University of Nairobi

School of Engineering

CREATION OF A WEB-BASED DATABASE APPLICATION FOR MANAGEMENT OF COMPULSORY LAND ACQUISITION.

CASE STUDY: A SECTION OF THE NAIROBI -NAKURU HIGHWAY (UPLANDS TO KIMENDE)

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A Project 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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UNIVERSITY OF NAIROBI

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Dedication

To my parents and siblings for continued moral support.

Acknowledgement

I would like to acknowledge my Supervisor Mr. P.C Wakoli for his advice, encouragement and assistance in completion of the project. I would also like to acknowledge MR. Gacoki, Head of Survey Department – KENHA for his assistance and Vincent Kiarie for guiding me through the Software issues.

Abstract

Compulsory acquisition is power of the State to deprive or acquire any title or other interest in land for a public purpose subject to prompt payment of compensation (Land Act,2012).This project explored how geospatial technology can be used to assemble, manage and disseminate information required in the process of compulsory land acquisition. This involved use of Web GIS for creation of a web-based database application; this would assist in making the land acquisition process more effective, efficient and transparent.

Datasets were assembled from reliable sources and relevant analysis carried out, with the end result being a set of digital maps and a web-based database application to assist in visualization of the process of compulsory land acquisition.

From the work done and results obtained, it was concluded that the RIMs are not updated to conform to KENHAs data. The government bodies should standardize their data on road reserve by updating RIMs to show the exact size of the road reserve. This will increase public trust on land cadastral system and government projects.

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List of abbreviations

GIS-Geographic information system

RIM- Registry index map

FR- Folio Number

KENHA – Kenya National Highway Authority

NLC- National Land Commission

CLA-Compulsory land acqisistion

CHAPTER 1: INTRODUCTION

1.1 Background

Compulsory acquisition is defined as power of the State to deprive or acquire any title or other interest in land for a public purpose subject to prompt payment of compensation (Land Act, 2012). From the Land Act, (2012), compulsory land acquisition process involves the following steps:

1. Preliminary Notice.

"Whenever the national or county government is satisfied that it may be necessary to acquire some particular land under section 110 of this Act, the respective Cabinet Secretary or the County Executive Committee Member shall submit a request for acquisition of public land to the Commission to acquire the land on its behalf. The Commission may reject a request of an acquiring authority, to undertake an acquisition if it establishes that the request does not meet the requirements prescribed under subsection (2) and Article 40(3) of the Constitution of Kenya

2. Power of entry to inspect land.

The Commission may authorize, in writing, any person, to enter upon any land specified in a notice published under section 107 of the Act and inspect the land and to do all things that may be reasonably necessary to ascertain whether the land is suitable for the intended purpose.

3. Payment for damage entry for inspection.

As soon as practicable after entry has been made under section 108 of this Act, the Commission shall promptly pay in full, just compensation for any damage resulting from the entry.

4. Notice of acquisition and effect of acquisition on plant and machinery.

Land may be acquired compulsorily if the Commission certifies, in writing, that the land is required for public purposes or in the public interest as related to and necessary for fulfillment of the stated public purpose.

5. Inquiry as to compensation.

At least thirty days after publishing the notice of intention to acquire land, the Commission shall appoint a date for an inquiry to hear issues of propriety and claims for compensation by persons interested in the land

6. Award of compensation.

Upon the conclusion of the inquiry, the Commission shall prepare a written award, in which the Commission shall make a separate award of compensation for every person whom the Commission has determined to have an interest in the land.

7. Payment of compensation.

After notice of an award has been served on all the persons determined to be interested in the land, the Commission shall, promptly pay compensation in accordance with the award to the persons entitled thereunder." (Land Act, 2012)

The land acquisition process involves a number of government departments that have various mandates depending on the purpose for acquisition (Kamunyu, Kuria et al 2015). In some instances, departments involved have been seen to be incoherent, thereby causing gaps and unfinished work in the entire procedure. In some cases, the government has postponed occupation of acquired land, the case study in this exploration being an example. This has caused in encroachment by the already compensated parties or new occupants on the already acquired land, either deliberately or unconsciously.

Documents and survey maps are yet to be updated, with the attained information causing considerable losses where constructed developments have been demolished particularly where road development areas where the land is already acquired. Acreage in the title deeds is yet to be adjusted to indicate changes due to road acquisitions which had occurred in the past.

This project shows the most favorable conditions to create a one-stop-shop to show the CLA process using GIS, by uniting all the data from the respective departments. In this project, the Registry Index Maps (RIMs) from land registry of Kiambu and the road layout from the Roads Department were overlaid and acquired acreage which is not surrendered on parcels identified. Using GIS a rundown of every single influenced divide with the applicable traits can be separated and sent to the significant departments as seen essential. This will improve straight forwardness in activities where there are covering commands and feature holes in the entire CLA process. The structures on the present road reserve can easily be identified by overlaying on Google earth, this will decrease the cost brought about of employing Consultants to mark the

structures. Additionally, it indicates how GIS can be utilized to spread information to people in general by making a model web based database; this can be utilized by land owners, land buyers and investors.

1.2 Problem Statement

In Land Act (2012), the National land commission has been authorized to manage public land by identifying, preparing, and keep databases of the public land which should be georeferenced and authenticated by the statutory body responsible for survey and management of public land.

The information should be easily accessible to other relevant government departments and the public. The road reserve should be clearly marked on the ground to curb road encroachment. The data from different government departments should be standardized and uniform.

Currently, road information can be obtained from the road departments, while land parcels information is obtained from Survey of Kenya for fixed boundaries and respective County Survey department for general boundaries. Information on land parcel acquired is published in the Kenya Gazette while the Resettlement Action Plan information can be obtained from NLC and the acquiring body. Most of the data is in hard copy and the process of obtaining is bureaucratic and time consuming .None of it shows the land acquired and the process behind it.

It takes time to adjust RIMs and FRs, this may lead to people buying land which has already been acquired since the survey map still indicates that the land is still under the previous owner. Hence, the need to have maps and databases on land acquired as per KENHAs' data. For transparency, there is the need for people to understand the parcels of land being acquired, structures and the costs for compensation. There is a high rate of encroachment of road reserves by individuals and private developers. Hence there is a need to establish a transparent way showing how road reserves are placed and acquisition of land upon expansion.

When acquired land is not marked both on the ground and on maps and the land registry does not show interest on the land, then it shows that this public land is unprotected and ownership not yet transferred to the Government. This has caused embarrassing situations for Government departments like the case of Rironi demolition of a four storied building under construction in Kiambu County. The owner had purchased half an acre from the original owner and obtained a title deed. Most government departments depend on each other: Planning, Survey and Engineering department, the information sharing between departments take is too bureaucratic, hence taking a long period resulting to a delayed decision making. KENHA's document shows

that the current road reserve is 80 metres along Nairobi– Nakuru Highway, while the RIMs shows the road to be 40 metres wide. The Lands Ministry' has not adjusted the changes on the respective documents from CLA as recorded by KENHA.

Creation of a web-based database will assist in solving the above issues, since all data from relevant government authorities is overlaid in one platform which is to access and enables sharing of data. The public can enquire on parcels which are already compensated and the acreage acquired, without moving from authority to the other.

Overlaid data shows the current state of the road, therefore investors cannot purchase already acquired land for RIMs which have not been updated. With such an application, development plans cannot be issued for areas which are already acquired. It also helps reduce road encroachment, since the structures on the road reserve are clearly indicated and one can update the application where new structures have been built and removed.

The web application can be used by NLC to manage public lands required by the law. There is no clear guideline the platform on which the database should be created; therefore a web based application enables the NLC to standardize the database and share data among the relevant government bodies.

RIMs which are to be updated can be identified from the application and the necessary action taken. The cost of obtaining desktop software such as ARCGIS is high; each department has to have such software to enable data access. The Web application is free, therefore saving on the above costs. It is cheaper to update, maintain and disseminate land acquisition information using a Web application as compared to the current use of hard copies, which require a secure facility and are tedious to retrieve.

1.3 Objectives

Overall objective:

To create a web-based application for management of compulsory land acquisition for widening of a section of A104 road from Uplands to Kimende.

Specific objectives:

a) To document the process of Compulsory Land Acquisition (CLA).
b) To develop geospatial database for the section of the road, between Uplands and Kimende, to facilitate management of the land acquisition process.
c) Identify and document the attributes of the parcels of land affected by compulsory land acquisition in the case study area,
d) To develop a web application to facilitate online access to the database.
e) Document the issues arising from CLA in the case study area and the suggested measures for resolving them.

1.4 Justification for the Study

The results of the study will be useful to the following:

1. General public- With transparent land acquisition process the public can easily collaborate when a new project is to be started.
2. Land owners- knowing which amount of land has been acquired and ease the process of property sale or use. Also understand the process involved in land acquisition.
3. Relevant road Authority- ease decision making on road reserve such as demolition of structures on road reserves.
4. Investors-avoiding buying land which is under the road reserve, since structures built on road reserves are not entitled to be compensated.
5. Department of Survey- updating of survey plans and maps.
6. Other government Departments- Such as planning which utilize the current Survey maps to make decisions.

1.5 Scope of work

The area is located along A104 road, from Uplands to Kimende which is approximately 10 kilometres in length. The area of study is located within Kiambu County.

Abutting land parcels and plan & profile plans adjacent to the road will be identified. A 20 M road widening will be done and the land parcels affected identified. A web-based database application will then be created from Arc GIS online.

CHAPTER 2: LITERATURE REVIEW

2.1. Compulsory Acquisition.

Land is defined as the surface of the earth and the subsurface rock, any body of water on or under the surface, marine waters in the territorial sea and the exclusive economic zone, natural resources completely contained on or under the surface and the air above the surface (Land Act,2010). Dale & Mclaughlin (1988) defines land as the physical thing that encompasses the surface of the earth and all things attached to it. Land ownership in Kenya is categorized into three categories; private land, public land and community land (Constitution of Kenya, 2010). Private land consists of registered land held under freehold tenure, leasehold tenure and any other land declared private under an Act of Parliament. Public land consists of land not set aside for any purpose, land set aside for public utility, transferred land to the state, land whose ownership cannot be retrieved, government forests and any other declared by an Act of Parliament. Community land consists of land transferred to a community, land registered in name of group representatives and any other land declared as community land by an Act of `parliament.

Methods of acquisition of title to land according to the Land Act in Kenya (Land Act, 2012):

a) Allocation; the legal process of granting rights to public land
b) Land adjudication process; process through which existing rights in a particular parcel of land are finally and authoritatively ascertained.
c) Compulsory acquisition;
d) Prescription; the process of acquiring rights and in particular obtaining a good title to land as a result of the passage of time
e) Settlement programs;
f) Transmissions;
g) Transfers;
h) Long term leases exceeding twenty-one years created out of private land;
i) Any other manner prescribed in an Act of Parliament

According to the Kenya's Land Act, 2012, compulsory acquisition refers to the power of the government to acquire rights in a parcel of land without the willing consent of its owners or occupants to benefit society but with a just and prompt compensation. This was shown in Maisha

Nishike Ltd v. the Commissioner of Lands High Court at Nairobi (Nairobi Law Courts) Miscellaneous Civil Application 66 of 2010 court ruling, where the land owner had gone to court to stop the Nairobi Northern Bypass Contractor from entering his land, until he was fully compensated. Stay orders prohibiting the contractor from entering the land were issued on 30th July, 2010 and extended on 24th January, 2011. The Ministry argued that the stay orders had stopped the completion of the road and the Contractor was threatening to lodge a claim of KSHs. 2000000 per day for idle equipment, plant and labor. It was further stated that an award had offered to the land owner but the applicant wanted a higher amount. The respondent the public interest in the construction of the road and it outweighed private interest of the applicant. On 25th February, 2011 the judge issued vacate orders to enable construction of road, since the public interest outweighed private interest and the applicant did not stand to gain from losses made when the road construction had stalled.

The law governing compulsory acquisition is in Part VIII, Section 107 to 133 of the Land Act 2012. The process involves:

PRE-INQUIRY

Preliminary Notice, Land Act Sec. 107(1) and (5): The National Land Commission (NLC) receives a request for acquisition from the acquiring body (for instance, Kenya Railways or Ministry of Roads) from the respective Cabinet Secretary or County Executive Member. The land should be acquired for public purposes or in public interest (Land Act,2010).

Preliminary Requirements, Sec. 107(2): NLC will require the acquiring body to provide a comprehensive list of the affected parcels of land and the respective owners, title search details, cadastral maps of the affected areas, a Resettlement Action Plan accompanied by a list of Persons Affected by Project. All the rights of the affected persons should be addressed through compensation (Land Act,2010).

Notice of intention to acquire, Land Act Sec. 107 (5) 110(1): This is published in the Kenya Gazette after the commission certifies in writing that the land is required for public purposes or in public interest. Upon certification, the commission shall publish notice of intent and shall

deliver a copy of the notice to the registrar and to every person who appears to have an interest in the land (Land Act,2010).

Ascertainment of suitability of land (survey), Sec. 108: The authority responsible for survey both at the national and county level authenticates all land to be compulsorily acquired (Land Act,2010).

INQUIRY

"Notice of inquiry, Land Act Sec. 112 (1,a): The NLC shall appoint a date for inquiry at least 30 days after publishing the notice of intention to acquire, and at least 15 days before the actual date of the inquiry. A copy of the notice is served on every person who appears to have an interest in the land.

Receipt of claims Sec. 112 (2): Any written claim for compensation should be delivered to the commission before the date of inquiry. The inquiry determines who are the persons interested in the land.

Powers of the commission, Sec. 112 (5): The commission shall have powers of the court to summon and examine witnesses including persons with interest, to administer oaths and affirmations and to compel production and delivery of title documents to the commission." (Land Act,2010)

POST-INQUIRY

"Award of compensation, Sec. 113 and 114(1): Upon conclusion of the inquiry, the commission shall make a separate award of compensation for every person whom it has determined to be interested in the land. The commission shall then serve on each person a notice of the award and offer of compensation." (Land Act.2010)

"Land in lieu of compensation, Sec. 114(2): Land can be given in lieu of monetary award but such value of land shall not exceed the amount of money the commission considers would have been awarded. Such award shall be deemed to be all the compensation conclusively to which the person is entitled to in respect to the interest in that land." (Land Act, 2010)

“Payment of compensation, Sec 115: Upon acceptance of the award, the commission shall promptly pay compensation. If the award is not accepted or there is a dispute, the amount is paid into a special compensation account held by the commission.” (Land Act,2010)

“Payment of interest, Sec 117 & 119: If the amount of any compensation is not paid, the commission shall on or before taking possession open an account into which it shall pay interest on the amount awarded at the prevailing bank rates from the time of taking possession until the time of payment.” (Land Act.2010)

“Payment of additional land, Sec. 118 and 119: If the acquired land is greater than the area of land in respect to which an award is made, compensation shall be paid for the excess area.” (Land Act,2010)

Land which is not entitled to be compensated includes:

1. Public land which is owned by the government.

2. Titles issued with conditions- A property may be issued with a title on condition that they will cede ownership upon request. Such properties are earmarked for acquisition. The conditions restrict development under any circumstance. An example of such a situation occurred in outer ring Road in Nairobi where the owners of land adjacent to the road were required to surrender seven metres of their property to Kenya Urban Roads Authority for construction of service lanes and parking lots.

