UNIVERSITY OF NAIROBI

APPLICATION OF GIS IN PHYSICAL PLANNING:

CASE STUDY: PART OF MWINGI TOWN

MWANZIA, CHRIS VUNDI

F56/79883/2012

A project report submitted in partial fulfillment for the degree of *Master of Science in Geographical Information Systems (GIS)* in the Department of Geospatial and Space Technology in The University of Nairobi.

Department of Geospatial and Space Technology, School of Engineering.

JUNE, 2014.

DECLARATION/APPROVAL

***Declaration*:**

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

Candidate: **Mr. MWANZIA CHRIS VUNDI**

……..……

Date: ……..……

Approval:

This project report has been submitted for examination with my approval as university supervisor.

Supervisor: **Mr. D. K. MACOCO**

……..……

Date: ……..……

ABSTRACT

This research deals with the application of GIS in physical planning where the case study is part of Mwingi Town in Kitui County. Mwingi Town has grown in uncontrolled manner with all sorts of planning problems such as: poor roads, drainage, housing, garbage disposal among others. These problems result to a dysfunctional urban setup. Using GIS, planning can be done to find solutions to these problems.

This research project will produce a functional and versatile urban physical plan for use by the County Government, public and private entities.

The existing land uses were examined and compared against the physical planning standards. After this, images of the study area were digitized and analysis on the output was data done to bring out information that answers the research questions.

Key findings are presented in line with the objectives. Capabilities of GIS in creation of land use maps, decision support and in guidance for zoning are shown with examples drawn from the GIS project. Analysis of questionnaire is done and presented in pie charts.

In conclusion, GIS is a powerful planning tool that needs to be universally adopted in planning and research and training be done to make it more applicable.

DEDICATION

Dedicated to

Lillian Mbuli and Purity Mutheu

ACKNOWLEDGEMENTS

I give thanks to God for the life and the chance to do this research project. I also thank members of staff of the Department of Geospatial and Space Technology, especially Mr. D. K. Macoco for assistance offered around the clock. My sincere and heartfelt appreciations also go to all my colleagues, specifically Caroline Mwende for the encouragement and assistance she offered. To my friends Lilian Mbuli, Roy Kemboi and Mr & Mrs. Dominic, I am sincerely grateful for the support you provided. Daniel Mwangangi, Tindo Kim and Kim Mwalimu, their input on local information on streets and buildings names is highly appreciated. Finally, I thank Mr. Kamau of Ministry of Lands, Infrastructure and Urban Development in Kitui County for his professional advice.

TABLE OF CONTENTS

Declearation……. i

Abstract……...……ii

Dedication……...iii

Acknowledgement…….…….iv

Table of contents……..v

List of figures……..…vii

List of tables……...……..viii

Acronyms……..…..x

1.0 INTRODUCTION

1.1 Background 1

1.2 Problem Statement 2

1.3 Objectives..... 3

1.4 Justification for the Study 3

1.5 Scope of work..... 3

1.6. Methodology Overview 4

1.7. Limitations of the Study..... 4

2.0 LITERATURE REVIEW

2.1. Structure urban plan 6

2.2. Inception of Computer Aided Design Urban Planning 7

2.3. Application of GIS in practice 8

2.4. Case examples..... 11

2.5. Importance of GIS to Urban Development 14

3.0 METHODOLOGY AND MATERIALS

3.1. Introduction 16

3.2. Study Area 16

3.3. Data 21

3.4. Software and equipment 22

3.5. Methodology 25

4.0 RESULTS AND DISCUSSIONS

4.1. GIS in Mapping; 34

4.2. GIS as a planners' decision support tool 34

4.3. GIS in land use zoning 367

5.0 CONCLUSION AND RECOMMENDATIONS

5.1. Conclusion 41

5.2. Recommendations 41

References 42

Appendices 44

Appendix I: Non-Spatial data questionnaire 45

Appendix II: Geodatabase design 47

LIST FIGURES

Figure 1: GIS and Urban Planning ……..……9

Figure 2: (a and b): Application of GIS in Land Management and Land Use Planning …….....10

Figure 3: (a and b): Application of Planning in Environmental Planning and Assessment……. 11

Figure 4: A screenshot of the Concord GIS powered physical structure plan……...……13

Figure 5: A screenshot of the Concord GIS……...14

Figure 6: Kitui County in the National Context. ……..…..…17

Figure 7: Mwingi Central Sub-County within the greater Kitui County……...18

Figure 8: A flow chart showing a summary of the methodology applied…… 25

Figure 9: Snapshot of An image loaded in to ArcGIS for georeferencing……26

Figure 10: Georeferenced image in ArcGIS…… 26

Figure 11: A mosaic of two georeferenced images ready for digitization…….27

Figure 12: Creation of a file geodatabase……..28

Figure 13: Creation of a feature database……..28

Figure 14: Digitization of highway feature…….....29

Figure 15: Adding attributes of a feature class……..……29

Figure 16: A mosaic of two georeferenced Google earth images……..30

Figure 17: Partly digitized image of Mwingi town showing several land use zones……31

