University of Nairobi

School of Engineering

A WEB-BASED SPATIAL MANAGEMENT INFORMATION SYSTEM FOR INSTITUTIONS OF JUSTICE IN NAIROBI CITY COUNTY.

BY

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A research submitted in partial fulfillment of the requirements for the degree of Master of Science in Geographic Information Systems, in the Department of Geospatial and Space Technology of the University of Nairobi.

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Declaration

I, Ruth Kamunya, hereby declare that this project is my original work. To the best of my knowledge, the work presented here has not been presented for a research project in any other university.

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Name of student	Signature	Date

This project has been submitted for examination with my approval as university supervisor(s).

DR. –ING S.M MUSYOKA	……..…….	……
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Name of supervisor	Signature	Date

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List of Acronyms

GIS	Geographic Information Systems
KHRC	The Human rights institutions like the Kenya Human Rights Commission.
KNCHR	Kenya National Commission on Human Rights
NPSC	National Police Service Commission
GPS	Global positioning system
JLOS	Justice Law and Order Sector
JLO	Justice, Law and Order
ESRI	Environmental Systems Research Institute
GoK	Government of Kenya
GoU	Government of Uganda
MIS	Management information systems
IEBC	Independent Electoral and Boundaries Commission
ICT	Information and Communication Technology
IT	Information Technology
HTML	HyperText Mark-up Language
CBD	Central Business District
INGO	International non-governmental organization
NGO	Non-governmental organization
WWW	World Wide Web
URL	Unified Resource Locator
CGIS	Canada Geographic Information System
US	United States
CERES	California Resources Agency Program
M&E	Monitoring and Evaluation

Abstract

The manner in which geographic data is acquired, processed and applied continues to change with advancing technology. This study focused on the development of a web-based spatial management information system for the justice institutions in the Nairobi City County. The overall objective of the study was to develop a web-based spatial management information system for the institutions of justice in Nairobi City County.

The study area was Nairobi City County, and the institutions of interest were the police, prisons, courts, civil societies and the human rights commissions. The data was acquired from direct field visits to these institutions of justice, through which comprehensive attribute data for all these features was developed. Administrative boundaries data was also used, most of it coming from the Independent Electoral and Boundaries Commission (IEBC). Nairobi Population data was also used which was sourced out from the Kenya 2009 Census data. Smart mobile phone handsets were used to collect data from these institutions. Data collected was edited, verified before uploading it on the on the Justice, Law and Order (JLO) database. HyperText Markup Language (HTML) was used to create a front-end user interface. Google Maps JavaScript Application Programming Interface (API) was used to embed maps on the web pages. ArcGIS online was used as the web-GIS application with a six months online subscription.

The final output was a web-based spatial management information system that displays layers of the institutions of justice in Nairobi City County, with added functionality such as pan, zoom and query. Analysis of the population of these institutions verses the population of the Nairobi City County residents was conducted, analysis of the various resources at the disposal of these institutions was also carried out.

The finding of this study was that GIS is a viable proposition for use with institutions of justice, and a web-based spatial MIS adds value in the management of information. The web-based MIS provided a suitable option for performing analysis, presenting information and sharing information with the interested stakeholders within the justice system.

With the current trend in Information and Communication Technology (ICT) there is more adoption of the web technology due to ubiquitous access and also due to the low cost of ownership of internet-based solutions.

CHAPTER 1: INTRODUCTION

1.1 Background to the study

As we look into Kenya's Development blueprint – Vision 2030 and into the three main pillars that the vision is anchored on; Economic, Social and Political Governance, we can only conclude that the vision is focused on having a better society than the one we are living in now. Geographic Information System (GIS) is widely used in the three pillars of the vision 2030 and in this case we will look into detail the use of GIS in the three pillars;

a. First we have the economic pillar. GIS can be used in mapping and managing business activities. It can be used to map revenue collection and allocation, tourism industry performance, agricultural practices and patterns, and in the manufacturing sector.
b. In the social pillar, GIS can be used in the planning and management of education, health care, housing and urbanization, environment and also poverty elimination.
c. In the political pillar, we discuss the use of GIS in justice delivery to the people. Under this pillar we find discussions in the areas of conflict management and resolution, the electoral process and also the transparency and accountability visions.

The proposed area of study is the Nairobi City County. Nairobi City County is also the capital city of Kenya with an estimated population of 3.138 million (Kenya National Bureau of Statistics (KNBS), 2010) and seats on an area of 696 $Km^{2.}$ The study will focus into understanding how the various institutions of justice work together and how GIS can be used to accelerate justice. By first understanding how the institutions of justice work together, there will be need to clearly demonstrate where and how the various institutions work and their mandate. This is a timely study in the County and country at large as it is with this web-based system that the various stakeholders will be informed of the spatial distribution of the various institutions of justice in the County at a glance through the web view. With quality and quantity information, we find that the courts of justice will be aware of the police systems infrastructure and that of the prison systems too. The human rights commissions and the civil societies who are the watchdogs of these institutions will have current and updated information on the status of these institutions giving them an opportunity for them to be advisors on infrastructure improvements for the purpose of justice delivery in the Nairobi City County.

A Geographic Information System is a system that lets us visualize, question, analyse, and interpret data to understand relationships, patterns, and trends. GIS is now more than even being used to better decision making, for improved communication, for better record keeping, cost saving from better efficiency and also managing geographically (ESRI, 2015).

A web-based GIS is an online tool that performs the GIS functions on spatial information over the internet and that provides access to the information with added functionality such as the ability to query and zoom interactive maps. Visualization on web-based GIS can be provided in three ways; static map renderers, slippy maps, and also through flash mapping.

In using web-based GIS to map the institutions of justice, the study aims at exposing the need to have a management information system whereby all these institutions can better themselves in the delivery of justice within the Nairobi City County.

1.2 Problem Statement

There are several institutions of justice in Kenya and specifically in the Nairobi City County, and these institutions may not have spatially collated information that is updated centrally, and if the data is there, it is not centrally shared and accessed. As a result of this understanding, there is need for the development of a web-based spatial management information system that is constantly updated and also collated and available on the web for easy access by all the stakeholders.

The prison services, police service, the judiciary, civil societies and the human rights commissions will benefit from a spatial management information system that is elaborate in terms of both the spatial and non-spatial attributes description, creating some level of transparency and also information availability to the stakeholders who make decisions on the operations of the justice delivery in the county. The police services management will be able to plan better on the expansion plans as they will have a better idea of the population pattern of all the police stations and other institutions that are of interests to them like the prisons and the courts.

1.3 Objectives of the study

1.3.1 Overall Objective

The overall objective of this study is to develop a web-based spatial management information system for the various institutions of justice in the Nairobi City County.

1.3.2 Specific Objectives

1. To map and develop a centralized geodatabase for the institutions of justice in the Nairobi City County.
2. To publish and share the management information system on ArcGIS Online.
3. To perform spatial analysis for decision making by the various institutions of justice.

1.4 Justification for the Study

The institutions of justice are institutions that are charged with a very high responsibility of justice delivery to the people. This is a task that is of high mandate and can be aided further with the assistance of a web-based spatial management information system that will create a portal where all these institutions have most and current records of their institutions' human resource capacities and all other resources at their disposal. The policy makers and planners have access to the most precise and current information about these institutions giving a good basis to plan and budget on guided information as they will be able to evaluate the population of the people visa vice the spatial distribution of these resources through-out the Nairobi City County.

The advantages of viewing data in form of a map compared to tabular data will be achievable through the digitization of these institutions' locations and through their descriptive non-spatial data that the study will try to achieve by visualizing all these institutions on a web-based GIS.

Some of these advantages are;

a. Operational awareness is created by supporting a comprehensive, relevant view into the institutions' activities.
b. Information integration and analysis is achieved by managing data effectively and reducing information overload.

c. Strategic and tactical planning is achieved by creating more opportunities for proactive policing through analytic tools.
d. Field mobility is realised by providing a platform for data and information exchange into and out of the field thus creating the capability of always having an updated database with information from all the institutions.

1.5 Scope and limitations of the study

This study will only cover the Nairobi City County and will look into the mandate of the following institutions;

a. The Kenya Police System that includes the provisional police, to community policing centres.
b. The Kenya Prison System that has what is referred to as the main prisons, the medium-term prisons and juvenile, remand prisons.
c. The Judiciary that comprises the high courts, supreme courts, industrial and commercial courts, not to mention the Kadhi courts.
d. The Human rights institutions like the Kenya Human Rights Commission (KHRC), Kenya National Commission on Human Rights (KNCHR).
e. Civil society organizations with offices of operations within the Nairobi City County.

These institutions are however in existence in all the other counties of Kenya but owing to the limited time and scarcity of human, financial and material resources, the scope is objectively narrowed down to the development of a web-based spatial Management Information System (MIS) for the same institutions within the boundaries of the Nairobi City County. These include maps for the prisons, the police stations and posts, the courts, the human rights commissions and the last the civil societies. With use of the mobile phone collector application the GPS coordinates of these features are picked on a real-time basis at the point of data entry.

It is very important to note that as a country we are facing tremendous challenges with the insecurity heightened levels in the past months and this has greatly affected the process of data collection due to restricted access into some of these institutions namely the police stations/posts and the prisons. Even with the necessary introductory and supporting documents, the security personnel remained very reluctant in issuing any data/information that was necessary for the

comprehensive coverage of this study, but reference was made where possible to historical data to try and fill the gaps between the available and missing data.

1.6 Organization of the Report

This report is organized in five chapters. Chapter one generally presents the background to the study, problem statement, justification of the study, objectives, scope and limitations. Chapter two provides a review of the literature that is relevant to this study. Chapter three details the methodology used during the study. Chapter four presents the results and discussions from the study, and lastly we have chapter five that puts forward the conclusions and recommendations that accrue from the study.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

This chapter introduces a review of literature as a background to institutions of justice. The chapter will also focus on GIS and web GIS in relation to the development of a web-based spatial management information systems for the institutions of justice.

2.2 Introduction into the justice system in Kenya

In August, 4th 2010, the new constitution was promulgated; a constitution that was widely and well received by the people of Kenya. If we look into various chapters of these constitution we can relate them to the justice system in the country and specifically in chapter four; the Bill of Rights; Part 1- General provisions relating to the bill of rights and specifically Section 48 that highlights on access to justice, stating that 'The State shall ensure access to justice for all persons and, if any fee is required, it shall be reasonable and shall not impede access to justice' (Constitution of Kenya, 2010). In section 49 it goes on to elaborate further the rights of arrested persons.

In the Judiciary Transformation Framework 2012-2016 Report, we find that the judiciary is dedicated into bringing change into the judiciary as they execute their mandate. Their mandate amongst others is to expeditiously administer justice to all irrespective of status, to protect and promote the purpose and principles of the constitution 2010 and to promote other forms of dispute resolution including reconciliation, mediation, arbitration, and even traditional forms of dispute resolution mechanisms.

When we look into the police force, numerous effort and investments has been noted in this line of justice delivery. We have the National Police Service Commission (NPSC) in exercise of its mandate and in line with the provisions of the Constitution as outlined in Article 246 (3). NPSC is charged with the responsibility of police officers recruitment, manage transfers and promotions, exercise disciplinary control over and remove persons holding or acting in offices within the service. This process will ensure competent workforce in the police system at all times.

