UNIVERSITY OF NAIROBI

School of Engineering

DEPARTMENT OF GEOSPATIAL AND SPACE TECHNOLOGY

THE USE OF LINEAR REFERENCING IN MAPPING OF ROADS

Case Study: Machakos Turnoff- Syongila (C97) Road

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DECLARATION

I, AKUMU, MILDRED A. K., hereby declare that this project report is my original work. To the best of my knowledge, the work presented here has not been presented for examination in any other university.

AKUMU, MILDRED ANYANGO KOJO   16/11/2018

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

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The Almighty God is sovereign and His guidance and strength is my inspiration. Without His help I could not have completed this study.

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ABSTRACT

Geographic Information Systems (GIS) is an indispensable tool for automating processes in various disciplines. Road chainages are the most appropriate way of geographically locating areas of interest in the road sector. An intuitive method for referencing therefore serves to enable users of road data to locate whatever information that they need. In this project such a referencing system has been employed and it is easier to mark a linear referenced hatch line (chainage), than to memorise the northings and easting of the same point where one has interest in.

The main objective of this study was to map a linearly referenced road section (Machakos - Syongila) C97 road to be used in subsequent mapping of KeNHA roads. Data used was collected from journals (The Kenya Gazette), AutoCAD design drawings, and Survey of Kenya registry index maps. After georeferencing, Registry Index Maps were digitised delineating only the land parcels abutting the right of way otherwise known as the road reserve. Road roughness index also was mapped from the information provided by the maintenance department at the Kenya National Highways Authority. From the centreline which was plotted for the whole stretch of the road, a route feature dataset was created using GIS analysis techniques that enable hatching of the station lines along that same centreline. A tool was customised to enhance the identification of the route at any point.

The key results included a digital map of the road with referenced location chainages overlaid with other datasets that are incorporated as the land acquisition data and International Roughness Index (IRI) along the road.

In conclusion, this research demonstrated that it is possible to map the acquisition, road roughness and chainages at any point along the centreline using a linear referencing method. The research project gives several hard copy maps and a web based map as products for the road, covering 108+800 km. Conversion of point features to events was possible but polygon features are quite challenging to be mapped in the same way as point features and line as well. Linear referencing is one dimensional, but if accuracy is of importance then the coordinates for each station lines need to be documented

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ACRONYMS

AADT	Average Annual Daily Traffic
ARNOLD	All Roads Network of Linear Referenced Data
CAD	Computer Aided Design
COTs	Commercial Off The Shelf
DOT	Department of Transportation
FRs	Folio Reference Numbers
GIS	Geographic Information Systems
HDM4	Highway Development Model
IRI	International Roughness Index
KeNHA	Kenya National Highways Authority
LRM	Linear Referencing Methods
LRS	Linear Referencing Systems
PAPS	Project Affected Persons
RIMS	Registry Index Maps
RCMRD	Regional Centre for Mapping of Resources for Development
SLD	Straight Line Diagrams
URISA	Urban and Regional Information Systems Association

CHAPTER ONE

INTRODUCTION

1.1 Background

The Kenya National Highways Authority (KeNHA) is an autonomous road agency responsible for developing, constructing, and maintaining, upgrading, managing and rehabilitating national trunk roads. It was established under the Kenya Roads Act of 2007. Among its strategic objectives is security and protection of national trunk road reserves and assets and improvement of the same. It is important to add value to the services provided in the authority by integrating more advanced spatial analyses in Geographic Information System (GIS) that will help in the management of dynamic attributes of national trunk roads in Kenya. A Geographic Information System (GIS) is a collection of computer software, hardware, data, and personnel used to store, manipulate, analyse, and present geographically referenced information. (Pandey, D.; et al.; 2013) Currently road data is kept in different locations mostly by contractors, engineers, surveyors and various cadres of staff dealing with road issues in the eight directorates in the KeNHA. A linear referencing method (LRM) can be defined as a mechanism for finding and stating the location of an unknown point along a network by referencing it to a known point (Adams,T. M.;et al 2000).

According to *Curtin K.M; et al (2007),* linear referencing is a spatial analysis method that enables relative positions along linear features, whose measurements are known to be stored as geographic locations. There is a set of tools and methods in GIS designed to associate geographic locations with networks. These tools and methods are known collectively as Linear Referencing tools. The measured distances, which make a lot of sense to engineers and surveyors, can be very instrumental to locate segment events along the linear feature. Linear referencing can also be defined as a support system for storage and maintenance of linear feature's events which occur along the feature or within it. Events are the set of objects that have properly defined geographic locations.

Types of Linear Referencing

Interpolative Linear Referencing Method is where interpolation is computed for a target point between two known distances. This type is mostly used by plotting of road centreline. The centreline is determined by creating anchor sections along the curvy road, at similar intervals of say 50 metres. From these anchor sections, fairly accurate station lines joining the centreline are plotted.

Referent Linear Referencing Method (LRM), is the other type in which discrete location of a point is measured by coordinates, intersections other fields in a database or particular m-values determined from the interpolative LRM method above." Having the ability to locate traffic and road conditions on the highway in a convenient manner has a direct impact on the highway improvement and maintenance funds that are apportioned to each state and then distributed to each maintenance authority" (Litton A;, 2015).

This research project report embraces the use of both the methods above to map an accurate centreline whose coordinates can be retrieved.

1.2 Problem Statement

The Kenya National Highways Authority (KeNHA) has been facing very high costs of project implementation since its inception due to the need for quality, adequate and safe roads and challenging economic times in the country. Operational costs always adjust upwards due to changing climatic conditions, encroachment of roads and hence compensation for project affected persons (PAPs). Road networks may need to be properly managed so as to utilize functionalities in Geographic Information Systems (GIS). Global Positioning Systems (GPS) are much better for collection of point data, much so, the chainages along a road, as this data collected by GPS is two dimensional and more accurate compared to linear referenced data. However, because of the vast use of road chainages in their native form by various users in the road fraternity, this study intends to apply Linear Referencing Systems (LRS) as a more intuitive way of referencing in road data mapping. Linear Referencing Systems (LRS) can be precisely and accurately plotted at a lower financial strain than that which may have to be used in marking of road marker posts bearing pairs of coordinates. For example, measurements along any road segment can be easily identified as a measure from the beginning of the road junction, than having to plot x, y coordinates on a map using the classical method. Therefore Linear Referencing Systems (LRS) is the way to go and should be made to grow. It is after this milestone is reached that the need for an integrated Highway management System containing the subsystems e.g. Road Condition Management System, Highway Development Model (HDM4), Annual Road Inventory and Condition Survey (ARICS), Geographic Information Systems (GIS) that are highly used in production of jobs in road agencies can be developed.

In the Kenya National Highways Authority, KeNHA road centrelines are also designed in AutoCAD by engineers and or Contractors working on specific road segments. It is notable that tables bearing annotations in AutoCAD defining the chainages are not spatially attached as attributes the way that is possible to do in a GIS environment. A Geographic Information Systems (GIS) which is more functional to assign a chosen intersection as kilometre zero will standardise the chainage allocation using the linear referencing system. AutoCAD generated station lines may not accommodate cartographic manipulations such as attribute entry and querying or precision and accuracy of the data. From my experience, images referenced in Computer Aided Design (CAD) have had to be re- Georeferenced in ArcGIS so as to overlay the road centreline for further processing.

This project presents a comprehensive method for linear referencing of the Machakos – Syongila (C97) road. Historical development of this technique indicates a dominative usage in the transportation sector. This project is to influence the potential use of this spatial process to utilise the many advantages of the use of Linear Referencing Systems for future applications by the various directorates inside KeNHA as an organisation, and spread to the other road agencies in the country.

Figure 1. 1: Records keeping in one of the desks in the drawing office

Due to lack of space for hard copy maps, plan and profile books and even for plotters and scanners, in many organisations, a geospatial technique that will address data keeping in a digital format is needed. Drawings need to be georeferenced not only in AutoCAD drawings, but in fully functional Geographic Information Systems (GIS) which offers easier retrieval and vast functionality. Figure 1.1 showing how records kept in one of the offices. These records are at risk of loss or damage.

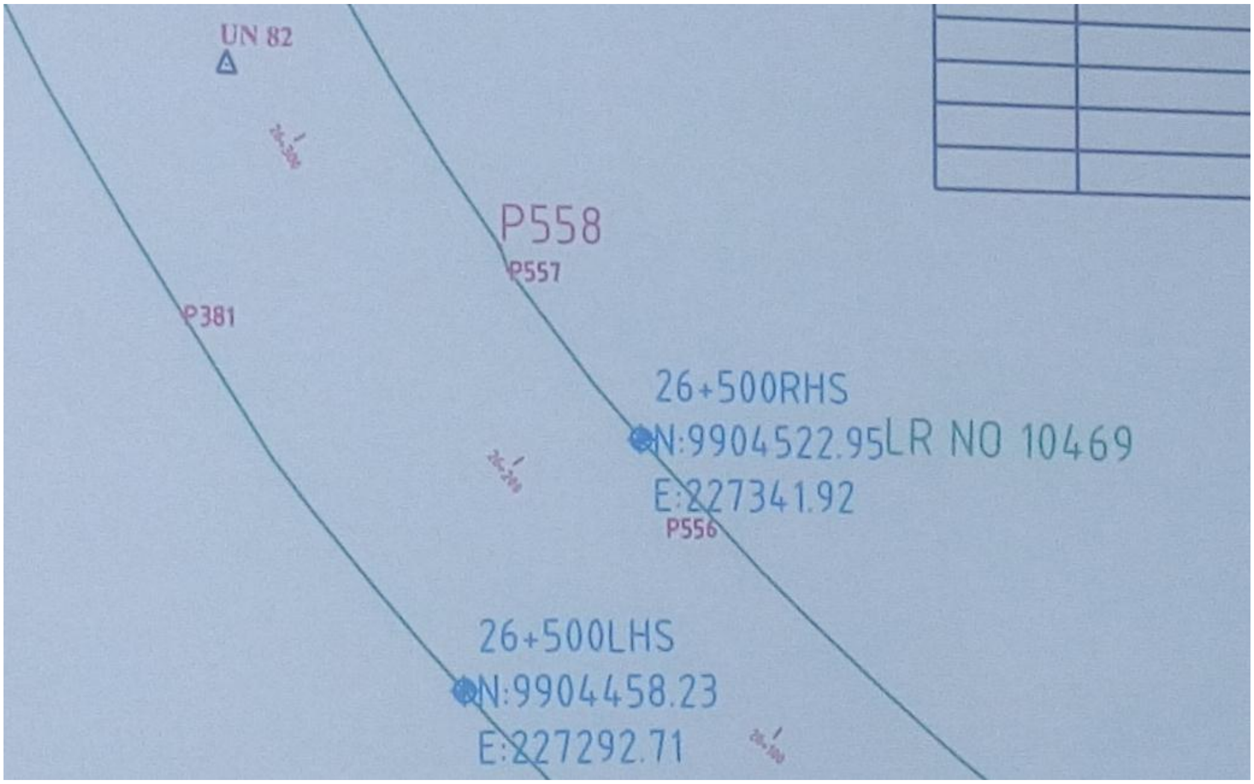

Figure 1. 2: Coordinates identifying a section of the road

Figure 1.2 is an extract from the conventional title survey file compilation for a road which clearly, is laborious to explain any event with reference to coordinates above. It may be less complicated to say L.R. No. 10469 is located around **Km 25+500**, than to mention the coordinates as northing and easting **(9,904,495.23 , 227,292.71)** meters.

In Kenya National Highways Authority (KeNHA) therefore, linear referencing will be applied in creation of a digital geodatabase, mapping of accident spots, marker post identification, road furniture and condition, encroachments by public or governments, feasibility studies, land acquisition mapping, asset management e. g. Pavement condition only to name a few. This is mainly because locations by LRS methods are intuitive and easier than coordinates when one is in the field. Projects where a survey of the road corridor leads into acquiring a title deed for the land acquired, will best be addressed by coordinates (X, Y), however general operations in the field may only require the road chainage enhanced by a Linear Referencing System. This system does not obscure the exact coordinates picked in the field, rather it makes easy identification of any part of the road and integrates other data attached to the centreline

1.3 Objectives of the Study

1.3.1 Main Objective:

To map a linear referenced Machakos -Syongila C97 road using geospatial techniques.

1.3.2 Specific objectives:

- To collect road centreline data for the Machakos Turn-off- Syongila (C97) road.
- To map a route feature dataset with station lines of the same road.
- To map any related data along the carriageway.eg. IRI, road furniture and acquisition parcels.
- To produce a sample map that can be used in the field for monitoring and evaluation exercises, road condition surveys, and inquiries during verification of ownership of land earmarked for acquisition.

1.4 Justification for the Study

This project will offer a new way of mapping of road feature centrelines in the organisation. The new approach will enable comparison of data and analyses that have not been available in Computer Aided Design or Drafting CAD environments in the Kenya National Highways Authority. However, it is good to declare that all road features are unique and do not contain equal datasets and also they cannot be versatile enough to house a wide spectrum of related information. Linear Referencing Systems are bound to be the most important and complex datasets within Kenya National Highways Authority.

