UNIVERSITY OF GHANA

DEPARTMENT OF GEOGRAPHY AND RESOURCE DEVELOPMENT

SPATIO-TEMPORAL ANALYSIS OF ROAD TRAFFIC ACCIDENT ON THE ACCRA-TEMA MOTORWAY: CAUSES AND RISK FACTORS

BY

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DECLARATION

I hereby declare that this thesis is my own work. To the best of my knowledge, it contains no material previously published by another person, nor material which has been accepted for the award of any other degree from the University of Ghana, except where due acknowledgement has been made in-text.

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DEDICATION

This thesis is dedicated to the Almighty God. I also dedicate it to my late father, Mr. Raymond Gumah; my mother, Lardi Gumah; my Uncle, Professor Gabriel Abudu and all my siblings – Charlse, Faustina, Clemencia, Helen and Ruby. I also dedicate this thesis to all the many lives that are lost through Road Traffic Accidents and their families.

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ABSTRACT

Road transport faces a host of challenges with road traffic accidents (RTA) being notable among them and RTAs are well-known for causing most deaths in many countries. The main objective of this study was to analyse the spatio-temporal pattern of RTAs on the Accra-Tema Motorway and the extent to which motor vehicle drivers contribute to accident on the motorway. The Haddon Matrix and the Systems Theories were applied to give a holistic view of RTAs. The cross-sectional research design of the Accra-Tema Motorway for the period of three years (2011-2013) was developed. Forty questionnaires were distributed to taxi and minibus drivers through a multi-stage sampling, while 40 private car drivers and 40 passengers were also purposively sampled for the study. Seven key informants from five stakeholder institutions and 10 pedestrians were also interviewed.

The kernel density analysis performed showed there was an increase in the number of accident black spots (location of high accident frequency) on the motorway from six medium spots and one high spot in 2011 to seven medium and two high spots in 2013. The major causes of RTAs at the black spots identified on the Accra-Tema Motorway are the many illegal routes along the motorway, especially at the abattoir area and at the several U-turns at different locations. A total of 47.4% of passengers responded that drivers' attitude and the car's condition were the major causes of RTA on the motorway. RTAs usually occur when it rains and this was confirmed by the 79.2% response from drivers. Most drivers do not have a routine check of their vehicles so that only 45 out of the 120 respondents had a routine check of their vehicle. The majority (78.3%) of drivers strongly disagree that it is proper to drive above the speed limit. Pedestrians cross the motorway indiscriminately, some routinely, and this has increased the rate of RTAs on the motorway. Most of the pedestrians interviewed acknowledged that they were unaware of the illegality of using the motorway though they were not ignorant about the dangers. All illegal routes should be blocked and wrongful use of the motorway discouraged. Overpasses should be constructed for pedestrians to cross from one side of the motorway to the other and service routes should be constructed along the motorway that vehicles entering or exiting can use. There is the need for the provision and accurate positioning of road signs to make the use of the motorway safe. Drivers and other road users should be well educated to understand the rules and regulations on the motorway and also for the need to repair their vehicles routinely.

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LIST OF ABBREVIATIONS AND ACRONYMS

AMA	Accra Metropolitan Assembly
BRRI	Building and Road Research Institute
CBD	Central Business District
DVLA	Driver, Vehicle and Licencing Authority
ENVI	Excelis Visual Information Solution
ESRI	Environmental Systems Research Institute
GHA	Ghana Highways Authority
GIPC	Ghana Investment Promotion Centre
GIS	Geographic Information Systems
GPRS	Global Road Safety Partnership
GSS	Ghana Statistical Service
ICT	Information and Telecommunication Technology
IRTAD	International Road Traffic Accident Database
ITS	Intelligent Transport Systems
MTTU	Motor Traffic and Transport Unit
NASA	National Aeronautics and Space Administration

NRSC	National Road Safety Commission
NRSS	National Road Safety Strategy
PIARC	Permanent International Association of Road Congresses
RTA	Road Traffic Accident
SPSS	Statistical Package for Social Science
TMA	Tema Metropolitan Assembly
WHO	World Health Organisation

CHAPTER ONE

INTRODUCTION

1.1 Background to the Study

Transportation maintains and contributes remarkably to the economy of every country in the world (Rodrigue *et al.*, 2009; Litman, 2010). Road transport is very flexible and useful for transporting both human and goods (Rodrigue *et al.*, 2009; WHO, 2009). However, road transport faces a host of challenges with road traffic accidents (RTAs) being notable amongst them (Driss *et al.*, 2011) and are noted for most deaths in many countries (Kudebong *et al.*, 2011). For instance, in the year 2004 it was noted that RTA killed an estimated 1.2 million people worldwide, and it was responsible for injuries which accounted for about forty times the number of death (WHO, 2004). The death toll increased to 1.3 million in 2009 (WHO, 2009). Road traffic accidents (RTAs) are also found to be the prominent cause of death among the 15-29 age category (Chauhan *et al.*, 2014). This has prompted most countries in the world to take traffic safety as a priority in their transport policy formulation (Driss *et al.*, 2011; Lawson *et al.*, 2009; World Bank, 2009).

Road traffic accident is considered as one of the human induced disasters (WHO, 2004; GRSP, 2013) which is increasing at a high spate and are multidimensional and complex (Sorensen, 2007; Hosseinlou & Sohradi, 2009). Among all the determinants of RTA, the human action and behaviour is the most important determinant (Pivoosh & Swarn, 2007). There is a need for movement of people and goods (Urry & Larsen, 2011) for economic, social and political reasons. However, the need to travel increases the risk of RTAs and injuries (Peden *et al.*, 2004).

Crashes involving vulnerable road users represent a major road safety problem worldwide (Oxley *et al.,* 2004; WHO, 2013).

The tendency of RTAs to occur at a few spots on road sections usually known as 'black spot' is very common on lots of roads (Guerts *et al.,* 2005; Moon *et al.,* 2008). The identification of RTA locations is a vital process in road safety. The cluster of RTA spots can be considered as sources of critical spatial information on RTA (Driss *et al.,* 2011). In order to improve road safety, there is a dire need to identify and remove common causes of RTAs on the road system. This is done by investigating the spatial clusters of RTAs (Steenberghen *et al.,* 2010; Driss *et al.,* 2011). Analysing black spots has "implications for effective planning, disaster preparedness, and loss prevention. The highest risk areas are those in which RTAs are expected to occur most frequently and losses are expected to be highest. This provides a rational basis for prioritizing risk-reduction efforts and highlights areas where risk management is most needed" (Dilley *et al.,* 2005: 115).

According to Booth (2004), there is an increasing investigation into the use of GIS technology to manage, analyse and visualise spatial data. Identifying the RTA clusters on the roads, adopting effective means of data collection as well as manipulating the data helps most countries in the world and this is also related to probing the frequency and intensity of occurred RTA (Zhang, 2010). Many countries in the world have resorted to the use of GIS to collect and analyse RTA data for policy formulation on road transport (Liang *et al.,* 2005). Developed countries like the United States, Belgium (Moon *et al.,* 2008), and developing countries like Iran (Hosseinlou & Sohradi, 2009) and Algeria (Driss *et al.,* 2011), have advanced systems for spatio-temporal analysis of RTAs but these are less frequently found in most developing countries.

According to Lawson *et al.* (2009) and Bliss (2013), about 90% of the RTA cases and injuries occur in less developed or developing countries and 12 African countries are listed in the top 20 RTA-prone countries for cases and casualties, according to WHO (2009). The alarming rates of RTA in developing countries are as a result of the increasing population, together with the growth of car ownership and the import and use of rickety vehicles (Siaw, Duodu & Sarkodie, 2013). The rate of death through RTA per every 100,000 people is highest in Africa which has 24.1 deaths per a 100,000 population (GRSP, 2013). Afukaar *et al.*, (2003) add that, between the 30 and 49 age category, RTA is among the prominent causes of death and this group forms a critical mass of the working population. Coleman (2014) notes that US $65 billion is spent on RTA in low and middle income countries. Mwatellah (1994) opined that as compared to any other region in the world, RTA fatalities are highest in Sub-Saharan Africa which has both social and economic implications for national and regional concerns. Mwatellah (1994) further states that the region has 11% of the world's reported cases of RTA fatalities though it has only 4% of the world's motor vehicles. The death and damages cost nations within this sub-region millions of money and a significant amount of their GDP is allocated to victims of RTAs in terms of health care and awareness compaigns and the replacement of damaged parts of roads (Mwatelah, 2001).

In recent times, Ghana has been experiencing a high spate of RTAs (Nyarko, 2012) many of which occur in the Greater Accra Region. The Region in 2013 had 55% of the total RTA cases recorded nationally (GNA, 2013). The growing commercial activities in Ghana have induced an increasing trend of vehicular movement in the country which has attracted the attention of authorities and raised the stakes of safety on roads (Nyarko, 2012). The record of RTAs in

Ghana is continually increasing and this is alarming and the 2020 projections show that if the current trend persist, Ghana is likely to place third on the global level (Sackey, 2005). As car ownership increases and transportation increases in the cities of Ghana compounded by the poor traffic control system, RTAs have been increasing rapidly and have induced major economic losses (Nyarko, 2012). Nyarko (2012), again notes that averagely, 1,800 people die on the roads and more than 10,000 vehicles are involved in RTA whereas about 10,000 people sustain diverse injuries through RTAs annually. The trend of RTA in Ghana also shows that on a daily basis 6 people are killed (Sakyi, 2003). According to Sakyi (2003), victims of RTAs who have their ages between 25 and 35 years represented 25% of the total national deaths and available statistics show that speed is a contributory factor in 60% of the RTA cases recorded. Records show that RTAs in Ghana injured 63,384 people and killed 20,503 between between January 2000 and December (GNA, 2013). The statistic indicates that road safety is a major problem in Ghana and hence the need for a study to unravel the locations and causal relationship of these accidents.

1.2 Problem Statement

The Accra-Tema Motorway has been facing myriads of challenges which include but are not limited to encroachement on the motorway, high traffic growth, illegal criss-crossing of vehicles. The motorway has therefore become a death trap, as it kills hundreds of people annually (Nyarko, 2012; Adano, 2013). The growing complexity of the Accra-Tema Motorway environment increases the rate and spate of RTA occurrence (Adano, 2013). In 1991, the number of RTAs recorded was 260 with 45 deaths and this increased to 503 in 2010 with 130 people killed (Okutu, 2011).

According to Madsen (2005), identifying RTA clusters and managing black spots helps in reducing the RTAs rather than the severity of the accidents. One good way of achieving this is through the collection, archiving and analyses of RTA data. However, collection and analyses of RTAs data have not been identified as a priority nor been developed. This has over the years made the monitoring and evaluation of accident data very difficult. Identifying locations of road accidents and investigating why they occur are very crucial in developing counteractive measures. This therefore requires a detailed recording of spatial data and attributes of RTAs. According to Afukaar (2007), the location and time periods associated with individual RTA cases on a particular road is essential in making the data useful and relevant for analyses. Spatial data which can be easily updated, manipulated and analysed have not been incorporated into RTA data collection and analyses in Ghana. Black spots identification on roads helps investigating the intensity and frequency of RTAs and this promotes the advancement of road safety at a particular place over time (Sorensen, 2007). Black spot analysis through spatial data collection gives a picturistic view of the RTA situation, the pattern and the trend in space over time.

The study of the spatial distribution of RTAs has been done extensively by Driss *et al.* (2011); Deepthi & Ganeshkumar (2010); Zhang (2010); Brose (2001) whose works show the distribution of accident locations and clusters of accident revealing dangerous sections of the roads. A critical overview of the literature shows that there are limited researches on the identification of the causes and risks at the locations that demonstrate high accident distributions and which will help explain the occurrence of black spots. According to Zhang (2010), it is necessary to investigate the factors that cause RTAs and the accompanying risks

after identifying the black spots and this can be done effectively by comparing the various traffic accident-prone areas and thus understanding their similarities and differences.

Despite the strategies and tools available to aid in accident location data collection and analysis, these have not been used much in the identification and analysis of RTA black spots on the Accra-Tema Motorway. Hence, the spatial identification of RTAs on the study routes and the identification of the causes and the risks at areas where accidents frequently occur are worth investigating. Therefore, this research seeks to utilise the Geographic Information System (GIS) to investigate the spatio-temporal patterns of road accidents on the Accra-Tema Motorway. This knowledge will be a major input into any road safety management strategy and programme that will hopefully help in bringing down the frequency of RTAs.

1.3 Research Questions

1. Where are the accident prone locations on the Accra-Tema Motorway?
2. What are the major causes of accidents on the Accra-Tema Motorway?
3. What are the various risks road-users identified?
4. How effective are existing policies to make roads safe?

1.4 Aims and Objectives

The aims of this study is to identify the spatio-temporal pattern of RTAs on the Accra-Tema Motorway and also the extent to which this pattern is partly a function of risk being taken by motorists using the road.

Specifically, the study sought to:

i. Map out the spatial distribution of accident cases on the selected road;

ii. explain the patterns of accident clusters;

iii. identify the causes of RTAs;

iv. assess the risk road users take on the motorway especially sections prone to RTAs; and

v. evaluate the effectiveness of road safety policies in improving road safety.

1.5 Proposition

Road traffic accidents (RTAs) are more likely to be caused by drivers not observing road safety rules and regulations.

1.6 Rationale for the Study

This study is very relevant because the findings from the study will provide a guide for policy makers on road safety in the country.

The research will promote effective RTA data collection and provide a platform to update the data collected spatially. This will give the appropriate authorities such as the Motor Traffic and Transport Unit (MTTU) a spatial view of RTAs and at the same time provide a comprehensive attribute table for updates, queries and sharing of information. Hence there will be a centralised system of collating RTA information which can be made available to government and private institutions, to academic and research institutions for further research and access to current and previous RTA data.

Also, the research will better inform planning decisions and enhance future projections since the spatial distribution of accident cases will provide some information on particular spots on

the motorway that need special attention and repairs. This should gradually reduce the occurrence of accidents in places which used to record high accident rates.

Furthermore, investigations into the causes and available risk in high RTA-prone areas will contribute to the work of road safety institutions such as the National Road Safety Commission. The concerned institutions will be in a better position to engage in road safety campaigns and education on the appropriate use of portions of the motorway.

Vulnerable road users will be educated about road safety. This study will better inform road users, both drivers (private and commercial) as well as passengers/pedestrian on the causes and the risk that exist on portions of the motorway that spatially exhibit frequent RTAs and the cumulative effects of risk, if they persist.

1.7 Scope of Study

Considering the large extent of highways in Greater Accra and the application of GIS in this study, the research only focused on the Accra-Tema Motorway which connects the Tema Municipal Area (TMA) and the Accra Metropolitan Area (AMA). The 19 kilometre Accra-Tema Motorway is a very busy road and has increasing accident cases each year. According to Tanko (2004), the average traffic volume on the Accra-Tema Motorway is between 30,000 and 40,000 daily since there are heavy movements of vehicles from Tema to Accra and vice versa. This has increased the probability of RTAs occuring. For this purpose, the road accident data for the years 2011, 2012 and 2013 pertaining to Accra-Tema Motorway were used. The three year period was chosen because it was the first three years of the decade of road safety in Ghana in response to the Global decade of road safety.

1.8 Limitations of the Study

The first limitation of the study is the lack of absolute location accident data with the MTTU in a digital format. The available accident data describe the relative location of the accident in relation to prominent structures/companies and so forth that serve as bench marks. There is a possibility of approximation and missing some bench marks. These relative accident data were converted into absolute location by the use of the Environmental Systems Research Institute (ESRI) ARCGIS application with an in-built global positioning system (GPS).

The second limitation is the incomplete accident totals collected from the MTTU. The study required a more detailed accident data which could only be provided by the MTTU of the Ghana Police Service. However, the MTTU does not have the final RTA totals since some cases go unreported or uninvestigated. The figures show 296, 363 and 404 accident cases for years 2011, 2012 and 2013 respectively. According to an expert in the NRSC, the margin of errror between the figures collated by the NRSC and MTTU is usually not more than 5% and thus makes the statistics valid for the study.

1.9 Organisation of the Study

The study covers seven chapters which are further divided into sub-themes.

Chapter One which is the Introduction gives the background of the study, the problem statement, the objectives and the relevant questions pertaining to the study.

Chapter Two deals with the description of the study area, the history of the Accra-Tema Motorway; it's original design and emerging challenges confronting the safe use of the motorway. It also deals with the research methodologies applied to the study showing how RTA and digital data were collected, analysed and interpreted.

Chapter Three reviews related and relevant literature to understand in the broadest perspective, the issue of RTA. The chapter also reviews the related theories used in the study and the conceptual framework that defines the morphology of the study.

Chapter Four of the study presents and discusses the spatial distribution of RTAs on the Accra-Tema Motorway and highlights the temporal patterns of RTAs on the Accra-Tema Motorway. The chapter also describes the associated causes and risk factors accompanying the spatial patterns of RTAs on the motorway.

Chapter Five presents the findings pertaining to the perception of road users such as drivers and passengers on risk factors. Also, the chapter discusses road users' views on the effectiveness of policies implemented.

Chapter Six provides a discussion on the effectiveness of road safety policies in reducing RTAs and provides some statistics that indicate that RTAs are a problem on the Accra-Tema Motorway. The final chapter, Chapter Seven, presents summary of the major findings, conclusion and recommendations.

CHAPTER TWO

RESEARCH METHODOLOGY

2.1 Introduction

This chapter describes the characteristics of the study area, that is relating the Accra-Tema Motorway to the various districts it passes through detailing the economic activities that heighten the use of the motorway. The chapter also addresses the research methodology that was employed to collect, analyse and interpret relevant spatial and social data to achieve the objectives of the study.

2.2 Accra-Tema Motorway (Location and Site Observation)

Greater Accra Region is the capital of Ghana, bordered by the Eastern Region to the north, the Volta Region to the east, the Central Region to the west and finally, the Gulf of Guinea to the south (GSS, 2000; 2010). As part of plans to transform Tema into an industrial hub, the Accra-Tema Motorway which is found in the Greater Accra Region was opened in 1964 to serve as a conduit to link Tema and Accra (Amoo-Asante, 2011). The motorway is 19 kilometre in length and it is one of the oldest paved roads in Ghana made of concrete. The motorway is a 7.3 metres, double lane, dual carriageway with a central reservation area that completely separates the two carriageways. It also has 2 metres reserved shoulders made of bitumin, though it is fast degrading (Amoo-Asante, 2011). It starts from the Tema Roundabout to the Tetteh-Quashie Interchange with an original design speed of 100 Kilometres/hour. The Accra-Tema Motorway was designed to prohibit pedestrian movement, parking, stopping, U-turn and building indiscriminately close to it. The economic importance of the motorway cannot be over emphasised as it is the main route for the transportation of goods to and from the Tema harbour

and also of passengers and goods to the Volta and the Northern Regions from Accra, and the neighbouring countries (Amoo-Asante, 2011). Until recently, no road joined the motorway at any other section except the entry and the exit points. The trend of vehicular movements is unfortunately changing with more roads constructed from the Spintex road and the Adjiringano/Trassaco suburbs to join the motorway and these pose serious road safety issues. The sprawling activities ranging from farming, food vending, vehicle repair shops and industries has increased pedestrian movements and recently caused an increase in pedestrians being hit by vehicles.

Most transport systems especially road networks are found in AMA, TMA and Ashaiman Municipal Areas. Most of the roads in the various districts lack road signs and some lack speed-bumps. Unfortunately, some of the available street lights on the Accra-Tema Motorway are barely maintained and this leaves the roads dark and dangerous for driving (GSS, 2000). Recently, the Accra-Tema Motorway has witnessed different roads joining it from Tema Communiy 18, from Spintex and from the Adjiringanor/Trassaco residential areas.

The motorway serves almost all the districts in Greater Accra and passes through three major districts namely AMA, the TMA and Ashaiman Municipal. It is therefore essential to understand the characteristics of these districts which influence the flow of traffic on the Accra-Tema Motorway. The map of the study area showing the location of the motorway is illustrated by Figure 2.1.

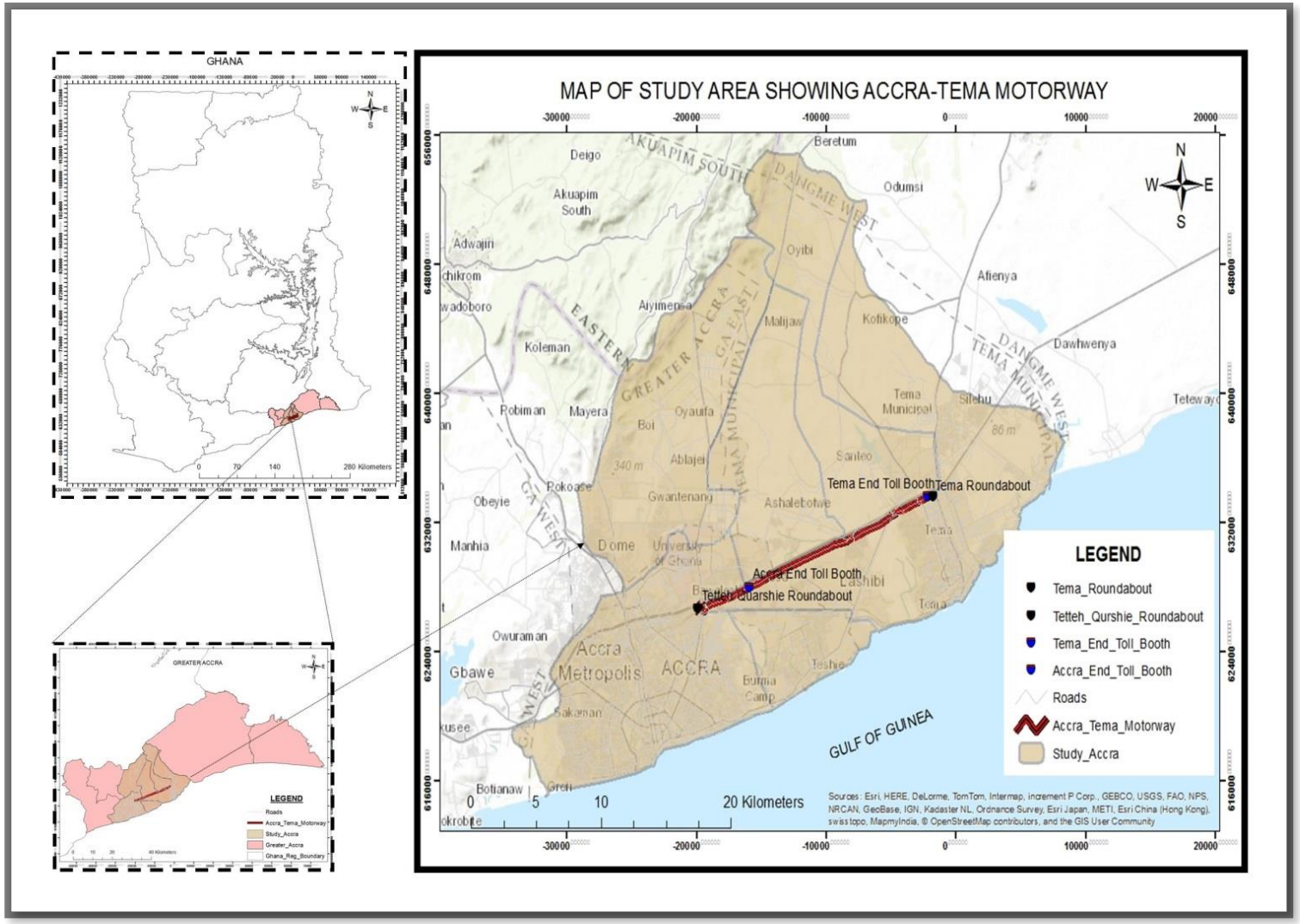

Figure 2.1: Map of Study Area

Source: Author's Own Construct, 2014

2.2.1 Socio-Economic and Demographic Characteristics of the Area

The Accra-Tema Motorway passes through the economically active districts in Greater Accra Region such as TMA, AMA and Ashaiman. There are several manufacturing and industrial activities within TMA and AMA (GSS, 2010). AMA and TMA have most of the industries in the country. The economic activities in these districts have induced more vehicular movements on the Accra-Tema Motorway and thus increased the likelihood of vehicles getting involved in RTAs or pedestrians knocked down by vehicles which explain the high rate of road accidents.

According to the GSS (2000), there are several consequences of a particular regional population size and these includes 'demographic, social and political' reasons. The population of Accra has increased from '491,817' in 1960 to '2,905,726' in 2000 (GSS, 2000) with a further increase to '4,010,054' in the 2010 national census showing a 38% increase from the year 2000. Greater Accra Region has more females (51.7%) than males (48.3%).

2.2.2 Modern Health Facilities

In terms of health facilities, records show that there are hospitals located within all communities of AMA. Notable among these are the Korle-Bu Teaching Hospital and 37 Military hospitals which host most victims of RTAs on the Accra-Tema Motorway. Population per doctor is 1 doctor to 2,686 persons in the region, far better than the national average of 1 doctor per 9,418 persons. This is however, deceptive in terms of spread because 991 (44%) are in AMA and another 83 (7.7%) in TMA. There are six public health facilities, two quasi-government facilities and about 50 Private health facilities comprising hospitals, clinics, maternity homes and health posts in Tema (AMA, 2013). It is therefore most likely that the death toll after

accidents on the roads under study will be low since the motorway connect AMA, TMA and Ashaiman and since RTA victims can get easy access to healthcare delivery (GSS, 2000; 2010).

2.3 Research Philosophy

The philosophical assumptions underpining this research needs to be clearly presented since the research has adopted the mixed method. The philosophical basis for the integration needs to be understood to determine how different data collection procedures in the research were used. According to Pierce (2008:41), both qualitative and quantitative approaches "represent fundamentally different epistemological frameworks for conceptualising the nature of social reality and procedures for comprehending those phenomena".

Qualitative research refers to the 'meanings, concepts, definitions, characteristics, metaphors, symbols and descriptions of things' (Berg, 2007:3). Qualitative research plays the role of theory development (Tewksbury, 2009; Bryman, 2007). According to Worrall (2000), qualitative research sets the theoretical stage for quantitative research and thus will continue to be secondary. Worrall (2000) adds that qualitative research is not restricted to any one correct way to collect and analyse data. The collection and analysis of data helps in detecting trends and patterns. Hence, the collection, analysis and interpretation of data under qualitative research require a degree of creativity and innovation (Worrall, 2000).

On the other hand, quantitative research focuses on the relationship that exists between variables and their numerical descriptions (Tewksbury, 2009). Tewksbury (2009:53) further states that quantitative research is geared towards and 'focused on testing the strength and persistence of relationships between distinct measures'. Worrall (2000) adds that what makes a

quantitative method of research strong and unique is it's ability to make correct predictions of expected outcomes in a research.

This research adopted mixed methods, specifically the concurrent triangulation. According to Creswell (2003); Cressswell and Plano-Clark (2007) the mixed method approach is one in which both quantitative and qualitative data are integrated in a single study by the researcher through the collection, analysis and presentation of data. Cresswell and Plano-Clark (2007) again added that, the mixed method is a research design with philosophical assumptions as well as methods of inquiry. 'As a methodology, it involves philosophical assumptions that guide the direction of the collection and analysis of data and the mixture of qualitative and quantitative approaches in many phases in the research process' (Cresswell and Plano-Clark, 2007:5). As a method, it focuses in a single study or series of studies on the collection, analyses, and mixing of both quantitative and qualitative data. This has been confirmed by Tashakkori and Creswell (2007), Creswell (2003) and Bryman (2008). Symonds and Gorard (2010) states that the triangulation of different methods provides better quality data collection and analysis by using mixed methods rather than a single approach.

Onwuegbuzie and Johnson (2004) and Tashakkori and Teddlie (2003) and many other theorists, have proposed that 'pragmatism', or the philosophy of 'free choice', is the most appropriate epistemology for mixed methods. According to Onwuegbuzie and Johnson (2004), mixed methods was claimed to be a third paradigm. The mixed method is however described by Cressswell and Plano-Clark (2007:13) as the 'third methodological movement'. When a researcher includes both quantitative and qualitative data in a study, the results may be augmented in ways that one method of data collection, analysis and presentation cannot achieve (Tashakkori & Tedllie, 2003).

The concurrent triangulation is a strategy in which the researcher collects both forms of data at the same time during the study and then integrates the information in the interpretation and explanation of the overall results. The convergence model of triangulation (Creswell & Plano-Clark, 2007; Terrell, 2011) was adopted. This means that, the quantitative and qualitative data for the study was collected and analysed separately and then the results of both compared and contrasted; and the interpretation was given (Creswell & Plano-Clark, 2007; Terrell, 2011). This leads to validity and ensures that salient issues are not left out of the data collected (Hanson, Creswell, Clark, Vicky, Petska, & Creswell, 2005). The qualitative data was used to complement and explain further information obtained through quantitative analysis.

2.4 Research Design

The cross-sectional research design of the Accra-Tema Motorway for the period of three years (2011-2013) was developed. In this regard, multiple sources of evidence on RTA distribution on the Accra-Tema Motorway was considered. This was done through the collection of both qualitative and quantitative data, and from both primary and secondary data sources in order to understand issues and to increase validity of the findings.

2.5 Research Techniques

There are several research techniques that were carried out in the study. The various research techniques that were utilised to collect data from participants included participant observation, semi-structured interviews/interviews, documentation analysis and questionnaires. Personal interviews were employed to enrich the study and provide a valuable source of information. Each technique collected data in different formats yet the purpose was to compliment not complicate the research analyses.

2.6 Data Collection Methods

Both primary and secondary data were collected in the study. The systems theory and the Haddon Matrix theory in Figure 3.3 and Table 3.2 respectively served as guides for the collection of data for the study. However, the study only extracted the methodological process of collecting RTA data in the post-crash phase of the Haddon Matrix.

2.6.1 Secondary Data Collection

Secondary data refers to second-hand data retrieved from other studies **(**Trzesniewski *et al.*, 2011; Vartanian, 2010). This means that the data obtained is from an already researched material that provides relevant information for another research and was intended for another purpose (Vartanian, 2010; Saunders *et al.*, 2009).

A careful examination of road accidents cases in Ghana from the colonial period to the present, including the development and improvement of highways, shows that authentic, credible and reliable information have their sources in secondary data. The study, therefore, made use of secondary data sources such as books, journals, magazines, newspapers, official documents and electronic materials. Also, annual reports and technical documents from the MTTU and the Building, Road and Research Institute (BRRI), the NRSC and Ghana Highways Authority (GHA) were also collected and analysed. The policy documents concerning road safety and accident was obtained from the NRSC. This helped to authenticate official documents, to obtain and analyse data on the trend of RTAs in the country, the region and the Accra-Tema motorway before and during the period covered by the study.

2.6.2 Primary Data Collection

Primary data are data that has been collected from first-hand-experience (Creswell, 2003; Hanson *et al.*, 2005). In general, there are two main sources of primary data which can be obtained from qualitative and quantitative sources. Shank (2002) defines qualitative research as a systematic empirical enquiry where issues are researched to find answers to problems/questions. By systematic he means it is well planned and ordered, following rules agreed by the qualitative community. By empirical, he means that this type of inquiry is grounded in the world of experience. Investigation into meaning says researchers try to understand how others make sense to their experience. It is often used to explore an issue and gain a better understanding of it, rather than to test or support a relationship.

Creswell (1994) has given a very brief definition of the quantitative research. He explains that quantitative research is a type that uses mathematical methods to analyse and explain different phenomena by collecting numerical data. Essentially primary data collection is about explaining a particular phenomenon through the collection of relevant numerical data and answering questions that pertain to that data.

Questionnaire

Questionnaires were designed to collect data on causes and risk related to the accident patterns on the Accra-Tema Motorway. Participation in the survey was voluntary. The questionnaire covered demographics, maintenance of the vehicles, drivers perception of risk and causes of accident on the Accra-Tema Motorway, drivers view of policy effectiveness, Crash mitigation, driver behaviour, crash involvement and crash risk. The questionnaire were semi-structured with both close-ended and open-ended questions. The close-ended questions sought to limit the

respondents to some selected options while the open-ended questions allowed respondents to provide their own answers to the given questions suggesting that a wide range of answers were expected and after that, the researcher grouped and arranged them to give meaning and facilitate interpretation. The respondents were contacted through the station masters who gave permission to distribute the questionnaires to the drivers.

Interviews

Structured interviews were organised for pedestrians and other road users who live along the Accra-Tema Motorway since they use the road frequently either by walking along, crossing or boarding a vehicle from one place to the other. Limited resource meant that only the pedestrians found within communities closely associated with the Accra-Tema Motorway such as Trassaco and Adjiringano, were considered. Key informants from NRSC, BRRI, GHA, DVLA and MTTU were interviewed to provide technical input into the research. The semi-structured interview guide was used to collect data from the key informants. An interview is a good approach that helps researchers collect and collate in-depth attitudes, beliefs, and structures or policies from individuals in charge of certain subjects or expertise (Joan & Fisher, 2005; Creswell, 2009). In the semi-structured interview, the researcher had a list of themes and questions that were answered by the respondents, although these varied from one place or organisation to another. The researcher ignored some questions in particular interviews given the specific organisational environment which the researcher faced in relation to the objective set. The questions also varied in order depending on the flow of the dialogue. Informal interviews were also used along the motorway to harness quality information from pedestrians. Key informants were served with letter of introduction stating the purpose of the study and an appropriate time were scheduled for the interview.

Observation and Photography

Observation on the field is an excellent approach to identify behaviours (Joan & Fisher, 2005). According to Tewksbury (2009:44), observation is a systematic gathering of relevant information about people, places and things through thorough 'looking at and breaking down of actions and interactions'. In the field, observations of areas along the road under study was essential. This provided several key indicators of the impact of RTAs and the location of areas prone to RTAs were more reliable than some data gained by asking people questions. Three days were used for the transect walk and this was done between the hours of 9:00 to 12:00 and 15:00 to 17:00 each day. The researcher took a transect walk for 12 kilometres in total around Adjiringano, Trasacco Estate and Kings Cottage for the first day; around Abattoi and Klagon/Adjei Kojo for the second day; the Ashaiman overhead to the Tema Roundabout on the third day. These movements were to perform the observational task. The researcher took public transport (Bus and Taxi) to observe the state of the road and also observed the human activities that have worsened and created unsafe conditions for road users. The purpose was to observe vehicular movements and their relationship with other components that contribute to RTAs. The use of a digital camera was key in collecting pictorial data of observed phenomena and behaviour. The observation and photography provided essential information which aided in analysing causes and risks along the motorway especially in areas with high accident clusters. The use of photography and observation enhanced the analysis of the road environment which provided vital information for the study.

2.6.3 GIS Data and Processes

Geographic Information System (GIS) refers to 'computer system for capturing, storing, querying, analysing, and displaying of geographically referenced data' (Chank, 2004:1).

'Geographically referenced data are data that describe both the location and characteristics of spatial features such as roads. The ability of GIS to handle and process geographically referenced data distinguishes GIS from other information systems and establishes GIS as a technology important to a wide variety of applications' (Chank, 2004:1). RTA data including precise geographical information based on location are required to detect and improve frequent accident sites on the road network under study. The efficiency of the processes depends on the comprehensiveness of the data vis-à-vis the number of accidents in different categories of severity.

Strategy

There are several methods of handling accident black spots analysis which according to (Rodrigue *et al.*, 2009) includes 'Single Site Treatment' (e.g. intersections, bends, etc), 'Route Treatment' (e.g. expressway links), 'Mass Action Treatment' (e.g. pedestrian accidents) and 'Area Action Treatment' (e.g. Central Business District). For the purpose of this study, the route treatment/action which is for express routes was considered. This method of treatment focuses on express routes that records RTA rates usually higher than regional and sometimes national rates.

