BLACK SPOT ALERT SYSTEM

Thika Superhighway, Kenya

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GDP-Gross Domestic Product.

NTSA-National Transport and Safety Authority

POI-Point of Interest

RTA-Road traffic accidents

WHO -World Health Organization

ABSTRACT

Road safety is a major concern in the present situation around the globe and majorly in our country Kenya, which ranks at number seventeen in the riskiest countries worldwide with an accident rate of 39.63% (World Health Rankings, 2021). A report from World Health Organization(WHO) projects that Road Traffic Accidents(RTAs) will be the third leading cause of death by the year 2020 with the number of such deaths projected to reach 8.4 million in the same year. Worldwide, road traffic accidents lead to death and disability as well as financial cost to both society and the individuals involved. Road traffic accidents are preventable with the implementation of efficient methods. This project focuses on a method by which the accident-prone locations on roads, commonly termed as accident blackspots, can be detected by road users with the help of a smartphone alert application. The project involved the collection of various road attribute data and blackspot data from Thika superhighway and later Jogoo road for comparison purposes. These data were used for road characterization and classification of blackspots as per their severity. The study's findings indicated that in addition to road users' behavior, road attributes such as the type of road, its width, and many more, were among the causes of some areas on roads to be termed as blackspots. Additionally, some blackspots were prone to a higher frequency in accident occurrences than other spots, besides, some previously identified black spots are no longer points of concern for road users due to infrastructure improvement over the years. Nine blackspots along the Thika superhighway were identified from NTSA's 2018 accident data and used in this project. The prototype application developed, focuses on using an alert system to warn motorists and urge them to drive carefully when approaching known blackspot locations along Thika superhighway and also gives road users the flexibility to add blackspots that were previously not available or ones discovered on newly constructed roads. This study met its overall objective of creating an alert system for road users, however, it is limited to people with smartphones and those who have the application. Incorporation of road design data and speed limits observation, improvement, and maintenance of roads enforced by traffic safety officers, engineers, and road planners will ultimately help in saving lives.

CHAPTER ONE: INTRODUCTION

1.1: BACKGROUND INFORMATION

National highways form the economic backbone of the country second to agriculture and have often facilitated development along their routes. Nothing is more important to civilization than transportation, communication and apart from direct tyranny and oppression, nothing is more harmful to the wellbeing of society than an irrational transportation system (Sorate et al.,2015).

According to the 2018 Global status report of the World Health Organization, approximately 35 million people lose their lives in traffic crash-related accidents while about 20 to 50 million more people are involved in non-fatal traffic accidents. More than ninety percent of road traffic deaths occur in low- and middle-income countries with the highest being recorded in the African region, claiming lives of children and young adults aged between 5-29 years with 73 % of them being young males under the age of 25 (World Health Organization, 2020). In terms of road safety, Africa cannot be emulated by the rest of the world, as statistics by WHO indicates a road traffic mortality rate of 26.6 deaths per 100,000 people and accounts for the highest mortality rate in terms of pedestrians and cyclists (Atlas Magazine, 2020) The morbidity, disabilities as well as the economic costs associated with traffic accidents make them a major public concern, especially because there are proven preventive measures. Drastic actions are required to put these measures to work and meet global set targets to save lives. In Kenya, it is estimated that about 3000 and 13000 people lose their lives annually through road accidents (World Health Organization, 2020). As of the 18th of November 2019, the NTSA traffic data confirms that the number of people who have died on roads in 2020 has surpassed those who perished in 2019 by 385 people and the design of the Kenyan roads has given rise to various notorious blackspots within the country's major roads due to steep curves and blind corners.

An accident blackspot is a length of the road marked as having high road accidents potential. There are at least 160 accident blackspots identified along highways across the country (Nyamori, 2015), with an example of this being the 14-kilometer stretch between Salgaa and Sachangwan along the Nakuru-Eldoret highway which has been the scene of multiple horrific accidents involving trucks. Mention of the area sends shivers down the spine of many motorists who use the Nakuru-Eldoret highway. Most Kenyan highways have become a nightmare to Passengers, drivers, and pedestrians in the recent past. The situation is traumatizing especially when traffic volumes are high. Most people have lost their lives while others are left disabled.

Statistics obtained from the National Transport and Safety Authority (NTSA) and the Traffic Police confirm that in 2017, total accidents reported along the Salgaa area were 50 with total victims being 284. Out of this number, 138 people died. The numbers reduced in 2018 to 23 accidents, 22 deaths, while this year, from January to October, there have been 19 accidents and 16 deaths. This has been attributed to the erection of a concrete barrier by the government in 2018, separating traffic lanes, proper signage, and careful driving (kahenda & chepkwony,2019). However, most other blackspots on major roads are not known to most road users due to lack of proper signage and most have claimed many lives. Despite authorities using various methods to raise awareness of blackspots including the use of speed guns detectors, the rate of accidents on the roads is still at an alarming rate. More often, signposts on the road can be vandalized or even be hit by a reckless driver. There is also an assumption that every driver reads and understands these signposts, hence, my project is propelled by the desire to reduce these incidents by the use of a black spot detector mobile application.

The blackspot detector mobile application will be developed to warn road users about approaching these locations. It will incorporate the points of interest (POIs) which will be all the blackspot locations along Kenyan roads. A POI specifies at minimum the latitude and longitude of a given map or datasets. Annually Kenya experiences one of the highest fatality rates that bring the economic cost to 11% Of GDP (mutune, mang'uriu, & Diang'a, 2017). The use of this technology will likely reduce the number of accidents on blackspots as road users will be aware of these zones.

1.2: STATEMENT OF THE PROBLEM

Kenya experiences one of the highest fatality rates in the world due to the systematic failure in the management of road construction standards. By comparison, Norway has more cars but just a tenth of Kenya's traffic fatalities per 100,000 (Gathara, 2017). There is not a single solution to curbing traffic accidents on black-spot zones around the country and most researchers have attributed these traffic accidents to lack of proper signage and markings on the roads, reckless driving, lack of proper pathways for pedestrians, and of lack of proper specifications on lanes to avoid collision between opposite moving traffic. The causes of any one single accident are multi-factorial, involving human, vehicular, environment, and road design variables.

Blackspots on Kenyan highways are causing a high morbidity rate on both pedestrians and motorists with one such example being the 14 km stretch of Salgaa along Nakuru-Eldoret highway, which has claimed hundreds of lives over the years. The morbidity, disability as well as economic cost associated with traffic accidents makes them a major public concern.

The development of an alert system, that contains coordinate information for all blackspot points on the major roads as mapped by NTSA, provides a possible solution to the minimization of traffic accidents on the identified spots. This will come into play by alerting road users when they get closer to the blackspot area at about one kilometer from it they will get the first warning then get a series of beeping sounds at about 500 meters from the area, throughout the area and stop immediately after they have passed the point of interest. This will significantly minimize the occurrence of accidents as road users will be more vigilant and careful.

1.3: OBJECTIVES

1.3.1: The general objective

The project aims to establish possible mitigation measures for the rampant accidents that occur along Kenyan roads by developing a mobile alert system for road users.

1.3.2: specific objectives:

- To do hotspot characterization and categorizing.
- To predict and identify blackspot areas along Thika superhighway with the use of GIS software and weighted methods
- To design and develop a mobile application.
- To incorporate an audio directive notification on the app

1.4: JUSTIFICATION OF STUDY

According to statistics collected by the WHO in the year 2018, Kenya experiences thousands of deaths related to road traffic accidents which in turn costs, the country a significant GDP, with Nairobi and its environs accounting for approximately a quarter of road accidents fatalities. Some of the high-risk roads in Nairobi and its environs include Thika Superhighway, Airport North Road, Eastern Bypass, Jogoo Road, and Mombasa Road. Our roads are not only harming the economy but also, they are detrimental to human lives and for these reasons, we need to look for alternative ways in which we can mitigate the issues. Due to the technological advancement in the 21st Century, most people use smartphones that convey information wherever the user is located. Thus, the exploration and use of geospatial techniques incorporated in the development of the alert application will help mitigate the problem at hand. With an increase in the number of accidents, an alert system will provide tools to help reverse the curve.

1.5: SCOPE

The study aims to establish the probable use of GIS techniques in predicting and identifying black-spot areas along Thika Superhighway with the use of GIS software, weighted methods for classifying black-spot. The area under study covered an extent of approximately 50km along the Thika superhighway. The study was looking at mapping blackspot in the area of interest.

1.6: AREA OF STUDY

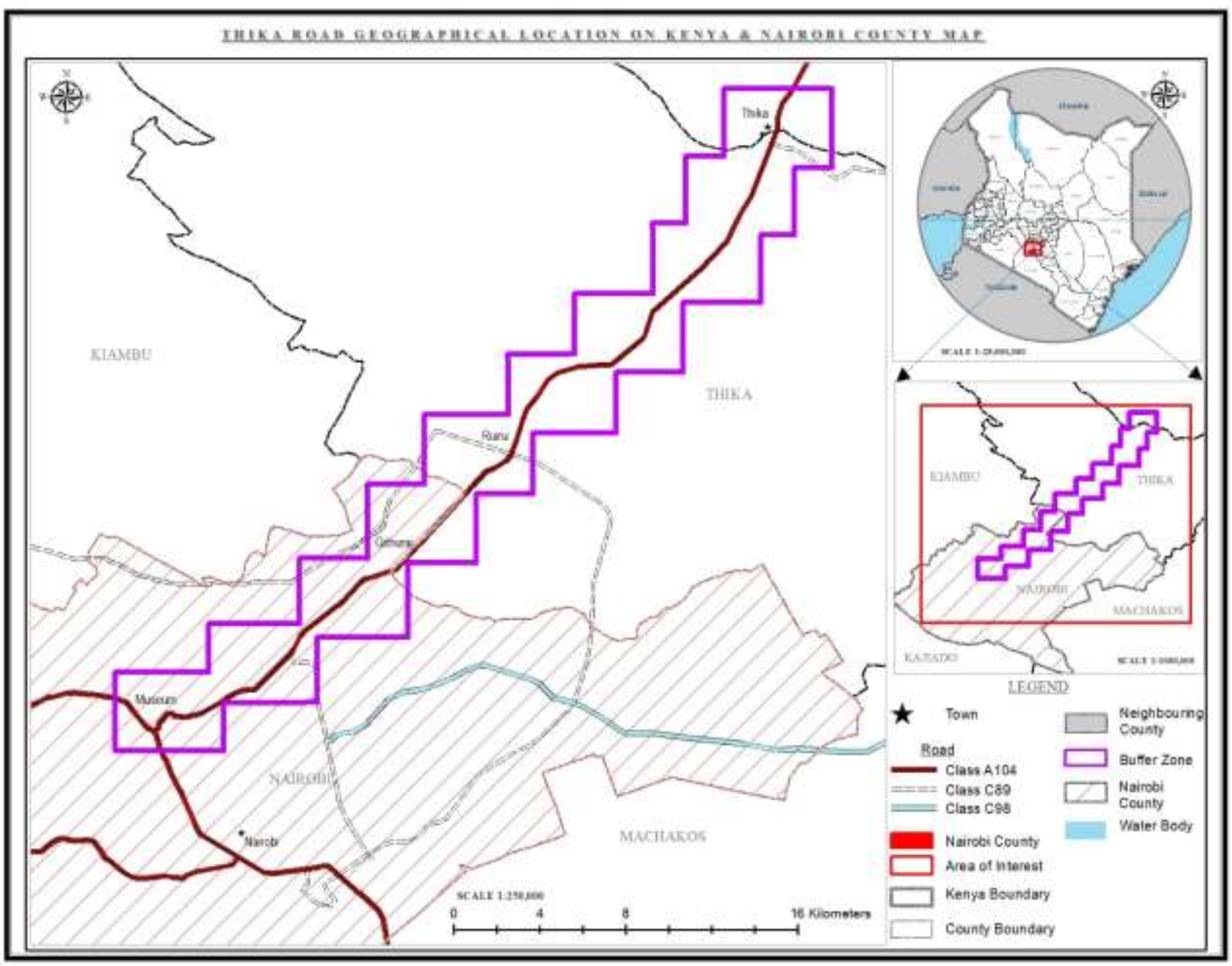
The initial stages of this study will use black-spot zones along Thika road for easy demonstration then the study will be expanded to include all black-spot zones along Kenyan roads which will be incorporated in the mobile application after its approval.