1.5 Scope of the project

This project, located in the Upper Eastern region as defined by regions designed by KeNHA is to cover only one road segment, Machakos Turnoff – Syongila road. This study will rely entirely on desk work and will utilise land acquisition data, gazette notices, compensation data and the possibility of using traffic count data. The project will cover the following processes:

- Data acquisition for the linear feature centreline and integration or transfer into GIS from CAD.

- Editing for linear geometry and entry of extra attributes in the event tables.
- Conversion of the centreline into route feature dataset
- Coding of the mileage along the centreline of the road.
- Spatial conversion of event tables to merge onto the linear feature.
- Visual output of the road segment customised using linear referencing.

CHAPTER TWO

LITERATURE REVIEW

2.0 Introduction

This Chapter will review linear referencing technique for utility mapping relating the use scenario in Kenyan Road agencies and especially Kenya National Highways Authority (KeNHA).

In Hawaii, some scholars reckoned in a document that mileage based data were first presented in 1970 by means of Straight Line Diagrams (SLD). In 1997 there was the first digital representation of mileages with route network of road centrelines which were being imported into Micro Station software. Databases were also migrated from excel to MS Access in 2002. Highway departments of transport in the world are speedily developing Linear Referenced Methods for their use as in this case of Hawaii.*Hershey, P.A; .DOT, G. S. H.* (2011). As recently as 2005; a temporal LRM was deployed in Hawaii. Route maintenance was being done previously by editing tables directly but has since improved by employment of Commercial off- the -Shelf (COTS) tools.

It however has been seen that analytical capabilities that have been used traditionally have slowly lost their flavour with the advent of utilisation of LRMs, for example network analysis, geocoding and geostatistical analysis cannot be used with linearly referenced events. Events can take the form of intersections, culverts, right of way, bridges, signpost, accidents, traffic Average Annual Daily Traffic (AADT) curves or projects to mention a few.

As Litton A ;,(2013) says, virtually every highway department in the world uses linear referencing in one form or another to locate their data along their highway systems.

Measurement systems can be supported for the same route in a geodatabase. Database constructed is to have the following features:

- Line feature classes.
- Point event features like signposts, points, road condition land acquisition data which are point, linear, and areal events respectively.

- Type of each measurement system, stating how many classes will be needed.
- Definition of m-units and the tolerance and resolution.
- For more than one measurement system that is more than one route feature class then they will have to be organised as one dataset containing different routes in a geodatabase.
- A single topology integrating those single route features with the whole dataset.
- Finally, a test and refinement of the design using a file or personal geodatabase in ArcGIS. *(http://desktop.arcgis.com/en/arcmap/10.3/guide-books/linear-referencing/designing-a-linear-referencing-system-in-your-geod.htm)*

There are **two** modes of mapping road networks, the segment approach and the route based approach. Both are applied by different strata of the engineering fraternity and so to work out something good for the system, there has to be a linear referencing system that will contain both the modes. In a segment based network attributes are stored as database fields associated with each segment. In a route based network attributes are stored as events that are measured along the route.

Linear referencing a method of storing geographic locations by using relative positions along a measured linear feature is yet to be exhaustively employed in road agencies in the country. Traditionally AutoCAD has been able to fix annotations denoting road chainages along a centreline and so is widely in use across road, rail and oil pipeline mapping. ESRI (Environmental Systems Research Institute) has written many publications on the use of this linear referencing tool together with its application in the transportation sector.

GIS functionality is vast and applications on data and still is superior to CAD software as this study will prove. Station lines that are annotated with the chainages have been in use for many years but it has not been possible to place a cursor along the centreline and identify what chainage the point is. The ‘identify route’ tool in Arc MAP can be clicked on a point along a route and the detailed chainage information retrieved, with the coordinates of the same obtained.

ESRI uses a code written below which is used to place labels and marks (station lines), along the road centreline in a familiar way for those who work with roads and highway. The code is employed via a plugin ETGeowizards which performs additional powerful functions for use with ArcGIS software.

The Visual Basic Script code entrenched in ETGeowizards shown in equation (2.1) was used to distribute station lines on roads as applied in other linear referencing systems for road departments abroad.

Left ([ET_STATION], 1) &"+"&Right ([ET_STATION], 3) (2.1)

2.1 Land Acquisition

The mandate for road agencies includes, to construct, manage, develop and maintain public roads is applied as stipulated in CAP 399 of the Kenya Law Act. Users are also provided for, a right to access their property abutting a road or a railway. Land may also be compulsorily acquired for purposes of road construction and due compensation done, with a value to the land and developments on it. When land is acquired, a gazette notice is usually published indicating the government's intention to acquire that land, consequently the land is valued and an award is issued to the land owner or the owner of the developments therein.

2.2 Road Furniture

Road furniture refers to all road fixtures on the road and on the road reserve. They include constructed culverts, road signs, bridges, safety barriers and even the pavement itself. These items provide road users with the needed safety and control warnings, rules and directional information so that both the user and the pedestrian are safely protected from crashes and collisions.

2.3 International Roughness Index

International roughness index, IRI, was developed by World Bank in the 1980s. Road condition has a standard classification that numerically denotes the state of the road and the intervention needed to bring the road back to its best. Longitudinal profiles of roads are measured and a calculation done using a special vehicle. This vehicle uses a mathematical model which responds to yield a standardised roughness measurement in metres per kilometre. Pavement roughness is defined as an expression of irregularities in the pavement surface that adversely affects the quality of the ride for a vehicle. Figure 2.1 is a summary of the indexes given to the road condition.

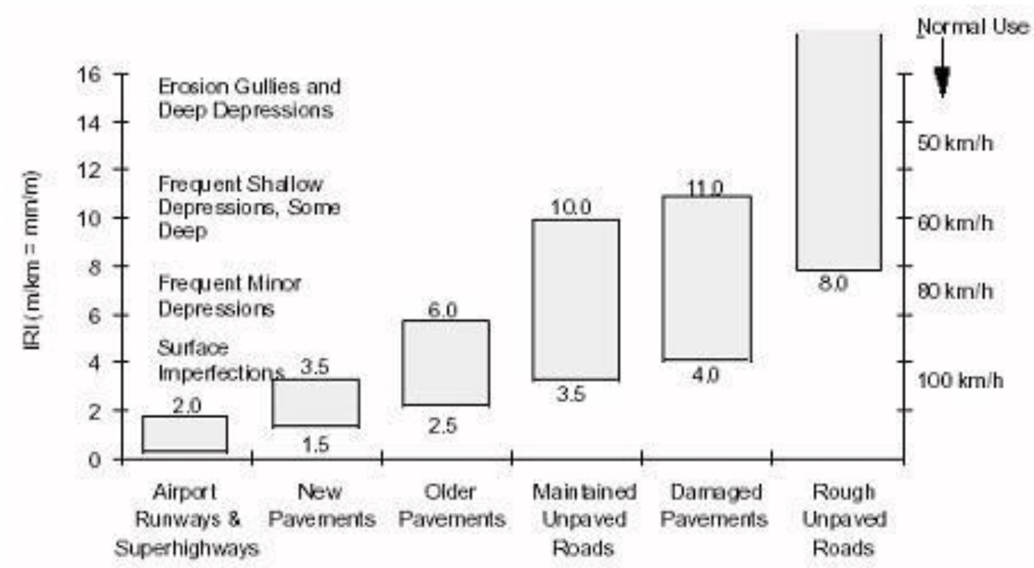

Figure 2. 1: IRI Classification scale (Sayers et al., 1986)

2.4 Definitions

Route: Is a Street or highway with an assigned number, a defined beginning point (M - value), a defined ending point, and a defined pathway between the beginning and end. Routes may run continuously or be separated into more than one segments.

Route Length: This is the distance measured from the starting point of the linear feature to the end point in most instances, the positive direction.

Chainage: Is an imaginary line used to measure distance often corresponding to the centre of a road. In surveying it refers to the distance measured along such linear feature.

Milepost: A marker(s) that indicates or is inscribed with the chainage notation and are in series along a highway.

Attributes: Qualitative data that can be recorded in a table, then be used to label a spatial feature.

Road segment: Is the specific representation of a portion of a road with uniform characteristics.

Pavement: The applied improvement on the surface of a road, for example asphalt.

Hatches: these are ruler marks of specified distances at regular intervals that are user defined.

HDM-4 This is computer software for Highway Development and Maintenance. It is a Management System computer software used as a decision making tool for checking the Engineering work that relates to road design and maintenance.

2.5 Benefits of Linear Referencing

Linear referencing is beneficial in that, definition of points along the route feature can be done using just a minimal amount of information. Features with linear referencing are easily recovered during field activities. Sometimes field activities may be in remote areas where access to online maps is not possible. Linear referencing adds value to the centreline mapping as they offer cost effective, accurate and even sub-meter accuracy.

According to an ARNOLD (All Road Network of Linear Reference Datasets) reference manual for Departments of Transportation in the United States, it is of importance to consider road network elements that are special in nature like the ones below:

Dual Carriage Ways: In Kenya, Thika Super Highway, Nakuru town approach and Kisumu Bypass have already constructed. They all need separate chainage calibration through linear referencing for the different geometries.

Overpasses; The acceleration and deceleration sections may need to be marked as LRS (linear referencing systems) events while the ambiguous tricky nature of the ramps can be curbed by definition of start to the end points.

Traffic Circles: Smaller traffic circles as in a roundabout are easier to represent in a simple way.

2.6 Interpolative Linear Referencing

Adrienne Litton (2015) observed that the beauty of interpolative Linear referencing is that they don’t have to be based on real world measurements, they can entirely be arbitrary, even in the measurement units and still the user will precisely find what he she is looking for. This statement implies that, a culvert marked by its chainage at a point along the road centreline is easy to access on the ground, or otherwise by a descriptive method explained in the next topic 2.7.

2.7 Referent Linear Referencing

This is a simpler way of referencing that can be more convenient to the road user who has no access to a well-arranged database. It literally describes a location like, "Turn left from Ruai Bypass and when you see a Total petrol Station on your right, turn further left to a green gate marked Karimis" This is the commonest way of finding routes and measuring for people.

2.8 Concept of Dynamic Segmentation

This is a process of transforming linear referenced road networks information (events) into a more descriptive display that can be analysed. For example a road condition stretching from one point along the centreline to another, and the surface type, can be visualized on the same map view. It is a method that imposes two needs in the event table, where each has a unique identifier and unique measurement system.

2.9 Considerations when setting chainages along a route

1. The most usable unit of measure e.g. miles, kilometers or meters.
2. The source or **From** Measure, which is by default the upper left hand side of the linear feature.
3. The direction by which the measures should increase towards.

The (UTM) Universal Transverse Mercator is the best coordinate system and most especially for the Kenyan region which lies on the equator. This metric coordinate system is preferred to the imperial coordinate system. The latter system uses imperial coordinates and linear measures, which may necessitate tedious conversions to do on site. However, it is clear that no measurement system (metric or imperial) is of higher grade than the other.

Considerations may again need to be factored into road segments that have been realigned due to change in design. Different measurement values may result from elongated or reduced road segments thus marker post locations may need to be adjusted to account for the same changes. Linear referencing systems developed for road networks serve to create reference locations say, at road intersections, to calculate distances to other geographic locations, and the events placed along the route are maintained at their location consistently.

Numerous studies have been devoted to conceptual data modeling of linear referencing systems. *Bigham, J; Kang, S; (2013).* In order to harvest the full benefits of geographic Information system, relative locations can be integrated into a linear referencing system.

2.10 Linear Referencing Systems in Africa

Linear referencing as a spatial process was once described as a set of objects, but it now addresses topological representation, network characteristics and determination of measures along linear features, and more advanced display and analysis of events. This system has been used in the United States, initially for locating motor vehicle collision patterns, and due to improvements in its accuracy the system is widely gaining usage in more countries.

CHAPTER THREE

MATERIALS AND METHODS

This chapter explains how the research was done using materials and tools that will enable and sufficiently detail the methods for achieving a linear referenced road segment.

Figure 3.1 is a map of Kenya highlighting the study area in light purple at the central, lower part of the country.