The first step in this type of study was to plot the accidents on as large a scale plan as possible with great accuracy. It will almost unvaryingly be found that the accidents tend to spread evenly along the route with some stretches exhibiting clusters. The whole route is treated as a single entity, with emphasis being placed on identifying contributory factors which are common to a significant number of the accident clusters along the Accra-Tema Motorway.

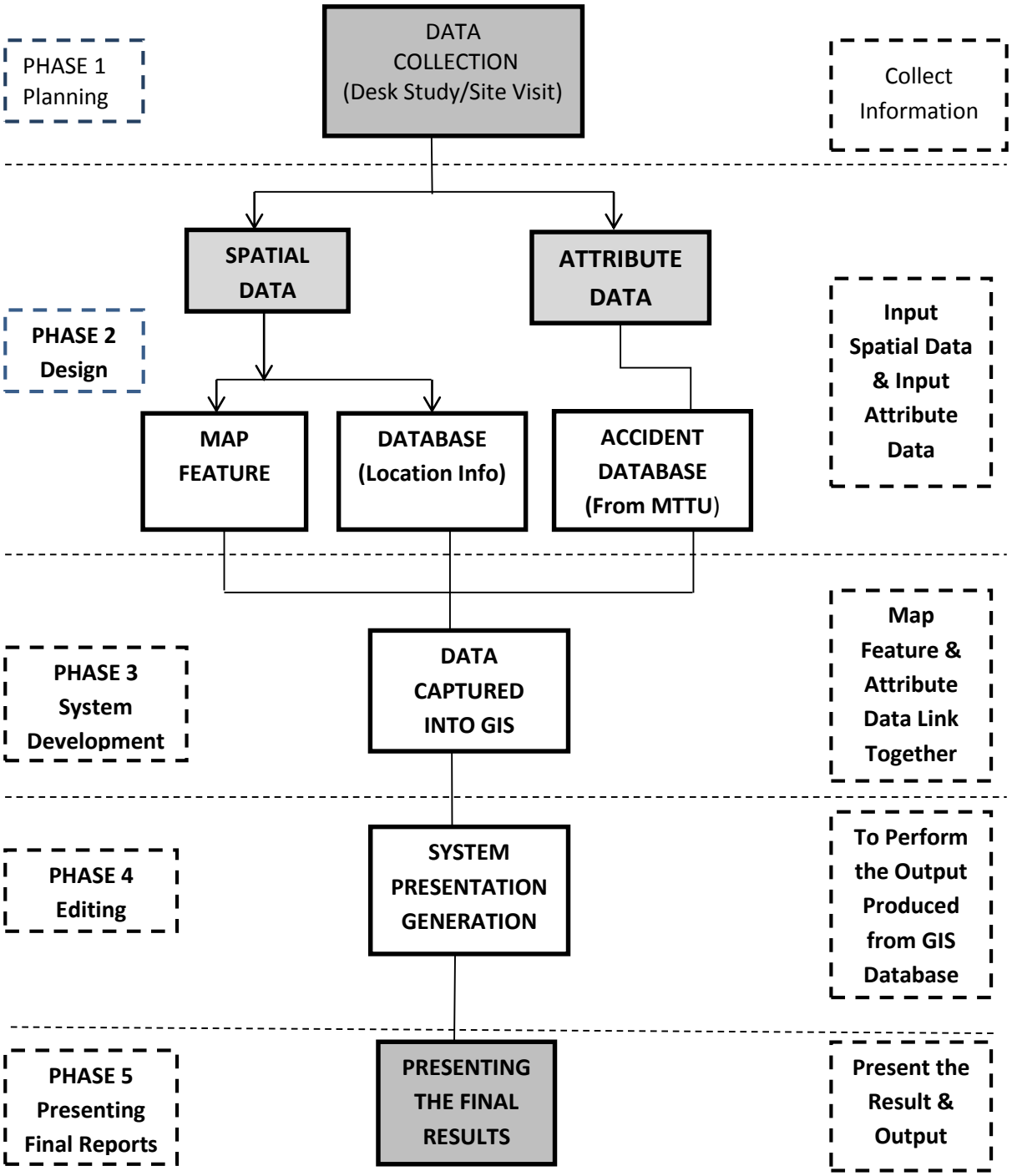

Figure 2.2: Flow Diagram of GIS Processes

Source: Adopted from Liang *et al.*, (2005)

Sources of Accident Data for GIS Process

For the study to be successful there should be the existence of a reliable and easy-to-guide database. Phase one in Figure 2.2 describes the various RTA data required for a successful GIS analysis. The most valuable and common source of RTA data in Ghana are the accident report dockets/booklets completed by reporting police (MTTU) officers at the scene of an accident. The collection of RTA data in Ghana is the responsibility of the MTTU. All accidents, whether non-injury or injury, are required to be reported and investigated by the Traffic Police at the time and scene of the accident. Essential elements of an accident report form include factual and accurate data about the accident location, the casualties and vehicles involved, the immediate environment and witness' statements.

The RTA data used for the study was the Accra-Tema Motorway accident data collected from both Airport and Ashaiman Police stations. The Airport MTTU collects RTA data from Tetteh Quashie Roundabout to Abattoir and the Ashaiman MTTU collects RTA data from Abattoir to the Tema Rounabout. The accident data collected included accident locations and their respective attributes such as time of the day, day of the week and month of the year.

Site visitation was relevant to familiarise myself with the study route and the various MTTU offices where the data would be collected. Undertaking site visitation also helped obtain useful site information, such as the name of the road, the length and width of the road, and the location indicators (Liang *et al.,* 2005).

GIS Data Processes

Locations of accidents spots with the help of information from MTTU divisions involved were identified using ESRI ARGIS software with an inbuilt GPS device. This made it possible for

all the accident points for each year to be collected. These points were overlaid on the base map with the study road after the points had been geocoded.

The base map was acquired from the GIS and Remote Sensing laboratory of the Department of Geography and Resource Development of the University of Ghana. Other satellite or settlement maps were acquired where necessary to help with spatial explanation of congestion and development along the motorway.

System Development

Attribute data is information that help geographers answer the questions, such as *where*, *when*, *what*, *who* and *how* (Liang et al., 2005) and attribute information describes the features the researcher is interested in. Attribute data are used when creating layers in GIS and can be useful in carrying out spatial analysis (Wilpen & Kristen, 2007; Chank, 2004). After using the ESRI ArcGIS application to input each accident point, the attribute table with the required fields were generated. Accompanying parametres related to the accident locations on the motorway were collected along with the digital data. These parametres form part of the attribute data for the various accidents. For this purpose, the RTA data for the years 2011, 2012 and 2013 pertaining to Accra-Tema Motorway were used. The attributes for every accident point were collected along with the relative locations of RTA on the Accra-Tema Motorway. The time an accident occurred, the months and day of the week each accident occurred were collated.

2.7 Sampling/Selection Size and Technique

Taking the context in which the research was undertaken and the nature of the research objectives, 160 respondents were sampled for the study constituting 80 commercial drivers

(both Trotro/minibus and Taxi drivers), 40 private car drivers and 40 passengers. The research used multi-stage sampling and the target groups for the questionnaire were the commercial, private car drivers and passengers who frequently use the Accra-Tema Motorway since they are familiar with the motorway. The questionnaires were distributed among five bus stations namely Tema, Ashaiman, Achimota, Madina and Lapaz stations through cluster sampling where each bus station had questionnaires for the drivers to answer. The respondents were randomly selected to fill the questionnaires because each driver who used the motorway was qualified to fill the questionnaire.

A sampling frame was not generated to inform the sample size of 80 commercial vehicles in the five stations since each transport station have different unions who register commercial drivers especially those who frequently use the Accra-Tema Motorway. The limited resources also compounded the ease with which the researcher could collate the list from all the unions operating in the various stations. Also, the purpose of the sample was not for a rigorous statistical analyses but to gather views of commercial drivers to support the spatial data analyses and explain trends of RTAs on the motorway. In view of this, equal number of drivers who frequently use the motorway from each station were selected. For the commercial drivers, the researcher randomly selected 8 taxi drivers and then 8 trotro drivers making a total of 16 drivers for each station (Table 2.1).

Table 2.1: Number of Commercial Drivers Per Station

Stations	Number of Questionnaires Per Station	Taxi Drivers	Trotro Drivers
Tema	16	8	8
Ashaiman	16	8	8
Madina	16	8	8
Lapaz	16	8	8
Achimota	16	8	8

Source: Fieldwork, 2014

However, private car drivers who live around Tema and Ashaiman were identified through purposive sampling since only the private car drivers who use the road frequently were needed. Hence, questionnaires were issued for the private car drivers with 20 drivers living in Ashaiman and the other 20 living in Tema irrespective of the community.

Eighty Passengers for each station who use the Accra-Tema Motorway were also sampled purposively to have a holistic study.

One key informant each from the NRSC, BRRI, GHA, DVLA and three officers from MTTU were interviewed. These institutions are the major stakeholders in road safety in Ghana (GNA, 2012) and experts in these institutions were in better positions to provide vital information for the study. There were three people from MTTU because, first and foremost, they deal directly with accident issues and data related to accident; secondly, information was sought from the national MTTU headquarters and one officer each from the two police stations responsible for collecting RTA data along the Accra-Tema Motorway. Ten Pedesterians along the motorway were engaged in an informal interview which was done at their own convenience.

2.8 Data Analysis

The strategy for analysing data was through a case description. Hence, the analysis of the data collected was organised on the basis of a description of the general characteristics of the issues being studied. The techniques that were used for developing case descriptions comprised of pattern matching and time-series analysis. Also, aided by an appropriate statistical tool and computer software, the study used Statistical Package for Social Sciences (S.P.S.S.) where frequencies, cross-tabulations and chi-square were generated. The chi-square was used to ascertain the significance level of driver's adherence to road safety rules and regulations.

Lastly, the likert scale was used to evaluate the perception of risk and causes of RTAs. According to Cohen *et al.,* (2000), the likert scale is a psychometric response scale which provides a range of responses to a given statement and used basically to measure respondents attitude or preferences. This shows that the likert scale gives the respondents several options to choose which makes it objective in soliciting responses (Cohen *et al.,* 2000*).*

2.8.1 GIS Data Analysis

The road attribute shapefile generated with the ERSRI ArcGIS application was joined to the road map on the study road. A kernel density method was applied to establish accident prone locations on the Accra-Tema Motorway. The data was edited by modifying and updating graphics, attribute data and maps. From the ArcMap interface, the ArcTool box provides several spatial analyses tools. To perform a kernel density analysis, the ArcTool box was selected and then the spatial anayst tools opened. The kernel density tool in the density box was opened where the shape file for each years' accident points were selected to perfom the analysis. There was a defined distance of 1000m to help project the desired results. This distance was chosen

based on the distance of the motorway (19 kilometre) and how clustered the individual RTA points are to one another. The motorway was divided into nineteen sections to perfom the kernel density. The output showed the number of RTAs within each kilometre and how clustered they were. After the analyses were completed, a GIS database was obtained which consist of a well-designed map for visualisation and a well-organised attribute table for querying. The patterns of accidents for each year and the kernel density analysis were displayed. Maps from the query were exported into JPG file and inserted into the study.

2.8.2 Remote Sensing Data Analysis

The tools used for this analysis includes ENVI 5.0, ArcMap 10.2 and Google Earth. To observe the trend of change along the motorway for 1985, 2002 and 2013, Landsat images were acquired and appropriately used. Using ENVI 5.0, bands 3, 2 and 1 of the Landsat images were calibrated to reflectance and stacked. The images gave a coloration as shown in the Table 3.3 below:

Table 2.2: Coloration of Generated Images Using ENVI 5.0

Ground Cover Type:	**In Natural Colour (3,2,1), Appears:**
Trees and bushes	Olive green
Crops	Medium to light green
Wetland vegetation	Dark green to black
Water	Shades of blue and green
Urban areas	White to light blue
Bare soil	White to light gray

Source: Author's Own Contruct, 2014

An area of 1 kilometre width around the motorway was digitised in Google Earth and exported to ArcMap to be converted from KML to shapefile, this was used as a subsetting polygon. The images were then subsetted with the motorway area polygon. The subsetted image was then taken through a supervised classification in which four classes were obtained. These classes included settlement, vegetation, water and bare land. The classified images were then masked to produce an image bordered by the motorway area polygon. The trend of change in the various classes was ascertained by using the change detection tool in ENVI 5.0. The Accra-Tema Motorway with 1 kilometre corridors on both sides of the road was extracted from Google Earth. This was randomly selected since the reserved corridors for both sides of the motorway are less than 1 kilometre (500 metres for each side) and using the reserved length of 154 metres it would not be clear within the scale used.

CHAPTER THREE

REVIEW OF RELATED LITERATURE

3.1 Introduction

This chapter describes related literature to the study. The literature elaborates on the techniques, methodology and policies/strategies used by other researchers, institutions and countries to solve complex and diverse road safety issues. The chapter also addresses the theories relevant to the study and the conceptual framework that guided the study.

3.2 Transport, Development and RTA

There is an unprecedented increase in the demand for motorised vehicles, especially in the developing countries where there is rapid economic growth (Bekefi, 2006). As the economy of nations grow, there is usually the demand for effective, flexible and faster modes of transport as a result of the per capita GDP growth (Bekefi, 2006). 'Additionally, increasing motorised mobility fosters a feedback loop in which the need for better roads propels the expansion of infrastructure assets, which in turn drives GDP' (Bekefi, 2006:5). RTA occurrence and carnage become inevitable when the increasing motorisation and mobility is not accompanied by appropriate strategies to enhance road safety (Bekefi, 2006).

In Ghana, road transport facilitates the movement of people, goods and services (Adu, 2009). The Accra-Tema Motorway is a conduit for transporting people, services and goods from Tema to some parts of the country and across the borders of Ghana to neighbouring countries such as Cote D'lvoire, Togo and Burkina Faso. According to Addo (2006), the economic development in every country has a direct relationship with the number of transport facilities. There is a

greater advantage of economic boom if the available transport facilities are diversified and well distributed. Adu (2009) explains that, transport is a catalyst for the acceleration of socio-economic development. This implies that, road transport facilitates the growth of other sectors such as industry, health, mining, trade and agriculture which all tend to increase the per capita income. McKinnon (2006), however, adds that while the economy grows, there is a need for an accompanying high capacity, high speed and reliable transport network that can accommodate the increasing number of vehicles that ply the road. This view is also supported by Addo (2006) who reinstates that there are different stages of development and each stage requires that, authorities provide a definite capacity of transport to achieve it's optimum potential.

In many developing countries there is an increase in urbanisation and the number of vehicles are likewise increasing. This has led to the increase of RTAs on 'road networks that were never designed for the volume and types of traffic which they in current times are required to carry' (Mustakim, Yusof, Onn, Rahman, Samad & Salleh, 2008:122). This problem is compounded by the unplanned urban growth which has eventually led to the incompatibility of the road system with other land uses such as housing, industries, among others, which lead to conflict between vehicle and pedestrian (Mustakim *et al.*, 2008).

3.3 Global Patterns of RTAs

According to Bekefi (2006) and Murray, Pratt, Hingston and Dubens (2009) road safety is both a problem of public health and it pertains to issues of the economy. Bekefi (2006) further describes road safety as the 'hidden epidemic' which he claims have been neglected over the decades by governments globally especially in the developing world. According to a WHO & World Bank reports cited in Bekefi (2006), deaths from non-communicable diseases are

expected to climb from 28.1 million a year in 1990 to 49.7 million by 2020 (an increase in absolute numbers of 77%).

Road traffic crashes will contribute significantly to this rise. According to the report, in 2020, injuries caused by RTAs are predicted to move from the ninth position to third place in the order of disease burden ranking.

Table 3.1: Projected Ranking Order of Disease Burden from 1990 to 2020

1990			2020
Lower Respiratory Infections	1	1	Ischaemic heart
Diarrhoea	2	2	Unipopular Major Depression
Perinatal	3	3	Road Traffic Crashes
Unipopular Major Depression	4	4	Cerebrovascular
Ischaemic heart	5	5	Pulmonary
Cerebrovascular	6	6	Lower Respiratory Infections
Tuberculosis	7	7	Tuberculosis
Measels	8	8	War
Road Traffic Crashes	9	9	Diarrhoea
Congenital Anornalies	10	10	HIV

Source: Bekefi (2006:10)

According to the National Road Safe strategy-NRSS III (2011), the average global population at risk was 18.8% for road traffic injury and fatalities as modelled by the WHO. A WHO (2004) report shows that 1.2 million people die annually. Road traffic accidents also injure and disable millions of people globally, especially in low-income and middle income countries. This leaves about 20-50 million people injured (Bekefi, 2006; WHO, 2004). According to GRSP (2012), 80% of the deaths recorded globally are within middle income countries and yet they have 52% of the world's vehicles.

3.3.1 Global Road Safety Strategies

According to GRSP (2012) and Bekefi (2006), in 1999, the World Bank established the GRSP to bring together government organisations, civil society and other business organisations to

help contribute meaningfully in promoting road safety globally. According to the GRSP report in 2004 as cited in Bekefi (2006:17), the 'principal objective of the GRSP is to facilitate the sustainable reduction of RTA in developing and transitional countries through partnerships between business, civil society and government'. The GRSP works in ten countries (Bekefi, 2006) of which Ghana is an integral partner and they only operate in a country upon the concern and invitation of the government of the country.

The United Nations during the 64th general Assembly passed a resolution proclaiming the decade of Action for Road Safety from 2011 to 2020 (GRSP, 2012; IRTAD, 2011; NRSS III). This tackled road safety at the national, regional and global levels with the aim of stabilising and putting up strategies to reduce the increasing levels of RTA fatalities. According to the NRSS III (2011:13) safe system approach are the guiding principles to promote and achieve the goals of the action which challenges all member countries to implement activities that aim at improving road safety especially those pertaining to 'road safety management, road infrastructure, vehicle safety, road user behaviour, road safety education and post-crash response'. This makes the action more holistic in its perspectives. It is important to note that by using a safe system approach, there is a shared responsibility and more of these responsibilities will be shifted from 'road users to planners, engineers, road managers and politicians' (NRSS, 2011:12). This means that when these governments, agencies, educationists, civil societies and engineers perform their function, road users will also be mandated to take full responsibility to follow the regulations and rules in their respective countries.

As evidenced by recent road safety strategies, such as the Australian National Road Safety Strategy 2001-2010 (Australian Transport Council, 2000), the Swedish Vision Zero and the

Netherlands' Sustainable Safety approaches, road safety policies and strategies are now gaining credence within the domain of road transport (Stanton & Salmon, 2009; WHO, 2004).

3.3.2 RTA Causation

There are several definitions of RTA that can be explored in literature to help understand the subject matter. Taylor *et al.,* (2000:6), defined RTA as any 'incident which occurred on a public road and which involved injury to the driver or another person and/or damage to property or to the vehicle being driven'. Similarly, Hakkert and Braimaister (2002:8) define RTA as an 'event in which at least one-motor-vehicle is involved, that occurred on a public road and which resulted in injury'. These reseachers do not include damage to property or vehicles as perported by Taylor *et al.* (2000). Both studies however, neglect the carnage associated with RTAs, which is also critical. Road networks are convenient and flexible and hence frequently used for transporting people and goods from one place to another (Ito *et al.*, 2001). However, the frequent movement of vehicles increases the constant risk of RTAs which has multivariate causes.

Understanding the causative factors of RTAs provides the most effective way of reducing RTA. The occurrence of RTA is due to a 'confluence of complex, interactive elements' (Bekefi, 2006:6) and rarely from one single factor (Guerts *et al.*, 2005; Sayed & Abdelwahab, 1998). Causes of an accident stem from several underlying factors which tend to increase the risk of RTAs which include reckless driving (Ayeebo, 2009), environmental factors and roadway conditions (Mustakim *et al.,* 2008). Atta (2013) supports the stance that RTAs occurs because of the 'recklessness', 'carelessness', 'overconfidence' and 'illiteracy' among others on the side of drivers and usually of wrong overtaking especially on the highways such as the Accra-Tema Motorway.

Radin (2005), adds that RTAs are always preceded by situations in which one or more road users have failed to cope with their environment. This is highlighted by Liang et al., (2005) who observed that most RTAs that occur on the highways are as a result of error and careless driving and walking on the part of drivers and pedestrians respectively. From another angle, Bekefi (2006) explains that RTAs also occur as a result of improper lane separation for the various categories of road users such as drivers, pedestrians, motorist and cyclist, improper restraint, damaged/faulty vehicles that ply the road and unsafe driving behaviours. By 'improper separation' he means that pedestrians should have a proper located zebra crossing, overhead walkways and reserved shoulders for walking; other motorist and cyclist must also have reserved routes for independent driving. By faulty vehicle he opined that vehicles that are not road worthy should not be allowed to ply the roads, those that also break down in dangerous locations should be removed immediately, with all urgency.

Bekefi (2006) also tackled the issue of institutional failures and commitments. He stated that poor legal capacity also contributed to the problem we face in road safety. There must be the appropriate legal backing and enforcement through the establishment and effective implementation of laws. The various authorities should be empowered and also see to it that the accepted laws are implemented and adhered to without compromise and favour. Despite the many human errors and irregularities, proper institutional commitments can minimise the mistakes and gradually make roads safe.

3.3.3 Composition of RTA Crash Contributing Factors

It is noted in literature that most accidents are caused by human error with fluctuating contributions from the road design, environmental factors and other road infrastructure problems such as poor lightening systems. According to the PIARC (2003) as shown in Figure

3.1, the highest contributing component of the road system to RTAs are the human road users with about 93% which indicates the interaction between both road factor and human behaviours (26%) and both vehicle and human behaviour (6%) and all the three factors standing at 4%. This indicates that human behaviour alone is 57% which is very significant. The road users are categorised into motorist, cyclist, passengers and pedestrians. The PIARC (2003) shows that road factor only is 3% and vehicle only is 13% to the occurrence of RTAs.

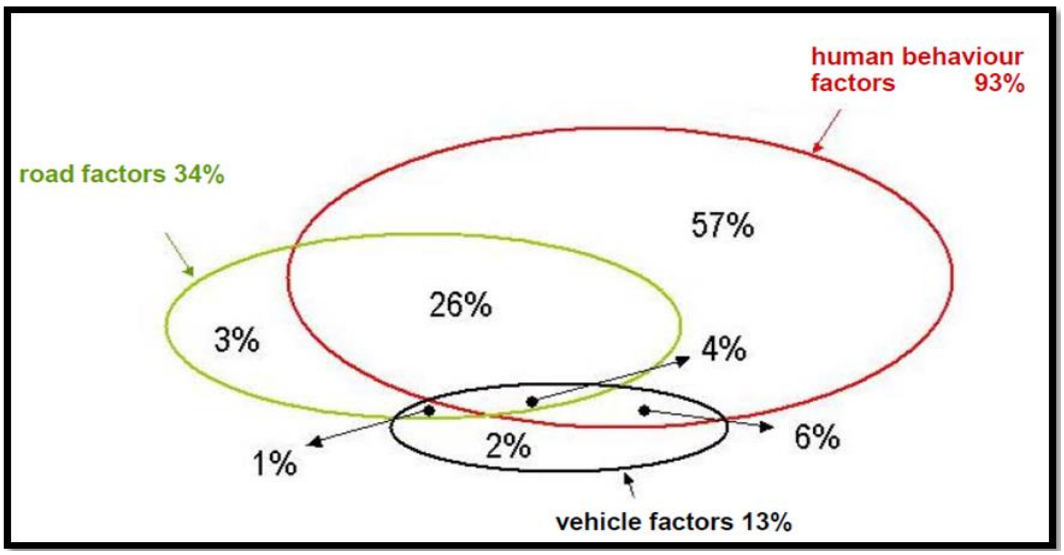

Figure 3.1: Factors Contributing to RTAs

Source: PIARC (2003:6)

According to Bekefi (2006:10), 'the combination of unsafe vehicles, poor road conditions, and unsafe driving habits' as speculated by the PIARC (2003) causes RTA which kill and injure road users on roads, sometimes immediately and in the hospital at the post-crash phase.

3.3.4 Risk and Risk Taking Behaviours

Risk is basically the tendency of an occurrence (McCarthy, 2011). According to Hakkert and Braimaister (2002), there is no one definiton of risk and therefore researchers must define risk in the context of their study. Risk, according to Hakkert and Braimaister (2002) is the possibility

that RTA will occur on a particular road as road users are exposed to and interact with the road environment. The behaviour of road users forms key determinants in understanding risk. This is because the frequency of a particular behaviour or the frequency of mobility increases the probability of an RTA occuring. 'Risk is often used to describe the level of safety in transportation systems by incorporating a measure of exposure, such as traffic flow' (McCarthy, 2011:6).

3.3.5 Effects of RTAs

In the last century, 3 million people died as a result of RTAs globally (Fiander, 2001), and it is estimated that between 30 and 45 injuries occur for every road death, many involving permanent disability and high lifetime cost of on-going care, support and lost earnings. It is evident that victims of RTAs and communities have to spend enormous amounts of money on health care and funerals (Bekefi, 2006; GRSP, 2012). Bekefi (2006) adds that the age group that suffers the most deaths and injuries is the productive age group (15-44 years). Fiander (2001) reveals that road users can be disabled and might in addition have psychological, emotional and economic damages when there are serious injuries.

Developing countries, according to Bekefi (2006), are and continue to be the worse hit when it comes to death and injuries since most of their institutions are not functional enough to tackle RTAs at the various phases (pre-crash, crash and post-crash). WHO (2009) estimates show that road traffic injuries cost low and middle income countries between 1% and 2% of their GNP.

Ghana as a country has its toll of the negative consequences of RTAs (Sackey, 2005). This influence cuts across sectors, institutions, class of people and all categories of settlements and roads. RTAs are becoming very common and eventually depriving the nation of its valuable

human resource. Some of the impacts of RTAs are social and economic. Social in the sense that there is great loss of human resources in terms of deaths recorded and it was noted that especially men in the 15 and 44 age group die out of RTAs. These men are sons, future husbands and fathers and their death leaves a vacuum in their communities and homes (Sakyi, 2003). In addition, 'when a nation gains a reputation for dangerous or unpredictable roadways, other nations caution their visiting citizens, scholars and investors against road way travel, which discourages important commerce and foreign investment' (Sakyi, 2003). Ghana loses about 1.6 % of GDP through RTAs (Agyemang *et al.*, 2009). There is obvious damage when RTAs occur and this includes damages to road facilities, vehicular damage and cost of insurance. Millions of money is spent to cater for medical expenses of victims of RTAs in major hospitals and clinics. The majority of the victims are within the economically active age group and their loss is a cost to the nation (www.myjoyonline.com-saturday).

3.4 The Use of Geospatial Technology (RS/GIS) in the Analysis of RTAS

GIS is not a recent science (Goodchild, 1991; 1994) and it has been in existences for several decades. According to Foresman (1998), the 1960's marked the inception of Geographic Information Systems. There are several definitions of GIS identifying the various functions and elements that underpin the proper utilisation of the system (Chrisman, 2002). According to Chrisman (1999; 2002) and Maguire (1991), some researchers focus on the connection that exist in the map; some emphasise on the database and software and others put stress on the applications of GIS.

Chank (2004:1) defines GIS as a computer system for capturing, storing, querying, analysing and displaying geographically referenced data. Geographical data are unique (Goodchild, 1992)

and by using geographically referenced data, Chank (2004) refers to data that describes various features in space in terms of their location and characteristics. These data come in the form of points, lines and polygons which represent spatial features and phenomena (Chank, 2004). Chrisman (2002:12) in his quest to explore the software and data aspect of GIS defines GIS as 'a system of hardware, software, data, people, organisation and institutional arrangements for collecting, storing, analysing and disseminating information about areas of the earth'. According to Chrisman (2002) the definition includes the various characteristics of GIS. NASA (2013) stress that 'GIS is an integrated system of computer hardware, software, and trained personnel linking topographic, demographic, utility, facility, image and other resource data that is geographically referenced'. This can be well understood when the various terms within the definitions are further expanded. GIS measures 'geographical phenomena and processes; represents the measurement in a computer database and discovers new relationships by integrating disparate sources as well as confirming the transformed elements to other frameworks of entities and relationships' (Chrisman, 2002:13)

'The term GIS is now invariably used to describe a computerised system, which comprises of digital map background and layers of additional information which can be viewed in any desired combination and at any scale' (Liang *et al.*, 2005:3574). 'A GIS is a computer-based tool for mapping and analysing things that exist and events that happen on earth. GIS technology integrates common database operations such as query and statistical analysis with the unique visualisation and geographic analysis benefits offered by maps" (http://www.gislounge.com /what-is-gis/). Theobald (2007) also noted that maps serve as the basic means of displaying varied phenomena and features and their attribute confirming the definition by Liang *et al*. (2005). As an application, GIS can be defined as a 'computer application capable of performing

virtually any conceivable operation on geographic information' (Wright *et al.*, 1997). The operation makes visualisation, querying and analysis possible. However, for GIS to have the power to analyse, researchers ought to understand clearly the 'underlying digital data that is associated with the map display' (Theobald, 2007:3).

Among all the definitions reference is made to geographic data or information. This indicates that data is very critical (Chank, 2004) in using GIS as a tool in understanding spatial variation.

3.4.1 Spatial Analysis

According to Goodchild (1992), there are two different ways spatial database can be accessed and these are either by location or by attributes. By location, Goodchild (1992:33) explains that the 'spatial key is based on two continuous dimension' which can be presented in an (x, y) for accuracy. This gives the bases for spatial analysis and interpretation. GIS' ability to conduct a spatial analysis differentiates it from other spatial technologies and performing spatial analysis describes a common characteristic of GIS. According to Theobald (2007:5) 'spatial analysis is a general term which encompasses the manipulation of spatial data to examine the location, attributes and relationships of geographic features to gain information'.

There are three spatial relations which are topological, directional and proximity (Theobald, 2007; Chank, 2004) and there are several spatial analyses that range from simple to advanced forms and are used to analyse different spatial relations. Theobald (2007) explains a few of them. The first to note is the locational analysis which permits the researcher to query "what is here". The nearest-neighbour analysis utilises adjacency relations and this could be applied to accident clusters to identify adjacent accident locations. Another useful analytic tool is the proximity analysis which uses the concept of buffer around an object to determine what features

are within a certain distance range of another feature. Some of these proximity analyses include simple and kernel density analysis. This helps the researcher to answer questions like what areas along the Accra-Tema Motorway are sensitive to encroachment or exhibit higher RTAs.

3.4.2 Geographic Information Systems in Transportation (GIS-T)

Some studies describe how GIS help the integration of many transportation elements. Sarasua and Meyer (1996) envision a common and coordinated database system that will serve all aspects of transportation management such as congestion, pavement, bridges, safety, and inter-modal activities and public transportation. Martin (1993) did a similar study, in which he proves that incorporating GIS in a pavement management programme improves the reporting and analysis of data through the production of maps and graphic displays.

3.4.3 GIS Application in Road Safety and Cluster Identification

There are several names given to describe RTA clusters and the literature review shows that there is no generally accepted definition of accident clusters. Some researchers describe accidents clusters as black spots (Guerts & Wets, 2003; Mustakim *et al.*, 2005; GRSP, 2012) and others describe clusters as hot spots (Zhang, 2010). Accident locations are ranked by some researchers as accident rate which is explained as accident per vehicle Kilometre; some use accident frequency (accidents per year) and others combine the two. After identifying the accident distribution, and establishing locations exhibiting clusters, the Bureau of Transport and Regional Economy (2002) explains that the level of risk must be assessed to help classify a particular section or area of a road/highway as a black spot and the likelihood of accident

occurring on each location. Obviously, the level of risk and causes will differ from one site to another.

Works by Driss *et al.* (2011), Deepthi and Ganeshkumar (2010), Zhang (2010) and Brose (2001) delve into the spatial distribution of RTAs. They identify the various clusters on the study roads through the use of GIS. Steenberghen *et al.* (2010) further explain that the RTA distribution exhibits concentrations which could be compared to establish the causes of RTAs and to provide remedial measures. Driss *et al.*, (2011:1) in their study 'determined how, what, and where the measures of accident can be implemented by means of GIS'. They utilised GIS to understand the distribution and concentration of RTAs on a 39 kilometre road in Algeria. The data covered a period of four years (2005-2008). According to Cheng and Washington (2005) and Moons *et al.* (2009), ideally for GIS application to be effective in analysing accident data, a period of three to five years is required. The main source of data for the study was the police department and GPS used to collect the digital accident data as geospatial data (Driss *et al.*, 2011). In using the Arcview, the study utilised the spatial autocorrelation functionality to determine the concentration of accident locations into 'black zones' and 'probable black zones'. The relevant risk locations and behaviours were consequently investigated as well as other temporal analysis such as daily accidents. The strategy Driss *et al.* (2011) used was that of the route action which according to Rodrigue *et al.* (2009), is used on highways or express routes which exhibit higher accidents rates above the regional average.

Although Driss *et al.* (2011) investigated accident concentration on a single route, researchers like Deepthi and Ganeshkumar (2010) and Brose (2001) researched into accident concentration on roads within an area which according to Rodrigue *et al.* (2009), is called 'area action' where

the total accidents on each road within an area is collected and analysed to identify clusters on each road but not independently. Deepthi and Ganeshhkumar (2010) used three years' data obtained from the Kanur district police station in Kerala state in India. The study applied both simple and kernel densities methods to identify RTA prone locations. Brose (2001) on the other hand, utilised GIS to analyse five years (1994 to 1998) RTA data for La Crosse collected from the Wisconsin Department of Transportation database. After, the accident points had been geocoded and overlaid on the study area, the 'point density calculations' were performed to estimate the intensity, 'how high or low' or 'moderate collision areas' (Brose, 2001).

Zhang (2010), noted that RTAs exhibit spatial patterns as he undertook a research on areas with the frequent occurrence of RTAs in Houston. The strategy Zhang (2010) used was single site treatment which according to Rodrigue *et al.* (2009) is the application of GIS to investigate accident concentration at intersections where several roads converge and with alarming rates of accident. Zhang (2010) explained that 'network spatial weights' and 'euclidian distances' are different methods that could be used to calculate the spatial distance between accident data. Furthermore, Zhang (2010) employed Getis-Ord Gi* to categorise the data and then the results were compared by utilising the density function.

3.5 Finding Solutions to RTAs

Attaining a high level of driving safely is of paramount importance as well as putting in structures to solve and prevent RTAs from occurring (Ito *et al.*, 2001). In this vein, Liang *et al.*, (2005) explain that the probability of occurrence and severity of accidents can often be reduced by the application of proper traffic control devices and good roadway design features. According to Bekefi (2006), the evolving trend of RTA requires a rapid and proactive response.

This means that government, non-governmental agencies and other stakeholders concerned about road safety must share and implement the public policy lessons, technologies and institutional innovations that have underpinned safety improvements (Bekefi, 2006). This indicates that all stakeholders ranging from government to business, civil society and general public (Bekefi, 2006, GRSP, 2012) should be involved in planning, policy, enforcement and implementation should be actively contributing their quota to accomplish the tripartite goal of creating safer roads, safer road users and safer vehicles (Bekefi, 2006).

