University of Nairobi

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Assessment of Use of GIS Technology in Fire Control

Case Study: Nairobi County

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DECLARATION

This research project report is my original work and has not been presented for a degree in any other university.

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ABSTRACT

Fire control services are critical services in every society which aim at protecting life and property. Kenya has experienced fire breakouts in recent years, where property worth millions of shillings was destroyed and lives were lost. Indeed Urban fire is a menace to property and human lives, for both the developing and developed countries.

When a fire breaks out, it requires immediate fire control services. Globally, the fire control system has embraced the use of GIS technology which enhances efficiency in controlling fire incidents, thus saving lives and preventing destruction of property. GIS is computer software that links geographic information (where things are) with descriptive information (what things are). It integrates geographic features with tabular data to assess and better understand real-world problems.

Fire services in Nairobi County are mainly provided by the County's Fire Department. To become competitive and resilience, the County ought to minimize loss of lives and damage to properties. This study seeks to assess the potential of GIS Technology in enhancing the efficiency of Fire Control services, in Nairobi County. Ultimately, for more than a decade, GIS has helped fire departments across the world reduce risk, increase efficiency, and improve outcomes.

The report uses spatial and non-spatial data having assessed their validity and reliability. Shapefiles for fire stations, fire hydrants, roads, major hospitals, fire incidents, land uses and population were used as well as statistics for population, fire stations and incidents were captured. The Google earth and ArcGIS version 10.2.2 were the main programs that were applied for the analysis of the data. Through the analysis, the report documents the existing scenario of fire services and it examines the potential of GIS technology applications.

The report is organized in chapters; the background of the study, the existing situation on fire control services in Nairobi County, as well as the need for use of GIS program to control fire in Nairobi County and the research objectives that guided the research are presented in chapter 1. Chapter 2: looks at the fire response capacity in Nairobi County, the GIS program and its application in the fire management globally and case studies on how the GIS technology has underpinned efficiency in provision of fire control services. Chapter 3: defines the study area

upon which it develops research strategies, data collection and analysis and presentation techniques used. Various research tools, data collection methods and data analysis methods that are particular to the study are identified. The findings from fieldwork and analysis on data to establish the need for use of GIS technology in fire control in Nairobi County are outlined in Chapter 4. Finally, Chapter 5 concludes and outlines recommendations based on the findings and analysis of the study.

The report concludes that, there is need for the fire department to apply GIS technology in fire control operations. It recommends that, the GIS technology will have great impact in ascertaining the location of fire stations, data storage, analysis and assessing the functionality of fire hydrants. In return this will go a long way in saving lives and loss of property.

Key Words: GIS Technology, Fire control, Efficiency.

DEDICATION

To my family namely; Mum, Regina Ibasha & Sisters; Mr & Mrs Rod & Avis Converse.

Shileche, S. S **……**

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF MAPS

ABBREVIATIONS

EMS	Emergency Medical Services
FDC	Fire Department Connections
FIS	Fire Information System
GDP	Gross Domestic Product
GIS	Geographic Information System
IMS	Internet Map Server
KARA	Kenya Alliance of Resident Associations
KBS	Kenya Bureau of Statistics
KML	Keyhole Markup Language
NCC	Nairobi City County
NCCG	Nairobi City County Government
NFPA	National Fire Protection Association
OB	Occurrence Book
UNEP	United Nations Environment Program

GLOSSARY

Dispatch time: The time between the point of receipt of the emergency alarm at the public safety answering point to the point where sufficient information is known to the dispatcher and applicable units are notified of the emergency.

Flashover: It is the near-simultaneous ignition of most of the directly exposed combustible material in an enclosed area. When certain organic materials are heated, they undergo thermal decomposition and release flammable gases.

Fire control: The prevention and monitoring of fire breakouts.

GIS: is a technology that integrates geographic features with tabular data to assess and better understand real-world problems.

Response time: The time that begins when the fire brigade is en route to the emergency incident site and ends when the team arrives at the scene.

Turnout (turn round) time: The time that begins when units acknowledge notification of the emergency to the beginning point of response time.

CHAPTER 1: INTRODUCTION

1.1 Background

In recent years, various places in Kenya have experienced fire outbreaks in which property worth millions of shillings was destroyed and lives were lost (Nabutola, 2004). Fire is a condition arising out of the rapid oxidation of a flammable material in the exothermic chemical process of combustion producing heat, light and various reactive products (Pyne, 1982). Fire can begin in different ways, namely; accidents (misuse of appliances), deliberate ignition and equipment failure (electrical malfunction). According to the Kenya National Fire Brigade Association, there are approximately 30 operational fire engines in the country, with another 34 out of commission (Wachira and Smith, 2013). There are 535 trained firefighters in 26 major towns across the country. Nairobi, being the capital city of Kenya, is served by three fire stations, with a number of fire engines and 146 employees who work in shifts.

The fatal fire incidents that have resulted in loss of human lives and destroyed property in Kenya in the recent past are as shown in the Table 1;

Table 1: Recent Fire Incidents in Kenya.

FIRE INCIDENTS IN KENYA

No.	Date	Fire incident location	Description	Major effects	Source
1	2014	Muthurua slums	Slum fires	Houses & property destroyed	
2	2012	Industrial area, Nairobi	Kenya Power Substation got fire	The Power Substation got damaged	Muchira, 2012
3	2011	Sinai slum in Industrial Area,Nairobi's	Petrol leakage & got fire	82 died and over 100 people injured	
4	2011	Matayos , Busia	Petrol tanker got fire	Over 10 dead and 45 people injured	(Republic of Kenya, 2009).
5	2009	Sachanguan in Molo Sub-County	Petrol tanker got fire	131 died and over 138 people injured	
6	2009	Nakumatt Downtown in Nairobi	Supermarket got fire	46 died	
7	2006	Elburgon		7 members of a family were burnt beyond recognition	
8	2006	Libra House in Industrial area, Nairobi	House fire	11 workers died and three were declared missing	
9	2005	Rift Valley region	Wild fire	Extensive environmental and ecological damage	
10	2004	City Hall, Nairobi	Office fire	Valuable documents and property worth	
11				KShs.70 million were destroyed	
12	2001	Kyanguli Boys (Machakos)	School fire	68 students burnt to death and property destroyed	
13	2001	Free Market (Uhuru Park– Nairobi)	Market fire	Entire market and property was destroyed	
14	1990	Lamu	Rural fire	20 people died	
15	1998	Bombolulu High School, Kwale	School fire	26 students perished	

Fire rescue and emergency medical services are critical services in every urban set up which aims at protecting life and property. Every authority and agency providing such services experiences increased demands as the urban areas keep expanding. Hence, authorities must look for proper and advanced systems and programmes that achieve their objectives and provide public safety. For instance, efforts have been undertaken in the past to ensure that Nairobi City attends to fire incidents promptly. The County has three fire stations; the first fire station was built in 1907 while the second one was built in 1956 and the third was leased from the East Africa Breweries in 2006 by the County Government (then City Council of Nairobi). In 2014, the Nairobi County Chief Fire Officer remarked that the county was ill equipped to handle fires and other emergencies and deserved installation of advanced facilities such as the GIS systems to enhance efficiency (Private conversation).

Despite Kenya having already been rocked by several high-risk fire events in the recent past, the security and disaster response policy remains under the spotlight as response to fire breakouts and other major accidents on national disasters is limited due to ineptitude and perceived poor planning. Therefore, the National Government ought to urgently invest in rapid response and fire fighting advanced programmes (KARA, 2012). The fire brigade has in the past claimed that most buildings in the city do not have smoke and fire detectors, a condition that leads to immense delays in responding to the fire outbreaks. KARA (2012) further notes that despite perennial tragedies claiming lives and destroying property worth millions of shillings, disaster preparedness in Kenya has never been handled with the seriousness it deserves, which would turn catastrophic in high risk events such as fire break outs, bomb attacks, drought and major accidents. Lack of an integrated emergency services and resources, poor coordination of major incident management activities, and a lack of standard operational procedures and emergency operation plans have all been shown to expose victims to increased morbidity and mortality (Wachira and Smith, 2013). The county has had to rely in some instances on private fire fighters as well as army personnel and the National Youth Service when a big fire breaks out (Njoroge, 2013).

Nairobi City is a renowned prime city in the Eastern African region and a strategic location for world organizations such as UNEP and HABITAT, part of World Bank and various international companies. However, according to a report released earlier this year, in respect to City rankings,

Nairobi was classified as the second worst city to live and drive in globally, due to traffic jams and congestion and the minimal attention given to fire incidents (Schwab, 2013). The City is heavily congested with residential premises, businesses and commercial centers and there is much encroachment of buildings and businesses on roads. Apparently, the issue of traffic jams is not treated seriously and urgently by the government of Kenya and may worsen in future. According to the UN-Habitat (2011), it was observed that urban fire disasters receive a baffling lack of response from disaster agencies due to lack of preparedness. From the foregoing, Kenya is faced with inadequacy in responding to fire disasters of high magnitude and rescue teams have failed in many of the occasions to live up to their billing by arriving late at the incident scenes and/or not having adequate knowledge about the neighbouring activities, land uses and network connectivity. The possible outbreaks of fire in homes and especially in the informal settlements is attributed to the poor quality of houses, construction materials, haphazard electricity connections and the overcrowding conditions of residential areas (Hakijamii, 2011).

It is observed that, internationally, a City like Nairobi should have more than 15 fire stations with the different types of equipment relevant for fire incidents that may occur in Nairobi. Such locations as the Industrial Area should have equipment that can deal with chemical fires, depot fire (petroleum and gas stores), and be in a position to penetrate any area of fire outbreak. In this respect the fire departments in the country have come under sharp criticism for not responding to emergencies with urgency (Njoroge, 2013).

1.2 Problem Statement

Many incidents of fire breakouts have occurred in Nairobi City in the recent past leading to serious destruction of property and loss of lives. When a fire breaks out, it requires immediate fire control services. Any delayed reaction to control the fire may lead to escalation that destroys property to irreversible state and loss of lives. It is common knowledge that the conventional fire approach by the Nairobi County is that one that was used by the fire brigade in early 1900s, with a 30m fire tower which was then the tallest building in Nairobi, smoke would be detected through the tower, and the fire officers would rush to the site to control the fire. This system gradually evolved to the use of street telephones, running calls, exchange calls and V.H.F radio calls. In the wake of this century, the fire alarms were introduced to the fire control system. Globally, the fire control system has embraced the use of GIS technology which is aimed at enhancing efficiency in controlling fire incidents, thus saving lives and preventing destruction of property. While it is likely that the application of GIS technology will enhance emergency service delivery and provide substantial data for gaining future public and political support for enhancements in emergency services delivery, the effort to incorporate the program in the fire department operations has been a dream. This study intends to demonstrate the potential of using GIS Technology in enhancing the efficiency of Fire Control services, in Nairobi County.

1.3 Study Objectives

1.3.1 General Objective

To demonstrate the potential of GIS Technology in enhancing the efficiency of Fire Control services, in Nairobi County.

1.3.2 Specific Objectives

- To document how fire services are provided in Nairobi County.
- To establish the potential of applying GIS technology in the provision of fire services in Nairobi County.
- To provide recommendations to the policy makers on the use of GIS in fire control in Nairobi County.

1.4 Organization of the Report

Chapter 1: Introduction.

This chapter generally introduces the contents of the study. It begins by outlining the background of the study, which majorly looks at how fire has caused damages to property and loss of lives. Recent fire incidents in Kenya are enumerated. The existing situation on fire control services in Nairobi County is then explained. The need for use of GIS program to control fire in Nairobi County is introduced, thus prompting this research. Research objectives that guide this research are then outlined. The chapter concludes by outlining the general organization of the entire research paper.

Chapter 2: Literature Review.

This chapter begins by looking into the fire response capacity in Nairobi County, in reference to the past occurrences and ability of the fire brigade to handle fire breakouts. The GIS program is introduced and explained in detail. The chapter then attempts to provide applications of Geographic Information System (GIS) in fire management globally. Finally, case studies on how the GIS technology has underpinned efficiency in provision of fire control services are given.

Chapter 3: Methodology and materials

Chapter three develops from the preceding chapter in order to establish an appropriate way to carry out the study. The chapter defines the study area upon which it develops research strategies, data collection and analysis and presentation techniques to be used. Various research tools, data collection methods and data analysis methods that are particular to the study are identified. This chapter forms the basis of and is the backbone of the field study.

Chapter 4: Research Findings.

This chapter lays out the findings from fieldwork. The existing facilities and utilities for fire control in Nairobi County are documented. The statistical data collected is converted into shape files and overlaid on a map. An analysis of this data is carried out in a bid to establish the need for use of GIS technology in fire control in Nairobi County. The chapter concludes by giving the importance of using GIS technology and the priority areas where is applicable in respect to the economic status of Nairobi County.

Chapter 5: Conclusions and Recommendations

From the findings and analysis done in chapter four, various conclusions are drawn. First, on the use of GIS technology in fire control and how best this program can be established at the Nairobi City County Fire Department. The author then outlines recommendations based on the findings and analysis of the study.

CHAPTER 2: LITERATURE REVIEW

2.1 Fire Response Capacity in Nairobi County.

Fire services in Nairobi County are mainly provided by the County's Fire Department, which is composed of three fire stations, with a number of fire engines and 146 employees who work in shifts (Joselow, 2013). The department has been ridiculed as having faulty equipment, arriving at fire scenes late, running out of water and having difficulties putting out fires in high-rise buildings as was the case at Kimathi House, in 2012 (Njoroge, 2013). Indeed the Fire Department has been struggling to offer fire control services whenever there is an outbreak of a fire in the county, characterized by broken down engines. According to Obala (2010), the level of preparedness and ability to effectively tackle fire breakouts is limited. Communication, planning processes, tactics and materials development are critical elements in dealing with incidences of fire occurrences (Muraya, 2013). For instance, in the recent past, three separate fires occurred in Nairobi County; Gikomba, Kenyatta University and Kawangware. Due to the inadequacy of fire facilities, the Nairobi's fire fighting department engaged in putting out fires in Gikomba and Kenyatta University but did not dispatch fire engines to Kawangware leading to a massive destruction of property and loss of four lives in the informal settlement inferno (Standard, 2014).