2.2 Structures.

2.2.1 Structures on the road reserve.

“78. (1) Except as provided in subsection (2), a person or body may not do any of the following things without the respective Authority's written permission, or contrary to such permission.
(a) Erect, construct or lay, or establish any structure or other thing, on, over or below the surface of a road reserve or land in a building restriction area;
(b)make any structural alteration or addition to a structure or other thing situated on, over or below the surface of a road or road reserve or land in a building restriction area; or .” (Road Act,2007”

(c) “Give permission for erecting, constructing, laying or establishing any structure or other thing on, over, or below the surface of a road or road reserve or land in a building restriction area or for any structural alteration or addition to any structure or other thing so situated.” (The Kenya Road Act,2007)

(2) “The Authority may, in its discretion, give or refuse to give any permission under this section.” (Road Act,2007)

(3)” When giving permission under this section the Authority may prescribe
(a)the specifications with which the structure, other thing, alteration or addition for which permission is requested must comply;
(b)the manner and circumstances in which, the place where, the conditions on which the structure, other thing, alteration or addition may be erected, constructed, laid, established or made; and
(c)the obligations to be fulfilled by the owner in respect of the land on which the structure, other thing, alteration or addition is to be erected, constructed, laid, established or made.” (Road Act,2007)
(4)”Where a person, without the permission required by subsection (1), or contrary to any permission given thereof, erects, constructs, lays or establishes a structure or other thing, or makes a structural alteration or addition to a structure or other thing, the Authority may, by notice in writing, direct that person to remove the unauthorized structure, other thing, alteration or addition within a reasonable period which shall be stated in the notice but which may not be shorter than thirty days calculated from the date of the notice.
Any structure on the road reserve is not entitled to compensation.” (Road Act,2007)

(5)” If the person to whom a notice has been issued in terms of subsection (4) fails to remove the structure, other thing, alteration or addition mentioned in the notice within the period stated therein, such item may be removed by the Authority itself which may recover the cost of the removal from that person.” (Road Act,2007). This indicates that all structures within the road reserve cannot be compensated.

2.2.2 Structures on the road extension.

All structures which are partially or fully affected by the road reserve are entitled to full compensation.

When the road extension process is about to begin, the Authority issues a notice for all structures and utilities situated in the road reserve to be remove to facilitate road construction. The cost of removing them is met by the owner. Structures which fall on the area to be affected are entitled to be compensated whether they are fully or partially affected. The affected parties are identified through the resettlement action plan (RAP), which is also used as a tool for informing the public about the intended road acquisition.

2.3 Kenya National Highway Authority.

KENHA is a state corporation started under Kenya Road Acts (2007) and has a responsibility of management, development, rehabilitation and maintenance of class A,B and C roads. Class A roads are international trunk roads linking centres of international importance and crossing international boundaries or terminating at international ports (Kenya Road Bill,2007). Class B roads link internationally important centres and Class C are roads linking centres to each other to two high class roads.

From time to time , the Authority may decide, based on various legitimate considerations, to change the width of or alignment of a given section of a highway, This will precipitate the consequence of compulsory acquisition of land affected by the changes.

Class A, B and C roads network are shown in Figure 1, 2 and 3 respectively.

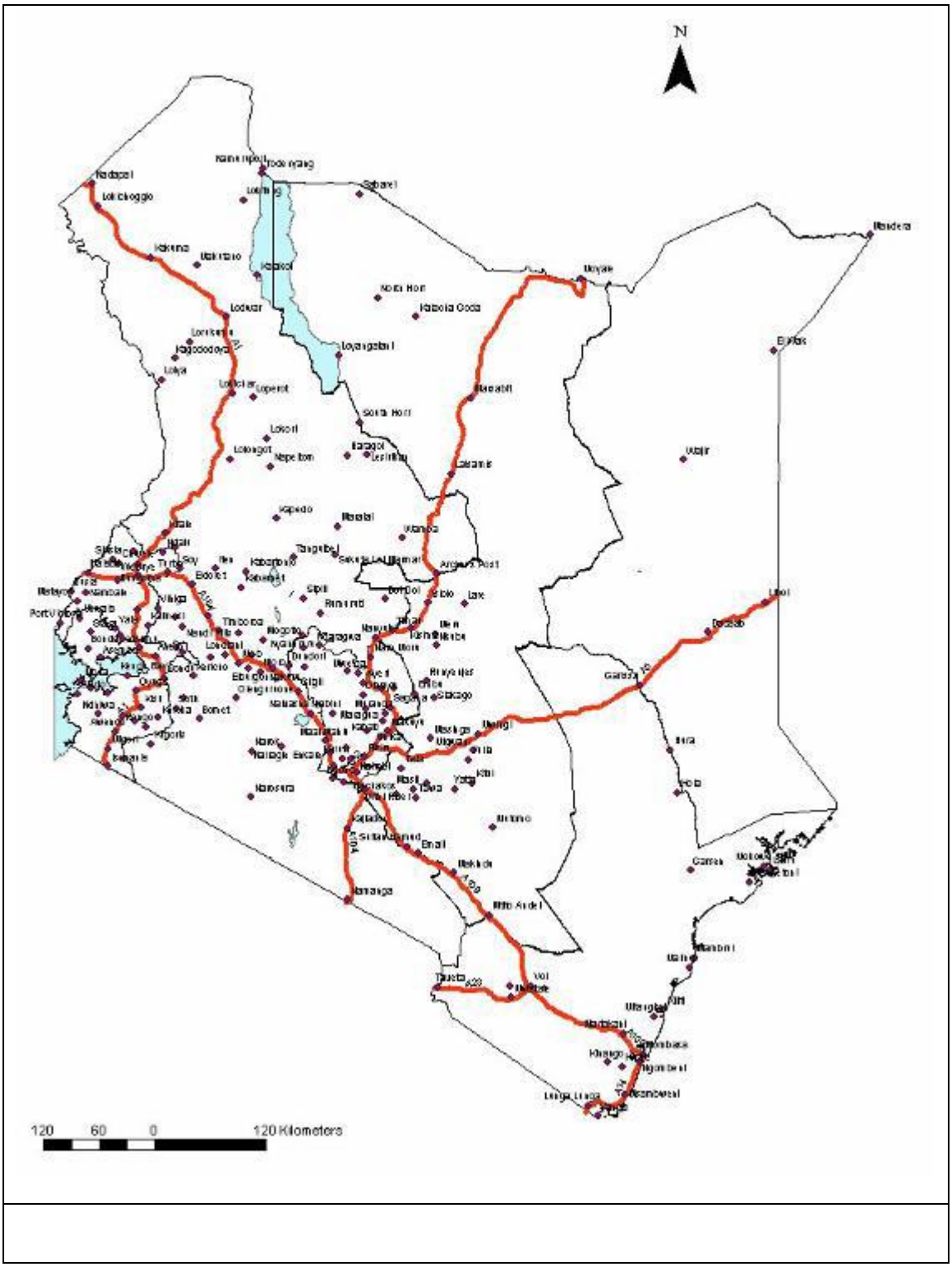
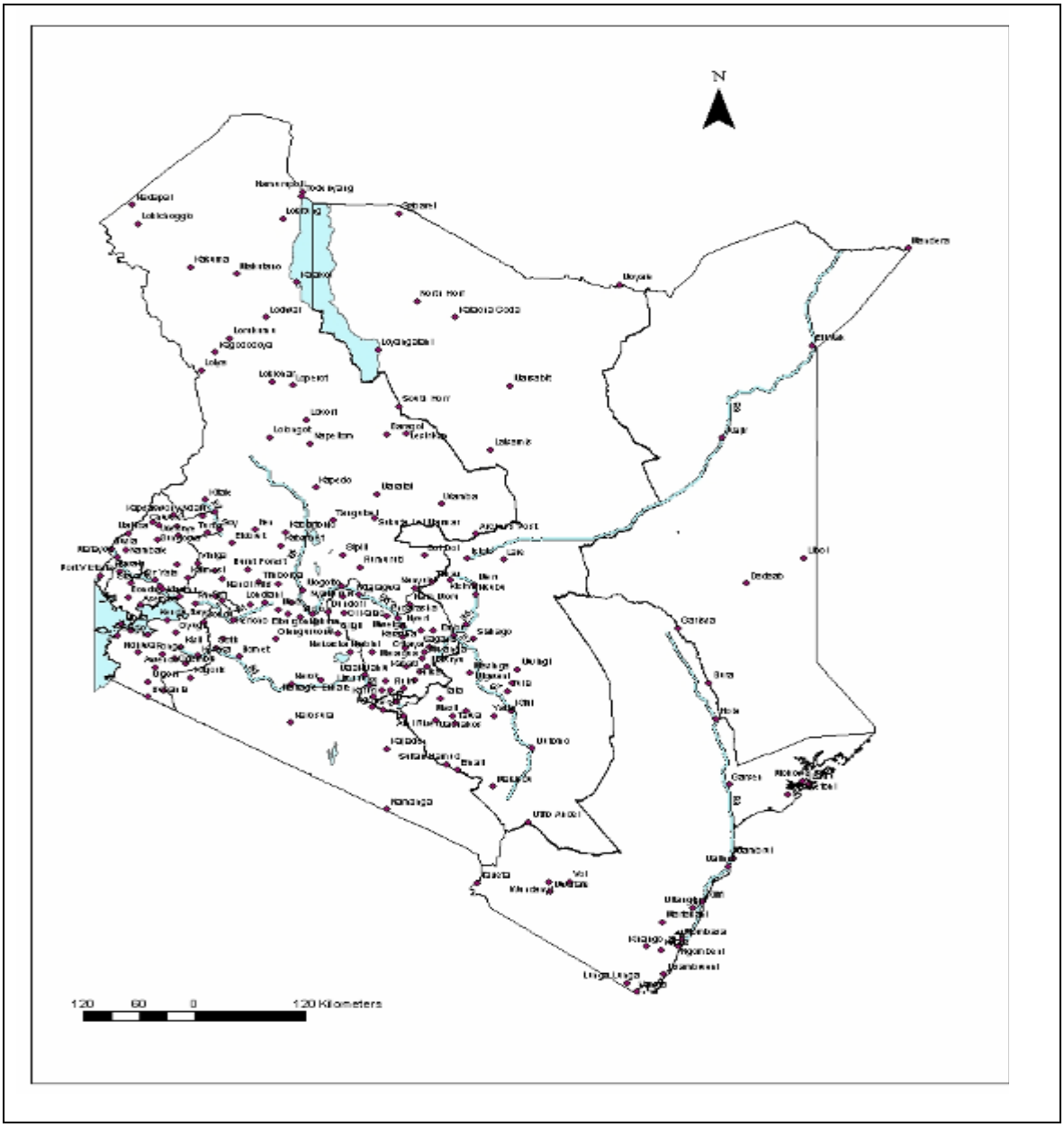


Figure 1: Class A roads in Kenya

Figure 2:Class B roads in Kenya



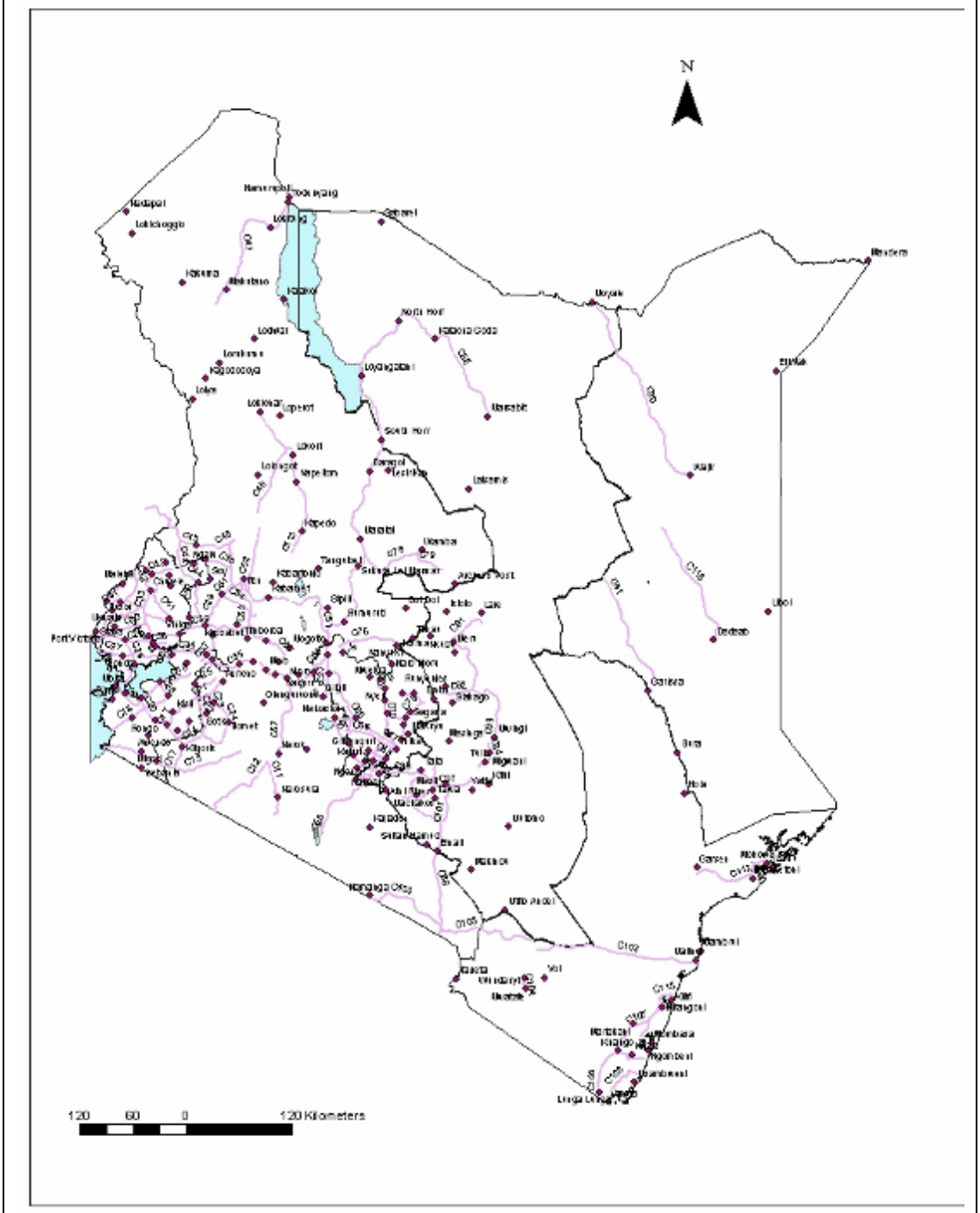


Figure 3: Class C roads in Kenya

2.4 Utilities.

The term utilities can also refer to the set of services provided by these organizations consumed by the public: electricity, natural gas, water, sewage, telephone, and transportation. Broadband internet services (both fixed-line and mobile) are increasingly being included within the definition (Wikipedia). It is recommended for utilities to use public land to reduce the cost of acquiring land. Hence utilities such as electricity, power posts are established along road reserves. The Roads Act however states that the owner of the utilities, upon notice, should remove the utilities. Failure to which, it will remove the utilities at the cost of owner of the utility.