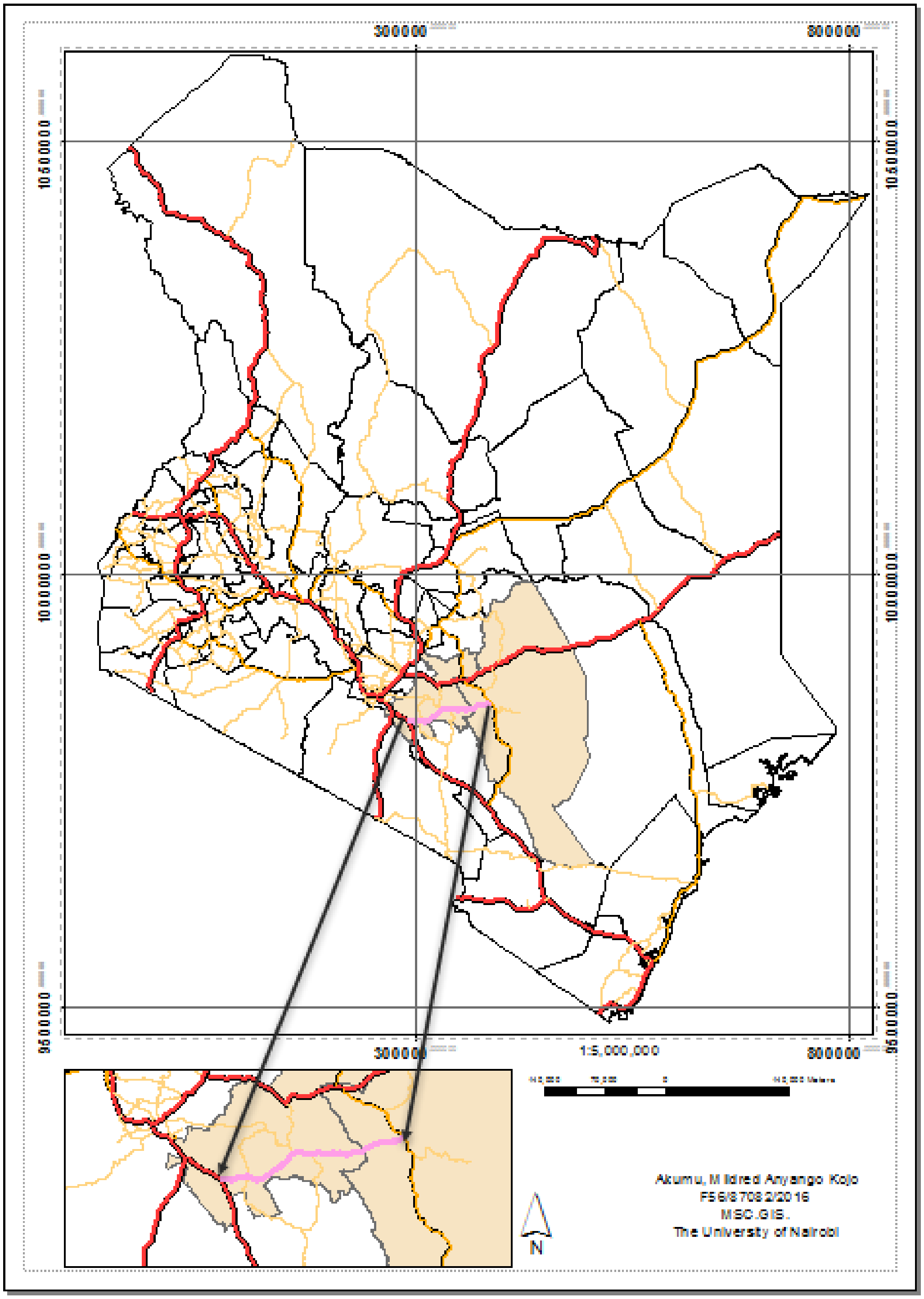

Figure 3. 1: Study area, Kenya Map Showing Machakos Turnoff- Syongila

3.1 Study Area

The road stretches north eastwards from A109 to the west to B7 in the north east direction. The study area geographically traverses across Machakos County and part of Kitui County. The (x, y) coordinates in metres, for the first and last points on the road are Easting, 292,145, Northing, 9,830,500 to Easting 387,250, Northing 9,852,180.

3.1.1 Data

Datasets were drawn from the sources listed in Table 3.1. The datasets were used in this project and out of them information was digitized and entered as attributes.

Table 3. 1: Datasets to be used

DATASET	SOURCE	ORGANISATION
Feature Datasets	AutoCAD drawings	KeNHA
As-Built Drawings	Booklets to be scanned	KeNHA
Road condition Data	Excel workbook	KeNHA
FRs	Raster/ Scanned hard copies	Survey of Kenya
Gazette Notices	Kenya Gazette	Kenya Law Review website

3.1.2 Apparatus

The software listed in Table 3.2 includes two GIS software, namely ArcGIS and QGIS. Both are essential as the user shuttles from one to another so as to maximize the functionalities of both software to achieve desirable results.

Table 3. 2: Apparatus and tools

Tools	Version	Licence
Autocad	Autocad 2015	KeNHA
ArcGIS	ArcGIS 10.1	KeNHA
QGIS	QGIS 2.16	OpenSource

3.1.3 Methodology

Figure 3.2 illustrates the sequence of the methodology that was adopted. Data was identified and collected, the spatial and non-spatial data was input into the geodatabase, editing and querying of the information and finally the linear referencing as a spatial analysis of the resultant centerline. In addition, other relevant road data for example, land acquisition, culverts and road condition was overlaid. The results were interpreted and conclusions drawn.

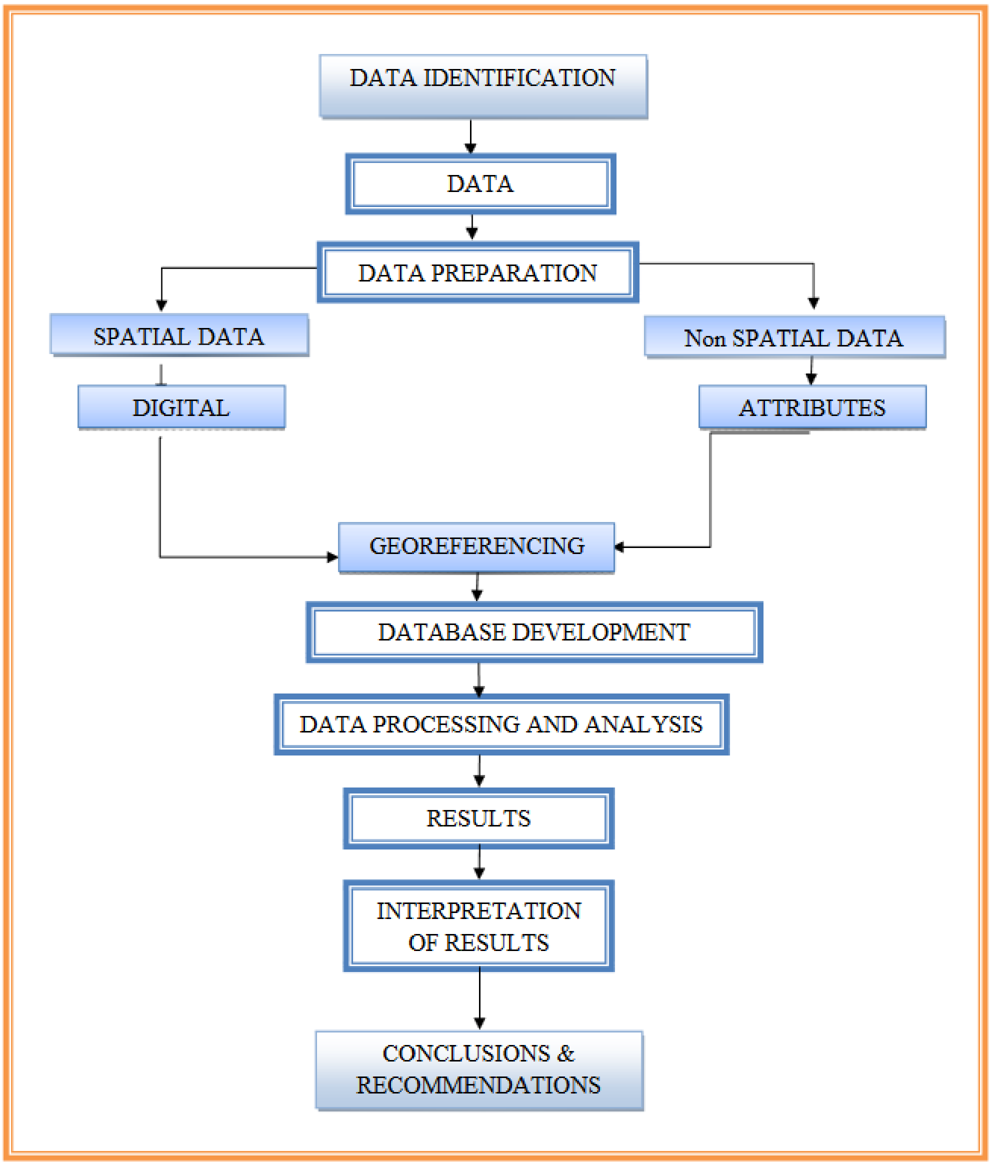

Figure 3. 2: Flow chart of the Methodology

3.2 Data Collection

Data was gathered from KeNHA's Design and Construction Department where data resides in AutoCAD format. The data is in Arc 1960 Datum and although it shows in AutoCAD as adequately referenced, when converted to shapefile for visualization in GIS, there are many aspects of linear features that cannot be done in a CAD environment, but are possible in a GIS environment. Attribute data was gathered from journals and the Kenya Gazette website among other sources. This is for instance, creation of attribute tables that can be queried, route data creation that expand the analytical capability of line features, and also linear referencing that enables easier identification of events along the line feature.

3.3 Data Preparation

AutoCAD drawing was opened in GIS and all the features in it converted into Shapefile format. The resultant shape was edited by populating each feature table with the necessary detail to be used for spatial analytics. The road centreline, road corridor data like gazette notices which contain acquisition data, usually in hard copy were digitized. The road centreline was calibrated with the other available details along the road by creating a route feature dataset. A spatial join of the individual AutoCAD designed acquisitions and the general parcels along the road were inevitable because the alignment was changed and additional land acquired in 1980. However, acquisition records in the gazetted notices referred in Table 3.1 there were only records for Embui and Kambiti sub locations. This means that acquisition covered a few patches gazetted in the two Kenya Gazette notices.

3.4 Georeferencing

Georeferencing of the as built profile drawings were transferred to GIS and reprojected in order to achieve uniformity in spatial referencing systems to be well mapped. The bounding box for the raster image is selected in AutoCAD and the list of coordinates is noted then using the coordinates from the CAD, the same image is Georeferenced in GIS. In this stage, therefore the real world coordinates assigned during georeferencing in AutoCAD are also plotted and attached to the same image in GIS and stored in jpeg or Tiff format.

3.5 Data Processing

Spatial data was processed using tools provided for by the relevant software in use. Large volumes of geographical data are used to answer questions that solve problems in research and answers a number of business questions. The end result is a map, a code, a table figures and reports among many others.

3.5.1 Creating Routes

Routes are polyline features that are able to store values that are measured on their vertices thus modelling the distance along the line. These measured values are usually employed as fit for purpose mapping since the road centrelines may at times not be as accurate in geometry as the measured length. The chainages displayed as 10+250 denotes kilometre 10.250.

3.5.2 Hatching

The creation of a new feature which has route property allowed for hatching, (generating of chainages) is done at this stage. The route feature needs to be in a geodatabase so that the route lengths onto which chainages will be based are generated. The hatch definition is set to the required interval between chainages i.e. 200 or 400 metres depending on the scale that will enable easy viewing. Labels will be expressed as km 0+000 as is usually required by users of the road data. Therefore some coding will be done to convert the labels to the format.

Figure 3.4 shows the identity of the location on a route feature is customised using the command feature in linear referencing. The ’identify route location’ tool must be pulled onto the view by customising the main toolbar.