According to the Fire Department annual records (2006-2014), the City loses 12 lives and property worth Ksh. 118,814,167 on average due to fire breakouts. The vehicular traffic which has been a long range problem to the city has made it difficult for the fire engines to penetrate and take the shortest time to arrive at the incident scenes. On average, the fire engine track takes 45 minutes to arrive at the scene, while it is supposed to take 8 minutes as stipulated in the World Fire Standards guidelines.

The Nairobi City County Fire department has no proper database for the existing facilities such as fire hydrants; road network; land uses and hospitals, data on the past fire incidents showing damages on property and loss of lives and inspection reports. This is because much of the systems are still manually operated with no post analysis on fire incidents since the entire system has not been automated. In certain areas of the City, the fire spreads so quickly due to the proximity of house units and the flammable building materials that was used for constructing the units. A turn out fee is always charged for every hour taken to put out the blaze when the fire

brigade visits the sites, of which most people cannot afford especially those in the low income zones of Kibera, Mathare, Embakasi and Muthurwa, just to name a few. Several attempts have been made to upgrade the City's fire control system, with no much success. The introduction of the GIS program will go a long way in enhancing efficiency leading to reduced loss of lives and damage to property.

2.2 The Geographic Information System (GIS)

GIS is a technology that integrates geographic features with tabular data to assess and better understand real-world problems. It is computer software that links geographic information (where things are) with descriptive information (what things are) (Esri, 2012). GIS is a fundamental technology that enables better planning and action for both strategic and tactical needs. The GIS program began in the 1960's with the discovery that maps could be programmed using simple codes and stored in a computer, allowing future modification when necessary (Esri, 2007). Previously maps were painstakingly created by hand and even such small changes required the creation of a new map. The earliest version of a GIS was known as computer cartography and involved simple line work to represent land features. Unlike a flat paper map, a GIS-generated map can present many layers of different information that provide a unique way of thinking about geographic space. By linking maps to databases, GIS enables users to visualize, manipulate, analyze, and display spatial data. The most powerful aspect of GIS is its comprehensive analysis capability. It enables map layers to be selected and displayed (overlaid). The layers are allied to data tables that contain attribute data about the geographic features being displayed. The main objective of using the GIS program is to help users understand how the world works, make the best choice from among options, or develop plans through the what-if scenarios.

Some of the GIS map layers that fire departments use include:

1. Fire station locations
2. Fire hydrants
3. Road network
4. Utility networks
5. Hospital locations
6. Fire districts

7. Historical incident or emergency call locations
8. Parcels
9. Topography
10. Lakes and rivers
11. Commercial and government buildings
12. Police station locations
13. School locations
14. Satellite or aerial imagery

2.3 Application of Geographic Information System (GIS) in Fire Management

In recent times the fire service operation aimed at saving life and protecting property has become multifaceted and fire professionals are becoming more strategic in the use of technology to successfully overcome challenges. Fire agencies at all levels strive to preserve lives, property, and natural resources. Agencies are using GIS as a tool to help them balance needs, uses, and hazards to uphold sustainability of the environment while identifying and limiting vulnerability (Sohyda, 2009). Basically, for more than a decade, GIS has helped fire departments reduce risk, increase efficiency, and improve outcomes. Currently, the fire management team and information technology professionals are innovating modern and creative ways to apply this new technology to solve ever increasing fire service demands (Thomas and Williams, 2007). GIS is a powerful information management system having unique abilities to collect, analyze, and visualize information based on location (Esri, 2012). The GIS fire tools include; Internet applications using Internet Map Server (IMS) technology and desktop applications developed using ArcView GIS with extensions to enable real-time enterprise wide applications using ArcInfo (Sohyda, 2009).

According to Esri (2007), GIS supports planning, preparedness, mitigation, response, and incident management extending the capability of maps—intelligent, interactive maps—with access to all types of information, analysis, and data. As a fire incident occurs, any delay of responding by the fire companies can make the difference between the rescue of occupants and property versus serious injury or death and damage of goods. The critical time between fire containment and flashover can be measured in seconds. As the GIS helps reduce critical time and

increases efficiency, it also empowers the fire personnel; through the evaluation of hazards, service demands analysis, and resources deployment.

GIS is a scalable, standards based technology platform, which works on desktop computers, in the cloud, in server environments and on mobile devices. It provides powerful spatial analysis that enables the user to effectively solve problems and make better decisions. In fire services, GIS is used to help meet mission requirements at every level of the organization from frontline responders to mid - level and senior level commanders to Chief fire officers. GIS has the ability to retrieve large amounts of data maintained by agencies and organizations outside the fire service. GIS also allows fire staff to access and integrate diverse datasets maintained by outside organizations enabling integration of these data sets with the existing preplanning, incident, and other fire data (Thomas and Williams, 2007). Moreover, comprehensive analysis and modeling is performed to predict, monitor, and model service delivery in respect to the fire incident history (Bukowski, 2008).

Further the GIS programme is capable of applying a layer-centric approach in managing, creating, analyzing, and visualizing data which creates an accurate information picture and an analytical framework for an area of interest producing a map. The first layers on a map are almost always things like political boundaries, large natural features like water and mountains, and common infrastructure features like roads; a collection of data called base maps which are frequently referred to by descriptive names, like street maps or topographic maps. Base maps are the platform upon other layers containing information about features, such as fire stations, vehicles, hydrants, or hazardous material locations can be referred and represented, providing the members of the fire service with a visual or map centric approach to bringing information together for situational awareness or other specific needs. Additionally, it creates a map view of real-time data in the vehicle, on a mobile device, or in the command center, enabling users to make quick assessments and take precise action with the available paramount information.

Fire personnel can use GIS to query an unlimited number of characteristics, or attributes, in the data because GIS has the ability to manage physical features that are geographically referenced, such as those that have a physical address or latitude - longitude grid reference. Much like the

columns of data in a spreadsheet, GIS allows people to add any attribute to any feature. For example, the way to track inspection dates on fire hydrants is simply to include a field, or an attribute, called "inspection date" in the database. This ability to query unlimited attributes provides a powerful construct for modeling or accessing very detailed data about a feature on the map.

Geography makes it possible to focus on an area of interest and in creating a large - format wall map, fire department staff starts with base map data showing jurisdictional boundaries, streets, and bodies of water. Depending on the size of the community and the purpose of the map, additional information layers, such as parcel boundaries, hydrants, school and fire station locations, and reference grids, can be easily added, which are used as fire preplan documents. By mobile GIS, station crews often collect data during pre incident surveys to capture information such as the locations of building features like fire department connections (FDC), stairwell entrances, and lockboxes or perhaps notes about dangerous construction features. These new datasets are added to the existing database, and through the use of different map layouts, accurate, detailed, individual pre incident plans can be produced. Because the same layers of data are being reused, and each map product is referenced to a common geography, agencies can leverage work from one map product to another.

According to analysis by Esri (2007), the most effective way to improve outcomes for both fire and medical emergency response is to reduce response time. By understanding the objectives of each step in the response sequence, a fire department can measure its current performance. The several ways an organization can establish a response/travel time standard are through (1) the use of historical fire and EMS response data, (2) demand for service, (3) the level of care that the society demands, and (4) the level of care that the organization is able to afford.

According to the National Fire Protection Association (NFPA) of the USA, 1710 the following specifications on time limits are observed.

- Turnout time: One minute (60 seconds) for turnout time.
- Fire response time: Four minutes (240 seconds) or less for the arrival of the first arriving engine company at a fire suppression incident and/or eight minutes (480 seconds) or less for the deployment of a full first alarm assignment at a fire suppression incident.
- First responder or higher emergency medical response time: Four minutes (240 seconds) or less for the arrival of a unit with first responder or higher-level capability at an emergency medical incident.
- Advanced life support response time: Eight minutes (480 seconds) or less for the arrival of an advanced life support unit at an emergency medical incident, where the service is provided by the fire department.

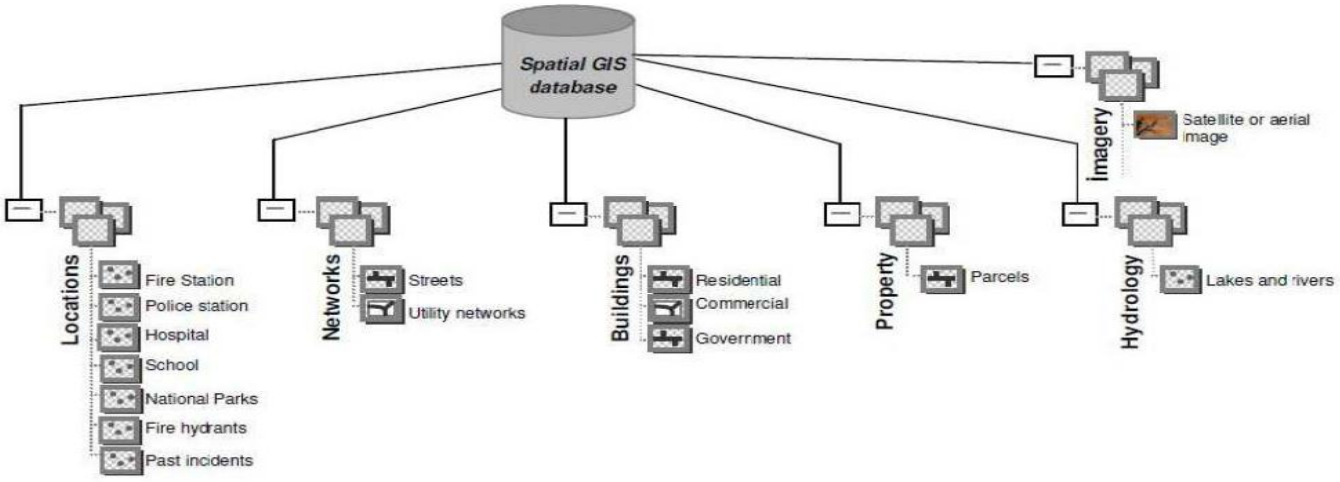


Figure 1: Fire control GIS database elements. (Source: Sohyda, 2009)

A complete fire control GIS database mainly comprises of the following key aspects; Location elements, Network aspects, Building typologies, Property, Hydrology and Imagery as shown in Figure 1.

2.4 Case studies of GIS application in Fire Control

2.4.1 Wild land Fire Management

In the USA, maps are essential tools in fighting wildfires. For instance, fire fighters must be able to quickly answer questions such as; Where is the fire and how fast is it spreading? What are the priority values to protect? and, What are the risks to fire fighters and the community? GIS produces maps that answer these and other questions and provides a robust platform for fast, efficient analysis and data dissemination. Fire planning, preparedness, mitigation, incident response, and recovery are vital functions for managing effective wild land fire programs. GIS enables wildfire agencies to do the following:

• Develop fire management plans to enhance situational awareness and improve fire fighter safety.
• Access real-time fire status and control efforts that aid in developing and implementing mitigation strategies.
• Optimize resource placement and allocation through the development of budget requirements.
• Support incident management mapping and analysis requirements.

2.4.2 Urban areas Fire Management

Urban fire is a vehement problem, for both the developing and developed countries. GIS is used in the analysis of data concerning urban fires in the current times since it has the ability to analyze intensive data volumes and is highly effective in responding to spatial queries. For effective fire management, conventional fire records must be supported with maps and there should be dynamic integral spatial data, such as the location of hydrant access routes together with limitations and information on risk areas. For effective firefighting it is of crucial importance that there are sufficient fire hydrants and they are adequately maintained.

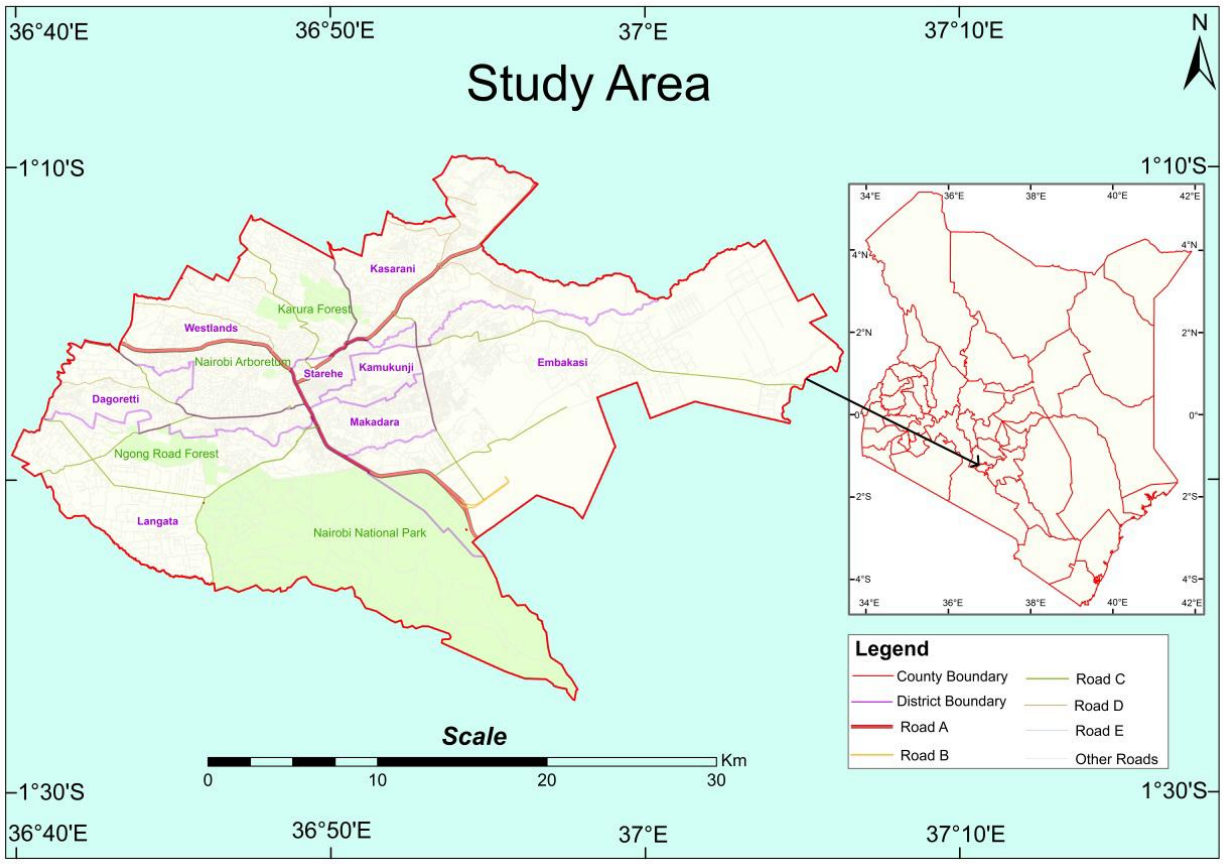
In the case of the Trabzon City in Turkey, the GIS program is used in fire control operations. The fire risk areas are established by using spatial databases and the determination of the optimum route, accessibility analysis, and emergency response management applications is realized by performing GIS-based fire scenarios on the risk areas. In the analyzed risk areas, fire hydrant