1.7: LOCATION

Thika Superhighway is an 8-lane controlled-access highway in Kenya, with 12 lanes in some sections. It links the capital city of Nairobi with the industrial town of Thika. Thika Road forms 50 km of the A2 Highway. The Highway passes through both Kiambu and Nairobi County. It lies between the latitude of 10 14' 51.94''S and the longitude of 360 51' 49.85''E.

STUDY AREA MAP

Figure 1Map of the area of interest



CHAPTER TWO: LITERATURE REVIEW

2.1: OVERVIEW

Road traffic accidents and their associated injuries are a major cause of death and disability around the world with an estimate of 24 million people injured and 1.24 million people dying annually. As of 2019, road accidents and accompanying injuries made the 10^{th} ranked cause of death in lower-middle-income countries and the ranking is projected to rise (WHO, 2020). Most of the deaths occur in developing countries. In Kenya, over 3000 people die through road accidents every year with most of them being at their prime age, (Manyara,2016). The cost of these accidents is causing staggering effects to the economy and the families involved. Furthermore, it is noted that countries which neglect their road safety are likely to lose between 7%-22% of potential GDP growth with diminished productivity and reduced growth prospects, over 24 years since most casualties are prime working-age adults (The World Bank, 2018).

In Kenya, most fatal accidents occur on identified black spots. Although measures such as enacting road signs have been put in place, most drivers ignore or simply do not notice the signs as their concentration is mostly on the road.

2.2: SIMILAR PROJECT DONE IN OTHER COUNTRIES AND KENYA

Currently, in the world, there is no universal distinct compiled framework to define and recognize a road accident accumulation zone, also known as a black spot or accident hotspot, with different countries using different approaches and definitions. To identify road accident accumulation zones there are different approaches, with the common and mostly used one being analysis of historical data of traffic accidents. In developed countries such as the USA and western Europe GIS has been developed rapidly and used broadly in the field of traffic safety. In developing countries, however, research into the area of GIS technology applications in traffic safety started rather late (Chen, 2012).

One of the methods used in china is the use of virtual reference station (VRS)-Based Traffic Accident Mobile Position that utilizes GIS technology to locate the traffic accidents that are described as address with text in the road network. The location system contains three parts: the VRS network, the communication network, and the user terminal (Chen, 2012).

The user terminal receives the different messages from the VRS system recurrently through the communication network, while it also calculates the position from the GPS. In the process of the position calculation, the handheld PC is the middle link that obtains the difference data from the VRS control center and also acquires data from Bluetooth GPS. Additionally, it is in control of data download, data decoding, result displaying, and equipment control. This allows the mobile location instrument to obtain the high precision position of each traffic accident and also to store attribute information. Based on the spatial relationship between traffic accidents and road network attributes, black spots are extracted. This is done by comparing the distribution of road accidents which are classified as either decentralized or intensive. Decentralized distribution of accidents mostly concerns the unsafe behavior of the drivers and other road users while the intensive distribution of accidents is more related to the road attributes, conditions of traffic facilities, and the traffic environment. A distribution showing an accident-intensive section of the road network indicates a blackspot point or section.

In Kenya, Mr. Muthungu did a similar study on black spots and developed LUAM a "black-spot tracer". The device alerts motorists whenever they approach blackspots from as far as 500 meters and signals them whenever they exit the targeted area. The gadget is a hybrid of two electronic devices, an ordinary television remote control and signal module receiver fitted in a vehicle, which is configured through software that he invented. The remote control is upgraded through the software such that it sends a signal which is then captured by the signal module receiver fitted in a vehicle. The receiver encodes the signal and transfers it to an LCD fitted in the dashboard, which warns the driver that they are in an accident-prone area (Weru, 2016)

Although Mr. Muthungu's idea and gadget are brilliant innovations, I find them to have a couple of demerits such as: -

- ➢ The ordinary television remote operates on battery cells which will require constant replacement and that will be challenging
- ➢ Infrared remote signals have a range of only about 30 feet (10 meters), and they require line-of-sight. This means the infrared signal won't transmit around corners. This is also a setback on his projection of 500 meters.
- ➢ The use of a remote control which is to be placed at every blackspot in Kenya seems to be a tedious process, time-consuming, and will require too much manpower.

2.3: MY PERSPECTIVE

This project will be concentrating on improving road safety by developing an alert system with an audio directive feature that notifies a driver to reduce the cruising speed when approaching black spot areas and this will be achieved by the use of geofencing to define the geographical boundaries around the black-spot on a defined radius. Geo-fences when crossed by an equipped vehicle or person can trigger a warning to the user or operator via notification. This reminder effort will make drivers aware and alert hence be on the lookout for anything that might cause accidents such as oncoming vehicles, overtaking vehicles, crossing pedestrians, etc. This approach is more accurate as compared to the study mentioned above since it involves the use of GPS acquired coordinates to develop a mobile application that can be used by anyone with a smartphone. This application is free from experiencing downtime as compared to the system above that will require batteries in the remotes to be changed frequently. The application can detect the black spot and alert the motorist from a minimum distance of 500 meters whereas LUAM detects the black spot only when in line of sight at about 10 meters.

2.4: INVESTIGATIVE RESEARCH

Investigative research is a collection of research techniques and methods used by researchers who intend to obscure information that can build a more comprehensive picture of the issue under investigation. In this section I will be focusing on hotspot characterization and categorization, investigating the challenges faced in the identification of road black spots, and investigating existing techniques and models for black spot identification.

2.4.1 Hotspot characterization and categorization

Identification and remediation of blackspots are some of the most effective ways to enhance road safety. This can be achieved by systematic collection of data of traffic crashes. Presently, Kenya does not have a comprehensive Black Spot Management Program. Black spot identification rather, identification is based on ranking the number of crashes at specific locations without reference to severity, traffic volumes, length of the crash-prone locations among other factors. With this approach, which does not take all relevant parameters, some black spots may remain unidentified. This approach may lead to twisted prioritization of locations for treatment and consequently road safety strategies therefore identification, analysis, development of measures, and prioritization of black spots treatment and programs is a critical procedure that has far-reaching economic repercussions.

Blackspots in Kenya are areas identified as locations that experience at least five crashes per year and of related causes. This is since a black-spot location has a higher number of crashes than other similar locations, due to local risk factors.

Crashes are caused by four factors:

- Road environment
- Road engineering design
- Vehicle condition
- Pedestrians and road users

Parameters that should be taken into consideration during black-spot identification and characterization are as follows:

- **Crash frequency**-which is the number of crashes per year. To acquire reliable data, it should be collected for at least three years.
- **Crash severity-**severity of injuries, fatalities, and serious crashes are weighed.
- **Crash rate-**The observed crash frequency per factors such as traffic volume, length of the section, or the number of vehicles.
- **Vehicles Involved-** crashes involving public transit/ par transit vehicles tend to have more casualties than private vehicles.

Other factors such as crashes involving public transit tend to have more casualties than private vehicles. Collision diagrams are an important part of the black-spot analysis as they make it easier to identify repetitive crash patterns and their concentration in certain travel directions. Crashes are clustered, and patterns of crashes are identified based on:

- Type and number of crashes
- The exact location of the crashes
- Travel direction of each vehicle
- Maneuvers of each vehicle
- Type of collision

2.4.2: Blackspot Categorization Methods

WEIGHTED SEVERITY INDEX (WSI)

According to Patankar, 2017, the Ministry of National Highways and Road Transport, Government of India, used **Weighted Severity Index (WSI)** method to identify accident black-spot areas. Yearly accident data (secondary data) for the Pune district were collected from the Ministry of Highways, Government of India. The top-ranked six accident black spots in Pune were identified using Weighted Severity Index Method (WSI) by assigning scores based on the number and severity of accidents in that particular location during the last year. Weighted Severity Index, (WSI) = (41 x K) + (4 x GI) + (1 x MI) Where K is the number of persons killed; GI is the number of grievous injuries; and MI is the number of minor injuries. (Athira & Landge, 2017)

Similar studies were done on Asian Highway 46 and Lagos Metropolis where they both used the Weighted Severity Index (WSI) method to rank the accident locations. The top five spots in the Asian Highway 46 were selected as blackspots as per the WSI value from the collected data and suggested some possible alternative measures to improve the transportation system. (Athira & Landge, 2017). In Lagos Metropolis, various factors that cause road accidents were evaluated and fourteen factors were identified. Different datasets, both spatial and non-spatial, were collected, processed, and analyzed. The weighted Severity Index (WSI) was created based on these factors. Results on accident spot severity and vulnerability level across the Metropolis based on the Weighted Severity Index (WSI) were obtained. (JO & WA, 2017). Other countries such as India have used the same method in their studies (Mr.R.S.Pandey & Khan, 2017) and Kozhikode district, Kerala (Saran, 2017)have also used the Weighted Severity Index method.

REGRESSION ANALYSIS.