Liang et al. (2005:3575) argued that 'conventional accident analysis has not been effective in reducing and solving the issues pertaining to traffic accidents'. The researchers found that there is a need to identify and utilise more systematic and scientific approaches to collect accurate and reliable accident data for effective accident reduction. By this statement, the researchers meant that better information with regards to the precise locations of accidents will eventually give a good picture of the data. This will help practitioners and agencies concerned with road safety in their enforcement, education, maintenance, vehicle inspection, emergency medical services and engineering to improve streets and highways.

Researchers sometimes refer to the '5 E's approach' (Education, Encouragement, Enforcement, Engineering and Evaluation) in order to reduce road crashes. 'Education targets the road user and tries to change the attitudes and behaviour of individuals through various forms of communication. Encouragement is sometimes intertwined with education and can include some form of incentive programmes. Enforcement refers to legal actions such as traffic enforcement. Engineering describes measures taken to improve transport infrastructure and last but not least Evaluation aims to assess if the strategy used was successful or not' (Adamos *et al.*, 2009:1). Bosman (2008), however highlights only three 'Es' as very important in improving road safety

and reducing RTAs. He notes that there is a dire need for education, engineering and enforcement. By stating only three 'Es' out of Adamos *et al.* (2009) it does not necessarily mean that encouragement and evaluation are ruled out. Bosman (2008) means that as authorities educate road users, construct roads, repair damaged parts and effectively enforce regulations and rules, relevant stakeholders directly or indirectly encourage and evaluate since accountability is key in any institutional setup.

In controlling and finding solutions to curbing or reducing RTAs, drivers must be able to concentrate on and scan their environment to detect and avoid any unsafe situations (Ito *et al.* (2001). Ito *et al.* (2001), also add that the quest to achieve safety requires both passive safety measures which protect passengers and pedestrians during a collision and active safety measures which prevents accidents from happening at all.

A comprehensive and inexhaustible list of systems that must be put in place utilising electronic technologies like 'Intelligent Transport Systems (ITS)' and 'Information and Communication Technology (ICT)' are suggested by Ito *et al.* (2001:1) to assist road users in driving safely to prevent potential RTAs from occurring. Ten of these support systems are spelt out below.

1. *Support for prevention of collision with forward obstacles*
2. *Support for prevention of lane departure.*
3. *Support for prevention of left turn collision*
4. *Support for prevention of collision with pedestrians crossing streets*
5. *Support for road surface condition information for maintaining headway*
6. *Forward Obstacle Warning System*

7. *Side Obstacle Warning System*
8. *Rear Vehicle Approach Monitoring System*
9. *Lane-keeping Support System*
10. *Vehicle Dynamics Control System*

Despite the support systems that may be put in place strategically to reduce and solve road accident, Ito *et al.* (2001) emphasises that conditions of a drivers vehicle and the surroundings must be critically observed since visual distraction can interfere with 'recognition', 'perception' and other 'cognitive behaviours' when driving. Figure 3.2 illustrates explicably the connection between the information available to drivers along the highways and how there is a critical need for concentration and decision making when handling the wheels.

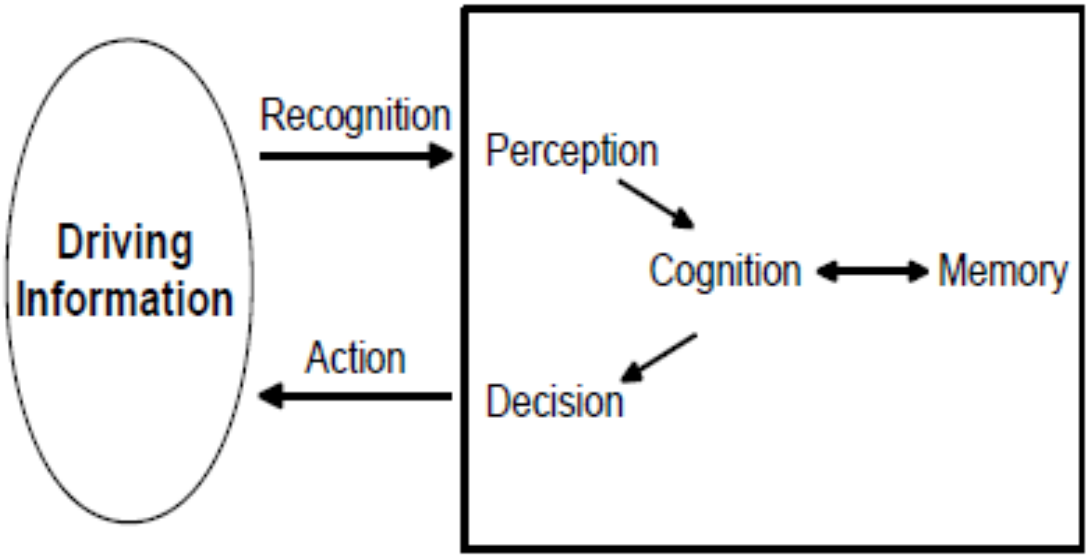

Figure 3.2: Drivers' Cognitive Behaviour When Driving

Source: Ito *et al.* (2001)

3.6 Theories of RTA

Researchers have over the decades propounded many general theories to dilate on road safety and the causes of RTAs. Among the theories known, a few relevant ones are useful in helping to develop a theoretical framework for this study. The Systems Theory and the Haddon Matrix were adopted to help explain the study.

3.5.1 Systems Theory Approach

The 1930´s and 1940´s saw the emergence of the systems theory approach which began as a 'response to the limitations of the classic analysis techniques and their possibilities to cope with the more and more complex systems being built' (Larson, 2007:16). According to Wegman (2002), in the system theory, it is possible to outline any part of the road transport as more crucial than others for the smooth operation of the system. However, this does not mean one single part can be analysed independently. There have been several approaches that focus on one component of road transport. For instance, WHO (2004), explains that the individual road-user is solely responsible when an RTA occurs. This has been supported by several works such as PIARC (2003), Sabey and Taylor (1980) and Wegman (2002). The consequences of this stance are that institutions and agencies tend to focus on the countermeasures that are mainly geared towards changing human behaviour.

However, in 'systems theory terminology, safety is an emergent property that arises when the system components interact within an environment' (Leveson, 2004:13). According to Reason (1990; 2000) and Rasmussen (1997) there have been significant safety results in the application of system theory over the years and this have improved road safety. The system theory is based on the notion that human performance is a function of many interacting system-wide factors

and not solely human behaviour (Salmon and Lenne, 2009; Ottino, 2004). According to Leveson (2002:48) systems theory 'provides the theoretical foundation for systems engineering, which views each system as an integrated whole even if it is composed of diverse individual and specialised components'.

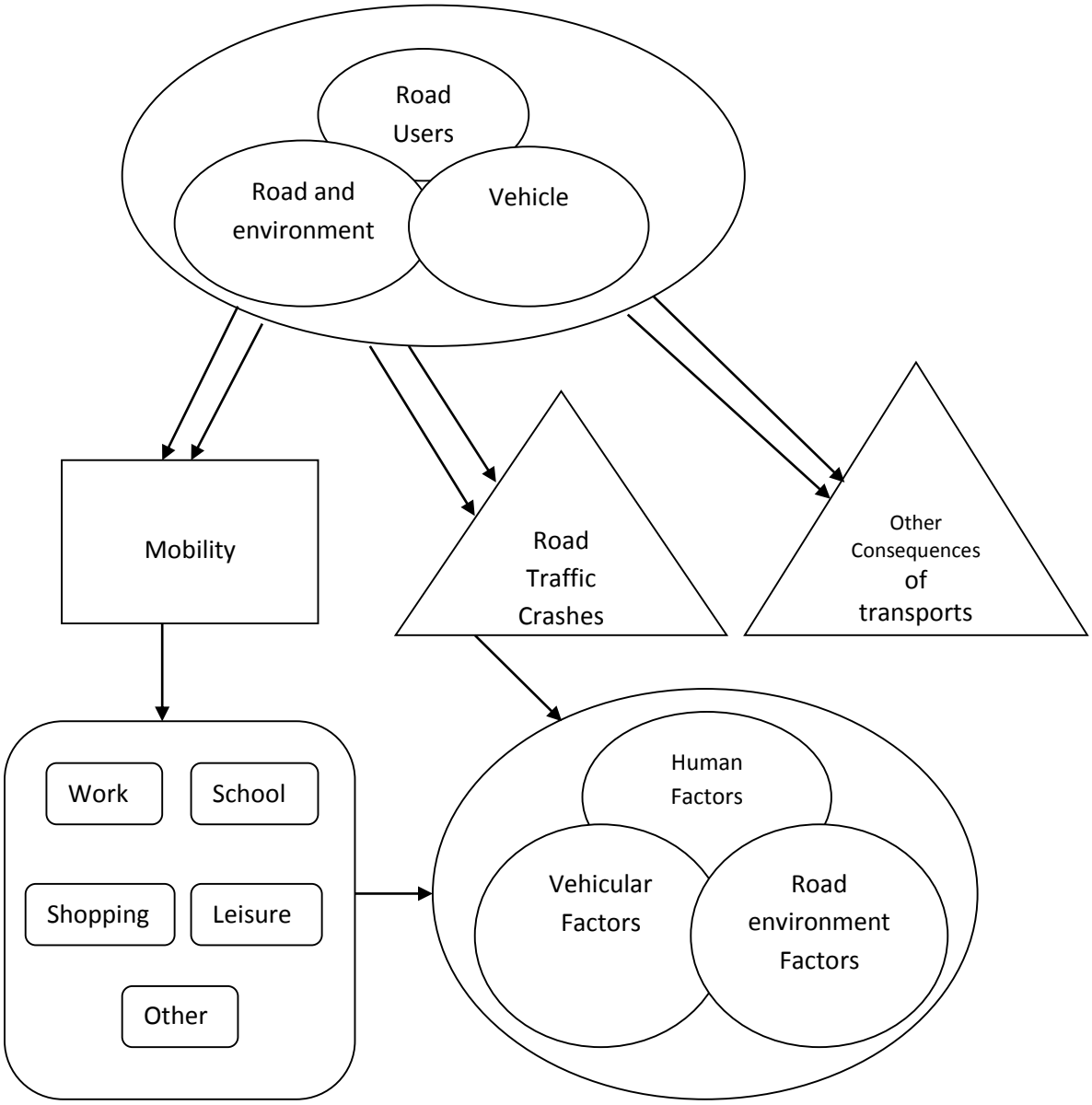

Figure 3.3: System theory to Understanding RTAs

Source: Muhlrad and Lassarre (2005)

The interaction among a number of factors and subsystems is the paramount cause of RTA. This clearly shows that none of the components in the system is independent. Every road traffic system is complex and can be hazardous to human health if the appropriate facilities are not in place and rules are not adhered to. Elements of the system include motor vehicles, roads, and road users along with their physical, social and economic environments. Making a road traffic system less hazardous requires a systems approach which helps in understanding the system as a whole and the interaction between its various elements, and identifying where there is potential for intervention. In order to prevent the present and future occurrence of RTAs, there must be a thorough investigation and finding solution to the causes of accidents through effectively and intensively identifying appropriate measures to control if not curb them (Ottino, 2004)

3.5.2 Haddon Matrix

Roads with their environment, vehicles and road users are components of a road traffic crash which results from a combination of factors related to each component and the way the individual components interact with other components. The Haddon matrix was developed by William Haddon (Barnett, Balicer, Blodgett, Fews, Parker & Links 2005). He combines the epidemiology triangle (host, agent, and environment) and 'levels of prevention' (Barnett *et al.*, 2005). The Haddon Matrix explains the causes and risk ' 'before the crash', 'during the crash' and 'fter the crash', in relation to the person, vehicle and environment" (Barnett *et al.*, 2005). Other writers use different phrases for the various phases. For instance, Murray *et al.*, (2009), uses 'pre-crash/pre-drive', 'crash' and 'post-crash' and Barnett *et al.*, (2005) puts it as 'pre-event', 'event' and 'post-event'. For the purpose of this study pre-crash, crash and post-crash will be used. According to Murray *et al.*, (2009:3**)**, the Haddon Matrix is a system based

framework which ‘appears to be the most appropriate way to make sustainable long-term improvements’ in road safety management. The Haddon Matrix also identifies why an accident occurs more frequently at particular spots than others by examining the causes and risk that accompany the areas prone to RTAs and provides remedial steps to curb the situation. Barnett *et al.* (2005), adds that the Haddon Matrix has contributed to understanding injury prevention and aided in appropriate response strategies.

The Haddon Matrix is represented in a grid format with three rows and four columns. The rows denote different phases of an accident (pre-crash, crash and post-crash), and the columns represent different influencing factors (host, agent/vehicle, physical environment, social environment). The three phases of the Haddon Matrix (pre-crash, crash and post-crash) are analysed systematically and thoroughly for human (host), vehicle, road and environmental factors (Runyan, 1998: Tom & Gallagher, 2005). Runyan (1998) shows that though the original Haddon Matrix had three columns, the recent Matrix have four columns dividing the environmental factors into the physical environment and the social environment. The physical environment deals with the road environment and design and the social environment tackles the community norms, rules and policies. Table 3.2 illustrates the Haddon Matrix**.**

Table 3.2: Format and Example of the Haddon Matrix

Phase	Host/Human	Vehicular Factors	Physical Environmental	Social Environment
Pre-Crash	Attitude, Information, Impairment/ Vision	Speed management, Proper car maintenance	Nature of road, zebra crossing, Location of overhead (Properly-designed highways), street lights etc.	Behavioural control, check drunk drivers, regulate crossing points.
Crash	Motorcycle helmets, seat belts	Use of Restraint e.g. air bags, brakes etc.	Crash protective road side devices	Mandate the use of safety glass in windows
Post-Crash	First-aid skill, Access to medic and emergency medical care	Materials that resist burning	Parking Space, Vehicle Repair centres, Repairs of damages, removal of hazards and construction	Crowd control, Ambulance services,

Source: Adapted from Murray *et al.*, (2009)

'By dissecting a problem into its dimensions of time and contributing factors, the Haddon Matrix can be applied as a practical, user-friendly interdisciplinary brainstorming and planning tool to help understand, prepare for, and respond to a broad range' (Barnett *et al.*, 2005:563) of accident distribution and clusters. Table 3.2 illustrates that the framework has three major roles to play in a sequential manner which when adhered to will promote road safety. In the first place, there is the need to prevent a potential accident from occurring and this looks at the factors that affect the host before the accident occurs. The second is to abate the possibility that injury will occur when the collision is taking place and the last phase is to reduce the unnecessary effects of the injuries sustained by the road users. Therefore, for each phase, countermeasures are developed to curb if not totally prevent accidents and injuries. There are policies and road safety measures that have generally been laid down to regulate each phase of the Haddon Matrix by the Ministry of Transport and other institutions such as NRSC, DVLA and MTTU. These policies and safety measures may involve changes in human behaviour,

vehicles, the physical environment/road design or the socio-economic environment and the means of data collection, analysis and presentation.

In the first phase, the human factors have to deal with accident prevention which identifies the causes of RTAs and the risk road users take whether they are ignorant of road signs and regulations or not; negative attitudes and their level of vulnerability in terms of age, physically challenged and so forth. The condition and use of the vehicle; road environmental factors and design as well as the perceived behavioural control and activities influences the degree, frequency and intensity of road accidents.

The second phase identifies elements or factors that increase the fatality and injury when vehicles collide or vehicles run over pedestrians. The last and third phase of the Haddon Matrix shows factors that increase the consequences of injury sustained by victims of road accidents. This shows clearly the first aid skills of the drivers, access to health facilities and/or the availability of ambulance services. When accident distribution and clusters are located and mapped out, it will help the researcher know the specific areas which records high RTAs and investigate the various factors that are spelt out in the various phases of the Haddon Matrix.

The results of elements in one phase can serve as the basis for dealing with other phases. However, there is a limitation in investigating all the elements within each factor. Runyan (2003) notes that there is a linkage between the strategies identified in the various phases, such that strategies utilised in the post-crash phase may be potentially effective as far as the pre-crash is concerned for any subsequent crashes.

3.7 Conceptual Framework

A conceptual framework is a construct or simplification of reality that aids researchers to clearly understand the systems in the world, facilitate communication and promote the integration of knowledge across disciplines (Heemskerk *et al.*, 2003; Ford, 2009; Schepers *et al.*, 2014). According to Miles and Huberman (2002; 1994), a conceptual framework showcases the 'key factors', the 'variables' and help understand the relationship that exist among the variables. The conceptual framework used for this study is adapted and modified from Schepers *et al.* (2014) which explains clearly the various components of road safety, the risk and causes; how they work together or separately to cause RTAs on highways. According to Schepers *et al.* (2014:331) a comprehensive 'framework would be useful for both road safety researchers and policy makers' (Figure 3.4).

The original framework by Schepers *et al.* (2014) also included certain theories which were not added to the adapted conceptual framework for this study. There were four main theories which were the 'travel behaviour theory' which Schepers *et al.* (2014) used to explain the link between location and travel resistance, the 'crash risk theory' and the 'injury risk theory' were together used to explain the relationship between infrastructure and vehicles, and lastly, theories explaining the link between exposure/travel behaviour and risk were included in the original framework. The study avoided the use of the afore-mentioned theories but rather included the preventive measures, behaviour management and accident data collection using GPS and GIS technology after RTAs occur. These sections were added because understanding the causes of RTA is not enough. There is a dire need to collect the spatial data and their accompanying attributes which could be analysed for predictions and planning. Also, human behaviours can be effectively managed when RTA patterns and trends are known.

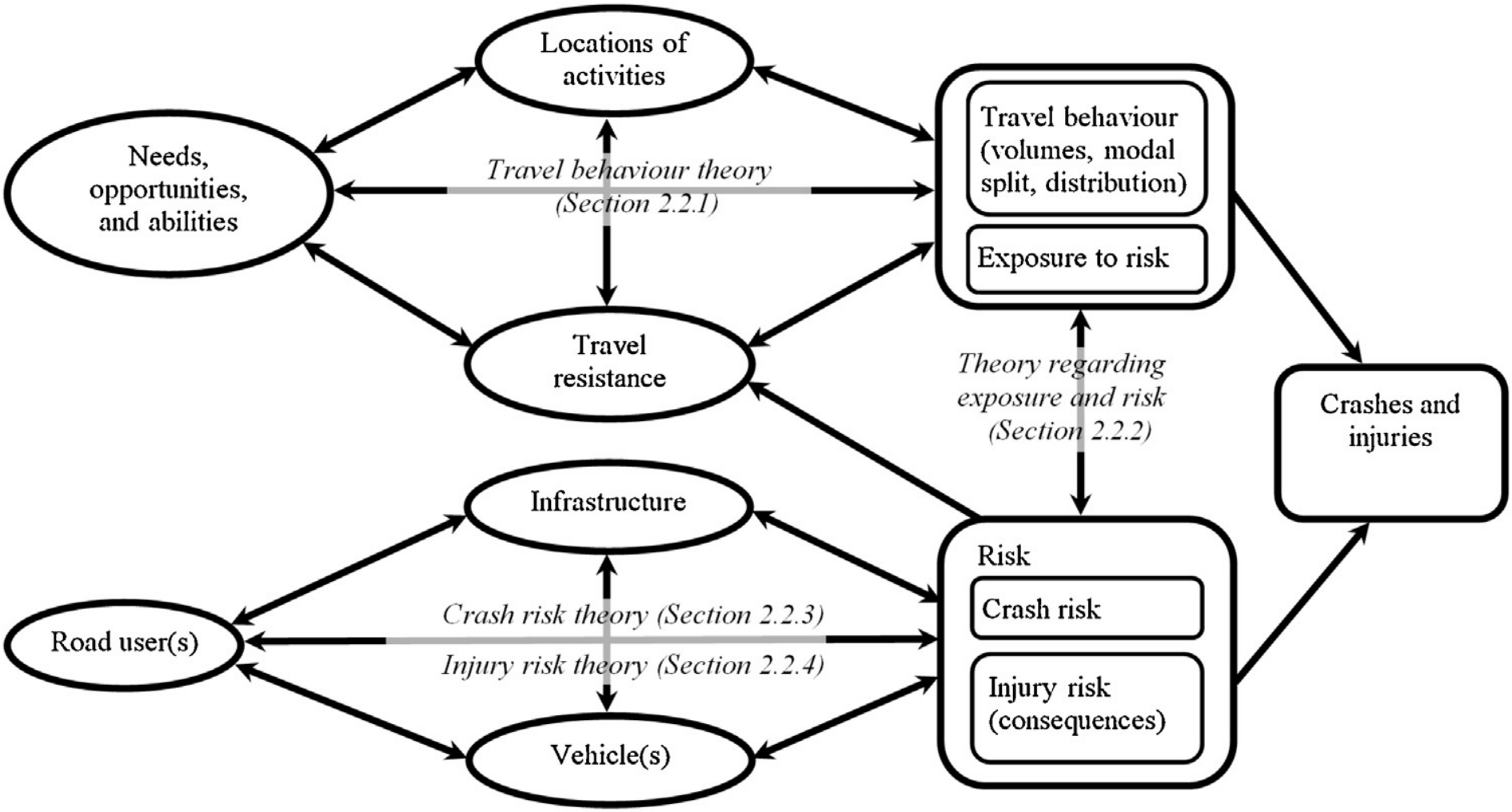

Figure 3.4: Original Framework

Source: Shepers *et al.* (2014)

According to Schepers *et al*. (2014) a conceptual road safety framework comprising factors for risk (crash and injury risk), and for exposure to risk resulting from travel behaviour (volumes, modal split, and distribution of traffic over time and space) is useful in understanding the occurrence of RTAs. It is important to note that an RTA results from exposure, risk and the interaction that exist between the human, the vehicle and the road environment. The interplay of these factors are so important in understanding road safety and accident causation that the neglect of one factor might lead to RTAs and improper policies. The original framework of Shepers et al. (2014) was modified to suit the study (Figure 3.5).

Traffic volumes, modal split and distribution of traffic over time and space usually describe travel behaviour (Van Wee, 2009). In terms of movement of people, location of activities and transport resistance such as transport cost play such a huge role (Van Wee, 2009). On the Accra-Tema Motorway, the location of activities in Tema, Ashaiman and Accra attracts a lot of movement of people on the motorway to perform activities such as living, shopping and working. Travel resistance comprises the cost of travel, discomfort, time and perceived risk. The needs, opportunities and abilities (e.g. Vulnerble road users) also affect the travel behaviour of road users. Travel behaviour determines the traffic volumes and how traffic is distributed over time and space (Van Wee & Maat, 2003). As a result, road users depending on their decision to travel are invariably exposed to risk and hazards during movement.

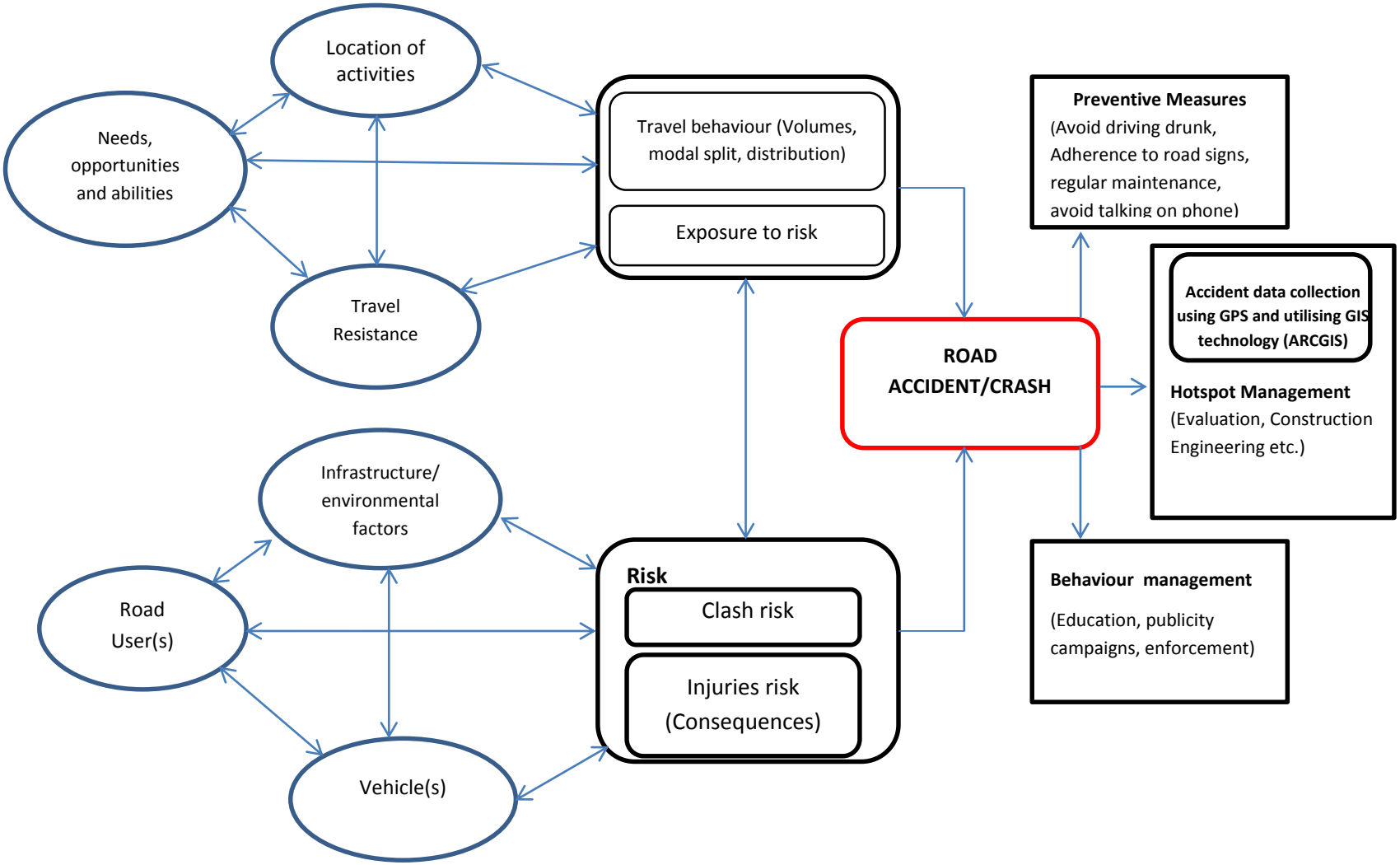

Figure 3.5: Conceptual Framework

Source: Adapted from Schepers *et al.* (2014)

On the other hand, the three road traffic safety pillars as described by Othman, Thomson and Lanner (2009) are 'road user(s), vehicle(s) and infrastructure'. According to Haddon (1980), instead of the terms road users, vehicle and infrastructure which are more appropriate for this work, epidemiologists rather use the terms host, agent and environment respectively. There is an interaction as well as conflict between these three factors. When vehicles interact with people and road infrastructure, there is a high risk of RTA and the amount of energy released will influence the risk of injury (Van Wee & Maat, 2003). The accident fatalities could be high or low according to how different categories of people tolerate the impact and this depends on sex, age, health status and other characteristics of road users involved in the crash (Oxley *et al.*, 2004).

The combined effect of each phase is RTAs or crashes. The key stakeholders of road safety such as the Police (MTTU), DVLA, NRSC, BRRI and the GHA are responsible for the prevention, management, data collection and interventions before and after RTAs. It is important to note that these actions spelt out are necessary because RTAs do occur. Hence, effective data on road accident must be collected to help road safety stakeholders identify and manage RTAs effectively to reduce the rate of occurrence and fatalities. The various mechanisms and strategies adopted to eliminate or curb RTAs when they occur are explicitly explained and outlined.

CHAPTER FOUR

SPATIO-TEMPORAL ANALYSIS OF RTAS

4.1 Introduction

This chapter analyses the occurrence of RTAs on the Accra-Tema Motorway. The chapter begins with a discussion on the Spatial Distribution of RTAs and provides a time series or temporal analysis of accident data collected over the period 2011-2013. The causes and risk of RTAs pertaining to the Accra-Tema Motorway are discussed specifically on the accident prone sections. Appropriate observations and photography to complement the data collected were included.

4.2 Spatial Patterns of RTAs

For the purpose of this study, the accident data analysis utilised all accident crashes collected by the MTTU irrespective of the type of collision or the vehicle involved in the accident on the Accra-Tema Motorway. RTA occurs on different sections of the Accra-Tema Motorway and these accident locations exhibit certain spatial patterns which show clusters or concentrations. This supports the view of Zhang (2010) that there is an existence of spatial patterns in RTA. Figure 4.1 shows the annual RTA clusters for 2011, 2012 and 2013.

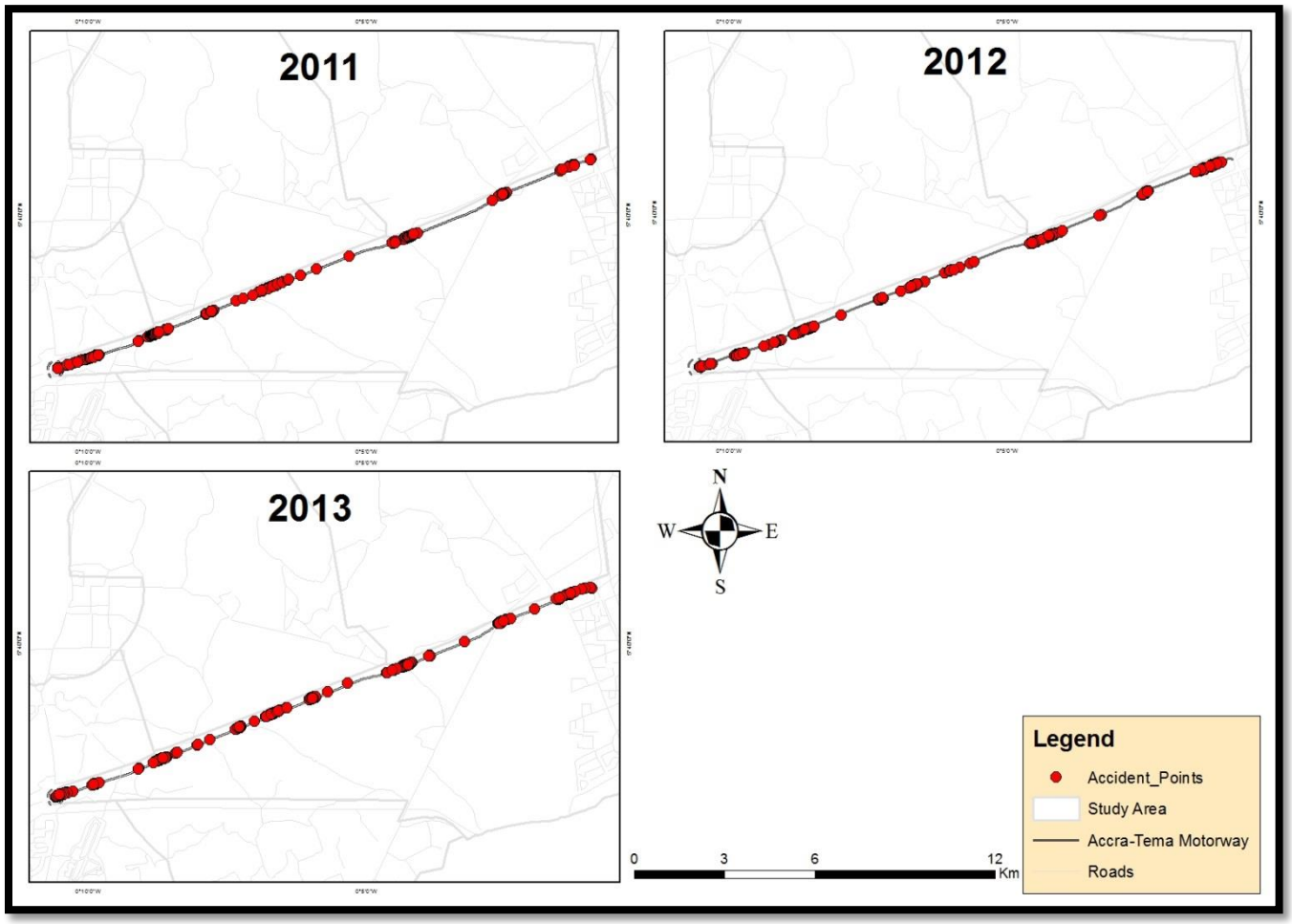

Figure 4.1: Map Showing the Distribution of RTAs for 2011-2013

Source: Author's Own Construct, 2014

The annual RTA data for 2011, 2012 and 2013 are 294, 363 and 404 respectively giving a grand total of 1,061 accidents for the three years of study. The percentage increase in accidents cases shows that accidents increased by 23.50% from 2011 to 2012 and 11.29% from 2012 to 2013. After generating the distribution of the accidents spots on the Accra-Tema Motorway, the next step was to utilise one of the spatial analysis functions in ArcGIS to conduct an accident black spot analysis. The Kernel density analysis tool was used in this study to establish accident clusters for each year and the results compared.

4.2.1 Cluster Analysis of RTA Locations

The Kernel density function in ArcGIS shows the highest concentration of road traffic accidents and areas that exhibit comparatively low concentrations. The results help to understand the patterns of road accidents rather than just looking at individual accident locations. The application of the kernel density helps to understand and identify accident prone areas. The mapping of RTA locations and identifying accident prone areas is the first and major step in reducing RTAs and improving road safety in a cost-effective way since the results allows the appropriate authorities to take action (PIARC, 2003).

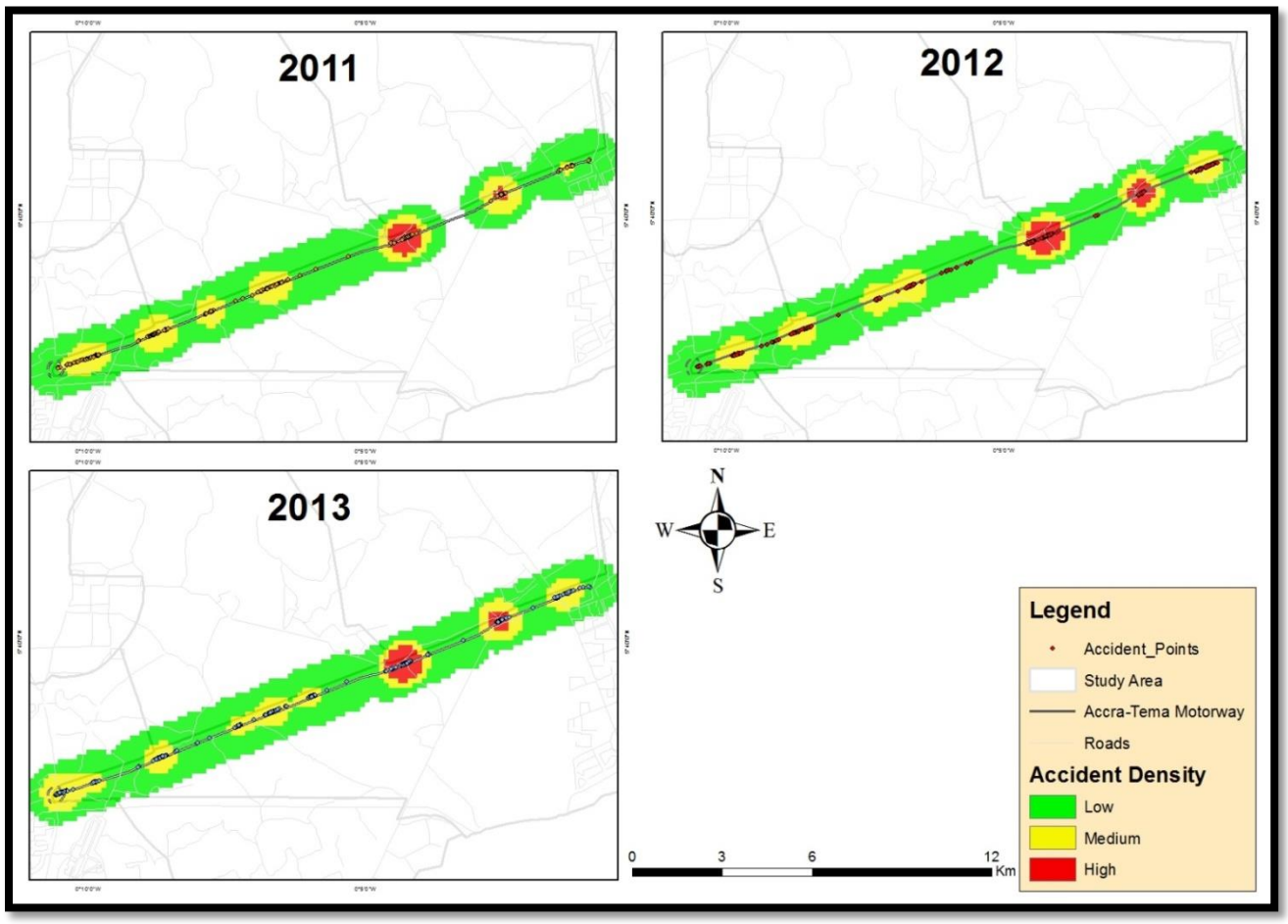

Figure 4.2: Density Mapping of Road Accident Points for 2011-2013

Source: Author's Own Construct, 2014

Figure 4.2 shows the various density levels with green showing low, yellow showing medium and red showing high. In the year 2011, the pattern of RTA locations showed that locations of RTAs were spread through the 19 kilometre motorway except for some areas especially the area between Abattoir and Klagon/Adjei Kojo. There was one major high cluster of RTA locations at the Abattoir area and other five areas with medium concentration of RTAs though the Klagon/Adjei Kojo area recorded higher than the other four areas.