areas are optimized, and associated with a spatial fire database (Nisanci, 2010). Through modeling the GIS program is able to show the streets that are narrow which can prevent the entry of fire trucks and first aid teams and the close proximity of buildings which would result in rapid spread of fire (WarMack et al, 2012). This is aimed at enhancing efficiency in fire control operations resulting in saving lives and minimizing destruction of property. This data needs to be in a common database and GIS can play a significant role in the accumulation and maintenance of information. In preparation for fire management, GIS helps to determine the best distribution of hydrants, location of fire stations, classification of fire regions according to fire type and the creation of region specific early intervention plans (Nisanci, 2010). In the event of fire, in order to minimize loss of life and property, it should be ensured that areas such as shopping centres, hospitals, schools, hotels and convention centres have fire escape plans and floor plans added to the fire databases. According to Jasso *et al.* (2009), location information of fires from 911 emergency calls could not be determined accurately; therefore the GIS program by matching address information with coordinate information directly helped in the determination of places of fires or accidents in the shortest time. Indeed location of fire stations, determining the shortest path and incident density analysis are important steps for effective fire control.

CHAPTER 3: METHODOLOGY AND MATERIALS

3.1 The Study Area

Nairobi County is one of the 47 counties in Kenya, as well as the capital city of Kenya. It is a renowned prime economic hub for the East and Central African regions. Nairobi City County accounts for 50 % of formal employment in Kenya and generates over 50 % of GDP (Nairobi City County, 2014). It covers approximately 700km^2 with a population of 3.1 million people (KBS, 2010) and is divided into 8 sub-counties as shown in map 1.



Map 1: Study Area (Source: Nairobi City County, 2014)

Nairobi is a rapidly expanding city and the question of unpreparedness in disaster response and inadequate fire engines continues to haunt residents of Nairobi who dread fires because they know the fire department cannot be relied on to make any meaningful intervention. It is thus vital to make the city safe and appealing to both locals and foreign investors who are apprehensive of

incidents that could expose them to huge losses. The possibility of fires breaking out in the city and the outskirts as a consequence of illegal power connections and poor electrical workmanship should ensure that the county government makes fire fighting a priority. By virtue of being the seat of government, Nairobi collects enough revenue to give competent service to tax payers. It has the capability to buy new fire engines and install fire hydrants and water points at strategic points around the city to ensure that fire engines do not run out of water midway through fighting fires, as is the case currently. The central fire station established in 1907 remains as the only effective station in Nairobi County and the establishment of several other sub-stations becomes a must to improve efficiency in emergencies. The fire fighters in Nairobi are approximately 100 serving a population of over four million residents under a conventional strategy of fire control; a disparity that should be addressed as a matter of urgency.

3.2 Research strategy

This is an exploratory type of research whose objective is to demonstrate the potential of GIS Technology, in enhancing the efficiency of Fire Control services in Nairobi County. Survey and modeling strategies were employed to carry out the research on how GIS technology can enhance efficiency in the provision of fire services. Both qualitative and quantitative data were predominantly collected on the past, current and forecasted elements of fire services in Nairobi County.

3.3 Data and Tools

The data obtained for the research were;

a) Shapefiles classified as roads, fire hydrants, fire stations, fire incidents, land uses, hospitals and population.

b) Statistical data on fire incidents, fire stations, casualties and financial costs of destroyed property. (See Appendix 1)

c) Population figures

d) Google images (See Appendix 4)

The materials and tools used for collecting, processing and analyzing the data were;

a) Interview sheets with open ended questions,(See Appendix 3)

b) The software used included:

1. Microsoft word: Typing the contents of the report.
2. ArcGIS 10.2.2: For Spatial analysis of data.
3. Global Mapper v11: For Georeferencing.
4. Google earth: For obtaining locations.
5. Microsoft Excel: For Coding & Analysis of statistical data.

c) The hardware used included:

1. Intel(R) Core (TM) 2 Duo 2.13 GHz processor, 4GB RAM and 500 GB HDD computer,
2. Scanner,
3. Printer.

3.4 Methodology overview

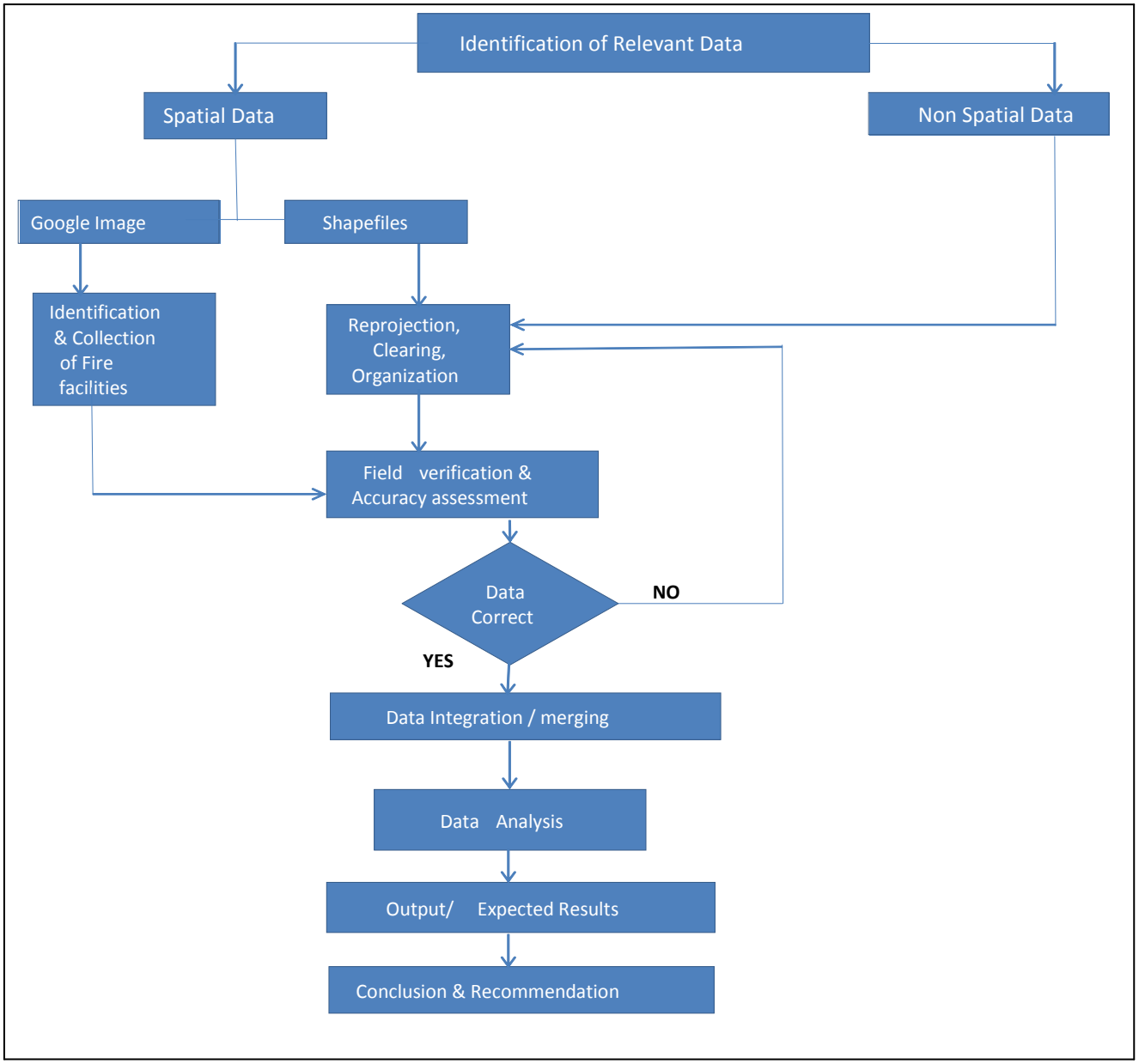


Figure 2: Methodology Scheme

Primarily, both the spatial and non-spatial data were identified and collected. Spatial data comprised Google images and shapefiles while the non-spatial data were statistics and literature obtained from secondary sources. The validity and reliability of the data was assessed accordingly. The statistical data on fire stations, fire hydrants, fire incidents and major hospitals

obtained from the Fire Department was referred during picking points using the Google earth, underpinned by the site knowledge of each facility and incident location, as exhibited in annex 4.

The correct data was used for analysis while the uncorrect data was reprojected or cleaned. Projection was done for all the shapefiles: Nairobi Districts, road network and fire hydrants to ensure uniformity. The data collected from the internet was triangulated alongside the data collected from the Fire Department and site verification through ground truthing. Data obtained by the Google Earth, was saved in the KML – Keyhole Markup Language format, which were then converted into shapefiles, vide the Data Management process in the ArcGIS. In analyzing the data sets, merging, joining, integration, overlaying and network analysis was done. The data for finding the optimal route was first converted into the Network Data sets after which the Network Analysis strategy was used to determine the proximity of facilities – Fire stations, hospitals and police stations and the optimal routes – best possible route from the Fire station to the incident. The conclusion and recommendations were drawn from the findings and analysis of the data.

3.4.1 Validity and reliability

a) Validity

The data collected was validated by the triangulation approach, using semi-structured interviews with open questions for every indicator, secondary data analysis using the existing documents such as Nairobi City County (NCC) Policies, Government reports, and international standards or benchmarks for best practices. Member check or respondent validation was also used to check if the respondents really understood the questions from the way they contributed.

b) Reliability

For collection of reliable results, the questions were properly worded and made easy to interpret. Pre-test was applied to test reliability before the actual data collection was conducted to enhance reliability of the instrument. Reviewing of the collected data and the composition of the related questions was further cross checked.

CHAPTER 4: RESULTS AND ANALYSIS

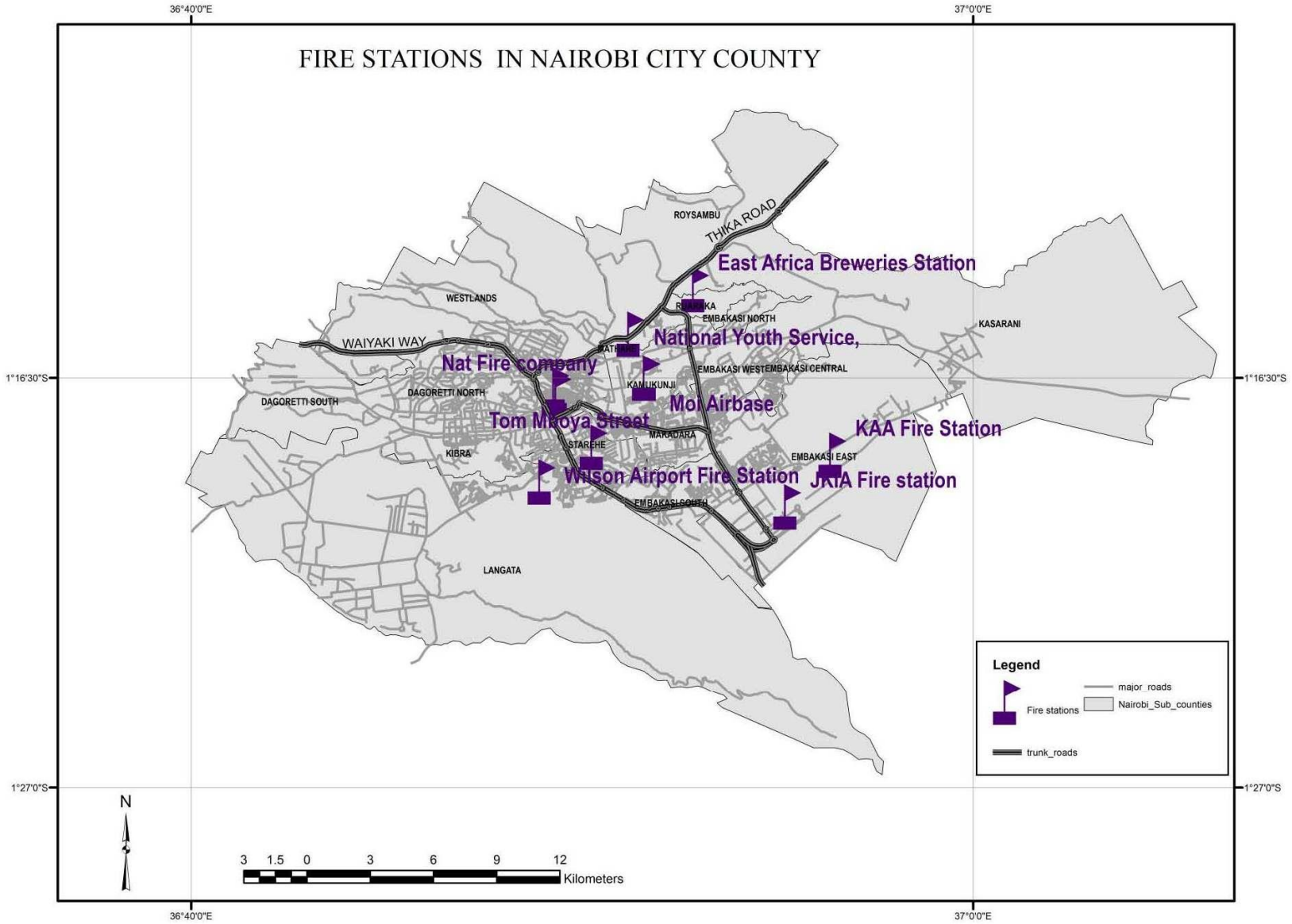
The chapter seeks to explain how fire services are provided in Nairobi County and also establishes the potential of applying GIS technology in the provision of fire services in Nairobi County. The data used in this analysis comprises of shapefiles for fire stations, fire hydrants, roads, major hospitals, Nairobi Sub-Counties and population statistics. Both the spatial and non-spatial data were obtained and used for the analysis after checking their reliability and validity.

a) Findings

i) Fire Stations

Referring to Map 2, it is evident that, the City is being serviced by 9 fire stations. Three of these stations belong to the NCCG while 6 are privately owned. The most utilized are the 3 fire stations belonging to the NCCG, which are located along Tom Mboya Street, East Africa Breweries-Kasarani and Enterprise road in Industrial area. The private fire stations are used for minor incidents and as a complement to the NCCG fire brigade during major fire incidents.
This is because a fee is always demanded for every fire control operation, making the public to seek help from the NCC fire stations which offers subsidized fees. According to the international fire standards and basing on the current population, Nairobi County deserves to have modern and fully equipped 17 fire stations, in order to effectively control fire breakouts in Nairobi County.