Another common effective method used in the research of modeling the interaction between the accident incidences, highway geometries and road traffic characterization, is **regression analysis.** The ease of modeling readily favors the regression approaches. However, this method is highly dependent on traffic flow data like Average Daily Traffic (ADT) and the data collected by the traffic police from the accident sites. But traffic flow data are rarely available in sufficient quantity or accuracy to justify these regression approaches. Moreover, the traffic police may not be able to collect all the necessary data required to carry out the analysis using that data (Kalga and Silanda,2002).

In Stockholm, Sweden, a study was conducted using a similar method, regression analysis, to analyze road accidents. According to Gustavsson 2017, the number of accidents on a particular day, at a road net, is assumed to have a normal distribution where the mean is a linear function of some regression variables while the variance is constant. The expected number of road accidents on a certain day is therefore assumed to depend linearly on the accident frequency. The variance, however, is assumed to be the same for all the days of the specified period studied. The number of accidents on different days is assumed to be independent. If one is interested in comparing the accident development during different periods, this can be done by comparing corresponding regression planes (Gustavsson, 2017) Additionally, similar studies and methods have been used in various counties such as Ghana, (Agyemang, Abledu, & Semevoh, 2013) to estimate and forecast accident crash areas.

PRIORITIZATION AND GIS

In this method, a road network is distributed over a given area, hence it always possesses a 'spatial characteristic' i.e., it always has the geographic locations associated with it. Therefore, to model a road network, an information system capable of processing spatial data is required. GIS can easily handle, store, analyze, manipulate and retrieve spatial data and a model for identifying an accident-prone location on roads can be easily implemented using GIS.

The method used, requires a map of the desired road network digitized in a suitable form and certain specified road attributes to carry out prioritization the analysis then identifies accident black spots on the given road network. While carrying out the analysis the model only incorporates the road-related factors such as road geometries, which lead to accidents. The factors considered for evaluating accident-prone locations on road are as follows:

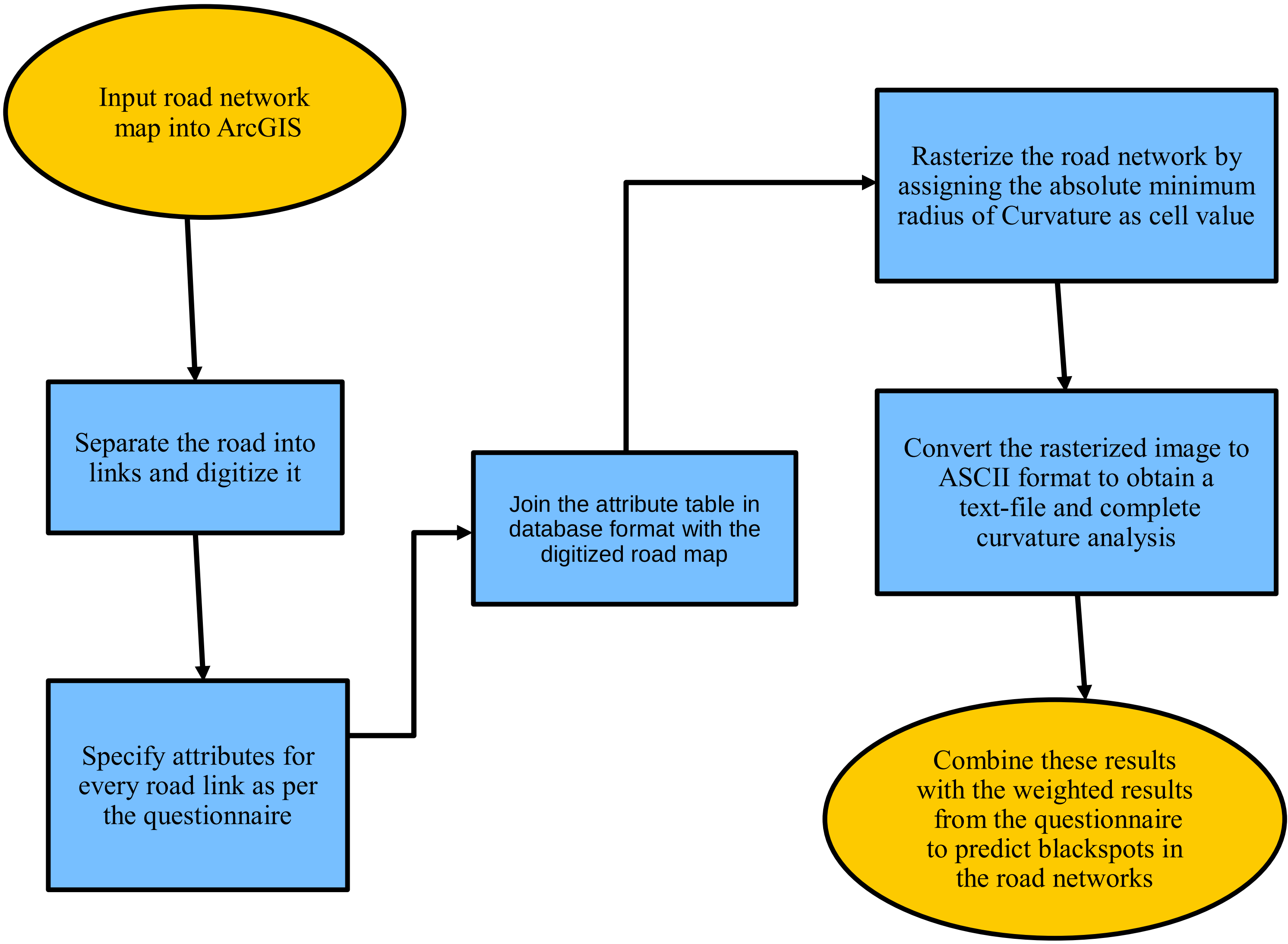
- Road width.
- Number of lanes.
- An approximate number of vehicles per day.
- Type of road.
- Drainage facilities.

- Surface condition of the pavement.
- Frequent vehicle type.
- Presence of shoulders, edge obstructions, median barriers, and ribbon development.
- Radius of horizontal curve.

(Shree, Shashikiran, & Shanabog, 2020), (Mandloi & Gupta, 2003), (Nodrat & Kang, 2018), (Gupta & Singh, 2014), (Isen, A, & S, 2013)

To model the mentioned factors and achieve the desired result, a step-by-step procedure as given below is adopted.

Figure 2:GIS and prioritization flow diagram



Prioritization of roads for accident occurrence

Prioritization involves assigning suitable weights to different factors to achieve the desired result. In this method, the various factors, which tend to influence the occurrence of accidents on roads are assigned weights on a scale of 0-10 in such a manner that the factors which tend to increase the probability of the accidents have lower weights. To prioritize roads for the occurrence of accidents, the various factors considered and the weights assigned to them are given in the table below and the final weight assigned to each road link is obtained by adding all the individual weights and normalizing the value using maximum weight (in this case 110) that can be assigned

Factors affecting the occurrence of accidents	**Possible variations**	**Weights Assigned**
Number of lanes in each direction	0 1 2 3 4	2 4 6 8 10
The approximate number of vehicles per day	Less than 1000 Less than 2500 Less than 5000 Greater than 5000	10 7 4 1
Width of the road	Single lane 3.75 m Two lanes without raised kerbs, 7.0 m Two lanes with raised kerbs,7.5m Intermediate carriageway Multi-lane pavements	2 4 6 8 10
Type of road	National Highway State Highway Major District Roads Other District Roads Village Roads	10 8 6 4 2
Drainage facilities provided	Good Satisfactory Poor No Drainage	10 7 4 1
The surface condition of the pavement	Concrete WBM Surface Painted Other Bituminous Earth Roads	10 8 4 6 2
Frequent vehicle type on the road	Bus / Truck Car Two Wheelers Bicycles Carts	2 4 6 8 10
Presence of shoulders	Yes No	10 4
Presence of edge obstructions like advertising hoardings, trees, etc. very close to the road	Yes No	4 10
Provision of median barriers to channelize the traffic	Yes No	10 4
Presence of ribbon development near roads	Yes No	4 10

Table 1 Sample questionnaire

Total weight = (∑ Individual Weights) x 100 / 110.

Thus, road links with high final weight are less prone to accidents than the road link with low final weight. The classification of roads for the occurrence of accidents based on final weights is done using the following classification scheme.

Final Weight (%)	Accident Prone Level
80 – 100	Very Low
60 – 80	Low
40 – 60	Medium
0 – 40	High

Table 2 Final weights

2.4.3: Existing techniques for black spot identification

The identification and documentation of road sections characterized by high-risk accidents (blackspots) is the first step for any successful road safety management process, considering the limited available resources. In the identification process of black spots two main methods have been used:

- **Clustering method.** The classical approach to identifying black spots is the marking of all accident points on the map and the identification of the site that included most of the marks. Geographical Information Systems (GIS) that developed in recent years are used frequently in accident analysis by mapping the coordinates of the locations of the accidents of an accident-prone zone can be identified by the ranking of the parameters based on their severity and calculating the severity index. (Katre 2019) Physical surveys are carried out at the actual location for selected stretches of Expressway and Highway. The consideration of parameters that cause the maximum number of accidents is assigned maximum weightage and top rank. The total severity index is calculated based on a summation of weights. The accident severity index is calculated by the addition of the Weightages value for each parameter present divided by the total severity. The readings are taken on the selected stretch and Analyzed by the ranking method and according to the importance of the parameter. The minimum rank is the most important parameter. After giving ranks the percentages were calculated based on the value percentage of the identified accidental black spots. (Maltaş, Özen, & Saraçoğlu 2018)

- **Network Screening**: Network screening is a process to review a roadway network to identify and rank sites according to the probability of a reduction in the crash frequency with the implementation of a countermeasure

2.4.4: Challenges faced in the identification of road black spots

Challenges Road Users Encounter in Identifying Black Spots

Blackspots on Kenyan roads have been identified by NTSA and traffic police by tallying the number of accident occurrences on the same spot with similar characteristics. Most motorists and pedestrians do not know or recognize them because of the following reasons:

•**Traffic Signs Damage -** Road traffic signs, including black spot signs, are prone to damage after installation causing a big challenge to road users. The damages are categorized into groups such as bending/cutting, cracking, vandalism, peeling, and fading. Bending can be a result of vandalism or when hit by a vehicle. Vandalism can result from deliberate action by human beings thus, other measures such as using an alert system are needed to substitute the conventional methods.

Figure 3 Peeling sign

- **Poor Visibility-** Most traffic signs can only be read accurately at night due to their retro-reflective material. Their visibility can be compromised by a couple of factors such as poor weather and fading of the signs. Traffic signs are therefore effective when they are seen.