2.5 Database.

"A database is a pool of integrated and structured data, which is a model of reality and from which relevant facts may be retrieved and processed to provide information to users." (Mulaku, 2009). A database has to have the following features:

- Reliable: it should be able to offer uninterrupted service to users.
- Correct and consistent: The information provided should be accurate and of integrity.
- Technology proof: It should evolve with change in technology in hardware and software.
- Secure: It should only be accessed by authorized parties. This done through measures such as encryption and hardware locks.

Database Design

Database design is the process of identifying the data that will go into the GIS database and how it will be presented. The database forms the foundation of all activities that will be performed using GIS. Creating a database is time consuming therefore should be undertaken with care to conform to the user requirements. A good database should contain all the necessary data that would accommodate different user views and to support data sharing with efficient data structures and retrieval mechanics. The data should be easily updated and maintained. It involves four steps:

a) External modeling.

External modeling involves determining potential users of a database, their information needs and the data required to satisfy the needs (Awange and Kiema, 2013).

b) Conceptual modeling.

This is the synthesis of all external modeling in an entity relation-diagram showing entities involved and attributes and relationships (Awange and Kiema, 2013).

c) Logical modeling

This involves mapping the conceptual model when using the database management system. The process answers the question 'how' the system will implement the conceptual model.

d) Physical modeling.

It specifies the physical configuration of the database on the storage media. This includes detailed specification of data elements, data types, indexing options, and other parameters residing in the DBMS data dictionary. (Lightstone,2007). An authoritative data dictionary document catalogs an organization's contents and conventions of one or more datasets benefits database users and application developers. This includes the names and descriptions of various tables and fields of a database, plus additional details, like the type of structure (permanent or temporary). There is no universal standard as to the level of detail in such a document, but it is primarily a distillation metadata about database structure, not the data itself.

The database created on land acquisition should be as per the NLC requirements on land acquisition and authenticated by the relevant Authority; for example, the survey boundary and plot number should be authenticated by the Survey body.

2.6 Geographic Information System (GIS)

Geographic Information Systems (GIS) is a computer system for capturing, storing, checking, and displaying data related to positions on earth's surface which can show many different kinds of data on one map that enables people to more easily see, analyze, and understand patterns and relationships (*http://www.mygeoportal.gov.my*).

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

"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." (Wairiuko, 2013).

GIS tools and applications are useful in land acquisition since it provide a platform which captures both spatial and non-spatial data on the affected land parcels. This provides an efficient and adaptable tool for prior and planning of the land acquisition process.

2.7 Web GIS

Web GIS is a sort of disseminated data framework, involving no less than a server and a client, where the server is a GIS server and the client is an internet browser, desktop application, or mobile application. In its easiest form, web GIS can be characterized as any GIS that utilization web innovation to impart between a server and a client. (Esri,2014).

According to resources.arcgis.com, the key elements essential to web GIS include:

- The server has a URL so that clients can find it on the web.
- The client relies on HTTP specifications to send requests to the server.
- The server performs the requested GIS operations and sends responses to the client via HTTP.
- The format of the response sent to the client can be in many formats, such as HTML, binary image, XML (Extensible Markup Language), or JSON (JavaScript Object Notation).

The web GIS advantage

According to resources.arcgis.com, the advantages of web GIS over desktop GIS are:

- "A global reach: As an ArcGIS user, the world can access web GIS application through their computers and mobile devices. The global nature of web GIS is inherited from HTTP, which is broadly supported. Almost all organizations open their firewalls at certain network ports to allow HTTP requests and responses to go through their local network, thus increasing accessibility." (Esri,2014).
- "Better cross-platform capability: The majority of web GIS clients are web browsers: Internet Explorer, Mozilla Firefox, Apple Safari, Google Chrome, and so on. Because these web browsers largely comply with HTML and JavaScript standards, web GIS that

relies on HTML clients will typically support different operating systems such as Microsoft Windows, Linux, and Apple Mac OS." (Esri,2014)

- "Low cost as averaged by the number of users: The vast majority of Internet content is free of charge to end users, and this is true of web GIS. Generally, you do not need to buy software or pay to use web GIS. Organizations that need to provide GIS capabilities to many users can also minimize their costs through web GIS. Instead of buying and setting up desktop GIS for every user, an organization can set up just one web GIS, and this single system can be shared by many users: from home, at work, or in the field." (Esri,2014)
- "Easy to use: Desktop GIS is intended for professional users with months of training and experience in GIS. Web GIS is intended for a broad audience, including public users who may know nothing about GIS. They expect web GIS to be as easy as using a regular website. Web GIS is commonly designed for simplicity, intuition, and convenience, making it typically much easier to use than desktop GIS." (Esri,2014).
- "Unified updates: For desktop GIS to be updated to a new version, the update needs to be installed on every computer. For web GIS, one update works for all clients. This ease of maintenance makes web GIS a good fit for delivering real-time information" (Esri,2014).
- "Diverse applications: Unlike desktop GIS, which is limited to a certain number of GIS professionals, web GIS can be used by everyone in an enterprise as well as the public at large. This broad audience has diverse demands. Applications such as mapping celebrity homes, tagging personal photos, locating friends, and displaying Wi-Fi hot spots are a few of the many current examples of web GIS." (Esri,2014).

"These characteristics reveal both the advantages and challenges facing web GIS. For example, the easy-to-use nature of web GIS stimulates public participation, but it also reminds you to take into account Internet users who have no GIS background. Conversely, supporting a large number of users requires web GIS to be scalable." (Esri,2014).

2.8 Web bases GIS Applications

Technological overview

"Internet, a client/server system is a perfect means of GIS data accessing, analyzing and transmission. The World Wide Web, FTP (file transfer protocol) and HTTP programs make it

convenient to access and transfer data files across the Internet. The Internet provides GIS users easy access to acquire GIS data from central server system to diverse data source in distributed environment. The World Wide Web is a fast becoming standard platform for Geographic Information System (GIS) and related technologies. It is a means for GIS users to exchange GIS data, conduct GIS analysis and present GIS output in the form of maps, report and web services." (Harish Kamatash, 2014).

"The Geoweb 2.0 allows more interactive and latest GI system as a mash up architecture which is very effective for development of decision support tools for any decision problem where integration of latest information, public participation is important." (Harish Kamatash, 2014). The most important advantage of this technology is "dynamic" nature of GIS (https://nrsc.gov.in). "For example, once any client (s) or database administrator updates the data or information at server end, it will available for all the clients on web at the same time. The Internet GIS can also link with real time information, such as satellite images, traffic movements and accident information etc. by real time connection with the relevant information sources like sensor web. And also these GIS applications are cross-platform which means it can be accessed using any operating system or platform. The Internet GIS applications can categorize into three major categories i.e.

- Server-side applications;
- Client-side applications and
- Mix of server and client-side application." (Harish Kamatash, 2014).

"Server-side applications completely rely on GIS server (usually reside on a remote server) to perform all GIS activities including data analysis and processing, client-side applications perform GIS activities at client (user) end by using local data and application and the mix of server and client-side application allows to use local and remote data application together for producing GIS products" (Harish Kamatash, 2014).

2.9 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.

2.10 Previous publications.

Compulsory land acquisition database for road expansion-Case study: Upperhill Nairobi (Kinyugo Dennis Gitonga, 2011) is a publication on creation of land acquisition database on ARCGIS platform. The author also came up with error propagation method and calculation of areas to be acquired.

This study will improve on the following areas:

1. Creation of a web-based database application.
2. Show encroachment structures on the road reserve.
3. Comparison of existing road reserve from plan and profile maps to the existing RIMs, to check if the RIMs are updated. Also, for the updated RIMs, does the road size indicated on the RIMs and the existing road reserve match.

2.11 Registry Index Map.

A RIM is the main cadastral map prepared for the first registration of land (during the adjudication process) and amended during subsequent land subdivisions (Registered Act,1963). RIM facilitates; identification of a plot on shown on the register on the ground, boundary relocation, area calculation and enable subdivision.

A RIM contains the following information; location, sheet number, index number, edition of the sheet, sheet history, scale and plot numbers. The map user relies on the scale ruler to scale off dimensions from the map since no dimensions of the boundaries are indicated on the map.

The obvious disadvantage of the RIM is the lack of indication of measurements on both the length of the boundaries and of the areas of the individual parcel. Another limitation is that since all amendments are made on the original sheet whose scale is fixed, continuous changes on resultant parcels can make the map very congested which may lead to illegibility of the map.

Abutting parcels in the area of study were from RIMs, which were used for the road acquisition process and the areas calculated for the parcels affected.

CHAPTER 3: METHODOLOGY

3.1 Area of Study.

The area is located along A104 road, from Uplands to Kimende along Nairobi-Nakuru Highway. It is approximately 10 kilometres in length. The Highway is a Class A road and therefore falls under KENHA's jurisdiction. The road lies between latitudes 1° 03' and 0° 58' South of the equator and longitude 36° 37' and 36° 36' and 36° 38' East of the Greenwich Meridian.

The Area of study is located in Lari constituency in Kiambu County in the republic of Kenya. Lari constituency borders Kinangop, Naivasha and limuru constituencies to the north, west and south respectively, Githunguri constituency to the south east, Gatundu South constituency to the east and to the north east by Gatundu south and Gatanga constituency. Figure 4 and 5 shows the area of study.

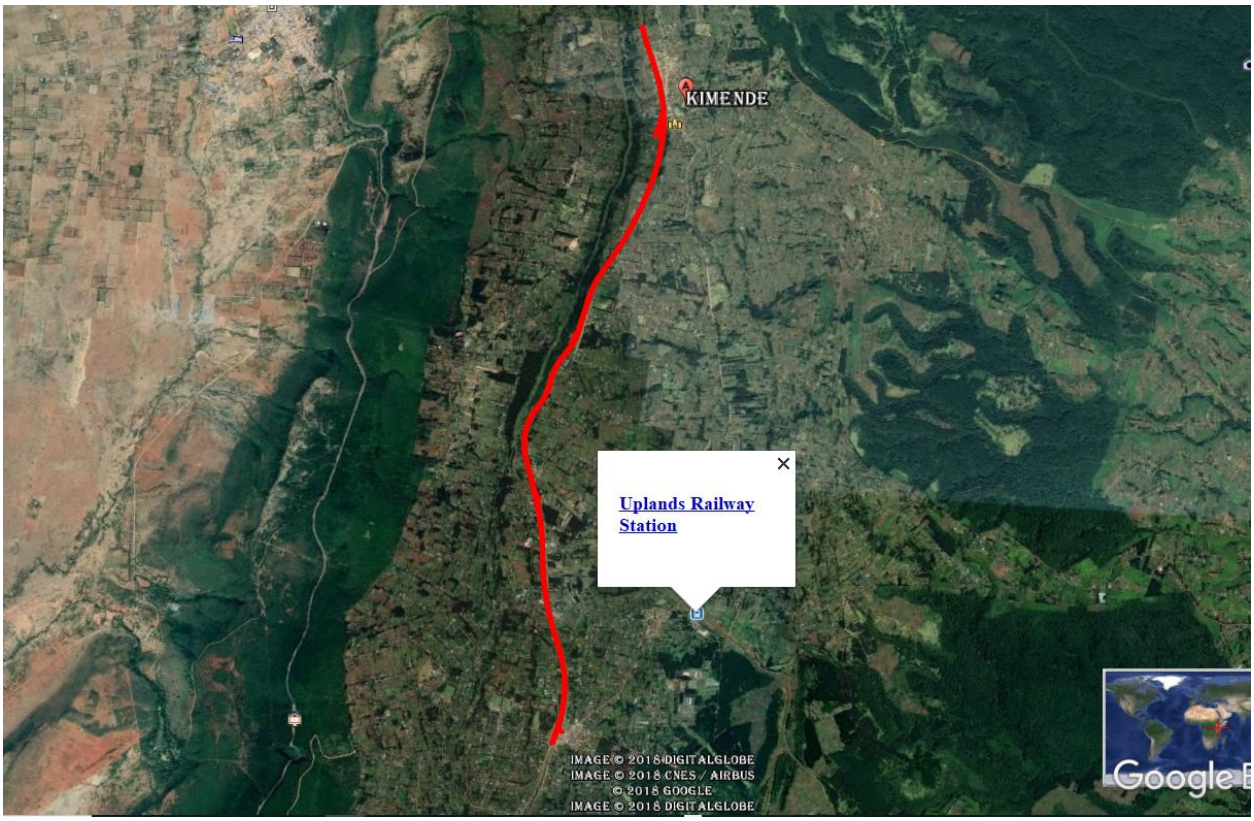


Figure 4: Google Earth image of the area of interest

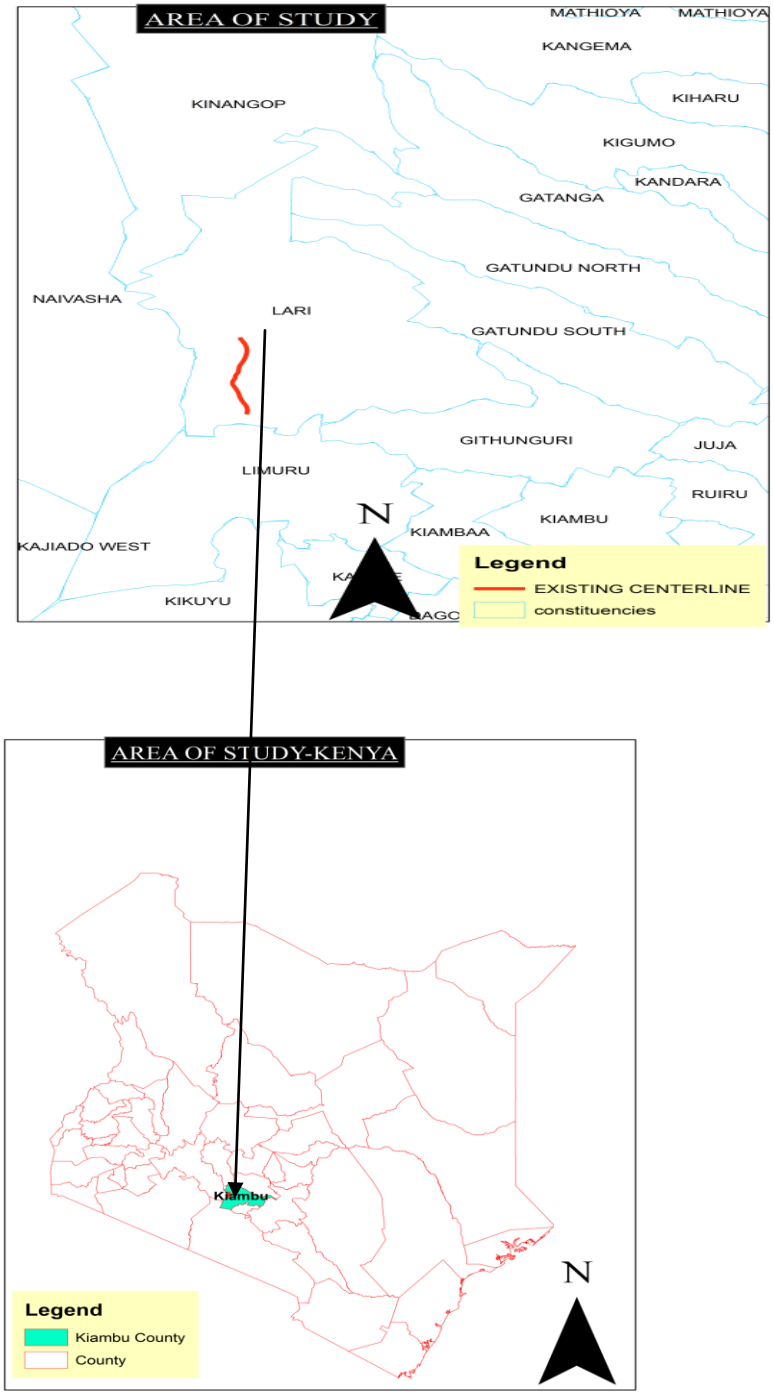


Figure 5: Digital map of area of study

3.2 Materials.

The following materials were used on this project:

3.1.1 Data and their formats.

Data	Source of data	Format
F.Rs	Survey of Kenya	Raster
RIMS	Land registry- Kiambu	Raster
Land acquisition drawings	Ministry of transport, infrastructure, housing and urban development	Raster
Gazette notices	National archives	JPEG
Conversion sheets	Survey of Kenya	Raster and excel
Toposheets	Survey of Kenya	Raster

Table 1: Data and their formats

3.2.2 Hardware**.**

i) Laptop-
ii) Flash disc.
iii) Printer.
iv) Scanner.