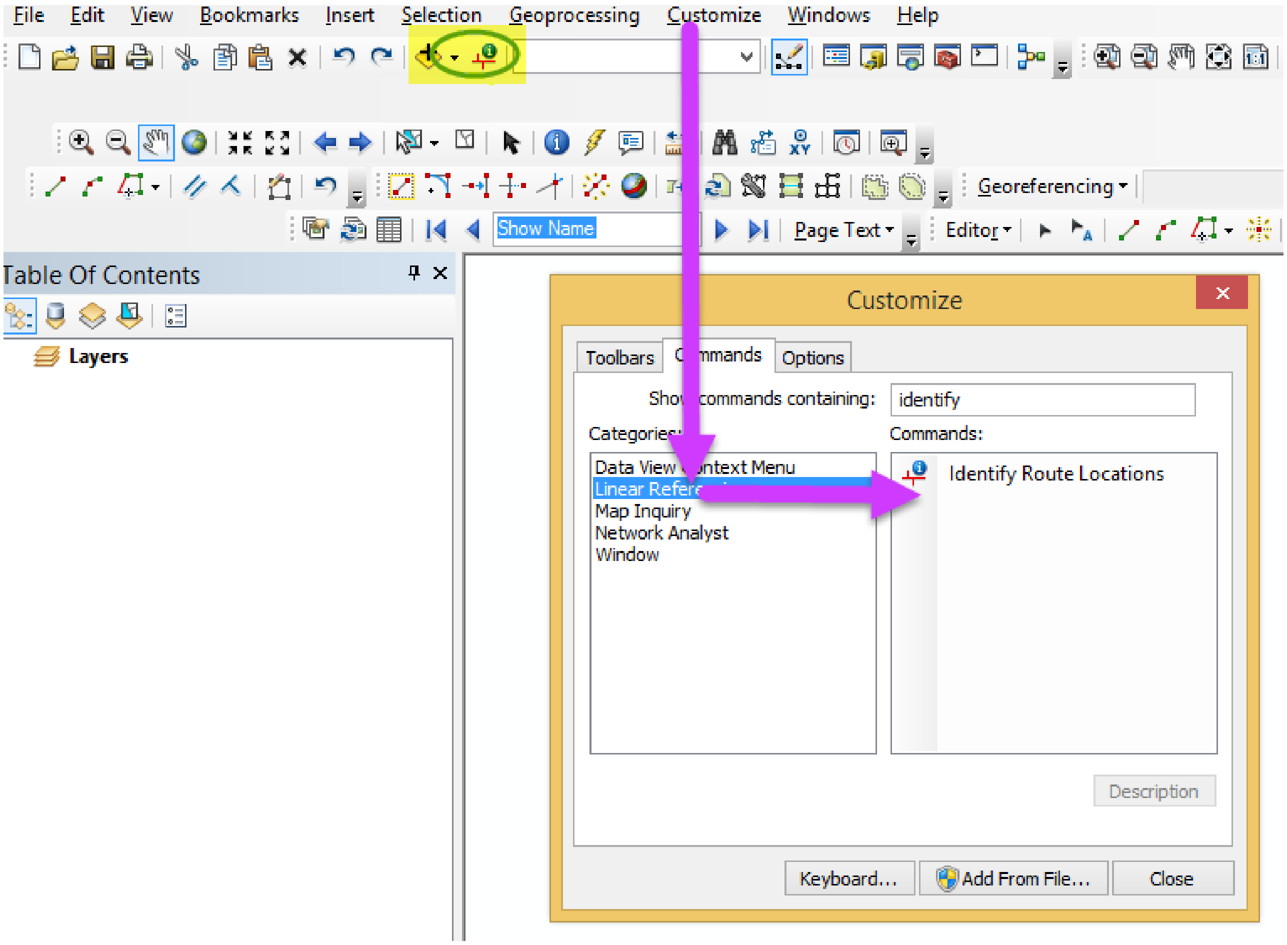

Figure 3. 3: Pulling the Identity tool for Routes

This feature is essential when it is hovered along the route to identify the measure trends and to check any anomalies that may arise as the creation of the route was being made.

Figure 3.4 shows the menu bar containing the tool used to locate a feature along a route. Using this tool, the chainage comes up in the drop down menu with the exact coordinates of the same point.

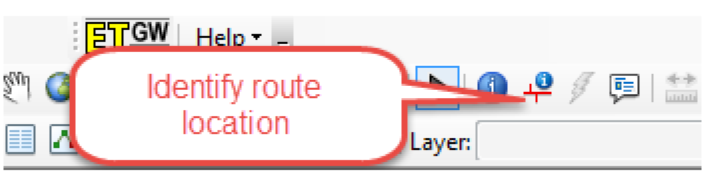

Figure 3. 4: Identification of the route station

CHAPTER FOUR

RESULTS AND ANALYSIS

4.1 Results

Having mapped the events namely the IRI data, culverts and land acquisition data onto the linear referenced road network, these events can be located with ease during field operations. The results of this research project has enabled a total mapping of the 108 kilometre stretch of the Machakos turnoff- Syongila junction, in a linear referenced system marked with road chainages from km 0+000 to km 108+800.The database has the midpoint coordinates of the station lines generated by calculation of the geometry using the spatial reference parameters specified for the map layers.

4.2 Geodatabase construction

A geodatabase was populated with the C97 data collected from the Design and Construction Department, Kenya Gazette notices details entered into the acquisition shape feature, all data required for the study were collocated in the single geodatabase as shown in figure 4.1. The geodatabase is designed to hold large amounts of data from different sources as allowed by the GIS software that was used. This centralised data storage is adequate for keeping of both spatial and non-spatial data and also to control data redundancy.

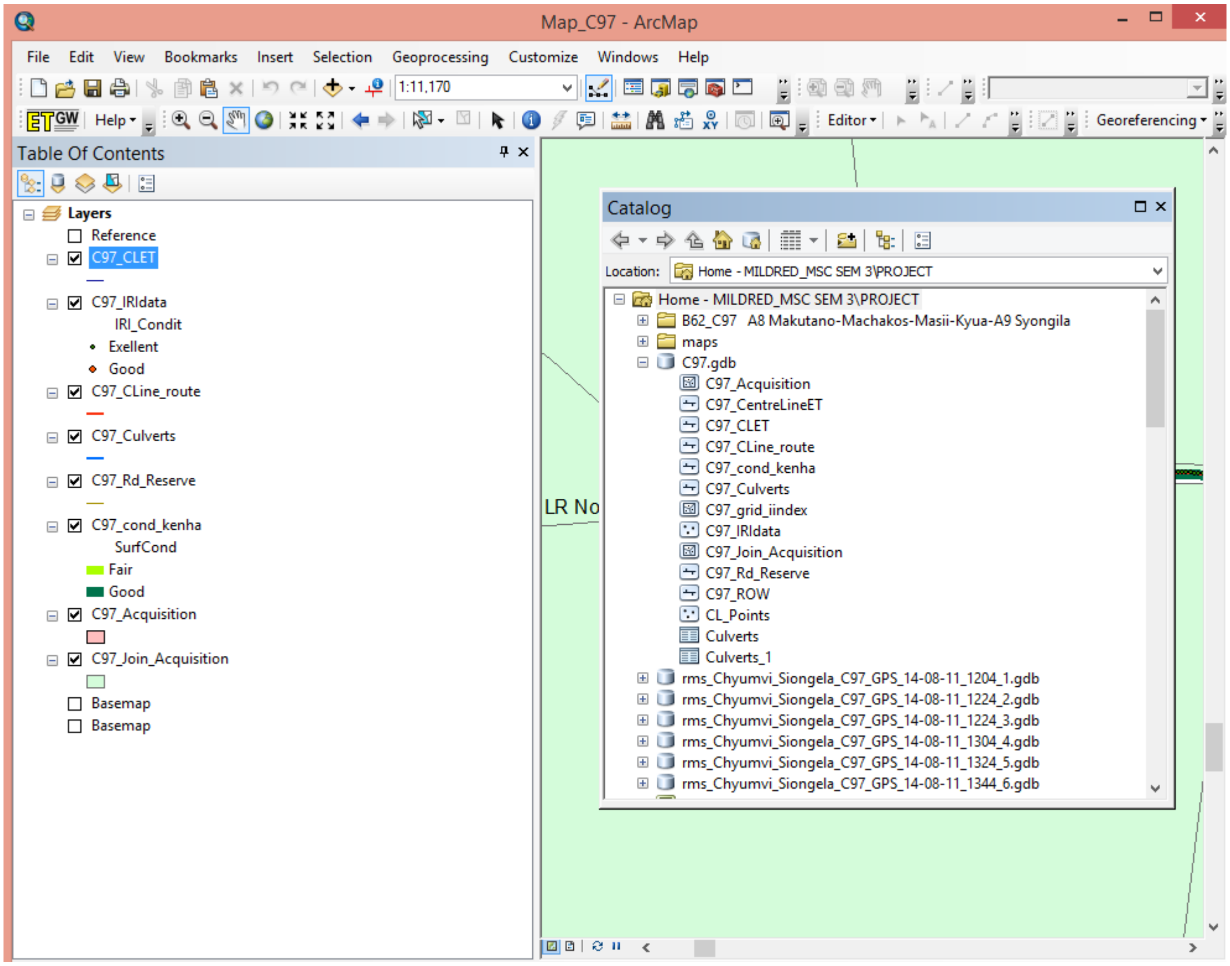

Figure 4. 1: The road class C97 geodatabase

4.3 Data Analysis

A normal shapefile in arcMap cannot be calibrated with chainages unless one decides to use ETGeowizards which just creates a separate chainage feature from the line feature (Road Centreline). In arcMap a process called hatching will be enabled to only a route feature dataset so that it will be possible to specify the distances between one marker post to another.

On the new created route it is then possible to specify the **From** and **To** Fields where the road segment starts and where it ends. A tolerance distance specifies how far a calibration point can stretch from the route. The method for calculation of distances uses metres as the unit of measurement. The above process facilitates the next step where one can query the location of a point or an event along the road.

4.4 Results of Analysis

The 1972 acquisition did not affect many parcels as the result in Table 4.3 shows. Only 8.93 % of the buffered 60 metres along the centre line of the road was acquired.

Table 4.3: Summary of computed results.

SUM OF ACQUIRED AREA(Ha)	LENGTH OF CENTRELINE (Km)	NO. OF PARCELS AFFECTED BY 1972 ACQUISITION	TOTAL AREA COVERED BY 60 METRE ROAD	PERCENTAGE OF HECTARES ACQUIRED	NO OF CULVERTS
117.408	108.88	124	1307 ha	8.93 %	60

4.4.1 Spatial querying.

Retrieval of data subsets in a GIS is the process called querying and is achievable by performing a query in analysing what is at any mapped chainage in a GIS view. Figure 4.2 illustrates how acquisition data that is mapped at, say, km 52+600. Information on the owner of the parcel of land; how much of his land was acquired; in which gazette notice was the parcel listed; is retrieved through a query. The query for km 52+600 here is a random selection that holds an example of information needed by GIS users to probably confirm whether a complainant was actually gazetted for acquisition and whether he has been paid or not. People usually visit the department to claim that their land was gazetted and was not paid or to claim ownership for land that they bought after acquisition had been done a long time ago. A GIS database like the one in figure 4.2 will avail information about a parcel so quickly. If the Surveyor or Asset protection officer wants to quickly identify the chainage where he found problems on the ground, a simple identify route tool is used on the land acquisition feature and the centreline.

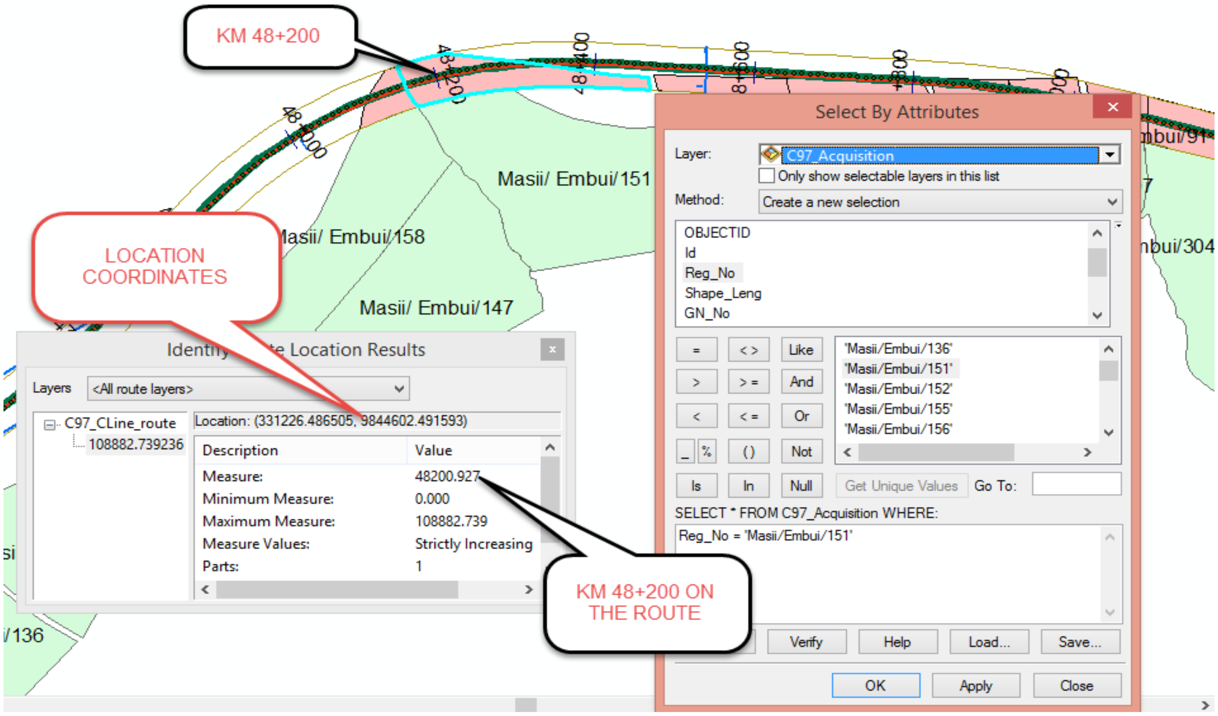

Figure 4. 2: Spatial querying the acquisition Database at km 48+200

4.4.2 Location of Culverts and Bridges along the route

There are several types of culverts, like box culvert or mitred drain. Figure 4.3 illustrates the outline of the type of drain (mitred drain).