The prison service systems are also institutions of justice delivery and with the Prison Act in the Constitution (Chapter 90), we can see what is expected of the prison officers and the rights of the inmates as well.

The human rights commissions are institutions that exist with a mission to foster human rights, democratic values, human dignity and social justice. This in most cases is achieved through multiple strategies and actions aimed at entrenching human rights and democratic values in the society by facilitating and supporting individuals, communities and groups to claim and defend their rights and holding state and non-state actors accountable for the protection and respect of all human rights for all peoples and groups. They act as a watch-dog over the Government in the area of human rights. They also provide a key leadership role in moving the country towards a human rights state.

2.3 Geographic Information Systems (GIS)

Geographic Information Systems (GIS) is a computer system for capturing, storing, checking, and displaying data related to positions on earth's surface. GIS can show many different kinds of data on one map. This enables people to more easily see, analyse, and understand patterns and relationships. GIS also refers to a system of hardware, software and procedures that capture, store, edit, manipulate, manage, analyse, share and display georeferenced data (Fu and Sun, 2011).

GIS technology has been in existence well before the emergence of the Internet and the World Wide Web (WWW). It was developed in 1962 by Roger Tomlison for the Canada's Federal Department of Forestry and Rural Development. At the time, it was called the Canada Geographic Information System (CGIS) and was used for Canadian land inventory and planning.

GIS is used to produce a wide range of maps but its capabilities go beyond mapping. It offers a rich set of analytical functions that can reveal hidden relationships, patterns ad trends that are not readily apparent, enabling people to think spatially to solve problems and make smart decisions (Fu and Sun, 2011)

With regards to needs assessment, ESRI (2015) notes that GIS generated maps are an important tool that helps to bring to light unmet needs and overlapping or redundant services through such GIS functions as thematic mapping and geo-coding locations of existing service centres for mapping and proximity analysis. On the other hand, for communication and reporting process, interactive maps from a GIS, enables programme management, policy makers and the public to stay informed about the progress made in meeting programme goals. Inclusion of GIS in mapping of institutions of justice and service delivery could have direct benefits since the processes described in this example are core to their work.

2.3.1 Web GIS

Web GIS is a GIS system that uses web technologies to communicate among different components of the system. In the architecture of Web GIS, at least one client and one server should be in existence as illustrated in Figure 1 below. The Internet supports many services with the web being one of these services. An internet GIS that only uses web is known as a web GIS.

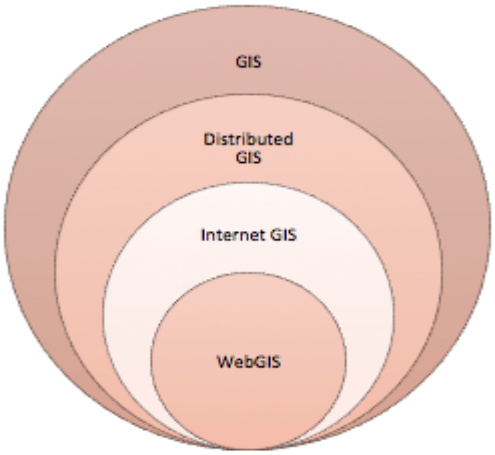

Figure 1: Web GIS and GIS Comparison

(Source: Morais, 2012)

Web GIS originates from a combination of web technology and the Geographical Information System, which is a recognized technology that is mainly composed of data handling tools for storage, recovery, management and analysis of spatial data Web GIS is a kind of distributed information system which in its simplest form is composed of at least a server and a client where

the server is a web application server, and the client is a web browser, a desktop application, or a mobile application as shown in **Figure 2**.

Figure 2: Architecture of Web GIS

(**Source**: Schnell Informatics http://schnellinformatics.com/webgisServices.html)

2.3.2 Why the use of Web GIS?

In recent years, the Unite States correctional institutions have begun exploring ways GIS can assist their daily operations. California is one of the first states to create a GIS dataset (a part of the database). It is a part of the California Environmental Information Catalog, which is a Web-accessible database of environmental data and information resources for California. It was developed through a collaborative effort with the California Geographic Information Association, California Resources Agency Program (CERES), and the Federal Geographic Data Committee to encourage data sharing by providing an easy way to create and share descriptions of data resources. It contains information about the California prison location and youth correctional facilities locations, including addresses, name of the city and the number of prisoners. California adult correctional facilities were mapped using GIS to aid local planning departments by providing the data on prisons and prisoners *(*Teale GIS Solutions Group, 1997*).*

2.3.3 Benefits of using web GIS

Web GIS allows visual interaction with data, maps and charts published on the internet. Users can view these updates on a timely seamless manner making it an efficient decision making tool.

Due to the ubiquitous nature of the internet, data can widely available and whenever you need it and you don't have to wait for someone to make it available. These makes it very efficient in sharing data that needs to be easily available to the end users.

The use of web GIS also cuts down on the costs of purchase of the expensive GIS applications, implementation and in most cases the licensing and the service and maintenance costs.

2.3.4 Esri ArcGIS Online

ArcGIS online is a product of Esri and it is widely used to create interactive web maps and applications that are easily and efficiently shared online, and no matter what you use - desktops, browsers, smartphones, or tablets you always have access to your content since ArcGIS online has developed with so much robustness that it is accessible from several platforms (Esri, 2015). ArcGIS Online provides ready-to-use base maps, tools, templates, and datasets making it easy to design and publish maps online. Not only does it provide ready to use functions, it also provides a location for online geographic resources.

ArcGIS is based on accepted IT standards and provides a high level of interoperability across platforms, databases, development languages, and applications. ArcGIS supports secure, reliable, and maintainable architectures and provides optimized performance, scalability, agility, and productivity.

Figure 3 below demonstrates how the users interact with the ArcGIS online portal as this is one of their online geographic resources.

Figure 3: An illustration of how the users interact with ArcGIS Online Portal

(**Source: Esri, 2015**)

2.4 Success stories on the application of web GIS

2.4.1 Justice Law and Order Sector mapping

Justice Law and Order Sector (JLOS) is a sector wide approach adopted by Government of Uganda (GoU) that brings together institutions with closely linked mandates of administering justice and maintaining law and order and human rights, into developing a common vision, policy framework, unified on objectives and plan over the medium term. JLOS focuses on a holistic approach to improving access to and administration of justice through the sector wide approach to planning, budgeting, programme implementation, monitoring and evaluation.

To enhance service delivery, the sector has focused attention on ensuring the existence of a complete chain of justice country wide. Building of this system involved the task of collecting spatial data on the physical presence of JLOS institutions with an aim of producing updated mapping of the sector institutions in both hard and soft form using Geographic Information System (GIS) offering robust capabilities to store, analyze, display, query and document geographical information relating to JLOS presence country wide, (URL: http://www.jlos.go.ug/).

Figure 4 gives an illustration of the police stations and posts in Uganda.

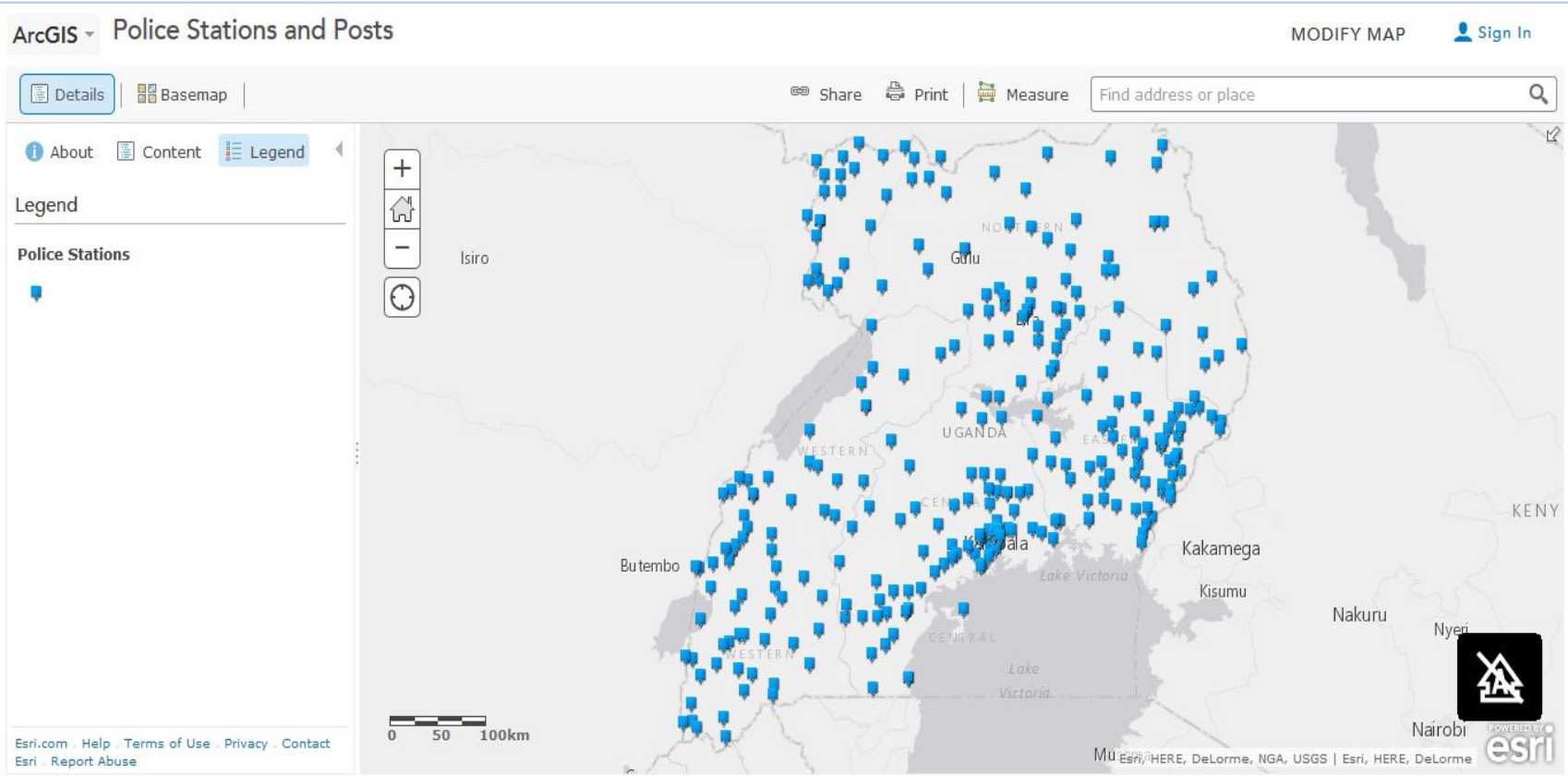

Figure 4: Map illustrating the JLOS mapping of Police Stations in Uganda.

JLOS has implemented a GIS Project that provides technology driven mapping of JLOS infrastructure in Uganda.

(Image: JLOS Media/GIS Project)

CHAPTER 3: METHODOLOGY

3.1 Introduction

This chapter highlights the various research methodologies in conducting the study and the techniques to be used in obtaining research data and how data was processed to obtain the subsequent recommendations. The aspects to be covered in this chapter include the description of the study area, data sources and tools, data collection, processing and analysis.

