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SPATIAL AND TEMPORAL DISTRIBUTION OF ROAD CRASH RELATED DISASTERS ON THE NORTHERN CORRIDOR ROAD OF KENYA

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ABSTRACT
Road Traffic Accidents (RTAs) are a major cause of death and disability around the world. Road accidents are ninth ranked cause of death in the world and the ranking is projected to rise to third by 2020. An estimated 85% of the deaths occur in developing countries where 65% of the deaths are pedestrians, of which 35 % are children. In Kenya over 3,000 people die through road accidents every year, most between ages of 15 and 44 years. The Kenya police service and NTSA classify areas of frequent and repeated RTI by sections stretching over 50 kilometers, the study identified and mapped 35 blackspots with GPS coordinates , using the LSE Modeling the study found Road Traffic Incident fatalities have steadily increased from 2533 fatalities in 2005 rising in 3149 in 2008 and peaking in 2009 at 4032 fatalities in 2015 the fatalities were 2957, motor private and commercial claims paid by insurance industry were at 6,206,700,000 ksh in 2005 the figure rose to 13,687,327,000 in 2011 and peaked in 2015 at some 25,811,991,000 (ksh,billion) a increase of 400% in economic and fatal life losses from RTI in Kenya, the country lost ksh 300 billion 5% of GDP in 2016.The study illuminates limitations that contribute to persistent rise in road crashes annually through economic impact of RTI to individuals and Kenyan economy it also highlight the gaps in the national psyche that relegates this economic impact away from the frontline of County Governments budgetary allocation for effective management of road safety.

Keywords: *Injury – Blackspot, Injuries – Spatial, Road crash – Temporal*

INTRODUCTION
Providing reliable transport infrastructure can stimulate economic development in several ways. For instance, foreign direct investment is attracted to regions that provide high-quality road infrastructure to facilitate efficient logistics. Within a country, road infrastructure connects remote areas with centres of trade and connects centres of industry to global markets, spurring the growth of trade and reducing costs by improving access to goods and services (Kessides *et al.,* 2010). Some of these economic gains are however severely impacted by Road traffic incidents (RTIs) that contribute to a significant proportion of the burden of disease in Kenya. They also have a significant impact on the social and economic well-being of individuals, their families, and society. However, although studies have been carried done assess the Road traffic injuries from a epidemiological point of view by the WHO Burden of Disease 2015 with estimates quantifying the burden of RTIs in Kenya RTAs continue to rise and no econometric data do exists to support policy makers and implementers arrive at optimum investment in road safety.

Traffic Safety Systems Approach
A traffic safety method developed by Dr. Haddon (Zein and Navin, 2003), breaks down the transport system into three components i.e. (road user, vehicle and road system) and three temporal sequences (before, during and after the crash) which are combined to form the 'Haddon matrix' containing nine cells. Each cell identifies the areas in which interventions can be initiated. For example, possible interventions aimed at the human factor are education (before the crush), restraints (during the crash) and trauma management (after the crash). A further elaboration of the Haddon matrix resulted in 2003 in the presentation of the CR-R3 systems approach of Zein and Navin. The fundamental building blocks of the C3-R3 approach are: three entities: the road user, the vehicle and the road system, three pre-crash timeline phases: creation, cultivation, conduct (which affect accident frequency); three post-crash timeline phases: response, recovery and reflection (which affect accident severity)

Mapping Road Traffic Accident Black Spots
In road safety management, an accident black spot is a place where road traffic accidents have historically been concentrated. It may have occurred for a variety of reasons, such as a sharp drop or corner in a straight road, so oncoming traffic is concealed, a hidden junction on a fast road, poor or concealed warning signs at a cross-road (Jackson JSH, Blackman R, 1994). For some decades treatment of accident black-spots (e.g. by signage, speed restrictions, improving sightlines, straightening bends, or speed cameras) was a mainstay of road safety policy, but current thinking has it that the benefits of these interventions are often overstated. Studies by Jackson show

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the effects, such as regression to the mean, risk compensation and accident migrationfor data taken over a long period with positive aggregation combine to reduce the overall benefit of road safety campaigns (Jackson, *et al.*,1994).

According to Hauer some researchers rank locations by accident rate (accidents per vehicle-kilometres or per entering vehicles), some use accident frequency (accidents per km-year or accidents per year) and some use a combination of the two. More recently, the proportion of accident types considered susceptible to treatment is also used for ranking. Another dimension of diversity in practice is that rank may be determined by the magnitude (of either of rate or of frequency) or, as is more common, by the amount by which the rate or frequency exceed what is normal for such sites (Hauer, 1996).

According to the Bureau of Transport and Regional Economics of Australia (2001), locations are in general classified as black spots after an assessment of the level of risk and the likelihood of a crash occurring at each location. At certain sites, the level of risk is higher than the general level of risk in surrounding areas. Crashes tend to be concentrated at these relatively high-risk locations. Locations that have an abnormally high number of crashes are described as crash concentrated, high hazard, hazardous, hot spot or black spot sites. Sites with potentially hazardous features are sometimes described as grey spots (Wets *et al.*, 2007).

Daniel suggests that human factors are the main cause of violation and increasing daily danger for road users (drivers, passengers and pedestrians) safer cars and roadways can be produced through design, but making drivers safer is much more difficult. Driver error can include a number of topics including misinterpretation of traffic control devices, road rage, driver expectancy, driver age, driver gender and mental workloads every day, drivers die in road collisions. Many die as a consequence of inexperience, speeding intoxication through drink or drugs or just plain recklessness (Wets *et al.*, 2007).

The majority of road crashes are caused by human error. According to Wets driver error accounts for over 80% of all fatal and injury crashes on Irish roads. The main causes of death and injury on Irish roads remain speeding, drink driving and non-wearing of seat-belts. Because most traffic accidents are the product of several factors, the probability of accidents can be reduced in many different ways (Wets *et al.*, 2007).

The Kenya Roads Board (KRB) now National Transport Safety Authority NTSA is the main institution responsible for the national road infrastructure network in Kenya. Other institutions include, the Transport Licensing Board (TLB), Motor .

The failure of the police to enforce traffic rules is due to massive corruption, ill equipment and the impracticality of some of the rules such as Section 66 of the Traffic Act, which prohibits continuous driving of PSV vehicles for more than eight hours, yet the police, cannot detect how long one has been driving continuously (IPAR, 2004).

Lack of a clear policy guideline on whether the government favours private or public transportation. Although private vehicles are uneconomical in terms of road space usage per head, their number far outweighs the number of Matatus and buses registered. While the number of buses has been declining steadily, that of Matatus has been increasing a large number of RTAs are

Neglect of pedestrians in road space design has resulted in the latter being not only the greatest casualties in road accidents, but also the second greatest cause of the same (IPAR, 2004; WHO 2015).

Since independence (1963) road transport in Kenya continue to be the predominant mode of transport carrying about 93% of all cargo and passenger traffic. Available data show that the government has greatly improved the major road networks especially in the 1990s. As of 2012 the road network was estimated at 160,886 km of which 61,936 km is classified roads. On average, the increase in mileage is about 400%-600%, depending on which roads from a low 548 vehicles in 1963 there were 333,300 vehicles registered in the country in 1990, 17,600 of which were Matatus (Bhushan, 1993). By 2003, the numbers of Matatus were estimated at 40,000 (Asingo, 2004). In 2009 there were 1,221,083 vehicles registered in the country. The highest growth has been in personal cars and motorcycles.

ISSN 2349-6193
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According to the Economic Survey of 2010, the registration of new vehicles had increased from 45,000 units in 2005 to 161,000 units in 2009. Since 2005 the number of registered motorcycles in Kenya has increased almost 40 times, accounting for 70 percent of all newly registered vehicles in 2011(Xinhua, 2012) According to the Police Department a total of 582 cases of motorcycle crashes were recorded in 2011 representing more than seven percent of all road traffic crashes. The number of cases has continued to sour that several public hospitals have dedicated some wards to victims of boda-boda accidents. For instance recently Kenyatta National Hospital's wards 6A, C and D have been converted into emergency wards to receive the swelling numbers of motorcycle victims. In 2012 the Head of Division of Non Communicable Disease in the Ministry of Health reported that between seven to ten percent of all those in surgical wards of public hospitals are injured in boda-boda accidents (Xinhua, 2012).

Based on the Accident Cause Code Classification, Kenya Police reports reveal that 85.5% of crashes are caused by poor driver behavior, of which driver error represents 44.4%, pedestrians and passengers 33.9% and pedal cyclists 7.2% (Odero et al., 2013 Odero *et al.*, (1997). Other proximal factors include vehicle defects 5.1%, road environment 2.9%, and other factors 6.4% (ibid) according to GBD 2010 However these statistics are not conclusive due to under-reporting by the various stakeholders and statutory bodies, Principle in bad driving habits is the total disrespect for the traffic rules (laws and regulations). It is estimated that intentional, out of habit driver errors account for over 70% of all fatal smashes and serious injuries. Often the contributing factors include inexperience, speeding, intoxication (from drinking or drugs) or just plain recklessness. Other more subtle causes are fatigue from overworked drivers who doze at the wheel and lose control.

A traffic safety method developed by Dr. Haddon (Zein and Navin, 2003), breaks down the transport system into three components i.e. (road user, vehicle and road system) and three temporal sequences (before, during and after the crash) which are combined to form the 'Haddon matrix' containing nine cells. Each cell identifies the areas in which interventions can be initiated. For example, possible interventions aimed at the human factor are education (before the crush), restraints (during the crash) and trauma management (after the crash).

According to Lammar (2006), seven risk domains have been identified. Road safety can also be decomposed into two main components, i.e. exposure and risk (Farchi *et al.*, 2006); pressure-state-response (PSR) model for modelling causal relationships between environmental pressures, the state of the environment and the policy response (Van Reeth and Vanongeval, 2005)

The principal driving forces are factors that create the need to travel. The degree of mobility is affected by the economic status of a country (e.g. employment rate), the distribution of wealth (e.g. average income), the distribution of population (demographic factors such as the number of inhabitants, the age distribution, the family composition, etc.) and the physical geography of the country (Lammar, 2006).

Pressure factors result from the need to travel. The most important ones are cultural and social norms which create the interest in having a car and mainly travelling by personal transport. Cultural believes may explain the difference in road safety between countries to some extent. Countries within a certain area (e.g. Europe) are considered to have more or less the same pressure as their level of mobility is quite similar (Lammar, 2006).

The Risk factors that either increase or decrease the probability of an accident are sometimes referred to as primary risk factors. Secondary risk factors increase or reduce the injury in case an accident happened. Some factors affect both accident frequency and severity. Examples of accident risk factors are listed: drinking and driving, speeding, use of mobile phone, auditory or visual disturbance, active safety of vehicles, new driver, older road user, children without supervision, tiredness, medical disorder, infrastructural design and maintenance.

The following factors are considered to affect the level of injury: drinking and driving, speeding, usage of seat belts, helmets and other protective systems, passive safety of vehicles, young and older road users, infrastructural aspects such as crash-protective roadsides and barriers, quality level of the rescue and pre-hospital emergency care and the health care system, etc.

From the registered accident information, the number of injury accidents, the number of fatalities and the number of injuries can be determined. Other interesting effect factors are the years of life lost, the degree of invalidity and the psychological effect.