For the RTA location distribution in 2012, there were two major high clusters of RTA and seven medium concentration of RTAs specifically Action Chapel, Accra-end toll booth, Trasacco, Kings Cottage and Ashaiman overhead areas. Few RTA locations are distributed in different sections of the motorway.

Records of RTA on the motorway for 2013 showthat RTAs had increased yet there were still two major high concentration of RTAs at the Abattoir and the Klagon/Adjei Kojo areas. There were about nine medium contractions of RTAs on the motorway. The distribution of RTAs in 2013 spreads widely as shown in Figure 4.2 by the low concentration of RTAs (Green Colour).

In the year 2011, there was one major high concentration of RTAs at the Abattoir area (84 accident points) and five other medium concentration of RTAs. Another high concentration was identified in 2012 at the Klagon/Adjei Kojo (76 accident points) underpass in addition to the Abattoir area (100 accident points) in the previous year. The total accident data for 2012 also saw an increase in medium concentrated zone from five to seven. There was an increasing growth of accident prone areas from seven medium areas to nine medium areas in 2013 with Abattoir (120 accidents) and Klagon/Adjei Kojo (66 accidents points) areas still exhibiting high accident records though the RTAs recorded are not similar. The Abattoir area had an increasing accidents rate but the Klagon/Adjei Kojo area increased in 2012 and dropped in 2013. The identification of the varying

black spot helps in locating the hazardous locations and predicts future similar developments (Zhang, 2010) on the motorway.

4.2.2. Cumulative Accident Data Analysis (2011-2013)

Each year's data were merged together using the merge tool in the Geo-processing to ascertain the cumulative nature of the three years' accident points collected. Figure 4.3 illustrates the total number of RTAs that occurred on the Accra-Tema Motorway and also shows the locations of areas exhibiting either a medium or high accident concentrations.

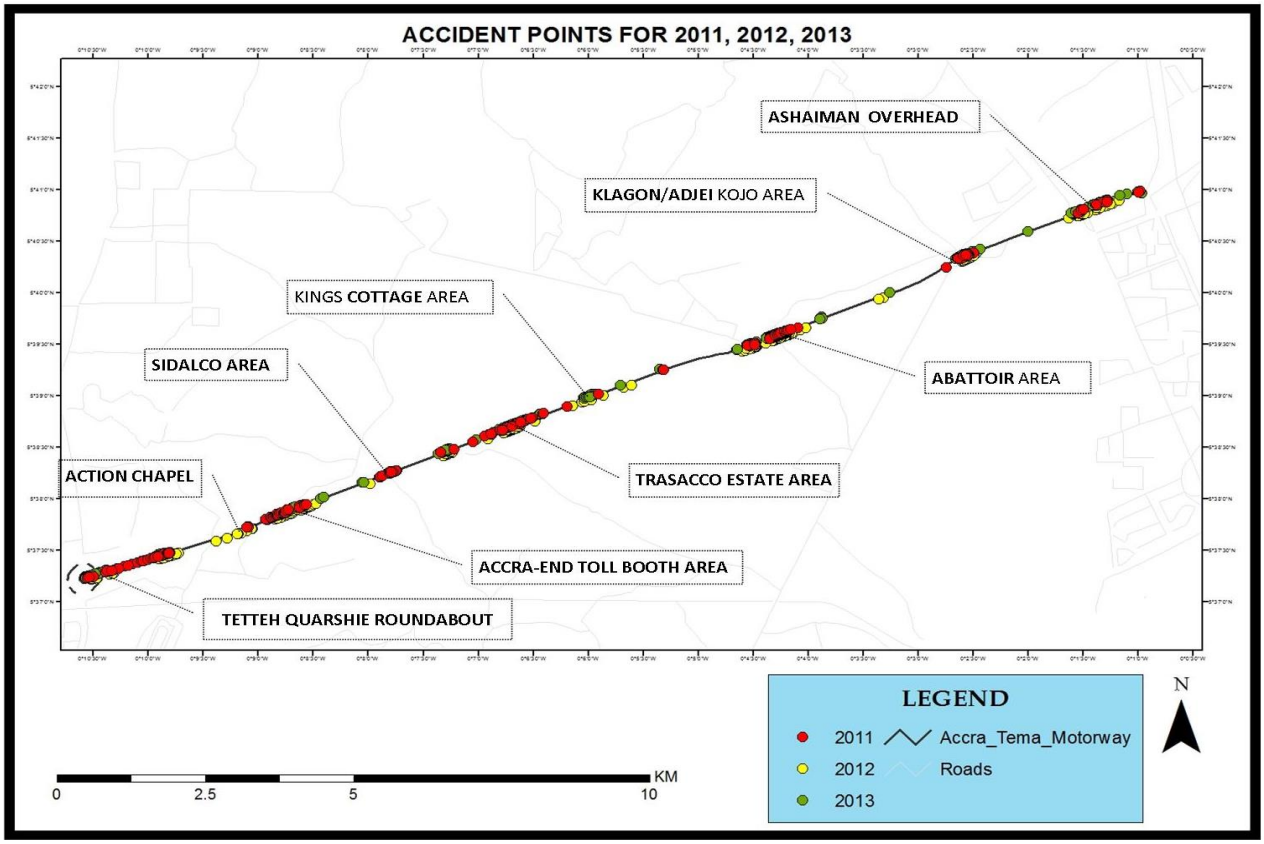

Figure 4.3: Map of Annual RTA Locations and Names of Accident Prone Areas

Source: Author's Own Construct, 2014

There are several areas within the Accra-Tema Motorway that have clusters of RTA and for easy reference, Figure 4.3 illustrates the major relative locations used by both Airport and Ashaiman Police to collect their accident locations during accidents. Those that have a high a accident cluster as seen in Figure 4.2, are Abattoir and Klagon/Adjei-Kojo areas. The rest, according to Figure 4.2, are in the medium category exhibiting different levels of clusters.

4.3 Land Use and Land Cover Changes

The Accra-Tema Motorway was originally constructed to link Tema and Accra and this formed part of the trans-West Africa Highway from Lagos to Abidjan. For this reason, the motorway was limited to vehicular movements at only the entrance and exit points (Amoo-Asante, 2011). There was a buffer zone of 500 ft (152m) on each side reserved to avoid expansion of settlement and other human activities which could impede the smooth movement of vehicles on the motorway. Figure 4.4 demonstrates the developmental changes along the Accra-Tema Motorway. In recent times, the motorway has experienced continuous growth in vehicular traffic and persistent encroachment on both sides of the motorway. The encroachment involves the expansion of industries and manufacturing companies closer to the motorway. Estate developments such as the Trasacco Estate and Kings Cottage with numerous other private houses have been constructed closer to the motorway. There is an increasing number of farmlands and mechanical shops along the motorway which have increased the rate of vehicles illegally entering/exiting via the motorway and pedestrians crossing indescriminately.

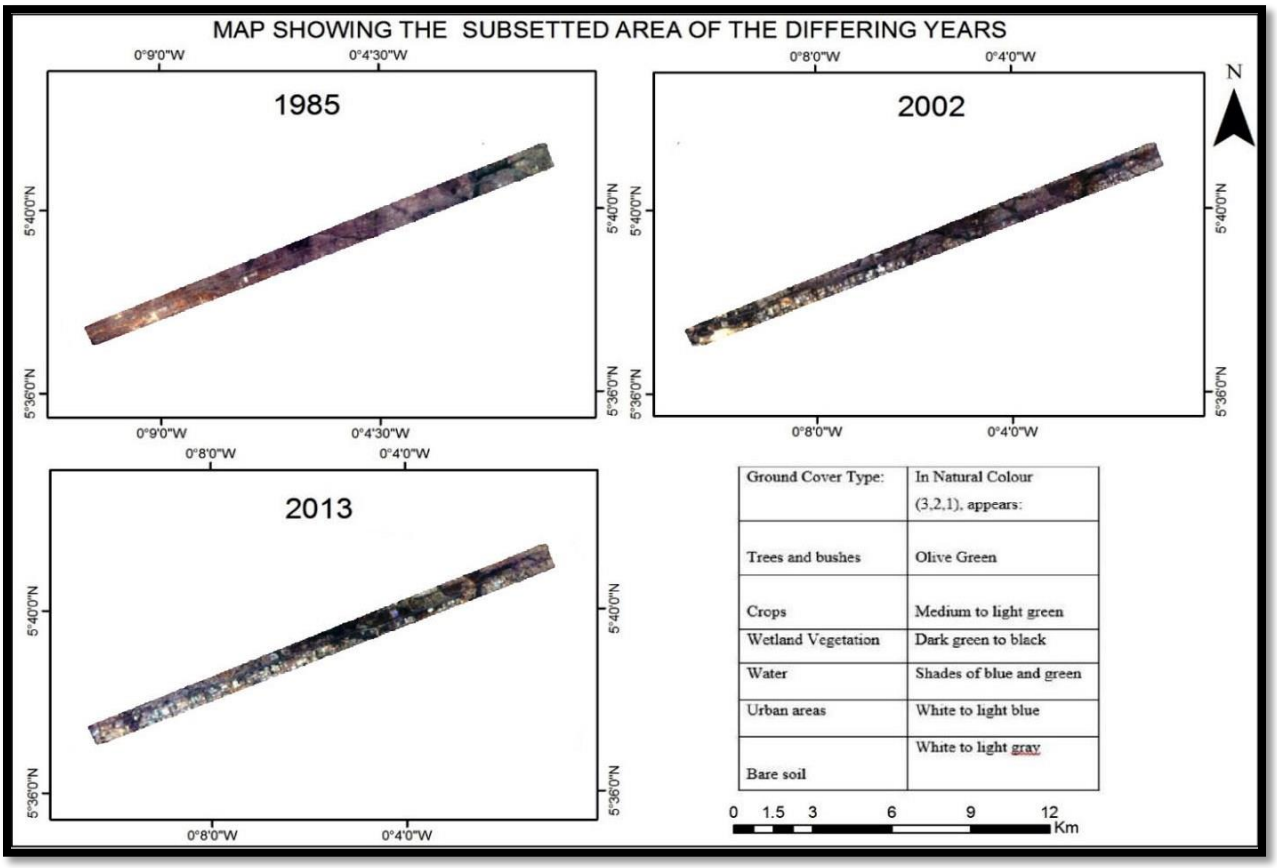

Figure 4.4: Map Showing the Sub-setted Areas for 1985, 2002 and 2013

Source: Author's Own Construct, 2014

Figure 4.4 shows the satellite maps for the years 1985, 2002 and 2013 which were obtained from the United States Geological Service (usgs.org). The map shows several ground cover types such as the built-up areas, bare lands, water, wetland vegetation, crops and trees.

4.3.1 Land Use and Land Cover Changes (1985-2013)

According to Jianya *et al.*, (2008), the use of a change detection analysis helps understand environmental changes and how anthropogenic factors have impacted the environment over the years. These maps help in classifying the necessary elements relevant for the study shown by Figure 4.5 below.

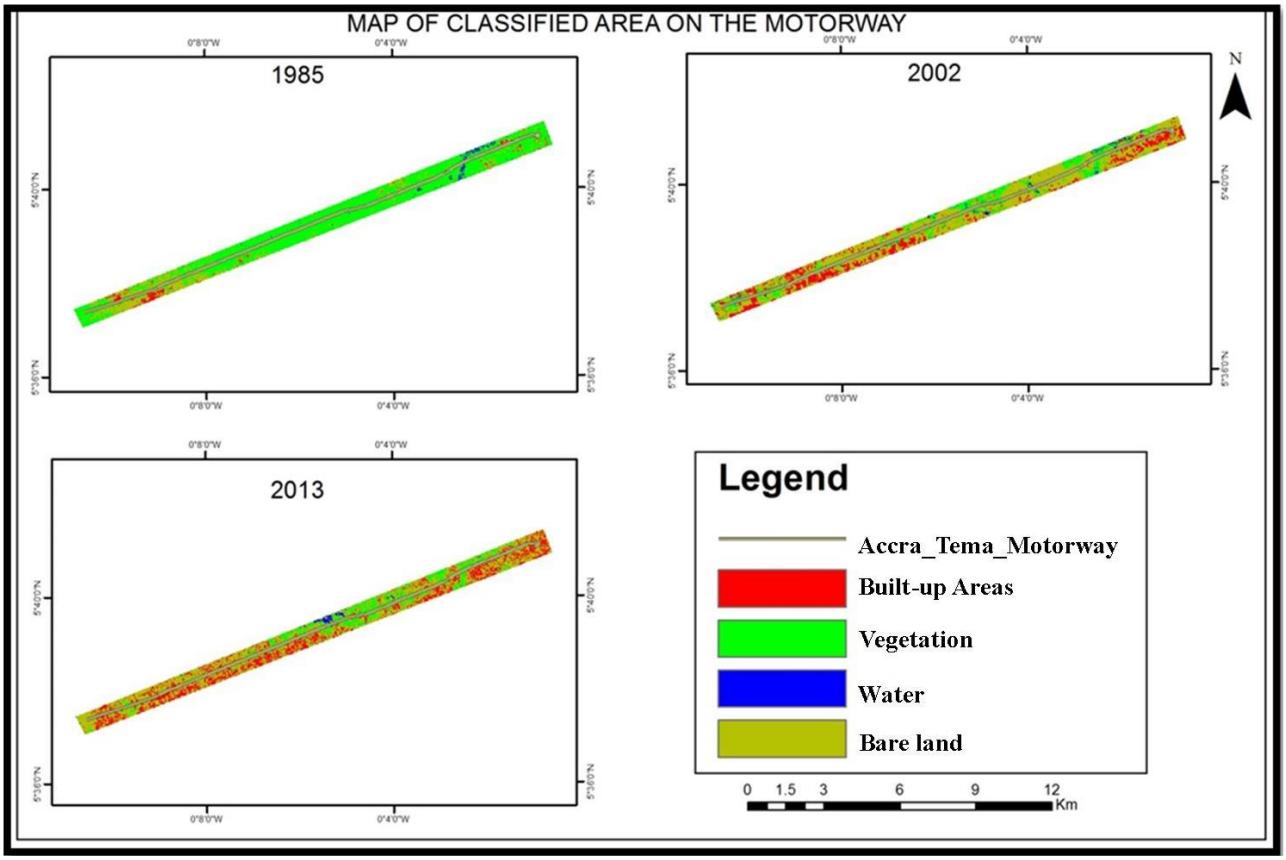

Figure 4.5: Development of Settlements along the Accra-Tema Motorway

Source: Author's Own Construct, 2014

Figure 4.5 exhibits patterns of spatial changes for the selected years (1985, 2002, and 2013) which shows the development of settlements and industries along the Accra-Tema Motorway which are represented by the red colour in the legend. After the satellite maps were acquired, the ENVI 5.0 software was used to classify the relevant features into settlement (Built-up area), vegetation, water and bare land. The maps in Figure 4.5 show the state of build-up areas for the years 1985, 2002 and 2013.

Percentage Changes of Features From 1985 to 2002

For the details of the changes, Table 4.1 and Table 4.2 were generated to detail the changes that had occurred for the periods 1985-2002 (17 years) and 2002-2013 (12 years).

Table 4.1: Change Detection Results - 1985 to 2002

Features	Percentages					
	Settlement	**Vegetation**	**Water**	**Bare Land**	**Row Total**	**Class Total**
Unclassified	0	0	0	0	0	100
Settlement [Red] 256 points	47.089	14.777	6.786	29.91	100	100
Vegetation [Green] 327 points	5.308	19.029	67.143	8.549	100	100
Water [Blue] 61 points	0.171	1.406	10.357	0.344	100	100
Bare land [Yellow] 51 points	47.432	64.787	15.714	61.196	100	100
Class Total	100	100	100	100	0	0
Class Changes	52.911	80.971	89.643	38.804	0	0
Image Difference	530.651	-77.425	-7.857	231.842	0	0

Source: Author's Own Construct, 2014

The increase in settlement area during the period of 1985 to 2002 is 27.891Km^2 which is equivalent to 530.65%. The over 100% value was due to the fact that there was so little settlements along the motorway in 1985. The 17 year period saw an avalanche-like increase in settlements along the motorway.

Percentage Changes of Features From 2002 to 2013

The degree of settlement growth along the Accra-Tema Motorway from 2002 to 2013 is illustrated statistically in Table 4.2.

Table 4.2: Change Detection Results-2002 to 2013

Features	Percentages					
	Settlement	**Vegetation**	**Water**	**Bare Land**	**Row Total**	**Class Total**
Unclassified	0	0	0	0	0	100
Settlement [Red] 299 points	45.425	11.243	5.814	21.863	100	100
Vegetation [Green] 10 points	3.231	35.12	39.535	12.85	100	100
Water [Blue] 30 points	0.217	4.723	4.264	0.311	100	100
Bare land [Yellow] 56 points	51.127	48.913	50.388	64.976	100	100
Class Total	100	100	100	100	0	0
Class Changes	54.575	64.88	95.736	35.024	0	0
Image Difference	30.79	-11.794	-14.34	-5.504	0	0

Source: Author's Own Construct, 2014

From 2002 to 2013, there was a 30.79% increase in settlement which is equivalent to 10.206 Km^2 increase in area.

The rate of change "Δ" is calculated as:

$\Delta = \frac{\Delta A}{\Delta T}$

Δ= Rate of change

ΔA= Change in area

ΔT= Change in Number of years

From the formula above, the rate of change from 1985 to 2002 is 1.641Km^2/yr and 0.928Km^2/yr for 2002 to 2013.

The change detections indicate that there has been great increase in anthropogenic activities (eg. building) along the motorway. There have not been enough regulations and traffic enforcement over the years and this has brought about encroachment leading to the various illegal entries, U-turns and the fast deteriorating shoulders of the road. The development constitutes industries, formal and temporary structures, houses, vehicle workshops and farm lands.

4.3.2 Implications of Land Use and Cover Change on RTA

According to an engineer at the GHA, '*the motorway has gradually developed to be a service road and this is as a result of the fast growth of houses and industries that has induced wrongful entry and exit of drivers on the motorway'*. The distance used in Figure 5.4 for both sides of the motorway was 1kilometre (i.e. 500 metres for each side) which is far above the 152 metres designated for the original design of the Accra-Tema Motorway. Currently, from the Tetteh Quarshie Roundabout to the Tema Roundabout, on the side of East Legon, Adjiringano, Trasacco and Ashaiman there is a reserved corridor of 145 metres which is 7 metres less than original reserved corridor. On the opposite side, the reserved corridor is 45 metres. According to an engineer in GHA,'*that side of the motorway is undergoing a rezoning in consultation with the lands commission and thus the reservation is not finalised*'. The right side of the motorway from Tetteh Quarshie roundabout to Tema roundabout has a number of industries and warehouses.

The development along the Accra-Tema Motorway has induced many drivers to illegally enter or exit the motorway to their destinations due to the many settlements that have sprung up. Also, most commercial drivers including mini bus, taxi and other cargo vehicle drivers stop on the motorway indiscriminately at unapproved areas which usually causes RTAs due to the speed difference either when stopping, taking off or taking a u-turn. The frequent movement of pedestrians, cyclist and motorist increases the risk of accident occurring on the motorway.

4.4 Temporal Analysis of Annual RTAs Statistics: 2011-2013

According to Driss *et al.* (2011), it is significant to understand the temporal dynamics associated with the location of accident points. Hence the research found it necessary to discuss for each year, the occurrence of RTAs in terms of the time of day, days of the week and the months of the year. The conceptual framework in Figure 4.4 shows that there is a high level of interaction between Tema and Accra. Since several accidents occur on the motorway which serves as an important conduit, an analysis of RTAs on a temporal bases will give a clearer understanding of the dynamics of RTAs on the motorway.

4.4.1 Temporal Analysis of RTA Data for Time of Day

Data collected for 2011 shows the number of accidents that occurred at specified time periods within 24 hours on the Accra-Tema Motorway. The analysis shows that, the time period with the highest recorded RTA is 12:00-15:00. This period recorded 62 accidents representing 21% of the total accidents for 2011 followed by the 18:00-21:00 (55 RTAs) and 15:00-18:00 (51 RTAs) which happens to be the peak hours where traffic volumes are high and people are rushing to get to their destinations.

In the year 2012, the time period, 15:00-18:00 recorded the highest (18%) of the total RTA cases with a slight margin of 1% to the second highest with 17%. Two time periods (15:00-18:00 and 18:00-21:00) recorded the same number of RTAs cases. The lowest of all the time periods was 00:00am-3:00am mid-night with only 11 RTA cases representing 3%.

In 2013, the time period between 18:00-21:00 recorded the highest (17.82%) number of RTAs followed by 18:00-21:00 time period representing 17.08%. Significantly, 21:00-00:00, 00:00-3:00 and 15:00-18:00 recorded RTA cases of 62, 59 and 60 respectively. The least accident cases were

recorded in the 00:00-3:00 time period with the reason being that there is always less movement of vehicles late at night. However, drivers agree that the high speed at mid-night has contributed to the RTAs recorded in this time period. Figure 4.6 below illustrates the comparative RTA records for time of day for 2011 to 2013.

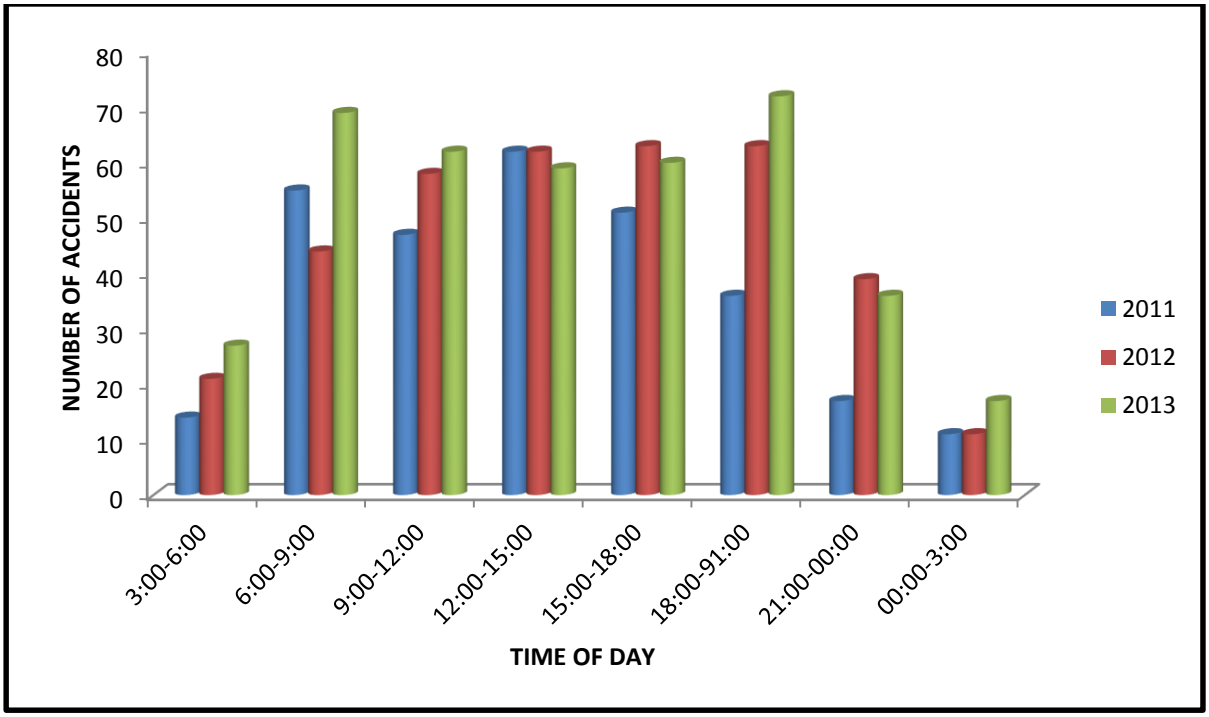

Figure 4.6: Comparative Analysis of RTA Per Time of Day

Source: Fieldwork, 2014

Generally, RTAs that were recorded during night time were less than in the day time as illustrated by Figure 4.6. This could be due to a lesser proportion of vehicles in the night though according to the Ashaiman MTTU, the less traffic induces drivers at night to take risks; a view that is also supported by drivers themselves. RTA figures in 2013 were high for all time periods except for 12:00-15:00, 15:00-18:00 and 21:00-00:00 time periods. On the contrary, 2012 recorded more accident cases for two out of the three time periods and it tallied with 2011 for the 12:00-15:00

time period. Field observations conducted revealed that drivers move at top speed during the 12:00 to 15:00 time period.

4.4.2 Temporal Analysis of Data for Days of the Week

Furthermore, a daily accidents analysis was done to identify the days with comparatively high RTA records in 2011, 2012 and 2013. For 2011, Thursdays had the slightest lead in accident records ahead of Tuesday with 49 RTA cases reported. Additionally, Tuesdays recorded 48 accident cases which show a difference of one RTA case. Other significant accident cases were recorded on Fridays, Wednesdays and Sundays with 43, 42 and 41 cases respectively. Mondays and Saturdays however, accounted for 11.22% and 11.56% of the total accidents in 2011 respectively.

In the year 2012, Tuesdays recorded the highest accident rate representing 19% (68 cases) of the total accidents for the year followed by Saturday with 59 accident cases representing 17%. This contrasts with the number of cases recorded for Saturdays in 2011 which were low within that year.

In 2013, Fridays had the highest rate of accident cases recorded for the year 2013. Saturdays and Tuesdays followed with the same number of RTA cases (63 cases each). Sunday recorded the least number of accident (42 cases) representing 10.40% of the total accident cases for the year. Figure 4.7 illustrates the comparative records of RTA for each day of the week for 2011, 2012 and 2013.

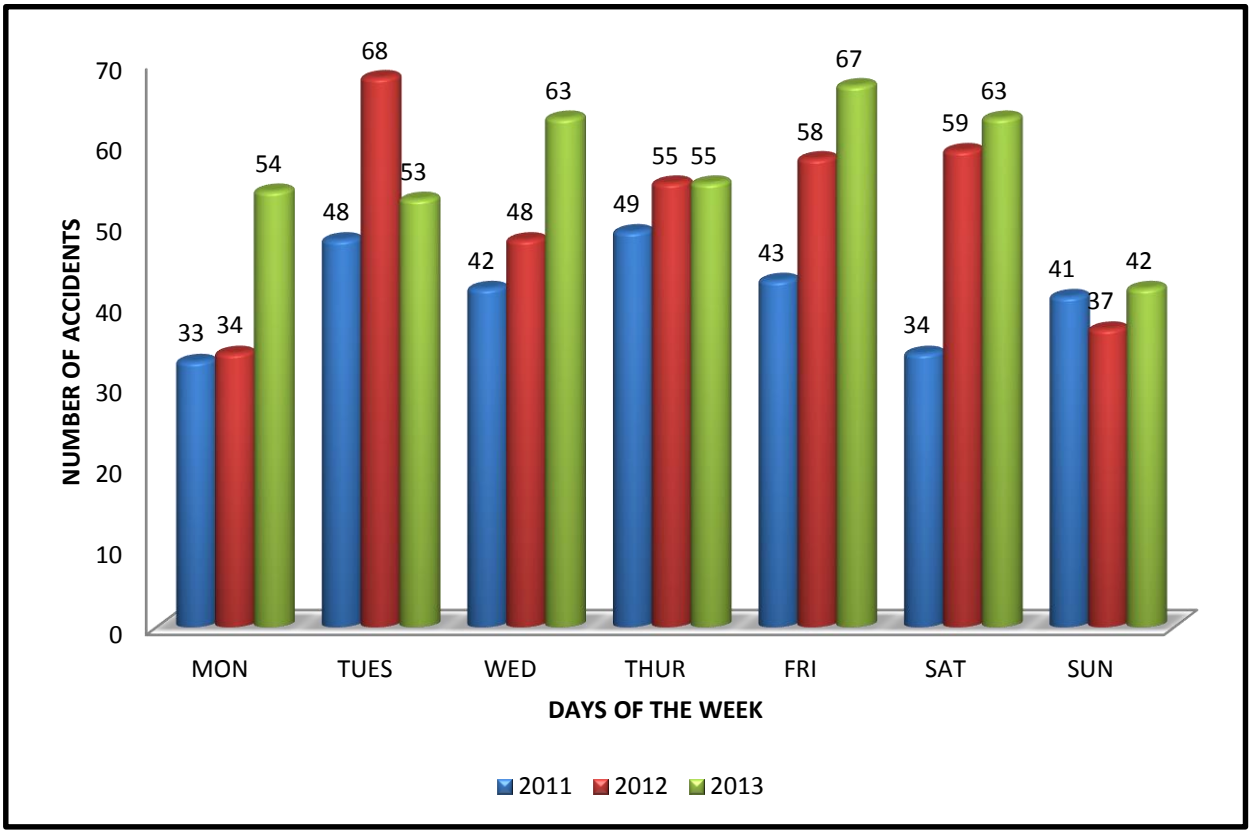

Figure 4.7: Comparative Analysis of RTA Per Days of the Week

Source: Fieldwork, 2014

The majority of the accidents occurred on Tuesdays (169 cases) and Fridays (168 cases) while less number of accidents were reported on Sunday (120 cases) and Mondays (121 cases). This shows that more RTA occurred during the week days. However, Saturday alone recorded moderately high rate with 156 cases where 2013 recorded the highest (63 cases). This could be as a result of the increased mobility of residents in Tema, Ashaiman and Accra who travel for social activities such as funerals and weddings. The site observation showed that there were less traffic on Sundays and also, fewer commercial vehicles. Wednesdays and Thursdays also recorded 153 and 159 RTA cases respectively which are moderately high.

4.4.3 Temporal Analysis of Data for Months of the Year

The accident cases for each month were collated to establish the months with comparatively high accident cases on the Accra-Tema Motorway. The months of the year with high accident rate coincides with the rainy season in the region though the patterns in recent times are changing unexpectedly.

The trend analysis for each month of the year 2011 shows an increase in RTA recordings from 11 cases in January to 15 cases in March. This figure doubled in April with 31 cases and had undulating records with August as the peak with 41 accident cases. This rate falls abruptly in September and reduces till December, which recorded 20 RTA cases.

Accident cases for the months of the year in 2012 saw an increasing trend of RTAs from 10 cases in January to 24 RTA cases in December. Within these two months, the data showed a peak in April with 47 cases and a drop in July with 21 cases. September and October recorded the same number of RTAs with 43 cases each.

RTA cases recorded for 2013 increased abruptly from 14 cases in January to 39 cases in April the start of the rainy season and reduced slightly to 30 cases in June and had a sharp undulating records from July to December. The red lines drawn in Figure 4.8 show that most of the accident cases recorded coincided with the rainy season (April to October).

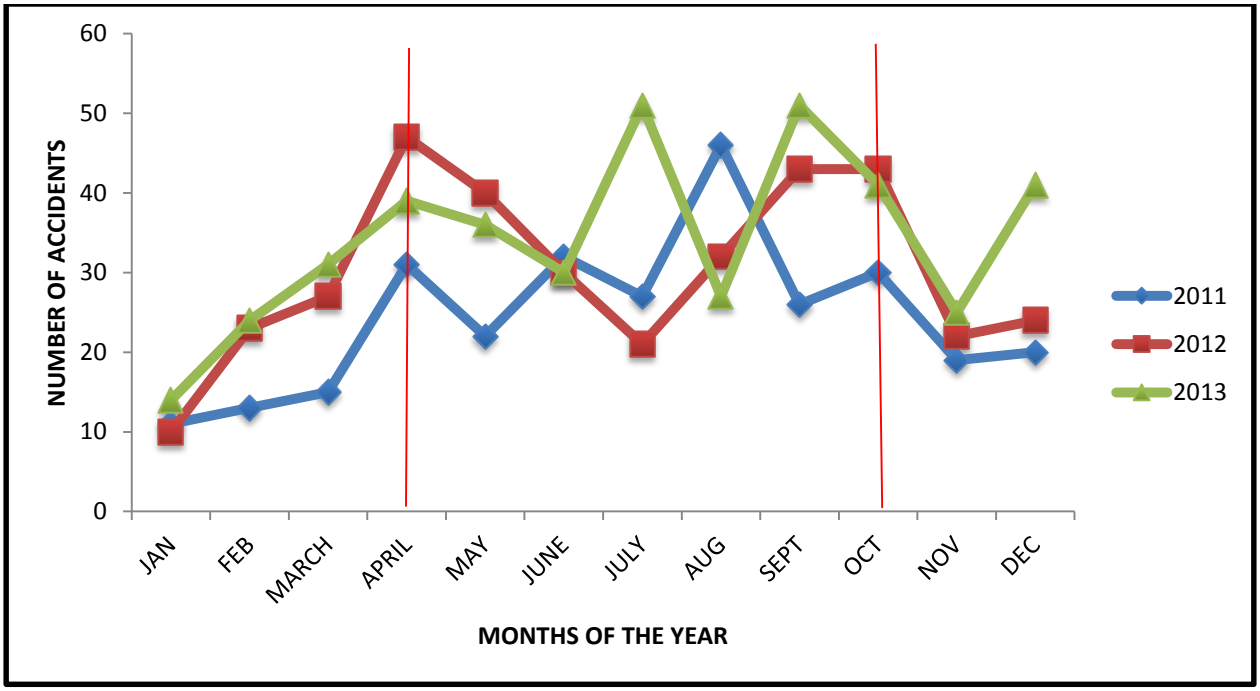

Figure 4.8: Comparative Analysis of RTA Per Months of the Year

Source: Fieldwork, 2014

Generally, each of the year under study had undulating records of RTAs for the months of the year. The majority of the RTA cases that were recorded were within April and October. The reason could be the high rains that fall within this period. Figure 4.8 also shows that 2013 recorded high RTA cases in December more than the number of cases recorded in 2011 and 2012. 2012 recorded the highest number of accidents in April and May while 2011 recorded the most RTA cases in June and August. Furthermore, Figure 4.8 shows that 2013 recorded the most accident cases for the rest of the months in that year.