3.2 The study area

Nairobi City County is one of the forty seven counties in Kenya, bordering Kiambu, Machakos and Kajiado counties. Nairobi City County has seventeen sub-counties and several wards within these sub-counties. Figure 5 below is a map illustrating the extent of the study area.

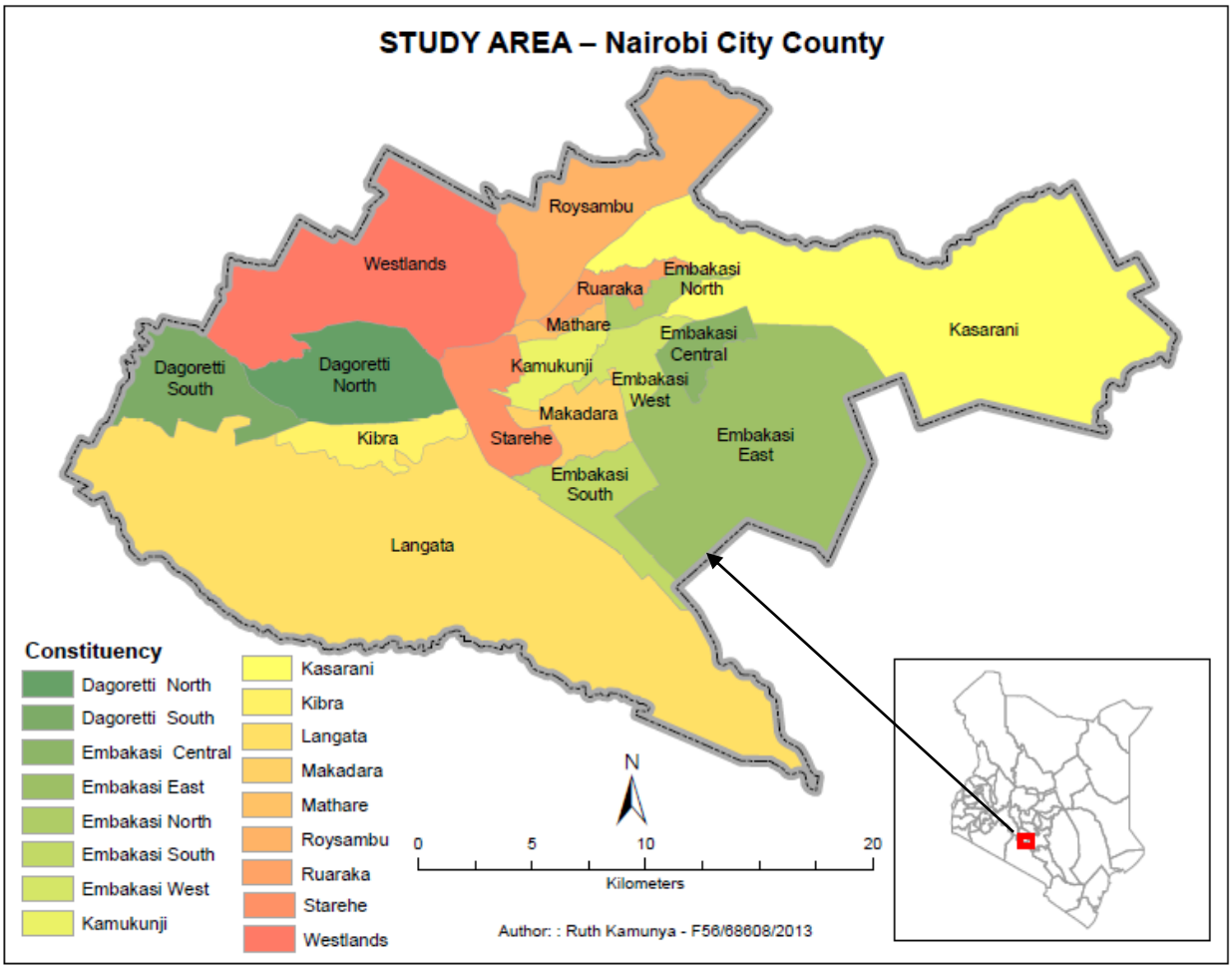

Figure 5: Study Area - Map of Nairobi City County

The proposed area of study is the Nairobi City County. Nairobi City County is also the capital city of Kenya with an estimated population of 3.138 million (Kenya National Bureau of Statistics (KNBS), 2010), seated on an area of 696 Km^2 and was founded in 1899. Table 1 below has listed down all the constituencies in the Nairobi City County and the wards within each of these constituencies.

Table 1: Sub-Counties and Wards in Nairobi City County

Constituency	Wards
Westlands	Kitisuru, Parklands/Highridge, Karura , Kangemi, Mountain View
Dagoretti North	Kilimani, Kawangware, Gatina, Kileleshwa, Kabiro
Dagoretti South	Mutu-ini, Ngand'o, Riruta, Uthiru/Ruthimitu, Waithaka
Langata	Karen, Nairobi West, Mugumo-ini, South C, Nyayo Highrise
Kibra	Laini Saba, Lindi, Makina, Woodley/ Kenyatta Golf Course, Sarang'ombe
Roysambu	Githurai, Kahawa West, Zimmermann, Roysambu, Kahawa
Kasarani	Clay City, Mwiki, Kasarani, Njiru, Ruai
Ruaraka	Babadogo, Utalii, Mathare North, Lucky Summer, Korogocho
Embakasi South	Imara Daima, Kwa Njenga, Kwa Reuben, Pipeline, Kware
Embakasi North	Kariobangi North, Dandora Area I, Dandora Area II, Dandora Area III, Dandora Area IV
Embakasi Central	Kayole North, Kayole NorthCentral, Kayole South, Komarock, Matopeni/ Spring Valley
Embakasi East	Upper Savanna, Lower Savanna, Embakasi, Utawala, Mihang'o
Embakasi West	Umoja I, Umoja II, Mowlem, Kariobangi South
Makadara	Maringo/ Hamza, Viwandani, Harambee, Makongeni
Kamukunji	Pumwani, Eastleigh North, Eastleigh South, Airbase, California
Starehe	Nairobi Central, Ngara, Pangani, Ziwani/ Kariokor, Landimawe, Nairobi South
Mathare	Hospital, Mabatini, Huruma, Ngei, Mlango Kubwa, Kiamaiko

3.3 Sources and Tools

3.3.1 Data Sources

This study uses both primary and secondary data, which are qualitative and quantitative in nature. The primary data is the data that will be originally collected by the researcher for the first time while in the case of secondary data the nature of the data is that it is already existing data. The collection of data involves the use of a mobile phone data collector application running on an Android smart phone. The type of data collected was both descriptive data and geographical coordinates of the various features under this study. With this tool, physical ground visits to the various institutions was done. The use of a well-defined data structure was used to clearly define the attributes of each feature under this study.

In Table 2 below, the various types of data collected, their sources and characteristics have been summarized and Table 3 clearly defines the software and hardware used and how they were used.

Table 2: Datasets: Sources and Characteristics

Data	Characteristics	Source of Data
Population data	Shape file of the population of Nairobi City County residents.	Kenya National Bureau Statistics(KNBS)
Administrative boundary maps 1. Kenya Counties 2. Nairobi City County 3. Sub-counties of Nairobi City County 4. Wards of Nairobi City County	Shape files of the Nairobi City County boundaries, the wards and sub-county maps.	IEBC
Point data for the institutions in this study; 1. Kenya police service centres 2. Kenya Prison services	The geographic coordinates (x,y) acquired at the point of data entry using the GPS enabled Android smart phones	Collected

3. Civil societies 4. Human rights and commissions 5. Courts		

3.3.2 Tools and Technology platform

Table 3: Hardware and Software used and their type of usage

Description	Type of usage
Hardware	
GPS enabled smart phone	Used to collect data on a real-time basis
Lenovo T420 laptop, i5 with Windows 7 Pro-64bit Operating system-SP2	Used to compile the report, to perform data entry and to also access the internet
DVD-4GB - rewriteable media	For storing and sharing the final reports and data with my supervisor.
Software	
Microsoft Office-2013 Professional	To generate reports using MS Excel, produced the final project report using MS Word, MS PowerPoint used in the preparation of the final PowerPoint presentation.
ArcGIS online	A subscription toe ArcGIS online was used to
ArcGIS Desktop 10.1	Used to generate web-based maps.
Google drive	This was used as cloud file storage throughout the project

ArcGIS Platform

The project made use of an ArcGIS platform which is a complete system for designing and managing solutions using geographic knowledge. It performs spatial analysis, allows stakeholders to gain a greater understanding of justice institutions and data allowing them to make more informed decisions.

ArcGIS will allow Justice Law and Order institutions to manage geospatial data and share capabilities throughout organization including:

- **In the cloud –** leverage GIS by publishing maps and data to the cloud. The end users can then access maps, data, and applications from a variety of devices without having to install software or worry about data management.
- **On the web –** GIS lets justice law and order institutions create web mapping applications that make it easy for stakeholders to access authoritative geographic information. Data can be published online and make it available to web, mobile, and desktop client applications. You can also search for, browse, and incorporate information that others have shared, creating mash-ups from shared services.
- **On desktops –** ArcGIS desktop applications will let justice institutions use predefined map and data templates that automate many aspects of cartography, helping with quick and comprehensive and functional maps. You can build models that help users scientifically analyze data for greater awareness and decision making. ArcGIS also helps you build geodatabases, manage geographic data, and edit data as it changes.
- **On mobile devices –** ArcGIS mobile applications gives these institutions immediate access to up-to-date information, regardless of their location.

ArcGIS for Desktop platform

ArcGIS for Desktop is the common authoring environment for maps and other geographic content. GIS professionals use ArcGIS for Desktop to compile and manage geodata and imagery, view data on maps and in 3D, perform powerful data analysis, and publish geographic content that can be shared with other users both within your organization and over the web.

ArcGIS for Desktop provides a broad set of authoring, editing, and analysis tools that turn your data into authoritative maps. These tools will help you:

- **Compile and manage data –** with support for more than 70 data formats, ArcGIS for Desktop helps you easily integrate and maintain your data and imagery. You can use ArcGIS for Desktop tools to create and manage geographic data, tabular data, metadata, data models, and schemas. Powerful editing tools let you manipulate your data interactively, automate editing workflows, improve data integrity, edit data concurrently with other users, and more.
- **Perform spatial analysis –** ArcGIS for Desktop includes hundreds of analysis tools that you can use to transform your data into actionable intelligence. These tools allow you to calculate density and distance, track statistical changes and trends, conduct overlay and proximity analysis, perform advanced surface analysis, examine and process imagery, identify locations that meet specific criteria, and more. Analysis can be done for individual datasets or run batch analysis on multiple datasets. And also create geo-processing models that chain multiple analysis methods together, or write analysis scripts using Python.
- **Visualize data using maps –** ArcGIS for Desktop helps to produce professional-quality maps that communicate your data in visual and intuitive ways. With ArcGIS for Desktop, you can use a large library of map symbols to identify features and attributes, include descriptive text or charts to present high-level detail, and load preset map templates to speed up production. Advanced drawing and cartographic tools help to create more sophisticated maps that tell more complex stories.
- **Share your findings –** ArcGIS for Desktop makes it easy to share this information by allowing map publishing of layers, geodatabases, imagery, analytic models, and locators using ArcGIS Online and ArcGIS for Server.