The fire station located along Tom Mboya Street in the CBD is the County's major station as compared to others. In assessing how services are provided, this station is yet to be automated and many of the operations are done manually. Further, data is manually encoded as well as records not properly kept. For instance, the author had to hire or assign an officer to obtain for him statistical data for the 2014 fire incidents from their archives as shown in appendix 2. The fire officers are notified of fire incidents mainly via phone calls and there is no system in place to receive or obtain fire detectors' signals when they occur. This leads to prolonged response time which often leads to loss of lives and damage to property. The connectivity of road network in Nairobi is effective and adequate (map 5) but challenged by traffic jams which always impede the movement of the fire engines resulting in consistent delays in response timings.



Map 2: Fire Stations

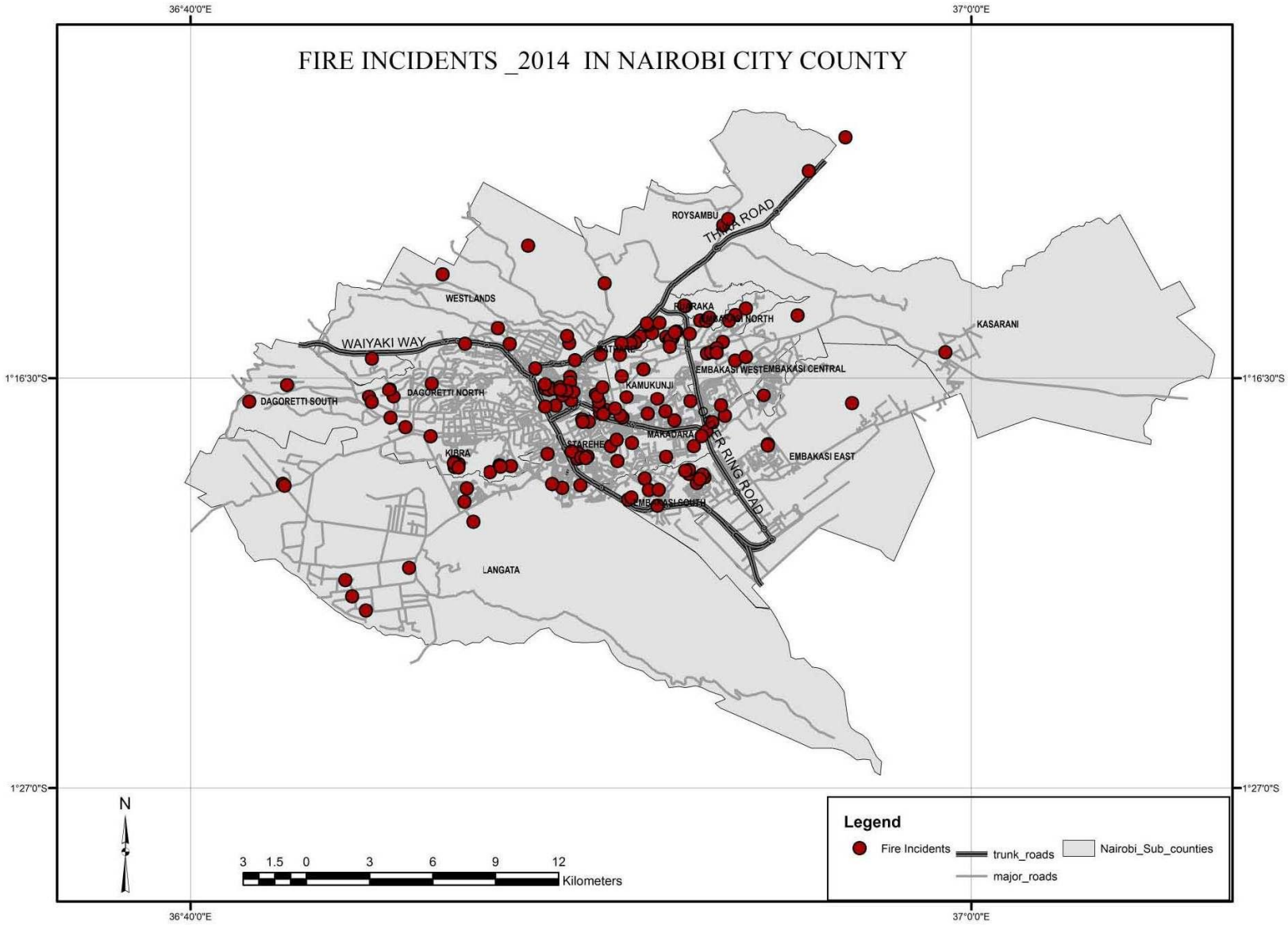
Fire incidents

Map 3 shows fire incidents that occurred in the year 2014. There was a high occurrence of incidents in Starehe, Mathare, Makadara, Kamukunji, Ruaraka, Kibera, Embakasi North and South. These areas are mainly characterized by low and medium income earners. The fire incidents spatially happened in Dagoretti, Langata, Westlands and Embakasi East. Medium and high income earners, reside in these areas, where primarily buildings are on big plots and are well developed. Proportionally, there is a high concentration of people in areas where fire break outs are predominant.

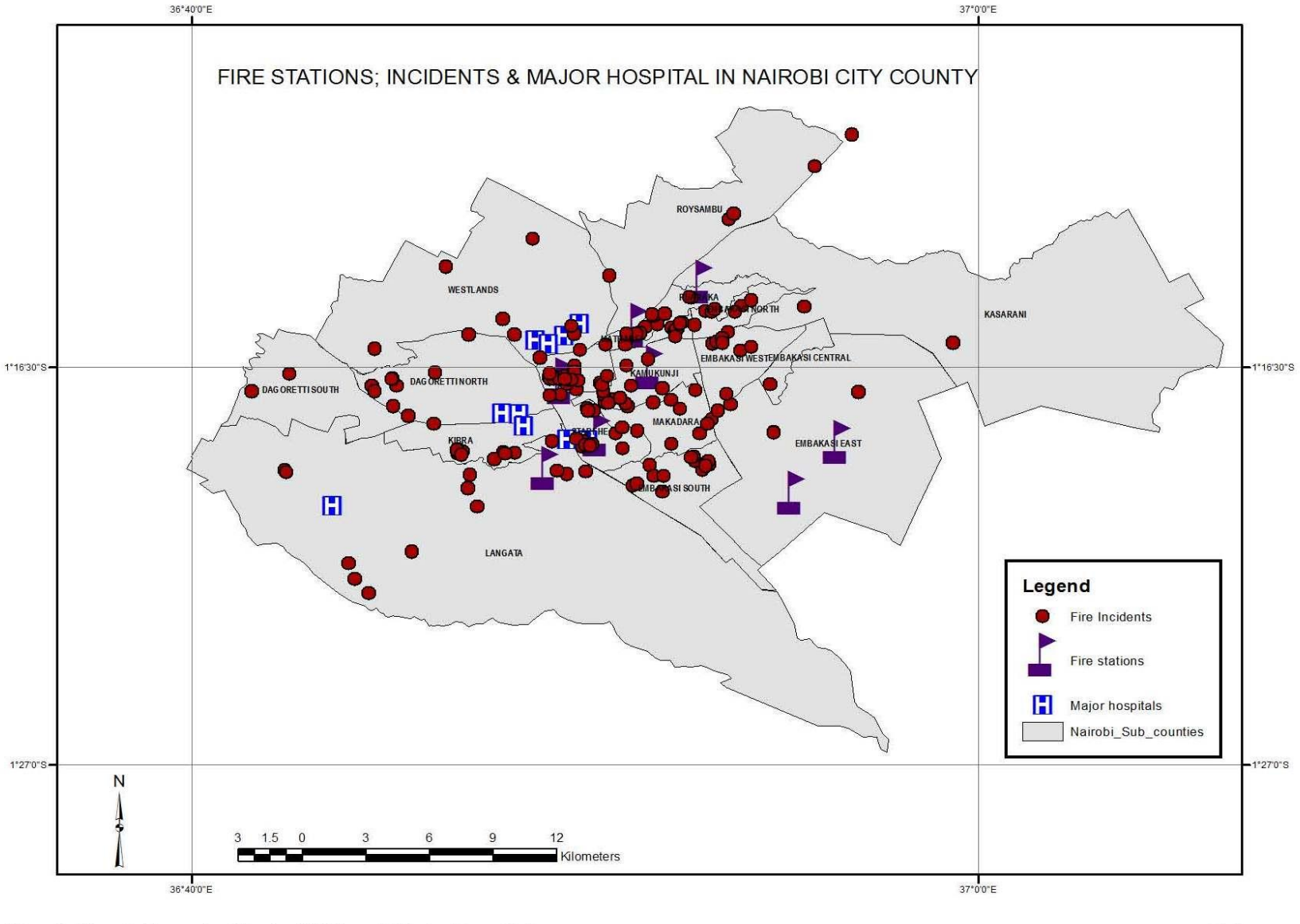
These areas hold an approximated total population of 1.9 million persons. According to map 4, the area has only 4 fire stations, which cannot keep up with the high demand for fire control services. The map also reveals that, there are no fire stations located in high income earners areas of Langata and Westlands and the medium income earners of Embakasi East and Dagoretti. Numerous fire breakouts have also been registered in these areas. In total, these areas hold a reasonable population. This calls for an introduction of 5 (1,000,000 (people)/ 200,000 people per stations) fire stations in the area.

ii) Major Hospitals

The fire brigade also offers Emergency Medical Services (EMS) on the incident site. This enables the team to save lives, especially when the fire control team arrives within a short period. Casualties are taken to Hospitals for proper treatment. As shown in map 4 there are 10 hospitals that the fire brigade prefer to take casualties to for treatment depending on proximity to the zone the incident has occurred. These facilities are located in Upperhill, Westlands, and Karen and Nairobi West areas. The areas that seem far from the defined hospitals are Embakasi, Kasarani, Dagoretti and Roysambu areas.



Map 3: Fire incidents



Map 4: Fire stations, Incidents_2014 and Major Hospitals

iv) Fire hydrants

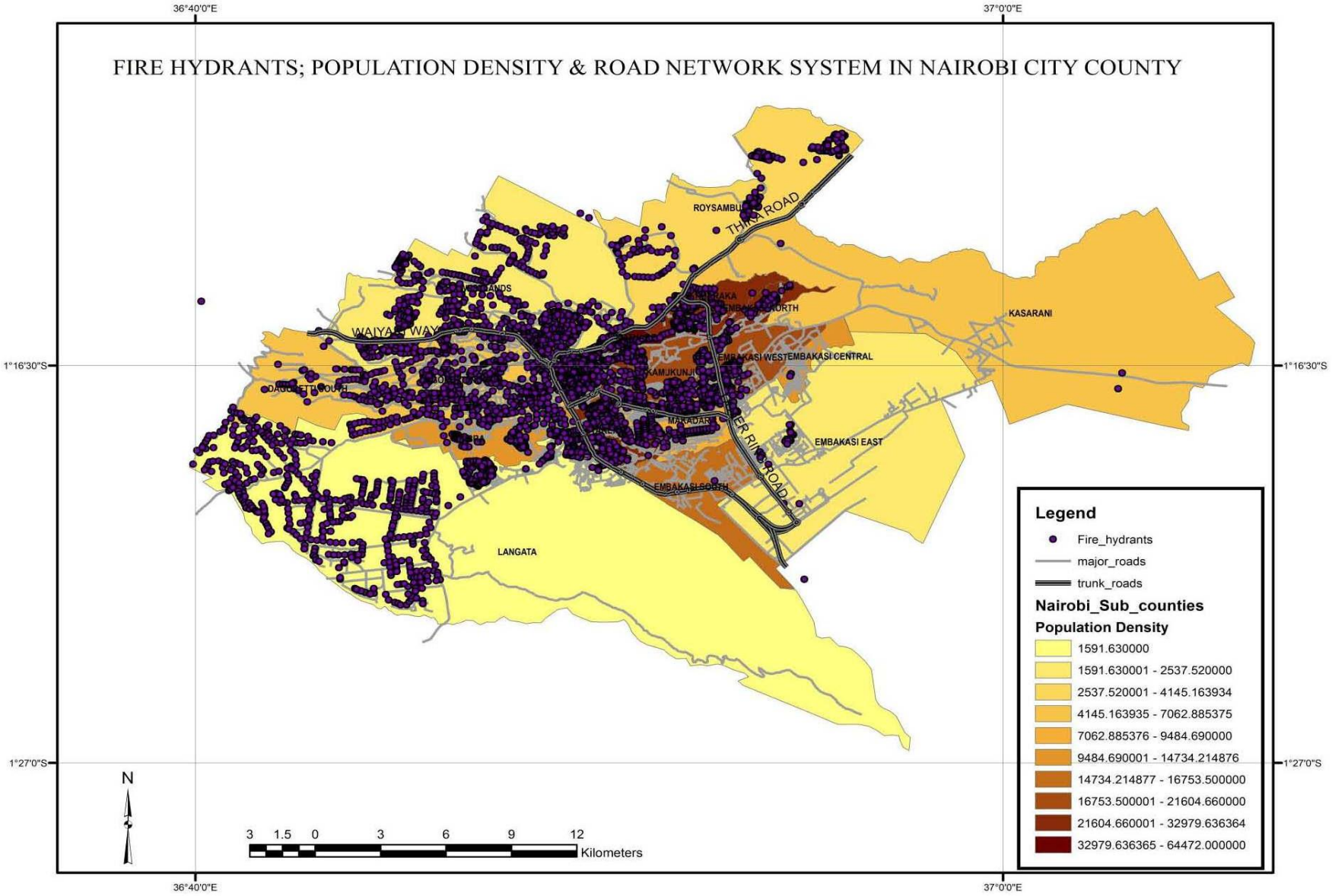
Map 5 shows how fire hydrants are distributed within the Nairobi County. Referring to the map, the distribution is concentrated in the CBD, Karen, Dagoretti, Westlands and parts of Roysambu. There are a few fire hydrants in Embakasi and Kasarani. According to the Fire Department records, there are over 4,000 fire hydrants in Nairobi County and most of these fire hydrants have no water and others do not function. It was noted that the Fire department is supposed to inspect them quarterly; an assignment that, they do annually or do not perform at all to some hydrants rendering them dysfunctional. It becomes disastrous, when there is need to refill the fire trucks and the hydrants are dry or are not functioning properly. This leads to loss of lives and heavy damages to goods and properties.