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Actions include a wide range of preventive interventions, policies, laws, structural changes, etc. These actions can be mainly related to engineering, education or enforcement. They are mostly aimed at reducing the health effects of accidents, reducing the prevalence of a risk factor or reducing the amount of exposure, but could also try to affect the driving forces, pressure and state. The effect of actions on the target can be monitored by means of indicators.

Spatial distribution of RTAs

The need for the analysis of the spatial distribution of traffic accidents, as an aid to select the most appropriate type of accident reduction programme (e.g. site, route and area plans) and assessing the effectiveness of such plans after implementation, is very important The basic variables for accident analysis are; distance and direction of accident locations in terms of North and East co-ordinates, azimuth, and the year of the accident.A method for analysing the spatial pattern is, whereby detection of a particular pattern indicate which type of accident reduction programme is most appropriate. This method distinguishes the spatial distribution (point cluster, line cluster, area cluster or a completely spatially random distribution) of accidents in different types of road networks (regular or irregular and dense or sparse). The method also helps assessment of the changes in spatial distributions of accidents.

Temporal Variation of Road Traffic Accident Black Spots

Road Traffic Accident Black Spot Analysis

Black spots, which are defined as relatively high-risk locations, are commonly identified on the basis of some specific selection criteria. Many different methodologies and criteria have been developed for improving the accuracy of the black spot identification process, thus the cost-effectiveness of a safety improvement program (Highway Safety Manual [HSM], 2010). One of the most commonly used selection criteria is defined by the expected collision frequencies at the sites of interest. According to Tarko and Kanodia (2003), this particular criterion emphasizes on maximizing the system-wide benefits of safety intervention targeted to the black spots, whereas another commonly implemented criterion is considering the expected collision rate (i.e., expected collision frequency normalized by traffic exposure) which emphasizes on individual road user's equity perspective.

Objective:

This article aims to present the Spatial distribution and Temporal Variation of Road of RTAs related disasters on the Northern Corridor Road of Kenya, using data from the police NTSA, i, emergency response support teams such as Kenya Red cross/St John, Hospitals and individuals involved and affected by RTAs in Kenya, we present the current Spatial distribution and Temporal Variation of RTIs on the NCR it also assesses the status of 3 well-known risk factors for RTIs- poor driving culture: speeding alcohol, badly designed and neglected roads; lack of road signs misplaced speed bumps, and inadequate enforcement of existing traffic laws: overloading bribery unroadworthy vehicles.

MATERIALS AND METHODS

Data for this study were collected in 3 steps. The first step involved the collection of secondary data from the Kenya traffic police NTSA, insurance companies, emergency response support teams such as Kenya Red cross/St John, Hospitals to assess the current trends of RTIs in Kenya. Following this, observational studies and interviews were conducted along the NCR in Chimoi Athi river Mlolongo and Salgaa in Kenya to assess the current status of fatalities and non-fatalities and arising economic losses to individual and corporates involved and affected by RTI, The investment in road safety was also assessed against economic losses and to determine the econometrics of RTI and opportunities to mitigate the economic losses.

System theoretical approach

The system theoretical approach. Explains man-environment adjustments and maladjustments (Muhlrad *et al*., 2005). Components of the theory are the environment, the means of transport (vehicles) and the behaviour of man (Krug *et al*., 2000). The environment component comprises of the natural and the built environments and transport networks. The means of transport component comprises of the volume and quality of vehicles on the modes of transport. The behaviour of man component comprises of demographic characteristic of road users (age, sex, education, socio-economic status, stage in life cycle), people's perceptions of risk and people's general behaviour on the streets.

ISSN 2349-6193
Impact Factor: 3.866

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International Journal of Engineering Sciences & Management Research

Integrated in the systems theory is a system of highway codes and enforcement mechanisms designed to ensure that road users adhere to the controls and regulations of traffic flow for maintaining road traffic safety. Comprehensive traffic management should be sufficient to maintain road traffic safety (Haur, 1995 and Button, 1993).

RESULTS AND DISCUSSION

1. Introduction

This publication presents the findings on the spatial and temporal distribution of road crash related disasters on the Kenyan Northern Corridor Road (NCR) for a period of five (10) years between 2005 and 2015. it begins by characterizing the demographics of respondents in terms of gender and education level, type of incident, time of occurrence, the type of vehicle(s) involved and blackspots/zones sections.

2. Social Characteristic of the Respondents

2.1 Gender

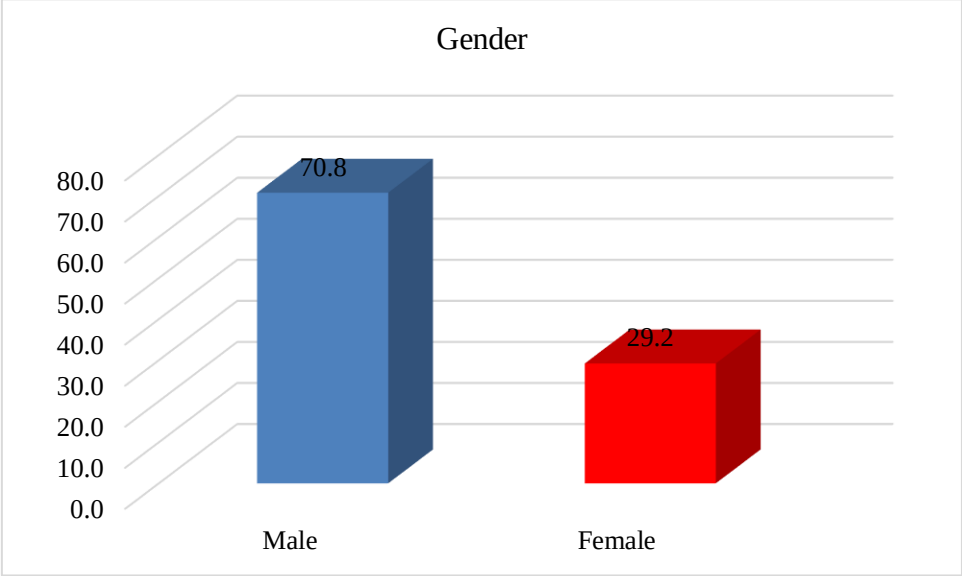

fig 1:Gender

A Chi Square test of variation and degrees of freedom of Age Distribution of Respondents found ($p<0.01$) variation in the distribution of gender ($\chi^2_{2,0.5} = 175$)

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2.2 Age Distribution of Respondents

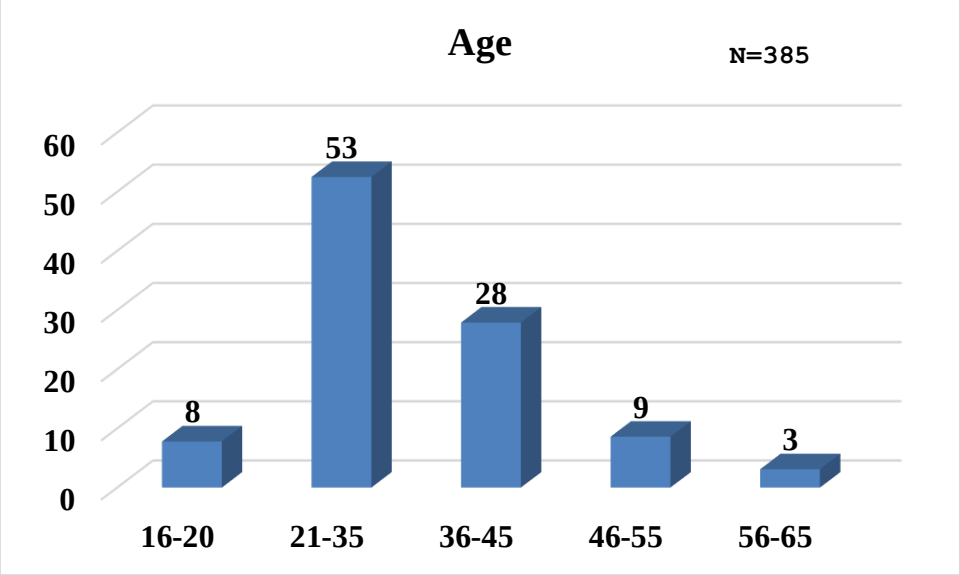

fig 2:Age Distribution of Respondents

A Chi Square test of variation measured degrees of freedom for age distribution of respondents probability was ($p<0.01$) and variation in the age distribution was ($\chi^2_{5,0.01} = 76.6$). The study found that a majority 53% respondent are aged 21 to 35 years old, whereas 28 % are aged 36 to 45 years old, while 9% are aged 46 to 55 years old, 8% are aged 16 to 20 years old 3% are aged 56 to 65 years old. The degree of freedom of age distribution of Respondents was 124 indicating a high probability of age group 21 to 35 found within the sample population that correlates and triangulates with casualty and fatality data from the Kenya police service (KPS) indicating that drivers and motor/cyclists were the highest category of RTI causes (KPS 2017)

2.3 Level of Education

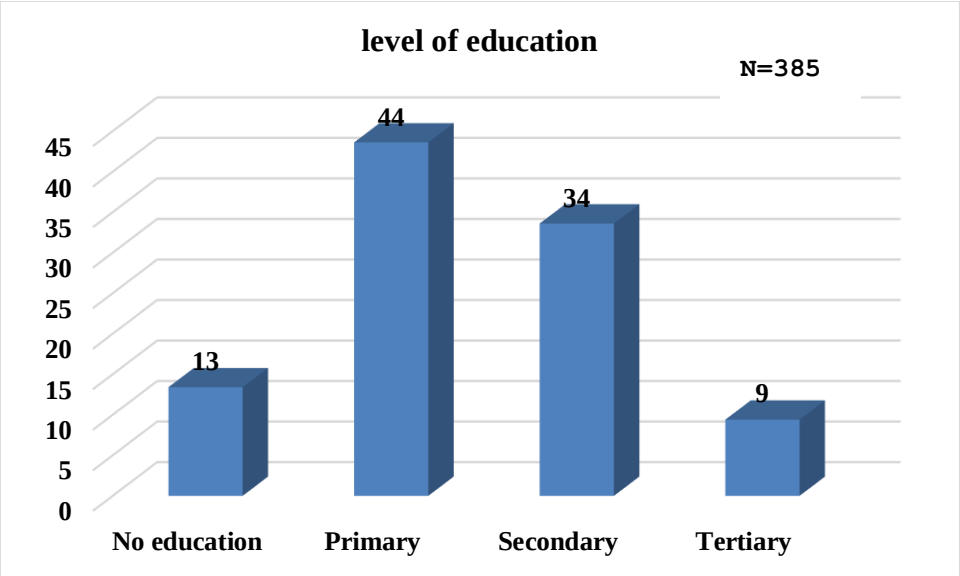

Fig 3: Level of Education

A Chi Square test of variation conducted on the responses indicated that there was a highly significant ($p<0.01$) variation in the distribution of Level of Education ($\chi^2_{4,0.01} = 352.75$)

ISSN 2349-6193
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The study found that 44% respondents have primary secondary education, 34% have secondary education 9% have Tertiary education and 13% have no formal education.

3. Respondents Participation in the Road Traffic Incidents (RTI)

a question asked in the study to residents of this area to determine the extent to which they have participated, witnessed or been affected by RTIs in this section of the north corridor road Findings from the pilot study showed that 100 % respondents have experienced an RTI in their lives.