3.2.3 Software.

Software	Purpose
Global mapper	-Georeferencing RIMs, FRs and land acquisition drawing.
AUTOCAD	-Digitizing of georeferenced maps.
ARCGIS 10.5	-Creation of database from the digitized maps
	-Creation of a geoportal
Excel	-Conversion of coordinates from cassini to UTM
Google Earth	-Act as an accuracy check by overlying the

	georeferenced and acquired lparcels.

Table 2: Software

3.3 Methodology.

Overview of the Methodology.

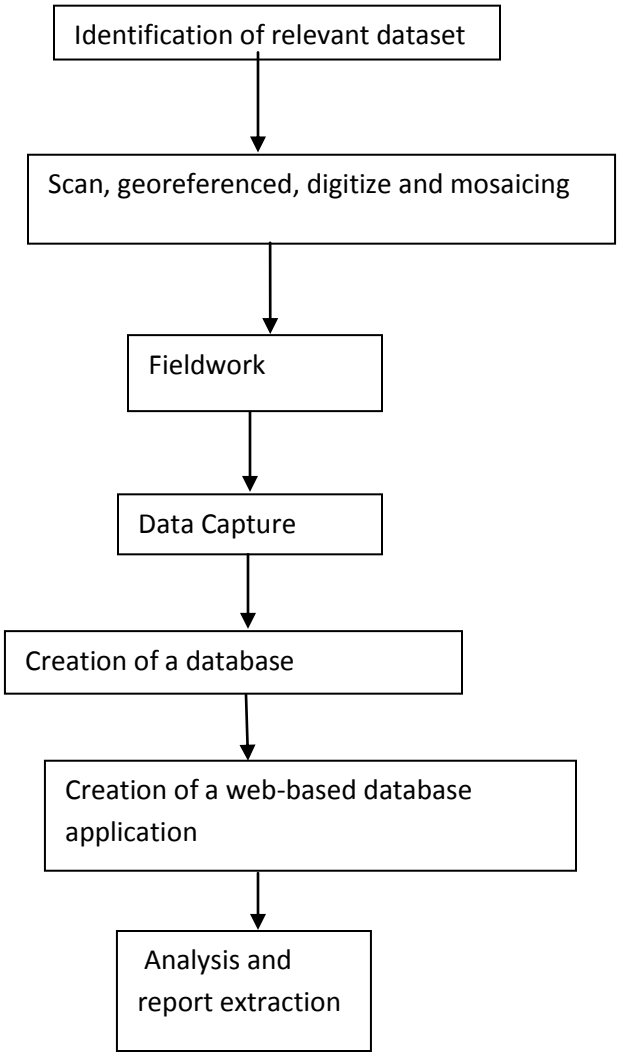


Figure 6: Methodology overview

3.3.1 Identification of relevant datasets.

The following data was identified:

1. Registry index maps (RIMs)

Thirteen RIMS were identified and obtained from the Land, Housing, Physical Planning and Urban Development Department in Kiambu. The RIMs obtained are shown below:

Registration Section	Sheet No.	Total
Escarpment Settlement Scheme	1,2,3	3
Lari Kirenga	1,2,3,7,12,24,19	7
Lari Magina	8,10,11	3

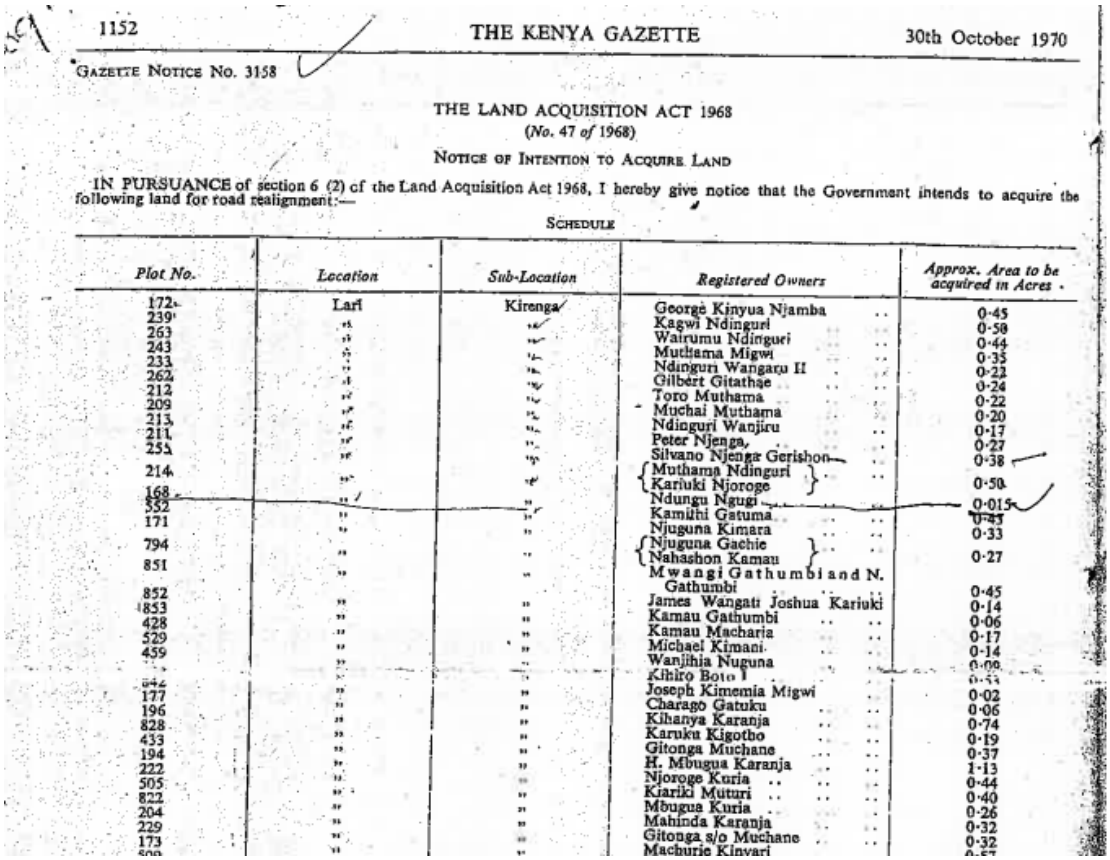
Table 3: RIMs

2. Plan and profile maps.

These were obtained from KENHA and were used to delineate the current road reserve before extension by 20 m on the right-hand side.

3. Gazette notices.

These obtained from the National archives and used to identify parcels that already compensated for. The gazette notices were issued in 1970 and subdivision has been done for these sections, therefore the parcels which are have not been updated on the RIMs were the only ones used for analysis. An example of gazette notice is shown in figure 7.



1152 THE KENYA GAZETTE 30th October 1970

GAZETTE NOTICE No. 3158

THE LAND ACQUISITION ACT 1968
(*No. 47 of 1968*)

NOTICE OF INTENTION TO ACQUIRE LAND

IN PURSUANCE of section 6 (2) of the Land Acquisition Act 1968, I hereby give notice that the Government intends to acquire the following land for road realignment:—

SCHEDULE

Plot No.	*Location*	*Sub-Location*	*Registered Owners*	*Approx. Area to be acquired in Acres*
172	Lari	Kirenga	George Kinyua Njamba	0·45
239	"	"	Kagwi Ndinguri	0·58
263	"	"	Wairumu Ndinguei	0·44
243	"	"	Muthama Migwi	0·35
233	"	"	Ndinguri Wangaru II	0·22
262	"	"	Gilbert Gitathae	0·24
212	"	"	Toro Muthama	0·22
209	"	"	Muchai Muthama	0·20
213	"	"	Ndinguri Wanjiru	0·17
211	"	"	Peter Njenga	0·27
255	"	"	Silvano Njenga Gerishon	0·38
214	"	"	Muthama Ndinguri / Kariuki Njoroge	0·50
168	"	"	Ndungu Ngugi	0·015
552	"	"	Kamithi Gatuma	0·45
171	"	"	Njuguna Kimara	0·33
794	"	"	Njuguna Gachie / Nahashon Kamau	0·27
851	"	"	Mwangi Gathumbi and N. Gathumbi	0·45
852	"	"	James Wangati Joshua Kariuki	0·14
853	"	"	Kamau Gathumbi	0·06
428	"	"	Kamau Macharia	0·17
529	"	"	Michael Kimani	0·14
459	"	"	Wanjihia Nuguna	0·09
[illegible]	"	"	Kihiro Boto	0·53
177	"	"	Joseph Kimemia Migwi	0·02
196	"	"	Charago Gatuku	0·06
828	"	"	Kihanya Karanja	0·74
433	"	"	Karuku Kigotho	0·19
194	"	"	Gitonga Muchane	0·37
222	"	"	H. Mbugua Karanja	1·13
505	"	"	Njoroge Kuria	0·44
822	"	"	Kiariki Muturi	0·40
204	"	"	Mbugua Kuria	0·26
229	"	"	Mahinda Karanja	0·32
173	"	"	Gitonga s/o Muchane	0·32
[illegible]	"	"	Machuria Kinyari	0·57

Figure 7: Gazette notice

4. Topographic survey data.

This data contains features picked along the area of study. Features in the topographic data include existing road edge and reserve, fences, power post and culverts.

3.3.2 Data Preparation.

3.3.2.1 Scanning, Georeferencing and digitizing.

RIMs and data from KENHA was scanned and saved in JPEG format. The scanned maps were in Cassini coordinate system, therefore coordinate transformation was required to convert the data from Cassini to UTM (37S).

Coordinate transformation is the process of converting coordinates from one coordinate system to another. The four-parameter transformation was used for this transformation. The similarity transformation, which is introduced by means of transformation (horizontal shifts), a rotation through an angle and change of scale by a factor (Yeung,2007) was used. The transformation uses the following equation:

X=ax -by +c
Y=bx + ay +d
X and Y are coordinates in UTM
x and y are coordinates in Cassini
a, b, c and d are transformation parameters

This formula in excel form (Corner sheets) was obtained from Survey of Kenya, which is derived by converting topo cadastral maps as base maps since they are already in UTM. Four intersection points on each of the cadastral index maps in cassia were picked and transformed to Cassini, hence ensuring processing is carried out in a common coordinate system.

RIMs and profile plans were geo-referenced using the respective grid coordinates. The geo-referencing ties the images to the national UTM Grid. Transformation formula is shown in figure 8.

	COORDINATE TRANSFORMATION (CASSINI TO UTM)							
DATUMS	148/2/17							
CASSINI (X)	CASSINI (Y)	UTM (E)	UTM (N)					
-146344.6	-399687	232905.7	9878320.5					
-128088.1	-399684.4	238473.3	9878325					
-128085.1	-417821.5	238477.7	9872794.3					
-146342.2	-417823.8	232910.2	9872789.7					
TRANSFORMATION PARAMETERS								
a=	0.304950764	b=	0.00020415609					
Tx=	277452.0945	Ty=	10000235.2863					
	E	equals	aX-bY+Tx					
	N	equals	bX+aY+Ty					
	CASSINI (X)	CASSINI (Y)	UTM (E)		UTM (N)		#VALUE!	#VALUE!
							0	0
M3	-136000	-408000	236062.086		9875787.609	236062.086208533,9875787.60929304	-446194.2264	-1338582.679
M4	-132000	-408000	237281.889		9875788.426	237281.88926546,9875788.42591738	-433070.8668	-1338582.679
B2	-132000	-412000	237282.706		9874568.623	237282.705889806,9874568.62286046	-433070.8668	-1351706.039
BK5	-136000	-412000	236062.903		9874567.806	236062.902832879,9874567.80623611	-446194.2264	-1351706.039

Figure 8: Transformation formula

Georefencing was done using Global Mapper software, this was done using the transformed coordinates. The ground coordinates of the chosen grid intersection points on the maps were specified in a clockwise manner. The georeferenced maps were then rectified by exporting the maps in TIFF format which allows affine transformation. The RMS error on the Global mapper was ensured to be less than 0.5mm which ensures the end results falls within an accuracy of 2 M on the ground.

Georeferenced RIMs, profile and profile maps were digitized using AUTOCAD 2019. Features (eg, current road reserve, cadastral boundary) were stored in different layers for further analysis.

The current road reserve was delineated from the digitized plan and profile maps obtained from KENHA. As shown in figure 9.

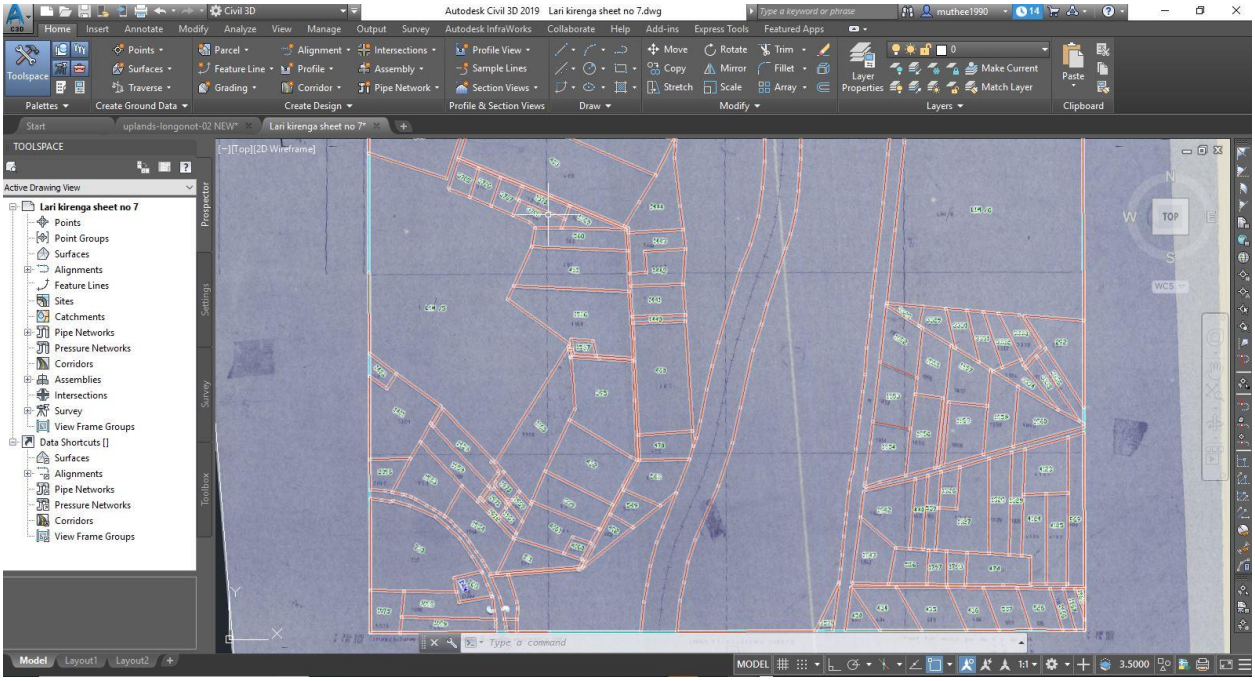


Figure 9: Digitization of Lari/Kirenga Sheet 7.