iv) Population density

According to map 5; there is a high concentration of persons in Mathare, Starehe, Ruaraka, Embakasi North and West. These areas are mainly inhabited by low and medium income earners. The population density is lower in Langata and Westlands since the areas are delineated for high income earners, who stay in spacious plots characterized by single dwelling units, unlike Dagoretti, Kasarani and Embakasi East which are occupied by medium income earners and characterized by multiple dwelling units. According to the international fire control standards, a fire station should be provided for every 200,000 persons. The projected population of Nairobi City by 2014 was 3.5 Million (Nairobi City County, 2014), thus the City deserves to have approximately 17 modern and equipped fire stations owned by the NCCG.

v) Road network

Map 5 shows the road network comprising of the trunk and major roads that are mainly used by the fire engines. The County is well networked and almost every part is accessible. The slum areas which are poorly planned do not have defined access routes, making it difficult for the fire brigade to penetrate the incident scenes, which has resulted in great loss of lives especially in Sinai slum, where over 80 lives were lost in a morning inferno.



Map 5: Fire hydrants, Population density and Road network system

b) Analysis

i) Optimal location of the incident area and time modeling

The transport network often plays an important role in fire control operations. The characteristics of the transport infrastructures enable precise response time and this is done by the modeling of the time and cost of travel between locations. Network based measures are determined by summing the lengths of links or other criteria related to the length (e.g. distance-time, distance-cost). Nairobi City County has a circumferential transportation network system with the CBD acquiring the grid orientation of the network. In most cases the City experiences traffic snarl ups which make it difficult to control and manage disasters. During the peak hours, the fire engines take over 45 minutes to penetrate the traffic jam, thus arriving at the incident site when lives have been lost or massive properties damaged. According to the Nairobi City County master plan, (Nairobi City County, 2014) the NCCG has proposed to introduce the Mass Rapid Transport which is an integration of the train – railway, buses –road and cycling systems. These applications are aimed at reducing traffic congestion and solving the menace of traffic jams. In addition, the installed traffic lights are rarely used to control traffic. Instead, it is the traffic officers that usually make the effort to control traffic flow. Installation of a traffic control station underpinned with properly functioning traffic lights, will enable the fire engines to take a shorter time to arrive at the incident sites, since the fire engines/truck and ambulances shall be given the first priority.

By creating a GIS road network containing attribute information, such as road type, name, distance and its condition users can identify a station location, specify a travel time and run a network analysis. The result will be displayed by an irregular polygon around the station that illustrates where the fire apparatus could travel in any direction for the specified time. This type of analysis can be performed on a single station or simultaneously on all stations to analyze gaps in coverage and establish run orders. Fire station locations, the shortest path and incident density analysis are important steps for effective fire control.

ii) Incident trend, data collecting and modeling

From the findings, the fire control operations in Nairobi City are not automated. Pre, during and post incident data is manually collected and recorded in the Operation Book (OB). When need arises for the data, a fire officer has to be assigned the duty of searching in the archives, an activity that takes 2-4 days to accomplish. By introducing the GIS program, incident trend analysis can be done quickly, displayed logically and understood easily. For instance, a GIS user could request to see arson fires that occurred between the hours of 2:00 p.m. and 11:00 p.m. on Sundays in Nairobi County. The GIS program will interrogate the record database and place points on the map that match the request. In essence these types of analyses provide decision support for issues related to fire prevention, acquiring better fire control strategies, staffing requirements and equipment placement. It is important to mention here that the GIS software adds intelligence to spatial data; raw data, measurements and field sketches can be encoded directly into the GIS, which enable an efficient managing of data in a geodatabase with other spatial information. Precisely, the GIS technology can be used for collecting, importing, converting and storing spatial measurement and computational fabrics. These spatial data can be presented into two basic categories namely:

1. Vector data: Represents discrete features, such as incident locations.
2. Raster data: Represents continuous numeric values, such as elevation.

iii) Fire Information System

A Fire Information System (FIS) which includes all spatial and non-spatial data related to fire should be connected to the GIS database so that any query can be acted upon to receive the required information from the GIS database. This approach has been supported by the Kenyan E-Government strategy which focuses at automating all the departmental operations.

If this is initiated the FIS ought to be able to access information in the GIS database at the moment of the fire about the building (architectural details including fire escapes, building structural projects, the location of gas and electricity supplies). Evidently, the fire teams will be able to act quickly and effectively, and more importantly, with greater safety when dealing with a fire. Moreover, the address of the building on fire or the address of the reporter should be

acquired by integrating GIS database for fire management with the database of the Telecommunications Directorate and Civil Registry. In order to maximize the fire fighting ability of the Fire Brigade and thus save lives, prevent injury and reduce economic losses, the Fire Directorate should ensure that the records are regularly updated and undertake such studies as necessary to maintain an accurate database that can be shared with relevant parties.

c) **Demonstration on the use of GIS technology in fire control**

This part demonstrates how the GIS technology is used in fire control. The aim is to enhance efficiency in provision of fire control services. By using Network analysis strategy, the optimal route can be determined and the close facilities can be located. The optimal route is the most convenient route preferred by the fire rescue team, that is, the route with less traffic congestion and which will enable less time consumption. Nearby facilities such as fire stations, hospitals, fire hydrants and police stations can be located quickly and decision made effectively.

The following two scenarios; a) the optimal route and b) the location of closer facility (police station) are shown.

i) Optimal route

The data being used in this demonstration is referenced to map 2 – Fire stations, map 3- Fire incidents and map 5 – road network. To run the network analysis application, the road data sets which are classified into minor, major and trunk roads are merged; after which they are converted into network datasets. Under the network analyst drop down menu in the ArcMap, the option for new route is selected.

In the Network Analyst route_4 layer, with Stops layer active as shown in figure 3, select the preferred facility (Fire station) (1) and the fire incident (2). By right clicking on the Route 4 layer in the table of content, as shown on the left side of figure 4, and selecting the solve button, the program runs and gives the optimal route as shown in blue colour, figure 5. The directions from the facility to the incident can also be shown and printed for use by the rescue team, figure 6.