- **Road Environment -** The road condition characteristic is influenced by the climate conditions in its environment. The climate conditions include downpour, mist, snow, wind, lightning, residue, and high temperature. These conditions enhance possibilities of finding it difficult to identify black spots using existing means and Chances of causing accidents fundamentally increase.

Figure 4 Driver in poor weather conditions

- **Ignorance -**pedestrians can ignore signs and crossroads where they are prohibited while motorists can ignore signs or not see them. There is also a possibility that motorists and pedestrians do not know what specific signs mean contrary to popular belief.
- **Inadequate Traffic Guidance** -Even though there are policies to ensure dangerous sections are made aware to road users, this is not accomplished to the latter. Some road signs are too small or too huge and some are confusing. This has given pedestrians and motorists a difficult time in wayfinding. When a road sign indicating a black spot takes time to comprehend or even read it leads to poor decisions and may consequently result in a road accident.

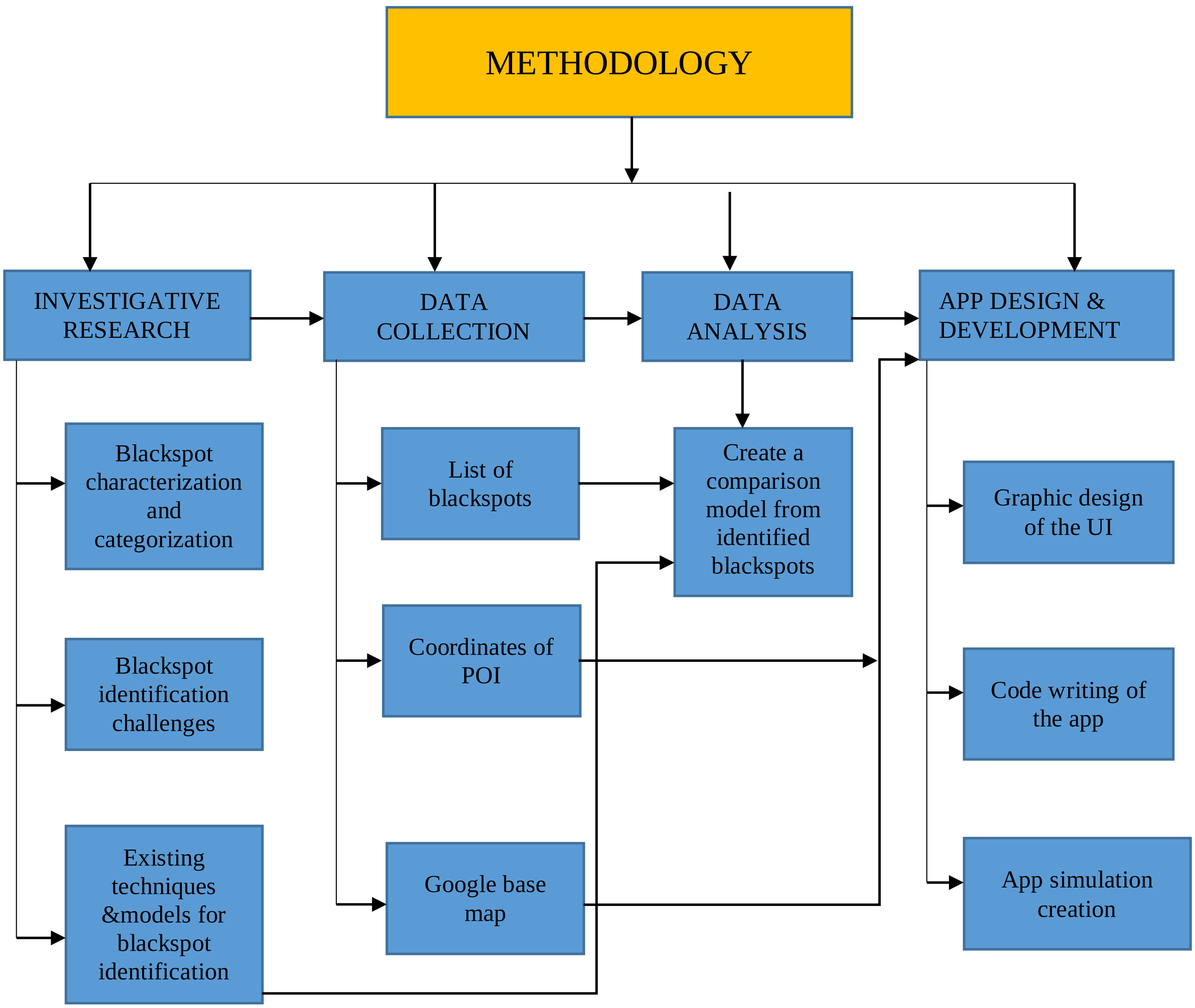
2.5: MOBILE APPLICATION DEVELOPMENT

The relevant technologies considered for the alert app creation are as follows

- ***Android Studio:*** this is the primary integrated development environment for Google's Android application development. It is built on JetBrains' IntelliJ IDEA software. It provides the facility to execute the codes in any language suitable to the user be it JAVA, C++, Python, etc. It allows the programmer to develop an android code in its IDE and then boot it on a simple mobile phone for a trial run (Patankar, Walunj, Pimple, & Kadhane, 2017).
- ***Geo-Fencing:*** Geo-fencing (geofencing) is a feature in a software program that uses the global positioning system (GPS) to define geographical boundaries. A geo-fence is a virtual barrier. It allows the user to create a standard program that allows the administrator to set up triggers, so when a device enters (or exits) the boundaries defined by the administrator, a text message or email alert is sent (Patankar, Walunj, Pimple, & Kadhane, 2017)
- ***Audio directive notification:*** Since most accidents occur at blackspots, audio directives have been employed to warn road users when they are approaching identified blackspots to exercise caution. According to research conducted on drivers in Iran, it was concluded that the variation of average speeds at black spots between warning and non-warning states was significant with a 95% confidence level and the use of warning applications was effective in reducing the number of drivers with speed limit violations at black spots. Most drivers were highly gratified with the warning from car speakers, advisory warnings, and warning distance from the black spot. Additionally, the results of the study revealed that not only did warnings not cause a distraction for the drivers but were also effective in increasing their caution. These findings can be used to eliminate the shortcomings of the hazard warning application. (Yazdani & Rassafi , 2019)

CHAPTER THREE: METHODOLOGY

Figure 5:methodology flow diagram



BLACKSPOTS ALONG THIKA ROAD AND THEIR TRAFFIC ACCIDENTS DATA

Identified black-spots along Thika road were all categorized as per different parameters as indicated below;

1. **As per the type of collisions**

The following are identified black-spot areas in my study area with traffic accident data from 2017 and 2018 were acquired from the NTSA

website. V-V represents vehicle-to-vehicle

collisions. V-P represents vehicles hitting a

L-C these represent vehicles that lost control and plunge.

CRASH SPOTS	V-V	V-P	L-C
Muthaiga-Kiambu road	8	19	5
NYS/Utalii Drift	13	6	13
Survey of Kenya		1	0
Drive Inn	3	12	
Mathare North Road		5	2
GSU/Allsops Drift	1	2	
Garden Estate Road		4	17
Homeland Area		5	4
Safari Park Area		14	1
Kasarani/Kamiti Road	4	15	
Kenya Tents	15	11	5
Clay Works Area		1	0

Table 3 Number of accidents per blackspot

2. **Time of the day-** this was a determinant in ranking crashes whereby data collected considered time of day to be a propagator of traffic accidents.in some areas, accidents were more frequent during the night as opposed to those that occurred during the day. Despite

   60 percent less traffic on the roads, more than 40 percent of all fatal car accidents occur at night. According to a study conducted by Pine Solomon accident lawyers, our ability to perceive and judge distance is severely impaired at night as the human eye requires light to see making night driving a top cause of car accidents. An estimated 90 percent of all driver decisions are made based on what they see. While your eyes are capable of seeing in limited light, the combination of headlights and road lights, with the darkness beyond them, can cause several problems for your vision. Therefore, car drivers are advised to take extra precautions to avoid an auto accident during the night.

3. Road design- Studies have tried to relate road geometric design elements such as lane number, sight distance, super-elevation, median width and type, lane and shoulder width, curve radius, gradient, and horizontal and vertical alignments to accident rates, (Islam, Md & Law, Teik Hua & Hamid, Hussain & Azarkerdar, Arash,2011

GENERAL RANKING OF THE BLACK SPOTS IN TERMS OF SEVERITY OR LIKELIHOOD

Table 4 Sample questionnaire

FACTORS AFFECTING OCCURRENCE OF ACCIDENTS	**POSSIBLE VARIATIONS**	**WEIGHTS ASSIGNED**
Number of lanes in each direction	0 1 2 3 4	2 4 6 8 10
The approximate number of vehicles per day	Less than 1000 Less than 2500 Less than 5000 Greater than 5000	10 7 4 1
Width of the road	Single lane 3.75 m Two lanes without raised kerbs, 7.0m Two lanes with raised kerbs,7.5m Intermediate carriageway Multi-lane pavements	2 4 6 8 10
Type of road	National Highway State Highway Major District Roads Other District Roads Village Roads	10 8 6 4 2
Drainage facilities provided	Good Satisfactory Poor No Drainage	10 7 4 1
The surface condition of the pavement	Concrete WBM Surface Painted Other Bituminous Earth Roads	10 8 4 6 2
Frequent vehicle type on the road	Bus / Truck Car Two Wheelers Bicycles Carts	2 4 6 8 10
Presence of shoulders	Yes No	10 4
Presence of edge obstructions like advertising hoardings, trees, etc. very close to the road	Yes No	4 10
Provision of median barriers to channelize the traffic	Yes No	10 4
Presence of ribbon development near roads	Yes No	4 10

Section	No. of lanes	Weights assigned	Approx. no. of vehicles per day	Weights assigned	Road Width	Weights assigned	Road Type	Weights assigned
Muthaiga - Kiambu area	6	8	Greater than 5000	1	Intermediate carriageway	8	National Highway	10
NYS/Utalii Drift	4	6	Greater than 5000	1	Intermediate carriageway	8	National Highway	10
Drive Inn	12	14	Greater than 5000	1	Intermediate carriageway	8	National Highway	10
Mathare North Road	8	10	Greater than 5000	1	Intermediate carriageway	8	National Highway	10
Garden Estate Road	4	6	Greater than 5000	1	Intermediate carriageway	8	National Highway	10
Homeland Area	6	8	Greater than 5000	1	Intermediate carriageway	8	National Highway	10
Kasarani / Kamiti Road	6	8	Greater than 5000	1	Intermediate carriageway	8	National Highway	10
Kenya Tents (Githurai)	12	14	Greater than 5000	1	Intermediate carriageway	8	National Highway	10
Safari Park Area	8	10	Greater than 5000	1	Intermediate carriageway	8	National Highway	10