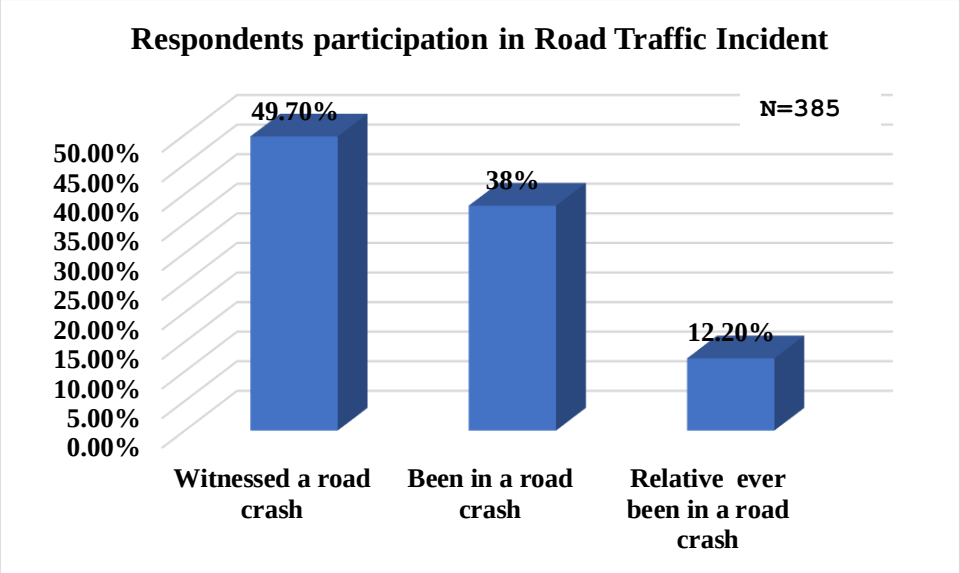

Fig 4: Respondents participation in Road Traffic Incident

A Chi Square test of variation conducted on the responses indicated that there was a highly significant ($p<0.01$) variation on where they were when the accident occurred ($\chi^2_{3,0.01} = 353.27$).

Northern corridor road NCR blackspot sections have experienced several RTIs and all respondents interviewed have experienced or been affected by an RTI, the majority 49% have been in a road crash and 38% have Witnessed a road crash in this blackspot section whilst, 12.2% of the respondents have had a Relative in a road crash. A Chi Square test of variation measured degrees of freedom for respondents who experienced or been affected by an RTI respondents probability was ($p<0.5$) and variation in the experienced or been affected by an RTI ($\chi^2_{0.5} = 128$).the residual value of respondents who Witnessed a road crash was 63 indicating a low measure of freedom and probability, residual value for respondents who have Been in a road crash was 18 a statistically insignificant indicator amongst respondents in RTI , whether Relative has ever been in a road crash has a chi-square of-81.

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Plate 1: NCR Crash Timboroa along Nakuru-Eldoret Highway

Seven people die and 30 others injured in a grisly road accident involving a trailer and crown bus at Hill top area in Timboroa along Nakuru-Eldoret Highway.

The morning accident occurred after crown bus rammed into a trailer as it was trying to overtake another vehicle. The area Police boss Agnes Kamau said the bus was travelling from Mombasa to Kakamega and it had 30 passengers on board. Rescue operations are underway and the injured have been rushed to the nearby hospital. The incidence happens in the wake of new rules and guidelines by National Transport and Safety Authority (NTSA) to name and shame speeding motorists in order to curb road accidents (Daily Nation Mercy Asamba | Thursday, Jul 27th 2017 at 14:27).

4. Spatial distribution of RTAs

The spatial distribution of RTAs follows systems theory in understanding the accident black spot were be seen at three different levels, the theory helped to identify the system of traffic laws, regulations and mode of enforcement designed to ensure traffic safety on NCR in Keny

Table 1: 2015 Distribution of absolute fatalities as per counties

County	Total Fatalities	Fatalities Along NCR	% Fatality Along NCR
Nairobi	668	123	18.41
Nakuru	258	151	58.53
Mombasa	118	40	33.90
Machakos	125	44	35.20
Kiambu	116	29	25.00
Bungoma	95	25	26.32
Makueni	93	35	37.63
Kilifi	74	33	44.59
Uasin Gishu	78	23	29.49
Taita Taveta	44	29	65.91
Busia	29	9	31.03
TOTAL	1698	541	

ISSN 2349-6193
Impact Factor: 3.866

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5. Crash Hour Time

Wets attributes road crush incidents to Factors influencing exposure to risk which include economic factors such as level of economic development and social deprivation; demographic factors such as age and sex; land-use planning practices which influence length of trip and mode of travel;

According to an NTSA official, Mr Samuel Musumba, most drunk drivers are arrested during the weekend between 10pm and 3am.

"For example, if we make twenty arrests on Friday night, you realise on Saturday at the same point we can make thirty arrests," he said in an interview with Nation on Thursday.

Mr Musumba said most drivers do not fear for their safety when driving under influence of alcohol.

"Drivers need to understand that when they are intoxicated, their ability to see the road and steer the car is limited," he said.

He said the authority is planning on starting campaigns and programs on behaviour change aimed at sensitising drivers on the dangers of drunk-driving NTSA (2017)

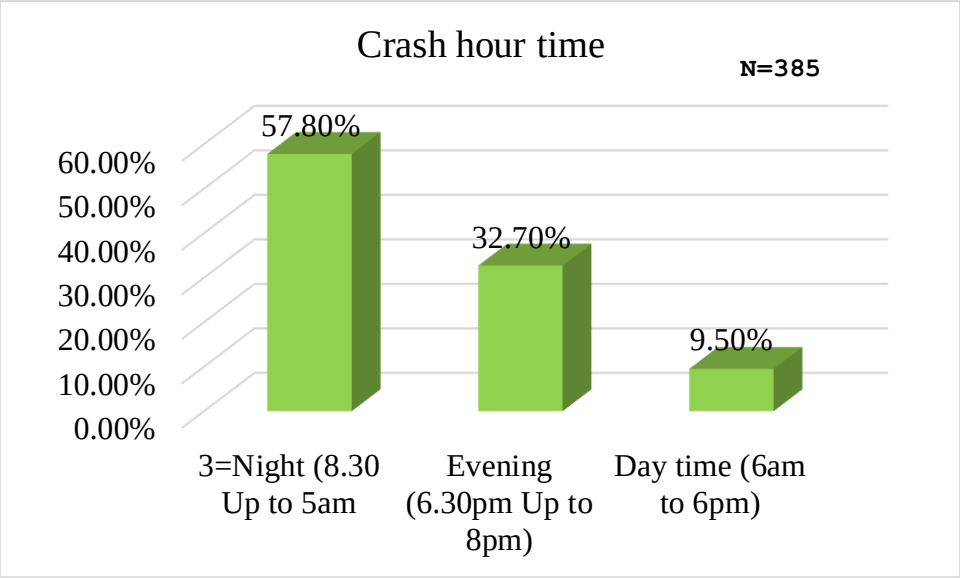

Fig5: Crash hour time of day

Source: Researcher, 2017

A Chi Square test of variation conducted on the responses indicated that there was a highly significant ($p<0.01$) variation in the distribution of Crash hour time of day ($\chi^2_{3,0.01} = 352.75$).

The study found that a majority 57.8% respondents reported witness of RTI during the day time period 8.30 pm to 5 am period when alcohol, and fatigue become significant with driving hours and evening stop overs, a significant 32.7% reported incidents between 6.30pm to 8 pm a time, a time movement is at its commercial pedestrian and passenger apex 9.5% reported witnessing incidents between 6 am to 6 pm amongst several contributory factors of RTI, time of incidents is a significant contributing factor as it determines stages at which some or all these variables nexus at highest levels.

Most fatal road traffic crashes occur between 6 pm and 11pm, with the peak time being around 9 pm. There are also spikes in road crash deaths around 6am and 7pm, especially in Nairobi. Especially in Nairobi.

Reasons include reduced enforcement during these times and high speeds. During these times motorcycles operate in the dark without correct gear, such as reflective jackets, hence they are not seen by fast-flowing traffic. Pedestrians also cross at non-designated areas and easily get knocked by speeding vehicles.

Driving, riding and walking while drunk are also major contributors, says Dr Duncan Kibogong, Deputy Director, and Safety Strategies & County Committees.

Fatal road crashes increase sharply as the weekend nears. From January 1 to October 18 2015, more people died in traffic road crashes on Saturday and Sunday than on any other day of the week.

ISSN 2349-6193
Impact Factor: 3.866

IJESMR

International Journal of Engineering Sciences & Management Research

One is almost twice as likely to die in a road collision on Saturday or Sunday as on Monday or Tuesday.

Nairobi contributed about one quarter of all road crash deaths in Kenya over this period. Nearly half of all deaths from road crashes in the capital's roads take place on nine high risk roads – Mombasa Road, Thika Road, Kagundo Road, Eastern Bypass, Southern Bypass, Northern Bypass, North Airport Road, Waiyaki Way and Jogoo Road. Pedestrians constituted more than 70 per cent of deaths on these nine roads NTSA (2017).

Table 2: Distribution of Fatalities based on Days of the week

Days	**2015-Fatalities**	**%**	**2014-Fatalities**	**%**
Monday	349	11.4%	342	11.7%
Tuesday	349	11.4%	320	11.0%
Wednesday	361	11.8%	334	11.5%
Thursday	363	11.9%	372	12.8%
Friday	465	15.2%	423	14.6%
Saturday	603	19.7%	584	20.1%
Sunday	567	18.5%	532	18.3%
TOTAL	**3,057**	**100%**	**2,907**	**100%**

The study found that a majority 57.8% respondents reported witness of RTI during the weekend time Saturday period when alcohol, become significant with driving hours and evening stop overs, a significant 32.7% reported incidents between 6.30pm to 8 pm a time, a time movement is at its commercial pedestrian and passenger apex 9.5% reported witnessing incidents between 6 am to 6 pm amongst several contributory factors of RTI, time of incidents is a significant contributing factor as it determines stages at which some or all these variables nexus at highest levels.