4.5 Risks and Causes of RTAs at Accident Prone Areas

According to an MTTU inspector at the Airport Police station, invariably, the high prone areas such as the Abattoir and Klagon/Adjei Kojo sections of the Accra Tema Motorway are usually caused by the illegal entry and exit by motorist, the indiscriminate crossing of pedestrians and the

passengers alighting or getting on board a vehicle. Additionally, the medium accident prone areas are usually caused by similar factors, but most often by potholes/bad nature of the motorway and U-turns. Speeding is a contributing factor in all the accident prone areas. Figure 4.9 shows some pictures of illegal entries at the Abattoir and Klagon/Adjei-Kojo represented by Picture 1 and Picture 2 respectively.

4.5.1 Illegal Entries and U-Turns

Vehicle manoeuvres around the Abattoir showed bad use of the road by private drivers who connect to the Accra-Tema Motorway from Tema Community 18 and the Spintex residential area as shown in Picture 1 in Figure 4.9. There have recently been three diversions at the Abattoir area and most of the drivers do not look carefully before entry.

Figure 4.9: Sections of Accra-Tema Motorway Showing Illegal Entries and Exits

Source: Fieldwork, 2014

According to the field observation, drivers exhibited less patience in getting in-lane, approaching the motorway and not timing incoming vehicles. This usually causes accidents on these sections of the road. Observably, vehicles from Ashaiman connect to a road leading to Nungua around the

Klagon/Adjei-Kojo area as shown in Picture 2 in Figure 4.9. This is also a major factor in the numerous RTAs recorded in this portion of the Accra-Tema Motorway. Figure 5.10 shows sampled U-turns on the Accra-Tema Motorway.

Figure 4.10: Illegal U-Turns on the Accra-Tema Motorway

Source: Fieldwork, 2014

There are several U-turns on the Accra-Tema Motorway. These U-turns include those at Tetteh Quarshie Roundabout, at the Trasacco area (Figure 4.10, Picture 1), at Kings Cottage (Figure 4.10, Picture 2) and several others around Abattoir and the Ashaiman overhead. U-turns needs to be carefully negotiated and drivers in doing so in the midst of high speeding vehicles usually cause RTAs. Observably, as noticed in picture 2 in Figure 4.10, authorities try to avoid this rampant behaviour by putting huge rocks in the middle of the reserved area. However, some drivers manage to manoeuvre their way through the blockade finding alternative points.

4.5.2 Indiscriminate Pedestrians Crossing

Per the original design of the motorway, the field observations indicated improper usage of the motorway and of poor road safety facilities on the Accra-Tema Motorway. Generally, since there are no pedestrian crossing zones such as a zebra crossing or an overhead walkway, pedestrians use the shoulders of the motorway and have created crossing points especially around the Tetteh

Quarshie Roundabout, the toll booth area (refer to map in Figure 2.1), in front of Sidalco Company, at the Trassacco Estate area, near the Abattoir and Klago/Adjei Kojo underpass (refer to map in Figure 4.3). Pedestrians use footpaths created through consistent use and cross the motorway indiscriminately, from one side to the other. A lady was interviewed around Klagon/Adjei Kojo area. She accepted that she crosses the road frequently. The woman commented: *'I have no option since I live close by; crossing the motorway has become a routine'*. This has increased the spate of pedestrians accidents on the Accra-Tema Motorway especially around the Trasacco area (in Picture 1) and the Klagon/Adjei Kojo area (in Picture 2) as shown in Figure 4.11.

Figure 4.11: Pedestrians Crossing the Accra-Tema Motorway

Source: Fieldwork, 2014

At peak hours in the morning (6:00-9:00) and the late afternoon (16:00-18:00), pedestrians cross the Motorway with ease because traffic is slow at this time. However, at other times of the day where vehicles move faster, pedestrians take a longer time to cross. Pedestrians cross one lane at a time and wait at the reserved area and wait for the appropriate time to cross to the other end of the motorway. A Trasacco construction worker interviewed commented *'I alight every day along the road because I do not live around'*. He acknowledged that it is dangerous for a vehicle to stop

along the motorway because of the unpredictable speed levels but he cannot afford to go through the long route to work.

4.5.3 Illegal Vehicular Stops

The questionnaire output shows that about 67.5% drivers nearly always stop on the Accra-Tema Motorway and 2.5% drivers reported they often stop on the Motorway. Cumulatively, most drivers stop on the motorway. Despite the danger and the risk involved in stopping and taking-off on the motorway, drivers continually park along the motorway without considering the danger. This exposes drivers and pedestrians, who alight along the motorway to the risk of an RTA when they fail to calculate the speed of passing vehicles.

Figure 4.12: Illegal Stopping of Vehicles

Source: Fieldwork, 2014

Vehicles of various categories from big trucks, to motorcycles, and other commercial vehicles stop on the motorway as shown in Figure 4.12. It was observed that some of the private vehicles stop to let people get off on the way or to pick up workers in the morning. They also stop to urinate and in some cases their cars had broken down. Broken vehicles cut across all categories of cars. When

interviewed, a Truck driver explained that he had stopped as his vehicle had broken down. He commented that '*I am used to repairing my own broken car since I have some knowledge about certain basic car faults. Also, I have to wait for a long time before I get a mechanic and their charges are usually very expensive'.*

According to an official in the NRSC, the emerging RTA prone areas along the Accra-Tema Motorway pose serious danger to road users. He identified that *'when one illegal route or U-turn is blocked, another emerges in a different location and this requires general and strict regulation of drivers' movements and of pedestrian crossings'*. However, an inspector in Airport Police MTTU division lamented that *'we have not been given the mandate to close and stop drivers from using illegal routes or to stop pedestrians from crossing'*.

4.6 General Causes of Accident on the Accra-Tema Motorway

A significant proportion (65%) of trotro/minibus drivers reported that they have witnessed an accident scene on the Accra-Tema Motorway. The data collated showed that 52.5% of the taxi drivers and 62.5% of private drivers also confirmed that they have either faced or been involved in an accident on the Accra-Tema Motorway. In all, a significant proportion (60%) of all drivers have either faced or witnessed an accident scene as illustrated in Figure 4.13.

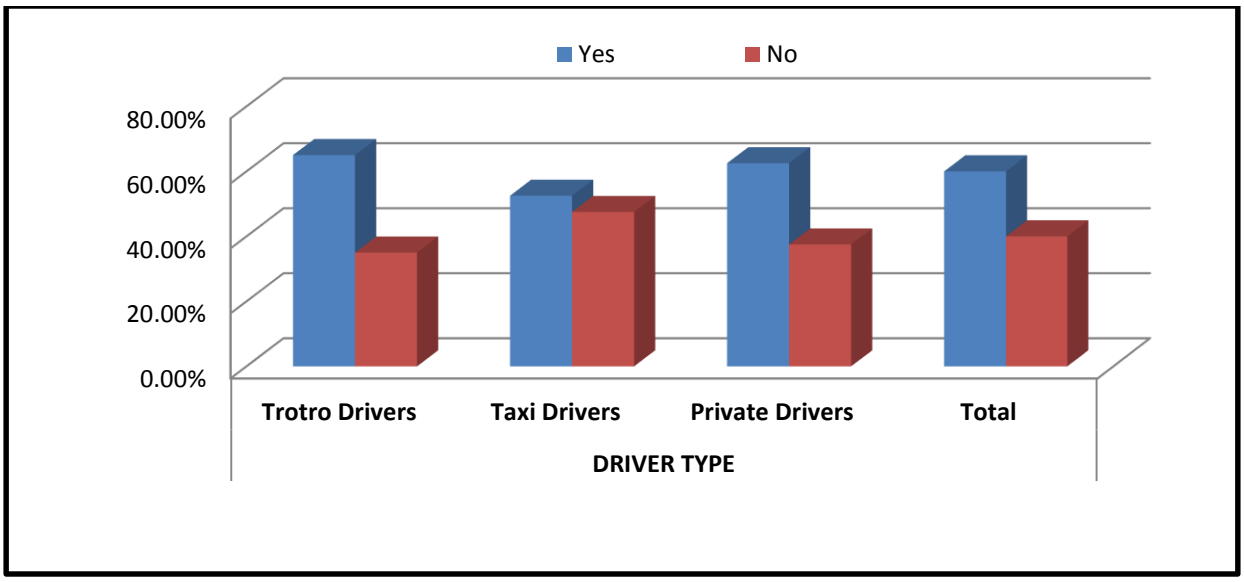

Figure 4.13: Accident Involvement on the Accra-Tema Motorway

Source: Fieldwork, 2014

Passengers were in agreement with drivers on the major causes of accidents but from their perception, the attitude of the drivers, the condition of the car and the number of cars on the road are other contributing factors to RTAs. However, the majority (87.5%) of the passengers agree that the attitude of drivers seem to play a major role in RTA (Table 4.3).

Table 4.3: Passenger's Perception of Causes of RTA

Sex	**Passenger's Perception**					
	Drivers Attitude And Car Condition	Drivers Attitude And Road Condition	Drivers Attitude And Weather Condition	Drivers Attitude And Number Of Cars On The Road	Car Condition And The Road Condition	Car Condition And Number Of Cars On The Road
Male	47.4%	26.3%	15.8%		5.3%	5.3%
Female	38.1%	38.1%	4.8%	4.8%	14.3%	

Source: Fieldwork, 2014

Table 4.3 indicates that driver's attitude, the condition of the car used by the drivers and the nature of the road play an essential role in RTAs.

4.6.1 Weather Conditions on the Accra-Tema Motorway

Drivers reported the weather, the state of the road, and light conditions as the major causes of the accidents they had witnessed. Many (79.2%) reported that the accidents occurred mostly during the rainy season, whilst a few (15.8%) reported that the accidents occurred on sunny days and very few (5%) had witnessed accidents on foggy days as illustrated by Figure 4.14. It can be generalised from this argument that most accidents occur on rainy days.

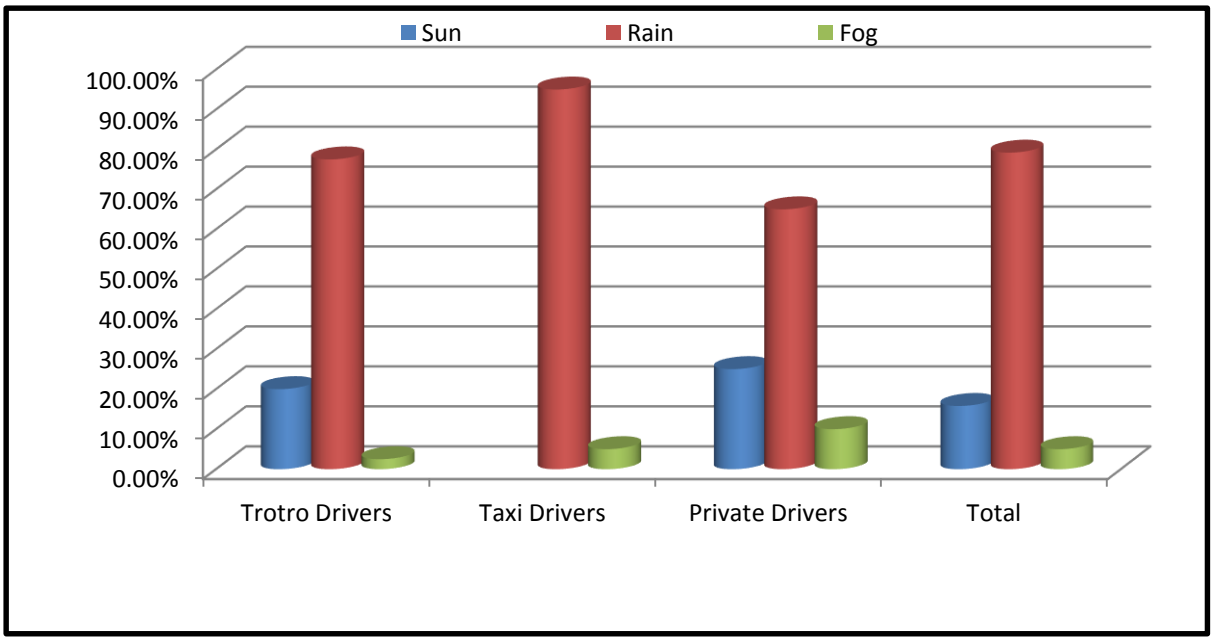

Figure 4.14: Effect of Weather Condition on RTA

Source: Fieldwork, 2014

The views of the respondents confirm the findings of the Roads and Traffic Authority (2004) and Mustakim, *et al.*, (2008) as they noted that RTAs mostly occur on wet roads. When it rains, the water makes the roads slippery and dangerous. All the category of drivers in Figure 4.14 recorded

that rains causes RTAs on the motorway. This is acknowledged by an inspector at the Ashaiman police station who claim that '*almost any time there is rainfall around the Accra-Tema Motorway, an accident occurs. The drivers skid off or run into other vehicles ahead of them*'. All the drivers reported that rain causes slippery conditions on the motorway and also reduces visibility which then needs extra caution. The argument has been confirmed by the majority (47.5%) of the drivers who reported to have witnessed accidents on wet road conditions as shown in Figure 4.14.

4.6.2 Light Conditions

In relation to light conditions, most (68.3%) drivers reported that RTAs normally occur during dark (night) conditions as shown in Figure 4:15.

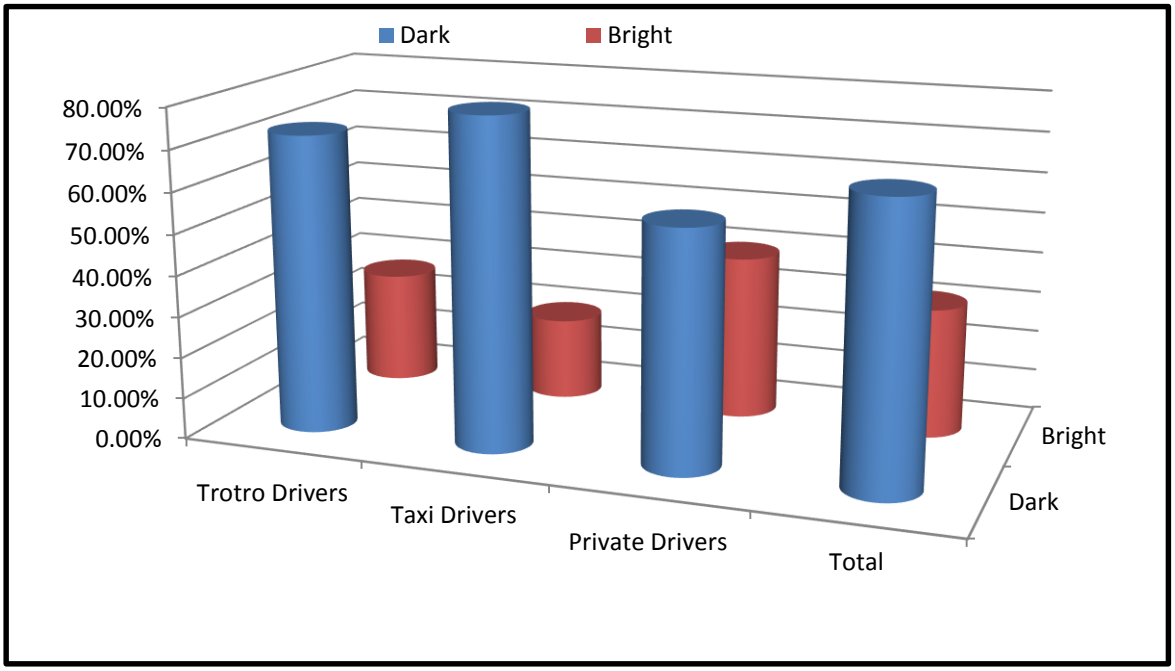

Figure 4.15: Effect of Light Condition on RTA

Source: Fieldwork, 2014

A driver in Madina commented on the dark nature of the road saying that *'some of the street lights are not working and others have been knocked down by vehicles and yet have not been replaced'*. Field observation confirmed that there are no reflectors on the Accra-Tema Motorway and the poor lighting system makes driving very difficult at night. According to the drivers this is a major cause of accident on the Accra-Tema Motorway.

4.6.3 Car Condition as a Factor of Accident Occurrence

Though 57.5% of the drivers reported they visit the mechanic or the workshop at least once every month, most (60%) of these same drivers said they only visit the mechanic or the workshop whenever their vehicles are faulty. This tells that most vehicles are not in good condition to be on the motorway. This, first and foremost, can lead to the malfunction of critical parts of vehicles such as the brakes or the shaft and that can lead to RTAs. Secondly, a drivers' vehicle can easily break down in the middle of the motorway which can pose a great danger to the safety of other road users.

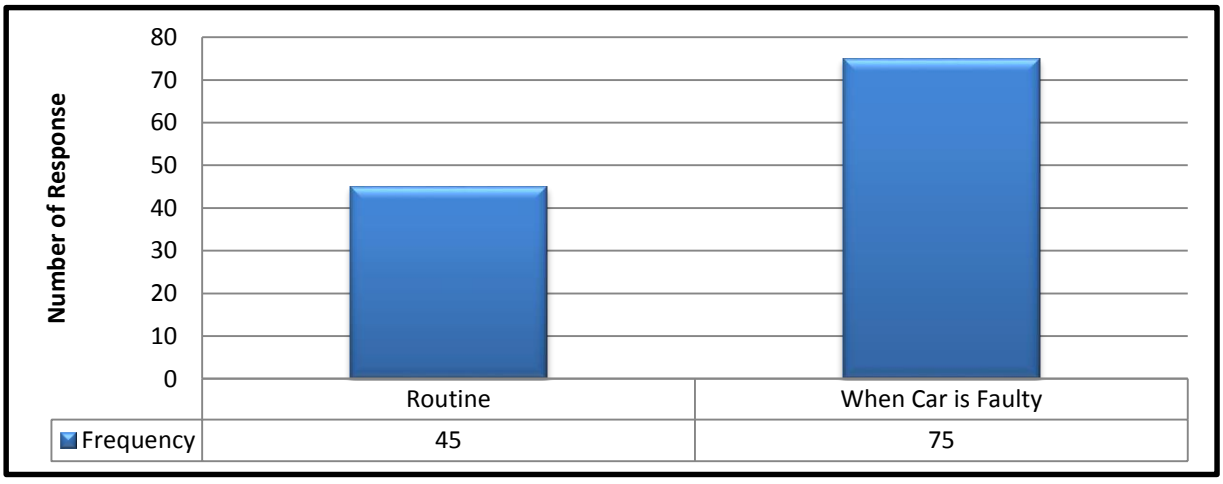

Figure 4.16: Drivers frequency of visiting the Mechanic

Source: Fieldwork, 2014

As shown in Figure 4.16, 37.5 % drivers reported that they routinely visit the mechanic to check the status of their vehicles. On the other hand, the majority of drivers (62.7 %) reported that they only visit the mechanic when the vehicle is faulty.

4.6.4 Inadequate Information for Safe Driving

Many drivers (86.6 %) reported they do not have adequate information on the road for their safe driving as shown in Figure 4.17. The drivers argued that information such as road markings, road signs and lighting are missing on the road. Such signs aid them to use the motorway safely.

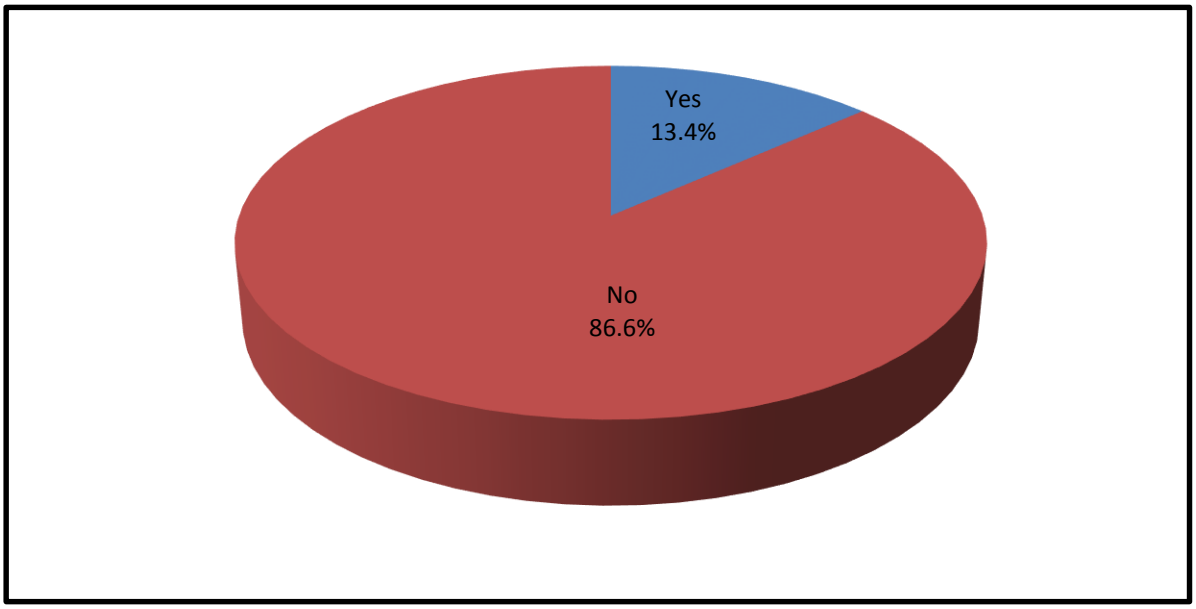

Figure 4.17: Drivers View of Information for Safe Driving

Source: Fieldwork, 2014

According to Radin (2005), when drivers fail to cope with their environment, there is the likelihood that RTAs may occur. However, Figure 4.17 above shows that the situation is worsened when drivers do not have the requisite information to aid them in driving. Among the inadequate information on the Accra-Tema Motorway that causes RTAs, most drivers chose lack of road signs (35 %) and lack of road markings (37.5 %) as the most prominent. A significant number of 23 drivers representing 19.2% recorded both lack of road signs and road markings. It was also

observed that a number of road signs were damaged, defaced or ruined. Figure 4.18 below show the few road signs available and a sampled advertisement bill boards along the routes. Interestingly, some of the advertisement bill boards have small precautionary phrases written beneath the adverts which can barely be seen at a distance and which are also blocked by bushes along the motorway.

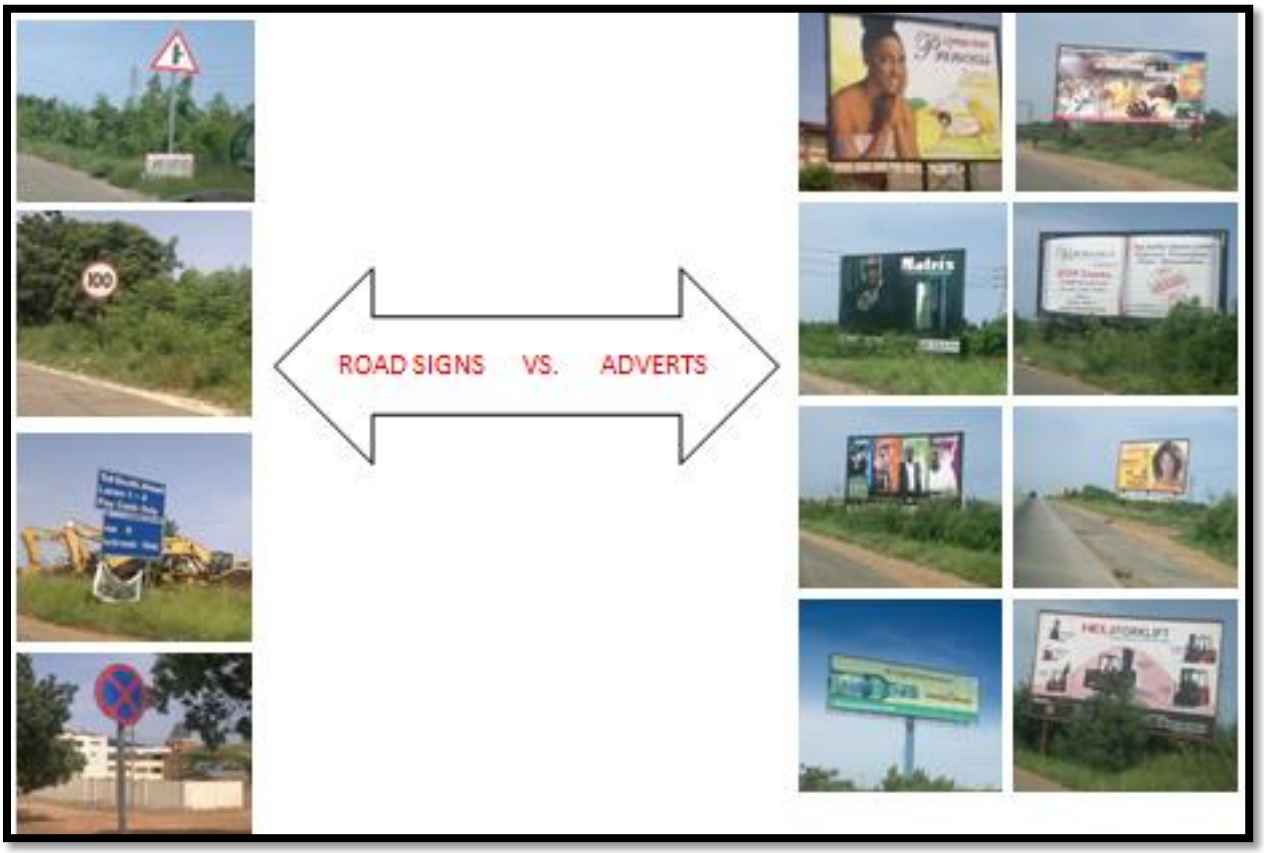

Figure 4.18: More Adverts than Road Signs

Source: Fieldwork, 2014

It is unfortunate to note that very few road signs are available on the 19 Kilometre express route that link AMA to TMA (see study area map in Figure 2.1). According to an MTTU police inspector in the Airport Police station, '*apart from the regulatory and mandatory road signs that help road users especially drivers to use the Accra-Tema Motorway though woefully inadequate, there must*

be provisional road signs for the deteriorating nature of the Accra-Tema Motorway. Road signs must specifically be provided to caution and warn road users of hazardous locations'. Drivers must be notified of broken parts at the bridges; potholes and adjoining vehicles from Tema Community 18, Spintex road, East Legon, Adjiringano/Trassacco and Ashaiman areas that may easily cause an accident.

Also, road markings that separate the outer lanes from the inner lanes have faded out and this makes it difficult for drivers to stick to their lanes, especially at night.

4.6.5 Potholes and Cracks

One serious cause of accident on the Accra-Tema Motorway is the bad nature of some parts of the road, especially the outer lane from Tema Roundabout to Tetteh Quarshie Roundabout. This according to some drivers is as a result of the heavy vehicles that use the slow moving lane. This has induced most drivers including heavy duty vehicles, and other slower vehicles, to use the inner lane which is meant for high speed and over-taking. Drivers in their quest to avoid the potholes end up running into oncoming vehicles causing RTAs. According to an inspector in the Ashaiman police Station, '*Some drivers in some cases unexpectedly run over these potholes and because of the accompanying speed, they vie off and skid into the ditch or run into vehicles on the other lane*'. This has increased the spate at which drivers get involved in RTAs on the motorway, especially through the unsafe changing of lanes to avoid the potholes. Slow moving vehicles do not stick to their lanes (i.e. the outer lane) and because their speed is comparatively lower, and so a collision is inevitable. According to an expert in NSRC, '*in using a motorway, the deferential levels of speed of vehicles moving in the same direction can easily cause accident if the speed difference is wide*'. Figure 4.19 below illustrates some of the potholes and cracks on the Accra-Tema Motorway.

Figure 4.19: Sampled Potholes and Cracks on the Accra-Tema Motorway

Source: Fieldwork, 2014

There is no urgency to undertake major repairs and the Figure 4.19 above show the bad nature of the road and the improper materials used to patch the road. It is unacceptable to use bitumin to patch a concrete road. Figure 4.19 shows how the bitumen wears out in no time. According to an engineer in the GHA, these minor repairs are either handled by the mobile maintenance team or given to sub-contractors. The results in Figure 4.19 show the unprofessional way of repairing the road. According to GIPC (2014), there is a proposal to upgrade the Accra-Tema Motorway to include two additional service roads for both sides to support the fast changing development and to avoid criss-crossing into the existing route. Also, the project includes the replacement of the

'existing 150mm reinforced concrete slabs with 200mm ones'. However, this does not justify the improper repairs and materials used on the road since they cause RTAs on the motorway. According to Lawson *et al.* (2009), many RTAs on roads can be reduced or avoided if safe roads are well constructed. Also, safe roads have the capacity to contain and control behavioural issues on the motorway (Lawson *et al.* 2009). The nature of the Accra-Tema Motorway coupled with reckless and careless driving cause RTAs.

In conclusion, it is noted that with the right and timely interventions, RTAs can be avoided completely. On the Accra-Tema Motorway, there is lack of identification of hazardous locations and the nonavailability of road signs to show broken bridges and areas where vehicles enter illegally. This lack is a major cause several RTAs. As indicated in the Haddon Matrix theory in this study, the three phases of RTAs should be strictly adhered to by road users in order to avoid road carnage. The theory argues that during the pre-crash phase, road users should observe the road traffic rules and regulations, the terrain of the road, the weather condition and the state of the vehicle.

The theory further discusses the crash phase of RTAs, that drivers should pay heed to protective mechanism such as always wearing seatbelts, helmets as well as being careful at the application of their vehicular brakes. The theory adds that the lack of crash protective road side devices are some of the reasons for RTAs and high fatalities. This study, however, employed the methodology section of data collection from the post-crash phase of the Haddon Matrix theory. As was supported by the conceptual framework, RTA data was collected through the use of ESRI ArcGIS application with an inbuilt GPS. This explanation by the theory agrees with some of the afore mentioned findings that there are several RTA clusters on the Accra-Tema Motorway. As such motorists need to fully comply with road traffic rules and regulations. The study also employed the systems theory to explain further the interrelated issues in RTA. The theory illustrated how the various component

of the road system interact to cause RTA on the Accra-Tema Motorway. The findings support the systems theory which argues that an RTA is not caused by one single isolated factor but by a collection of several integrated factors, as seen in Figure 3.3. Some of the drivers were of the view that an RTA occurs incontrollably and throughout the year on the motorway. Some drivers attributed this to 'bad omen' and other superstitious causes.

CHAPTER FIVE

DRIVERS' RISK TAKING BEHAVIOURS AND PERCEPTION OF POLICY EFFECTIVENESS

5.1 Introduction

The chapter starts with an understanding of the demographic composition of the drivers and passengers who responded to the questionnaire. The chapter further examines the perception of roads users on risk factors associated with RTAs on the Accra-Tema Motorway and further reveals the perception of road users on how effective selected rules and regulations have been in reducing road traffic accident. This chapter shows how movement of road users from Ashaiman, Tema and their environs to Accra exposes them to risks. According to the conceptual framework in Figure 3.4, these movements expose the drivers, passengers and pedestrians alike to diverse risks which directly or indirectly lead to RTAs.

5.2 Demographic Analyses of Questionnaire Respondents

Before analysing the views and responses of road users who constitute the respondents of the study, preliminary analyses such as the demography and the respondents' activities on the motorway were gathered. Respondents of the study involved 120 drivers constituting 75% of the respondents and 40 passengers who constituted 25% of the respondents.

5.2.1 Demographic Characteristic of Drivers

Out of the 120 drivers included in this survey, 40 were trotro/bus drivers, 40 were taxi drivers and 40 were private car drivers. This constitutes an equal proportion of 33.33% for each group of drivers. The variety of drivers was sampled to obtain a holistic view of issues related to road accidents and risks on the Accra-Tema Motorway.

About 100 per cent (99.2%) of the drivers were males above 15 years and the only female driver constituting 0.8% was between the age of 36-45. In total, 6 drivers constituting 5% were between the ages of 15 and 25, 44 (36.7%) were between the ages of 26 and 35, 43 (35.8%) were between the ages of 36 and 45, 26 (21.7%) were between the ages of 46 and 55 and only one driver constituting a small proportion of 0.8% was above 55 years. Table 5.1 shows the sex and age distribution of drivers.

Table 5.1: Sex and Age Distribution of Drivers

Sex		Age					Total
		15-25yrs	26-35yrs	36-45yrs	46-55yrs	Above 55	
Male	Count	6	44	42	26	1	119
	% within Sex	5.0%	37.0%	35.3%	21.8%	0.8%	100.0%
Female	Count	0	0	1	0	0	1
	% within Sex	0.0%	0.0%	100.0%	0.0%	0.0%	100.0%
Total	Count	6	44	43	26	1	120
	% within Sex	5.0%	36.7%	35.8%	21.7%	0.8%	100.0%

Source: Fieldwork, 2014

Other bio-data relevant for the study to understand the detailed characteristics of the drivers sampled were collated. Table 5.2 displays the educational level, driver experience in driving (i.e. number of years in driving), attendance of driving school, possession of driving licence and insurance for their vehicle.

Table 5.2: Driver's Educational level, Experience, Insurance Status and Licencing

		Frequency	Percent (%)
Educational Level	None	10	8.3
	Tertiary Level	4	3.3
	Secondary Level	21	17.5
	Junior High School Level	61	50.8
	Primary Level	23	19.2
	Others	1	0.8
Driving Experience	1-5yrs	16	13.3
	6-10yrs	66	55.0
	11-15yrs	26	21.7
	16-20yrs	6	5.0
	Above 20yrs	6	5.0
Utilising Driving School	Yes	63	52.5
	No	57	47.5
Possesion of Drivng Licence	Yes	115	95.8
	No	3	2.5
	Expired	2	1.7
Vehicle Insurance	Yes	117	97.5
	No	3	2.5

Source: Fieldwork, 2014

A significant proportion (70%) of the drivers were Primary and Junior High School (JHS) leavers. Only a few (3.3%) were tertiary graduates; 17.5% were Senior High School leavers and the remaining 9.1% were drivers who have had no formal education. In terms of experience in driving, 16 (13.3%) of the drivers have up to five years' experience, 66 (55%) had 6 – 10 years' experience, 26 (21.7%) had 11 – 15 years' experience, 12 (10%) had 16 or more years' experience. About 53 % (52.5%) of the drivers had attended a driving school and the remaining (47.5%) had not attended a driving school. Nearly 96 %(95.8%) of the drivers were licenced to drive and the remaining (4.2%) had no licence or were driving with an expired licence. These drivers obviously should not be permitted to drive until the appropriate procedures have been duly followed to get a valid licence or renew those that have expired. About 98 % were driving vehicles which were insured and the remaining 3 (2.5%) were driving vehicles with no insurance.

5.2.2 Demographic Charateristic of Passengers

Out of the 40 passengers included in this survey, 19 (47.5%) were males and 21 (52.5%) were females. The majority (90%) of the passengers were between the ages of 15 and 45 and the remaining passengers were above the age of 45. All passengers were educated with 40% being tertiary graduates, 27.5% being SHS graduates and 32.5% who have had some Primary School or JHS education. Figure 5.1 shows the bio-data of passengers who were issued with questionnaires.