3.4 Data Collection

Using a GPS enabled smart phone, data was collected from the selected institutions of justice. This data was both qualitative and quantitative. Using an Esri ArcGIS application that is uploaded and installed on the GPS enabled smart phone, attributes of each institution were recorded, creating a record entry for each feature, one at a time. The attributes chosen for each

institution were based primarily on the type of information that is relevant to data analysis. A picture of the institution was also uploaded whenever possible. The same feature would reflect on the Institutions of Justice Nairobi City County web portal as per the geo-coordinates of that feature, as shown in Figure 6 below.

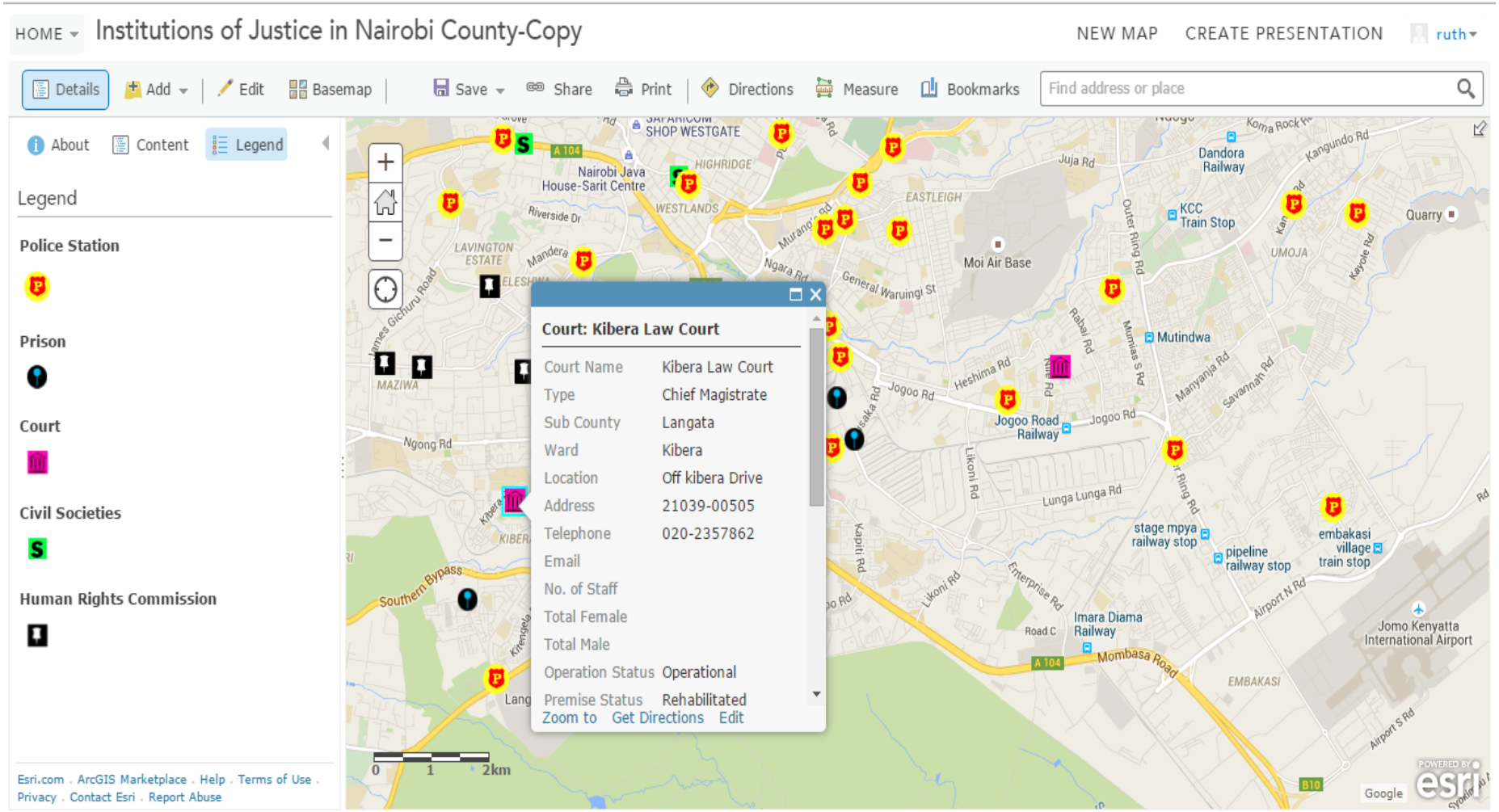

Figure 6: An illustration of Kibera Law Courts captured attributes

Methodology Flowchart Diagram

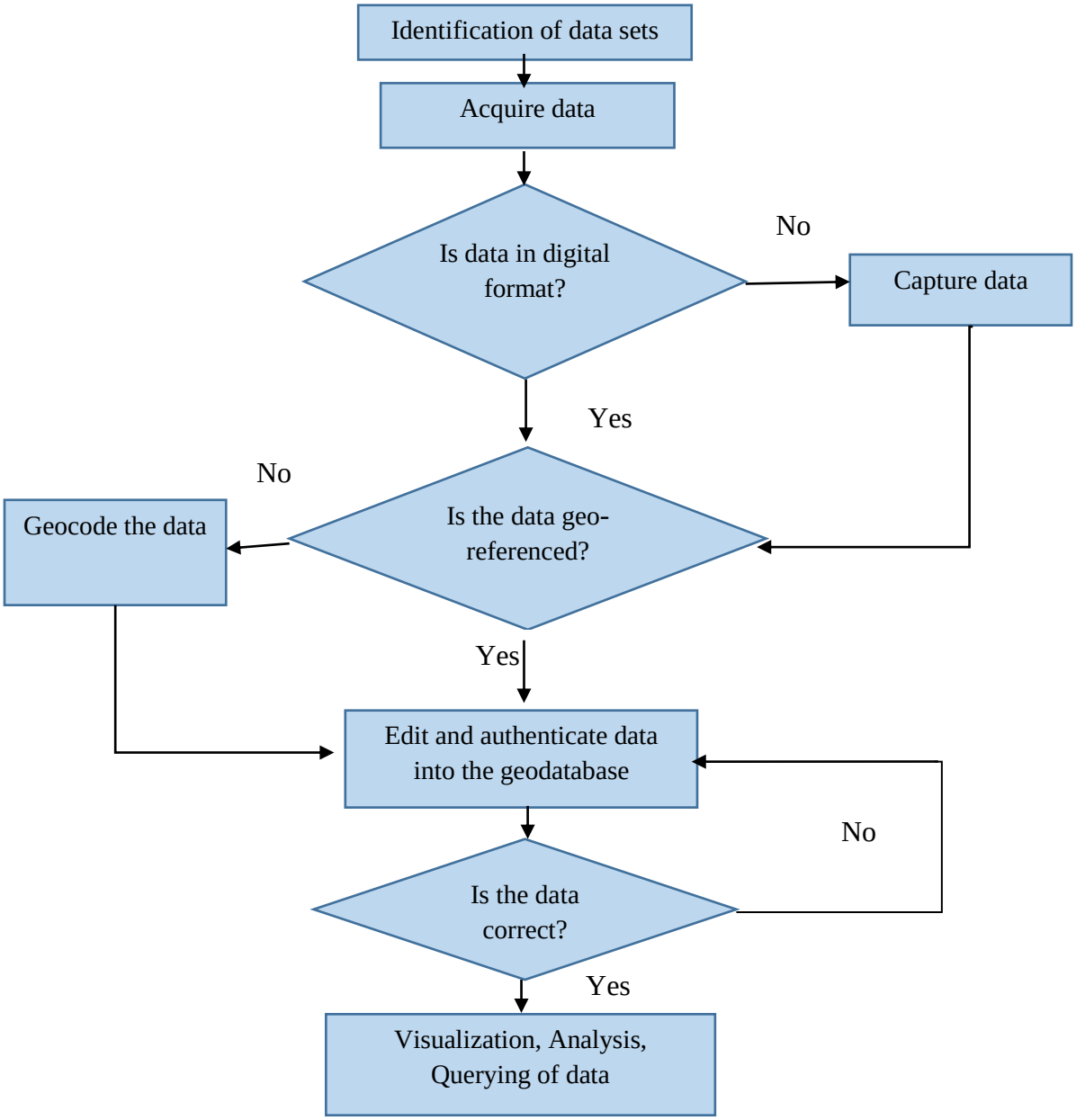

Figure 7: Methodology flowchart

3.5 Data Schema Creation

Database schema was created using File Geodatabase on ArcGIS for Desktop. A file geodatabase is a collection of files in a folder on disk that can store, query, and manage both spatial and non-spatial data. A file geodatabase can be used simultaneously by several users, but only one user at a time can edit the same data. Therefore, you can have multiple editors accessing a file geodatabase, but they must be editing different data as illustrated on Figure 8 below.

A geodatabase allows you to centrally store, manage, and maintain the quality of your GIS data. The geodatabase is the native data model for ArcGIS and extends the basic GIS storage model of using points, lines, and polygons to represent features.

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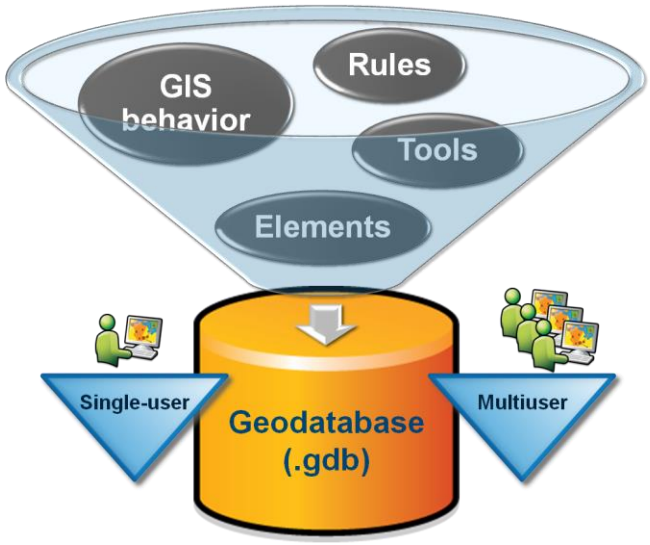

Figure 8: An illustration of a geodatabase

Inside the Geodatabase, feature classes of the justice institutions were created using Geographic Coordinate System WGS 1984 as shown in the Figure 9 below;

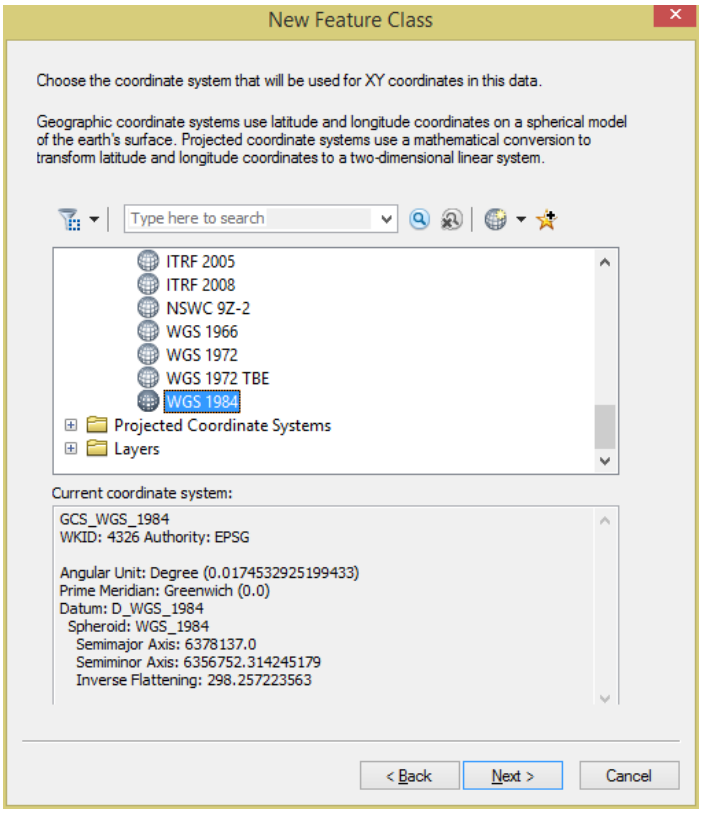

Figure 9: Creation of new feature classes

Attribute creation

Attributes were designed and documented on an Excel spreadsheet as shown in Figure 10. It documents the name of the feature class, geometry, domains, subtypes, required attributes, data type and description. Using this data, the feature class schema in the database was created and also the database behaviour such as domains (drop down menu) and subtypes.