Table 5 Questionnaire filled as per Thika road characteristics

Drainage Facility provided	Weights Assigned	Surface condition of the pavement	Weights Assigned	Frequent vehicle type on the road	Weights Assigned	Presence of shoulders	Weights Assigned
Good	10	WBM Surface	8	Car	4	yes	10
Good	10	WBM Surface	8	Car	4	yes	10
Satisfactory	8	WBM Surface	8	Car	4	yes	10
Good	10	WBM Surface	8	Car	4	yes	10
satisfactory	8	WBM Surface	8	Car	4	yes	10
Good	10	WBM Surface	8	Car	4	yes	10
Good	10	WBM Surface	8	Car	4	yes	10
Good	10	WBM Surface	8	Car	4	yes	10
Good	10	WBM Surface	8	Car	4	yes	10

Presence of edge Obstructions like advertising close to the road	***Weights assigned***	Provision of median barriers to channelize the traffic	***Weights assigned***	Presence of ribbon development near roads	***Weights assigned***
Yes	4	yes	10	yes	4
Yes	4	yes	10	yes	4
Yes	4	yes	10	yes	4
Yes	4	yes	10	yes	4
Yes	4	yes	10	yes	4
Yes	4	yes	10	yes	4
Yes	4	yes	10	yes	4
Yes	4	yes	10	yes	4
Yes	4	yes	10	yes	4

Table 6 Blackspot weights

Section	∑ Individual Weights	Total weight	Accident-prone level
Muthaiga -Kiambu area	77	69.99=70	low
NYS/Utalii Drift	75	68.18=68	low
Drive Inn	81	73.64=74	low
Mathare North Road	79	71.82=72	low
Garden Estate Road	73	66.36=66	low
Homeland Area	77	69.99=70	low
Safari Park Area	79	71.82=72	low
Kasarani/Kamiti Road	77	69.99=70	low
Kenya Tents (Githurai)	83	75.45=75	low

Total weight = (∑ Individual Weights) x 100 / 110.

3.2: DATA COLLECTED

3.2.1: accident black-spots in Kenya

The following sections are considered risky for motorists due to the number of accidents that have occurred in their vicinity.

EASTERN REGION

1. Nkubu - Embu Road Section
2. Konza Junction to Salama Road Section – Mombasa/Nrb At Chumvi Area
3. Salama - Sultan Hamud Road Section
4. Emali Simba Market to Kibwezi
5. Mtito To Tsavo River Stretch
6. Nanyuki To Isiolo Junction at Subuiga
7. Machakos - Warungu Road Section at Kithangathini
8. Mlolongo - Small World Club – And Junction To Namaga And at Mto Wa Mawe Bridge

CENTRAL REGION

1. Kiganjo - Narumoru Road
2. Kibirigwi - Sagana Road Section
3. Limuru - Uplands Section
4. Thika Blue Post - Sagana Bridge Road Section
5. Kiriaini – Muranga Road Section
6. Nyeri – Nyahururu Road
7. Makongeni (Along Thika – Garissa Road)
8. Makutano Embu Road
9. Kiambu – Muthaiga Road
10.Thika road-GSU
11Thika road-Githurai area

WESTERN REGION

1. Mbale - Vihiga Road Section
2. Kakamega Chavakali Road Section
3. Kakamega - Kisumu – Ilesi Museno
4. Kakamega – Mumias Rd – Makunga
5. Kakamega - Webuye – Lubao, Kambi Ya Mwanza Ejinya Corner, Malava Forest

6. Bungoma – Eldoret – Chemoi
7. Kitale Webuye – Lugulu Misikhu

RIFT VALLEY REGION

1. Kinungi - Naivasha – Gilgil Toll Station
2. Gilgil - Mbaruk Road Section
3. Molo G.S.U Camp - Salgaa
4. Salgaa To A.D.C. Farm Section
5. Timboroa - Burnt Forest Section
6. Chepsir - Kipkelion Junction
7. Kericho - Litein Road Section
8. Kericho - Kaitui Section
9. Endebes Eldoret Road Section
10. Nanyuki Isiolo Junction
11. Nyeri – Nyahururu Wiyumiririe Area
12. Gilgil Nakuru Road Kasambara Area

COAST REGION

1. Tsavo – Maungu – Voi Road Section
2. Wundanyi - Mwatate Road Section
3. Maungu - Tsavo East Gate Road Section
4. Maktau - Taveta Road Section
5. Mazeras Miritini Road Section
6. Rabai Ribe Road Section
7. Kaloleni Dzitsoni Road Section
8. Kilifi - Vipingo Road Section
9. Kibarani - Changamwe Makande
10. Kwale Matuga Junction Road Section
11. Tembo Disco Area Along Msa – Malindi Road
12. Kengeleni Traffic Lights
13. Buxton Traffic Lights
14. Saba-Saba Lights
15. Kibarani Area
16. Sportsman Changamwe Area
17. Navy Junction Long Lunga- Lunga/Likoni Rd
18. Shika – Adabu Area
19. Waa Sec. School Area
20. Gede Area Along Msa-Malindi Road

NYANZA REGION

1. Awasi Ahero Road Section
2. Kiboswa Kisumu Road Section
3. Daraja Mbili - Bondo Junction
4. Oyugis - Katitu Road Section
5. Migori Kakrao Road
6. Gucha Bridge

7. Migori Township
8. Ogembo Nyanguso Road
9. Kisii Township Main Road
10. Mwembe Area Kisii Town
11. Kisii Daraja Mbili

NAIROBI REGION

1. Kasarani G.S.U Stretch
2. Westlands Museum Roundabout
3. Westlands Kabete Road
4. Mombasa Road Between Kencell Hqrs 7 Cabanas
5. Jogoo Road Near Maziwa Stage
6. Waiyaki Way Near Kangemi Fly Over

NORTH EASTERN REGION

1.Garissa Madogo - Kbc Station
2. Modogashe - Habaswein
3. Ukasi - Bangale
4. Bangale – Hola Road Junction
5. Buna - Gurar

3.2.2: Coordinates of points of interest.

My points of interest are along Thika road and the following are the identified areas and their respective coordinates:

Crash spot	Northings	Eastings
NYS/Utalii Drift	-1.257387	36.854126
Drive Inn	-1.247662	36.864157
Mathare North Road	-1.258123	36.849694
Garden Estate Road	-1.213485	36.899793
Homeland Area	-1.233287	36.875132
Safari Park Area	-1.215971	36.895451
Kasarani/Kamiti Road	-1.213485	36.899793
Kenya Tents (Githurai)	-1.215971	36.8954451
Muthaiga -Kiambu area	-1.262928	36.83903

Table 7 Thika road blackspot coordinates

JKUAT demo coordinates

Location	Northings	Eastings
Gate C	-1.0987757	37.0116319
PAU	-1.098438	37.013860
ELB	-1.096320	37.014075

Table 8 JKUAT demo blackspot coordinates

3.3: DATA ANALYSIS

3.3.1: Blackspot comparison model

Using the prioritization and GIS model identified in the literature review, black spots on the Thika superhighway are categorized into levels of accident severity using characteristics and weights given in the questionnaire. From this method, it is evident that all blackspots are categorized as low-level threats, (see table 1.5). therefore, the GIS method will be incorporated and Jogoo road will be used. The method involves digitizing the road network in question and dividing it into links that are assigned weights as per their road attributes. The road attribute table in database format is then joined to the digitized road network followed by its rasterization by assigning the absolute minimum radius of curvature as cell values, (in this case 155). The rasterized image is converted to an ASCII format to obtain a text file which is finally added to the layer to obtain results.

The results from this method will be compared against those from accident statistics to determine the suitability of the model.

CHAPTER FOUR: RESULTS

4.1 Thika Superhighway black-spot characterization and categorization.

Using the prioritization and GIS method of blackspot characterization and categorization, several road characteristics were identified to be the major contributors to black spots and when each was assigned weights, they categorized the identified spots as per their severity. The following are the total weights and ranks:

Total weight = (∑ Individual Weights) x 100 / 110.

Table 9 Thika road blackspot weights

Section	∑ Individual Weights	Total weight	Accident-prone level
Muthaiga -Kiambu area	77	69.99=70	low
NYS/Utalii Drift	75	68.18=68	low
Drive Inn	81	73.64=74	low
Mathare North Road	79	71.82=72	low
Garden Estate Road	73	66.36=66	low
Homeland Area	77	69.99=70	low
Safari Park Area	79	71.82=72	low
Kasarani/Kamiti Road	77	69.99=70	low
Kenya Tents (Githurai)	83	75.45=75	low