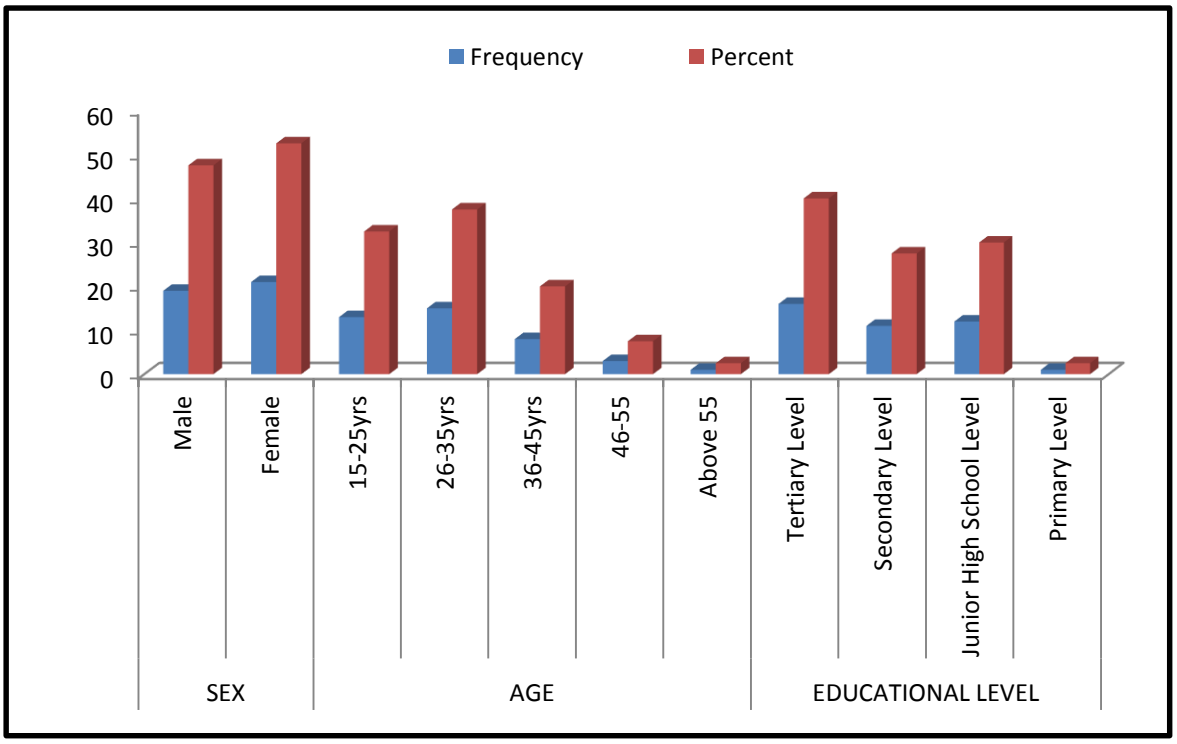

Figure 5.1: Distribution of Passengers by Sex, Age and Educational Level

Source: Fieldwork, 2014

5.3 Risks Often Taken by Drivers

The study also sought to investigate the possible risk road users such as drivers often take in other for the researcher to ascertain the frequency with which they undertake selected required actions necessary to promote road safety and reduce RTAs in general, or injuries and fatalities. The responses indicate how drivers responded to road safety issues as illustrated in the various phases

of the Haddon Matrix theory especially in the 'pre-crash' and 'crash' phases as shown in the Table 3.2.

5.3.1 Frequency of Wearing Seatbelt

Drivers were asked the frequency with which they wear their seatbelt as they drive (Figure 5.2).

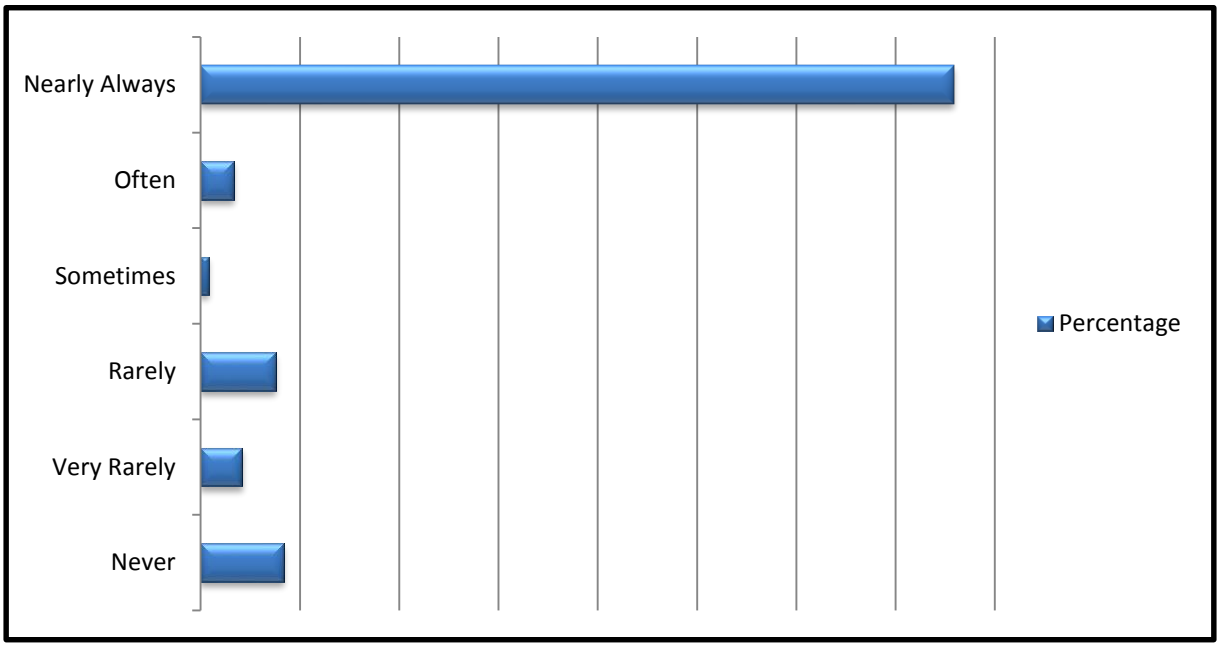

Figure 5.2: Driver's Frequency of Wearing Seatbelt

Source: Fieldwork, 2014

The majority of the drivers reported they wear their seatbelts frequently. Out of the 120 respondents, 76% responded they wear their seatbelts nearly always which is a good indication of driver's action to reduce injury and fatalities. In contrast, 8.3% reported they never wore seatbelts which could be attributed to the working status of their seat belts. A minibus/trotro driver in the Tema station commented saying *'I do not feel comfortable driving whilst wearing my seatbelt and I avoid wearing it whenever I am driving'.* Some drivers fail to notice that the seatbelt is not worn for comfort but for protection and that they must gradually adapt to wearing it for safe driving.

Table 5.3 shows a cross tabulation between the frequency of wearing seat belts and the type of driver interviewed.

Table 5.3: Drivers and Frequency of Wearing Seatbelt

Driver Type	Frequency of Wearing Seat Belt						Total
	Never	Very Rarely	Rarely	Sometimes	Often	Nearly Always	
Trotro Drivers	4	1	5	0	0	30	40
Taxi Drivers	6	3	3	0	0	28	40
Private Drivers	0	1	1	1	4	33	40
Total	10	5	9	1	4	91	120

Source: Fieldwork, 2014

Literature reveals that wearing a seat belt is very important since it prevents or reduces the rate at which drivers and passengers get injured or killed in the 'crash phase' of RTA as explained by the Haddon Matrix in Table 3.2. It is noted from Table 5.3 that private drivers had the highest response in terms of 'nearly always' and recorded nil for "never". Interestingly, majority (75%) of the minibuss/trotro drivers claim they wear seatbelts nearly always.

In developing countries, most of the vehicles do not have critical parts like seat belts working properly (Road and Traffic Authority, 2004) and the survey sought to find out the number of seat belts working in the vehicles. The drivers were issued with a questionnaire to ascertain the use and stateof seatbelts in vehicles that ply the Accra-Tema Motorway.

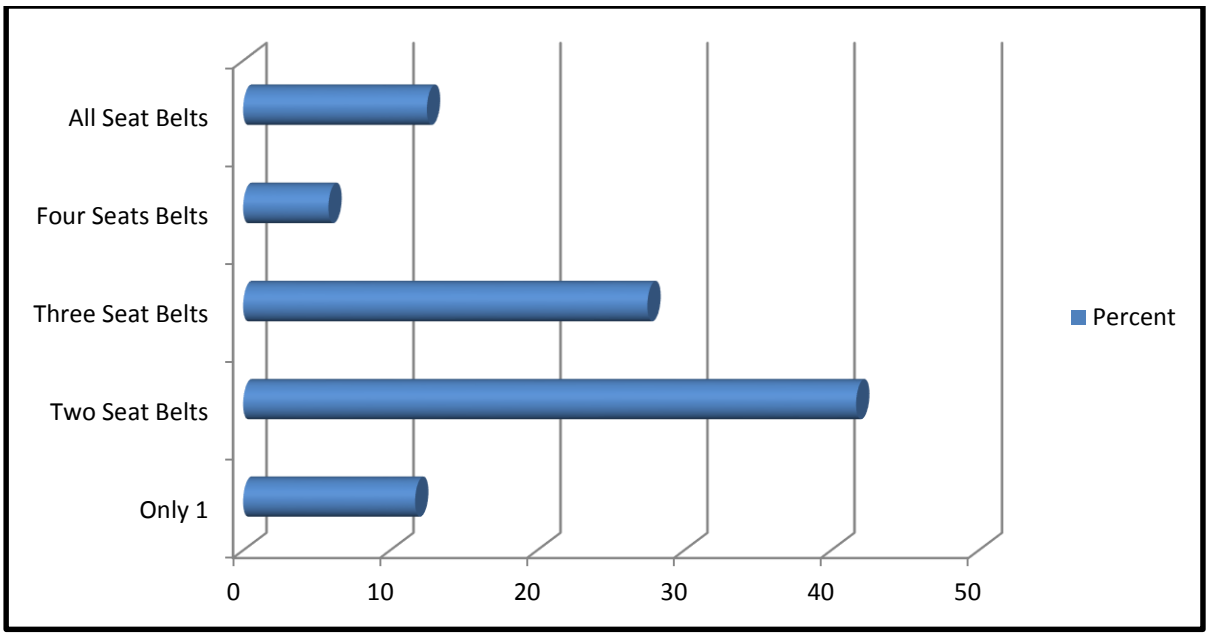

Figure 5.3: Working Seatbelts in Vehicles

Source: Fieldwork, 2014

Taxis and most private cars have five seat belts and minibuses/trotro has more than five though it varies according to the capacity of the minibus. Most of the seats in the trotro/minibuses observed are not original but locally assembled. Hence, they do not have seat belts for the passengers, even the front seats which include that of the driver do not have the required seatbelt. Some of the trotro/minibuses with original seats might even have their seat belts damaged. But the minibuses that go beyond the region appear to have seat belts intact. Figure 5.3 shows that most divers (41.5%) have only two of their seatbelts working, followed by those with three seatbelts (27.5%) and then those with all their seatbelts working (12.5%). None of the minibus drivers had all their seatbelts working. The majority of the minibus/trotro drivers had either one or two of their seatbelts working. This shows how the slightest crash can cause severe injuries to passengers on board a minibus/trotro on the motorway - if not killing them.

5.3.2 Driver's Perception of Driving Above Speed Limit

Speeding is an important indicator in the pre-crash phase of RTAs and this most often than not determines the probability of any vehicles involvement in an accident (Bekefi, 2006; Radin, 2005).

The speed limit on the Accra-Tema Motorway is 100 kilometre/hour and drivers usually go beyond the speed limit (Nyarko, 2012). Some of the drivers stressed that if the conditions are proper, drivers can speed and others also claimed with good driving skills, it is not dangerous to drive above the speed limit. To assess the compliance to this speed limit, Figure 5.4 shows the varying response of drivers on their level of agreement in terms of speeding beyond the speed limit.

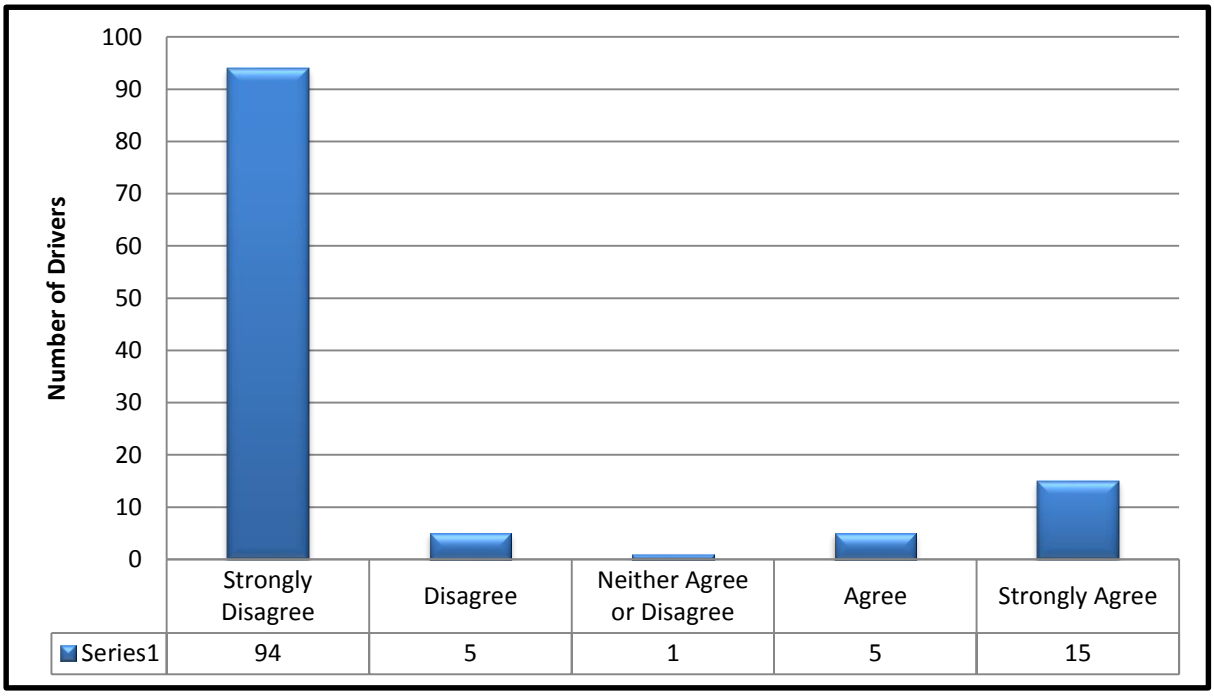

Figure 5.4: Drivers Level of Agreement in Terms of Over Speeding

Source: Fieldwork, 2014

It is observed from the driver's response in Figure 5.4 that the majority of drivers (78.3%) strongly disagree that it is proper to drive above the speed limit. A significant number of five drivers and 15 drivers 'agree' and 'strongly disagree' respectively. A comment made by one driver states that

'there is no problem to go beyond the speed limit if you have good skills and when the conditions are proper. Why should I be driving below 100 kilometre/hour if there are few vehicles on the motorway'. Out of the 120 respondents, 14.2% supported this comment and to the contrary, about 77% refuted this comment meaning that speeding is dangerous to safe driving. According to Taylor *et al.* (2000) more accidents will occur on a particular road if there are many drivers speeding. Taylor *et al.* (2000) further explains that vehicles are difficult to control during any potential collision if drivers are speeding.

5.3.3 Functioning of Speedometre

To further understand the dynamics of speed on the Accra-Tema Motorway, drivers were asked of the status of their speedometre, whether they are working or not. This is necessary since driving beyond the speed limit would not be easily realised if the speedometre is damaged.

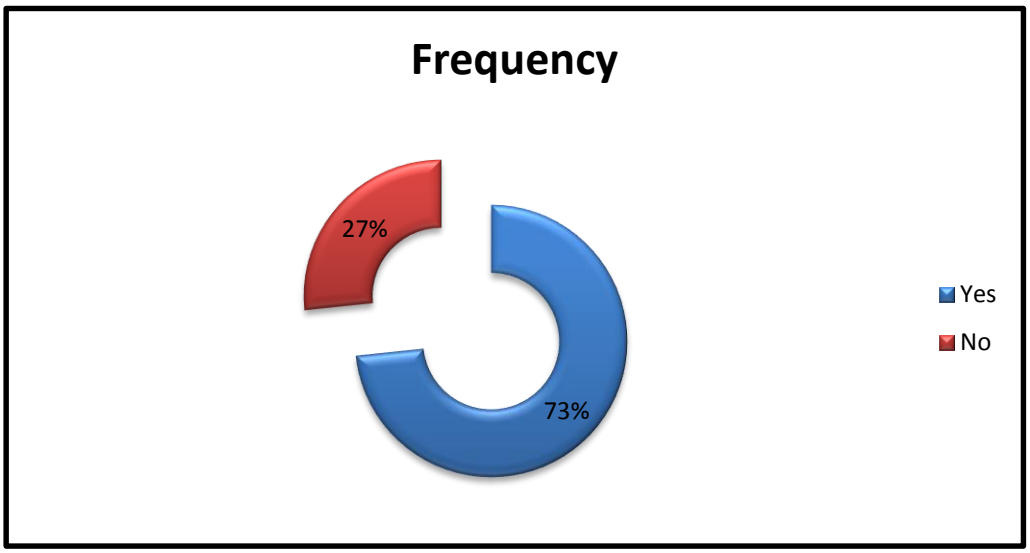

Figure 5.5: Status of Speedometre

Source: Fieldwork, 2014

Figure 5.5 displays that most of the drivers (73%) reported that their speedometres are functioning which is a good sign of drivers effectively managing their speed to conform to the official speed limit on the study road. However, a significant number does not have speedometres that are functioning and this raises the alarm of driver's risk of driving above the speed limit without noticing it. Table 5.4 below shows that varying views of drivers in terms of the functioning of their speedometres.

Table 5.4: Cross-tabulation of Drivers and Working Speedometre

Driver Type	Drivers' Response		Total
	Yes	No	
Mini bus/Trotro Drivers	26	14	40
Taxi Drivers	33	7	40
Private Drivers	31	9	40
Total	90	30	120

Source: Fieldwork, 2014

The results in Table 5.4 shows that more mini bus/trotro drivers (46.7%) do not have their speedometre working followed by private drivers (30%). Taxi drivers have the highest number of their speedometres working and more Taxi drivers (36.7%) reported their speedometres are functioning. A driver at the trotro/minibus station in Ashaiman acknowledged that though there are lots of campaign and education on speeding, it still exist among the drivers. He commented that '*there is a high competition among us the drivers and we need to meet our target before the close of the day. This has increased the rate at which we the drivers speed on the Accra-Tema Motorway. We have to get to our destination on time to be in the queue for our next trip'*. However, without the speedometre functioning properly, drivers and passengers are endangered.

5.3.4 Perception of Drink Driving

Driver's perceptions of drink driving were assessed through the questionnaire survey conducted (Figure 5.6).

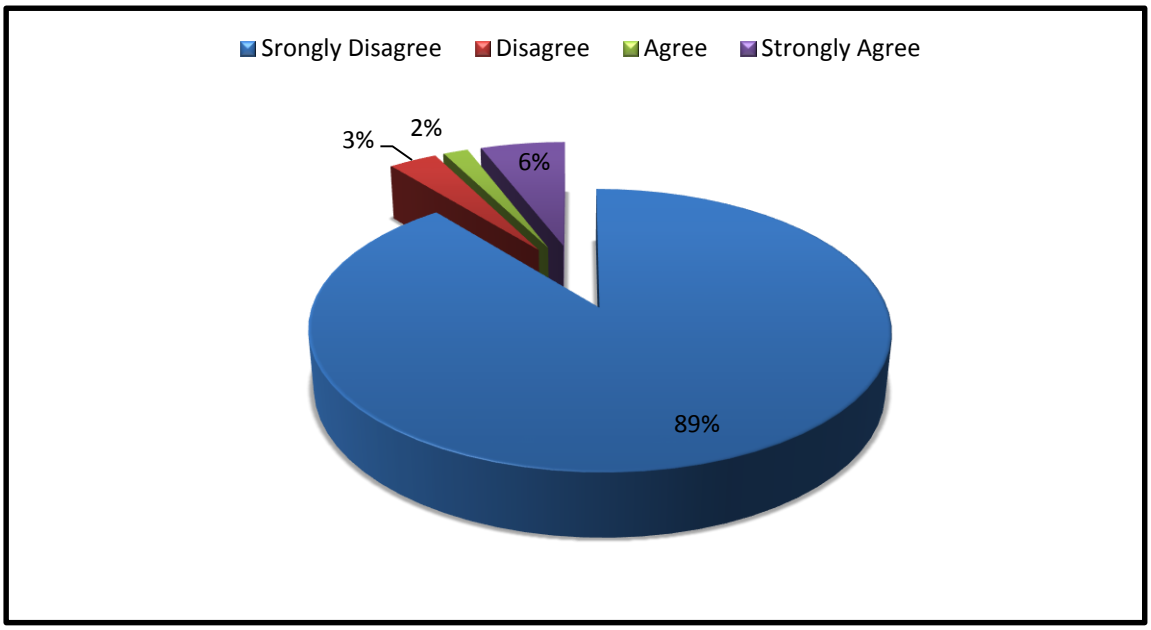

Figure 5.6 : Driver's Agreement to Driving Under the Influence of Alcohol

Source: Fieldwork, 2014

Figure 5.6 above shows a positive perception of drivers to drinking and driving. The majority of the drivers (89%) strongly disagree with drinking and driving while only 3% agree. Unfortunately, 6% of the drivers reported they strongly agree to the drink driving. A comment from a driver in Ashaiman station stated that *'drinking does not necessarily distract drivers on the road provided the driver does not drink too much. I drink but when I am driving I take very little so as not to put me off'*. On the contrary, another driver was very much concerned about the rate at which his colleagues drink and drive under various unjustifiable excuses and suggested that *'authorities should introduce alcohol testing devices at the various vehicle stations to regulate the drink*

attitude of certain drivers especially in the mornings. Also, drivers must be adequately educated on regular basis to avoid the occurrence of accident'.

5.4 Drivers' Obedience to Road Safety Rules and Regulation

In order to analyse whether drivers obey road safety rules and regulations or not, frequent wearing of seat belts by drivers, drivers driving too close to other cars, drivers crossing when traffic lights have turned red, drivers disregarding the speed limit at night or early morning, drivers driving five kilometre or 10 kilometres above the speed limit and drunk driving were identified to be some indicators to test drivers' obedience to road safety rules and regulations. In Figure 4.1, the trend of accidents on the motorway has been increasing from 2011 to 2013 and the contribution of drivers who ply the motorway frequently and occasionally is worth investigating. The attitude of drivers towards road signs, the obligatory rules and regulations pertaining to road safety was assessed to ascertain their level of obedience especially in the use of the motorway. This help to also understand the proposition stated in Chapter One.

Table 5.5 shows the variables that were used to determine and understand the significance level of drivers' adherence to road safety rules and regulations.

Table 5.5: Drivers' Adherence to Road Safety Rules and Regulations

Variables Selected	Driver Type	Never	Very Rarely	Rarely	Some-times	Often	Nearly Always	Sig.
Frequency of Wearing Seat Belts	Trotro Drivers	10.0%	2.5%	12.5%			75.0%	0.027
	Taxi Drivers	15.0%	7.5%	7.5%			70.0%	
	Private Drivers		2.5%	2.5%	2.5%	10.0%	82.5%	
	Total	8.3%	4.2%	7.5%	0.8%	3.3%	75.8%	
Driving Close to Other Cars	Trotro Drivers	12.5%	30.0%	37.5%	12.5%		7.5%	0.016
	Taxi Drivers	20.0%	45.0%	17.5%		2.5%	15.0%	
	Private Drivers	7.5%	60.0%	25.0%	5.0%	2.5%		
	Total	13.3%	45.0%	26.7%	5.8%	1.7%	7.5%	
Crossing When Traffic Lights Have Turn Red	Trotro Drivers	42.5%	17.5%	22.5%	5.0%		12.5%	0.137
	Taxi Drivers	35.0%	17.5%	27.5%	10.0%	2.5%	7.5%	
	Private Drivers	20.0%	30.0%	40.0%	10.0%			
	Total	32.5%	21.7%	30.0%	8.3%	0.8%	6.7%	
Drivers' Disregard of Speed Limit at Night or Early Morning	Trotro Drivers	20.0%	20.0%	30.0%	12.5%	7.5%	10.0%	0.257
	Taxi Drivers	30.0%	27.5%	27.5%	2.5%		12.5%	
	Private Drivers	12.5%	40.0%	22.5%	10.0%	2.5%	12.5%	
	Total	20.8%	29.2%	26.7%	8.3%	3.3%	11.7%	
		Strongly Disagree	**Dis-agree**	**Neither Agree or Disagree**	**Agree**	**Strongly Agree**		
Drivers Level of Agreement With Driving 5km or 10km Above Speed Limit	Trotro Drivers	87.5%	2.5%		5.0%	5.0%		0.179
	Taxi Drivers	97.5%				2.5%		
	Private Drivers	77.5%	10.0%	2.5%	7.5%	2.5%		
	Total	87.5%	4.2%	0.8%	4.2%	3.3%		
Drivers View of Drink Driving	Trotro Drivers	95.0%	2.5%			2.5%		0.625
	Taxi Drivers	92.5%			2.5%	5.0%		
	Private Drivers	87.5%	7.5%			5.0%		
	Total	91.7%	3.3%		0.8%	4.2%		

Source: Fieldwork, 2014

The frequency of wearing seatbelts and driving close to other cars (tailgating) were the only two points found to be significant at the 5% significance level since they recorded significant (Sig.) values smaller than 5%. Most drivers (75.8%) reported that they nearly always wear seatbelts and according to others, they often, sometimes or rarely do so. A significant proportion (65%) argued that they never or rarely drive closer to other cars. According to such drivers, they believe that can result in accidents. The other four variables used for the analysis were not significant at the 5% significance level since they recorded significant (sig.) values higher than 5%. The study then concludes that drivers do not adhere to rules and regulations pertaining to road safety since four out of the six variables used to test the significance level were found to be insignificant at the 5% significance level.

5.5 Passengers' View of Risk

All passengers agree that it is risky crossing the road after drinking alcohol as it is thought but they, however, added that some people still risk their lives. Figure 5.7 shows how passengers view the attitude of drivers concerning the drivers' use of the road.

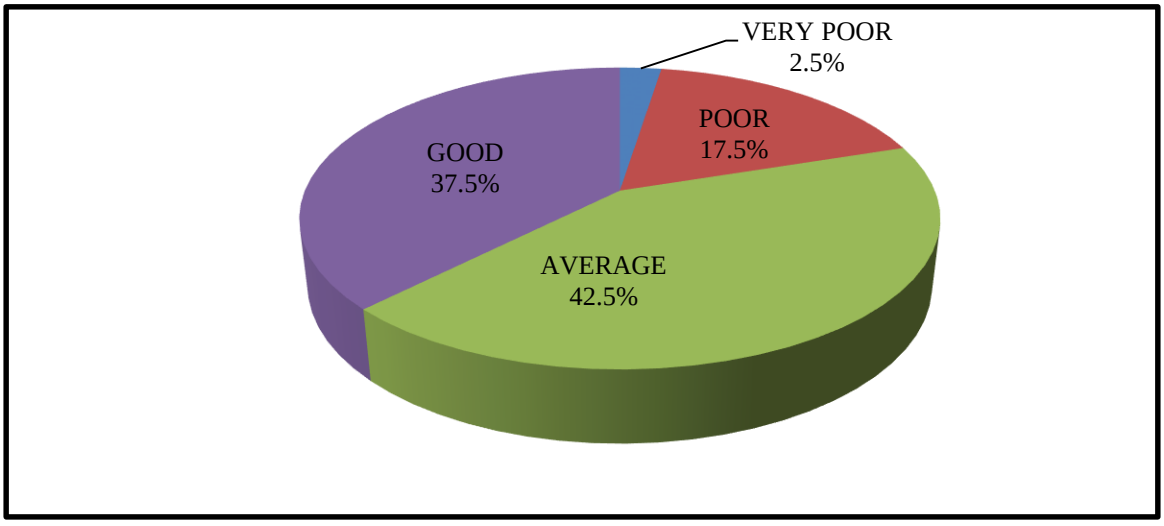

Figure 5.7: Passengers' View of Driver Attitude

Source: Fieldwork, 2014

Most passengers (80%) trust that the driving attitude of drivers is relatively good as illustrated by Figure 5.7. This confirms the argument that most drivers using the motorway uncommonly or sometimes expose themselves to risks.

5.6 Road Users' Perceptions of Policy Effectiveness

Most (85%) drivers think that regulations and rules concerning road safety are effective and adequate. Additionally, a significant proportion (65%) of passengers believe that the rules are effective and adequate (Figure 5.8).

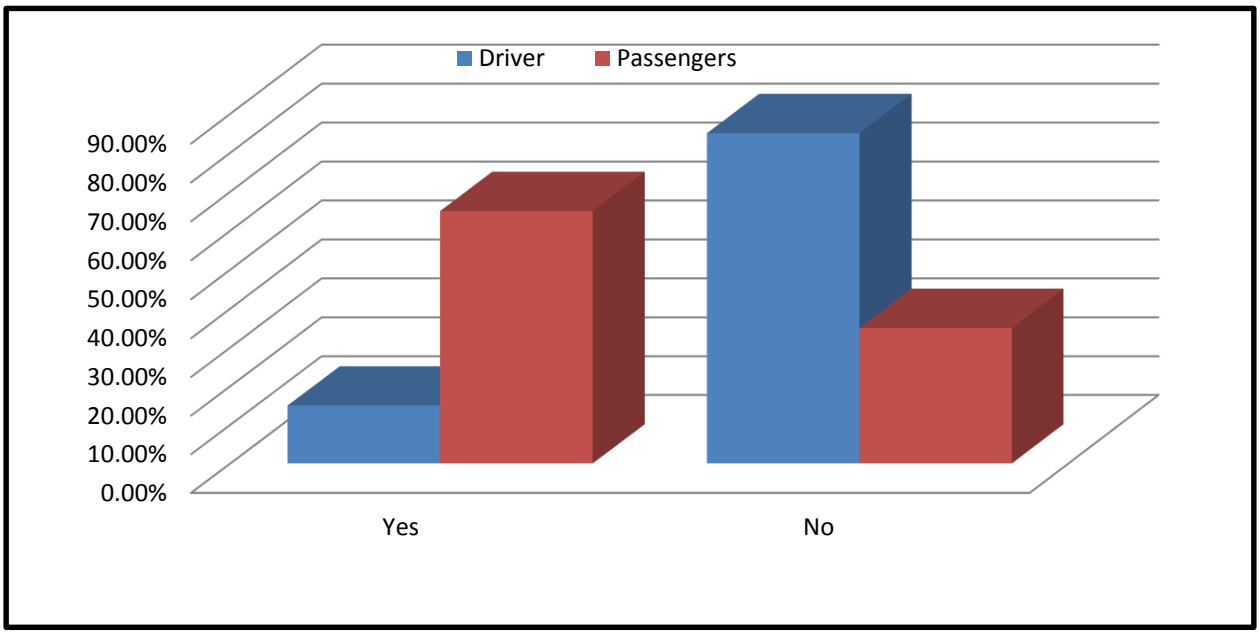

Figure 5.8: Road Users' Perceptions of Road Policy Effectiveness

Source: Fieldwork, 2014

To effectively reduce road crashes and injuries, road users suggested some pertinent policies which should be enforced. Some selected policies were analysed to identify how road users perceive them to be effective.

5.6.1 Road Safety Campaigns and Education

Drivers and passengers were asked about their view on the frequency of disseminating road safety information which is useful to adequately inform road users on the necessity of requisite rules and regulations. According to the survey, 87.5% of drivers and 67.5% of claim they could remember the last road safety campaign. A significant of 11.7% drivers and 32.7% passengers do not remember the last time they heard of a road safety campaign. This is unacceptable for road users using the motorway with comparatively high rates of RTAs. According to the NRSS III (2011), though NRSC have expanded their campaign on road safety, the commission acknowledged that the extent is inadequate. The report also shows that the campaign and education on road safety is inadequate because road safety in various ways is not a priority issue.

5.6.2 Restrictions for Learner and Provisional Drivers

Currently, DVLA has some restrictions on learner and provisional drivers who are considered inexperienced. They do not have the requisite skills, courage and know-how of the road traffic rules and regulalations to drive, especially on fast moving highways like the Accra-Tema Motorway.

Table 5.6: Driver's Perceptions of Restricting Learner and Provisional Drivers

Response	Drivers	(%)	Pedestrians	(%)
Very Effective	58	48.3	1	2.5
Effective	38	31.7	20	50.0
Satisfactory	13	10.8	2	5.0
Not Very Effective	7	5.8	17	42.5
Not Effective at All	3	2.5	1	2.5

Source: Fieldwork, 2014

Table 5.6 shows how effective drivers and passengers think restrictions of learner and provisional drivers will be in reducing RTAs on the Accra-Tema Motorway. The majority of drivers (48.3%) who were issued with the questionnaire recorded that this is very effective and must be well enforced to limit inexperienced drivers on the motorway. Some drivers (31.7%) and 50% of passengers acknowledged that this regulation is effective in reducing RTAs.

5.6.3 Fines for Traffic Offences

The MTTU is mandated to enforce the rules and regulations related to road safety and they have the responsibility of arresting and presenting traffic offenders for trial and prosecution (NRSS, III). The question is how effective is this action on the attitude of drivers and how effective has it been in reducing RTAs?

Table 5.7: Drivers' Views of Fines for Traffic Offences

Response	Drivers	(%)	Pedestrians	(%)
Very Effective	53	44.2	3	7.5
Effective	36	30.0	25	62.5
Satisfactory	16	13.3	1	2.5
Not Very Effective	4	3.3	11	27.5
Not Effective at All	11	9.2	3	7.5

Source: Fieldwork, 2014

Table 5.7 shows that, the majority of the drivers (44.2%) reported that fines for traffic offences would deter careless and inconsiderate drivers and eventually reduce RTAs. However, some drivers commented on the compromising attitude of the police in their enforcement. This has made some drivers engage in all forms of indiscipline on the motorway that eventually result in RTAs. One driver at Achimota commented that this policy is good but there must be a regulated process

of fining recalcitrant drivers and possibly relevant interactions between drivers and authorities should be digital and systematised.

5.6.4 Loss of Licences for Serious Offence

A licence gives the driver the authorisation to drive and this licence comes in different categories depending on the type of vehicle an individual is qualified to drive per the standards set by the DVLA. However, this does not give drivers the liberty to engage continuously in disobeying the rules and regulations and not to drive carefully. Table 5.8 shows drivers' response on how effective the loss of the licence for a serious offence such as a continuous record of drinking or speeding will be in promoting road safety.

Table 5.8: Loss of Licence for Serious Offence

Response	Drivers	(%)	Pedestrians	(%)
Very Effective	56	46.7	2	5.0
Effective	38	31.7	23	57.5
Satisfactory	18	15.0	2	5.0
Not Very Effective	3	2.5	13	32.5
Not Effective at All	4	3.3	2	5.0

Source: Fieldwork, 2014

The drivers were asked to rate how effective in their perspective, the loss of the driver's licence for serious offences such as continues record of speeding, drunk driving can be reducing RTAs. Out of the 120 driver respondents, 93.3% recorded that it is important to seize the licence of recalcitrant drivers when necessary.

A comment by a driver in Tema Community One stated that *'some of the drivers over speed, drink and engage in other unlawful acts on the road because they do not attract serious punishment and often go free after a few interrogations. I propose that there must be a tract record of drivers*

concerning their offences and continuous engagement of serious offences should lead to the loss of licence'. Currently, the MTTU are unable to keep track of individual recalcitrant drivers.