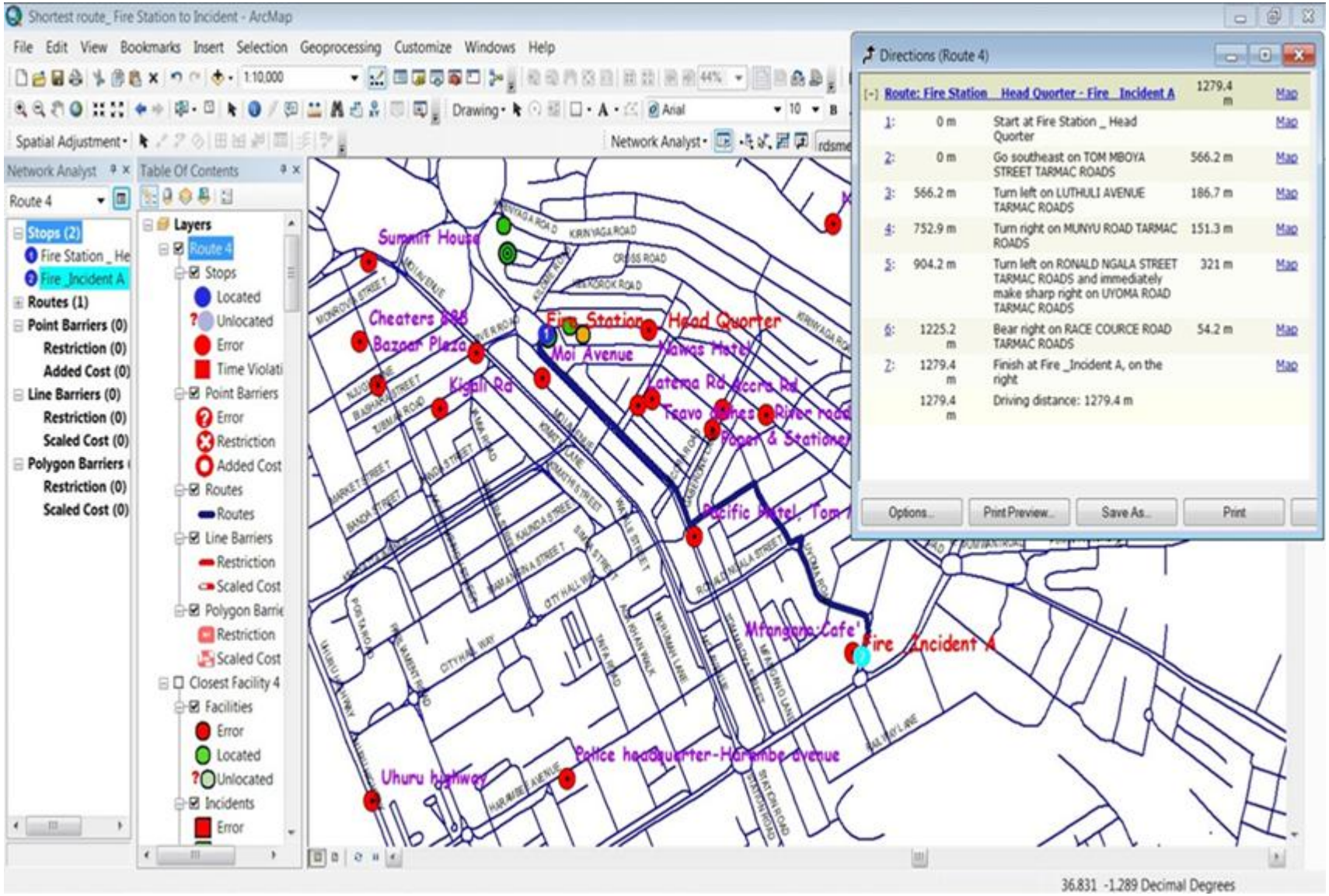


Figure 3: Optimal routing

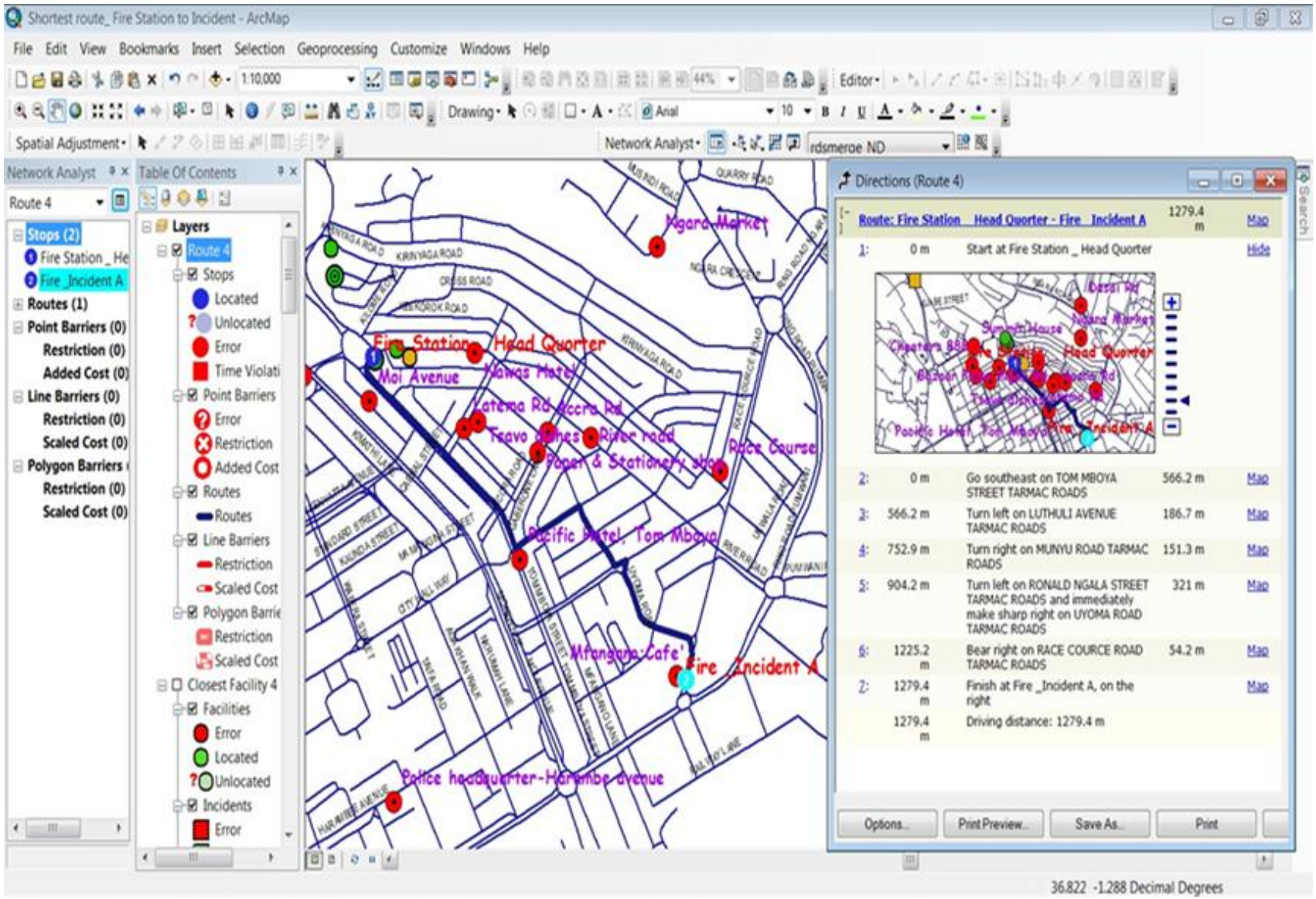


Figure 4: Inset map for direction

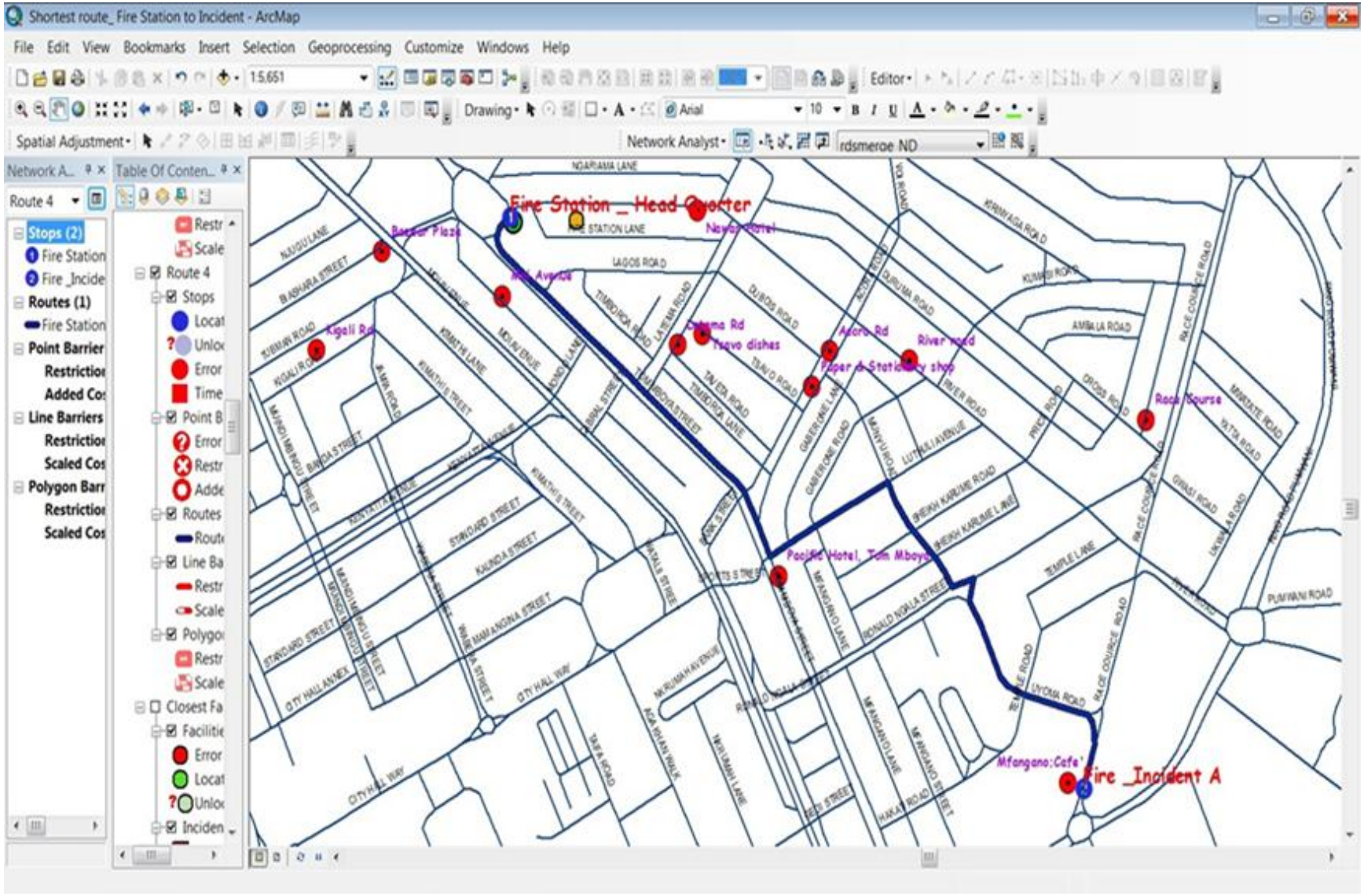


Figure 5: Stops (1) Fire station, (2) Fire Incident

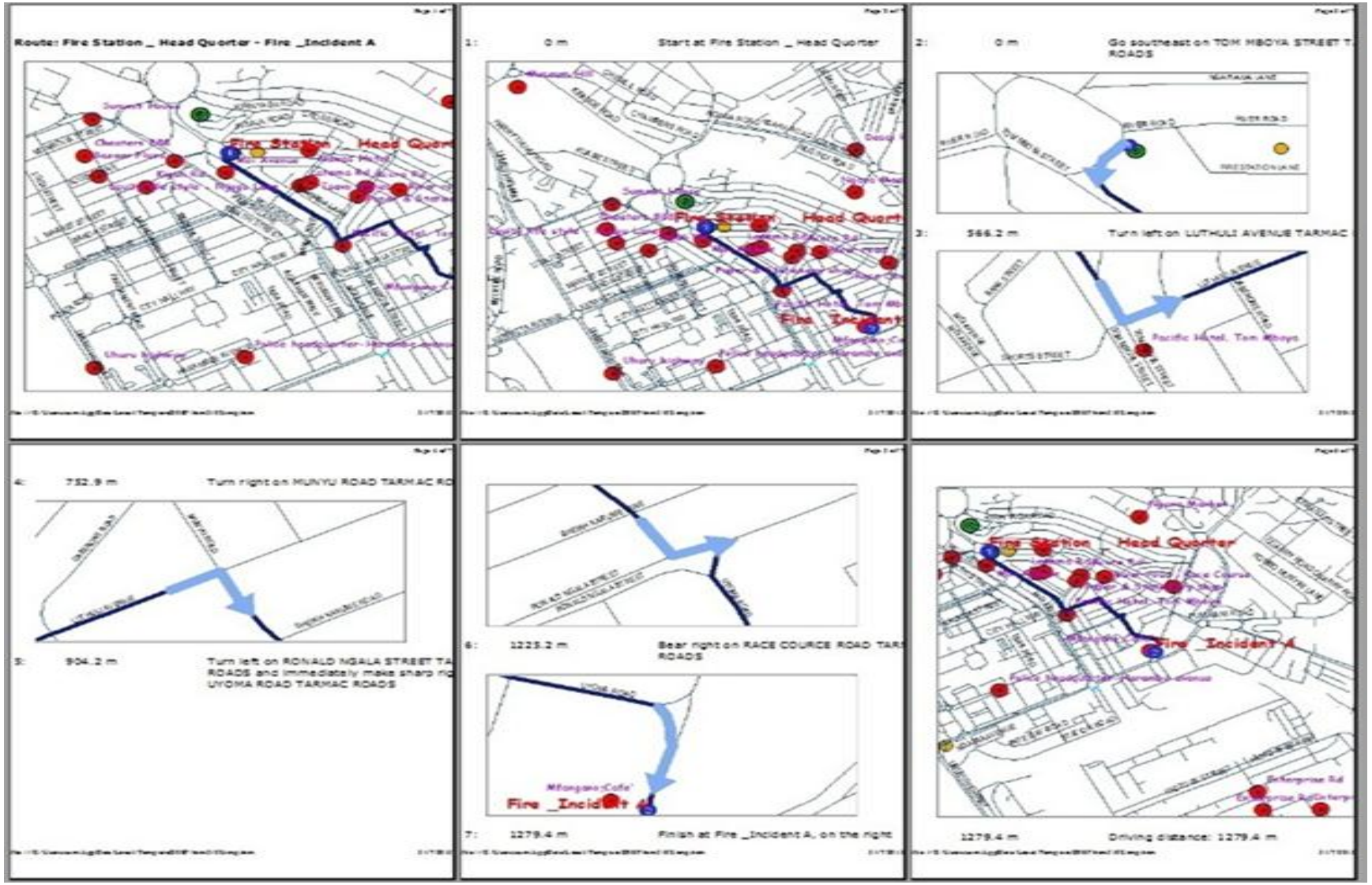


Figure 6: Direction map for the fire brigade

ii) Closer facilities

By selecting on the closer facility in the Network Analyst drop down menu, such facilities as fire stations and hospitals can be determined. Through this, the fire rescue team can be able to select the preferred hospitals to admit the casualties prior to arriving at the incident scene. This can also help the fire brigade call for reinforcement when need arises and or inform the located hospitals of the arriving casualties.

At the same time, the closer by police stations can also be located. The police can then be called upon to maintain law and order at the incident scene and also take statistics of any lost lives and damaged properties. Figure 7 shows the closer police station to both the Fire incident and the Fire station to be along Harambee Avenue.

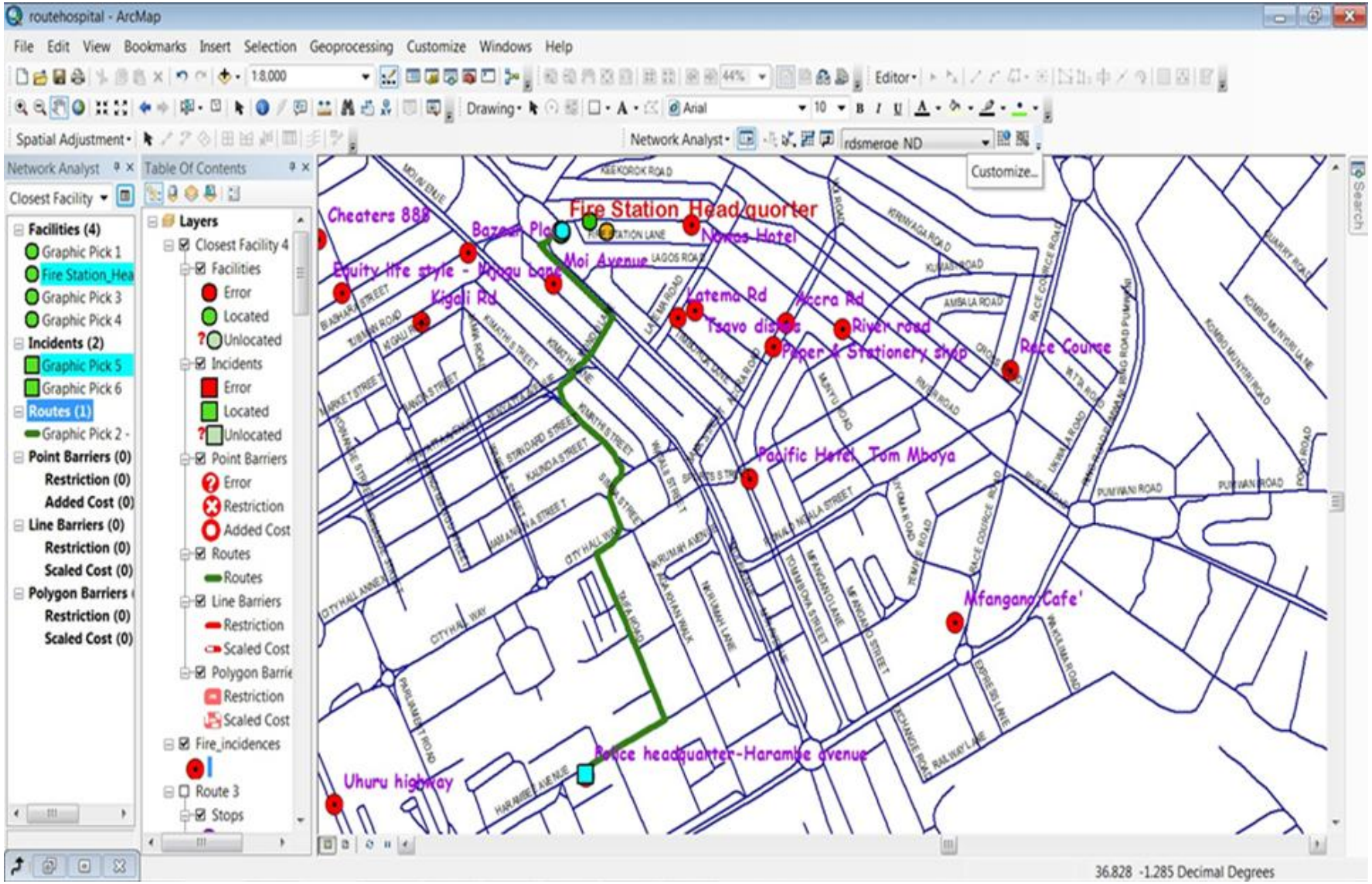


Figure 7: Location of police stations

CHAPTER 5: CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

For any society to grow both in development and population, measures should be undertaken to minimize loss of lives and destruction of property. Fire as a threat ought to be controlled at all cost. In this age of computer technology, the GIS technology has been proved to be a tool for enhancing efficiency in fire control services across the globe. Thus there is potential for Nairobi County to make use of this advanced technology to enhance efficiency in provision of fire control services.