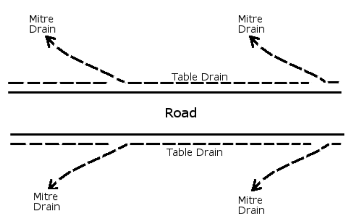

Figure 4. 3: Mitre drain

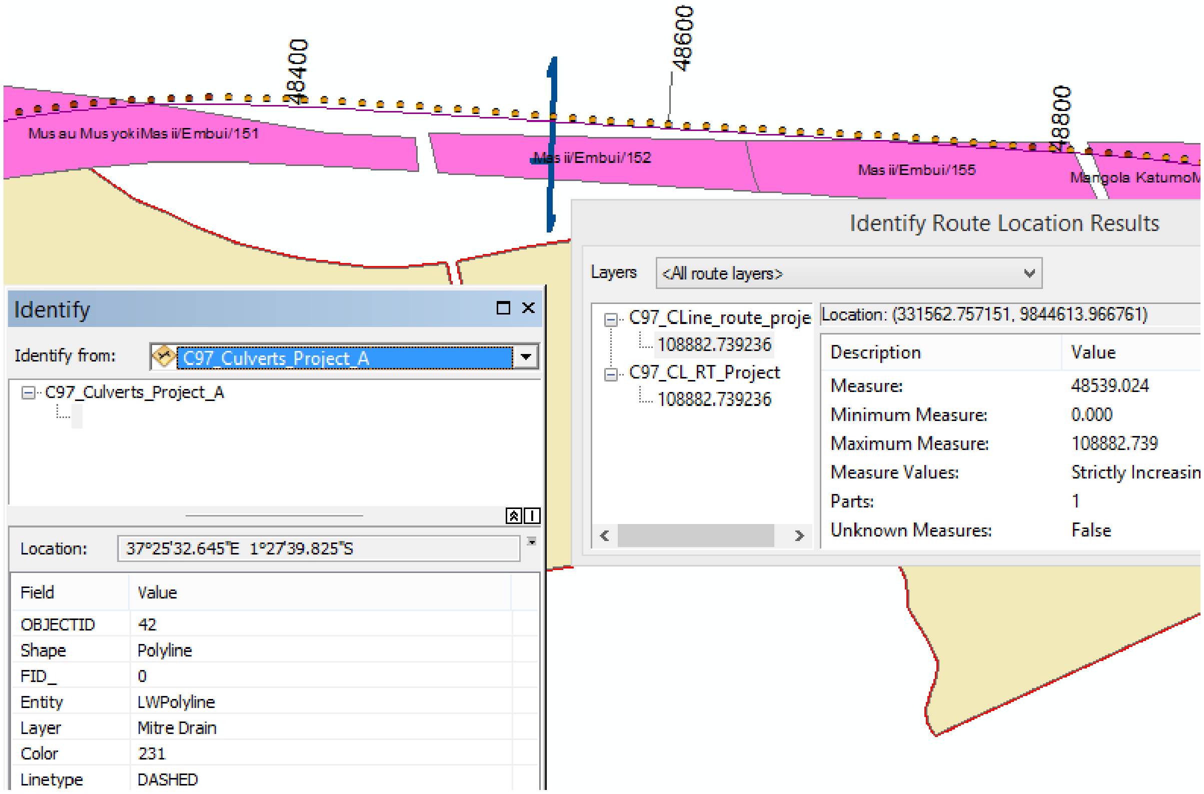

Figure 4. 4: Identification of the culverts along the road

4.4.3 Location of acquisition parcels along the Route

There are a total of 1031 parcels abutting the road and whose details were captured during land acquisition. The parcels have been gazetted in gazette notices 3479 of 14th November 1980, and 2799 of 15th September 1972. Generally the GIS mapping of the acquisition and the input of acquisition details as attributes add more value to the final product. It is very possible to analyse how many parcels there are altogether, how many were acquired in 1972 and how many in 1980.

Another possible analysis is to discern what chainages had the most acquired parcels and check the largest land acquired, indicating the chainage where it accurately falls. Figure 4.5 shows the selected parcels in light blue and the resultant attribute table within the map view.

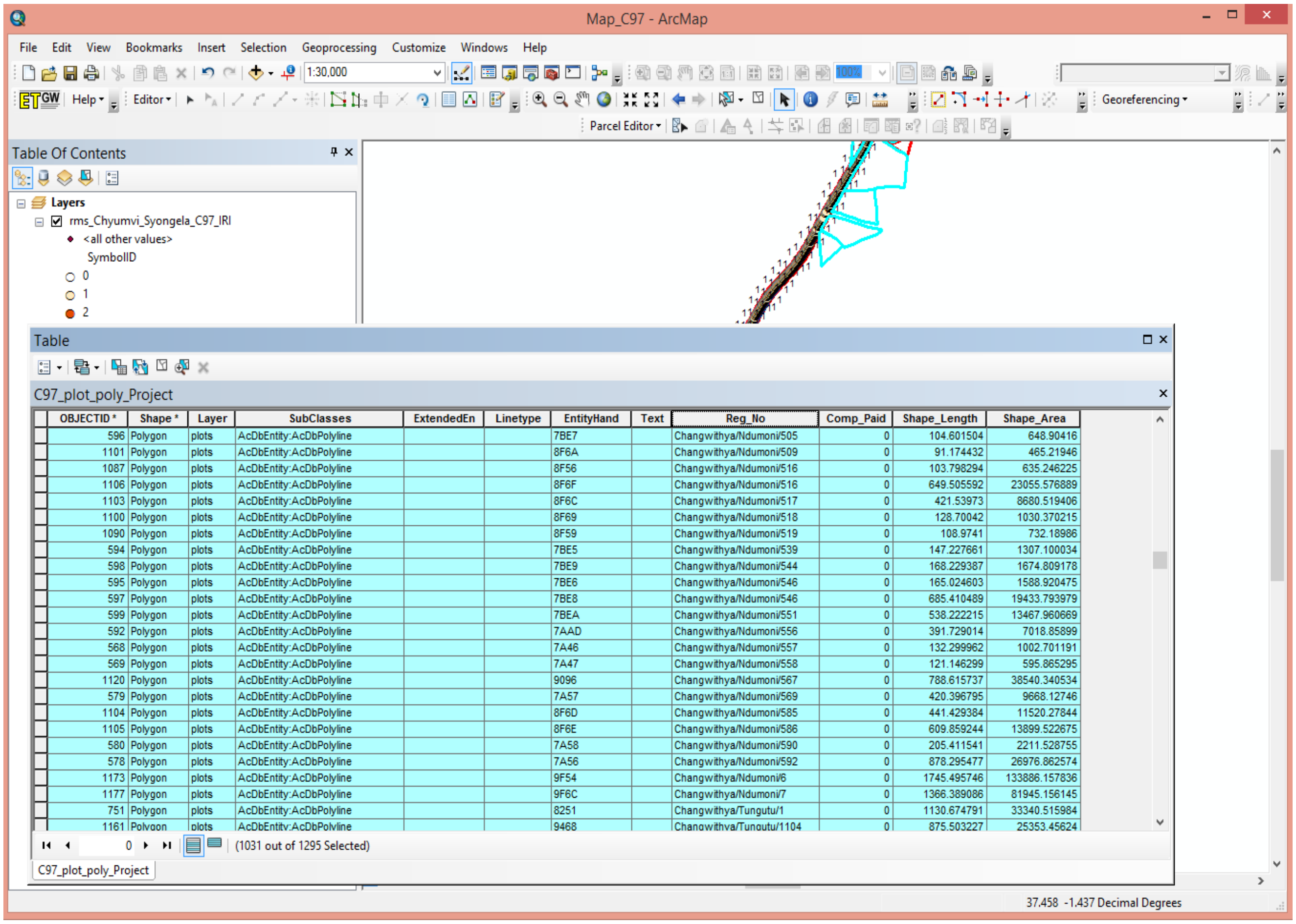

Figure 4. 5: Edited attribute tables

4.4.4 Location of International Roughness Index (IRI) data

This attribute of the longitudinal characteristics of a road is normally measured in millimetres per metre or imperially to denote the distance in a metre that the laser in the measuring instrument jumps. KeNHA staff needs to know the condition of various road stretches on the fly by searching and identifying the chainage as a reference. This international standard for coding of the roughness has been adopted and generalised to show only two codes:

1. Excellent
2. Good.

The road segment in this study in excellent condition generally, as the IRI index is below is **3** (ranging from index 1 and 2) in the entire road. This means that no intervention may be necessary as there is a probability that the potholes and cracks are less than 5%.

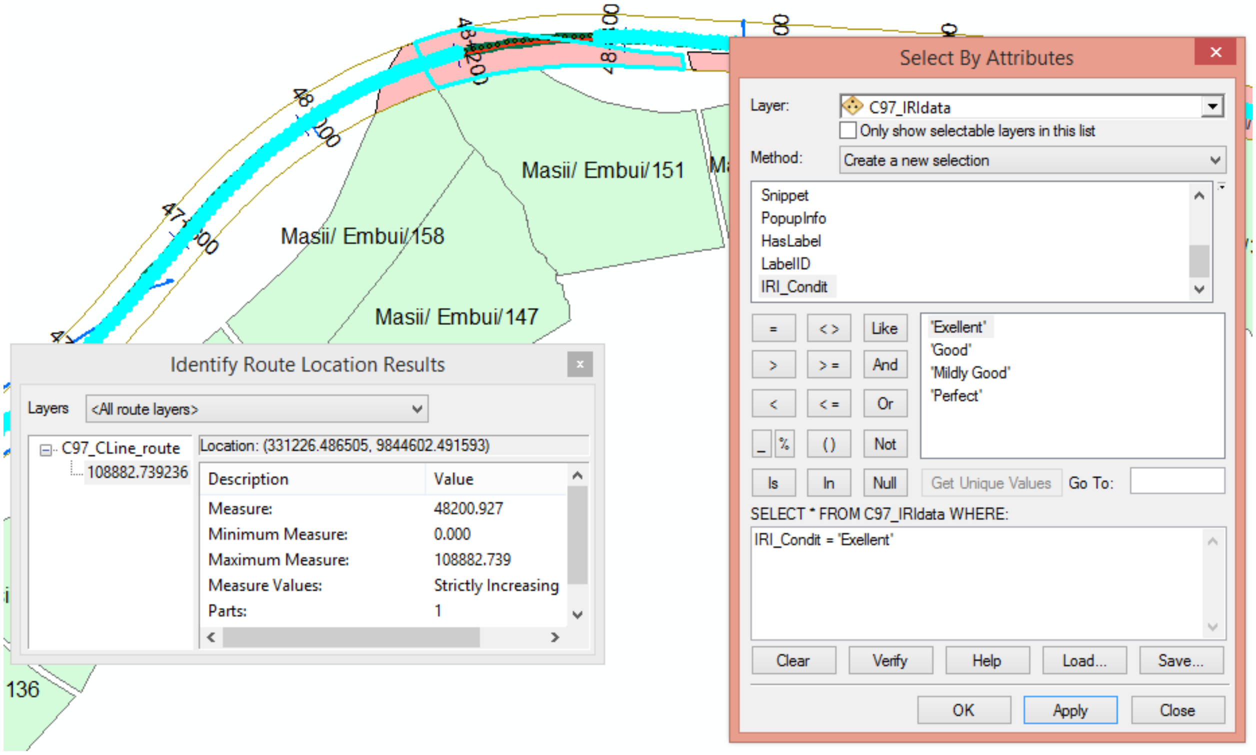

Figure 4. 6: IRI condition is excellent at KM 48+400 onwards

4.5 Discussion

There are various users of road data that need this kind of map to be availed on the intranet. This data on the web will be accessible on unified platform, the internet, thus can be accessed on the android phones while on field activities. ArcGIS online account users can access this data once they are registered as members of my web designed group. Different departments within KeNHA as an organization, and also stakeholders like Land valuers from National Lands Commission, who work hand in hand, find this information useful for their field activities. Road centreline is undoubtedly the spinal cord of any road agency's business. The linear referenced information adds value to the data in road databases which includes understandable map extracts for the roads that are used daily. Getting wholly new products is one reason for the implementation of this GIS project. Costs are bound to reduce, and thus an advantage for the organisation (KeNHA) among many other advantages. Staff time is bound to be saved by the development of this management system for road information and thus an increase in revenue generated for the country.

All acquisitions are gazetted formally in the Kenya Gazette as intention to acquire, later an inquiry and valuations follow by National Lands Commission on behalf of KeNHA, finally awards for compensation are distributed. Acquisition for this road was done in the year 1972 and later in 1980.The alignment of the road was reviewed due to results obtained from feasibility studies to avoid sharp corners and areas of unstable soil strata for the purpose of guaranteeing road safety. Therefore there was another acquisition done in 1980.

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATIONS

This chapter deals with concluding remarks based on objectives that were mentioned in chapter one. It also addresses the challenges of the study and suggests on any openings for advancing future studies.

5.1 Conclusions

Linear Referencing Systems have successfully been employed and the attached product (Maps) is more user friendly, considering that laymen too should be able to refer to a point of interest in terms of chainages on the road network. Results attained are in form of the geodatabases that were updated and queried in GIS analyses. From these queries, is possible to know how much was taken in hectares from any land owner selected on the GIS or web map. The summary Table 4.3 of results indicates that less than 10% of land abutting the road centerline was gazetted for acquisition out of a total area of 1307 hectares. The 1972 gazette notice did not adequately cover all the land needed for realignment and so a further gazette notice was done in 1980. Acquisition is continuous in nature till such a time when the society fully benefits from a complete road corridor.