Table 3: Persons Up To 16 Years

Persons Up To 16 Years	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
Killed	333	356	414	375	424	381	397	418	376	364	389
Seriously Injured	704	795	761	638	826	917	864	910	823	791	810
Slightly Injured	984	891	1186	826	896	875	830	874	821	836	939

Table 4: classes of persons killed & injured

Drivers	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
Killed	251	291	273	326	435	307	289	290	284	268	339
Seriously Injured	749	815	845	815	1008	869	799	654	507	535	507
Slightly Injured	982	1022	1123	972	1000	711	472	343	296	320	309
Motor Cyclists											
Killed	44	34	35	111	263	200	315	306	324	391	434
Seriously Injured	171	155	219	396	842	648	954	818	734	664	563
Slightly Injured	236	229	227	305	602	295	262	175	157	155	153
Pedal Cyclists	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
Killed	310	310	276	352	322	240	173	127	134	104	69
Seriously Injured	958	902	673	846	818	531	225	196	163	116	80
Slightly Injured	1157	1099	882	833	979	495	96	50	44	32	9
Passengers											
Killed	590	715	840	592	1036	738	824	745	810	642	668
Seriously Injured	3787	4517	4630	3426	4834	4423	4111	3398	2869	2066	2167
Slightly Injured	6898	6847	8200	5227	4212	6392	5351	3801	3776	2999	3464
Pillion Passengers											
Killed	96	112	127	138	221	126	156	124	157	162	203
Seriously Injured	256	229	282	706	588	569	578	541	467	453	311

ISSN 2349-6193
Impact Factor: 3.866

IJESMR
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Slightly Injured	194	118	203	916	781	273	220	195	142	176	106
Pedestrians												
Killed	1242	1253	1370	1630	1755	1434	1545	1549	1482	1340	1344
Seriously Injured	2137	2241	2283	2645	2554	2177	1977	1830	1559	1308	1099
Slightly Injured	2675	2492	3100	2571	2223	1569	746	470	419	287	313

6. Nature of the accidents

With regard to the type the accidents in 2007, table 4.7 shows that 41.4 percent are pedestrians, followed by the occupants (28.6 percent), 11.2 percent turns over, 13.1 percent falling off a vehicle, and 5.6 percent of the accidents occur as a result of the run over of a vehicle.

7. Reasons of Accidents

The overall RTI rate in Kenya was 59.96 per 100,000 population in 2009, with vehicle passengers being the most affected. Notably, injuries to motorcyclists increased at an annual rate of approximately 29 percent (95% confidence interval.

Table 5:Causes of accidents

Causes of Accidents	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
Drivers & M/Cyclists	5444	5646	5433	5087	6075	5284	4259	3486	3124	3097	2936
Pedal Cyclists	1545	1408	1288	1343	1257	1159	1071	912	819	704	598
Pedestrians	3035	2676	3089	2577	2450	947	936	725	620	512	610
Passengers	466	400	601	376	415	401	423	401	421	393	316
Animals	85	81	69	61	107	217	201	186	128	82	60
Obstruction	100	107	107	76	86	94	89	82	75	69	55
Vehicle Defects	557	530	600	445	528	489	412	359	338	289	267
Road Defects	164	220	260	185	149	131	104	78	69	60	51
Weather	89	86	119	66	95	73	85	65	62	56	35
Other Causes	914	1047	904	993	1207	976	613	623	549	403	382

Table 6: Time of day of Accidents

Time of Accidents	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
Day Time	7999	7414	2283	6981	7337	6420	5125	4028	4005	3475	3268
Night Time	4400	4784	4168	4228	5032	3337	3068	2889	2200	2190	2042

8. Temporal Variation of Road Traffic Accident Black Spots

The study found that blackspots are found in fifteen counties along the Nothern corridor road NCR, namely Mombasa, Kwale , Taita Taveta ,Makueni , Machakos ,Nairobi ,Kiambu ,Nakuru ,Kericho ,Baringo ,Uasin Gishu, Kakamega , Bungoma and Busia Table 7.

Table 7 List of RTA Hot Spots per County

S/N	County	Location
1.	Mombasa	Mazeras Miritini Road
2.	Kwale	Mariakani Samburu
3.	Taita Taveta	Maungu - Tsavo East Gate Road Section Tsavo - Maungu – Voi Road Section
4.	Makueni	Mtito to Tsavo River Stretch Emali Simba Market to Kibwezi Salama - Sultan Hamud Road Section Konza Junction to Salama Road Section Mlolongo - Small World Club – and Juction to Namanga and At Mto Wa Mawe Bridge
5.	Machakos	Chumvi Area Kithangathini
6.	Nairobi	Mombasa Road

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		Museum Roundabout (Westlands) Westlands Kabete Road Waiyaki Way Near Kangemi Fly Over
7.	Kiambu	Limuru-Uplands Section Kinungi – Naivasha
8.	Nakuru	Gilgil Toll Station, Gilgil - Mbaruk Road Section Gilgil Nakuru Road Molo G.S.U Camp – Salgaa,Salgaa to A.D.C. Farm Section Kasambara Area,
9.	Kericho	
10	Baringo	
11	Uasin Gishu	Timboroa - Burnt Forest Section Burnt Forest Juakali to Turbo section, Turbo to Kipkaren river section
12	Kakamega	Kipkaren R. Bridge, Lwandetito kabrengu section, Chimoi Kabrengu
13	Bungoma	Nzoia R. Bridge
14	Busia	Malaba

Table 8: Coordinates List of RTA Hot Spots per County

S/N	Location	Longitude	Latitude	Altitude
1.	Mlolongo	36.937473	-1.3904684	1608.3
2.	Devik	36.991283	-1.4436233	1512.9
3.	Mto Wa Mawe	37.00424	-1.458701	
4.	Small World	37.048775	-1.4833233	1605.6
5.	Makutano Junction	37.130806	-1.5314167	1719.0
6.	Kwa BEBORA	39.54744	-3.9603717	167.9
7.	BEBORA 2	39.546658	-3.95908	168.9
8.	Kwa BEBORA	39.54561	-3.9579234	173.3
9.	One 2 One	39.564842	-3.9891617	75.9
10.	Birikani	39.566967	-3.990605	68.5
11.	End Of Miritini Black Spot	39.569393	-3.9935334	59.5
12.	Bonje	39.551624	-3.9851568	77.7
13.	Bonje Blackspot			
14.	Kwa Rhama	39.542294	-3.9540434	166.5
15.	Kwa Magongo	39.53723	-3.947515	160.3
16.	Uwanja Wa Ndege	39.535423	-3.9392974	
17.	Akili Ni Mali	39.53508	-3.932815	176.5
18.	Taru	39.14119	-3.75331	358.0
19.	Maungu	38.75002	-3.5582066	524.1
20.	Kyulu	38.428955	-2.9542534	
21.	Kyulu	38.29884	-2.8128467	648.2
22.	Tsavo	38.374393	-2.9071667	
23.	Tasvo	38.173973	-2.7017486	
24.	Tsavo	38.173973	-2.7017486	
25.	Motto Andei	38.167217	-2.69437	693.7

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26.	Kambuu	38.09225	-2.6503434	931.7
27.	Kambuu	38.088882	-2.6480434	905.3
28.	Bridge	38.08611	-2.6161673	
29.	Bridge	38.067474	-2.601601	
30.	Bridge	38.067554	-2.6025767	891.0
31.	Kambuu Stretch	38.05522	-2.5744884	887.7
32.	Machinery	38.01928	-2.52507	937.9
33.	Kibwezi	37.96602	-2.4340067	948.2
34.	Masimba	37.593292	-2.1600683	1038.7
35.	Emali	37.48077	-2.0873866	1175.7
36.	Riverside	37.37175	-2.0142567	1242.2
37.	Kasikeu	37.37225	-2.014635	1246.8
38.	Kasikeu Junction	37.37581	-2.018	1223.8
39.	Kasikeu Riverside	37.36575	-2.0082567	1237.3
40.	Kilima Kiu	37.26383	-1.8712153	
41.	Blind Spot	37.26383	-1.8712153	
42.	Kilima Kiu	37.26383	-1.8712153	
43.	Salama	37.26383	-1.8712153	
44.	Blind Spot	37.254948	-1.8464283	1565.7
45.	Blind Spot	37.244675	-1.826448	
46.	Mlolongo Blackspot	36.948177	-1.4059823	
47.	Kapa	36.914635	-1.3648686	
48.	Flyover Mlolongo	36.892025	-1.335385	1450.6

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9 RTA Hotspots in the Busia County Segment of the NCR

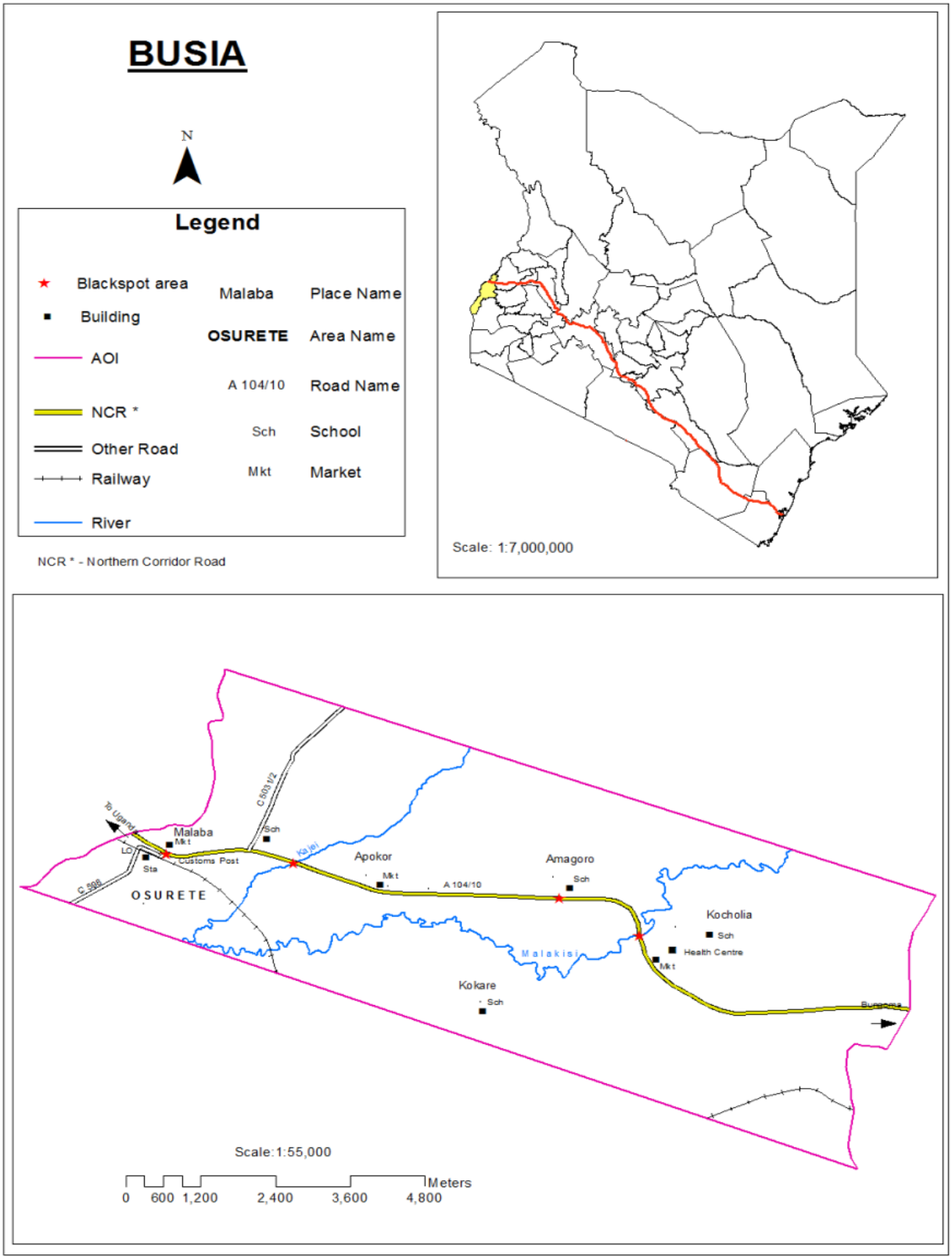

Fig 5: RTA Hotspots in the Busia County Segment of the NCR

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Busia county is the last county of the NCR, the Kenya police service characterizes the section of NCR between Kocholia and Malaba town as a frequent and repeated accident section of the road, the study found four distinct spots that are blackspots and mapped the GPS location of these spots at Kocholia malakisi river bridge, Amagoro, kajei bridge and Malaba town close to the border crossing