The objective of this research was to demonstrate the potential of GIS Technology in enhancing the efficiency of Fire Control services in Nairobi County. The specific objectives were:

- To document how fire services are provided in Nairobi County.
- To establish the potential of applying GIS technology in the provision of fire services in Nairobi County.
- To provide recommendations to the policy makers on the use of GIS in fire control in Nairobi County.

These have been worked out in chapter 4. Through the findings and analysis, GIS has been used to provide information in maps and attribute tables, from the raw statistical data which had been manually recorded and archived by the fire department. It is evident that, there is in adequacy of fire stations, fire hydrants are sporadically located and there is lack of prior knowledge on the incident site. In addition much of the operations are done manually. Based on current development conditions of Nairobi County, this research shows that the GIS technology can be used to locate fire stations in the first instance, as a quick win program.

This study has majorly focused on the use of the limited statistical data that was difficult to obtain from the fire department. Due to time constraint of, statistical data for other years was not obtained reducing the precision of the results. In further researches, more statistical data on the performance of stations, availability of equipment and data from private fire companies ought to be included. Having given an insight on the potential of use of GIS technology in enhancing efficiency in fire control services, the study sets a platform upon which researchers in the disaster

management and GIS specializations can build on to provide an integrated program for installing the GIS program at the Nairobi City County fire department.

5.2 Recommendations:

Based on the findings and analysis, it is recommended that:

- There is need to have additional fire stations well equipped with modern tools and equipment. From the study and according to the National Fire Protection Association (NFPA) of the USA, a fire station is needed for every 200,000 persons, thus Nairobi City requires 17 fire stations. The road network system is adequate though still challenged by traffic jams. Therefore, advanced digital strategies for controlling traffic should be adopted.

- Most of the activities are done manually, and notifications on fire breakouts are received via phone calls. This calls for need to automate the Fire Department Operations, which will enable creation of Fire Information System and the ability to make real time decisions. This will go a long way in improving the efficiency of service provision, enhance proper decision making and in turn lead to minimal loss of lives and damage to property.

- The fire brigade takes more than 45 minutes to arrive at the incident scene. According to the National Fire Protection Association (NFPA) of the USA, the fire engine should arrive at the incident scene within 8 minutes. A proper integration of the traffic control station, the use of global positioning system and the fire detectors to signal the fire brigade when a fire breaks out ought to be adopted.

- Through the use of the GIS programme, an effective analysis on location of fire stations and fire hydrants will be determined, shorter routing identified and land uses for the incident scene areas provided. The main need of the Nairobi City County at the moment is to establish additional fire stations.

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Appendices

1. Fire and rescue incidents annual record.

FIRE AND RESCUE INCIDENTS ATTENDED BY NAIROBI CITY COUNTY FIRE DEPARTMENT; 2006 - 2014

1	ANALYSIS OF CALLS	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
	ACTUAL FIRES	580	570	503	304	444	Nil	506	443	538	356	387	378	618	450	328	205	445
	FALSE MALICIOUS	39	39	39	26	26	24	13	12	37	16	20	39	34	24	12	13	19
	ALARM GOOD INTENT	30	42	27	17	15	12	12	9	12	11	9	11	5	3	2	10	4
	SPECIAL EMERGENCY	46	25	29	29	28	42	35	45	78	123	148	176	74	34	40	66	62
	SERVICES BY MANAGEMENT	73	49	44	54	61	64	65	96	0	0	0	0	28	24	0	0	0
	TOTAL	787	725	642	430	574	648	568	700	483	537	455	844	591	413	259	534	398
2	FIRE ATTENDED																	
	BUILDINGS	260	353	332	229	258	232	254	283	184	193	141	347	233	220	140	322	232
	CHIMNEY S	8	3	2	1	3	9	6	4	0	0	0	3	4	2	1	2	3
	VEGETATION AND REFUSE	79	98	47	22	39	64	35	43	8	24	9	36	30	24	4	17	7
	MOTOR VEHICLES	48	35	39	22	20	28	21	16	10	16	9	17	17	9	6	10	5
	OUTDOOR EQUIPMENT PLANT	2	8	6	8	1	11	12	1	4	5	2	0	0	0	0	0	0
	AIRCRAFT	2	3	0	2	2	0	0	0	30	1	0	2	1	1	1		0
	ELECTRICITY	18	23	14	18	23	27	30	42	28	22	8	37	26	23	12	22	5
	UNCLASSIFIED	9	6	3	1	6	11	9	14	14	3	0	7	13	5	1	9	4
	TOTAL	426	549	433	303	352	382	367	403	278	264	169	449	324	284	165	382	256
3	CASUALTIES																	
	NUMBER OF PERSONS RESCUED	504	0	6	4	12	10	30	1	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
	NUMBER OF DEATH BY FIRE	7	14	27	13	13	12	10	5	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
	DEATH ACCIDENTS	250	10	23	21	6	17	7	10	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
4	FINANCIAL LOSS AT FIRE																	
	TOTAL (KSH)	39,903,613	98,370,090	10,682,358	3,790,195	4,303,595	427,056,500	411,366,020	114,309,150	71,283,600	79,611,479	220,844,000	164,468,550	257,118,500	112,2260,00	140,000,00	61,733,190	55,000,000

2. Fire Incidents for 2014

NAIROBI CITY COUNTY FIRE BRIGADE

DATE	INCIDENT (FIRE)	LOCATION	LOCATION	PROPERTY LOSS (KSHS)	LIVES LOSS
1/1/14	MATHARE NO. 10	1	MATHARE NO10	2,000,000	—
1/1/14	SOUTH B	2	SOUTH B	2,000,000	—
1/1/14	CONVENT	3	MUTHANGARI	2,000	—
10/1/14	KOMAROCK PHASE V	4	KOMAROCK	2,000,000	—
12/1/14	LUNGA LUNGA SLUMS	5	LUNGA LUNGA	100,000	—
14/1/14	NJIRU HOUSE FIRE	6	NJIRU	2,000,000	—
15/1/14	LANGATA	7	LANGATA	20,000	—
15/1/14	KAWANGWARE	8	KAWANGWARE	1,000,000	—
16/1/14	ENTERPRISE ROAD	9	ENTERPRISE RD	20,000,000	—
19/1/14	RHINO PARK	10	DAGORETI	2,000,000	—
20/1/14	CITY PARK	11	CITY PARK	10,000	
21/1/14	MUKUNGA ROAD	12	MURANGA RD	2,000,000	—
2/2/14	POLICE HEADQUARTERS	13	HARAMBEE AV.	1,000,000	
3/2/14	SOUTH B	14	SOUTH B	20,000	
3/2/14	KOROGOCHO	15	KOROGOCHO	10,000	
7/2/14	EMBAKASI	16	EMBAKASI	40,000	
7/2/14	KIAMBU ROAD	17	KIAMBU RD	40,000	
16/2/14	HURUMA CITY HALL	18	HURUMA	200,000	
19/2/14	MAITHARE NORTH	19	MAITHARE NORTH	100,000	
19/2/14	EASTLEIGH II	20	EASTLEIGH	50,000	
24/2/14	MOTOR VEHICLE ~~UHURU HIGHWAY~~	21	UHURU HIGHWAY	400,000	
27/2/14	HURUMA CASSANOVA	22	HURUMA	150,000	
6/3/14	KANGEMI	23	KANGEMI	100,000	
9/3/14	KAWANGWARE 46	24	KAWANGWARE	20,000	
9/3/14	HARDY KAREN	25	HARDY KAREN	1,000,000	
11/3/14	A.P TRAINING SCHO	26	AP TRAINING SCHOOL	1,500,000	
12/3/14	BABA DOGO	27	BABA DOGO	90,000	
12/3/14	~~DAGORE~~ GRASS FI	~~28~~	DAGORETTI		
16/3/14	KAWANGWARE	29	KAWANGWARE	2,000,000	

NAIROBI CITY COUNTY FIRE BRIGADE

DATE	INCIDENT FIRE	LOCATION	PROPERTY LOSS (KSHS)	LIVES LOSS
1/4/14	KAMUKUNJI 36	KAMUKUNJI	40,000	
7/4/14	OLYMPIC KIBERA 31	KIBERA	500,000	
7/4/14	MUKURU KWA RUEBEN 32	MUKURU KWA RUEBEN	7,000,000	
19/4/14	EMBAKASI VILLAGE 33	EMBAKASI	50,000	
21/4/14	NEAR ~~MOMBASA~~ HOTEL 34	MOMBASA ROAD	70,000	
22/4/14	DONHOLM ESTATE 35	DONHOLM ESTATE	40,000	
23/4/14	KIAMBU TOWN 36	KIAMBU TOWN		
24/4/14	KIBERA SOWETO 37	KIBERA	5,000,000	
25/4/14	KIBERA OLYMPIC 38	KIBERA	700,000	
25/4/14	DAGORETTI CORNER 39	DAGORETTI NGANDO ~~CORNER~~	40,000	
26/4/14	HOG CENTRE KAREN 40	HOG CENTRE KAREN	120,000	
26/4/14	MARTHER LAND HOUSE 41 NAATHARE NORTH	MATHARE NORTH	600,000	
27/4/14	KASARANI 42	KASARANI		
27/4/14	NAIROBI WEST PRISON 43	NAIROBI WEST PRISON	200,000	
29/4/14	KAYOLE SOWETO 44	KAYOLE SOWETO	30,000	
27/4/14	KWA MBAO ~~KAMUKUNJI~~ 45	KAMUKUNJI SOUTH	40,000	
28/4/14	MUKURU KWA NJENGA 46	MUKURU KWA NJENGA	500,000	
30/4/14	TETRA PARK SHANTIES 47	TETRA PARK SHANTIES	1,000,000	
3/5/14	NEAR EQUITY LIFE ~~STAGE~~ 48	NJIRU LANE	40,000	
4/5/14	CITY STADIUM 49	CITY STADIUM	100,000	
9/5/14	UTHIRU/RIRUTA 50	UTHIRU/RIRUTA	200,000	
10/5/14	KIBERA SOWETO 51	KIBERA SOWETO	400,000	
12/5/14	GIKOMBA MARKET 52	GIKOMBA MARKET	2,000,000	
17/5/14	NEAR SCAN CITY ~~EASTLEIGH SEC~~ 53	EASTLEIGH SEC III	100,000	
18/5/14	KAREN HAKUMATT 54	KAREN SHOPING CENT.	45,000	
21/5/14	RUNWAY DUTY 55	MERU ROAD	800,000	
23/5/14	KIBERA OLYMPIC 56	KIBERA OLYMPIC	30,000	

NAIROBI CITY COUNTY FIRE BRIGADE

E.	INCIDENT (FIRE)	LOCATION	PROPERTY LOSS (KSHS)	LIVES LOSS
24/5/14	PCEA CHURCH NEAR 57	KOROGOCHO	200,000	
24/5/14	PLAIN VIEW PRI. SCHOOL 58 (GLASS FIRE)	SOUTH B		
29/5/14	STOREY BLD EASTLEIGH 59	11TH STREET EASTLEIGH	1,000,000	
30/5/14	NEAR OIL LIBYA PETROL 60	JUJA ROAD	1,200,000	1 ADULT MALE
31/5/14	KCC VILLAGE 61	KANGUNDO ROAD	500,000	
31/5/14	KARIOBANGI NORTH 62	KARIOBANGI NORTH	40,000	
1/6/14	BETHANY CHURCH 63	MATHARE NORTH	1,500,000	
2/6/14	MARBLE COURT HOUSE 64	WESTLANDS	2,000,000	
2/6/14	MOTOR VEHICLE FIRE 65	LANGATA NGEI ESTATE	3,000,000	
3/6/14	NEAR HOLY TRINITY 66	KISERA	200,000	
4/6/14	KAREN SHOPPING CENTRE 67	KAREN SHOPPING CENTRE	500,000	
7/6/14	CLEANWAY DRY CLEANERS 68	ROAD A INDUSTRIAL AREA	100,000	
9/6/14	TSIELMA RESTAURANT 69	BEHIND OLD NATION	30,000	
11/6/14	MUKURU KWA RUEBEN 70	MUKURU KWA RUEBEN	200,000	
11/6/14	MOTOR VEHICLE FIRE 71	MUSEUM HILL RD	4,000,000	
15/6/14	MUKURU KWA RUEBEN 72	MUKURU KWA RUEBEN	8,000,000	
19/6/14	TEMPORARY STRUCTURE 73	MATHARE RD TENA ESTATE	30,000	
21/6/14	HSE BLOCK NO. 149 74	SHAURI MOYO	200,000	
22/6/14	STOREY BUILDING 75	BIASHARA DOGO	1,200,000	
23/6/14	MATHARE MASHIMONI 76	MATHARE SLUMS	400,000	
24/6/14	RELIABLE ELECTRICALS 77	ROAD C IND. AREA	500,000	
27/6/14	AGRINER DEV. COMPANY 78	JAMHURI SHOW GROUNDS	50,000	
30/6/14	REFUSE FIRE 79	KIAREN		
30/6/14	TEMPORARY STRUCTURE 80	KISERA SIRANGA	200,000	
4/7/14	TEMPORARY STRUCTURES 81	NURUMA FLATS	88,000	
5/7/14	HAPPY FRIENDS CHAT 82	SOUTH C	100,000	
6/7/14	ELECTRICAL METER BOX 83	ZIMMERMAN ESTATE		
6/7/14	DORMITORY FIRE 84	MOI FORCES ACADEMY	150,000	
7/7/14	TAFINY BAR 85	KIAMBU STREET	60,000	
8/7/14	JOLLY BIRD CAFE 86	RIVER ROAD	35,000	