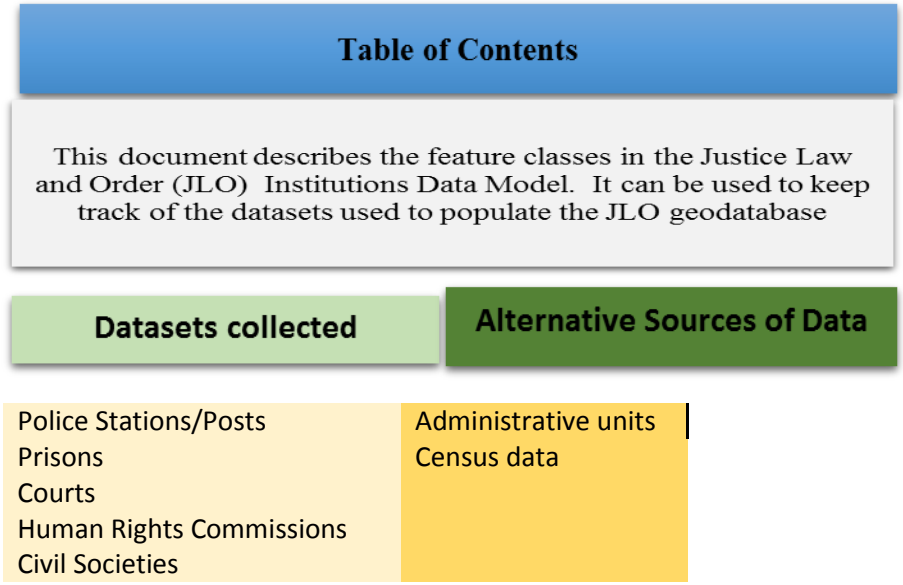

Figure 10: Table of contents for the datasets collected and the alternative sources of data

JLO Data Model									
Feature Class Name	**Geometry**	**Required?**	**Feature Types (Domain)**	**Sub Types**	**Required Attributes**	**DataType**	**Description**	**Preferred Data Source**	**Alternate Data Source**
Police Station	Point	☑						Field	N/A
		Primary Key			UniqueID	Text	Unique Identifier		
					StationName	Text	The name of the police station		
			Main station,police post		Feature Type	Text	Type of police station		
			Sub counties of Nairobi county		SubCounty	Text	Nairobi county subcounties		
			Wards of Nairobi county		Ward	Text	Nairobi county wards		
			Robbery with violence,petty theft,car ja		OccurrenceBook	Text	Occurrence book recordings of crime type		
					JLOSCode	Text	Unique JLOS code		
					Location	Text	The name of the place		
					Address	Text	Postal Address		
					Telephone	Text	PS Telephone number		
					Email	Text	PS Email Address		
					No_of_Staff	Long Integer	Number of staff		
					Female	Long Integer	number of female staff		
					Male	Long Integer	number of male staff		
			operational, gazetted but not operationa		OperationStatus	Text	operational or gazetted but not operational		
			Yes, No		ChildProtectionUnit	Text	Has child protection unit		
			Yes, No		GenderViolenceUnit	Text	Has gender violence unit		
			Yes, No		LegalMaterials	Text	Has reference legal materials		
			Yes, No		PoliceForms	Text	Has police forms		
					Vehicles	Long Integer	Number of Vehicles		
					MotorCycles	Long Integer	Number of Motor Cycles		
					Bicycles	Long Integer	Number of Bicycles		
					Photo	Text	Premise Photo		
					LastUpdate	Date	The last update date		
					Longitude	Double	Coordinates		
					Latitude	Double	Coordinates		

Table 4: Police stations data model structure

Using Microsoft Excel 2013, each feature class had an elaborate data model structure as is seen on Table 4 above. The data model above is for the Police station feature class.

And with an elaborate data model, the ArcGIS application was customized for each of the five features and their associative attributes, see Figure 11 and 12.

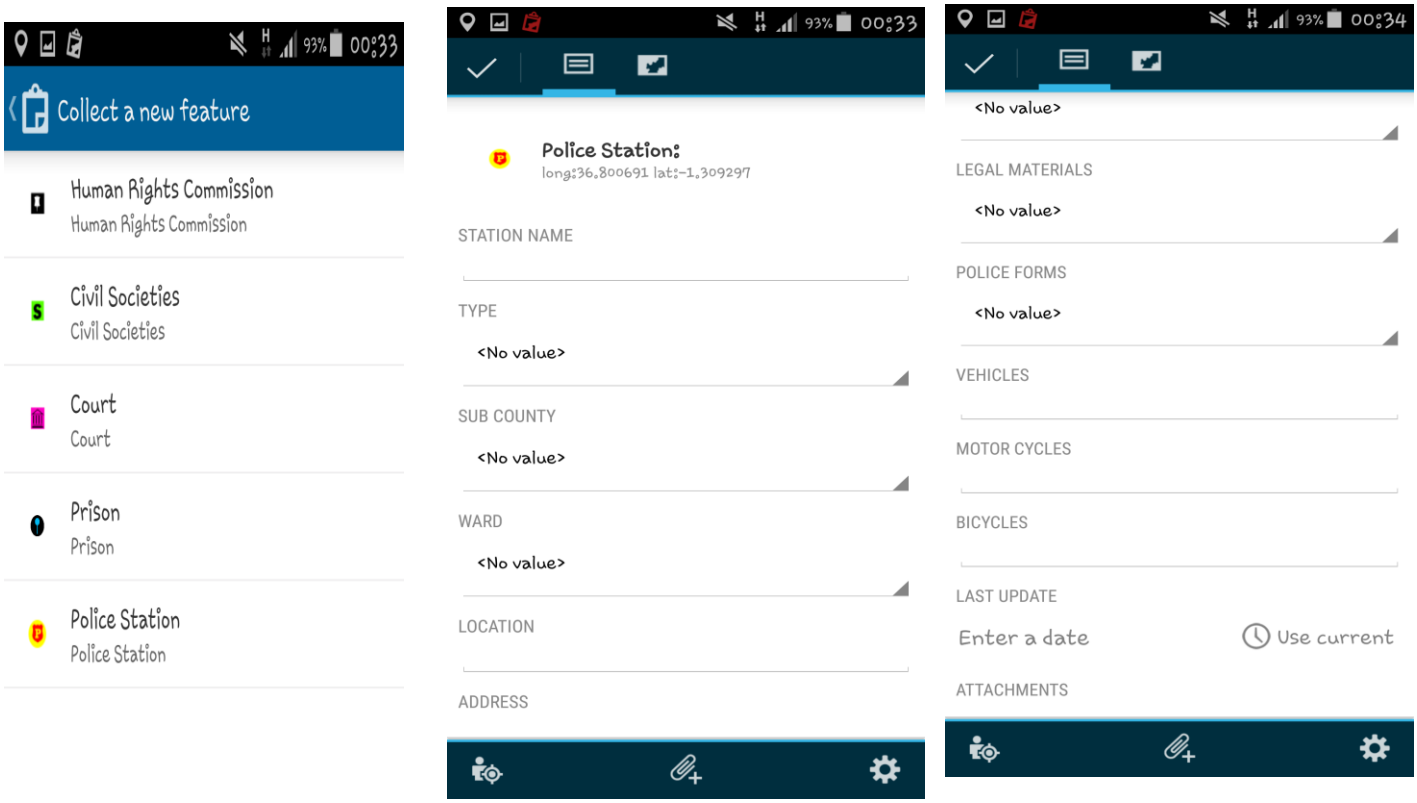

Figure 11: GPS enabled smartphone data collector menus

With a complete record entry of the specific police post/station, the feature is then populated on the web map as a point feature, which is visible from the smart phone screen display, see Figure 11 below.