10 RTA Hotspots in the Bungoma County Segment of the NCR

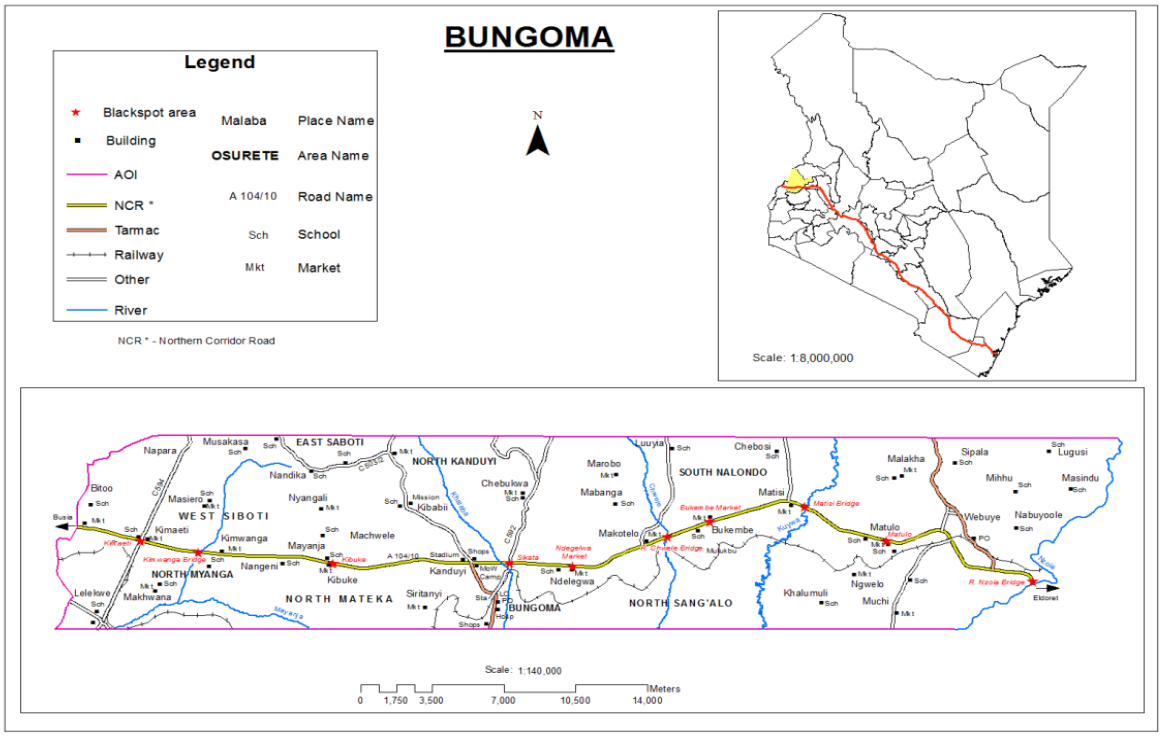

Fig 6: RTA Hotspots in the Bungoma County Segment of the NCR

Bungoma county is the second last county of the NCR, this section of NCR runs between Nzoia bridge and Kimaeti centre the study captured the GPS coordinates of frequent and repeated accident section of the road , the study found ten distinct spots that are blackspots and mapped the GPS location of these spots at Nzoia river bridge, Matulo,, Matisi, river bridge, Bukembe market,, Achwele river bridge, Ndegelwa market ,sikata junction to bridge, kanduyi juction , kibuke , kii wanga and kimaetei market at boarder with boarder county.

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11 Hotspots in the Kakamega County Segment of the NCR

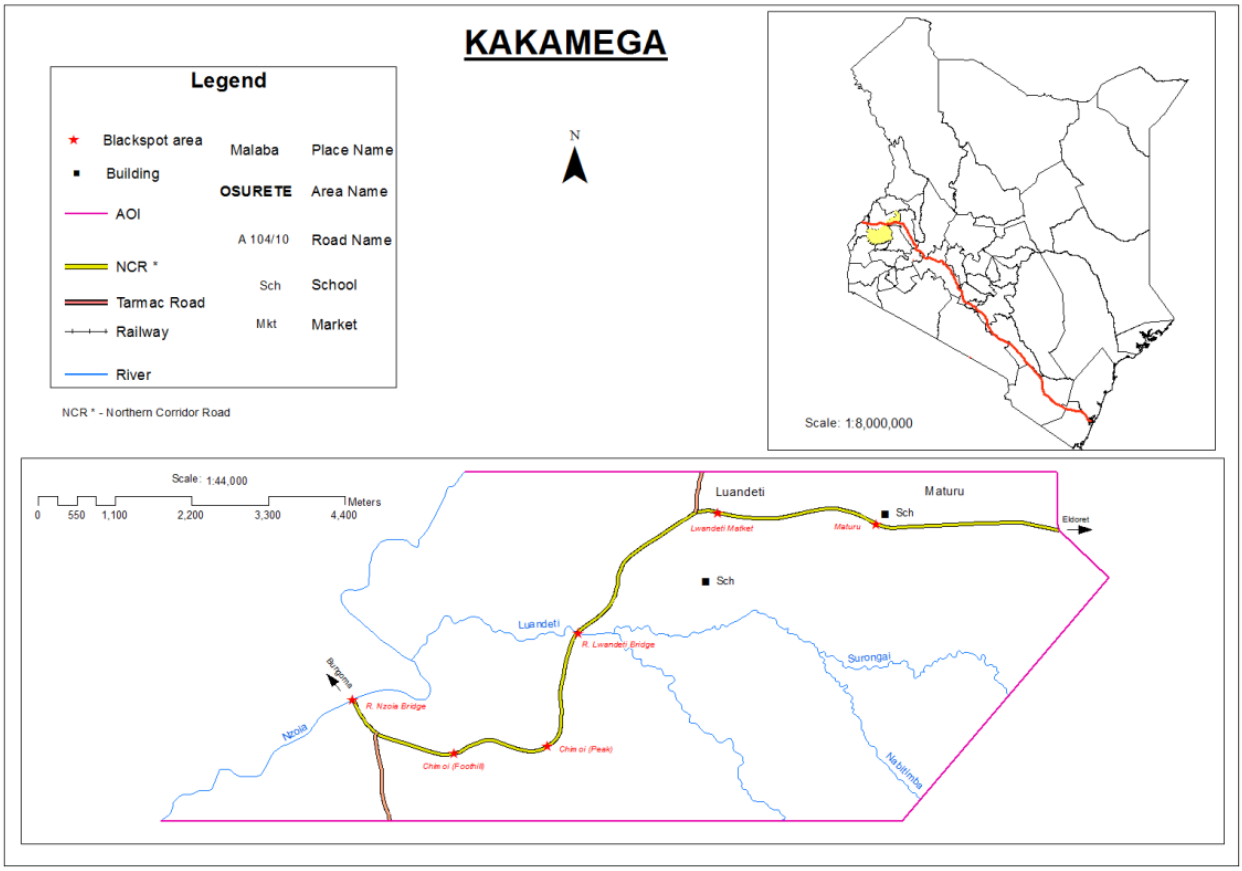

Fig7: RTA Hotspots in the Kakamega County Segment of the NCR

Kakamega county is the third last county of the NCR, this section of NCR runs between Nzoia bridge and kipkarren centre the study captured the GPS coordinates of frequent and repeated accident section of the road , the study found five distinct spots that are blackspots and mapped the GPS location of these spots at Maturu, Lwandeti market, lwandeti river bridge , Chimoi peak, Chimoi foothill, Matulo,, and Nzoia, river bridge,at boarder bungoma county.

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12 RTA Hotspots in the Uasin Gishu County Segment of the NCR

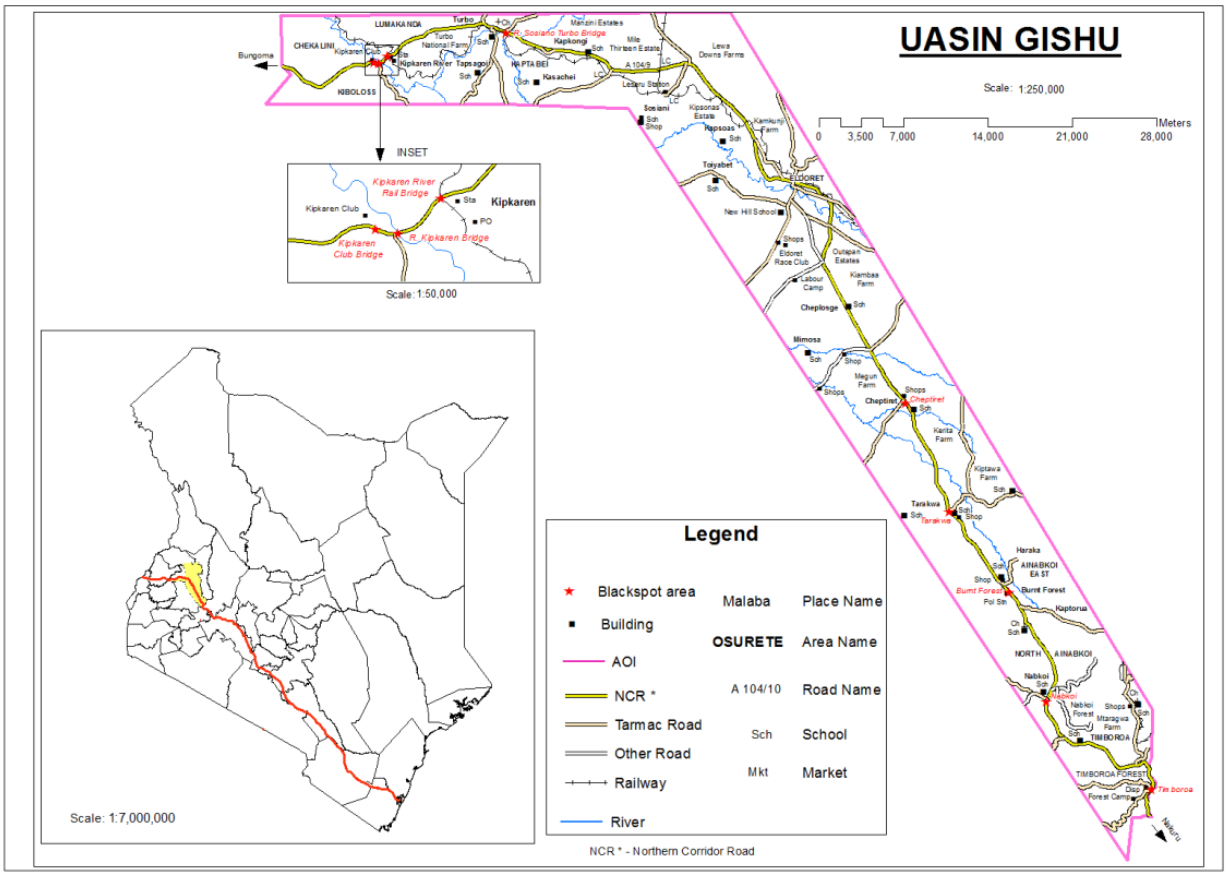

Fig8: RTA Hotspots in the Uasin Gishu County Segment of the NCR

Usin Gishu county is hosts a section of the NCR, that runs between Kipkarren river bridge and Timboroa the study captured the GPS coordinates of frequent and repeated accident section of the road , the study found four distinct spots that are blackspots and mapped the GPS location of these spots at Timboroa , Nabkoi, Burnt forest, Tarakwa, Cheptiret, Sosiano Turbo bridge, kipkaren river rail bridge kipkaren river bridge and kipkaren market at boarder with boarder Kakamega county.