The fusion of coordinates and the chainages makes it possible for verification of the accuracy of the linear referenced alignment as picked on the ground by Surveyors. The publishing of the resultant map avails the project to a user who logs in and has been given permission to act on the data at various levels, for example, some may only view the data while some may be able to analyze and create reports on the fly. If this paradigm is embraced by road agencies, then data management for information on road projects will be made easier, and the data access portal will offer a non- bulky storage with several maps for different road classes.

5.2 Challenges

- Inadequate funding for the production of the reproduced maps.
- Lack of cooperation among data owners in the separate directorates within the organization.
- Technical challenges in mapping of polygon events.

5.3 Recommendations

The web maps resulting from Linear Referencing were uploaded to a training portal owned by Regional Centre for Mapping of Resources for Development (RCMRD).This is to allow users of this information to easily access what they need on their phones or tablets when in the field. This alleviates the cost of hard copy map printing. Some security measures giving varied permissions to act at different level of editing, query, analysis and eventual downloads must be put in check so that data is not misused or deleted. Above figure dedicates one map package that is hosted in the Regional Centre Portal in their server. The following link *http://rcmrd.maps.arcgis.com/home/item.html?id=fff37b0f0bea4fe5a3f58a9df3c1c024* is the site where the linear referenced map package resides.

The map package can be opened in ArcGIS desktop to be visualized depicting the true picture of the road information mapped in the GIS. As we implement a LRS we need to embrace the web based approach that will ensure multiple businesses needs to be met in the organizational network. Another opinion is that linear referencing methods to be approved by decision makers as a complimentary reference to the coordinate systems and for updating of computer systems (Website) and documents.

Road agencies in the country need to adopt internationally approved highway linear referencing method in correspondence, business transactions, inventory surveys, and other activities where there is the need to share data , or otherwise communicate with exactness the linear location of an event or feature. This will ensure a standard reference that is as exact as the coordinates yet intuitive in nature.

The maps produced have to be easy to use in the field. The practice has been to bind a book for use in the field. Considering the length of the road and the orientation of the pages set on A1 Landscape, and a scale of 1:5000, the total number of maps generated by data driven pages, are **thirty two** maps for the whole stretch of 108 kilometres. However for the purposes of this research and to avoid repetitive work, the appendix will contain three sampled finished maps, namely, pages 11, 15, and 21 of the thirty two pages.

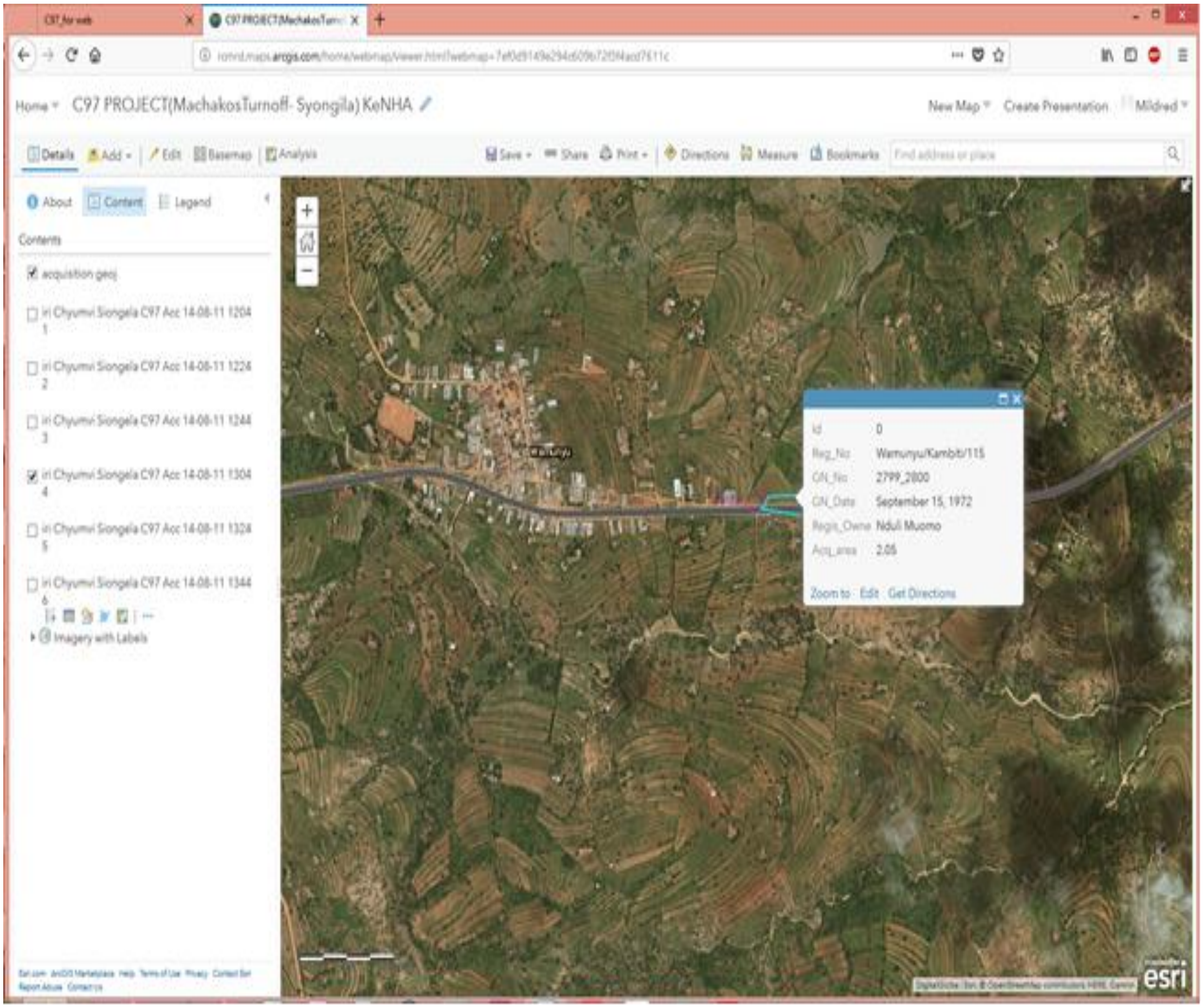

Figure 5. 1: Web mapping and simple analysis

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Internet links:

1. *(http://desktop.arcgis.com/en/arcmap/10.3/guide-books/linear-referencing/designing-a-linear-referencing-system-in-your-geod.htm)Accessed on 13/3/2018.*

APPENDICE: 1

Gazette Notices 2799 of 1972 and 3497 of 1980

done

THE KENYA GAZETTE

Published by Authority of the Republic of Kenya

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Vol. LXXIV—No. 45 NAIROBI, 15th September, 1972 Price Sh. 1/50

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SUPPLEMENT No. 60

Legislative Supplement

GAZETTE NOTICE NO. 2799

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*	*Registered Owners*	*Approx. Area to be Acquired in Acres*
1	Embui	Kiilu Mwange	0.296
2	”	Kasowa Mutua	6·916
3	”	Mukii Mutua	6·150
580	”	Masaku County Council	0·025
5	”	Makato Muluti	5·656
6	”	Peter Ngumbi Mulei	6·694
88	”	Yula Mutendwa	1·334
89	”	Nguli Kisilu	2·198
93	”	Joshua Mutua	1·112
94	”	Mutuku Mbiti	2·766
95	”	James Ngui Mutiso	5·286
99	”	Musumbi Mutiso	0·420
101	”	Munyalo Umwa	2·595
108	”	Ndambuki Kimani	1·087
110	”	Mwave Ngoi	3·063
111	”	Charles Nzioka	1·482
117	”	John Kithuka Nganga	3·705
136	”	Maingi Mawua	2·371
158	”	Joseph Musila Mbuvi	0·741
151	”	Musau Musyoki	2·495
156	”	Mangola Katumo	0·070
39	”	William Kiovi Manthi	0·32
91	”	Nzuki Nzioka	0·40
304	”	Mutiku Kiilu	0·97
305	”	Wambua Kieti	0·97
306	”	Mutuku Kieti	1·037
294	”	Ndivo Muthike	0·37
297	”	Musau Muthike	0·17
591	”	Masaku County Council	0·52
285	”	Kitonya Ngui	4·64
286	”	Muinde Nthiwua	5·286
310	”	Japheth Kitilu Ngui	1·951
316	”	Kiilo Mbuva	2·569
604	”	Mwanza Ndaka	2·688
429	”	Mativo Mwinza	3·483
426	”	Itaa Kiluu	2·223
606	”	Kavenge Kithembe	1·531
55	”	Kithitia Mwuinza	0·009
427	”	Wambua Kiluu	0·148
428	”	Mule Kiluu	0·025
431	”	Jones Nguli Kiluu	1·284
418	”	Muinde Kikanu	2·198
424	”	Ndambuki Mulului	4·594
421	”	Mutuku Mulinge	2·124
420	”	Ndambuki Mulinge	1·778
45	Kambiti	Kavuu Muoki	0·766
115	”	Nduli Muomo	2·050
116	”	Kitala Ngemu	0·667
117	”	Muia Muomo	0·272
113	”	Muli Mbososo	0·840
118	”	Kasyima Muomo	0·568
120	”	Nduli Muomo	1·383
114	”	Mulwa Mbososo	0·445
121	”	Kitala Ngemu	0·593
119	”	Kasyima Muomo	0·716
134	”	Masaku County Council	0·692
10	”	Kyengo Ndiku	0·618
7	”	Muthama Mulwa, Mbatha Mulwa Nduku Mulwa, Muteli Mulwa	0·57
318	”	Mwiki w/o Sila	5·829
319	”	Musembi Ngee	0·395
321	”	Mutike Mwangangi	0·939
322	”	Koki Kyui	5·014
334	”	Katunyo Nzoka	0·222
335	”	Kamoli Kithungu	0·963
338	”	Mutua Kitele	2·00
	”	Kimatu Mutyauvyu	2·742
341	”	Yatta Trust Land Vested in Masaku County Council	75·582

Plans of the affected land may be inspected during office hours at the office of the Commissioner of Lands, Nairobi.

Dated this 8th day of September, 1972.

J. A. O'LOUGHLIN

GAZETTE NOTICE NO. 2800

THE LAND ACQUISITION ACT, 1968

(*No.* 47 *of* 1968)

NOTICE OF INQUIRY

IN PURSUANCE of section 9 (*a*) of the Land Acquisition Act, 1968, I hereby give notice that an Inquiry will be held at 10 a.m., on the 19th October, 1972, at the office of the Chief, Wamunyu Location for the hearing of claims to compensation by persons interested in the following land:—

SCHEDULE

Plot No.	*Location*	*Registered Owners*	*Approx. Area to be Acquired in Acres*
1	Embui	Kiilu Mwange	0.296
2	”	Kasowa Mutua	6·916
3	”	Mukii Mutua	6·150
580	”	Masaku County Council	0·025
5	”	Makato Muluti	5·656
6	”	Peter Ngumbi Mulei	6·694
88	”	Yula Mutendwa	1·334
89	”	Nguli Kisilu	2·198
93	”	Joshua Mutua	1·112
94	”	Mutuku Mbiti	2·766
95	”	James Ngui Mutiso	5·286
99	”	Musumbi Mutiso	0·420
101	”	Munyalo Umwa	2·595
108	”	Ndambuki Kimani	1·087
110	”	Mwave Ngoi	3·063
111	”	Charles Nzioka	1·482
117	”	John Kithuka Nganga	3·705
136	”	Maingi Mawua	2·371
158	”	Joseph Musila Mbuvi	0·741
151	”	Musau Musyoki	2·495
156	”	Mangola Katumo	0·070
39	”	William Kiovi Manthi	0·32
91	”	Nzuki Nzioka	0·40
304	”	Mutiku Kiilu	0·97
305	”	Wambua Kieti	0·97
306	”	Mutuku Kieti	1·037
294	”	Ndivo Muthike	0·37
297	”	Musau Muthike	0·17
591	”	Masaku County Council	0·52
285	”	Kitonya Ngui	4·64
286	”	Muinde Nthiwua	5·286
310	”	Japheth Kitilu Ngui	1·951
316	”	Kiilo Mbuva	2·569
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55	”	Kithitia Mwuinza	0·009
427	”	Wambua Kiluu	0·148
428	”	Mule Kiluu	0·025
431	”	Jones Nguli Kiluu	1·284
418	”	Muinde Kikanu	2·198
424	”	Ndambuki Mulului	4·594
421	”	Mutuku Mulinge	2·124
420	”	Ndambuki Mulinge	1·778
45	Kambiti	Kavuu Muoki	0·766
115	”	Nduli Muomo	2·050
116	”	Kitala Ngemu	0·667
117	”	Muia Muomo	0·272
113	”	Muli Mbososo	0·840
118	”	Kasyima Muomo	0·568
120	”	Nduli Muomo	1·383
114	”	Mulwa Mbososo	0·445
121	”	Kitala Ngemu	0·593
119	”	Kasyima Muomo	0·716
134	”	Masaku County Council	0·692
10	”	Kyengo Ndiku	0·618
7	”	Muthama Mulwa, Mbatha Mulwa Nduku Mulwa, Muteli Mulwa	0·57
318	”	Mwiki w/o Sila	5·829
319	”	Musembi Ngee	0·395
321	”	Mutike Mwangangi	0·939
322	”	Koki Kyui	5·014
334	”	Katunyo Nzoka	0·222
335	”	Kamoli Kithungu	0·963
338	”	Mutua Kitele	2·00
	”	Kimatu Mutyauvyu	2·742
341	”	Yatta Trust Land Vested in Masaku County Council	75·582

Every person who is interested in the land is required to deliver to me, not later than the day of Inquiry, a written claim to compensation.