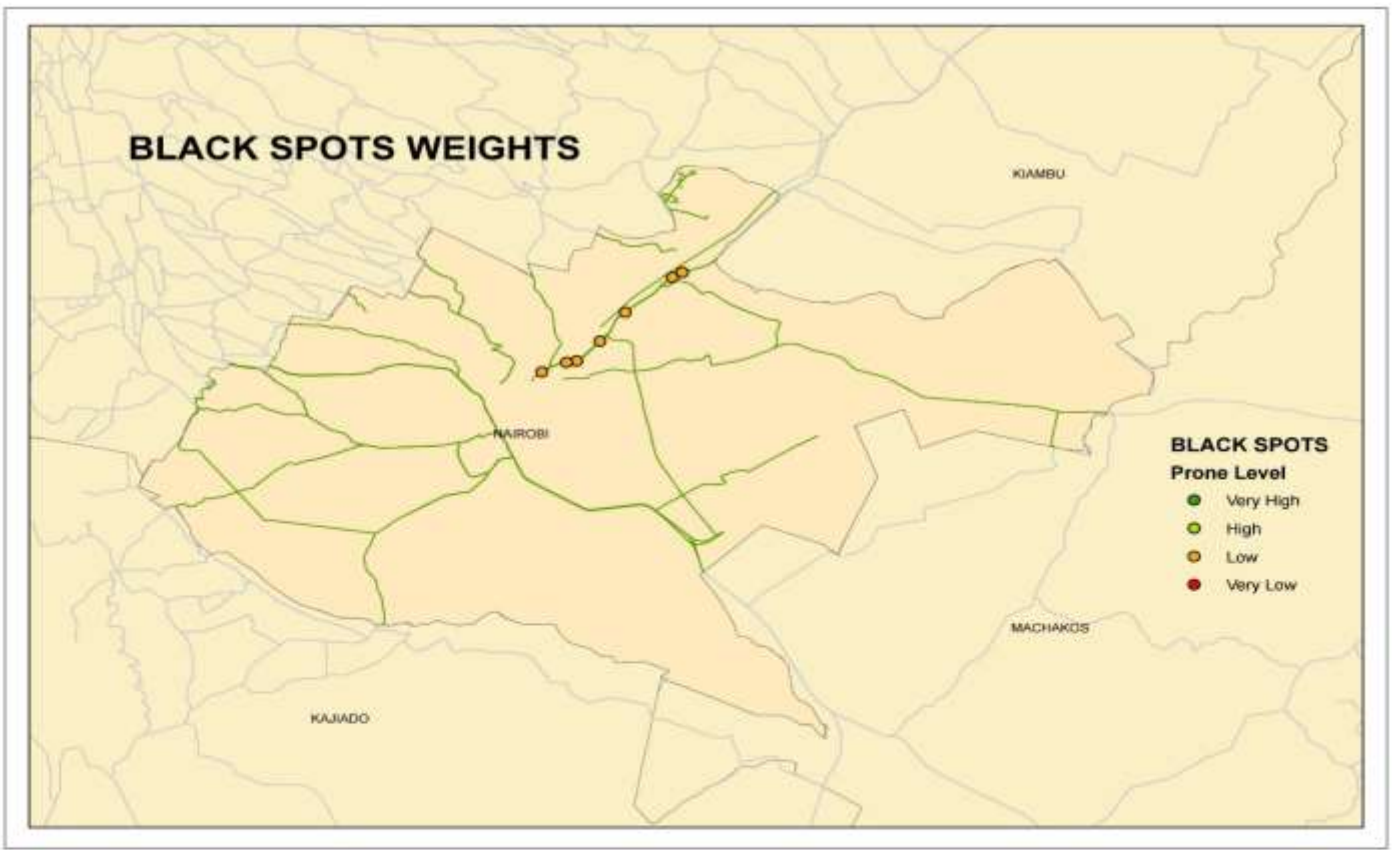


Figure 6:blackspot rank map

All identified black spots have been indicated to be of low severity irrespective of the statistics given by the NTSA. The recommended course of action is to use the same characteristics and method of characterization on another road to identify points that qualify as black-spots and their severity then later compare the results with those given by NTSA and Kenya Traffic Police to show the accuracy of the method and also to predict new black-spot points that had not been identified before

4.2 Accident statistics vs prioritization and GIS model

Accident statistics as per data collected by NTSA, KENHA, and the Kenya Traffic Police have indicated that along Thika road there are nine blackspots namely; Muthaiga -Kiambu area, NYS/Utalii Drift, Drive Inn, Mathare North Road, Garden Estate Road, Homeland Area, Safari Park Area, Kasarani/Kamiti Road and Kenya Tents (Githurai).

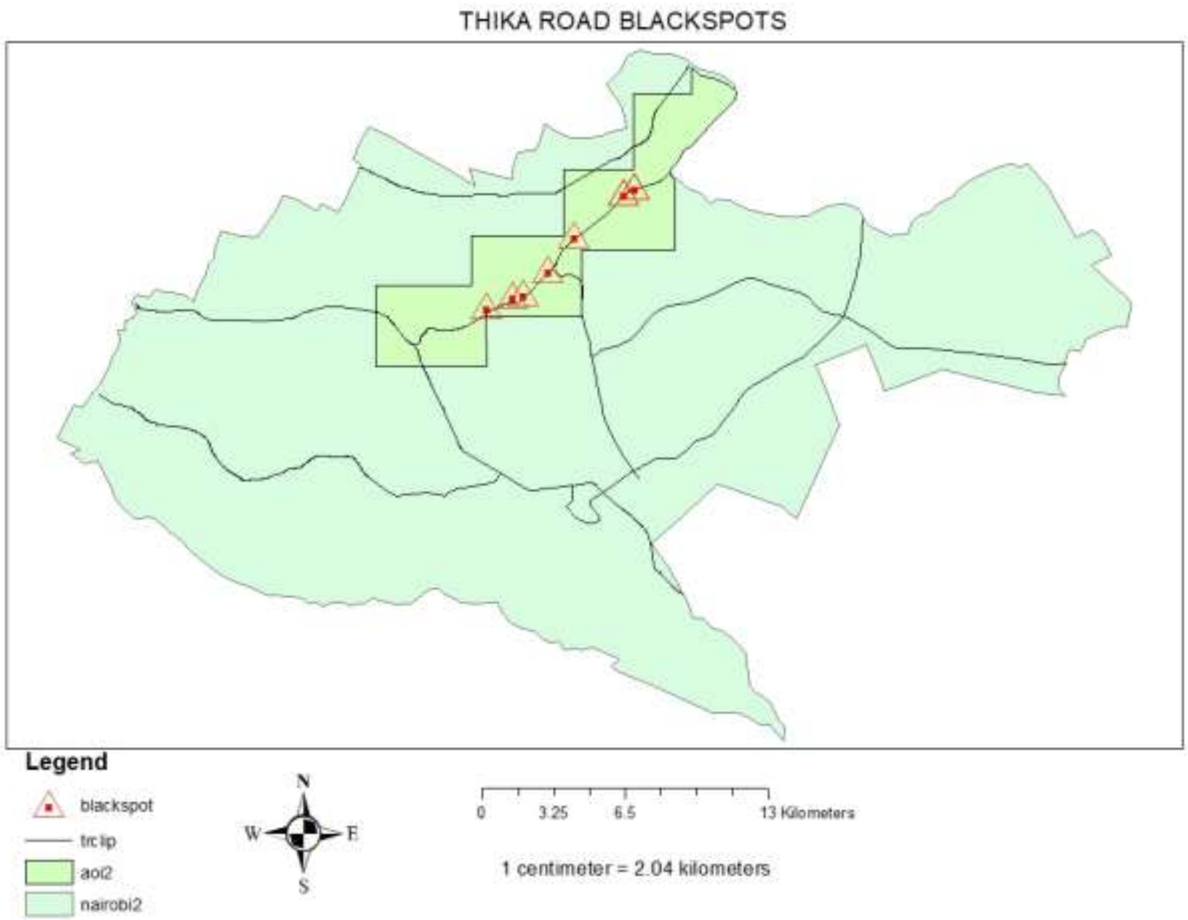


Figure 7:Thika superhighway blackspots

However, using the prioritization method only indicates that all the spots are low-level accident threats whereas when incorporating the GIS aspect that requires adding the road's horizontal curves, results vary and generalize areas without giving specific accident details. From the model, it can be seen that the whole area has been categorized into various zones and a number has been assigned to each area which represents the threat level from the least to the highest. The levels can be seen to be relatively low throughout the area as they are all below the average 50. This can also be backed by accident statistics from the relevant authority which show that there is only one area that is considered a black spot, the Maziwa stage area, the zone marked by the color neon green and represented by number 41. There are other zones with a higher probability of accidents as identified by the model which can be looked out for and updated by the relevant authorities.

GIS and prioritization method

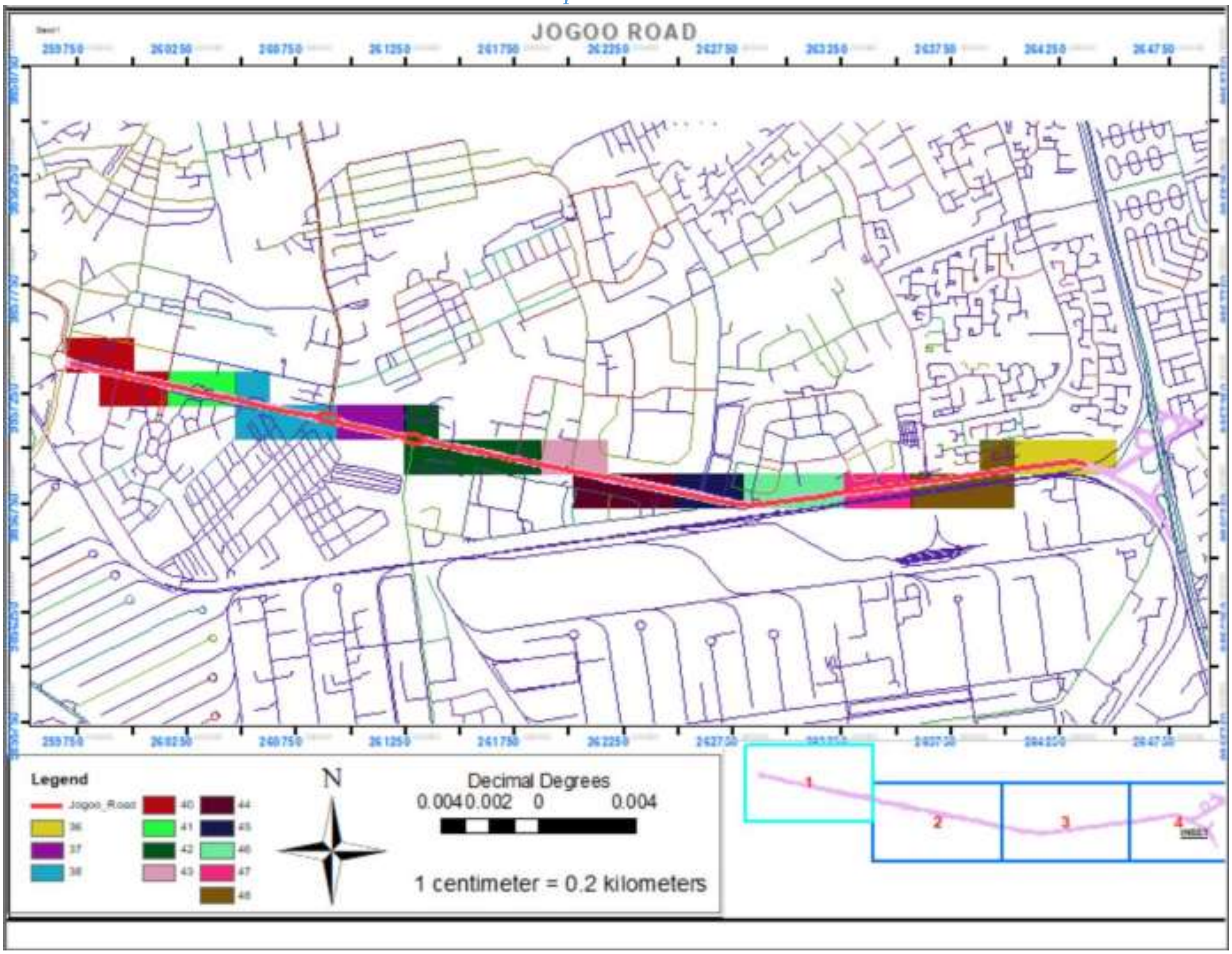


Figure 8:blackspot prediction map

4.3 The mobile application.

This alert application was developed using android studio software and using the javascript language incorporation with various blackspots as identified along Thika road. Once the app is open and the phone location is turned on, the app identifies the user's real-time location, and the destination is put to identify the route.