3.3.2.2 Mosaicing.

Mosaicing is the process of combining multiple, individual images into a single scene. The input images were ensured to be in the same projection system. Figure 10 shows the mosaiced plan and profile maps.

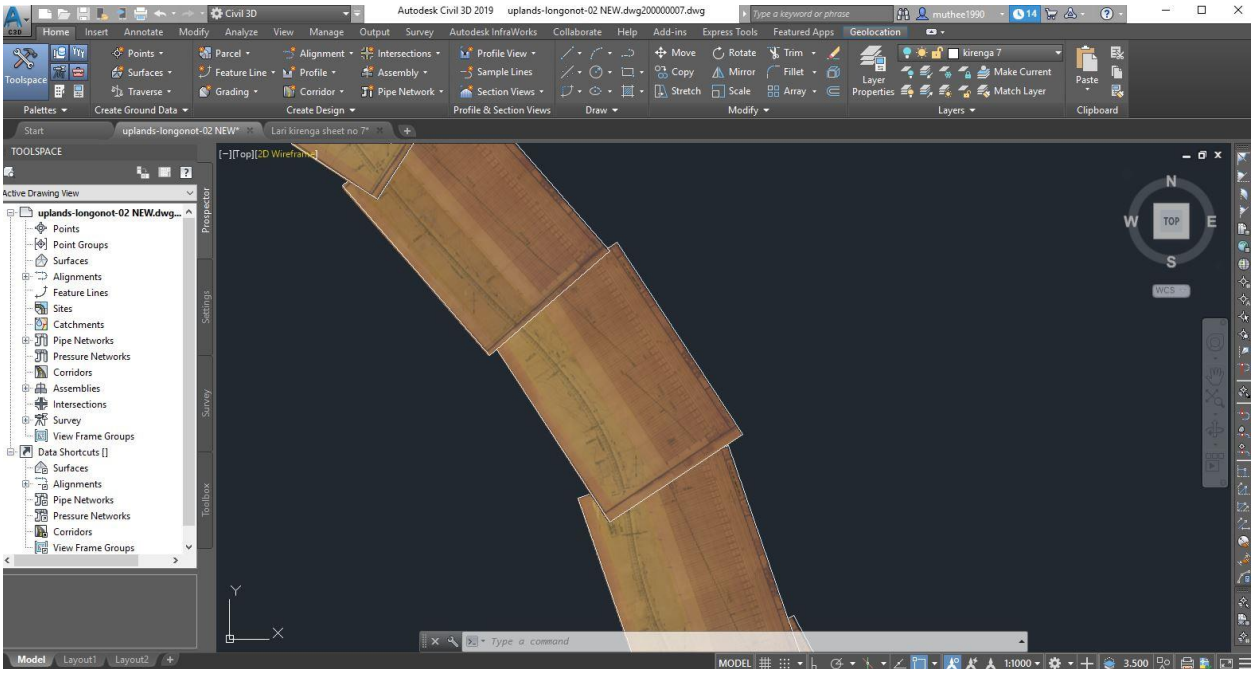


Figure 10: Mosaiced plan and profile maps.

3.3.3 Simulation of a 20M road extension.

From the delineated current road reserve, a 20 M road extension was obtained by offsetting the current road reserve by 20 M. The right-hand side was chosen since it had fewer structures as compared to the left-hand side. This reduces the cost for acquisition.

3.3.4 Field work.

This involves picking data along the road reserve which includes structures on the road reserve and the area to be acquired. These features are then drawn in AUTOCAD against the road reserve obtained in the previous section. This involves using a handheld GPS and picking and picking the corner coordinates of the structure which will be used when plotting the structures. Normally, the people are sensitized and the owners' details are picked with the assistance of the local Chief. But for this study names and structures will be generated due to the time limit. Structures within the current road and the 20 M road extension were picked.

3.3.5 Data capture.

Data capture involves two phases:

3.3.5.1 Spatial data capture.

The digitized data was then loaded in ARCGIS. For each theme-a shapefile was created from the ArcCatalog - by converting AUTOCAD drawings (.DWG) to shapefiles for each layer. The shapefiles created include: power posts, 20 m road extension, existing road reserve existing road edge, existing road centreline, structures in existing road reserve, survey boundary, structures in the road extension, area to be acquired. As shown in figure 11.

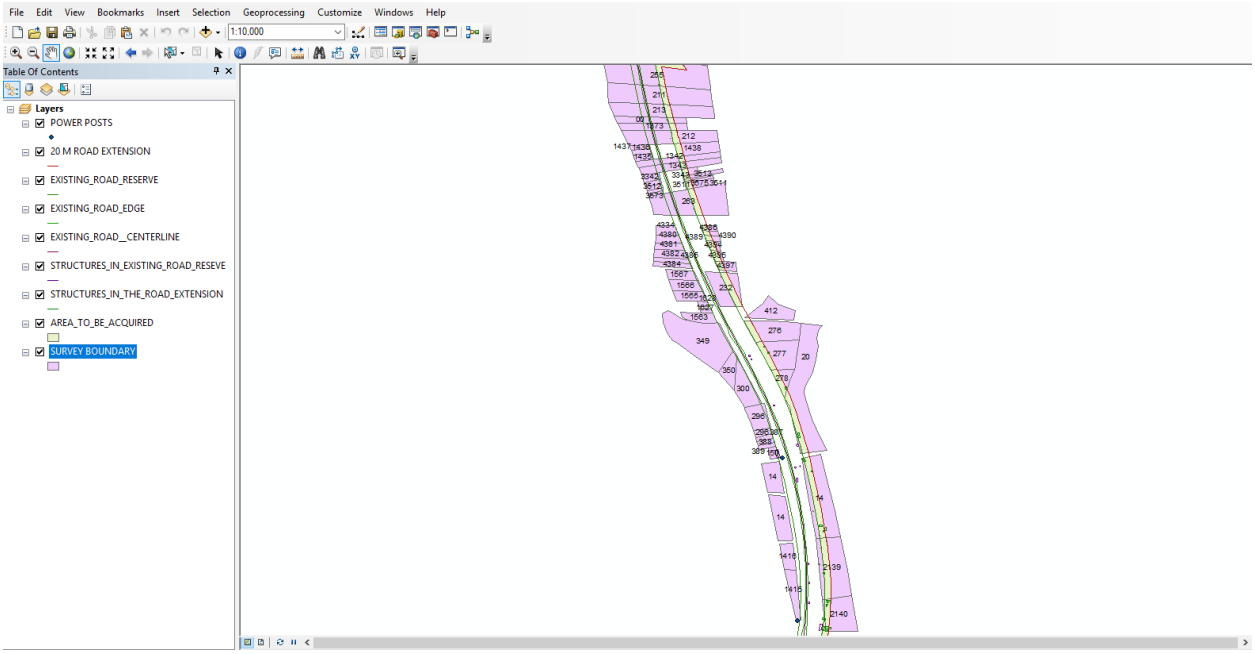


Figure 11: Spatial data capture.

3.3.5.2 Non-spatial data capture.

This involves creation of attributes of digitized themes. Some of the attributes created in area to be acquired shape file include; land registration section, plot number and owner of the plot. The tables created were normalized through 1NF, 2NF and 3NF. 1NF ensured that there was no data redundancy by ensuring that all rows had the same number of attributes and every value was atomic. 2NF ensures that no attribute depends on part of the key and 3 NF ensures that no non-key attribute should depend on non-key attribute. As shown in figure 12.

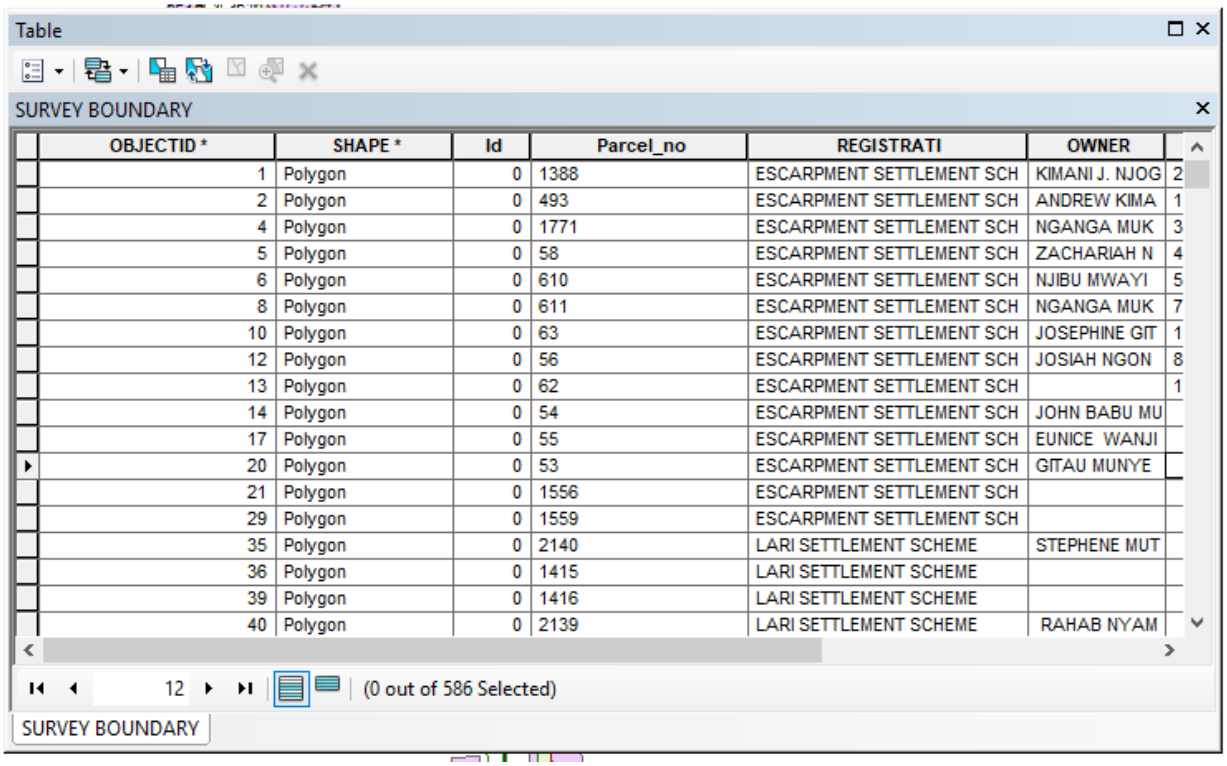


Figure 12: Creation of attributes of the Area to be acquired theme.

3.3.5.3 Data editing and validation.

This involves detecting and correcting errors (data cleansing) during data capture to ensure data quality hence they are correct and useful. This ensures that all polygons are closed and attributes created for each feature are correct.

3.3.6 Database creation.

The thematic layers to be used were identified; some of the layers identified include structures within the road extension and area to be acquired. Each theme was further defined by adding attributes.

3.3.7 Creation of a web-based database and application.

This involves the following steps:

1. Author a map document that supports web editing, one ensures that the map document is compliant with the feature service. This service allows updating of the geodatabase over the web.

2. Registering to ArcGIS server.
3. Publishing of the database as a map service.
4. Create a new web application from the web app builder and configure the map by picking a theme.
5. Add widgets which give the application function ability and configure attributes. A query widget allows one to retrieve information from source by executing predefined query (https://doc.arcgis.com/en/web-appbuilder/create-apps/widget-query.htm). Query widgets were created for structures in the road extension and area to be acquired themes.
6. Preview and launch. Figure 13 shows the web application and the query widget created is shown in figure 14 and the result in Figure 15.