Dated this 8th day of September, 1972.

SCHEDULE—(*Contd.*)

Plot No.	*Sub-Location*	*Registered Owners*	*Approx. Area to be Acquired in Hectare*
200	,,	Hezron Afwanda	0·0133
196	,,	Gilbert Agalo Ondiego	0·0200
933	,,	Naftali Rombo	0·0072
326	,,	Kefa Omolo Ochuoga	0·0132
325	,,	Jeremiah Ogola Olang	0·0105
251	,,	Okumu Nyando	0·0210
26	,,	Aram Oduor	0·0030
249	,,	Marko Odhiambo	0·0075
240	,,	Moris Okumu	0·0129
367	,,	Ochieng Mbaja	0·01665
272	,,	George Onyango Ngasi	0·0210
252	,,	Kisumu County Council	0·1364
323	,,	Ogada Ariga	0·0462
358	,,	John Agoro Oidho	0·0060
337	,,	Obonyo Sewe	0·0019
375	,,	Nicolas Owuor	0·0133
239	,,	Samuel Weda	0·0198
994	,,	Margarita Owang Ayieye	0·216
932	,,	Charles Onoka Odalo	0·0816
857	,,	Christopher Agalo Arunga	0·021
1687	,,	Ojuok Rombo	0·0605
1886	,,	Agingu Sangany and Onyiero Onguko	0·0120
1685	,,	Ngasi Obonyo	0·0523
1688	,,	Omolo Waga	0·0240
1689	,,	Otieno Opiyo	0·0114
1690	,,	Omolo Odongo	0·00054
16	,,	Jason Opiyo Rombo	0·0442
1879(*a*)	,,	Olewe Orina	0·0078
1879(*b*)	,,	Donde Dada	
1879(*c*)	,,	Bernard Nyapiedho	
1879(*d*)	,,	Owili Maguti	
1879(*e*)	,,	Oganda Nyandua	
1878	,,	Odero Nyandua	0·0094
1877	,,	Sewe Sewe	
1705	,,	Samuel Ocheing' Rambim	0·0339
1694	,,	Andoniko Rambim Oriendo	0·0381
1693	,,	Luka Ngasi Rambim	0·0564
2064	,,	Jason Opiyo Rombo	0·008
372	,,	Aoko Mbaja	0·009
367	,,	Acheing Mbaja	0·0275
339	,,	Naftali O. Michianga	0·031
325	,,	Jeremia Ogola	0·0048
532	,,	Ezekiel Were	0·0033
493	,,	Benson O. Aduogo	0·0031
		MATERIAL SITES 8 8(1) 5 8(*ii*)	
559		Oyieso Otee	0·805
		Henry W. Omolo	0·970
462		Dishon Abuodha	0·742
		Roche S. Ngasi	0·520

Every person who is interested in the land is required to deliver to me, not later than the day of Inquiry, a written claim to compensation.

Dated the 28th October, 1980.

done entry

J. R. NJENGA,
Commissioner of Lands.

GAZETTE NOTICE NO. 3497

~~C97~~ C97

THE LAND ACQUISITION ACT

(*Cap.* 295)

Typed.

NOTICE OF INTENTION TO ACQUIRE LAND

IN PURSUANCE of section 6 (2) of the Land Acquisition Act, I give notice that the Government intend to acquire the following land for Makutano—Kitui Road.

SCHEDULE

Plot No.	*Registration Section*	*Owner(s)*	*Approx. Area to be Acquired in Hectares*
159	Changwithya/ Ndumoni	Mutunga Kingee	1·41
6	,,	Masesi Nzusi	0·17
4	,,	Katumi Nzusi	1·70
3	,,	Masisi Nzusi	0·66
2	,,	Malombi Mbula	0·09
209	,,	Syovata Mbula	0·07
195	,,	Kakiti Ngalaka	2·91
212	,,	Mwati Kakiti Ngalaka	2·18
217	,,	Munyau Ngio	0·15
215	,,	Kakiti Ngalaka	0·84
218	,,	Musyoka Mwavuu	0·56
221	,,	Musyoka Mutuota	0·38
211	,,	Munyao Ngio	0·31
173	,,	Kivuva Mwani	0·78
172	,,	Munyoki Simba	2·02

SCHEDULE—(*Contd.*)

Plot No.	*Registration Section*	*Owner(s)*	*Approx. Area to be Acquired in Hectares*
224	"	Ngoe Nzula	0·09
225	"	Wambua Nzula	0·05
157	"	Mutui Simba	0·32
169	"	Mathano Nzula	1·82
167	"	Kasima Mwanguu	0·19
395	"	Kitui County Council	0·09
168	"	Kithambyo Mwanguu	0·29
231	"	Kilonzo Kusewa	0·17
599	Changwithya/Mulutu	Kithyambyo Mwanguu	0·77
598	"	John Mutunga Nzau	0·51
566	"	Munyoki Mumo	2·77
563	"	Kathule Kituvu	0·36
562	"	Nzau Kasyoki	0·11
504	"	Mutia Mbunzi	0·32
617	"	Wanyua Ndungo	0·22
615	"	Mbungu Ndungo and John Mutua Ndungo	0·46
483	"	Kamanza Nzinzi	0·64
533	"	Kimanzi Kisoi	0·31
511	"	Mutua Maithya	0·47
470	"	Maingi Ngule	0·09
484	"	Musyoka Kunuvwa	0·46
482	"	Mwinde Masai	0·13
481	"	Kyangangu Ndoto	0·03
477	"	Kitui County Council	0·07
476	"	Nzau Kunuvwa	0·56
475	"	Munaku Kasakwa	0·29
398	"	Justus Kalewa Ndoto	0·22
465	"	Mulwa Mulatya	0·26
452	"	Mbeva Mulinga	0·68
446	"	Mbavu Kisau	1·19
451	"	Mulwa Mwongela	1·11
255	"	Mitao Muli	0·48
268	"	Mutie Kilungya, Methu Muli, Mwilu Muli and Mitau Muli	0·11
235	"	Kasimbi Kimanzi and Mbiti Mwanga	0·76
231	"	Musyoka Mwanga	1·26
230	"	Munyili Mulinga	0·59
229	"	Wambua Mulinga	0·58
226	"	Munyoki Ngali	1·29
218	"	Ismail Mulinga	0·96
609	"	Boniface Masila	0·46
217	"	Mangethua Mumu and Bros.	0·44
215	"	Mwanza Maithya	0·25
214	"	Miminza Isika	0·40
213	"	Mulwa Maithya	0·61
203	"	Wambua Maithya	0·48
195	"	Henry Chamia Kilonzo and Kitili Kilonzo	0·21
196	"	Mrs. Muyia Mutua	0·21
197	"	Boniface Kasee Malombe	0·61
199	"	Kimanzi Mumu	0·35
23	"	Henry Chamia Kilonzo	0·21
24	"	Kitui County Council	0·50
41	"	Malombe Mwaniki	0·53
37	"	Kitui County Council	0·03
36	"	Munyalo Sila	0·13
35	"	Mwasya Mwaniki	0·21
34	"	Malombe Mwaniki	0·26
33	"	Boniface Kasee Malombe	0·75
27	"	Muinde Kitale	0·51
29	"	Mwasia Ndothya	0·72
28	"	Kalasa Ndana	0·14
1104	Changwithya/Tungutu	Nzaku Ivuku	0·11
982	"	Boniface Mwandikia Masila	0·09
1201	"	Kitui County Council	0·05
950	"	Makau Mbai	0·78
949	"	Mutua Mbai	0·13
951	"	Munyoki Nzau	0·66
955	"	Kakitia Mbai	0·71
1219	"	Kimanzi Mumu	0·07
945	"	Kilinge Sila	0·22
350	"	Malombe Munyala	0·75
352	"	James Mbuvi Maithya and Mutua Maithya	0·13
947	"	Kitonga Sila	0·12
371	"	Kamana Kithunu	0·26
373	"	Kisinga Kithunu	0·05
374	"	Kathonde Ndunda	0·34
375	"	Kamana Kithunu	0·27
919	"	Kimanzi Malombe	0·04
1151	"	Kimami Kalunditu	0·09
377	"	Munziu Kutu	0·03
923	"	Mailu Kimami	0·80
924	"	Nguno Kalunditu	0·25
922	"	Kitonyi Kamami	0·21
925	"	Kavete Nduva	0·36
926	"	Mwikali Kilunda	0·24
900	"	Mbusya Mbuvi	0·20
917	"	Misere Malonza	0·48
916	"	Mwongela Kikole	0·88
915	"	Katau Kikole	0·33
394	"	Mbole Mitau, Kasilia Mitau and Mutie Mitau	0·03
914	"	Charlis Kathunu	0·14
913	"	Maswili Mbua	0·09
395	"	Mbula Ndawa and Kimuli Mutisya	0·12
912	"	Ndiwa Mtua	0·01
1138	"	Francis Mutua Omari	0·44
398	"	Justus Muema Kalunda	0·91

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SCHEDULE—(*Contd.*)

Plot No.	*Registration Section*	*Owner(s)*	*Approx. Area to be Acquired in Hectares*
401	,,	David Nguli Kalua	0·43
379	,,	Nguuwe Isika	0·31
380	,,	Kitui County Council	0·28
7	,,	Charles Kisinga Kithonu	0·10
6	,,	Munyoki Ivala	0·13
5	,,	Joseph Musyoni	0·05
4	,,	Malusi Maithya	0·09
2	,,	Katuli Ndundu	0·42
1112	,,	Francis Mutua Omari	0·17
1	,,	Kanuku Ngolania, Kakai Ngolania and Wambua Ngolania	0·53
869	,,	Kitungu Ndundu	0·05
866	,,	Ndoyo Ndundu	0·07
865	,,	Mutia Ndundu	0·30
863	,,	Mwanzia Mbiti	

Plans of the affected land may be inspected during office hours at the Commissioner of Lands, Kencom House, 4th Floor, City Hall Way, Moi Avenue, Nairobi.

Dated the 28th October, 1980.

J. R. NJENGA,
Commissioner of Lands.

GAZETTE NOTICE No. 3498

Typed

THE LAND ACQUISITION ACT

(*Cap.* 295)

NOTICE OF INQUIRY

IN PURSUANCE of section 9 (1) of the Land Acquisition Act, I give notice that an Inquiry will be held at 10 a.m. on the 4th and 5th December, 1980, at Mulutu Primary School, Changwithya Location, for the hearing of claims to compensation by the persons interested in the following land:

SCHEDULE

Plot No.	*Registration Section*	*Owner(s)*	*Approx. Area to be Acquired in Hectares*
159	Changwithya/ Ndumoni	Mutunga Kingee	1·41
6	,,	Masesi Nzusi	0·17
4	,,	Katumi Nzusi	1·70
3	,,	Masisi Nzusi	0·66
2	,,	Malombi Mbula	0·09
209	,,	Syovata Mbula	0·70
195	,,	Kakiti Ngalaka	2·91
212	,,	Mwati Kakiti Ngalaka	2·18
217	,,	Munyau Ngio	0·15
215	,,	Kakiti Ngalaka	0·84
218	,,	Musyoka Mwavuu	0·56
221	,,	Musyoka Mutuota	0·38
211	,,	Munyao Ngio	0·31
173	,,	Kivuva Mwani	0·78
172	,,	Munyoki Simba	2·02
224	,,	Ngoe Nzula	0·09
225	,,	Wambua Nzula	0·05
157	,,	Mutui Simba	0·32
169	,,	Mathano Nzula	1·82
167	,,	Kasima Mwanguu	0·19
395	,,	Kitui County Council	0·09
168	,,	Kithambyo Mwanguu	0·29
231	,,	Kilonzo Kusewa	0·17
599	Changwithya/Mulutu	Kithyambyo Mwanguu	0·77
598	,,	John Mutunga Nzau	0·51
566	,,	Munyoki Mumo	2·77
563	,,	Kathule Kituvu	0·36
562	,,	Nzau Kasyoki	0·11
504	,,	Mutia Mbunzi	0·32
617	,,	Wanyua Ndungo	0·22
615	,,	Mbungu Ndungo and John Mutua Ndungo	0·46
483	,,	Kamanza Nzinzi	0·64
533	,,	Kimanzi Kisoi	0·31
511	,,	Mutua Maithya	0·47
470	,,	Maingi Ngule	0·09
484	,,	Musyoka Kunuvwa	0·46
482	,,	Mwinde Masai	0·13
481	,,	Kyangangu Ndoto	0·03
477	,,	Kitui County Council	0·07
476	,,	Nzau Kunuvwa	0·56
475	,,	Munaku Kasakwa	0·29
398	,,	Justus Kalewa Ndoto	0·22
465	,,	Mulwa Mulatya	0·26
452	,,	Mbeva Mulinga	0·68
446	,,	Mbavu Kisau	1·19
451	,,	Mulwa Mwongela	1·11
255	,,	Mitao Muli	0·48
268	,,	Mutie Kilungya, Methu Muli, Mwilu Muli and Mitau Muli	0·11
235	,,	Kasimbi Kimanzi and Mbiti Mwanga	0·76