5.6.5 Police Patrol

Police patrol is very essential in regulating the behaviour and movement of road users especially drivers as well as in monitoring the road environment safety. The study sought the views of drivers on how effective from their perspective, police patrols have been in reducing RTAs. The various responses are illustrated in Table 5.9.

Table 5.9: Drivers View of Effectiveness of Police Patrol

Response	Drivers	(%)	Pedestrians	(%)
Very Effective	67	55.8	3	7.5
Effective	41	34.2	21	52.5
Satisfactory	12	10.0	3	7.5
Not Very Effective	0	0	13	32.5
Not Effective at All	0	0	3	7.5

Source: Fieldwork, 2014

Out of the 40 passengers, 7.5% and 52.5% are of the view that police patrols are very effective and effective respectively. Also, majority of dirvers (55%) reports that police potrol is very in reducing RTAs. No driver responded 'not very effective' and 'not effective at all'. Some passengers are not in agreement with the fact that police patrols are effective.

5.6.6 Random Checks for Roadworthy Vehicles

The Driver, Vehicle and Licencing Authority (DVLA) have the mandate to check the roadworthiness through vehicular assessment. In addition, the MTTU with the help of the DVLA

check regularly for vehicles that are not roadworthy. Table 5.10 shows the degree of drivers' response in terms of how they think this exercise is effective in reducing RTA.

Table 5.10: Random Checks for Roadworthy Vehicles

Response	Drivers	(%)	Pedestrians	(%)
Very Effective	64	53.3	0	0
Effective	38	31.7	29	72.5
Satisfactory	14	11.7	2	5.0
Not Very Effective	3	2.5	9	22.5
Not Effective at All	1	0.8	0	0

Source: Fieldwork, 2014

Out of the total 120, 53.3%, 31.7% and 11.7% reported that random checks on roadworthy vehicles were 'very effective', 'effective' and 'satisfactory' respectively. In addition, 72.5% of passengers think the checks are effective.

5.6.7 Identifying and Fixing Road/Traffic Hazards

The GHA has the responsibility for undertaking major repairs and constructions on highways (NRSS III, 2011) and the Accra-Tema Motorway. According to the NRSS III (2011), GHA must identify all damages and hazardous locations on major highways which include the study road so as to curb unnecessary accidents that occur due to drivers avoiding potholes. All bridges, protective gauges, illegal U-turn and so forth are to be identified and immediately repaired. However, this process is not fully realised on the motorway since there are lots of hazardous locations unattended. Drivers, as illustrated in Table 5.11 think that this action is very relevant in reducing RTA on the motorway.

Table 5.11: Drivers View of Identifying and Treating Hazardous Locations

Response	Drivers	(%)	Pedestrians	(%)
Very Effective	71	59.2	2	5.0
Effective	33	27.5	36	90.0
Satisfactory	15	12.5	2	5.0
Not Very Effective	1	0.8	0	0
Not Effective at All	0	0	0	0

Source: Fieldwork, 2014

Table 5.11 shows clearly that road users on the Accra-Tema Motorway are very much interested in the authority's ability to identify and treat hazardous locations. It is clear that out of the 120 drivers surveyed, 59.2%, 27.5% and 12.5% thought it was important to consider this action for safer roads since they chose identifying and treating hazardous locations as very effdective, effective and satisfactory respectively. A private driver reported saying that '*the Accra-Tema Motorway is not in good shape as it used to be and the road keeps deteriorated without any urgency to repair the damages'*. All passengers also support driver's view that identifying and fixing hazardous locations on the study road are effective in reducing RTAs.

5.6.8 Drivers Education on How to Share Road Safely

The last policy drivers commented on is how 'driver's education on how to use road safely' have helped or can help in reducing RTAs. The NRSC is mandated to coordinated road safety in the country and is responsible for educating all road users especially drivers on how to effectively use the road to promote road safety (NRSS, 2011).

Table 5.12: Road Users View of Educating Drivers

Response	Drivers	(%)	Pedestrians	(%)
Very Effective	56	46.7	7	17.5
Effective	42	35.0	31	77.5
Satisfactory	21	17.5	1	2.5
Not Very Effective	0	0	0	0
Not Effective at All	1	0.8	1	2.5

Source: Fieldwork, 2014

Table 5.12 above illustrate that about 99 % (46.7% chose very effective, 35% chose effective and 17.5% chose satisfactory) thought that this initiative was effective in reducing RTAs on the Accra-Tema Motorway. This means that only one driver disagreed. Furthermore, all passengers except one thought educating drivers to use the road safely with other road users is effective in decreasing the indiscipline on the road and also help harmonise the varying users of the Accra-Tema Motorway. This will eventually make the motorway safe to use.

5.6.9 Significance Level of the Effectiveness of Road Policies

Table 5.13 illustrates the summary of some of the policies to ascertain the significance level of response given by both drivers and passengers (Table 5.13).

Table 5.13: Significance Level of Selected Policies

Suggested Policies	Significance Level
1. Restrictions for learner and Provisional Drivers	0.145
2. Fines for Traffic Offences	0.000
3. Loss of Licence for serious offences	0.000
4. Police Patrol	0.000
5. Random Checks for vehicles that are not Road Worthy	0.000
6. Better Roads	0.000
7. Identifying and Fixing Road/Traffic Hazards	0.000
8. Overtaking Lanes	0.000
9. Drivers' Education on how to Share the Road Safely	0.077

Source: Fieldwork, 2014

Construction of better roads was included. From Table 5.13, the policies with significant (Sig.) values less than 5% (0.05) were the policies which proved significant at a confidence level of 5%. That is, road users are 95% confident that their views concerning the selected policies Were significant with their scale of preference on the level of its effectiveness to the reduction of RTAs on the motorway. However, at a significance level of 10%, all the policies suggested by the road users would be significant except the 'restrictions for provisional and learner drivers'.

In conclusion, road users especially drivers and passengers commute from Ashaiman and TMA to AMA and vice versa for several activities such as trading, studies, business, construction. Figure 3.4 explains that mobility increases the risk of RTAs as the vehicle, the road and road users interact. There is the need for commercial drivers to transport people to their destinations and private drivers' ability to commute from their origin to desired destinations via the motorway. These movements define the travel behaviour and exposes both drivers and passengers to the risk of RTAs. The inability of some drivers to read and interpret road signs due to their level of education and non-attendance of driving school may have dire consequences on road safety. Also, drivers' level of experience as seen in Table 5.2 in terms of their number of years in driving as well as the familiarity of the terrain could influence their involvement in RTA.

CHAPTER SIX

EFFECTIVENESS OF ROAD SAFETY POLICIES IN REDUCING ROAD TRAFFIC ACCIDENTS

6.1 Introduction

The purpose of this chapter is to examine how effective road safety measures and strategies over the years have contributed to the reduction of road traffic accidents in Ghana. The chapter provides a brief overview of the responsibility of the NRSC and its key stakeholders since its inception. This provides a general description of road safety in Ghana, including the main components, functions, strategies and actors involved. Furthermore, the requirements of successful road safety strategies and recommended principles of road safety management are discussed, along with examples of good practises. The trend analyses indicate whether the rate of RTAs is on the increase or decrease over time.

6.2 Background of Road Safety in Ghana

In the year 1988, the Ghana Road Safety Project (GRSP) was launched under the World Bank financed Transport Rehabilitation Project (TRP). This contributed in a great extent to the development, organisation and the orderly management of road safety initiatives and activities in Ghana. 'The primary objective of the GRSP was to increase the knowledge, skills and capabilities of key Ghanaian organisations and professionals to tackle the country's road safety problems more effectively' (Kemeh, 2010:4). According to the National Road Safety Strategy (NRSS) III report, the GRSP had the main objective of increasing the 'knowledge, skill and capabilities of key Ghanaian organisations and professional' to tackle road safety issues in the country in a more effective way (NRSS III, 2011:2).

It is estimated that road traffic crashes costs Ghana about 1.6% of her GDP (Nyarko, 2012). In view of the magnitude of the problem of RTAs and fatalities, the NRSC was established in 1999 through an Act of Parliament (Act 567).

6.2.1 Act of Parliament (1999)

The Government of Ghana in response to the increasing spate of RTAs in the country established the NRSC in 1999. The NRSC was formed to coordinate policies related to road safety and to develop programmes that would promote safety on roads in the country (NRSS, 2011). The National Road Safety Act, 1999, Act 567 established NRSC to plan, develop and promote road safety for all categories of road users across the country (Kemeh, 2010; Siaw, *et al.*, 2013). The existing relevant institutions that play vital roles in road safety were included to form a collective contribution to road safety.

6.2.2 National Road Safety Strategy I (2000-2005)

In 2001, there was a need for appropriate strategies and systems to effectively manage road safety issues in the country. In view of this, the MoT and the NRSC launched the first National Road Safety Strategy (NRSS I) covering the period 2001 to 2005. This strategy provided a 'framework to coordinate efforts in reversing the upward trend in road traffic accidents and casualties' (NRSS, 2011:2).

6.2.3 National Road Safety Strategy II (2006-2010)

The assessment of the first strategy induced the launching of the second phase of the strategy in 2006 popularly termed as NRSS II. The NRSS II was launched to identify and address key challenges that were associated with the implementation of the NRSS I in Ghana. The programme which ended in 2010 was to improve road safety by providing long lasting, effective road safety practices in terms of resource mobilization and to address the observed weaknesses of the NRSS I (NRSS III, 2011).

6.2.4 National Road Safety Strategy III (2011-2020)

This third phase of Ghana's road safety strategy is in response to the International Decade of Action for Road Safety (WHO, 2013; Siaw, *et al.*, 2013). The NRSS III covers a 10 year- period (2011-2020) with a broad objective of reducing road traffic casualties by 50 per cent in 2020 (GNA, 2014) as recommended by the United Nations. The goal of this strategy is to stabilise the fatalities pertaining to RTAs globally and put measures to reduces the increasing level of these fatalities (NRSS III, 2011).

6.3 Stakeholders and their Responsibilities

The quest to reduce RTAs has over the years been the concern for many organizations and governmental institutions and agencies since RTAs have caused severe damages to both humans and property. There are several stakeholders that contribute to building a solid and effective road safety in Ghana and they include the Ministry of Transport, NRSC, DVLA, MTTU, BRRI, GHA, NGOs, the ambulance service and others. However, for the focus of this study, five key stakeholders that play an integral role in the different phases (i.e. pre-crash, crash and post-crash)

of an accident were considered for the study. Figure 6.1 shows the various key stakeholders that work together to promote road safety in Ghana.

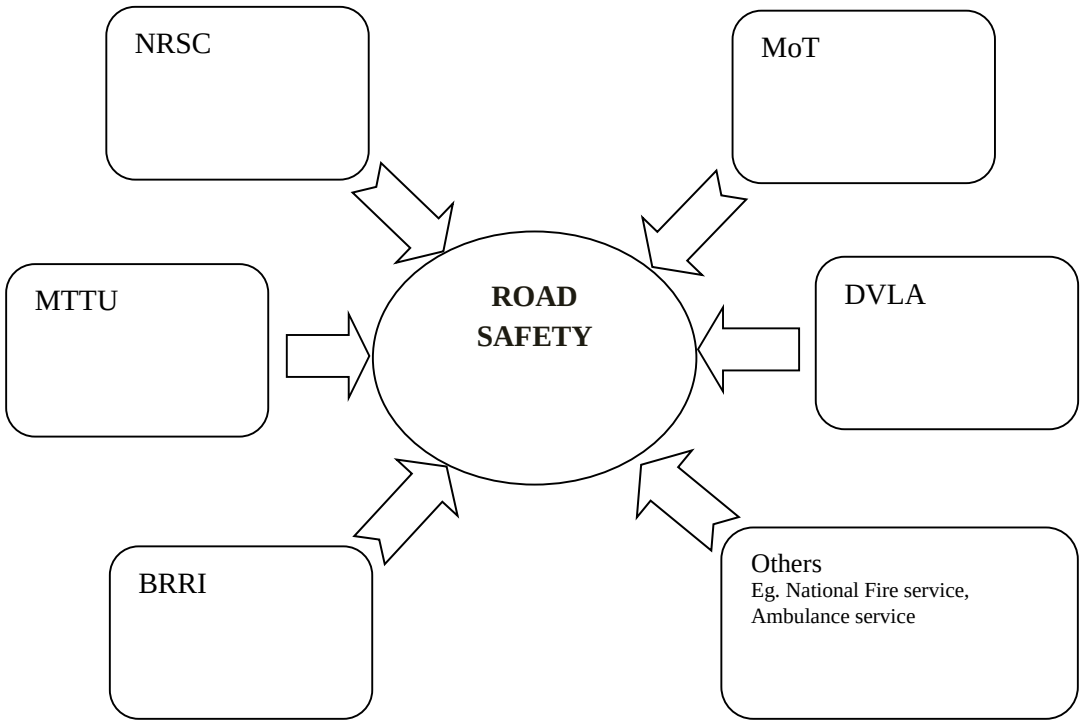

Figure 6.1: Composition of Key Stakeholders Related to the Study

Source: Author's Own Contruct, 2014

The key stakeholders in Figure 6.1 perform different functions and are responsible to perform these functions effectively to achieve the targets that are spelt out by the NRSC at the end of every period. Table 6.1 below shows the various key stakeholders and their corresponding responsibilities within the NRSS.

Table 6.1: Key Stakeholders and their Responsibilities

Name of Institution	Responsibility
Ministry of Transport (MoT)	Policy direction and institutional support
National Road Safety Commission (NRSC)	1) National planning of road safety activities 2) Road safety education, training and information 3) Coordination of National Road Safety Strategy
Motto Traffic and Transport Unit (MTTU)	Enforcement of road traffic rules and regulations
Driver, Vehicle and Licence Authority (DVLA)	Development and enforcement of safe driver and vehicle standards
Building and Road Research Institute (BRRI)	RTA data collection, analysis and maintenance
Ghana Highways Authority (GHA)	Development, construction and maintenance of safe urban highways.

Source: NRSS III (2011)

6.3.1 Broad Objectives of NRSS I

According to the NRSS III report (2011), the main objectives of the NRSS I was to reduce accident fatalities by 5% by the year 2005; reduce total fatalities by the year 2010 and 'develop the capacity to influence the quantity of and quality of road safety interventions.

6.3.2 Broad Objectives of NRSS II

The NRSC II sought to 'reduce RTA fatalities on a year-on-year basis and achieve a total of less than 1,000 by the year 2015' (NRSS III, 2011). This was to achieve a single digit fatality rate by thematically tackling pedestrians and bus/minibus occupants (NRSS III, 2011).

6.3.3 Broad Objective of NRSS III

The NRSC III has a broad objective of stabilising levels of road traffic fatalities by 2015 and at the end of 2020, reducing them them by 50% (NRSS III, 2011). The first target is the continuation of the NRSS II objective and the second target of 50% is in response to the United Nations (UN) recommendation for the Global Plan for the Decade of Action for Road Safety 2011-2020 (Siaw *et al.*, 2013).

Specific objectives of the Key Stakeholders were:

1. To improve road safety management
2. To provide safer roads and mobility
3. To ensure safer vehicles
4. To promote safer road users
5. To improve post-crash response
6. To improve enforcement

The specific objectives provided above cuts across the various stakeholders and each stakeholder has its own activities depending on its responsibility. The institutions are mandated to develop activities and devote a certain percentage of their budget to fulfilling these activities in order to achieve the broad objectives.

6.4 Trends of National Road Traffic Accidents (1991-2010)

The government of Ghana has invested millions of Ghana Cedis to combat the growing effects of RTAs nationally and regionally through campaigns, educational and empowerment. However, RTAs are increasing in the country (Afukaar *et al.*, 2003) despite the objective to reduce RTAs rate to a single digit by 2015 (NRSS III, 2011). Table 6.2 presents the annual national distribution

of crashes from 1991 to 2010. The statistics clearly shows that total national accident cases, number of fatalities and injuries are increasing with only a few drops.

Table 6.2: RTA Statistics in Ghana (1991-2010)

Year	Accident Cases	% Increase	Mortality	% Increase	Persons Injured	% Increase
1991	8,370	-	920	-	8,773	-
1992	6,922	**-17.30**	914	**-0.66**	9,116	**3.91**
1993	6,467	**-6.58**	901	**-1.43**	7,677	**-15.79**
1994	6,584	**1.81**	824	**-8.55**	7,664	**-0.17**
1995	8,313	**26.26**	1,026	**24.52**	9,106	**18.82**
1996	8,488	**2.11**	1,049	**2.25**	9,903	**8.76**
1997	9,918	**16.85**	1,015	**-3.25**	10,433	**5.36**
1998	10,996	**10.87**	1,419	**39.81**	11,786	**12.97**
1999	8,763	**-20.31**	1,237	**-12.83**	10,202	**-13.44**
2000	11,087	**26.52**	1,437	**16.17**	12,310	**20.67**
2001	11,293	**1.86**	1,660	**15.52**	13,178	**7.06**
2002	10,715	**-5.12**	1,665	**0.31**	13,412	**1.78**
2003	10,542	**-1.62**	1,716	**3.07**	14,469	**7.89**
2004	12,175	**15.49**	2,186	**27.39**	16,259	**12.38**
2005	11,320	**-7.03**	1,779	**-18.62**	14,034	**-13.69**
2006	11,668	**3.08**	1,856	**4.33**	14,492	**3.27**
2007	12,038	**3.18**	2,043	**10.08**	14,373	**-0.83**
2008	11,214	**-6.85**	1,938	**-5.14**	14,531	**1.10**
2009	12,299	**9.68**	2,237	**15.44**	16,259	**11.90**
2010	11,506	**-6.45**	1,986	**-11.22**	14,918	**-8.25**

Source: NRSC, 2010

From Table 6.2, before the year 2000, the year with the highest accident record was 1998 (10,996) which respectively recorded the highest number of deaths (1,419) and injuries (11,786). After the year 2000, the years with the highest accident were 2009 (12,299) followed by 2004 (12,175). A statement by an expert in NRSC shows that *'Accident rates and fatalities are usually high in election years due to the increasing mobility and exposure to risk'*. This can clearly be seen in the years 2000 (11,087), 2004 (12,175) and 2008 (11,214). The highest percentage increase in accident cases before year 2000 was 26.26% in 1995 followed by 16.85% in 1997. 2000 recorded a

percentage increase of 26.52% which indicates an avalanche increase in accident rates in the country. The rate of increase in 2004 (15.49%) was also very significant.

The highest accident figures according to Table 6.1 were accompanied by high mortality and injuries. In 1995, the mortality was 1,025 with a 24.52% increase and injuries recorded were 9,106 with an 18.82% increase. In the year 2000, total deaths recorded were 1,437 and total injuries were 12,310 with percentage increases of 16.17% and 20.67% respectively. The percentage increase of mortality in 2004 (27.39%) was far more than the percentage increase of injuries (12.38%) in the same year.

6.5 Temporal View of Accident in the Greater Accra Region

The number of road traffic crashes occurring in the Greater Accra Region as a proportion of the national total for the period 1991-2008 is by far the largest (42.1%). Again, during this same period, the region ranked 2nd in terms of fatal crashes (18.3%). The accident figure dropped abruptly to 5,044 in 2008 (-15.03%) and rose sharply to 5,588 in 2009 which is one of the highest so far. Statistics for the ending of 2009 show that the total cases for the year were 5,100 with 7,736 vehicles involved, 429 persons were killed and 4,542 sustained several injuries (BRRI, 2011).

Table 6.3: RTA Statistics in the Greater Accra Region (1991-2010)

Year	Accident Cases	% Increase	Mortality	% Increase	Persons Injured	% Increase
1991	2,835	-	103	-	1,462	-
1992	2,097	-26.04	164	59.23	1,741	19.09
1993	2,187	4.30	115	-29.88	1,588	-8.79
1994	2,302	5.26	155	34.79	1,664	4.79
1995	3,645	58.34	190	22.58	2,263	36.00
1996	3,654	0.25	186	-2.11	2,426	7.21
1997	4,231	15.79	174	-6.46	2,590	6.7
1998	4,963	17.30	258	48.28	2,924	12.90
1999	3,414	-31.21	172	-33.34	2,106	-27.98
2000	5,234	53.31	237	37.79	3,058	45.21
2001	5,003	-4.42	240	1.27	3,180	3.99
2002	4,229	-15.47	169	-29.59	2,629	-17.33
2003	4,110	-2.82	232	37.28	2,904	10.46
2004	4,624	12.51	299	28.88	3,483	19.94
2005	4,983	7.77	313	4.69	3,252	-6.64
2006	5,454	9.46	335	7.03	3,880	19.32
2007	5,936	8.84	407	21.50	4,450	14.69
2008	5,044	-15.03	385	-5.41	3,882	-12.77
2009	5,588	10.79	429	11.43	4,542	17.01
2010	5,122	-8.34	423	-1.40	3,869	-14.82

Source: Modified from BRRI (2011)

Table 6.3 show that RTAs in the Greater Accra Region where Accra-Tema motorway is situated has been increasing since 1991 (2,835) to 2010 (5,122) which shows a 55.35% increase over a ten year period. However, there have been intermittent drop and rise within these two contrasting years. Over the period, the highest accident cases was recorded in 2009 (5,588) with 429 deaths and 4,542 injuries recorded. The lowest was 1992 (2,097) with a -26.04% decrease from the previous year but with an increases in the number of deaths and injuries as compared to 1991. In 2013, there were 2,013 deaths involving a total of 3,099 vehicles within the third quarter of the year in the Greater Accra Region which currently tops the list of national fatalities from road traffic

accidents (GNA, 2013). The region recorded 1,996 total accidents cases with 1,539 deaths within January and September in 2013 which surpasses the 1,807 that were recorded in the previous year within the same period (GNA, 2013).

6.6 Temporal View of Accident on the Accra-Tema Motorway

Since the construction of the Accra-Tema motorway, it has witnessed increasing trends of RTA annually with a few interspersed drops. Figure 6.2 below shows that RTA cases recorded on the Accra-Tema Motorway from 1991 to 2010 with their corresponding number of deaths and injuries.

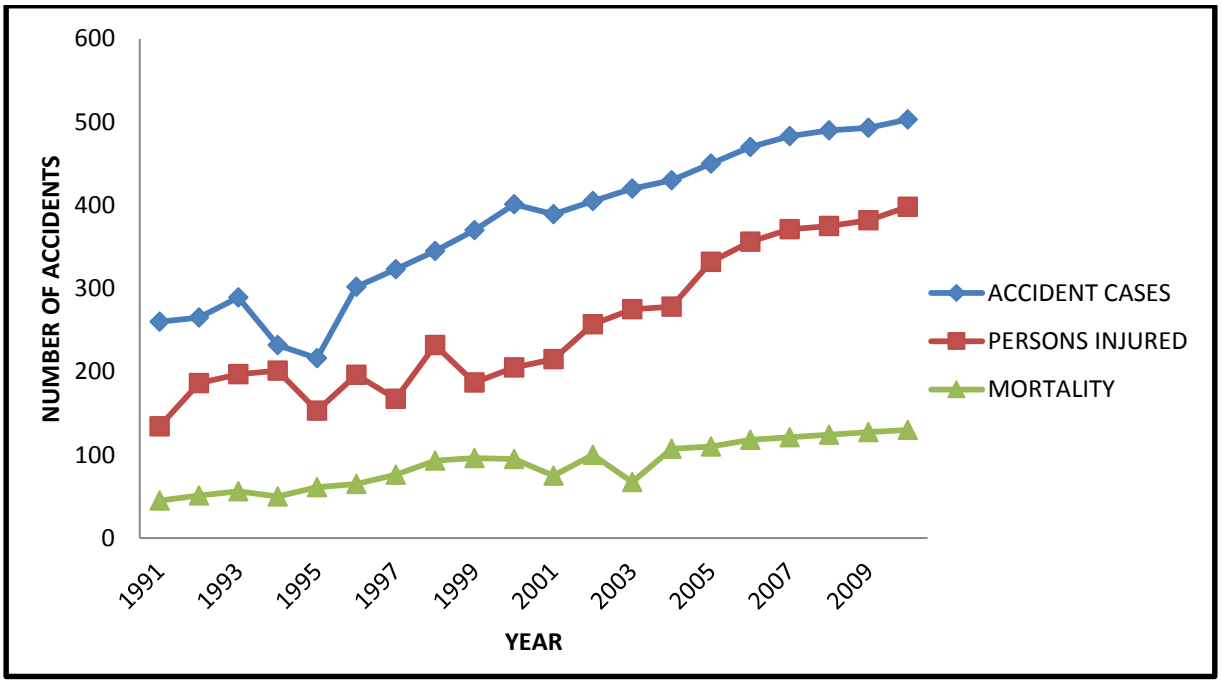

Figure 6.2: Trend of RTAs on the Accra-Tema Motorway

Source: Modified from Okutu (2011)

The trend analysis of total accident cases, number of persons killed and the number of persons injured on the Accra-Tema Motorway is presented in Figure 6.2. There were however, significant drops in 1994 and 1995 for both accident and mortality cases. The figures have since been increasing. Tables 6.4, 6.5 and 6.6 provide an analyses of accident cases, total mortality and

number of injured persons respectively in terms of their growth rates, average for five years intervals beginning from 1996 and their proportions to national and regional figures for the same periods. This has been divided into 5 years before the NRSS I, the 5 years of NRSS I's operation and the 5 years of the NRSS II operation. This enabled the study to evaluate the changes in accident cases, fatalities and injuries to understand how effective the strategies/policies have been in reducing accidents, mortalities and injuries.

6.6.1 Analysis of Total RTA Cases for the Study Road

Table 6.4 illustrates the increaing RTA cases on theAccra-Tema Motorway and how these figures relate to the time frames of the various strategies to improve road safety and reduce RTAs.

The average accidents for each phase shows that between the years1996 and 2000, the average accident for each year was 348 and this increased during the NRSS I phase which shows that accident cases for each year was 419 accidents. NRSS II also witnessed a higher annual average (488 per year) as compared to the previous phases.

Table 6.4: Increasing Accident Rates

Year	Total Accident Cases	Accident Growth Rate (%)	Average Accident for Each Phase	National Totals	Proportion of A/TM to national	Regional Totals	Proportion of A/TM to Regional
Before the First Strategy							
1996	302	-		8,488	**3.56**	3,654	**8.27**
1997	323	**6.96**		9,918	**3.26**	4,231	**7.64**
1998	345	**6.82**	**348**	10,996	**3.14**	4,963	**6.96**
1999	370	**7.25**		8,763	**4.23**	3,414	**10.84**
2000	401	**8.38**		11,087	**3.62**	5,234	**7.67**
National Road Safety Strategy (I)							
2001	389	**-3.00**		11,293	**3.45**	5,003	**7.78**
2002	405	**4.12**		10,715	**3.78**	4,229	**9.58**
2003	420	**3.71**	**419**	10,542	**3.99**	4,110	**10.22**
2004	430	**2.38**		12,175	**3.54**	4,624	**9.30**
2005	450	**4.66**		11,320	**3.98**	4,983	**9.03**
National Road Safety Strategy (II)							
2006	470	**4.45**		11,668	**4.03**	5,454	**8.62**
2007	483	**2.77**		12,038	**4.02**	5,936	**8.14**
2008	490	**1.45**	**488**	11,214	**4.37**	5,044	**9.72**
2009	493	**0.61**		12,299	**4.01**	5,588	**8.83**
2010	503	**2.03**		11,506	**4.38**	5,122	**9.82**
National Road Safety Strategy (III) – Decade of Road Safety							

Source: Modified from Okutu (2011)

When NRSS I started in the year 2001, there was a significant percentage decrease (3%) from the previous year 2000 (401 accident cases) to 389 accidents in the year 2001. However, after this decrease, accident rates continued to soar from 389 in 2001 to 450 cases in 2005. Accidents cases increased slightly from 2005 to 2006 at the beginning of the NRSS II. The significant thing to note is that from the beginning of the NRSS II though accidents cases have been increasing, the growth rate is slower than the previous phase (NRSS I). Table 6.4 also shows the proportion of accidents on the Accra-Tema Motorway to the national and regional totals. This indicates that the years with the high proportion to the national figure was 2010 (4.38%) and the year with the highest proportion to the regional total was 2003 with 10.22%. According to an inspector at the Airport

Police Station *'there are rigorous education and enforcement at the beginning of each phase of the NRSS and with time that attitude and attention to road safety reduces unless there is an alarm of the spate of accidents and deaths'.*

6.6.2 Analysis of RTA Mortalities

The total mortality rate in Table 6.5 exhibits similar trends as that of the total accident cases and these statistics are illustrated below.

Table 6.5: Total Deaths (Mortality)

Year	Total Mortality /Death A/T.M	Mortality Growth Rate (%)	Average Mortality for Each Phase	National Totals	Proportion of A/T.M to national	Regional Totals	Proportion of A/T.M to Regional
Before the First Strategy							
1996	65	-	**85**	1,049	**6.20**	186	**34.95**
1997	76	**16.93**		1,015	**7.49**	174	**43.68**
1998	93	**22.3 7**		1,419	**6.56**	258	**36.05**
1999	96	**3.23**		1,237	**7.76**	172	**55.82**
2000	95	**-1.05**		1,437	**6.61**	237	**40.09**
National Road Safety Strategy (I)							
2001	75	**-21.06**	**92**	1,660	**4.52**	240	**31.25**
2002	100	**33.34**		1,665	**6.01**	169	**59.18**
2003	67	**-33.00**		1,716	**3.91**	232	**28.88**
2004	107	**59.71**		2,186	**4.90**	299	**35.79**
2005	110	**2.81**		1,779	**6.19**	313	**35.15**
National Road Safety Strategy (II)							
2006	118	**7.28**	**124**	1,856	**6.36**	335	**35.23**
2007	121	**2.55**		2,043	**5.93**	407	**29.73**
2008	124	**2.48**		1,938	**6.40**	385	**32.21**
2009	127	**2.42**		2,237	**5.68**	429	**29.61**
2010	130	**2.37**		1,986	**6.55**	423	**30.74**
National Road Safety Strategy (III) – Decade of Road Safety							

Source: Modified from Okutu, 2011

Table 6.5 indicates that each year from 1996 to 2000, the average number people who die on the Accra-Tema motorway are 85. This increased to an average of 92 deaths and 124 deaths for the

NRSS I and the NRSS II phases respectively. This shows that the number of people who dies from accident on the Accra Tema motorways has been increasing over the years. The highest proportion of deaths to the national mortality rate was in 1999 which was 7.76%. The highest rate of mortality in the regional figures was also recorded in the same year at 59.82% followed by year 2002 at 59.18%.

6.6.3 Analysis of Total Injuries for Each Phase

A reduction of the rate of RTA injuries is an important objective of the NRSS, and Table 6.6 shows the statistics for injuries on the Accra-Tema Motorway each phase of the road safety strategies.

Table 6.6: Analysis of Total Injury

Year	Total Injury A/T.M	Injury Growth Rate (%)	Average Injurys for Each Phase	National Totals	Proportion of A/T.M to national	Regional Totals	Proportion of A/T.M to Regional
Before the First Strategy							
1996	196	**-**	**197**	9,903	**1.98**	2,426	**8.08**
1997	167	**-14.80**		10,433	**1.60**	2,590	**6.45**
1998	232	**38.93**		11,786	**1.97**	2,924	**7.94**
1999	187	**-19.40**		10,202	**1.84**	2,106	**8.88**
2000	205	**9.63**		12,310	**1.67**	3,058	**6.71**
National Road Safety Strategy (I)							
2001	215	**4.88**	**271**	13,178	**1.64**	3,180	**6.77**
2002	257	**19.54**		13,412	**1.92**	2,629	**9.78**
2003	275	**7.01**		14,469	**1.90**	2,904	**9.47**
2004	278	**1.09**		16,259	**1.71**	3,483	**7.99**
2005	332	**19.43**		14,034	**2.37**	3,252	**10.21**
National Road Safety Strategy (II)							
2006	356	**7.23**	**376**	14,492	**2.46**	3,880	**9.18**
2007	371	**4.22**		14,373	**2.59**	4,450	**8.34**
2008	375	**1.08**		14,531	**2.58**	3,882	**9.66**
2009	382	**1.87**		16,259	**2.35**	4,542	**8.41**
2010	398	**4.19**		14,918	**2.67**	3,869	**10.29**
National Road Safety Strategy (III) – Decade of Road Safety							

Source: Modified from Okutu (2011)

Table 6.6 indicates that each year from 1996 to 2000, the average number people injured on the Accra-Tema motorway were 197. This increased to an average of 271 injuries and 376 injuries for the NRSS I and the NRSS II phases respectively. This shows that the number of people who get injured from RTAs on the Accra-Tema Motorways are increasing over the years. The highest proportion of deaths of the national mortality rate was in 2010 at 2.67% and the highest number of injuries on the Accra-Tema Motorway to the regional figures was also recorded in the same year (10.29%).

6.7 Challenges of NRSS I And NRSS II

There are myriads of challenges that have influenced the inability of the policy to reduce road traffic accident. Road safety issues generally have been given less attention than expected. According to the NRSS III (2011), road safety and its associated policies 'is not well positioned' even within the Ministry of Transport. One important challenge the strategies have faced has to do with the weak collaboration and coordination between key stakeholders. According to the NRSS III (2011) there is no legal backing on the part of NRSC to demand compliance from stakeholder institutions. As a result, low performing institutions cannot be sanctioned.

Concerning funding for the various stakeholders, there is no advocacy, to gain access to guaranteed and adequate sustainable funding for road safety. Unfortunately, issues pertaining to road safety in various stakeholders do not have budget allocations from the institution. Hence, the stakeholders rely solely on the NRSC to fund their mandates which put stress on the already inadequate resources of the NRSC (NRSS III, 2011).

Secondly, the resources needed to effectively execute actions according to NRSS III were inadequate and this has incapacitated the various stakeholders to enforce road traffic laws and

regulations by the MTTU and the DVLA. It is also clear from the report that the personnel available at both DVLA and MTTU to carry out frequent checks of vehicles on the road networks are not adequate. The enforcement of road traffic regulations and laws has been low due to these constraints (NRSS III, 2011).

Another reason for the inefficiency of the NRSS I and NRSS II is the increasing number of vehicles on the roads especially the vehicle fitness deficiency (NRSS III, 2011). The non-compliance of road traffic rules and regulations by road users especially drivers have contributed to the failure of the strategies. The report noted that there are limited criteria for regulating and engaging the behaviour and attitude of drivers. There are several efforts to educate road users, yet, 'some drivers continue to indulge in negative attitudes such as drunk-driving and making of mobile phone calls, while most are often highly temperamental, leading to road crashes' (GNA, 2012).

The identification and improvement of hazardous locations on roads in the country was not fully realised and the process of achieving this goal was slow such that major roads and highways such as the Accra-Tema motorway were neglected. This is so evident in the deteriorating nature of the Accra-Tema Motorway which has been left unattended for many years now. An official of the DVLA said that '*the Accra-Tema Motorway has outlived its years and there have not been any major repairs on this prestigious motorway'*. Another official in the Ghana Highway Authority further added that for a calibre of road such as the Accra-Tema Motorway belong to, *'patching the road is not an option, it needs a major re-construction but funds are unavailable for such constructions'*. The GHA had lots of proposed projects and yet some of them are not accomplished. Also, the fixing of traffic lights and maintenance of most roads are delayed (NRSS III, 2011). Consequently, they have not been able to meet their objective of effectively maintaining roads and the motorway is an example.