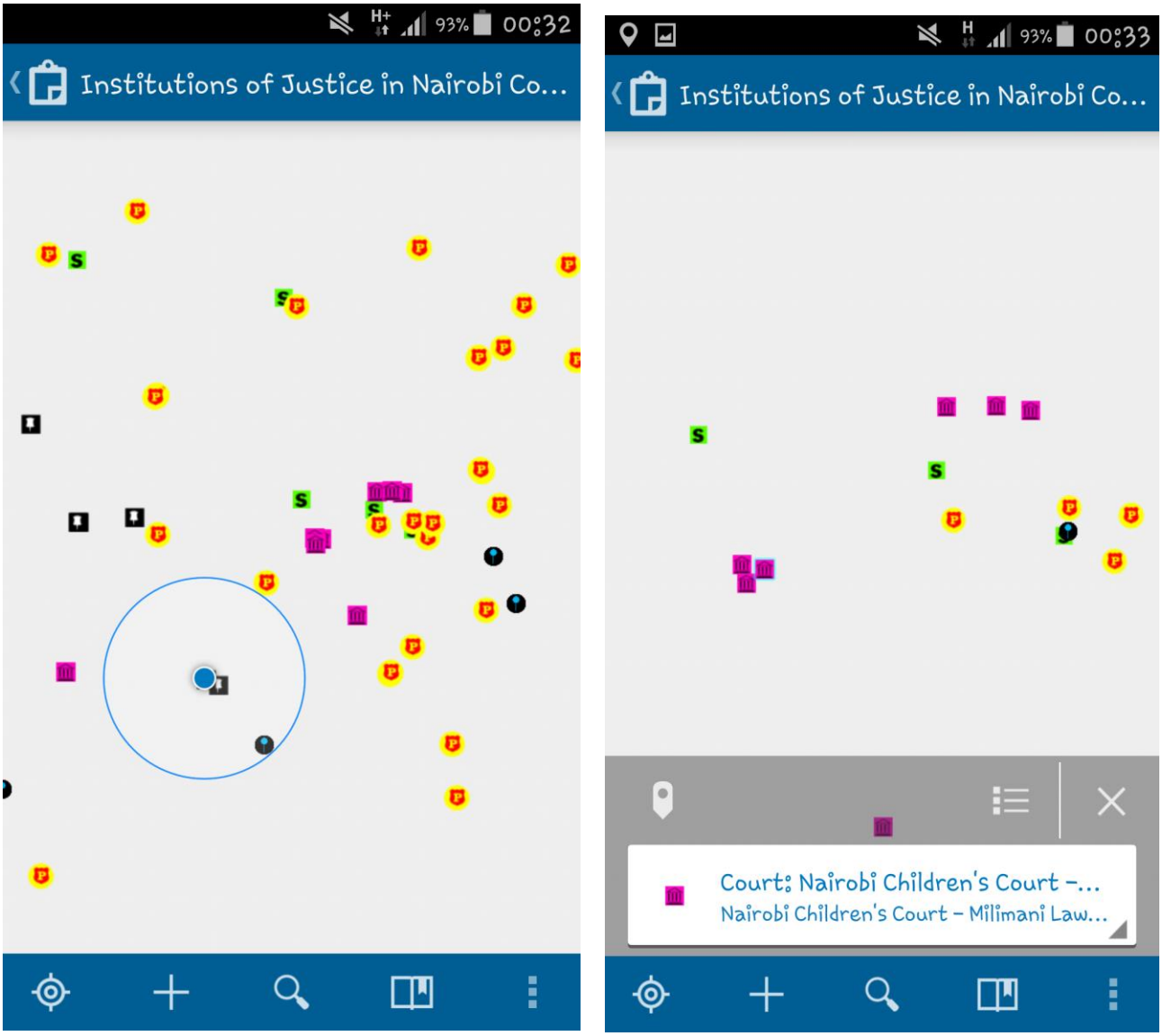

Figure 12: Point features populated on the map – Smart phone screen display

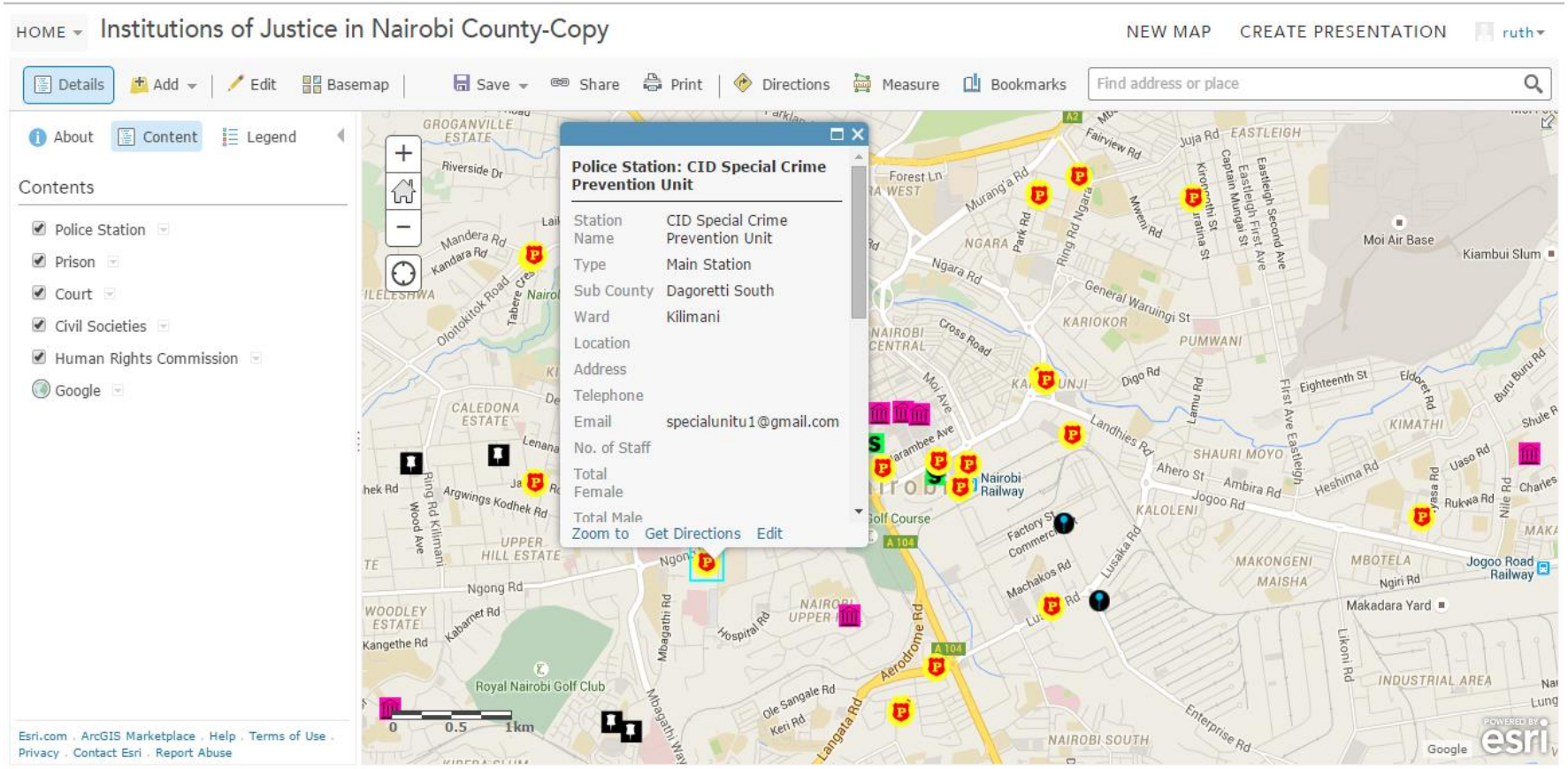

Figure 13: Map view of a police station

Figure 13 above is an illustration of a map view of a police station from which you can view the attributes of this feature class. These are the attributes collected from the field using the mobile smart phone mobile application.

3.6 Data Analysis

Data was tabulated using applications like Microsoft Access and Microsoft Excel. The use of charts to present queried data will also be incorporated into the analysis. As the Web will be the mode of data output, it is expected that data can be queried and presented in various forms. Some of the queries are presented below.

a. For instance, if you want to know how many justice institutions are within Nairobi CBD, you could select all the justice institutions that fall within the CBD boundary as illustrated on figure 14 below.

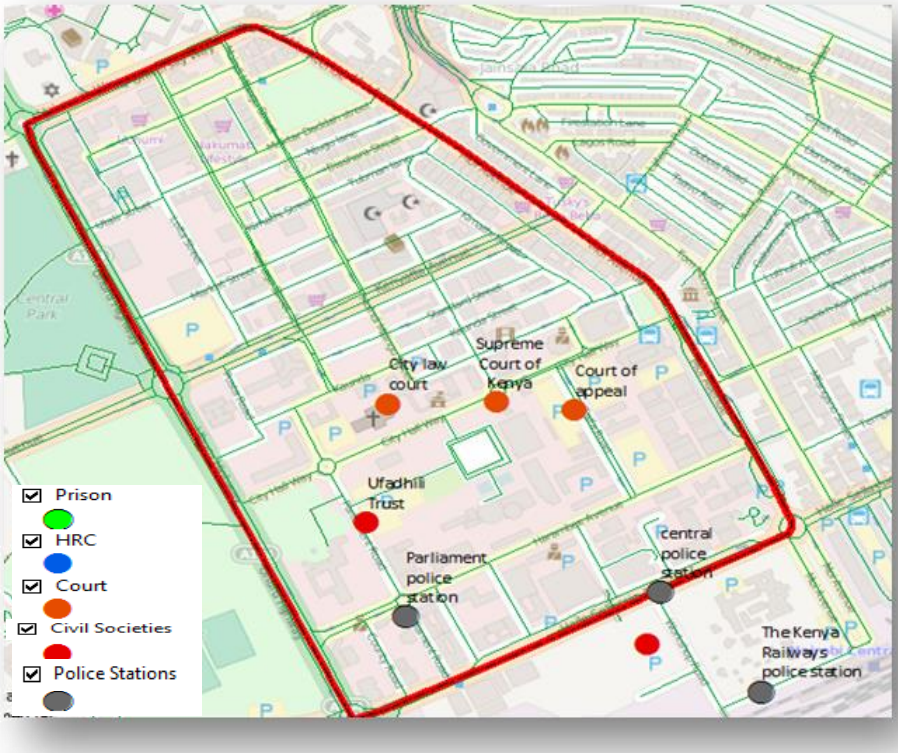

Figure 14: Queried results - Institutions of justice within the Nairobi City County CBD

Table 5: Summary of the queried results

Institutions	Total in CBD	Names
Prison	**0**	-
Human Rights Commission	**0**	-
Courts	**3**	City Law, Supreme and Court of Appeal
Civil Societies	**1**	Ufadhili Trust
Police Stations	**1**	Parliament PS

b. What is the population distribution of the civil societies and human rights commissions? The figure 15 below gives an analysis of the human rights commissions and civil societies.

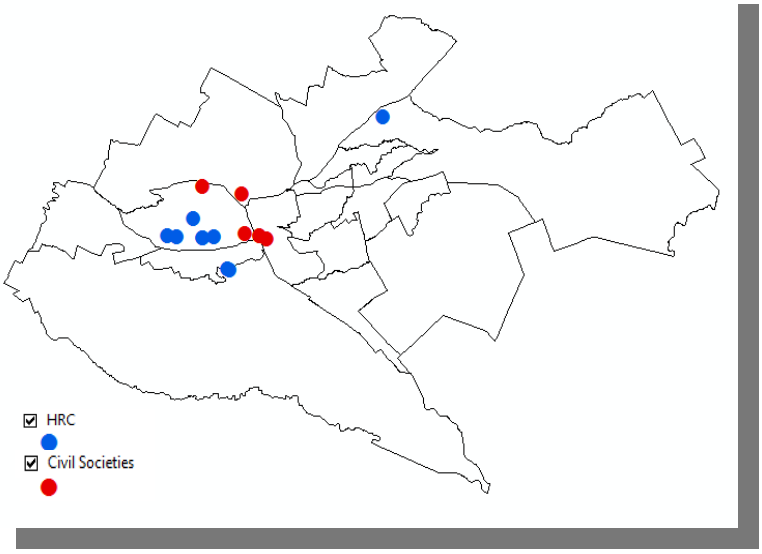

Figure 15: Population of Human Rights Commissions and Civil Societies

c. What is the ratio of state owned civil societies and human rights commissions verses NGO/INGO? Table 6 has been used to show the listed NGO/INGO.

Table 6: List of NGO and INGO

Name	Type
Ufadhili Trust	NGO
PAWA254	INGO
office of the ombudsman	INGO
Amkeni kenya	NGO

d. What is the ratio of female prisons verses the male prisons? The distribution of male and female prison is as illustrated in figure 16 below.