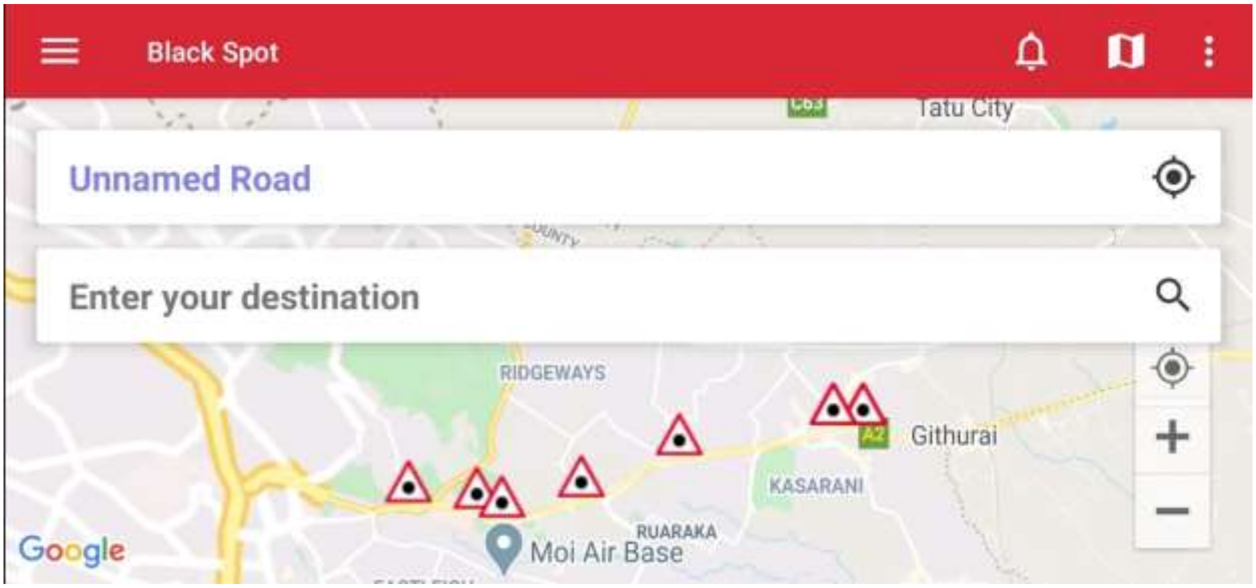


Figure 9:Thika road blackspots

Six arbitrary points were chosen for convenience in testing the prototype with the main three regions chosen randomly around the JKUAT school compound; at gate C, at ELB parking lot, and PAUSTI, taken as black spots for demonstration.

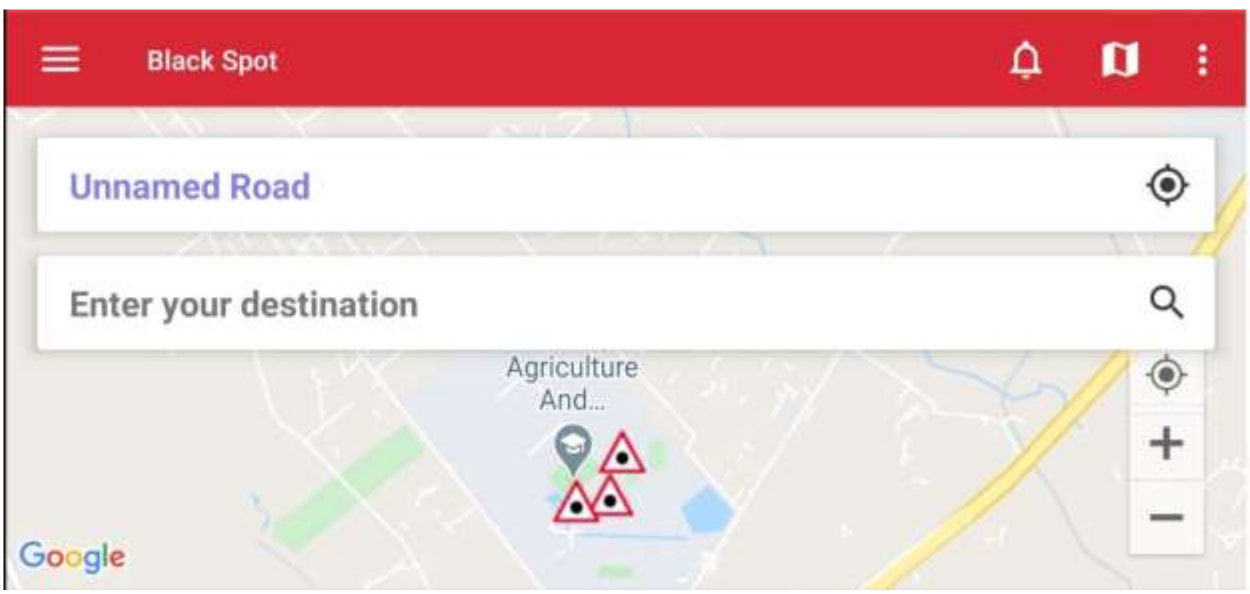


Figure 10:JKUAT demo blackspots

person moving carrying the device was used to simulate a vehicle moving along the zones with black spots. The person monitored for any notification from each designated zone. The expected notification is sent when the person approached the black spot, via a pop-up warning text when and an audio directive when one is at the blackspot region.

Figure 11:Text notification

CHAPTER FIVE: CONCLUSION

This research focused on developing a black spot alert system for road users, which uses coordinates of the blackspots incorporated in the application to give an alert whenever a vehicle is approaching a mapped blackspot. To guarantee a successful project with attained objectives, several steps were taken in its development, with a literature review being conducted on each part of this study to ascertain their aptness in the project.

The first two objectives were accomplished through a comprehensive literature review that involved looking at different sources such as previous research papers and determining the available techniques for identifying dangerous road sections and the characteristics that contribute to road sections being categorized as blackspots. When comparing results from NTSA statistics and the GIS comparison model, it can be concluded that blackspots along Thika Superhighway are decentralized while those identified on Jogoo road, by the prediction model are intensive.

Taking into consideration the two methods used in blackspot categorization and the factors considered by both methods to identify blackspots, I can conclude that using statistics yields better results as more factors influence such verdicts than those used by the counterpart model such as pedestrians, time of the day, conditions of drivers, conditions of vehicles using the road and many more. On the other hand, the prioritization method can be used on newly constructed roads since it majorly requires the road's spatial characteristics and does not require accident data.

The last two objectives were realized by building an alert black spot system and testing against selected arbitrary coordinates to ascertain its performance and accuracy. The alert system will serve a crucial part in warning road users when approaching blackspot areas and remind them to exercise caution.

CHAPTER SIX: RECOMMENDATIONS

- When identifying black spots on roads, I recommend using provided accident statistics from relevant authorities which are more reliable and most variables are considered as compared with the prioritization and GIS model, whose results can be biased because of the few parameters taken into consideration. however, the GIS model can be used when there is limited accident data available or on relatively new roads.
- This application can be improved by incorporating traffic events such as notifying the drivers about the roadblocks on the roads, alerting drivers whenever there is an accident ahead, and perhaps whether this accident can result in traffic jams so that he/she can change course.
- It will also be a good idea to incorporate a system that determines black spot coordinates in real-time as opposed to relying on predefined points. When data from the black spot is more dynamic the system will attract more users and its benefits shall span a wide scope

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Appendix

Maps

The application implements maps functionality in the following process;

Step 1: Creation of a Fragment to display the map on the screen. Permission to get device location is requested, this helps in rendering relevant part of the map, about the user.

Step 2: Importation of various classes in the Google Maps API after integration with the application.

Step 3: Upon creating the View (Fragment), the Maps API is called to generate and produce Google Maps based on the device location.

```java
import com.google.android.gms.common.api.ApiException;
import com.google.android.gms.location.FusedLocationProviderClient;
import com.google.android.gms.location.LocationServices;
import com.google.android.gms.maps.CameraUpdate;
import com.google.android.gms.maps.CameraUpdateFactory;
import com.google.android.gms.maps.GoogleMap;
import com.google.android.gms.maps.OnMapReadyCallback;
import com.google.android.gms.maps.SupportMapFragment;
import com.google.android.gms.maps.model.BitmapDescriptorFactory;
import com.google.android.gms.maps.model.CameraPosition;
import com.google.android.gms.maps.model.JointType;
import com.google.android.gms.maps.model.LatLng;
import com.google.android.gms.maps.model.LatLngBounds;
import com.google.android.gms.maps.model.Marker;
import com.google.android.gms.maps.model.MarkerOptions;
import com.google.android.gms.maps.model.Polyline;
import com.google.android.gms.maps.model.PolylineOptions;
import com.google.android.gms.maps.model.RoundCap;
import com.google.android.gms.tasks.OnCompleteListener;
import com.google.android.gms.tasks.OnFailureListener;
import com.google.android.gms.tasks.OnSuccessListener;
import com.google.android.gms.tasks.Task;
import com.google.android.libraries.places.api.Places;
import com.google.android.libraries.places.api.model.AutocompletePrediction;
import com.google.android.libraries.places.api.model.AutocompleteSessionToken;
import com.google.android.libraries.places.api.model.Place;
import com.google.android.libraries.places.api.model.TypeFilter;
import com.google.android.libraries.places.api.net.FetchPlaceRequest;
import com.google.android.libraries.places.api.net.FetchPlaceResponse;
import com.google.android.libraries.places.api.net.FindAutocompletePredictionsRequest;
import com.google.android.libraries.places.api.net.FindAutocompletePredictionsResponse;
import com.google.android.libraries.places.api.net.PlacesClient;

public class LocationFragment extends Fragment {

    GoogleApi mService;
    private SupportMapFragment mMap;
    private static final double EARTH_RADIUS = 6378100.0;

    @Override
    public void onViewCreated(@NonNull View view, @Nullable Bundle savedInstanceState) {
        super.onViewCreated(view, savedInstanceState);
        assert getFragmentManager() != null;
        mMap = (SupportMapFragment)
this.getChildFragmentManager().findFragmentById(R.id.locations_map);
        mapView = mMap.getView();
    }

}
```

Geo-location

To implement the Geo-location service in the app the following process is applied.