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13 Hotspots in the Intersect of Baringo and Kericho Counties Segment of the NCR

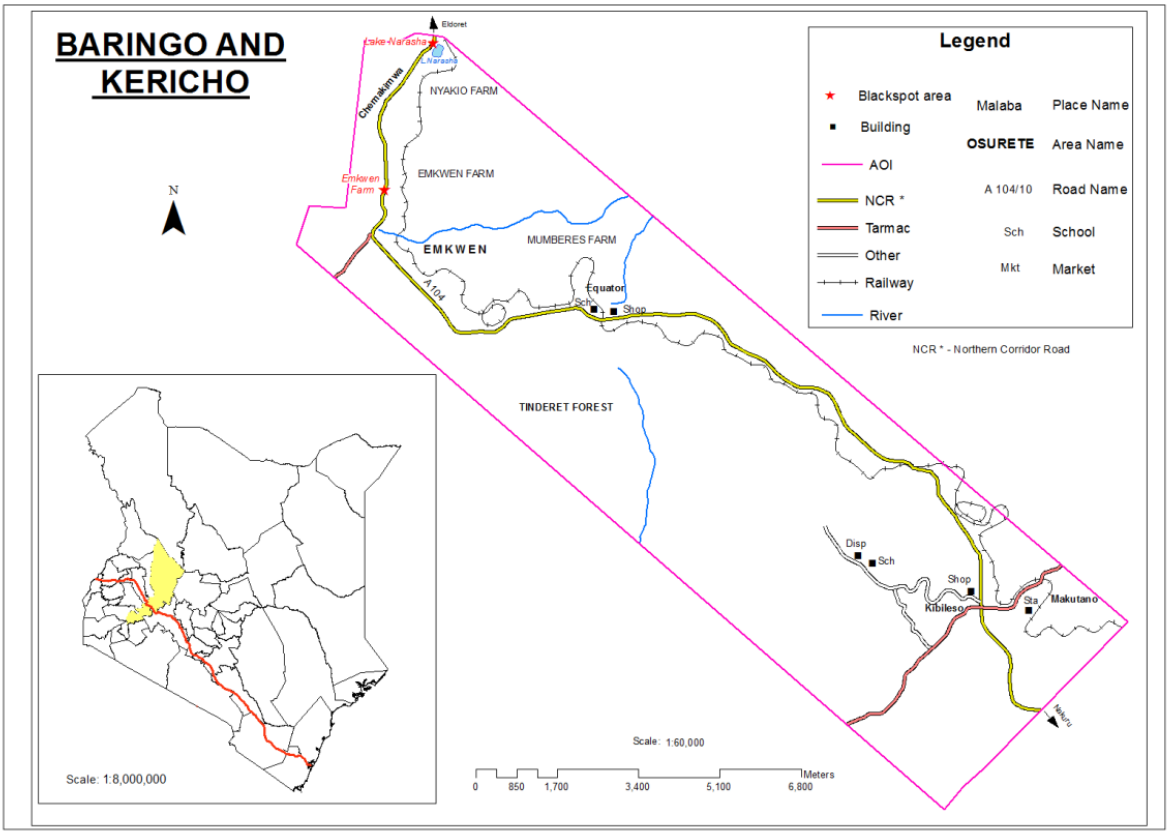

Fig9: RTA Hotspots in the Intersect of Baringo and Kericho Counties Segment of the NCR

Baring and Kericho counties a short section of the NCR, this section of NCR runs between kibileso and Lake Narasha the study captured the GPS coordinates of frequent and repeated accident section of the road , the study found two distinct spots that are blackspots and mapped the GPS location of these spots at emkwen farm and lake Narasha.

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14 Hotspots in the Nakuru County Segment of the NCR

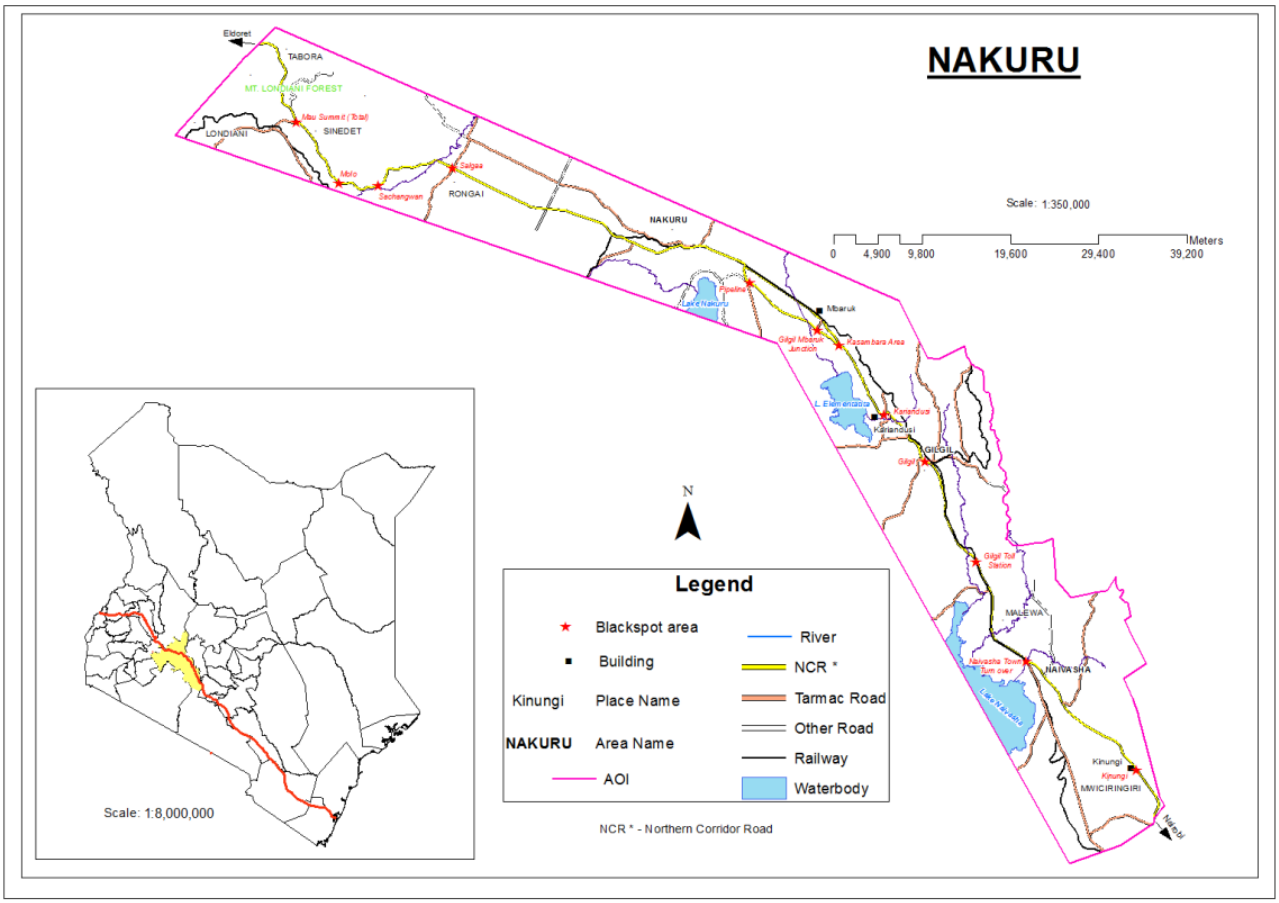

Fig 10: RTA Hotspots in the Nakuru County Segment of the NCR

Nakuru county is the most notorious RTI section of the NCR, this section of NCR runs between Kinungi and Mau summit centre the study captured the GPS coordinates of frequent and repeated accident section of the road , the study found 12 distinct spots that are blackspots and mapped the GPS location of these spots at Kinungi, Naivasha town turn off, Gigil toll station, Gilgil, Kariandusi, Kasambara area, Mbaruk, st mays hospital pipeline, Salgaa, Sachangwany, Mbio and Mau summit.

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15 Hotspots in the Nyandarua County Segment of the NCR

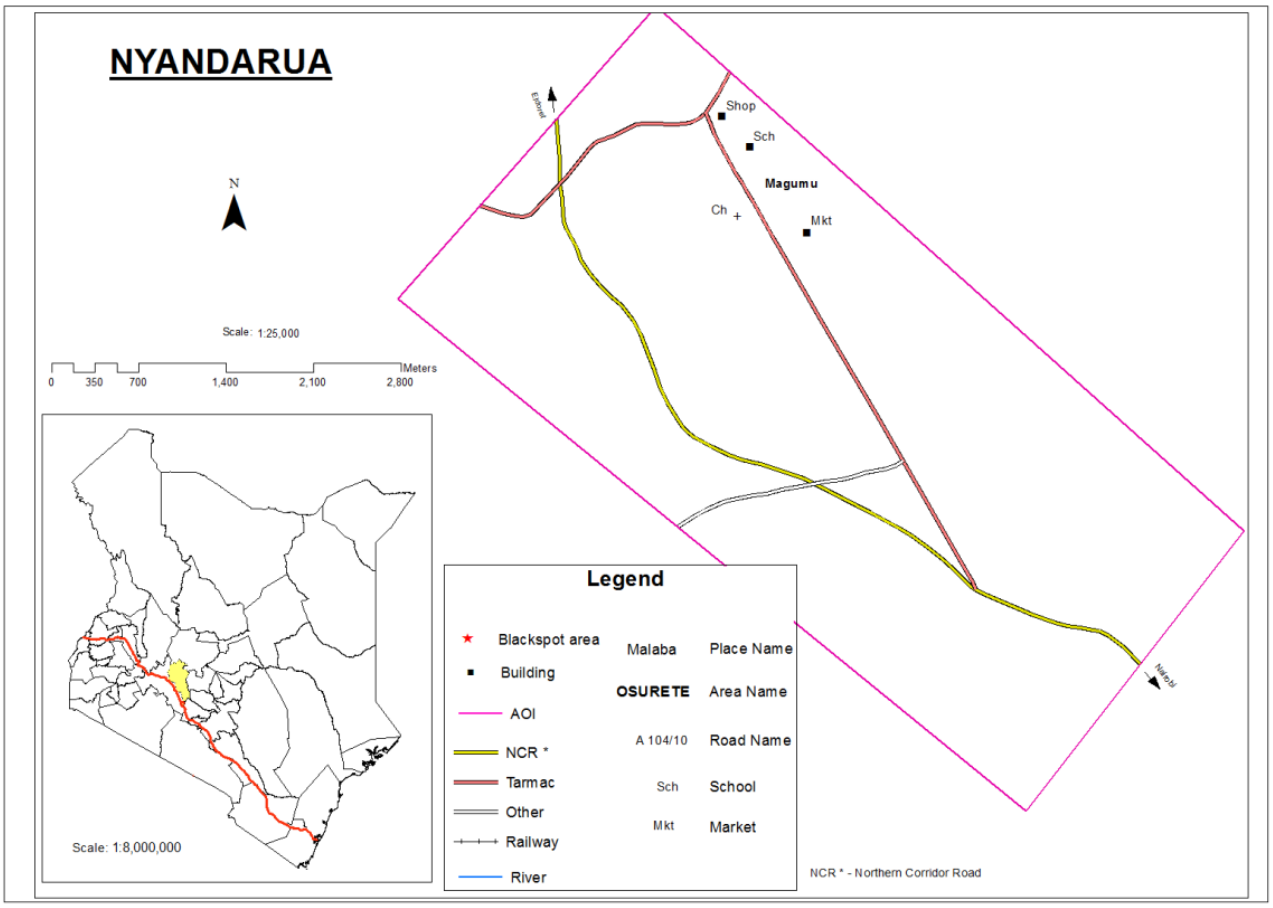

Fig11: RTA Hotspots in the Nyandarua County Segment of the NCR

Nyandarua county is the host of RTI section of the NCR, this section of NCR runs between Kinungi and Mau summit centre the study captured the GPS coordinates of frequent and repeated accident section of the road , the study found no distinct spots that are blackspots.