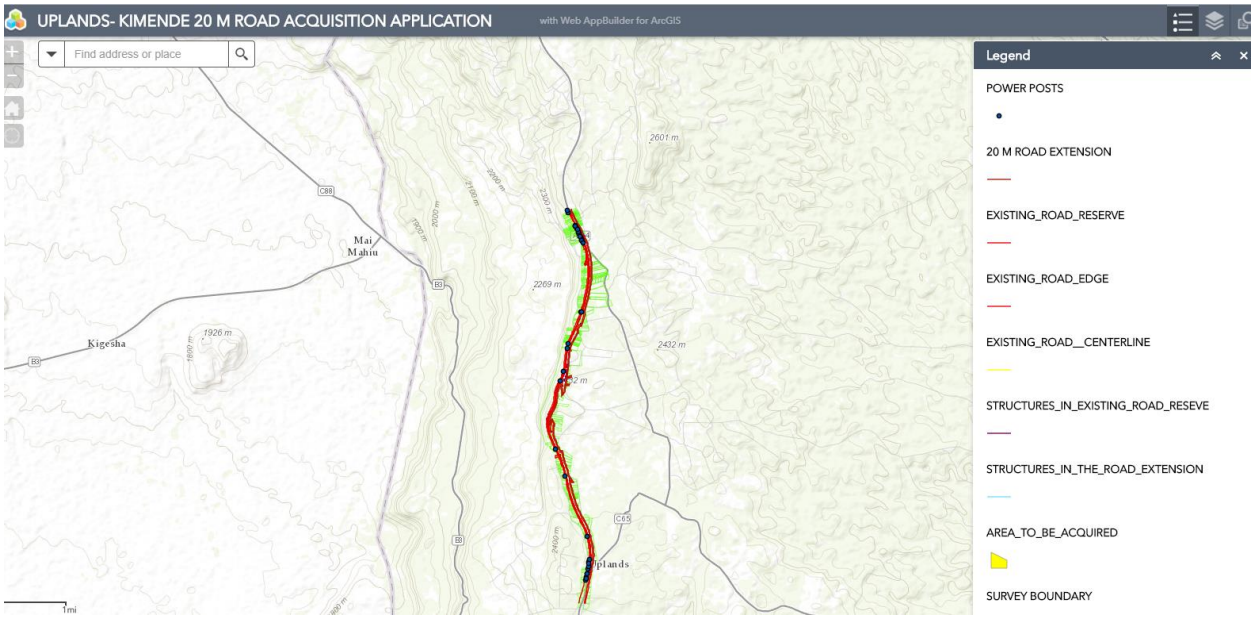


Figure 13: Web application

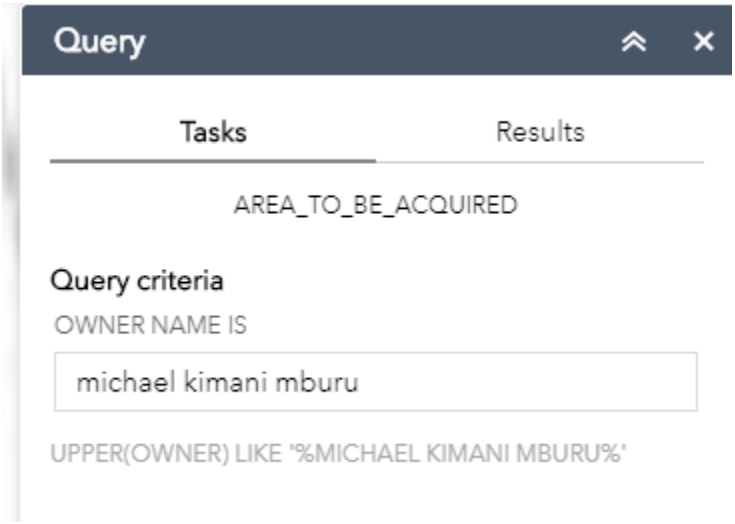


Figure 14: Query widget

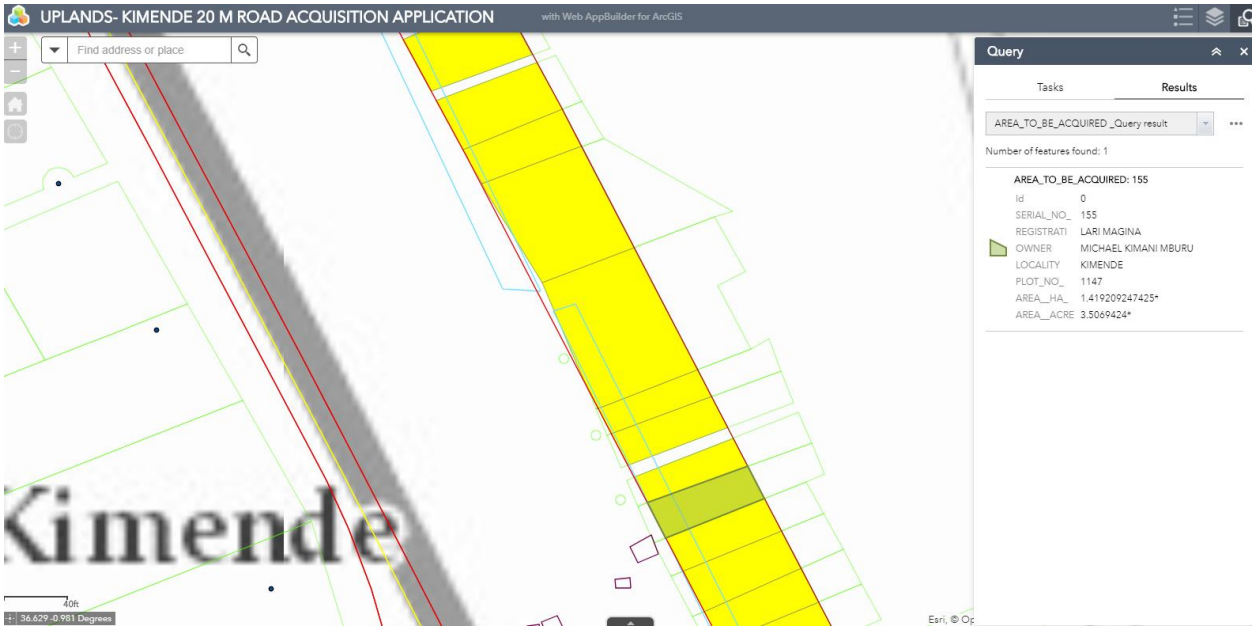


Figure 15: The Query widget enables one to obtain information from the source data.

CHAPTER 4: RESULTS AND ANALYSIS.

4.1 Web based database application.

The web application software interface and corresponding tools enables the user to visualize, interact with and work with geographic information. The application allows symbolization hence each theme has its own cartographic style. The application is easy to use and provides a valuable resource for accessing spatial dataset. Users can access the data and GIS analysis tools without buying the software. The web application is shown in figure 13.

4.2 Database.

One of the objectives was to create a database that describes parcels and structures. These databases are important for future references and auditing of data. The database meets the NLC's requirements of the attributes required in compulsory land acquisition. The databases are shown in figure 16, 17 and 18

Table

AREA_TO_BE_ACQUIRED

OBJECTID *	Shape *	Id	SERIAL_NO_	REGISTRATI	OWNER	LOCALITY	PLOT_NO_	AREA__HA_	AREA__ACRE	Shape_Length	Shape_Area
1	Polygon	0	8	ESCARPMENT SETTLEMENT SCHEME	KENYA FOREST SERVICE	UPLANDS	fores	0.501962920116*	1.2403773*	667.213471	5019.629201
2	Polygon	0	9	LARI SETTLEMENT SCHEME	STEPHENE MUTHINJI GIOKOMA	UPLANDS	2140	0.184157609073*	0.4550633*	244.602629	1841.576091
3	Polygon	0	10	LARI SETTLEMENT SCHEME	RAHAB NYAMBURA GIOKO	UPLANDS	2139	0.406527466943*	1.0045512*	446.934101	4065.27467
4	Polygon	0	11	LARI SETTLEMENT SCHEME	DAVID KARIUKI GIKO	UPLANDS	14	0.549759597497*	1.3584855*	589.837398	5497.595975
5	Polygon	0	12	LARI SETTLEMENT SCHEME	NDUNGU MUTHINJI	UPLANDS	20	0.398653863373*	0.9850951*	469.045961	3986.538634
6	Polygon	0	13	LARI SETTLEMENT SCHEME	ANNAH WAMBUI MBIRA	UPLANDS	278	0.176666289845*	0.4365519*	231.6728	1766.662898
7	Polygon	0	14	LARI SETTLEMENT SCHEME	GEORGE WAWERU NJUGUNA	UPLANDS	277	0.210153148335*	0.5192997*	254.820313	2101.531483
8	Polygon	0	15	LARI SETTLEMENT SCHEME	PETER MUTURI MUTHINJI	UPLANDS	276	0.159509081944*	0.3941555*	204.927996	1595.09082
9	Polygon	0	17	LARI KIRENGA	GEORGE MUTHINJI	UPLANDS	232	0.252308616754*	0.6234681*	294.490588	2523.086168
10	Polygon	0	18	LARI KIRENGA	SIMON MBUTHIA KAHIGA	UPLANDS	4397	0.067537384736*	0.1668885*	112.392966	675.373847
11	Polygon	0	19	LARI KIRENGA	GEORGE MWAURA KAMANDE	UPLANDS	4395	7.727828121094*	0.1909587*	121.723062	772.782812
12	Polygon	0	20	LARI KIRENGA	GEORGE KIHIKA GITHONDA	UPLANDS	4394	7.051354683944*	0.1742427*	114.992307	705.135468
13	Polygon	0	21	LARI KIRENGA	HANDI GATHUKU	UPLANDS	4390	3.782259988212*	9.3461679*	82.207126	378.225999
14	Polygon	0	22	LARI KIRENGA		UPLANDS	4389	3.392238762720*	8.3824045*	77.565601	339.223876
15	Polygon	0	23	LARI KIRENGA	ANASTACIA NYAKARO	UPLANDS	4386	3.584383319964*	8.8572040*	78.840744	358.438332
16	Polygon	0	24	LARI KIRENGA	FRANCIS MWAURA THUKU	LARI	263	0.184887671687*	0.4568673*	226.378823	1848.876717
17	Polygon	0	25	LARI KIRENGA	JAMES KAMAU MBUGUA	LARI	3575	4.247938470185*	0.1049688*	82.860703	424.793847
18	Polygon	0	26	LARI KIRENGA	GIKANYA WAITHIKA	LARI	3511	1.318664156943*	0.0325849*	53.524513	131.866416
19	Polygon	0	27	LARI KIRENGA	LYDIA WANJIKU	LARI	3512	1.412861136571*	3.4912559*	54.442562	141.286114
20	Polygon	0	28	LARI KIRENGA	KUONI MUREMWA	LARI	3513	2.333771090793*	5.7668739*	63.57545	233.377109
21	Polygon	0	29	LARI KIRENGA	PATRICK WAITHAKA KIHIKA	LARI	29	4.737740209806*	0.1170721*	87.560997	473.774021
22	Polygon	0	30	LARI KIRENGA	KARIUKI MBAI	LARI	3343	4.625676804758*	0.1143029*	86.57104	462.56768
23	Polygon	0	31	LARI KIRENGA	JOHANA KIRATU GICHUKI	LARI	1343	0.039054794553*	9.6506499*	79.521706	390.547945
24	Polygon	0	32	LARI KIRENGA	MURAGE CHEGE	LARI	1438	8.873061381448*	0.2192581*	129.502661	887.306138
25	Polygon	0	33	LARI KIRENGA	KAHIA WANGUNYU	LARI	212	9.463918259047*	0.2338585*	135.594877	946.391826
26	Polygon	0	34	LARI KIRENGA	NDUNGU NGANGA	LARI	1373	5.017629637365*	0.1239883*	91.377381	501.762964
27	Polygon	0	35	LARI KIRENGA	NGUGI GATHECE	LARI	00	3.926249067587*	9.7019727*	81.056747	392.624907
28	Polygon	0	36	LARI KIRENGA	ARTHUR KINUTHIA MBAGU	LARI	213	8.811219816056*	0.2177299*	129.851575	881.121982
29	Polygon	0	37	LARI KIRENGA	ARTHUR GIKANYA	LARI	211	0.124126627149*	0.3067235*	165.60149	1241.266271
30	Polygon	0	38	LARI KIRENGA	FRANCIS KUNYUGA MUIRU	LARI	255	0.331819279469*	0.8199432*	380.415556	3318.192795
31	Polygon	0	39	LARI KIRENGA	GATUMBI KUBIU	LARI	1849	0.145786321240*	0.3602458*	203.871691	1457.863212

1 (0 out of 193 Selected)

AREA_TO_BE_ACQUIRED

Figure 16: Area to be acquired database.

Table

AREAS ALREADY ACQUIRED

FID	Shape *	OBJECTID	FID_plots	Id	Parcel_no	REGISTRATI	OWNER	SERIAL_NO	LOCALITY	SHAPE_Leng	SHAPE_Area	OBJECTID_1	Id_1	SERIAL_NO_
225	Polygon	795	-1	0	1223		NELSON NJENGA			40.541443	40.611833	122	0	150
257	Polygon	902	-1	0	1741		NGAGE MUSA			39.682182	68.862392	136	0	
48	Polygon	195	-1	0	00		NGUGI GATHECE			217.13196	1678.080958	27	0	35
26	Polygon	110	-1	0	1565		NJERI MUTUA			78.336259	69.229196	164	0	181
306	Polygon	932	-1	0	1565		NJERI MUTUA			32.544594	9.614334	164	0	181
74	Polygon	343	-1	0	974		NJIHA NDENDERU			63.883177	98.379152	60	0	71
308	Polygon	941	-1	0	1253		NJOROGE NDIRANGU			3.325158	0.078225	167	0	184
100	Polygon	426	-1	0	2062		PAUL KARIUKI NJOROGE			26.060472	7.963285	77	0	92
84	Polygon	372	-1	0	558		PETER MWANGI			14.041793	2.669086	189	0	82
231	Polygon	812	-1	0	1146		PETER MWANGI MBUGUA			14.22534	9.224884	128	0	156
25	Polygon	97	-1	0	350		PETER NJOROGE			55.800857	100.246463	97	0	113
183	Polygon	575	-1	0	350		PETER NJOROGE			316.865461	2842.36879	97	0	113
223	Polygon	788	-1	0	928		RAPHAEL KAMAU NGETHE			89.64108	474.888897	120	0	148
240	Polygon	841	-1	0	1230		ROSE NYAMBURA KIMANI			21.086459	0.300042	153	0	162
256	Polygon	897	-1	0	1742		ROSE WANJIRU GACHOKA			38.149032	62.826649	132	0	173
251	Polygon	867	-1	0	1039		SAMUEL NGIHIA NDERIL			13.434225	7.846814	139	0	168
162	Polygon	504	-1	0	3230		SAMUEL NGUNGU			57.178074	77.595772	88	0	104
179	Polygon	563	-1	0	805		SAMUEL NYOTA MBURU			196.204301	1396.010771	96	0	112
192	Polygon	648	-1	0	805		SAMUEL NYOTA MBURU			42.031712	24.947288	96	0	112
59	Polygon	242	-1	0	1883		SCHOLAR WANGARI			81.74103	147.347151	37	0	45
30	Polygon	124	-1	0	4397		SIMON MBUTHIA KAHIGA			69.609965	48.373748	10	0	18
235	Polygon	822	-1	0	918		SPEPHEN KURIA GIKANGA			11.416478	1.128603	158	0	159
221	Polygon	775	-1	0	930		STEPHEN MBURU MAINA			68.048183	198.490672	184	0	145
195	Polygon	668	-1	0	1213		STEPHEN MUCHAI KANYORA			104.18673	451.126914	106	0	122
249	Polygon	859	-1	0	1037		STEPHENE KURIA GIKANGA			13.99878	5.366808	137	0	166
18	Polygon	63	-1	0	2140		STEPHENE MUTHINJI GIOKOMA			112.427976	220.3064	2	0	9
226	Polygon	799	-1	0	1048		TABITHA THUKU KARANJA			19.995715	17.699612	123	0	151
228	Polygon	804	-1	0	1054		TABITHA WANJIRU MWANGI			22.143675	21.166847	125	0	153
193	Polygon	650	-1	0	314		ZACHARIAH MUNGAI MBURU			270.597532	3948.404846	104	0	120
1	Polygon	7	-1	0	58		ZACHARIAH NGANGA			283.792026	1771.878653	177	0	1

0 (0 out of 312 Selected)