Step 1: Request to access device location is created. When a user accepts, then the device location is activated.

```
public class LocationFragment extends Fragment {

    @Override
    public void onRequestPermissionsResult(int requestCode, @NonNull String[] permissions, @NonNull
int[] grantResults) {
        super.onRequestPermissionsResult(requestCode, permissions, grantResults);
        if (requestCode == 101) {
            if (grantResults.length > 0 && grantResults[0] == PackageManager.PERMISSION_GRANTED) {
                getCurrentLocation();
            } else {
                ActivityCompat.requestPermissions(getActivity(), new String[]
{Manifest.permission.ACCESS_FINE_LOCATION}, REQUEST_CODE_LOCATION_PERMISSION);
            }
        }
    }

}
```

Step 2: Google Maps are generated with the location of the user.

```
public class LocationFragment extends Fragment {

    mMap = (SupportMapFragment) this.getChildFragmentManager().findFragmentById(R.id.locations_map);
    mapView = mMap.getView();
    client = LocationServices.getFusedLocationProviderClient(Objects.requireNonNull(getActivity()));
    getCurrentLocation();

}
```

Step 3: Get the current location method is called. The method determines the graphical presentation of current user location on Google Maps.

```
private void getCurrentLocation() {
if (ActivityCompat.checkSelfPermission(Objects.requireNonNull(getActivity()),
Manifest.permission.ACCESS_FINE_LOCATION) != PackageManager.PERMISSION_GRANTED &&
ActivityCompat.checkSelfPermission(getActivity(), Manifest.permission.ACCESS_COARSE_LOCATION) !=
PackageManager.PERMISSION_GRANTED) {
            ActivityCompat.requestPermissions(getActivity(), new String[]
{Manifest.permission.ACCESS_FINE_LOCATION}, REQUEST_CODE_LOCATION_PERMISSION);
            return;
        }
        Task<Location> task = client.getLastLocation();
        task.addOnSuccessListener(new OnSuccessListener<Location>() {
            @Override
            public void onSuccess(final Location location) {
                if (location != null) {
                    mMap.getMapAsync(new OnMapReadyCallback() {
                        @SuppressLint("MissingPermission")
                        @Override
                        public void onMapReady(GoogleMap googleMap) {

                            LatLng latLng = new LatLng(location.getLatitude(),
location.getLongitude());
                            googleMap.animateCamera(CameraUpdateFactory.newLatLngZoom(latLng, 12));
                            googleMap.setMyLocationEnabled(true);
                            googleMap.getUiSettings().setCompassEnabled(false);
                            googleMap.getUiSettings().setZoomControlsEnabled(true);
                            googleMap.setPadding(0, 0, 32, 0);

                            if (mapView != null && mapView.findViewById(Integer.parseInt("1")) != null)
{
                                View locationBtn = ((View)
mapView.findViewById(Integer.parseInt("1")).getParent()).findViewById(Integer.parseInt("2"));
                                RelativeLayout.LayoutParams layoutParams =
(RelativeLayout.LayoutParams) locationBtn.getLayoutParams();
                                layoutParams.addRule(RelativeLayout.ALIGN_PARENT_TOP, 0);
                                layoutParams.addRule(RelativeLayout.ALIGN_PARENT_BOTTOM,
RelativeLayout.TRUE);
                                layoutParams.setMargins(0, 0, 40, 300);
                            }
                            originAndDestination(location);
                            googleMap.setOnMyLocationButtonClickListener(new
GoogleMap.OnMyLocationButtonClickListener() {
                                @Override
                                public boolean onMyLocationButtonClick() {
                                    LatLng latLng = new LatLng(location.getLatitude(),
location.getLongitude());
                                    try {
                                        Geocoder geo = new
Geocoder(getActivity().getApplicationContext(), Locale.getDefault());
                                        List<Address> addresses = geo.getFromLocation(latLng.latitude,
latLng.longitude, 1);
                                        if (addresses.isEmpty()) {
                                            origin.setText("Your Location");
                                        } else {
                                            origin.setText(addresses.get(0).getFeatureName());
                                            origin.setPlaceHolder(addresses.get(0).getFeatureName());
                                            origin.setEnabled(false);
                                        }
                                    } catch (Exception e) {
                                        e.printStackTrace();
                                    }
                                    return false;
                                }
                            });
                        }
                    });
                }
            }
        });
    }
```

Alert and Notifications

The alert feature follows the following process:
Step 1: Geo-locate real-time device location relative to locations of black spots.
Since the first version of the application is just a prototype, the black spot locations are hardcoded within the system.
Black spots are added upon launching the Map View on the Locations Fragment.

```java
private void addBlackSpots() {
        mMap.getMapAsync(new OnMapReadyCallback() {
            @Override
            public void onMapReady(GoogleMap googleMap) {
                LatLng utaliiDrift = new LatLng(-1.257387, 36.854126);
                LatLng driveInn = new LatLng(-1.247662, 36.864157);
                LatLng mathareNorth = new LatLng(-1.258123, 36.849694);
                LatLng gardenEstateRd = new LatLng(-1.213485, 36.899793);
                LatLng homelandArea = new LatLng(-1.233287, 36.875132);
                LatLng safariParkArea = new LatLng(-1.215971, 36.895451);
                LatLng kasaraniKamitiRoad = new LatLng(-1.213485, 36.899793);
                LatLng kenyaTents = new LatLng(-1.215971, 36.8954451);
                LatLng muthaigaKiambu = new LatLng(-1.262928, 36.83903);
                LatLng home = new LatLng(-1.1007, 37.0092);
                LatLng newLocationA = new LatLng(-1.09611, 37.0141);
                LatLng newLocationB = new LatLng(-1.0983, 37.0135);
                LatLng newLocationC = new LatLng(-1.0986, 37.0118);
                LatLng[] blackSpots = {utaliiDrift, driveInn, mathareNorth, gardenEstateRd,
homelandArea, safariParkArea, kasaraniKamitiRoad, kenyaTents, muthaigaKiambu, newLocationA,
newLocationB, newLocationC, home};

                for (LatLng blackSpot : blackSpots) {
                    MarkerOptions options = new MarkerOptions();
                    options.position(blackSpot);
                    options.icon(BitmapDescriptorFactory.fromBitmap(getBitmap(blackSpot, googleMap)));
                    googleMap.addMarker(options);
                }
            }
        });
    }
```

Step 2: Cross-check after every location change whether the user is close to a roadblock spot.
To get location changes, the following method is implemented.

```java
private void readLocationChanges() {
        reference.addValueEventListener(new ValueEventListener() {
            @Override
            public void onDataChange(@NonNull DataSnapshot snapshot) {
                if (snapshot.exists()) {
                    try {
                        CurrentLocation location = snapshot.getValue(CurrentLocation.class);
                        if (location != null) {
                            runAlert(round(location.getLatitude(), 4), round(location.getLongitude(),
4));
                        }
                    } catch (Exception e) {
                        Toast.makeText(MainActivity.this, e.getMessage(), Toast.LENGTH_SHORT).show();
                    }
                }
            }

            @Override
            public void onCancelled(@NonNull DatabaseError error) {

            }
        });
    }
```

In addition to reading location changes, updating the movement of a device on Google Maps is quite challenging. The distance must be calculated and the margin of error to scale, evaluated. To do so, I implement GPS location, to minimize the margin of error, as compared to Network location.

```
private void getLocationUpdates() {
        if (ActivityCompat.checkSelfPermission(this, Manifest.permission.ACCESS_FINE_LOCATION) !=
PackageManager.PERMISSION_GRANTED && ActivityCompat.checkSelfPermission(this,
Manifest.permission.ACCESS_COARSE_LOCATION) != PackageManager.PERMISSION_GRANTED) {
            ActivityCompat.requestPermissions(this, new String[]
{Manifest.permission.ACCESS_FINE_LOCATION}, REQUEST_CODE_LOCATION_PERMISSION);
            return;
        }
        if (locationManager != null) {
            if (locationManager.isProviderEnabled(LocationManager.GPS_PROVIDER)) {
                locationManager.requestLocationUpdates(locationManager.GPS_PROVIDER, MIN_TIME,
MIN_DISTANCE, this);
            } else if (locationManager.isProviderEnabled(locationManager.NETWORK_PROVIDER)) {
                locationManager.requestLocationUpdates(locationManager.NETWORK_PROVIDER, MIN_TIME,
MIN_DISTANCE, this);
            } else {
                Log.d(TAG, "No provider enabled");
            }
        }
    }
```

MIN_TIME is a private variable set to the value of **2000.** That means, after every **2** seconds, the system initiates a geo-location service that checks the location of the device.
MIN_DISTANCE is another private variable that is set to the value of **5.** That means that when the device moves by **5m,** then the method to get the current location is called. That method is responsible for updating the location icon, on Google Maps and giving the user current real-time location.

Step 3: Run a notification alert when a user is approaching or at a road black spot.

The app plays a sound and vibration notification. This is implemented in the run alert method on the Main Activity.

```
public void runAlert(double latitude, double longitude) {
        final MediaPlayer alertSound = MediaPlayer.create(this, R.raw.male_speech);
        LatLng currentLocationCoordinates = new LatLng(latitude, longitude);
        LatLng utaliiDrift = new LatLng(-1.2574, 36.8541);
        LatLng driveInn = new LatLng(-1.2477, 36.8642);
        LatLng mathareNorth = new LatLng(-1.2581, 36.8497);
        LatLng gardenEstateRd = new LatLng(-1.213485, 36.899793);
        LatLng homelandArea = new LatLng(-1.233287, 36.875132);
        LatLng safariParkArea = new LatLng(-1.215971, 36.895451);
        LatLng kasaraniKamitiRoad = new LatLng(-1.213485, 36.899793);
        LatLng kenyaTents = new LatLng(-1.215971, 36.8954451);
        LatLng muthaigaKiambu = new LatLng(-1.262928, 36.83903);
        LatLng home = new LatLng(-1.1007, 37.0092);
        LatLng home2 = new LatLng(-1.2571, 36.9138);
        LatLng newLocationA = new LatLng(-1.09611, 37.0141);
        LatLng newLocationB = new LatLng(-1.0983, 37.0135);
        LatLng newLocationC = new LatLng(-1.0986, 37.0118);
        LatLng[] blackSpots = {utaliiDrift, driveInn, mathareNorth, gardenEstateRd, homelandArea,
safariParkArea, kasaraniKamitiRoad, kenyaTents, muthaigaKiambu, newLocationA, newLocationB,
newLocationC, home};


        for (LatLng blackSpot : blackSpots) {
            if (currentLocationCoordinates.equals(blackSpot)) {
                if (dialog.isShowing()) {
                    return;
                } else {
                    dialog.show();
                    new Handler().postDelayed(new Runnable() {
                        @Override
                        public void run() {
                            vibrator.vibrate(2000);
                            alertSound.start();
                        }
                    }, 1000);
                }
            }

        }
    }
```