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16 Hotspots in the Kiambu County Segment of the NCR

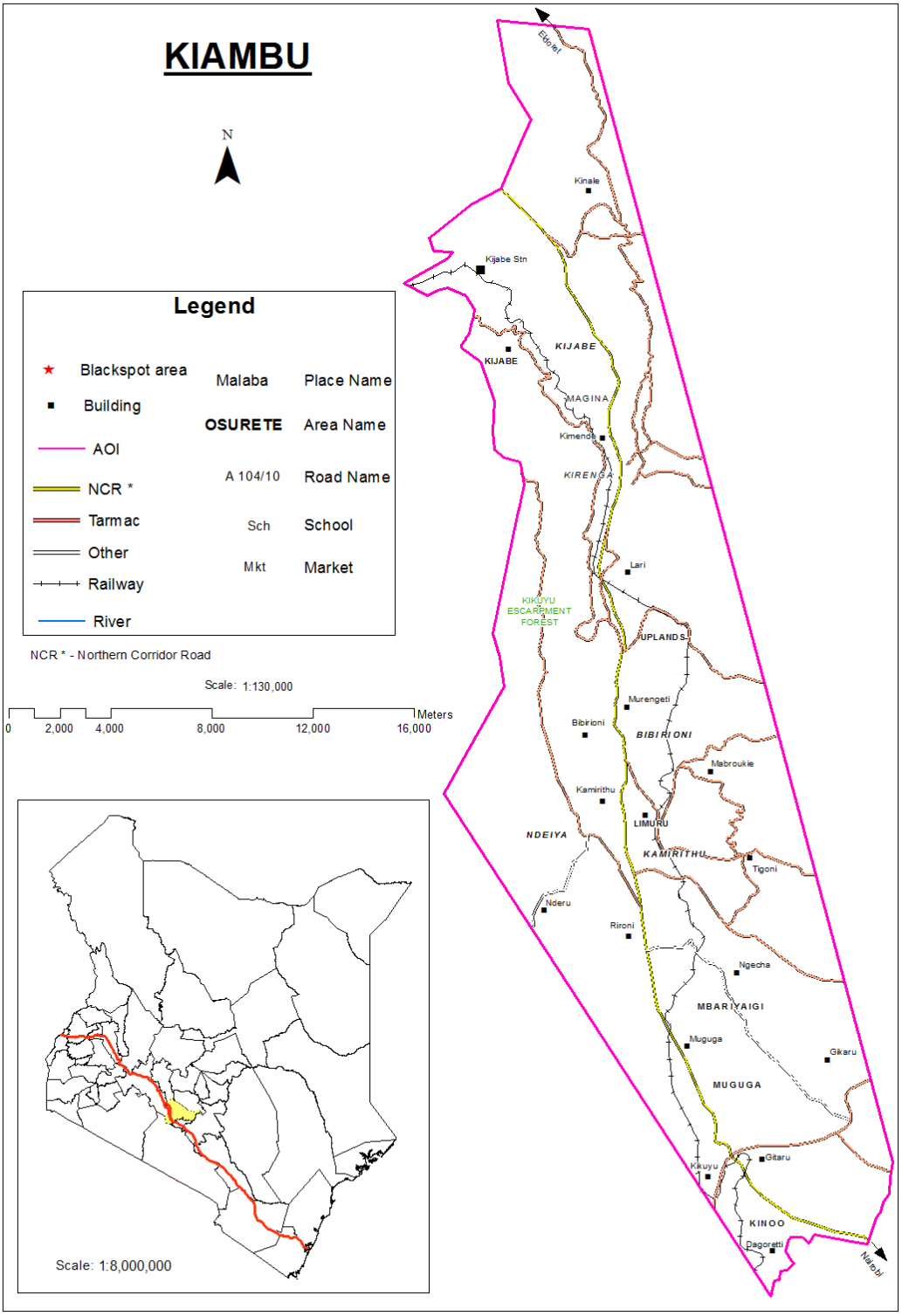

Fig12: RTA Hotspots in the Kiambu County Segment of the NCR

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17 Hotspots in the Nairobi County Segment of the NCR

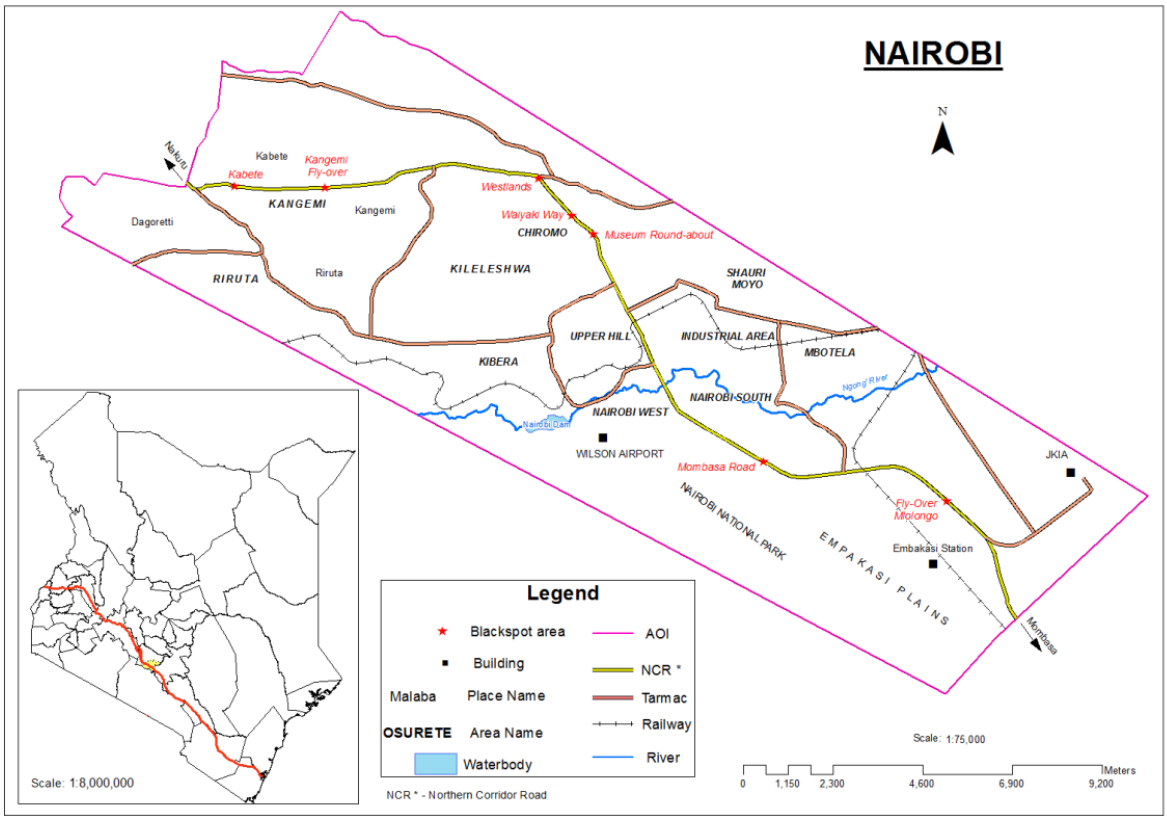

Fig 13: RTA Hotspots in the Nairobi County Segment of the NCR

Nairobi county is the host of RTI section of the NCR, this section of NCR runs between Mlolongo flyover and Kabete the study captured the GPS coordinates of frequent and repeated accident section of the road , the study found 12 distinct spots that are blackspots and mapped the GPS location of these spots at flyover mlolongo, Mombasa road cabanas junction, museum hill, Waiyaki way, westlands, kangemei flyover and kabete.

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18 Hotspots in the Machakos County Segment of the NCR