NAIROBI CITY COUNTY FIRE BRIGADE

DATE	INCIDENT (FIRE)	LOCATION	LOSS OF PROPERTY (KSHS)	LOSS OF LIVES
7/7/14	KINGS KITCHEN COMPANY 87	ROAD C INDUSTRIAL AREA	5,000,000	
8/7/14	MATHARE 4A 88	MATHARE 4A	600,000	
9/7/14	MUKURU KAIYABA 89	MUKURU KAYAKA	900,000	
9/7/14	REGAL PLANT COMPANY 90	MOMBASA ROAD	800,000	
10/7/14	GACHIE POWER AREA 91	GACHIE	200,000	
12/7/14	JEFF GUEST HOUSE 92	SOUTH B SHOPPING CENT.	40,000	
14/7/14	NGONDO FIRE 93	DAGORETTI	150,000	
15/7/14	STOREY BUILDING 94	KAMUNDE ROAD	120,000	
24/7/14	KARIOBANGI LIGHT IND. 95	KARIOBANGI NORTH	700,000	
28/7/14	KINYAGO SLUM 96	KINYAGO SLUM	50,000	
29/7/14	DANDORA II 97	DANDORA III	60,000	
31/7/14	RESIDENTIAL HSE 98	LAVINTONE	5,000,000	
2/8/14	SINAI CRESCENT 99	SINAI CRESCENT	160,000	1 FEMALE ADULT
3/8/14	ISIOLO RD TRANSFORMER 100	ISIOLO ROAD		
3/8/14	MARINGO HSE FIRE 101	MARINGO NEAR HURUMA	Girls 1,300,000	
5/8/14	KIAMARIGA WORKSHOP 102	KARIOBANGI LIGHT IND.	2,000,000	
7/8/14	KIALOLENI HSE FIRE 103	KIALOLENI ESTATE	170,000	
11/8/14	MOI NAIROBI INSTITUTE 104	RURIHAM ESTATE	200,000	
13/8/14	REFUSE FIRE 105	KITASURU ESTATE		
14/8/14	~~KITASURU ESTATE~~ TEMPORARY STRUCTURE ~~MATHARE NO. 10~~ 106	MATHARE NO. 10	700,000	
16/8/14	ROYAL MILLER FACTORY 107	RUAKA SHOPPING CENTRE	1,000,000	
17/8/14	MOTOR VEHICLE FIRE 108	WAIYAKI WAY	2,000,000	
19/8/14	SLUM FIRE 109	IMARA DAIMA EST.	30,000	
19/8/14	SINAI SLUM 110	SINAI LUNGA LUNGA	60,000	
20/8/14	~~HOUSE~~ BUILDING 111	ZIMMERMAN	500,000	
20/8/14	BUILDING DANDORA 112	DANDORA PH. I	400,000	
21/8/14	KIAWAS HOTEL 113	LATEMA/RIVER RD	80,000	
22/8/14	~~REFUSE~~ GRASS FIRE 114	NEAR E.A. BREWERIES		
24/8/14	SUMMIT HOUSE 115	UNIVERSITY WAY		
27/8/14	RUTUTEMA/RESTAURANT 116	NGONG SHOPPING CENTRE	1,200,000	
27/8/14	RAT FLAT 117	SIAKURU MOYO	1,500,000	

NAIROBI CITY COUNTY FIRE BRIGADE

DATE	INCIDENT FIRE	LOCATION	LOSS OF PROPERTY KSHS	LOSS OF LIVES
28/8/14	NAIROBI COUNTY HSE 118	ALCOMBA	2,000,000	
29/8/14	Kenyon College 119	Laboema Road	35,000	
31/8/14	Grogon Road Kiosk 120	Grogon Road	50,000	
31/8/14	Accra Exhibition 121	Accra Road	500,000	
21/9/14	Southlands cafe & Chemist ceiling 122	Kitengela Road		
2/9/14	KPLC Sub-Station 123	Enterprise Road		
3/9/14	Swala hotel 124	Magadi Road	2,000,000	
3/9/14	Bazaar plaza 125	Moi Avenue		
6/9/14	Dormkoth near Caltex filling station 126	Outerling Road	2,000,000	
7/9/14	NAIVAS SUPERMARKET 127	OPP. GSU TRAINING SCH	5,000,000	
8/9/14	PACIFIC HOTEL 128	TOM MBOYA STREET	400,000	
9/9/14	HURUMA HSE FIRE 129	HURUMA SPORTS GROUND	1,500,000	
11/9/14	MUKURU KWA NTENG 130	MUKURU KWA NJENGA		
12/9/14	~~Fat~~ SCRAP METAL 131	TELLOM EXCHANGE KILIMANI		
14/9/14	SOUTH B SHOPPING CENTRE 132	SOUTH B SHOPPING CENTRE	300,000	
15/9/14	LOWEN KABETE HSE FIRE 133	NEAR GACIO PRI. SCHOOL	200,000	
18/9/14	KARINGA BAR FIRE 134	JERUSALEM SHOPPING CENTRE	150,000	
23/9/14	~~JUJA RD HSE~~ FIRE KIAMBU ROAD 135	~~CHOMAZON OFF JUJA RD~~ MAKOYETI WEST		
26/9/14	HALAI ESTATE 136	HALAI ESTATE	200,000	
26/9/14	GIKOMBA MERCHANTILE FIRE 137	GIKOMBA	500,000	
28/9/14	RUIRU BY PASS HOUSE 138	RUIRU BY PASS	2,500,000	
29/9/14	LATEST INTERNATIONAL INVESTMENT 139	LIKONI ROAD	200,000	
30/9/14	MATHARE 4B 140	MATHARE 4B	500,000	
1st/10/14	Buruburu shopping centre 141	Buruburu	500,000	
2/10/14	Race Course Shanties fire 142	Old Race course	300,000	
2/10/14	Eva's cafe 143	Mjangano & Haile Selasie	250,000	
3/10/14	Savana Estate House Fire 144	Savana Estate	30,000	
4/10/14	Hazina masai slum 145	Hazina	2,400,000	
			500,000	

NAIROBI CITY COUNTY FIRE BRIGADE

	INCIDENT (FIRE)	LOCATION	COST OF PROPERTY (KSHS)	LOSS OF LIVES
1/10/14	specialized Fibre glass	Kibui Road	20,000000	
13/10/14	Food Kiosks/ Workshops	Makongeni shanties	400,000	
16/10/14	Gikomba Market	Near Family Bank	2,000 000	
18/10/14	K-A Building fire	South B.S. centre	200,000	
20/10/14	Nikana supermarket	Jogoo Road	200,000	
22/10/14	Shanties on fire	Mathare 4 A	400,000	
24/10/14	Ruai Shopping Centre	Ruai shopping Centre	100,000	
25/10/14	KIKUYU GARDEN HOTEL	KIKUYU TOTOTO Rd.	250,000	
26/10/14	KENYA DEFENCE FORCES CANTEEN	MOI AIR BASE	1,500,000	
3/11/14	TOY MARKET (STORE)	TOY MARKET	60,000	
3/11/14	TSAVO ~~DISHES~~	TSAVO ROAD	30,000	
6/11/14	KAWANGWARE CONCO	KAWANGWARE CONCO	100,000	
8/11/14	DONHOLM STOREY BLD.	DONHOLM ESTATE	200,000	
8/11/14	THEATERS 888 CENTRE	MUINDI MBINGU ST.	1,000,000	
9/11/14	HOMA CITY STADIUM (BLD)	CITY STADIUM	120,000	
13/11/14	BURHANI PAPER & STATIONERS	ACCRA ROAD	300,000	
15/11/14	MUKURU KWA RUBEN	MUKURU KWA RUBEN	200,000	
17/11/14	STAGE CAFE MAHANI HSE	KEEKOROK ROAD		
22/11/14	DODI COMPANY	RUNYENJES ROAD	1,500,000	
24/11/14	MATHARE KOSOVO	MATHARE KOSOVO	70,000	
26/11/14	CITY PARK STAFF HSE	CITY PARK	50,000	
29/11/14	KAWANGWARE ~~ESTATE~~ BUILDING	KAWANGWARE ESTATE	80,000	
1/12/14	OLE SOI SLUM	LUNGA LUNGARD	190,000	
1/12/14	GENERAL PLASTIC LTD	ENTERPRISE ROAD	90,000	
2/12/14	KIBERA MASHIMONI	KIBERA MASHIMONI	40,000	
5/12/14	MATHARE AREA 4	MATHARE AREA 4	100,000	
7/12/14	BARCELONA BASE CLUB	KAHAWA	80,000	
9/12/14	MUSLIM SEC. SCHOOL	AMBIRA ROAD	80,000	

NAIROBI CITY COUNTY FIRE BRIGADE

DATE	INCIDENT (FIRE)	LOCATION	LOSS OF PROPERTY	LOSS OF LIVES
12/12/14	TEMPORARY STRUCTURES	HAILCO ROAD	50,000	
12/12/14	LANGATA HSE FIRE	LANGATA BARACK	100,000	
15/12/14	OCA TYRES (UNUSED)	DESAI ROAD		
17/12/14	U.A.P GODOWNS	LUNGA LUNGA RD.	800,000	
20/12/14	NGEI II ESTATE	NGEI II	180000	
21/12/14	NGARA OPEN AIR MKT	NGARA OPEN MKT	150,000	
25/12/14	MUKURU KWA NJENGA	MUKURU KWA NJENGA	160,000	
27/12/14	KIBERA HIGH RISE	KIBERA HIGH RISE	120,000	
30/12/14	SHREE HOLDING LTD	MOMBASA ROAD	160,000	
31/12/14	GITHURAI HSE FIRE	GITHURAI NEAR UNCLE SAM	180,000	

Evans Akado

Evansakado@gmail.com

29th April Folder Paste

6 May — Presentation

30th April

Docking station for silicon-based Intelligent systems

Waste water will be regarded with the same horror that we now regard the spilling of blood.

3. **Questionnaire**

1.0 Objective

To demonstrate the use of GIS Technology to enhance efficiency on Fire Control services, in Nairobi County.

1.1 Specific Objectives

To seek and explain how fire services are provided in Nairobi County.

To establish the effect of applying GIS technology in the provision of fire services in Nairobi County.

To provide recommendations to the policy makers on the use of GIS on fire control in Nairobi County.

1.2 Interview questions

a) To seek and explain how fire services are provided in Nairobi County.

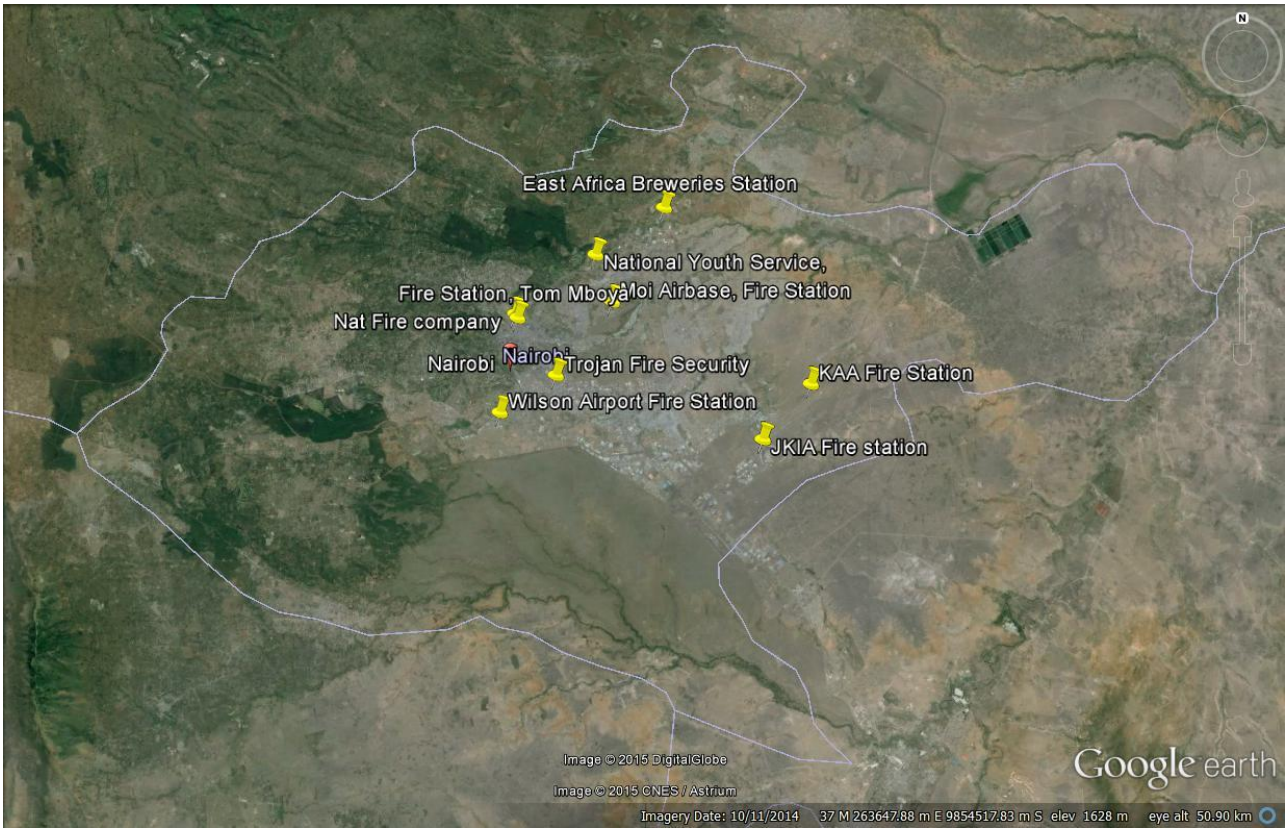
1. What type of fire services do you provide as a fire control department/agency?
2. How do you get informed of fire incidents when they occur?
3. How long do you take to arrive at incident sites?
4. Who pays for the expenses incurred during the fire incident operations?
5. How many incidents of fire breakouts do you attend to in a month?
6. How is the Fire control system integrated with the other supportive systems of the County?
7. What type of data do you collect from the incident site after the operation sessions?

b) To establish the effect of applying GIS technology in the provision of fire services in Nairobi County.

1. What kind of systems and programs do you use in your fire control operations?
2. What type of programs do you use?
3. How do you view your effectiveness in provision of fire control services?

4. Google Images

a) Fire Stations



b) Major Hospitals