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SCHEDULE—(*Contd.*)

Plot No.	*Registration Section*	*Owner(s)*	*Approx. Area to be Acquired in Hectares*
231	,,	Musyoka Mwanga	1·26
230	,,	Munyili Mulinga	0·59
229	,,	Wambua Mulinga	0·58
226	,,	Munyoki Ngali	1·29
218	,,	Ismail Mulinga	0·96
609	,,	Boniface Masila	0·46
217	,,	Mangethua Mumu and Bros.	0·44
215	,,	Mwanza Maithya	0·25
214	,,	Miminza Isika	0·40
213	,,	Mulwa Maithya	0·61
203	,,	Wambua Maithya	0·48
195	,,	Henry Chamia Kilonzo and Kitili Kilonzo	0·21
196	,,	Mrs. Muyia Mutua	0·21
197	,,	Boniface Kasee Malombe	0·61
199	,,	Kimanzi Mumu	0·35
23	,,	Henry Chamia Kilonzo	0·21
24	,,	Kitui County Council	0·50
41	,,	Malombe Mwaniki	0·43
37	,,	Kitui County Council	0·03
36	,,	Munyalo Sila	0·13
35	,,	Mwasya Mwaniki	0·21
34	,,	Malombe Mwaniki	0·26
33	,,	Boniface Kasee Malombe	0·75
27	,,	Muinde Kitale	0·51
29	,,	Mwasia Ndothya	0·72
28	,,	Kalasa Ndana	0·14
1104	Changwithya/Tungutu	Nzaku Ivuku	0·11
982	,,	Boniface Mwandikia Masila	0·09
1201	,,	Kitui County Council	0·05
950	,,	Makau Mbai	0·78
949	,,	Mutua Mbai	0·13
951	,,	Munyoki Nzau	0·66
955	,,	Kakitia Mbai	0·71
1219	,,	Kimanzi Mumu	0·07
945	,,	Kilinge Sila	0·22
350	,,	Malombe Munyala	0·75
352	,,	James Mbuvi Maithya and Mutua Maithya	0·13
947	,,	Kitonga Sila	0·12
371	,,	Kamana Kithunu	0·26
373	,,	Kisinga Kithunu	0·05
374	,,	Kathonde Ndunda	0·34
375	,,	Kamana Kithunu	0·27
919	,,	Kimanzi Malombe	0·04
1151	,,	Kimami Kalunditu	0·09
377	,,	Munziu Kutu	0·03
923	,,	Mailu Kimami	0·80
924	,,	Nguno Kalunditu	0·25
922	,,	Kitonyi Kamami	0·21
925	,,	Kavete Nduva	0·36
926	,,	Mwikali Kilunda	0·24
900	,,	Mbusya Mbuvi	0·20
917	,,	Misere Malonza	0·48
916	,,	Mwongela Kikole	0·88
915	,,	Katau Kikole	0·33
394	,,	Mbole Mitau, Kasilia Mitau and Mutie Mitau	0·03
914	,,	Charlis Kathunu	0·14
913	,,	Maswili Mbua	0·09
395	,,	Mbula Ndawa and Kimuli Mutisya	0·12
912	,,	Ndiwa Mtua	0·01
1138	,,	Francis Mutua Omari	0·44
398	,,	Justus Muema Kalunda	0·91
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7	,,	Charles Kisinga Kithonu	0·10
6	,,	Munyoki Ivala	0·13
5	,,	Joseph Musyoni	0·05
4	,,	Malusi Maithya	0·09
2	,,	Katuli Ndundu	0·42
1112	,,	Francis Mutua Omari	0·17
1	,,	Kanuku Ngolania, Kakai Ngolania and Wambua Ngolania	0·53
869	,,	Kitungu Ndundu	0·05
866	,,	Ndoyo Ndundu	0·07
865	,,	Mutia Ndundu	0·30
863	,,	Mwanzia Mbiti	

Every person who is interested in the said land is required to deliver to me, not later than the date of Inquiry, a written claim to compensation.

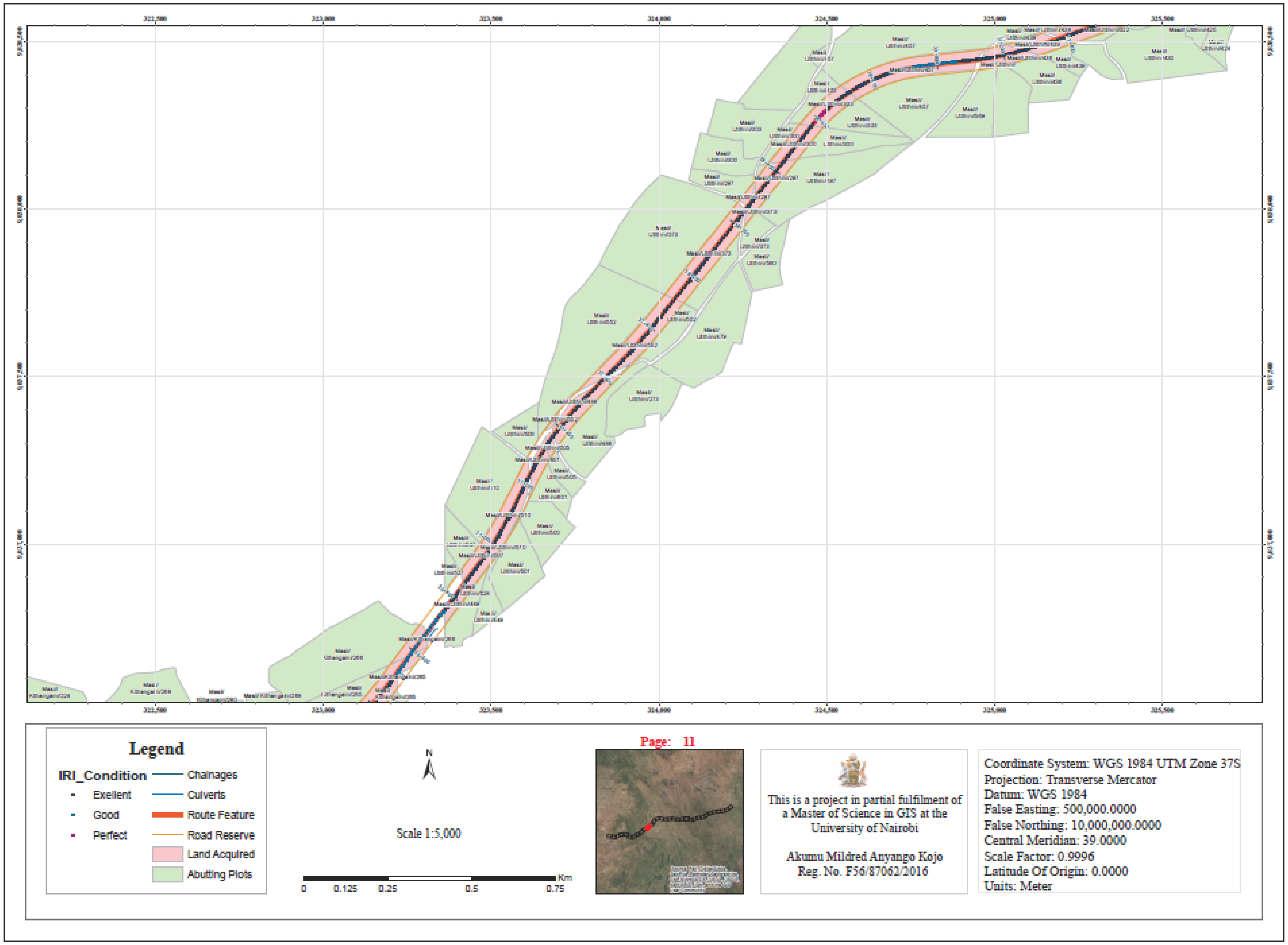
Dated the 28th October, 1980.

J. R. NJENGA,
Commissioner of Lands.

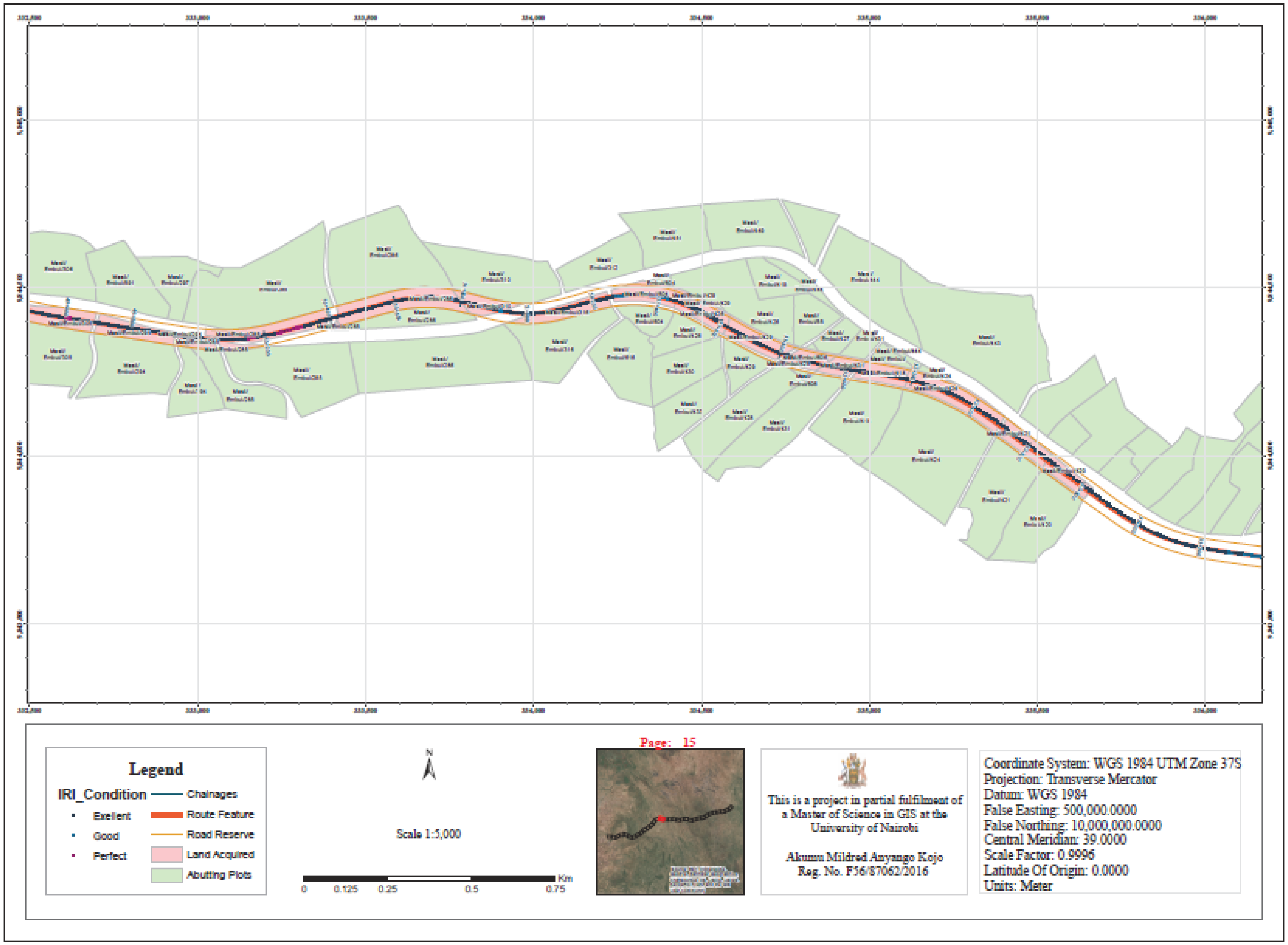
APPENDICE: 2

MAPS: Sheets 11, 15 and 21

LINEAR REFERENCING MAP OF MACHAKOS TURNOFF- SYONGILA ROAD C97



LINEAR REFERENCING MAP OF MACHAKOS TURNOFF- SYONGILA ROAD C97



LINEAR REFERENCING MAP OF MACHAKOS TURNOFF- SYONGILA ROAD C97