AREA_TO_BE_ACQUIRED | AREAS ALREADY ACQUIRED

Figure 17: Area already acquired

Table

STRUCTURES_IN_THE_ROAD_EXTENSION

OBJECTID *	Shape *	Id	SERIAL_NO_	OWNER	PLOT_NO	LOCATION	REGISTRATI	OWNER_ID	LOCATION_1	Shape_Length
57	Polyline	0	37	DAVID KARIUKI GIKO		UPLANDS	LARI SETTLENT SCHEME	86092103.*		14.909316
58	Polyline	0		DAVID KARIUKI GIKO		UPLANDS	LARI SETTLENT SCHEME	22351444.*		14.909239
59	Polyline	0	38	DAVID KARIUKI GIKO		UPLANDS	LARI SETTLENT SCHEME	63198791.*		35.387648
132	Polyline	0	102	DAVID KURIA NJOROGE		MAKUMU	LARI KIRENGA	42087288.*		10.739293
135	Polyline	0	105	DAVID KURIA NJOROGE		MAKUMU	LARI KIRENGA	89163411.*		26.502006
106	Polyline	0	79	DAVID MARARI		KARAI	LARI KIRENGA	84583314.*		40.885862
107	Polyline	0		DAVID MARARI		KARAI	LARI KIRENGA	85711501.*		114.465094
201	Polyline	0	171	ESTHER MUGURE KIRIGA		KIMENDE	LARI MAGINA	35075776.*		27.223457
202	Polyline	0	172	ESTHER MUGURE KIRIGA		KIMENDE	LARI MAGINA	8038234.1*		14.427905
203	Polyline	0		ESTHER MUGURE KIRIGA		KIMENDE	LARI MAGINA	79451130.*		23.881639
204	Polyline	0	173	ESTHER MUGURE KIRIGA		KIMENDE	LARI MAGINA	56447230.*		20.760769
205	Polyline	0		ESTHER MUGURE KIRIGA		KIMENDE	LARI MAGINA	69261370.*		17.971339
206	Polyline	0		ESTHER MUGURE KIRIGA		KIMENDE	LARI MAGINA	25683911.*		36.114062
207	Polyline	0		ESTHER MUGURE KIRIGA		KIMENDE	LARI MAGINA	51520347.*		23.836082
213	Polyline	0	179	ESTHER MUGURE KIRIGA		KIMENDE	LARI MAGINA	60672543.*		14.428023
214	Polyline	0	180	ESTHER MUGURE KIRIGA		KIMENDE	LARI MAGINA	3294127.6*		25.148041
215	Polyline	0	181	ESTHER MUGURE KIRIGA		KIMENDE	LARI MAGINA	47962700.*		20.760836
216	Polyline	0		ESTHER MUGURE KIRIGA		KIMENDE	LARI MAGINA	63074333.*		23.881605
217	Polyline	0		ESTHER MUGURE KIRIGA		KIMENDE	LARI MAGINA	77692075.*		17.971345
218	Polyline	0		ESTHER MUGURE KIRIGA		KIMENDE	LARI MAGINA	8461074.4*		36.114062
219	Polyline	0		ESTHER MUGURE KIRIGA		KIMENDE	LARI MAGINA	57227522.*		23.836014
222	Polyline	0	184	ESTHER MUGURE KIRIGA		KIMENDE	LARI MAGINA	27404880.*		61.880594
224	Polyline	0	186	ESTHER MUGURE KIRIGA		KIMENDE	LARI MAGINA	96182873.*		61.880643
200	Polyline	0	170	EUNICE MWIHAKI KIRIGA		KIMENDE	LARI MAGINA	61381315.*		32.55508
11	Polyline	0	10	EUNICE WANJIKU KIMUHU	55	UPLANDS	ESCARPMENT SETTLEMENT SCHEME	17242470.*		26.76153
12	Polyline	0	12	EUNICE WANJIKU KIMUHU	55	UPLANDS	ESCARPMENT SETTLEMENT SCHEME	86371375.*		17.141898
13	Polyline	0	11	EUNICE WANJIKU KIMUHU	55	UPLANDS	ESCARPMENT SETTLEMENT SCHEME	78177146.*		25.620239
14	Polyline	0	11	EUNICE WANJIKU KIMUHU	55	UPLANDS	ESCARPMENT SETTLEMENT SCHEME	5970185.3*		25.620307
15	Polyline	0	197	EUNICE WANJIKU KIMUHU	55	UPLANDS	ESCARPMENT SETTLEMENT SCHEME	32625300.*		17.141935
16	Polyline	0	13	EUNICE WANJIKU KIMUHU	55	UPLANDS	ESCARPMENT SETTLEMENT SCHEME	78680981.*		17.546506
17	Polyline	0	15	EUNICE WANJIKU KIMUHU	55	UPLANDS	ESCARPMENT SETTLEMENT SCHEME	29546084.*		32.946516

0 (0 out of 249 Selected)

AREA_TO_BE_ACQUIRED | AREAS ALREADY ACQUIRED | STRUCTURES_IN_EXISTING_ROAD_RESEVE | STRUCTURES_IN_THE_ROAD_EXTENSION

Figure 18: Database on structures

4.3 Attribute database query

This enables one to retrieve and analyse data from the database. Figure 19 shows the output of the query from the database.

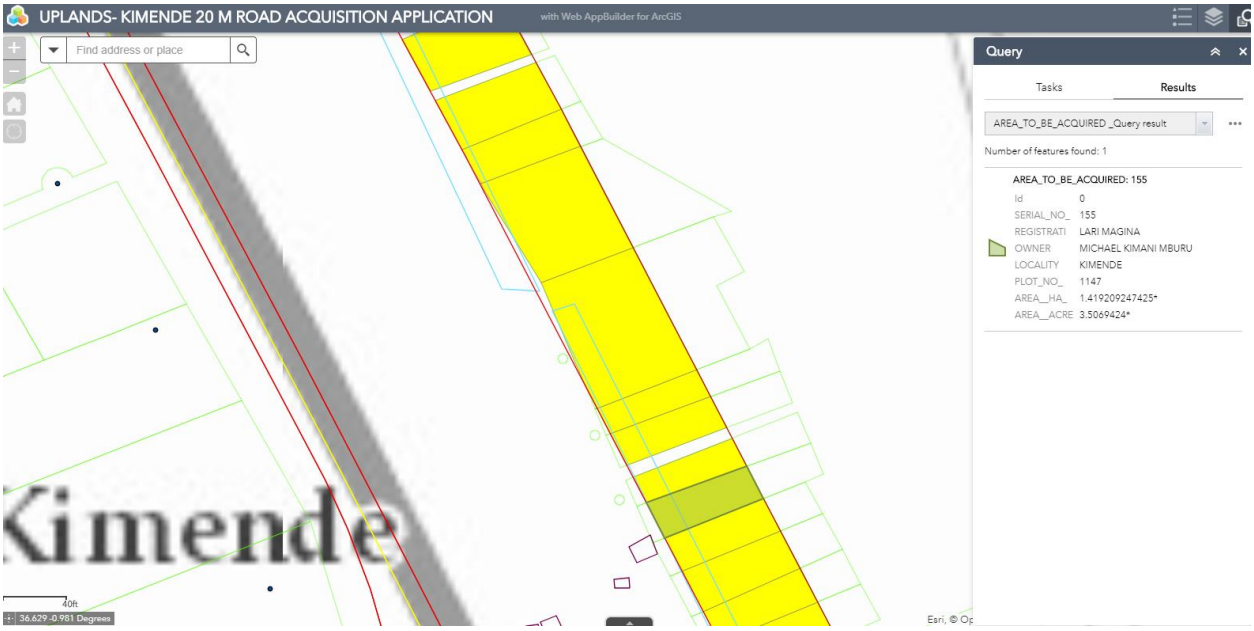


Figure 19: Results from querying

SELECT FROM ‘PLOT NUMBER’

WHERE

OWNER= ‘MICHAEL KIMANI MBURU’

The query widget displayed the results of the above query as indicated in the Table 4;

Serial No.	155
Registration Section	Lari Magina
Registered Owner	Michael Kimani Mburu
Locality	Kimende
Plot No,	1147
Area in Hectares (to be acquired)	1.41

Area in Acres (to be acquired)	3.50

Table 4: Query results

4.4 Digital maps.

These are maps of the various themes as a result of data capture. Figure 20 and 21 are some of digital maps created. CLA can be visualized from these maps and give a general view of the road corridor.

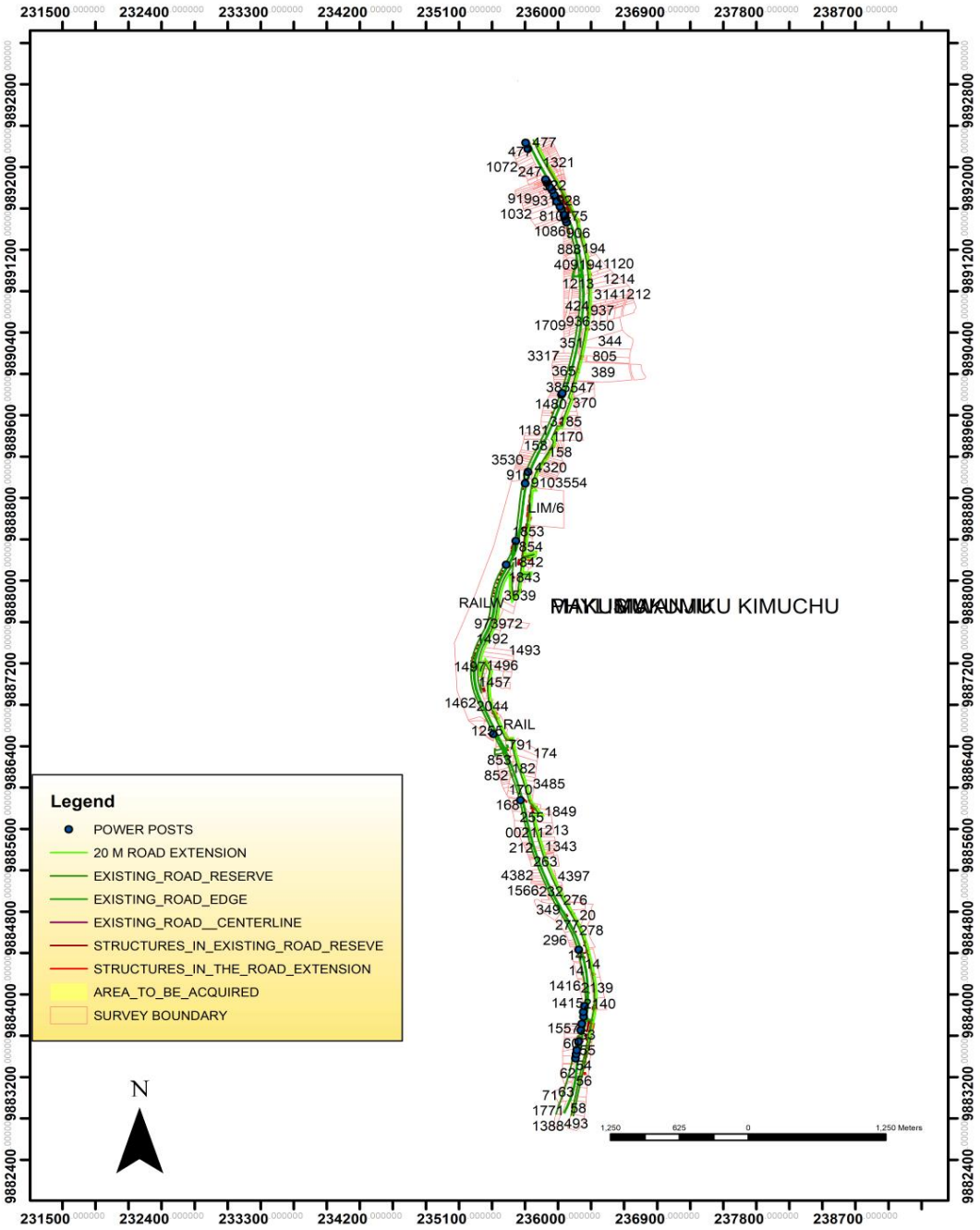


Figure 20: Digital map showing themes created.

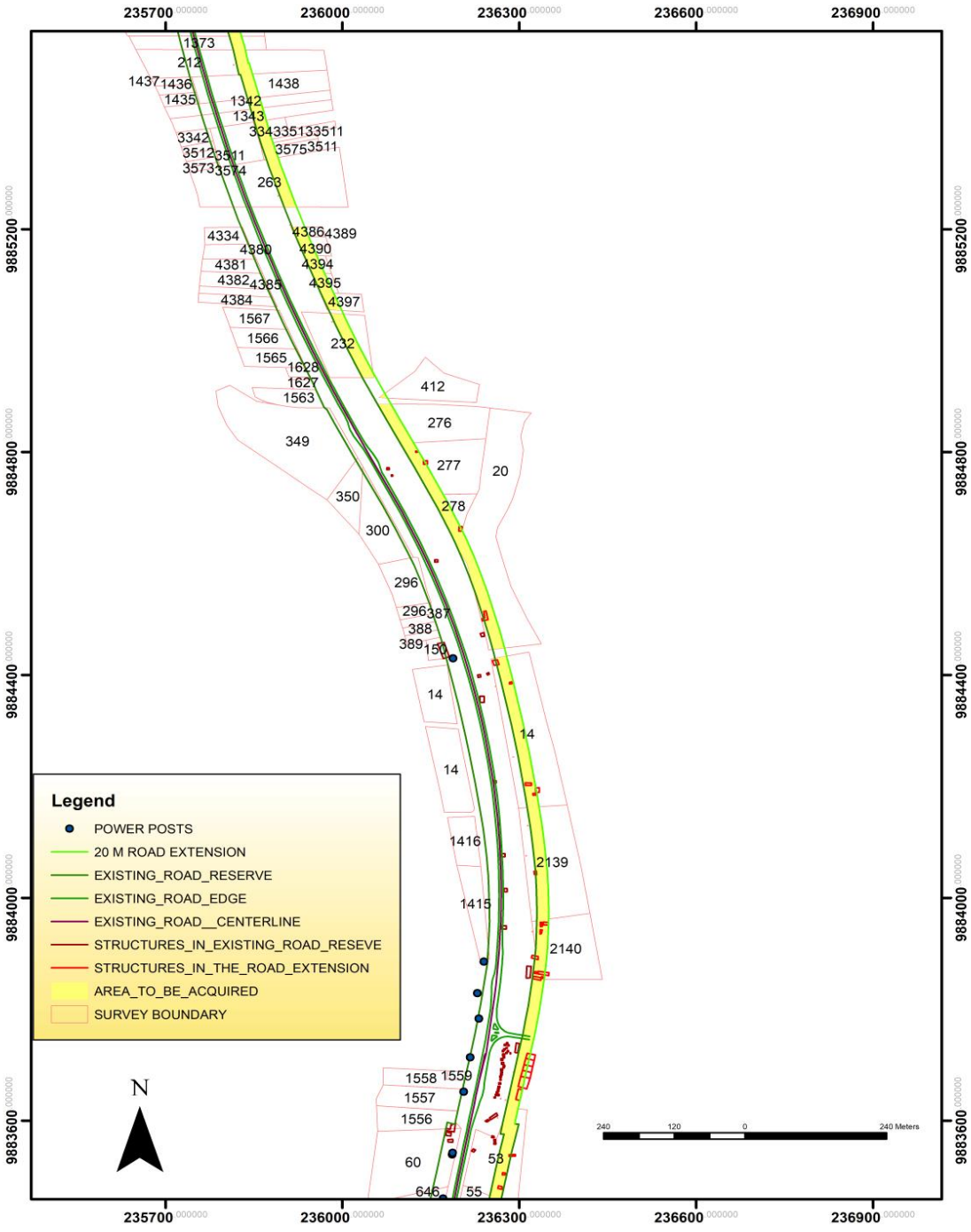


Figure 21: Close up digital map on themes created

4.5 Anomalies along the road.

RIMs which are not updated as per KENHA data.