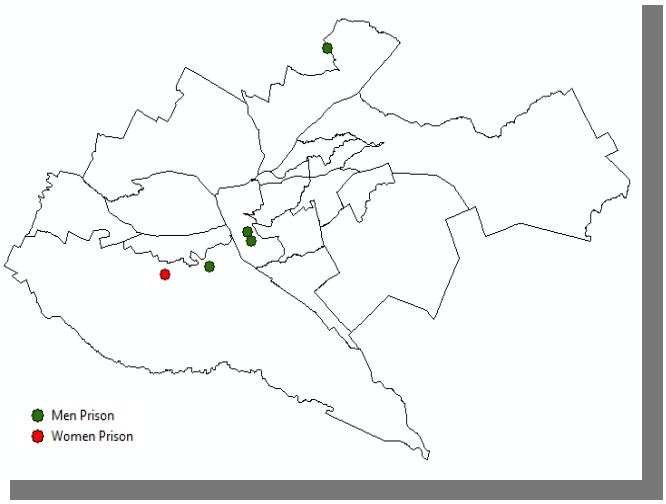

Figure 16: The men and women prisons population within Nairobi City County

Table 7: Tabulation of both male and female prisons within the Nairobi City County

Prison Name	Type	SubCounty
kamiti GK prison	muximum	Kasarani
GK Langata women prison	womens prison	Langata
prison timber kiln seasoning centre	prison industries	Makadara
G.K Prison Nairobi Remand and Allocation	Remand and Allocation	Makadara
Nairobi West Prison	disciplinary and correction prison	Langata

CHAPTER 4: RESULTS AND DISCUSSIONS

4.1 Institutions of justice in Nairobi City County - Web-Based GIS Application

The final result of the system development effort under this study was a web-based MIS. This system employed geo-referenced institutions of justice for the study area to produce an interactive map that showed the spatial dimension of the Institutions of justice on ArcGIS Online.

4.2 Institutions of justice in Nairobi City County Web-based interface

The resultant system was made up of geo-database that ran at the back end in ArcGIS online providing the users with an interactive interface. The interface provides a list of all the institutions of justice covered in this study and particulars of each feature can be accessed by selecting the specific feature that is of interest and from the pop-up window, the attributes of this feature will be displayed, as shown in Figure 17.

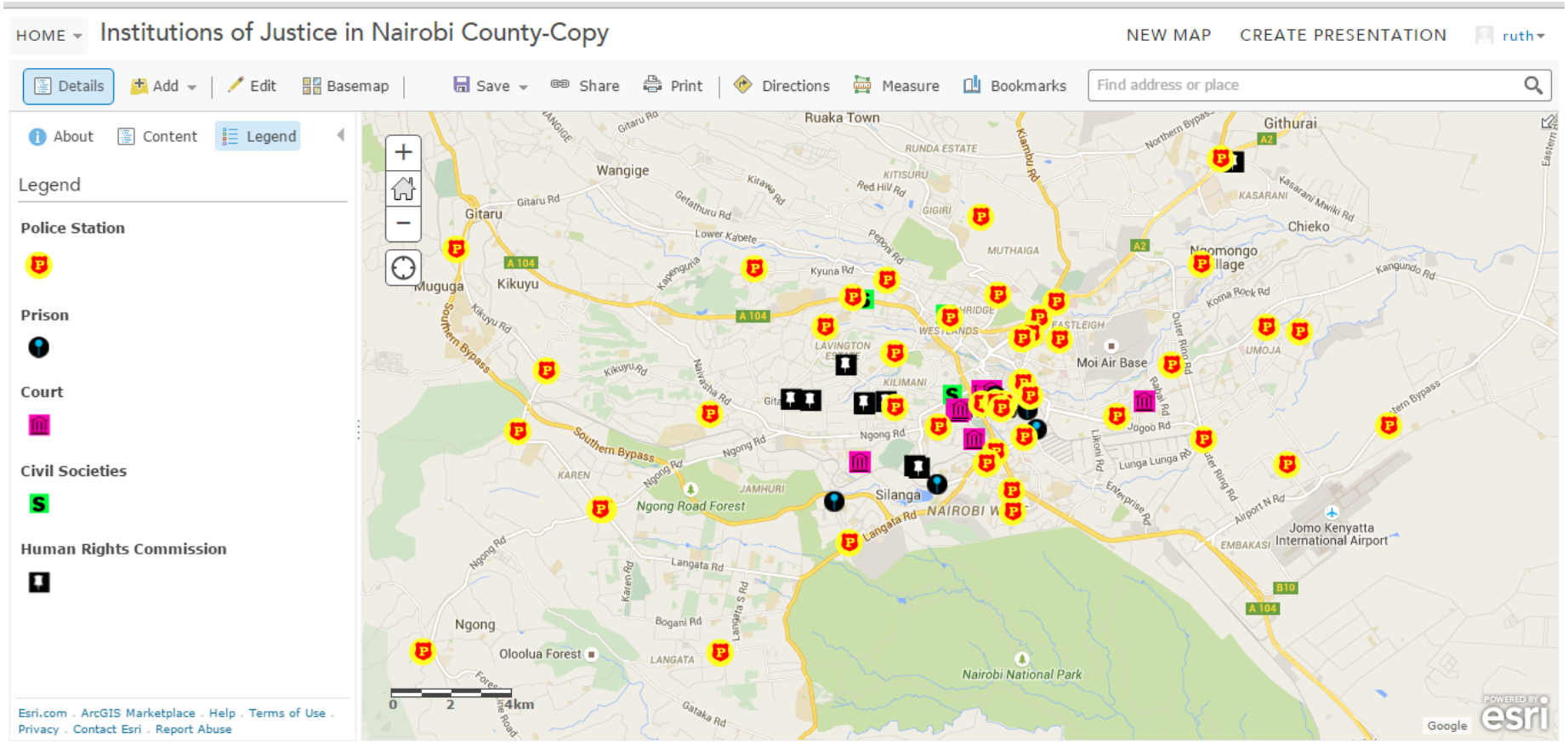

Figure 17: Institutions of justice Web-based home page

4.3 Functionality on the home page

From Figure 17 above, the user can perform numerous analysis and data manipulation depending on the specific query or report needed. From Figure 18 below; we find a calculation result of the Police Stations Density, which then highlights the area on the map with a high density.