There have been low levels of education and information dissemination (NRSS III, 2010). A considerable number of road users still have negative beliefs and attitudes towards road safety and some of the road users still do not understand why they are forced to be oblige to the road safety regulations and hence engage in various kinds of risk. There is a dire need not only to disseminate information relating to road safety but to engage the users at various levels in a dialogue to explain and erase false notions in such a way that road usage will be well-balanced and rules adhered to.

MTTU's lack of dedication to enforcing road safety issues is unacceptable. They have inadequate requisite equipments like breath-analyzers, height gauges, red light batons, radar guns and towing trucks to enable the various units function effectively. The researcher requested a radar gun from the MTTU headquarters and was told it's a long time since they used one since almost all the speed radar guns were broken and those that are available were not calibrated. The one in charge reported that, *'cost in calibration is so high that the speed radars are left unattended. The police stations do not have adequate equipments to aid in speed enforcement as well as regulating behaviour of drivers. Recently, the availability of pick-up for monitoring has aided the MTTU but the inadequate equipment has hindered their effectiveness'.*

Though each phase of the strategy presented different targets and objective, it is clear that some of the objectives overlap the duration of each phase; this is as a result of the inability of each phase to successfully meet their targets with minimum challenges especially with the key stakeholders. It is important to note that the strategies can be effective when all stakeholder responsibly execute their objectives and contribute their quota to making the road transport system safe. In addition, there must be ordered coordination, sharing of ideas and techniques and the coordinating body (NRSC) having the authorisation to direct stakeholders toward achieving the objectives.

6.8 Progress of NRSS III (2011-2013)

After three years into the decade of road safety in Ghana, there is little to discuss. There are five main items to be addressed: Improved road safety management, safer roads, safer vehicles, safer road user behavior and better post-crash response (NRSS III, 2011; Siaw *et al.*, 2013) which are well known as the 'five pillars' of road safety under the Decade of Road Safety. However, the summary of activities and the allocated funds for 2011-2013 is spelt out in Table 7.7 below at decreasing rates.

The highest allocation of the fund goes into improving safer road and mobility and the least allocation of the funds goes into enhancing safer vehicles. This is not necessarily prioritizing the objective but it however depicts the amount needed to making sure each objective is achieved. The grand total of GH₵ 151,669,160 indicates that a significant amount of the money is invested into road safety in Ghana. Hence, all things being equal, targets and goals must be achieved with an individual responsibility and a collective contribution to see our roads safe and comfortable to use.

The NRSC in many ways have successfully implemented good road safety measures but has been unable to meet the targets it has set for itself. The statistics from 2011 to 2013 give hope that the targets will probably be achieved by the close of 2020 since the percentage increase of accident, fatalities and injuries has been increasing at a decreasing rate since 2006. However, there is a dire need of commitment and dedication on the side of stakeholders. Also, there is the need for meticulous and mandatory coordination with an act of parliament to charge concerned stakeholders on their failure to execute their duties. Lastly, more funding and governmental, ministerial commitment is required to see to it that, the NRSS III becomes a success.

Table 6.7: Summary of Activities and Fund Allocation

	Activity	Total (Gh ₵)
1.0 Improve Road Safety Management	1.1 Empower NRSC to hold stakeholders to mandate 1.2 Solicit and sustain political commitment 1.3 Improve coordination of road safety activities amongst stakeholders 1.4 Improve capacity of key stakeholder agencies 1.5 Regulation of road transport industry 1.6 Build a centralised database 1.7 Increase funding levels for activities 1.8 Increase research on road safety issues 1.9 Encourage stakeholders to accord priority to road safety issues	3,597,160
2.0 Safer Roads and Mobility	2.1Train Road Safety Engineers on road safety 2.2 Increase budgetary allocations for road safety 2.3 Include safety provision in road design, construction and use 2.4 Train staff in road safety audit 2.5 Train staff in specialised fields for specific assignments	129,873,250
3.0 Safer Vehicles	3.1 Harmonise standards on vehicle and spare parts 3.2 Facilitate compliance with regulations on use and physical conversion of vehicle 3.3 Strengthen DVLA's capacity to effectively inspect vehicles to ensure compliance with regulations, conditions and operations 3.4 Improve enforcement of driver qualification index	1,820,500
4.0 Safer Road Users	4.1 Educate and upgrade driver skills 4.2 Enhance education, information and publicity 4.3 Establish national driver academy (NDA) model schools 4.4 Enhance awareness on cost of RTA crashes	7,288,000
5.0 Improved Post-Crash Response	5.1 Train emergency medical technicians 5.2 Train more first aid volunteers 5.3 Construct emergency post and provide logistics 5.4 Enhance community participation in emergency services 5.5 Establish effective coordination among stakeholders with linkages to otSher agencies	2,319,500
6.0 Improve Enforcement	6.1 Elevate road safety violations to a high priority 6.2 Apply modern technology in enforcement of road traffic regulations 6.3 Establish education and training programmes 6.4 Institute appropriate mechanisms for apportioning fines accruing from road traffic violations	6,770,750
Grand Total		**151,669,160**

Source: NRSS III (2011)

CHAPTER SEVEN

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

7.1 Introduction

The study sought to assess the spatio-temporal patterns of RTAs on the Accra Tema Motorway and the related causes and risk factors. Having covered thoroughly the pertinent issues relating to RTAs on the Accra-Tema Motorway in the previous chapters, there is the necessity to highlight the major findings and give relevant recommendations based on the findings of the study. The chapter therefore seeks to summarise the results realised at the end of the study and give due recommendations to that effect.

7.2 Summary of Major Findings

There have been two major strategies geared towards tackling road safety and reducing RTA which are the National Road Safety Strategy I and II and beginning from 2011, the third phase the NRSS was launched in response to the global decade of road safety. However, RTAs have been increasing annually on the Accra-Tema Motorway though there was a drop from 503 in 2010 to 294 in 2011 the beginning of the decade of road safety (2011-2020). The highest accident rate on the Accra-Tema Motorway so far is 503 in 2010.

There have been an increasing number of black spots or dangerous zones on the motorway with six medium spots and one high spot in 2011, to seven medium and two high black spots in 2013 according to the kernel density analysis performed. The study showed that there are two major high black spots on the Accra-Tema Motorway which are the Abattoir and the Klagon/Adjei Kojo underpass areas. There was a 530.65% increase in built-up areas along the Accra-Tema Motorway from 1985 to 2002 and 30.79% from 2002 to 2013. These increases correlate with the increasing

human activities and illegal routes that have endangered road users on the study road. In 2011, the day with the highest number of RTAs was on Thursdays with 49 accidents; the time period with the highest accident cases was between 12:00 – 15:00. August recorded the highest number of RTAs (41 accidents). In 2012, Tuesday recorded the highest RTA cases with 19% of the total accidents for the year while more accidents occurred within 16:00 to 18:00 period. April was the month with the highest record of RTA with 47 cases. For 2013, Fridays had the most RTA cases with 67 accidents followed by Wednesdays and Saturdays with 63 accidents each. The 6:00pm to 9:00pm time period recorded the highest RTA cases with 72 accidents. July and September recorded the highest accident rate for 2013 with 51 accident cases each. For each year, the time period between 00:00-3:00 recorded the least accident cases due to the low vehicular movement.

The major causes of RTAs on the black spots identified on the Accra-Tema Motorway are the many illegal routes along the motorway especially at Abattoir and the several U-turns on the motorway particularly those at the Trasacco area, the Kings Cottage area, the Klagon/Adjei Kojo area and around the Ashaiman overhead (see Figure 4.3). Authorities agreed that there was an increasing number of illegal entries and U-turns. Vehicular stops and take-offs are other causes of RTAs on the Accra-Tema Motorway especially around Trasacco area, Abattoir and Klagon/Adjei Kojo areas. Both drivers and passengers agreed that drivers' attitude contribute greatly for an accident to occur. A total of 47.4% of passengers responded that drivers' attitude and car conditions are the major causes of RTA on the motorway while 26.3% reported driver attitude and road condition as the major causes of accident on the motorway. RTAs usually occur when it rains and this was confirmed by the 79.2% response from drivers. An inspector from MTTU also confirmed this record.

Most drivers do not have a routine check of their vehicles and Figure 4.16 shows that only 45 out of the 120 respondent had a routine check of their vehicle. The rest (75 drivers) only check when

obviously their vehicle is faulty. Drivers noted that there is no adequate information like road signs, road markings and lighting systems on the road for safe driving. This has caused numerous RTAs and poses a threat to the safety of road users on the Accra-Tema Motorway. Nonetheless, the deteriorating nature of the motorway causes RTAs, injuries and deaths on the motorway. A high number of drivers (94%) disagrees with speeding and 75.8% (91 drivers) responded that they wear seat belts nearly always. In terms of driving under the influence of alcohol, the response was encouraging since 89 % of all the respondents disagreed strongly with the act of driving drunk.

The Policy has failed to reduce accidents and stabilise accident, as targeted by the NRSC though there has been a significant achievement that cannot be under estimated. However, the percentage in the increase of accident cases are increasing at a decreasing rate which shows that there are some achievements over the years. Road user education seems to be positive since 87.5% of drivers and 67.5% of passengers remembered the last road safety education and were able to give the source and what exactly was communicated. Road users view of policy effectiveness was assessed and it was noticed most road users think police patrols, loss of licence for serious offences, random check for road worthy vehicles, identifying and fixing hazardous locations, educating drivers on how to share road safely and other policies in place are effective in reducing road traffic accidents and improving road safety. From table 5.13, all the policies suggested by the road users are significant except the ‘restrictions for provisional and learner drivers’ at a significance level of 10%.

7.3 Conclusion

The two theories (Systems Theory and Haddon Matrix) failed to recognise one finding in the research. The two theories are silent on cultural issues such as peoples belief in superstition. Per the findings of the research some respondents attributed causes of accidents to nature where they

believe that accidents are pre-determined and can only occur when nature allows. To the drivers, causes of accidents are perceived to be external and not borne by themselves. The analysis performed in Table 5.5 indicates that drivers do not adhere to road safety rules and regulation which confirms the proposition stated in Chapter One. According to Deery (2000)people's perception can influence their attitude towards an event and hence, peoples' understanding of RTA occurrence is significant to the entire management process of road safety.

The distribution of RTAs on the Accra-Tema Motorway was shown in maps using ArcGIS 10.2 where sections exhibiting clusters were visible and easy to comprehend. The study utilised the Kernel density analysis tool in the ArcGIS software to show the density or the extent to which accident spots are distributed on different sections on the road. This proves the efficacy of GIS in spatial analysis of RTAs. The route action approach which indicates accident clusters on a single express route which exhibits higher accident levels than the regional average was used with the Accra-Tema Motorway as the study route. The system theory used gave the study a holistic perspective. The study looked at the human factors, the road environment and the vehicular quality. However, limited variables from each component were selected due to time and cost and the techniques required for achieving the desired results. The Haddon Matrix also provided a platform to assess the phases of accidents in the study especially the pre-crash and crash phases. Traffic data analyses though formed part of the post-crash phase, does not directly relate to injury and death. The key stake holders responsible for various phases were also assessed and duly included in the study.

Statistics show that RTAs are increasing on the Accra-Tema Motorway. Though there are good policies and strategies of international standard, they do not translate into the reduction of RTAs on the motorway. The Accra-Tema Motorway is a very important route that does not only serve the region but the whole country and beyond. Since it was completed and opened, there have not

been any major reconstruction and repair that is up to standard to curtail the many accidents that occur on it and to provide smooth movement of goods and people. The rapid development along the study road is rampant and uncontrolled.

The study is not only applicable to the Accra-Tema Motorway but can be replicated on other roads using any of the strategies noted in the literature (route action, area action, single action or mass action). RTAs exhibit clusters due to hazardous locations and risk often taken by road users especially on certain locations of convenience to the user. RTA causes are varied and from the study, RTAs occur as a result of bad road networks/road environment, driver attitude and careless driving, environmental challenges, institutional failures and improper enforcement of rules and regulations.

Interventions aimed at reducing RTAs include random checks for road worthy vehicles, police patrols and enforcements, driver and road user education and identifying and treating hazardous locations and so forth. However, Policy has failed to some extent in reducing RTAs over the years. Some drivers continue to indulge in negative attitudes such as drunk-driving and speeding despite the numerous education programme and interventions.

7.4 Recommendations

The results of the study have revealed many issues concerning RTAs on the Accra-Tema Motorway. Based on the findings of the study, the following recommedations are made.

1. Web-based, digital data collection, storage and management should be budgeted for and the stakeholders in charge of data collection should be trained to use various applications such as ESRI ARGIS and Google Collector as well as GPS devices to collect the appropriate data and attributes while the database is managed and updated. This according

to Deepthi and Ganeshkumar (2010) provides the basis for treating hazardous locations and making relevant policies.

2. Black spots and other hazardous locations should be treated with urgency through effective and frequent monitoring and expert's consciously identifying hazards locations through appropriate methodologies. Also, there must be the requisite budgetary provision for executing this task. However, this must be done with the whole network in consideration so that similar problems will not emerge on other sections of the road in the future.

3. The police (MTTU division) should be empowered to stop the use of illegal routes and U-turns that exist on the Accra-Tema Motorway despite the category of drivers that use them. Also, the police should frequently patrol the motorway to reduce the rate at which drivers stop and take-off indiscriminately.

4. Spatial planning into the future must be incorporated in the road environment and there must be proper regulation of human activities along the motorway. Alternative and safe routes for drivers from Tema Community 18, Spintex Road, Adjiringano, Trasacco and East Legon should be provided.

5. There is a need for a strong coordinative role by the National Road Safety Commission (NRSC) and a collective contribution from each stakeholder to realise all the objectives and targets set by the National Road Safety Strategy III. An act of Parliament should be passed to give NRSC the power to demand good service and delivery from each stakeholder. There must be an assessment of the strategy annually and institutions lagging behind should account for their portion of the budget. There is always a correlation between

the RTA cases and the fatalities and injuries. Hence, the NRSS III should aim first at reducing RTAs in general and then subsequently put measures in place to reduce deaths and injuries.

6. The Accra-Tema Motorway should no longer be considered a 'motorway'. Therefore, overpasses at major entry and crossing points must be built to make the road safe to use. In the design and construction of road systems, due consideration has to be given to vulnerable road users who have challenges using the road system (Oxley *et al.,* 2004).

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APPENDIX ONE - QUESTIONNAIRE FOR DRIVERS

DEPARTMENT OF GEOGRAPHY AND RESOURCE DEVELOPMENT - MPHIL THESIS

QUESTIONNAIRES FOR DRIVERS

This questionnaire is in aid of completing a Master of Philosophy (MPhil) degree in Geography and Resources development on the topic **"Spatio-Temporal Analysis of RTA on the Accra-Tema Motorway: Causes and Risk Factors".** These questions will help gather information from driver's wih ages above eighteen (18) years as specified by the Driver, Vehicle and Licence Authority (DVLA). The details of individuals would be kept confidential.

SETION A: BIOGRAPHICAL DETAILS AND DRIVING HISTORY

Select the appropriate answers to the following questions

1. Sex M ☐ F ☐

2. Age

a. 15-25
b. 26-35
c. 36-45
d. 46-55
e. Above 55

3. What is your highest education level.

a. Tertiary
b. Secondary
c. Middle or Junior High School
d. Primary education
e. None
f. Other

If other, specify: ……

4. How long have you been driving?

a. 1-5 years
b. 6-10 years
c. 11-15 years
d. 16-20 years
e. Above 20 years

5. Have you been to the driving school?

Yes ☐ No ☐

6. Do you have a driving licence?

Yes ☐ No ☐ Expired ☐

7. Are you insured?

Yes ☐ No ☐

8. Type of insurance policy (e.g. Comprehensive, third party etc.)

……..

9. How many hours do you driver a day?

a. 1-4 hrs
b. 5-10 hrs
c. 11-15 hrs
d. 16-20 hrs
e. 21-24 hrs

SECTION B: VEHICLE, NATURE OF ROAD AND ROAD ENVIRONMENT

10. Which sections of the Accra-Tema Motorway do you think are damaged?

……

……

11. Do you think you have all the information on the Accra-Tema motorway for your safe driving?

Yes ☐ No ☐ (If 'YES' Continue from question 13)

12. If 'No' what information are missing on the road?

....

.....

13. Why do you visit the mechanic?

Routine ☐ When car is faulty ☐

14. How often do you take your vehicle to the workshop?

○	○	○	○	○
Every Month	Every Three Months	Every Six Months	Every year	None

Please, tick either YES or NO if you have or do not have the following parts of your vehicle working

15. Is your horn working Yes ☐ No ☐

16. Does your vehicle have a mirror (two if it not a private car) Yes ☐ No ☐

17. Is your speedometre in working order? Yes ☐ No ☐

18. Do you have reflectors on your vehicle? Yes ☐ No ☐

19. Is your wiper working? Yes ☐ No ☐

Please, indicate how many of the parts mentioned are not working.

20. How many lights are not working?

○	○	○	○	○
Only 1	2	3	4	None

21. How many seat belts are working?

○	○	○	○	○
Only 1	2	3	4	All

22. When during any of these meteorological times do you take the greatest caution? (Choose maximum of two)

a. Raining b. High Temperature c. Winds d. Fog reducing visibility

23. What difficulty do you find with such factors in handling your vehicles

1. ……:.....

2. ……: .....

24. Have you ever experienced or witnessed an accident scene before? Yes ☐ No ☐

If 'Yes' please specify the appropriate condition (If 'No', move to question 25)

Weather conditions: Sun ☐ Rain ☐ Fog ☐

Road conditions: Dry ☐ Wet ☐ Mud ☐ Oil ☐

Light conditions: Bright ☐ Dark ☐

SECTION C: CAUSES, RISK, DRIVER ATTITUDE AND TENDENCY

In the following questions, please mark on the scale how often you perform the action described, the level of agreement and disagreement to a particular statement or your satisfaction level.

25. How often do you wear your seat belt?

○	○	○	○	○	○
Never	Very Rarely	Rarely	Sometimes	Often	Nearly always

26. How often do you drive especially getting close to a car in front as a signal for its drivers to go faster or get out of the way?

Never	Very Rarely	Rarely	Sometimes	Often	Nearly always

27. How often would you cross a junction knowing that the traffic lights have already turned against you?

Never	Very Rarely	Rarely	Sometimes	Often	Nearly always

28. How often do you fail to notice that pedestrians are crossing when turning from a side street into the main road?

Never	Very Rarely	Rarely	Sometimes	Often	Nearly always

29. How often do you disregard speed limit at night or early in the morning?

Never	Very Rarely	Rarely	Sometimes	Often	Nearly always

30. Driving 5 Kilometre or 10 Kilometre above the speed limit is ok because everyone does it.

Strongly Disagree	Disagree	Neither agree nor disagree	Agree	Strongly Agree

31. If you have good skills, speeding is ok.

Strongly Disagree	Disagree	Neither agree nor disagree	Agree	Strongly Agree

32. It is not risky to drive after drinking alcohol as it is thought.

Strongly Disagree	Disagree	Neither agree nor disagree	Agree	Strongly Agree

33. Sometimes it is important to bend the traffic rules to arrive in time.

Strongly Disagree	Disagree	Neither agree nor disagree	Agree	Strongly Agree

34. It is more important to keep up the traffic flow than always follow the traffic rules.

Strongly Disagree	Disagree	Neither agree nor disagree	Agree	Strongly Agree

35. There is no problem to drive above the speed limits if the conditions are proper.

Strongly Disagree	Disagree	Neither agree nor disagree	Agree	Strongly Agree

36. Have you received any traffic summons before? Yes ☐ No ☐

No (Proceed to Question 38)

37. How many times have you been summoned in the past three years?

○ ○ ○ ○ ○

1 – 5 6 – 10 11 – 15 16 – 20 Above 21

Have you been involved in any RTAs? Yes ☐ No ☐

No (Proceed to Question 40)

38. What was the specific cause of the RTA?

a. Adjusting radio, cassette or CD
b. Emotionally upset/relationship problem
c. Mobile phone
d. Eating/drinking
e. Bumps/potholes on the road
f. Other distractions (eg. medical problems, sneezing)
g. Inattention/daydreaming
h. Other (If 'other', Specify: ……

39. What do you think are the general causes of RTAs? (Choose TWO only)

a. Driving attitude of the driver

b. Car condition

c. Road condition

d. Weather condition

e. Numbers of cars on the road

40. What do you think are some of the causes of RTA on the Accra-Tema Motorway?

……

……

41. Which specific time do you regard as the most prone time for RTAs to happen?

(Choose TWO only)

○ ○ ○ ○ ○ ○ ○ ○

3am – 6am 6am – 9am 9am – 12pm 12pm – 3pm 3pm – 6pm 6pm -9am 9pm -12am 12pm -3am

42. What is the reason for your answers?

……

……

43. What will you do when your car breaks down in the middle off the road?

a. Push the car aside

b. Leave the car and put a warning sign

c. Call the Towing service

d. Leave the car with no warning and call a mechanic

e. Do nothing

44. How often do you stop on the Accra-Tema Motorway?

○ ○ ○ ○ ○ ○

Never Very Rarely Rarely Sometimes Often Nearly always

(If 'Never', proceed to question 47)

45. For what reasons do you stop on the Accra-Tema Motorway? (Write only TWO)

a. ……..... b. ……

SECTION D: UNDERSTANDING POLICY AND ROAD SIGNS

46. Do you think regulations and rules concerning safety are effective and adequate?

Yes ☐ No ☐

(Yes, proceed to question 49)

(No, What do you think must be added orwhat can Specific authorities do to improve road safety?)

DVLA:

.....

.....

MTTU (Police Department):

.....

.....

GHA:

.....

.....

NRSC:

.....

.....

47. If you could do one thing to reduce the road toll on the Accra-Tema Motorway, what would it be?

Please Specify

……

……

48. What is the last road safety message or advertisement do you remember?

Don't remember any ☐ Remember ☐

If you remember please specify .

.....

49. Where did you see or hear this advertisement? (e.g. radio, sign post, graphic etc.)

Please specify……..

How effective do you think the following initiatives are in reducing road crashes and injuries?

50. Restrictions for learner and provisional drivers

○	○	○	○	
Very Effective	Effective	Satisfactorily	Not Very Effective	Not Effective at All

51. Fines for traffic offences

○	○	○	◉	
Very Effective	Effective	Satisfactorily	Not Very Effective	Not Effective at All

52. Loss of licence for serious offences, (eg. Over- speeding or drink driving)

Very Effective	Effective	Satisfactorily	Not Very Effective	Not Effective at All
○	○	○	○	

53. Police patrols

Very Effective	Effective	Satisfactorily	Not Very Effective	Not Effective at All
○	○	○	○	

54. Random checks for unroadworthy vehicles

Very Effective	Effective	Satisfactorily	Not Very Effective	Not Effective at All
○	○	○	○	

55. Better roads, (e.g. sealed shoulders, wide lanes)

Very Effective	Effective	Satisfactorily	Not Very Effective	Not Effective at All
○	○	○	○	

56. Identifying and fixing road/traffic hazards

Very Effective	Effective	Satisfactorily	Not Very Effective	Not Effective at All
○	○	○	○	

57. Overtaking lanes

Very Effective	Effective	Satisfactorily	Not Very Effective	Not Effective at All

58. Roadside rest facilities

Very Effective	Effective	Satisfactorily	Not Very Effective	Not Effective at All

59. Driver education on how to share the road safely, (eg. Different types of vehicles sharing the road with pedestrians and cyclists)

Very Effective	Effective	Satisfactorily	Not Very Effective	Not Effective at All

60. In what way, if any, do you think the severity of penalties for breaking traffic laws should be changed?

Do not Know	Decrease slightly	Decrease	Increased	No Change

61. In what way, if any, do you think the overall amount of speed enforcement (including cameras) should be changed?

Do not Know	Decrease slightly	Decrease	Increased	No Change

62. Please, identify the following road signs as spelt out by the National Road Safety Commission (NSRC)

A.  B.  C.  D.  E. 

Please, fill in the box below for any extra comment you have concerning RTA and Road Safety

APPENDIX TWO - QUESTIONNAIRE FOR PASSENGERS

DEPARTMENT OF GEOGRAPHY AND RESOURCE DEVELOPMENT - MPHIL THESIS

QUESTIONNAIRES FOR PASSENGERS

This questionnaire is in aid of completing a Master of Philosophy (MPhil) degree in Geography and Resources development on the topic **"Spatio-Temporal Analysis of RTA on the Accra-Tema Motorway: Causes and Risk Factors".** These questions will help gather information from passengers with ages above eighteen (18) years who are believed to be matured and can provide the desired information needed to complete the study. The details of individuals would be kept confidential.

SETION A: BIOGRAPHICAL DETAILS AND DRIVING HISTORY

Select the appropriate answers to the following questions

1. Sex M ☐ F ☐
2. Age
    a. 15-25
    b. 26-35
    c. 36-45
    d. 46-55
    e. Above 55

3. What is your highest education level?
    a. Tertiary
    b. Secondary
    c. Middle or Junior High School
    d. Primary education
    e. None
    f. Other

SECTION B: ACCIDENT CAUSES AND RISK

In the following questions, please mark on the scale how often you perform the action described, the level of agreement and disagreement to a particular statement or your satisfaction level.

4. How often do you wear your seat belt?

Never	Very Rarely	Rarely	Sometimes	Often	Nearly always

5. How often would you cross a junction knowing that the traffic lights have already turned against you?

Never	Very Rarely	Rarely	Sometimes	Often	Nearly always

6. How often do you fail to notice that a vehicle is coming when you are crossing from one side road into the other side?

Never	Very Rarely	Rarely	Sometimes	Often	Nearly always

7. It is not risky to cross the road after drinking alcohol as it is thought.

Strongly Disagree	Disagree	Neither agree nor disagree	Agree	Strongly

8. Sometimes it is important to bend the traffic rules to arrive in time.

Strongly Disagree	Disagree	Neither agree nor disagree	Agree	Strongly
○	○	○	○	○

9. What do you think are some of the causes of accident on the Accra-Tema Motorway?

……

……

……

10. Which specific time do you regard as the most prone time for RTAs to happen? (Choose TWO only)

3am – 6am	7am – 10am	11am – 4pm	4pm – 7pm	8pm – 10pm	11pm -3am
○	○	○	○	○	○

11. What is the reason for your answers?

……

……

12. In your opinion, how is the driving attitude of drivers on the Accra-Tema Motorway?

Very Poor	Poor	Average	Good	Excellent
○	○	○	○	○

13. What do you think are the causes of RTAs? (Choose TWO only)

- Driving attitude of the driver
- Car condition
- Road condition
- Weather condition
- Numbers of cars on the road

SECTION D: UNDERSTANDING POLICY AND ROAD SIGNS

14. Do you think regulations and rules concerning safety are effective and adequate?

Yes ☐ No ☐

(Yes, proceed to question 15)

(No, What do you think must be added orwhat can Specific authorities do to improve road safety?)

DVLA:

.....

.....

MTTU (Police Department):

.....

.....

GHA:

.....

.....

NRSC:

.....

.....

15. If you could do one thing to reduce the road toll on the Accra-Tema Motorway, what would it be?

Please Specify

……

……

……

16. What is the last road safety message or advertisement do you remember?

Don't remember any ☐ Remember ☐

If you remember please specify:.....

17. Where did you see or hear this advertisement? (e.g. radio, sign post, graphic etc.)

Please specify……..

18. What was it about?

If you remember please specify

.....

.....

How effective do you think the following initiatives are in reducing road crashes and injuries?

19. Restrictions for learner and provisional drivers

Very Effective	Effective	Satisfactorily	Not Very Effective	Not Effective at All
○	○	○	○	

20. Fines for traffic offences

Very Effective	Effective	Satisfactorily	Not Very Effective	Not Effective at All
○	○	○	○	

21. Losing points for traffic offences

Very Effective	Effective	Satisfactorily	Not Very Effective	Not Effective at All
○	○	○	○	

22. Loss of licence for serious offences, (eg. Over-speeding or drink driving)

Very Effective	Effective	Satisfactorily	Not Very Effective	Not Effective at All
○	○	○	○	

23. Police patrols

Very Effective	Effective	Satisfactorily	Not Very Effective	Not Effective at All
○	○	○	○	

24. Random checks for unroadworthy vehicles

Very Effective	Effective	Satisfactorily	Not Very Effective	Not Effective at All
○	○	○	○	

25. Better roads, (e.g. sealed shoulders, wide lanes)

Very Effective	Effective	Satisfactorily	Not Very Effective	Not Effective at All
○	○	○	○	

26. Identifying and fixing road/traffic hazards

Very Effective	Effective	Satisfactorily	Not Very Effective	Not Effective at All
○	○	○	○	

27. Overtaking lanes

Very Effective	Effective	Satisfactorily	Not Very Effective	Not Effective at All
○	○	○	○	

28. Roadside rest facilities

Very Effective	Effective	Satisfactorily	Not Very Effective	Not Effective at All
○	○	○	○	

29. Road-based fatigue initiatives, (eg. Rumble strips / audible edge lines)

Very Effective	Effective	Satisfactorily	Not Very Effective	Not Effective at All
○	○	○	○	

30. Driver education on how to share the road safely, (eg. Different types of vehicles sharing the road with pedestrians and cyclists)

Very Effective	Effective	Satisfactorily	Not Very Effective	Not Effective at All
○	○	○	○	

31. In what way, if any, do you think the severity of penalties for breaking traffic laws should be changed?

Do not Know	Decrease slightly	Decrease	Increased	No Change
○	○	○	○	

32. In what way, if any, do you think the overall amount of speed enforcement (including cameras) should be changed?

Do not Know	Decrease slightly	Decrease	Increased	No Change
○	○	○	○	

33. Please, identify the following road signs as spelt out by the National Road Safety Commission (NSRC)

A. 

B. 

C. 

D. 

Please, fill in the box below for any extra comment you have concerning RTA and Road Safety

APPENDIX THREE – INTERVIEW AND DISCUSSION GUIDES

A. Interview Guide for Key Informants

Section One: General Questions

1. What is the role of your intitution in the NRSS?
2. Do you have the necessary resources to meet the goals defined in the NRSS.
3. What are the challenges you face in executing your responsibilities as a key stakeholder in road safety in Ghana?

Section Two: MTTU (Airport and Ashaiman Police Staions)

1. What is your unit doing to control the behaviour of drivers on the Accra-Tema Motorway?
2. Do you have the authority to close and prevent drivers from using the illegal entries, stopping and picking up passengers?
3. How often do you patrol the Accra-Tema Motorway?

B. Interview Guide for Pedestrians

I. Personal Information

1. Do you live or work along the motorway or both?
2. How long have you lived/worked here?

II. Risk Level

1. Do you sometimes walk along the Accra-Tema Motorway, cross it on foot or board a vehicle? Tell me about your movements?

2. Do you know that it is unlawful and dangerous to cross a motorway or for a vehicle to stop?
3. Are there any challenges you face while crossing or walking along the motorway? How would you describe your challenges?
4. Do you think pedestrian road use attitudes and behaviour pose danger to traffic safety in this area? In what ways?
5. Does the motorway and condition in this area influence how you or others cross/walk along the motorway?
6. Do you have issues with drivers who ply the motorway. Describe their use of the motorway?
7. Do you think the way you or others cross or walk along the motorway affect driving? Could you describe what people who walk in the street do that you think can bring about RTAs?
8. Could you tell me why you think pedestrians in this area behave that way?
9. Who do you think should be held responsible if a car kills a pedestrian: driver or pedestrian?
10. What do you perceive to be the risk factors on the motorway while crossing/boarding a vehicle?
11. ***Do you please want to add something?***

APPENDIX FIVE – AREA DETAILS FOR CHANGE DETECTION

A. Area Change Around Accra-Tema Motorway (1985 - 2002)

Area (Square Metres)						
	Settlement	vegetation	water	bareland	Row Total	Class Total
Unclassified	0	0	0	0	0	136287900
Built-up Area [Red] 256 Points	247500	2033100	17100	1017000	3314700	3314700
Vegetation [Green] 327 Points	27900	2618100	169200	290700	3105900	3105900
Water [Blue] 61 Points	900	193500	26100	11700	232200	232200
Bareland [Yellow] 51 Points	249300	8913600	39600	2080800	11283300	11283300
Class Total	525600	13758300	252000	3400200	0	0
Class Changes	278100	11140200	225900	1319400	0	0
Image Difference	2789100	-10652400	-19800	7883100	0	0

B. Area Change Around Accra-Tema Motorway (2002 - 2013)

Area (Square Metres)						
	Settlement	vegetation	water	bareland	Row Total	Class Total
Unclassified	0	0	0	0	0	136287900
Built-up Area [Red] 299 Points	1505700	349200	13500	2466900	4335300	4335300
Vegetation [Green] 10 Points	107100	1090800	91800	1449900	2739600	2739600
Water [Blue] 30 Points	7200	146700	9900	35100	198900	198900
Bareland [Yellow] 56 Points	1694700	1519200	117000	7331400	10662300	10662300
Class Total	3314700	3105900	232200	11283300	0	0
Class Changes	1809000	2015100	222300	3951900	0	0
Image Difference	1020600	-366300	-33300	-621000	0	0

APPENDIX SIX – CHI-SQUARE TEST FOR DRIVERS' ADHERENCE TO REGULATIONS

1. Drinking and Driving

Chi-Square Tests

	Value	Df	Asymp. Sig. (2-sided)
Pearson Chi-Square	4.386[a]	6	.625
Likelihood Ratio	6.428	6	.377
Linear-by-Linear Association	.110	1	.740
N of Valid Cases	120		

a. 9 cells (75.0%) have expected count less than 5. The minimum expected count is .67.

2. Drivers Level of agreement with Driving 5km or 10km above speed levels

Chi-Square Tests

	Value	Df	Asymp. Sig. (2-sided)
Pearson Chi-Square	11.414[a]	8	.179
Likelihood Ratio	13.823	8	.087
Linear-by-Linear Association	.225	1	.636
N of Valid Cases	120		

a. 12 cells (80.0%) have expected count less than 5. The minimum expected count is .33.

3. Drivers Disregard of Speed limits at Night or Early Morning

Chi-Square Tests

	Value	Df	Asymp. Sig. (2-sided)
Pearson Chi-Square	12.440[a]	10	.257
Likelihood Ratio	13.754	10	.185
Linear-by-Linear Association	.084	1	.771
N of Valid Cases	120		

a. 9 cells (50.0%) have expected count less than 5. The minimum expected count is 1.33.

4. Crossing When Traffic Light s have Turened Red

Chi-Square Tests

	Value	Df	Asymp. Sig. (2-sided)
Pearson Chi-Square	14.871[a]	10	.137
Likelihood Ratio	17.435	10	.065
Linear-by-Linear Association	.000	1	1.000
N of Valid Cases	120		

a. 9 cells (50.0%) have expected count less than 5. The minimum expected count is .33.

5. Driving Close other Cars

Chi-Square Tests

	Value	Df	Asymp. Sig. (2-sided)
Pearson Chi-Square	21.866[a]	10	.016
Likelihood Ratio	26.452	10	.003
Linear-by-Linear Association	2.474	1	.116
N of Valid Cases	120		

a. 9 cells (50.0%) have expected count less than 5. The minimum expected count is .67.

6. Frequency of Wearing Seat Belts

Chi-Square Tests

	Value	Df	Asymp. Sig. (2-sided)
Pearson Chi-Square	20.284[a]	10	.027
Likelihood Ratio	24.308	10	.007
Linear-by-Linear Association	3.042	1	.081
N of Valid Cases	120		

a. 15 cells (83.3%) have expected count less than 5. The minimum expected count is .33.