Lari kirenga sheet 19

Some of the RIMs are not yet to be updated to indicate the road reserve as shown in figure 22. For the land owners who have subdivided or updated their titles, the road reserve as per KENHA information. (The red line on the drawing indicates KENHA's road reserve extent.) as shown in Figure 23:

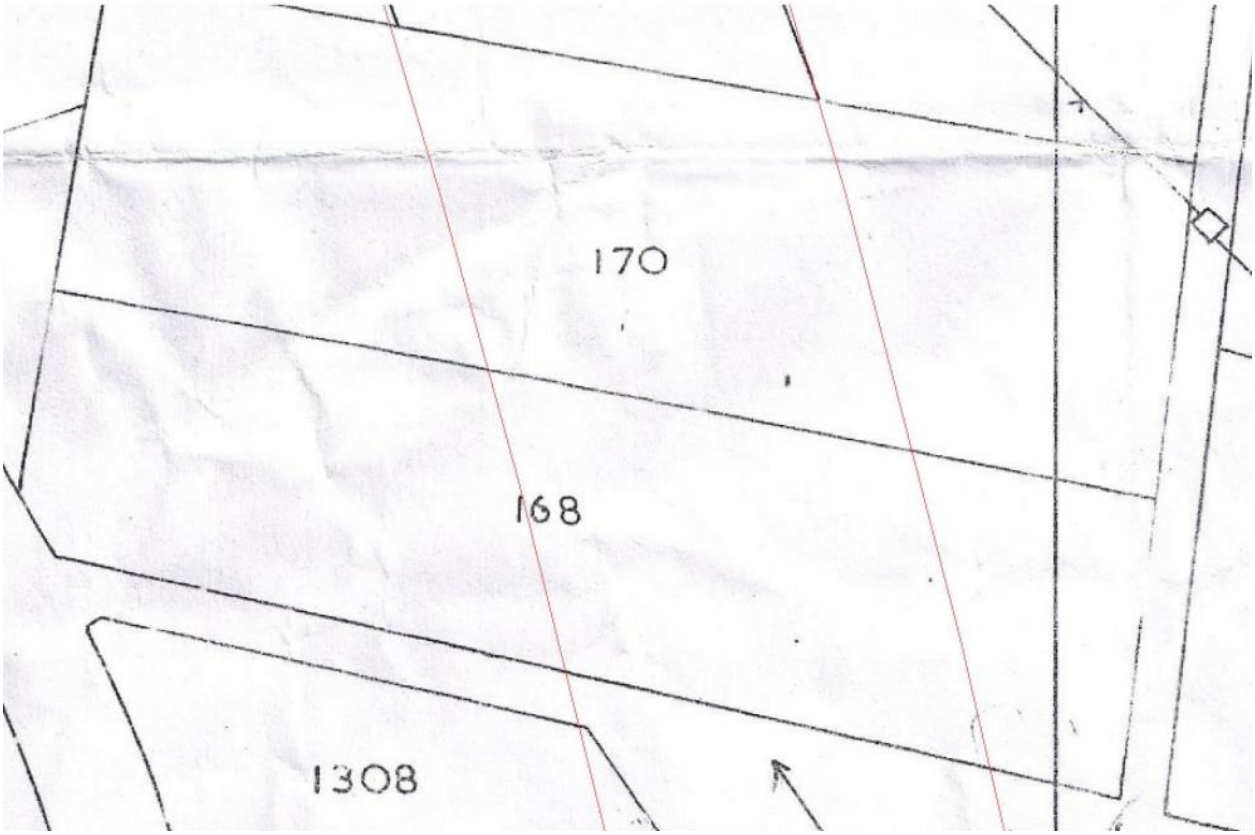


Figure 22:Lari/Kirenga/168-RIM has not been updated

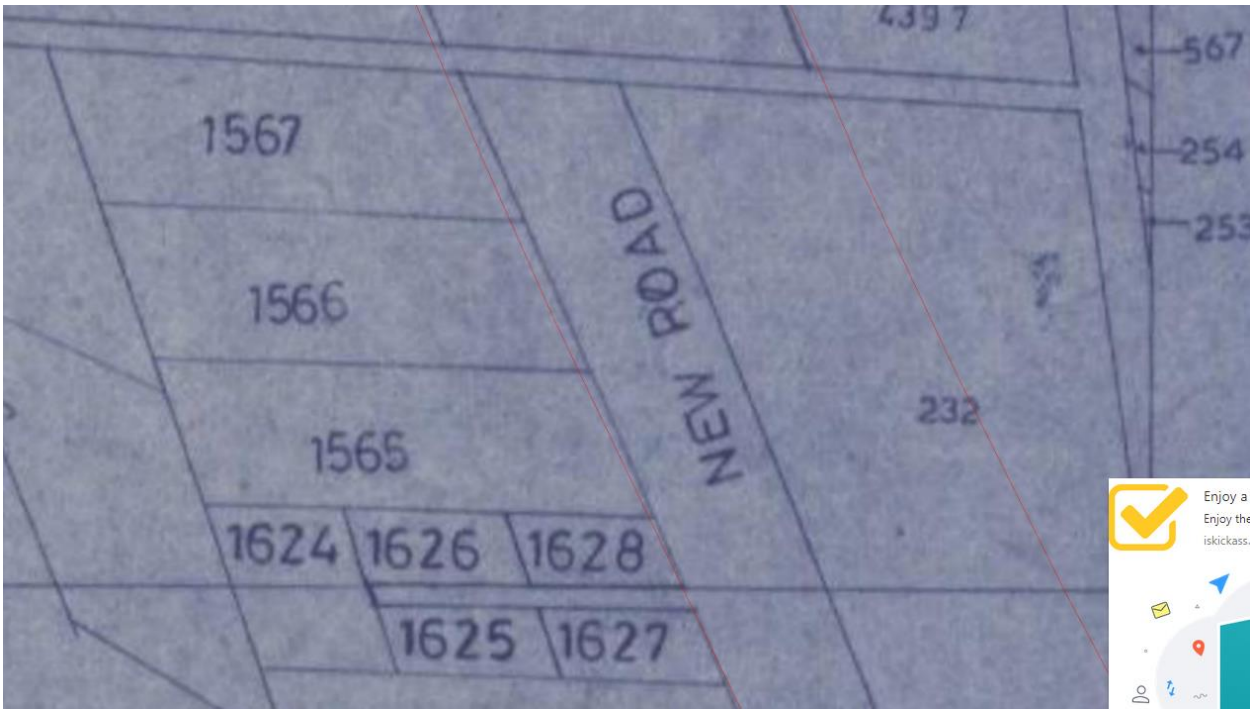


Figure 23: Lari/Kirenga sheet 24-The road size adjusted does not comply with the KENHA's road reserve.

4.6. Overlay analysis.

This involved combining themes created into one map. Using overlay analysis, it is possible to know the total number of utilities (power posts- for the case of this study) and structures in the road reserve and structures and parcels in the road widening area whose database had been created. The above analysis is shown in Table 5:

Number of parcels affected by road widening	Number of structures affected by road widening	Number of structures in the road reserve	Number of power posts in the road reserve
188	247	210	35

Table 5: Overlay analysis

4.7 Analysis of areas of current road reserve to Kenya Gazette areas

PLOT NO.	Area to be acquired (A) :Acres	Kenya Gazette area (B) :Acres	Difference (A-B) : Acres
Escarpment settlement Scheme/493	0.01	0.086	-0.08
Escarpment settlement Scheme/56	1.0739	1.83	-0.75
Escarpment settlement Scheme/55	1.50	1.73	-0.23
Escarpment settlement Scheme/54	1.51	1.50	0.02
Escarpment settlement Scheme/53	1.36	1.68	-0.32
Escarpment settlement Scheme/63	2.60	0.48	2.13
Escarpment settlement Scheme/62	1.44	0.29	1.15
ESCARPMENT SETTLEMENT SCHEME/53	1.25	1.68	-0.43
ESCARPMENT SETTLEMENT SCHEME/60	0.67	0.27	0.40
ESCARPMENT SETTLEMENT SCHEME/62	1.59	0.12	1.47
LARI/KIRENGA/263	1.65	0.44	1.21
LARI KIRENGA/213	0.89	0.17	0.72
LARI KIRENGA/211	1.26	0.27	0.99
LARI/KIRENGA/255	1.79	0.38	1.41
LARI/KIRENGA/168	1.31	0.02	1.30
LARI/KIRENGA/852	0.18	0.35	-0.16
LARI/KIRENGA/LIM/6	0.04	3.47	-3.43
LARI/KIRENGA/158	3.08	0.89	2.19
LARI/KIRENGA/351	2.89	0.03	2.86
LARI/KIRENGA/385	1.62	0.62	1.00
LARI/KIRENGA/365	1.24	0.34	0.90
LARI/MAGINA/421	0.24	0.1	0.14
LARI/MAGINA/266	0.03	0.08	-0.05
LARI/MAGINA/270	0.06	0.08	-0.02
LARI/MAGINA/366	0.02	0.05	-0.03
LARI/MAGINA/412	0.22	0.02	0.20
LARI/MAGINA/351	0.17	0.03	0.14
LARI/MAGINA/366	0.02	0.12	-0.11
LARI MAGINA/142	0.95	0.12	0.83
LARI/MAGINA/ 428	0.90	0.03	0.87
LARI/MAGINA/319	0.49	0.18	0.31
LARI/MAGINA/195	0.56	0.39	0.17

LARI/MAGINA/194	2.60	1.13	1.47

Table 6: kenya gazette analysis

The area differences as shown in Table 6, are as a result of errors obtained from geo-referencing and the method used for area calculations. ARCGIS is recommended to calculate the areas for uniformity purpose.

4.8 Statistical analysis.

Table 7 shows total area already acquired but yet to be updated on RIMs and the total area to be acquired. This will help to budget the total cost of the road.

Total area already acquired	Total area to be acquired	
38.669 Acres	11.114 Acres	

Table 7: Area analysis

4.9 Error propagation Analysis.

Errors encountered during the study include:

- Transformation errors,
- scanning and tracing error,
- digitizing errors
- georeferencing errors.

CHAPTER 5: CONCLUSIONS AND RECOMMENDATIONS

5.1. Conclusion

The main objective was to come up with a web-based database application for land acquisition. Based on results and analysis done, the objectives of the project were adequately met.

The digital maps created indicate the current state of the road corridor by overlying data from different government departments. This helps in identifying the anomalies along the road, such as RIMs which are not updated and road encroachments. 210 structures have encroached on the road reserve and 38.669 Acres are already but have not been updated on the RIMs. The digital maps also help visualize the CLA through the themes created. Parcels and structures affected details were captured by the database which 188 and 247 respectively were affected by the road widening. The total area of the land to be acquired was found to be 11.114 Acres which will assist in budgeting for the road's cost of construction.

The web based application is a one stop shop platform where one can obtain information about a parcel affected by CLA. This saves time and money used to access information since one does not have to different departments to obtain the information. The query builder in the application enables easy access of information; as compared to getting the information in hardcopies which involves a bureaucratic and time consuming process.

There is a notable difference in gazetted areas and area calculated for areas which are already acquired as shown in Table 6. This is due to the method used for area calculation, scanning errors, georefencing errors and transformation errors.

5.2. Recommendations

5.2.1 Adaptation of unified coordinate and land registration system.

Coordinate transformation from one coordinate system to another results to errors hence the land acquisition process is not as accurate as it should be. Adapting one coordinate system ensures working on a uniform coordinate system hence reduction of errors.

5.2.2 Adaptation of web-based database applications

Adapting such applications ensure sharing of data, increases public awareness on land along the road state and enabling fast and reliable decision making.

5.2.3 Having uniform datasets across the government bodies.

Despite the RIMs being based on features on the ground, there is need for uniformity of data from the roads body and survey body. Where the road sizes on the two bodies' maps should uniform. This will increase the public trust on land cadastral system and the government projects**.**

5.2.4 Having a large scale on RIMs.

From Kenyan Cadastre and modern land administration (David N. Siriba, Winrich Volfs, Galcano C. Mulaku), having a small scale in RIMs results to more errors in positioning accuracy**.** Creation of RIMs in large scale would increase the level of accuracy in calculation of area acquired.

5.2.5 Approval of development plans.

There should be clear policies that govern the procedures before approval of development plans. Information such as survey boundary and road reserve data should be considered before approving them; this will lead to reduction in road encroachments.

5.2.6 Public sensitization on public on boundary information.

Most land owners are not conversant with boundary information along road reserves. This is as a result of new land owners, government not clearly marking the road boundaries and adapting physical features which maybe from information sourced from an unqualified expert.

5.2.7 Updating the web-based application.

Road encroachment should be regularly monitored and structures which are built updated on the application. This will assist in decision making on the action to be taken.

5.2.8 Utility services.

Utility services providers such as Kenya power, fibre optics companies and water authorities can find such maps useful for routing purposes.

5.2.9 Using ARCGIS for area calculation.

For uniformity purposes, ARCGIS should be used to calculate the area of land parcel affected by CLA.

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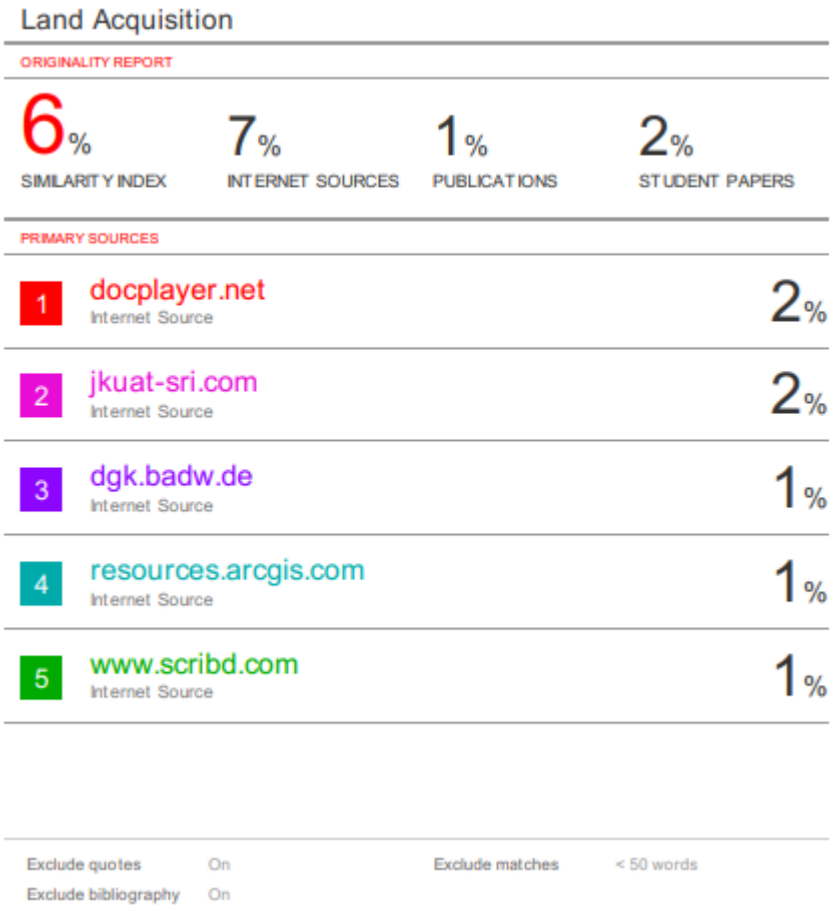
APPENDICES



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Appendix A: Similarity Report.