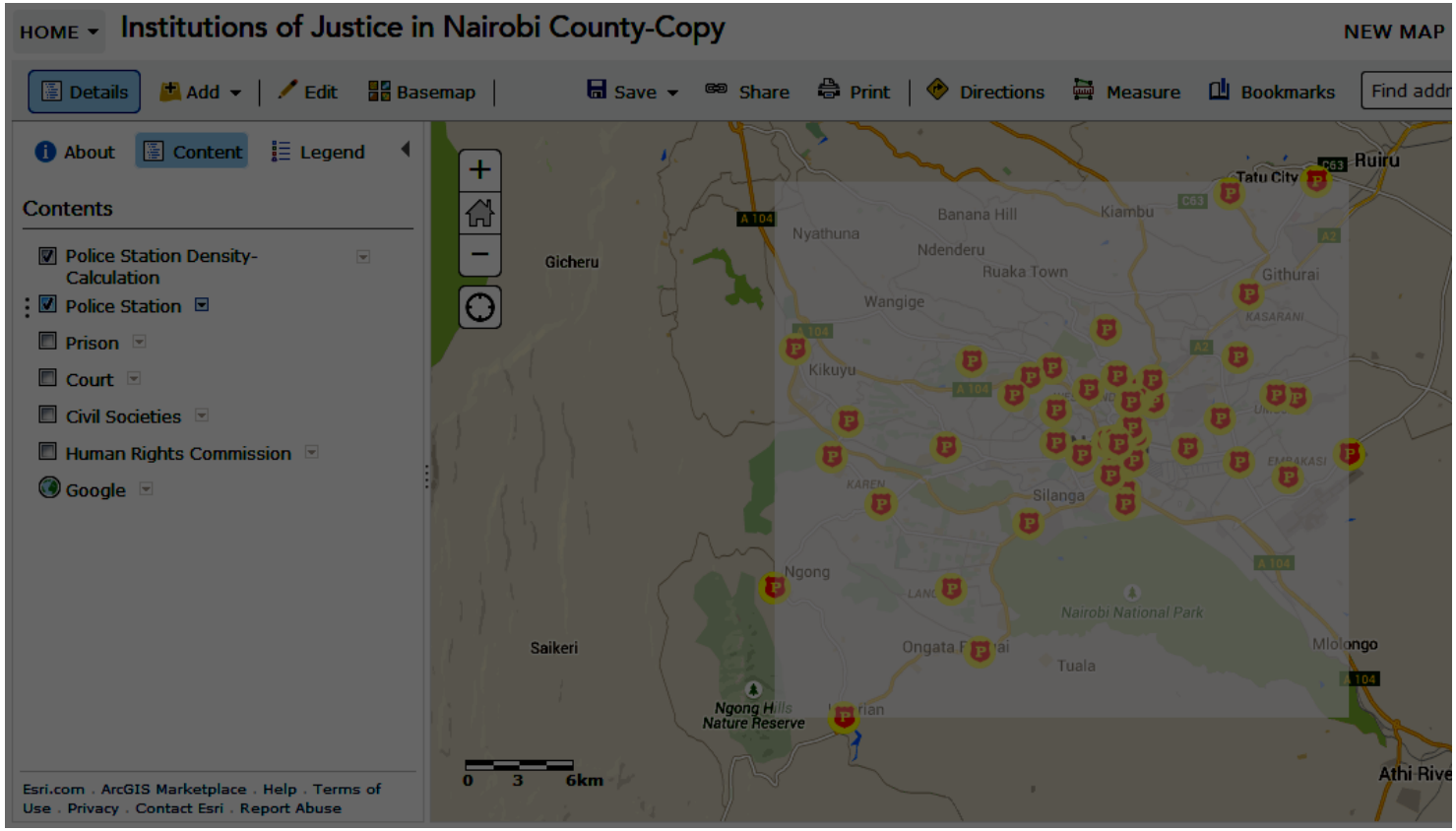

Figure 18 Police Station density calculation

2. Other functionality/analysis that the users can perform are;

    1. Summarize data as shown in figure 19 below.
    2. Find locations.
    3. Data enrichment.

4. Analyze patterns.
5. Use proximity.
6. Manage data.

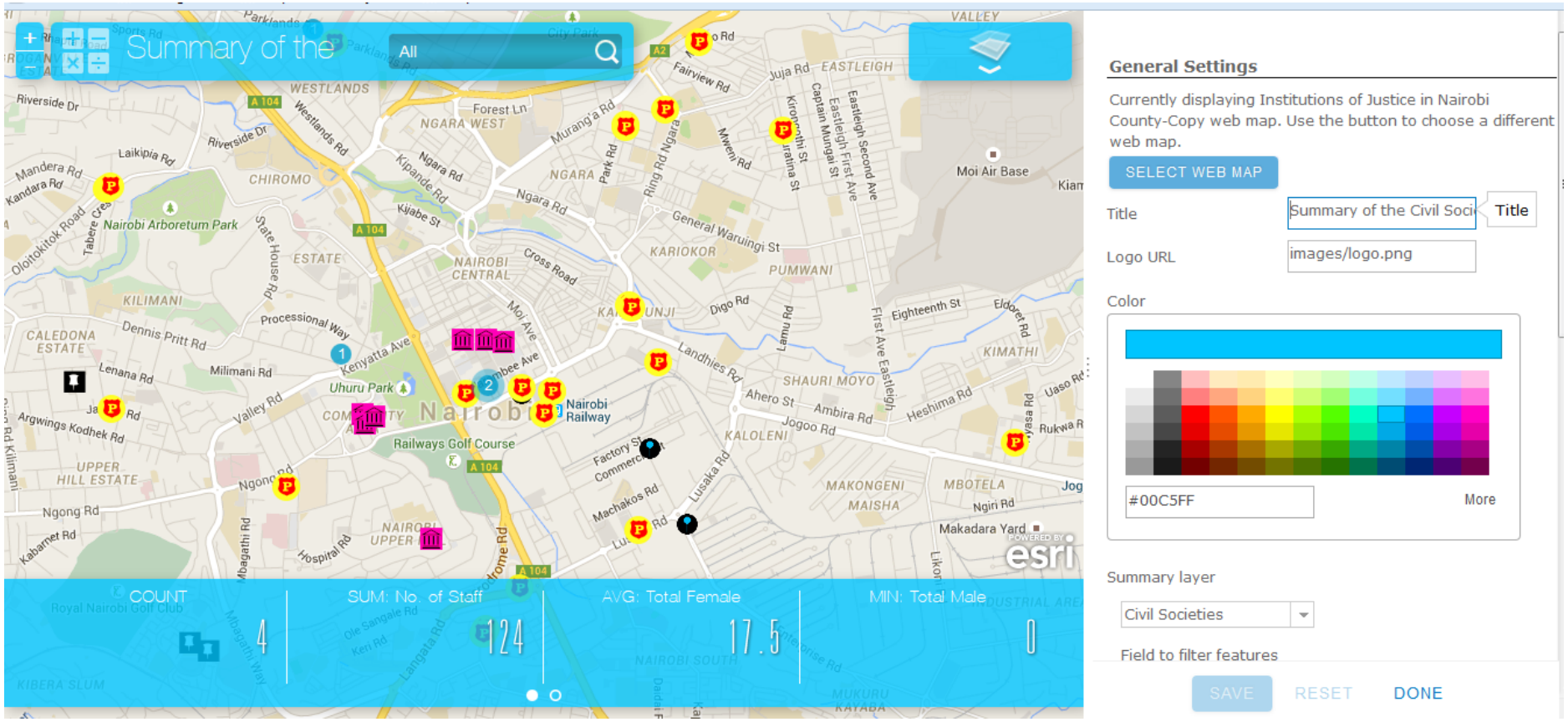

Figure 19 A summary of one of the Civil Societies

3. The user through the interface can use zoom and pan controls to further interact with the map as follows;

a. Zoom: The user could click on the zooms control on the left side of the map area to zoom in on an area on the map to have a closer look at finer details and the zoom out when this is done as seen in Figure 20 below.

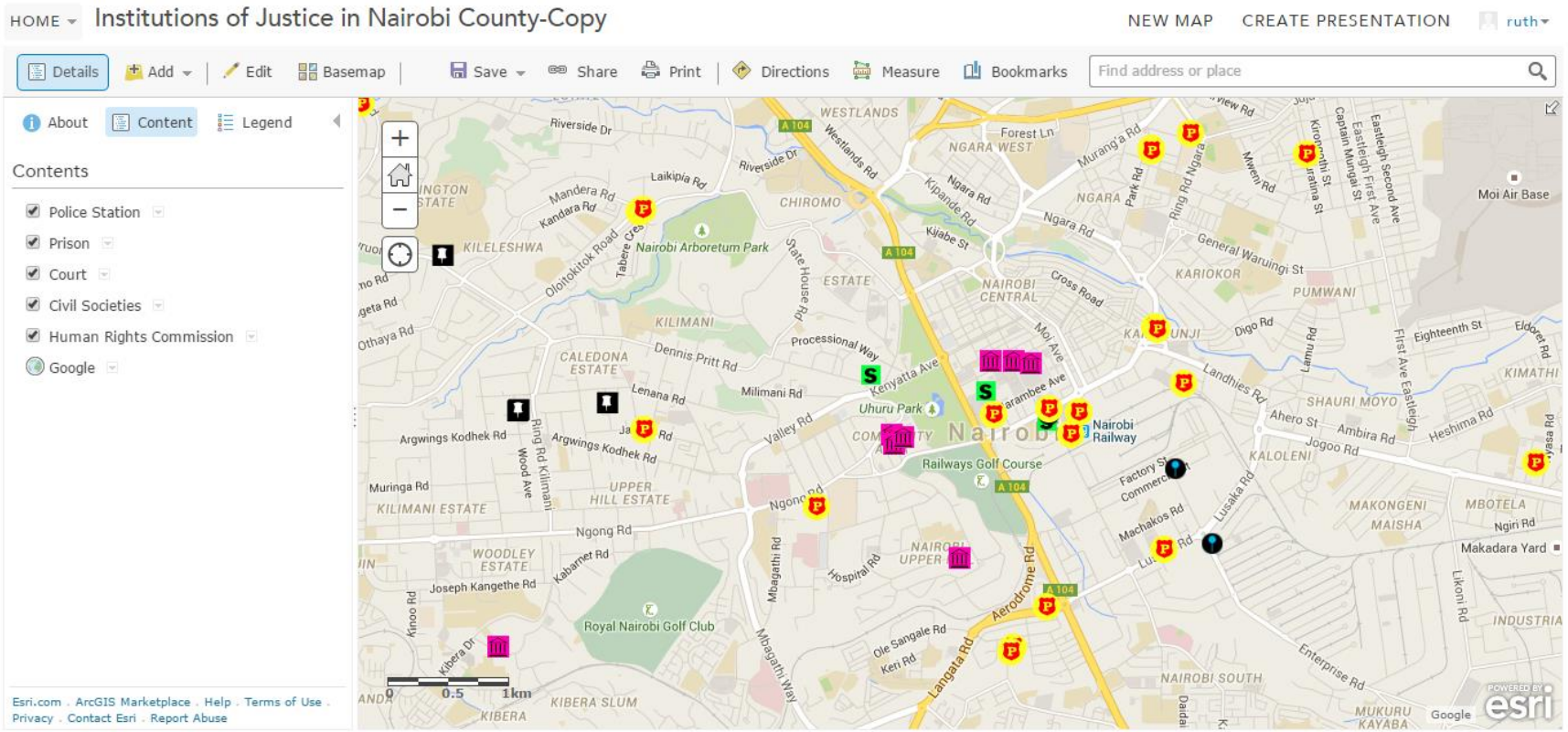

Figure 20: Map view based on the zoom and pan movement on the map

b. Pan: The user could use the pan control located at the top left corner of the map area to move the map up or down, left or right,

4.4 Discussion of the Results

A GIS based MIS system and in this case a web-based GIS system like the one developed and demonstrated in this study can make enormous contributions in the institutions of justice identified.

Management Information Systems in this case of the justice institutions was defined as the procedures, processes, and routines that meet the information needs of these institutions of justice. Monitoring and Evaluation (M&E) which is a component of MIS involves the regular collection and analysis of data that is greatly used by the various stakeholders who range from the government, to the civil societies, to the citizens of this country and more so the residents of Nairobi City County.

The web-based GIS portal developed in this study demonstrates that it has used attribute data collected from the various institutions of justice, incorporated geographic point data to produce geo referenced databases, analyzed and visualized the same using freely accessible internet tools. Among the interactive maps produced and which demonstrate the wide range of possibilities in its application are; maps of police stations population densities, the distribution of institutions of justice within the CBD of Nairobi City County and also the population ratios of female and male prisons. From these maps the user is able see the spatial distribution and could query and display information on individual institutions or a group of institutions. Based on information on these maps important decisions can easily be made by the stakeholders in these institutions. For example, considering the population of inmates in the female prison, is there need to have a second female prison in the Nairobi City County?

Sharing the MIS was through ArcGIS online. The intuitions of justice can now share information amongst themselves from the web-portal providing a good tool for initiating discussions as the databases shared provide detailed information about the staffing of these institutions, mobility capabilities in terms of vehicles and motorbikes. Other resources that can be queried from the database of these institutions is the Information Technology capacities, office space investments and much more.

Therefore, there is enormous potential for a web-based GIS system like the one developed and demonstrated in this study because sharing the GIS Portal's Uniform Resource Locator (URL) would provide instant access to information-rich interactive maps that would provide for data sharing among the institutions of justice.

CHAPTER 5: CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusion

The main objective of this study was to develop a web-based MIS for the justice institutions in the Nairobi City County that would bring all these institutions together on a single portal. The system was successfully developed and various interactive maps were generated and used to demonstrate the systems functionality as a management, reporting and monitoring tool. An example is the demonstration done by the visualization of these institutions on the map. There is a clear display of how these institutions' are spread out across the County, and also the ratio of these institutions to each other, for example; the ratio of the police stations/post to the prisons within the county, where do we have the highest population/density of police stations. The analysis reports are generated as maps, creating additional layers and tabulated tables with the analysis reports.

The targeted users of the system were the stakeholders within the justice system in Nairobi City County. The online maps and the real time analysis can be a great tool for the policy makers in matters concerning justice delivery. They would use this to plan on the expansion of the police stations and posts, the type of facilities and resources at their disposal, for example, the type and number of motorcycles, cars, vans, the type of leased/owned buildings etc. with this kind of updated and easily accessible information, the decision makers will be more informed on the kind of investments they need to make in this institutions for the purpose of improving service delivery. The civil societies and the human rights commissions whom in most cases act as the justice delivery watch dogs will benefit a big deal from this web-based spatial MIS as they will be up to speed in matters concerning the performance of the justice system. For example, they can use the system to monitor the flow of inmates into and out of the prisons and raise an alarm with the necessary persons whenever the numbers soar upwards.

The overall finding of this study was that the Web-based spatial MIS is a viable proposition for the institutions of justice that are sparsely spread out across the Nairobi City County and this could add value to the process of decision making and planning for the interested stakeholders.

The overall finding of this study was that Web-based spatial MIS is a viable proposition for the institutions of justice. It can therefore be concluded that the study met its stipulated objectives.

5.2 Recommendations

A web-based spatial MIS as is the outcome of this study has demonstrated how this system can provide great value proposition for the management, monitoring, sharing and planning within the justice institutions. With this in mind, the recommendations are as follows;

The institutions of justice can adopt this system as a tool for planning especially in matters concerning the delivery of service to the people as it clearly will help them analyse the distribution of each of these institutions and compare this distribution to the population patterns of the people of Nairobi City County.

The various institutions of justice can scale-up the study and implement the same in all the counties in Kenya. These can be done through the various ministries that these institutions are administered from, for example the Kenya Police Services through the Ministry of Interior and Coordination of National Government.

All forms of institutions of justice can be incorporated into this study. These includes the mobile courts and the mobile police posts. They can be considered in the next opportunity of implementation of this project on a bigger scale in all the counties in Kenya.

With the limitations of ArcGIS online which are for example, high internet costs and poor access speeds could be a limiting factor in how this system can be utilized by the stakeholders. With the current challenges of inadequate ICT systems in these institutions of justice, reliance on ArcGIS online would be a detriment issue. With this kind of a system, recommendations on how to improve on the system accessibility would be centred on the setting up of a thin-client web-access system that only allows users to access the data needed per session at a time, thus less information is downloaded at the client-end and by so doing traffic is reduced in each session.

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