	6.64344	LOC	2	1	0	0	4	3
98	2014	BNG-KAD	11KM	10.7096	6.64344	SLV	0	0	3	1	3	1
99	2014	BNG-KAD	11KM	10.7039	6.65869	TBT(1009)	2	1	0	1	2	3
100	2014	BNG-KAD	13KM	10.6964	6.67659	MDV	1	0	0	0	1	0
101	2014	BNG-KAD	15KM	10.6525	6.86196	SLV	3	0	0	1	5	1
102	2014	BNG-KAD	40KM	10.6347	7.00325	TBT(4512)	4	1	1	0	5	1

103	2014	BNG-KAD	58KM	10.689	6.59649	TBT(5211)	8	0	3	1	12	1
104	2014	BNG-KAD	5KM	10.6973	6.60032	TBT	14	1	1	2	15	5
105	2014	BNG-KAD	6KM	10.59197	7.363716	SPV	1	1	1	0	2	1
106	2014	BNG-KAD	NEW NDA GATE	9.77854	7.44897	SPV	7	2	0	0	7	2
107	2014	BNG-KAD	0.4KM	10.6698	6.55744		14	1	1	2	15	5
108	2014	BNG-KAD	10KM	10.7126	6.63398		1	1	1	0	2	1
109	2014	BNG-KAD	10KM	10.7126	6.63398		7	2	0	0	7	2
110	2014	BNG-KAD	10KM	10.7126	6.63398		1	4	1	0	2	5
111	2014	BNG-KAD	11KM	10.7096	6.64344		1	1	0	0	1	1
112	2014	BNG-KAD	11KM	10.7096	6.64344		5	1	0	0	6	2
113	2014	BNG-KAD	13KM	10.7039	6.65869		0	2	0	1	0	3
114	2014	BNG-KAD	15KM	10.6964	6.67659		1	0	3	0	7	0

TRAFFIC VOLUME COUNT SURVEY

Road Name ……………………………… Direction ……………………. DATE …………………………

Time	Motorcycle	Car	Bus	Lorry	Total
8-9am					
9-10am					
10-11am					
11-12noon					
12-1pm					
1-2pm					
2-3pm					
3-4pm					
4-5pm					
5-6pm					

Average Daily Traffic along Kaduna-Abuja (Dry Season)

Time class	Motorcycle	Tricycle	Private car	Pickup	Minibus	Lux-bus	Lorry/Truck	Tanker	Trailer
7-8am	34	15	124	16	59	2	27	24	31
8-9am	38	20	128	19	56	2	34	27	36
9-10am	41	21	138	21	59	2	30	31	36
10-11am	36	21	132	23	52	1	33	26	36
11-12noon	32	19	116	22	46	1	26	24	34
1-2pm	33	16	128	21	53	1	32	25	32
2-3pm	49	17	135	24	51	1	33	26	39
3-4pm	34	17	144	23	56	2	32	29	37
4-5pm	35	21	148	22	55	2	31	28	39
5-6pm	35	21	131	22	57	2	36	30	37

Appendix III: Average Daily Traffic along Kaduna-Abuja (Dry and Rainy Season)

Time class	Motorcycle	Tricycle	Private car	Pickup	Minibus	Lux-bus	Lorry/Truck	Tanker	Trailer
7-8am	55	48	135	146	68	4	66	52	35
8-9am	76	45	154	156	88	6	64	64	40
9-10am	86	45	177	184	83	3	66	52	53
10-11am	96	51	214	226	107	2	55	46	58
11-12noon	99	45	214	246	98	3	62	49	47
1-2pm	68	43	153	182	87	1	57	43	39

2-3pm	79	47	229	192	94	3	45	61	41
3-4pm	89	54	268	215	103	3	53	68	43
4-5pm	76	51	212	188	114	2	52	49	44
5-6pm	69	49	207	146	85	2	55	56	40

Appendix IV: Average Daily Traffic along Kaduna-Birnin Gwari (Dry Season)

Time class	Motorcycle	Tricycle	Private car	Pickup	Minibus	Lux-bus	Lorry/Truck	Tanker	Trailer
7-8am	16	7	96	104	51	5	45	29	37
8-9am	31	13	129	116	80	5	59	37	43
9-10am	37	20	146	116	80	3	57	39	49
10-11am	42	20	150	111	75	2	49	42	35
11-12noon	33	20	156	111	74	2	49	34	36
1-2pm	13	6	47	60	67	1	54	32	39
2-3pm	35	16	149	90	67	2	50	40	36
3-4pm	53	13	157	143	70	2	50	34	41
4-5pm	34	16	155	132	79	4	48	35	37
5-6pm	35	21	158	147	79	4	54	42	47

Appendix V: Average Daily Traffic along Kaduna-Birnin Gwari (Rainy Season)

Time class	Motorcycle	Tricycle	Private car	Pickup	Minibus	Lux-bus	Lorry/Truck	Tanker	Trailer
7-8am	34	36	67	94	51	5	45	29	37
8-9am	65	54	95	97	80	5	59	37	43
9-10am	73	59	93	106	80	3	57	39	49
10-11am	79	53	102	95	75	2	49	42	35
11-12noon	75	51	96	105	74	2	49	34	36
1-2pm	65	50	96	94	67	1	54	32	39
2-3pm	63	45	106	102	67	2	50	40	36
3-4pm	68	58	83	105	70	2	50	34	41
4-5pm	67	51	98	85	79	4	48	35	37
5-6pm	68	48	99	85	79	4	54	42	47