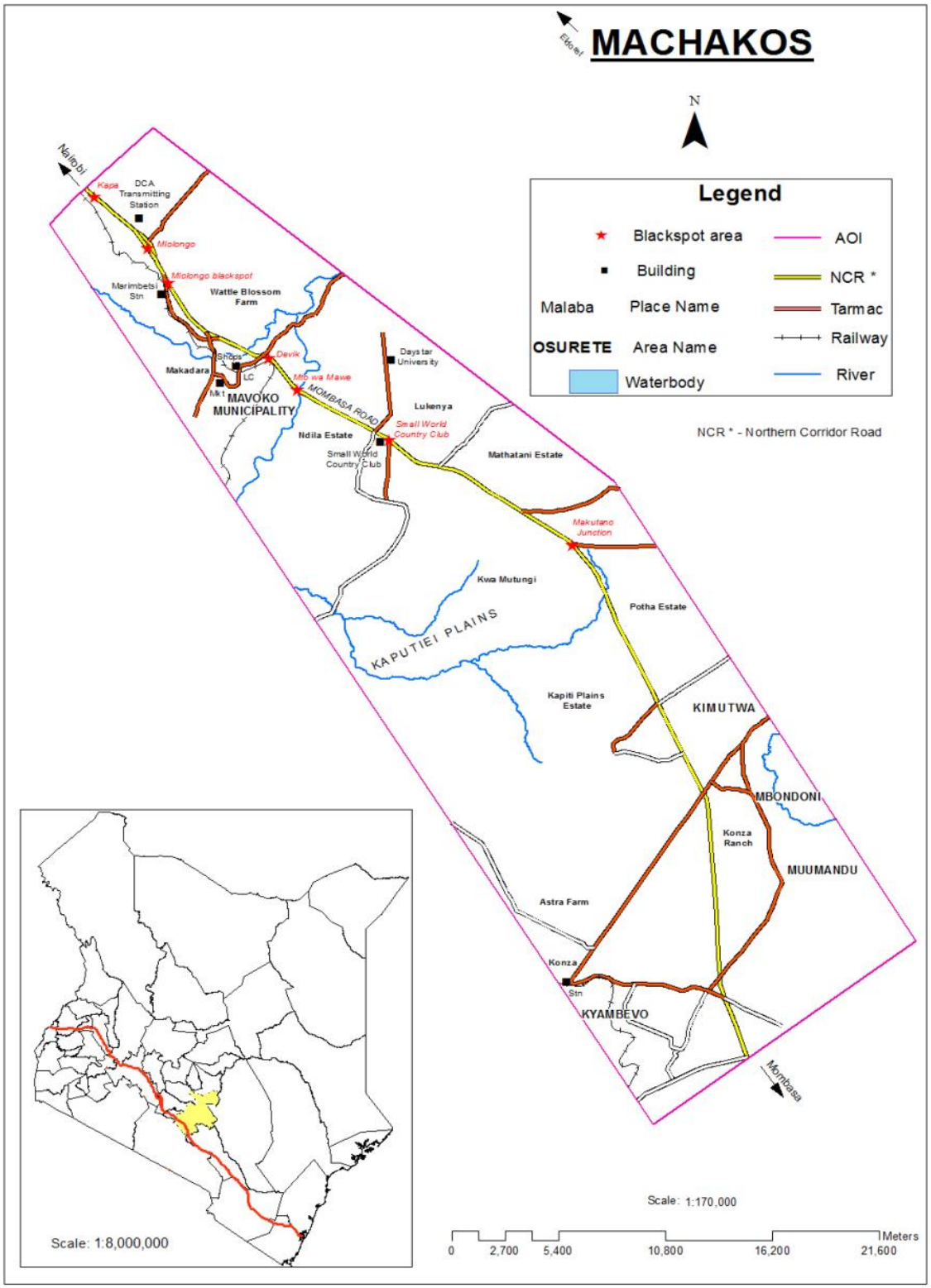

Fig14: RTA Hotspots in the Machakos County Segment of the NCR

Source: Researcher, 2017

Small World ,Makutano Junction ,Kwa BEBORA ,BEBORA 2 Kwa BEBORA

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19 RTA Hotspots in the Makueni County Segment of the NCR

Motto Andei, Kambuu , Kambuu, Bridge Bridge Bridge Kambuu Stretch, Machinery, Kibwezi, Masimba, Emali, Riverside

Kasikeu, Kasikeu Junction , Kasikeu Riverside , Kilima Kiu, Blind Spot , Kilima Kiu ,Salama Blind Spot ,Blind Spot ,Mlolongo Blackspot

Kapa Mtito to Tsavo River Stretch. Emali Simba Market to Kibwezi ,Salama - Sultan Hamud Road Section ,Konza Junction to Salama Road Section, Mlolongo - Small World Club – and Juction to Namanga and At Mto Wa Mawe Bridge.

20 RTA Hotspots in the Kwale County Segment of the NCR

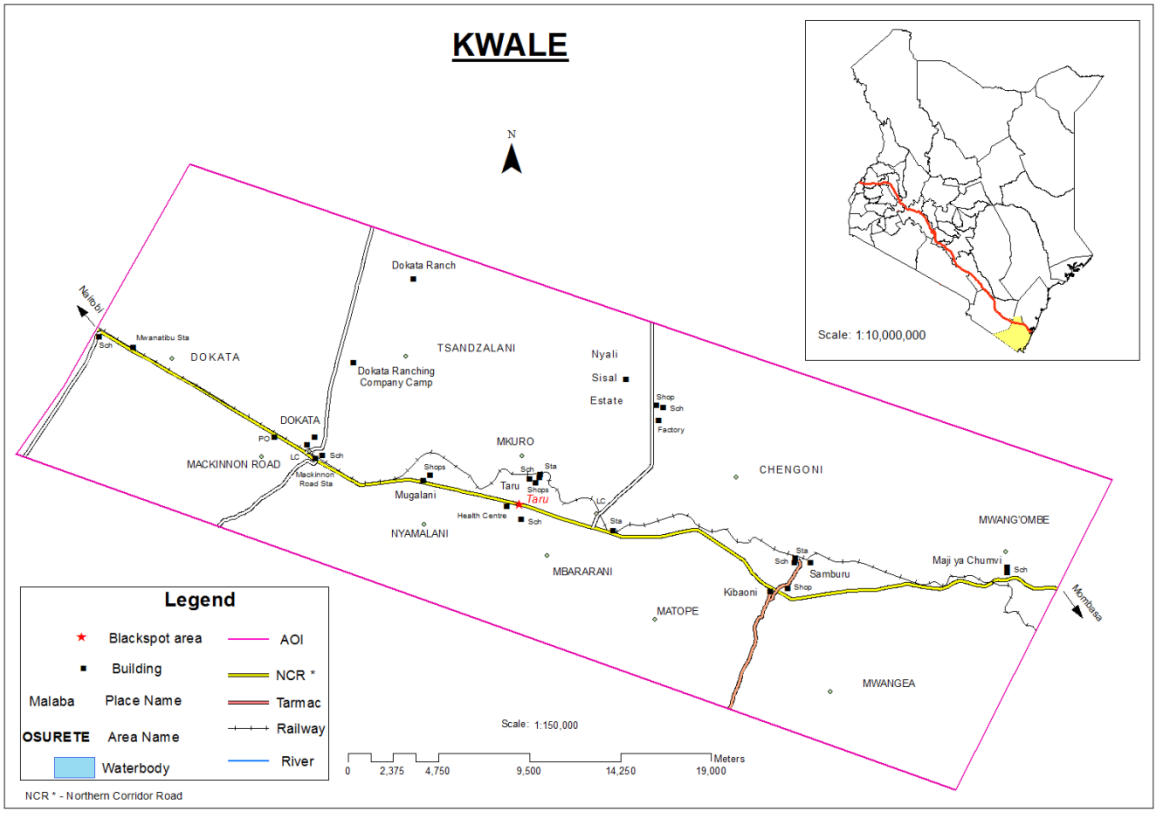

Fig 15: RTA Hotspots in the Kwale County Segment of the NCR

Mariakani Samburu

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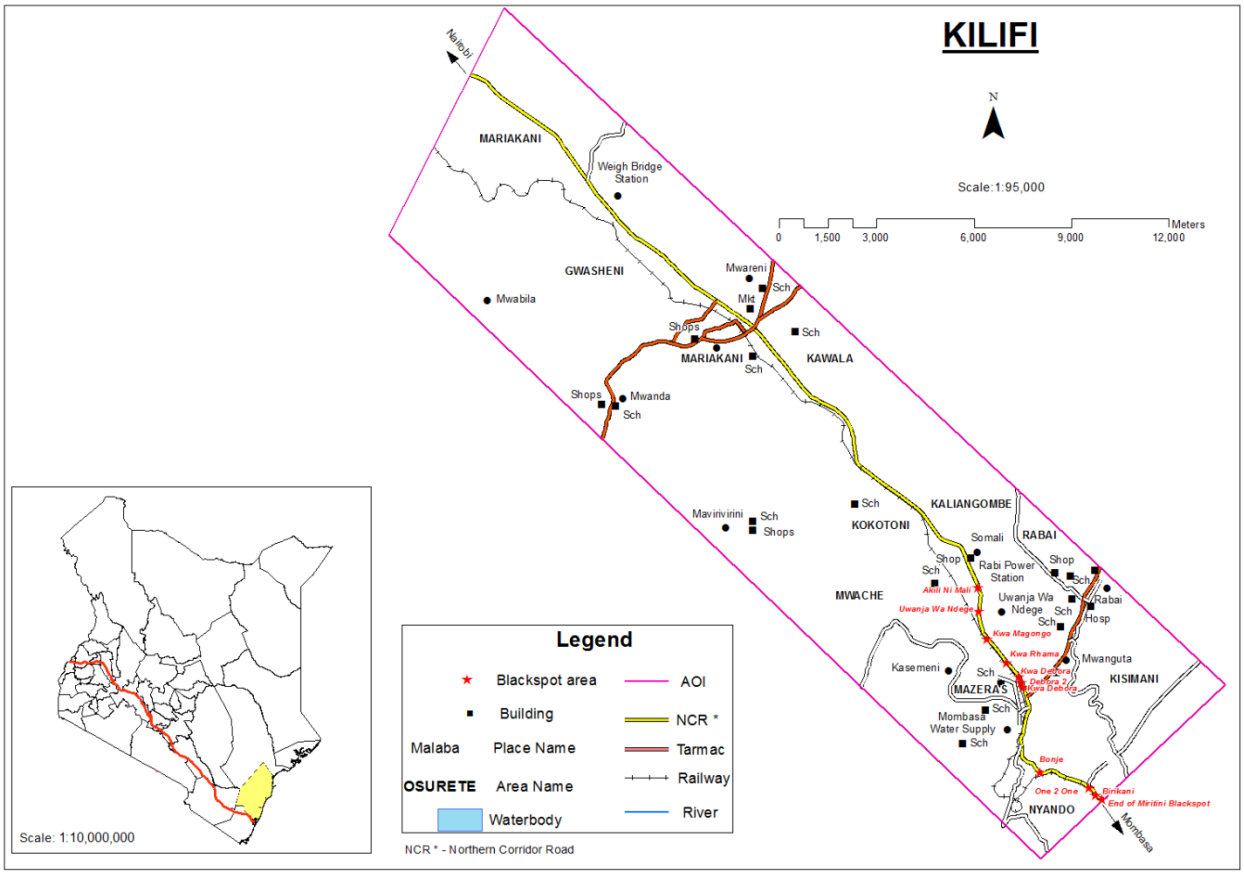

Fig 16: RTA Hotspots in the Mombasa and Kilifi County Segment of the NCR

CONCLUSION

Road accident black spots as identified by this study had different roadway design and conditions which possible has a contributively role in the frequency of the occurrence of road traffic accidents as shown. This study revealed that the road design of most black spot locations was characterized by steep declines, sharp bends, flat levels U-turn and intersections of which at such locations, over speeding drivers usually find it difficult to control their vehicles, which may eventually result to road traffic accident (Plate 1). This corroborates the assertion of Soltani and Askari (2014) that road traffic accidents occur more frequent in main arteries where more urban activities take place and cluster in the areas of urban that have high traffic volume and provide more accessibility to other roads.

Similarly, other road conditions like presence of potholes, eroded road shoulder and stationary vehicles were observed at the various black spot locations. This study revealed that the concentration of accidents is not evenly distributed along the roads as more of the occurrences appear to be regular at some black spots such as where there are sharp bends, slopes, U-turns, intersections, bridges and sharp declines along the roads. This agrees with the findings of Jobin (2015) that bridges (24.9%), built-up areas (24.9%) were the cause of accidents while sharp bend (21.9%), U-turn/intersection (13.8%), stationary vehicles (6.2%), slope (4.2%), market (2.7%), potholes (1.4%) contributed significantly to accidents.

Adverse weather conditions have a major impact on the safety and operation of our roads, from highways to local roads. Weather affects driver behaviour, vehicle performance, pavement friction, and roadway infrastructure. Some weather events and their impacts on roads can be viewed as predictable such as reduced visibility due to fog while some such as sporadic rains are unpredictable but they are all non-recurring incidents that affect safety, mobility and productivity. Weather affects roadway safety through increased crash risk, as

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well as exposure to weather-related hazards. Weather impacts roadway mobility by increasing travel time delay, reducing traffic volumes and speeds, increasing speed variance (i.e., a measure of speed uniformity), and decreasing roadway capacity (i.e., maximum rate at which vehicles can travel).

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