Figure 18: Information about a property of interest in a cadastral plan…….32

Figure 19: A buffer showing encroachment index on the A3 highway in Mwingi town……..35

Figure 20: Part Development Plan of the study area…….36

Figure 21: Pie chart of respondents' suggestions for a preferred dumping site location……...38

Figure 22: Pie chart showing responses on the preferred location for industrial land use zone…39

Figure 23: Pie chart showing responses on the preferred location for open air market…….39

LIST OF TABLES

Table 1: Development Plan land use numbers, land use descriptions and their color codes…….20

Table 2: Ground control points as collected using GPS phone…….22

Table 3: Equipment used, make, model and use……23

Table 4: A table showing software and applications used in the project……..… 24

ACRONYMS

CAD	Computer Aided Design
CDMA	Code Division Multiple Access
EAT	East Africa Time
ESRI	Economic and Social Research Institute
GCP	Ground Control Points
GCP	Ground Control Points
GIS	Geographical Information Systems
GPS	Global Positioning System
GWF	Georgia Wildlife Federation
ILRI	International Livestock Research Institute
KODI	Kenya Open Data Initiative
MP	Mega Pixel
MTPE	Mission to Planet Earth
NASA	National Aeronautics and Space Administration

PC	Personal Computer
PDP	Part Development Plan
SCDNR	South Carolina Department of Natural Resources
SoK	Survey of Kenya
TCM	Town Council of Mwingi
UTM	Universal Transverse Mercator
WGS84	World Geodetic System of 1984
WWW	World Wide Web

CHAPTER 1: INTRODUCTION

1.1 BACKGROUND

Geographical Information Systems (GIS) is a very significant tool in many aspects of physical planning. This study is geared towards use of GIS in physical planning. Planning can be made better -more efficient, user friendly and cost effective by inculcation of GIS in to the conventional physical planning methods.

Physical planning has in the recent years become a key determinant in development capacity of any place. The profession is further growing to include other technologies like GIS, cartography, photogrammetry and others to add value to physical planning to make them more responsive to the needs it is intended to serve.

The importance of inclusion of GIS in planning has been recognized in the County Government Act (2012) and in The Urban Areas and Cities Act (2012). Section 105 (f) of the County Government Act (2012) stipulates that, a county planning unit shall be responsible for ensuring the establishment of a GIS based database system.

Section 110 of the same act outlines that: there shall be a ten year county GIS based database system spatial plan for each county, which shall be a component part of the county integrated development plan providing a spatial depiction of the social and economic development programme of the county as articulated in the integrated county development plan; clear statements of how the spatial plan is linked to the regional, national and other county plans; and clear clarifications on the anticipated sustainable development outcomes of the spatial plan.

1.2 Problem Statement

- Mwingi town has expanded in uncontrolled manner. There is hardly any development control. The latest zonal land use plan of the town was made on 22nd May, 1973 and was never approved.

- There are many problems in the town which include but not limited to; lack of an adequate system of development control which is the major problem and it results to other problems which are clearly evident in the town like: roads, there a few roads that serve the town and most of those few roads heavily encroached up on or completely blocked. Also, because of the long period of development without proper development control, there has been a lot of haphazard development which do not conform to planning standards, to counter this confusion, a planner needs to make critical decisions on the actions to take and that is not possible without some means of visualization and analysis that can be offered by GIS.

- Planning entails setting aside land and assigning it to specific land uses as per the planning land use/zoning standards. Developments in Mwingi have been taking place without regard of this. To assign land to the various uses, several factors are considered to evaluate its suitability for the recommended purpose. Given the current situation, it would be hard for a planner to assign these zones without sidelining some important factors that need consideration. GIS comes in handy to combine these factors and bring out the most suitable site for different functions according to their specific requirements.

1.3 Objectives

1.3.1 Overall objective

1. To use GIS in improving physical planning of part of Mwingi Town.

1.3.2 Specific objectives

1. To show how GIS can be used in land use mapping.
2. To use GIS as a planners' decision support tool.
3. To examine and exploit GIS in guiding land use zoning.

1.4 Justification for the Study

This research project aims at producing a functional physical urban plan for part of Mwingi Town that will be available both in digital and paper form. This will be of benefit not only to the County Government of Kitui in development control and urban management but also to the larger residents of Mwingi town.

The plan will serve as a pilot project to show how GIS can be inculcated with planning to make it better and more responsive in solving issues it is supposed to. With more resources in human skills and finances, the plan can be duplicated at a large scale to create a countywide spatial plan anchored on GIS and also, the duplication can be applied in creating detailed physical plans for individual towns within the region and beyond.

1.5 Scope of work

The study will cover the urban center of Mwingi town and part of the immediate environs. The area is approximately 2 km^2 only because it is a Part Development Plan (PDP) of a part of Mwingi town and not a full physical development plan

GIS is a wide technology and its application in physical planning is very diverse. In this project, GIS will be used to aid in support of decision making on the best land use allocation in a particular area and in creation of a maps that will help in future urban management of the town. Also, it will generate custom paper maps that are printable. It will also be used in decision support

1.6. Methodology Overview

To accomplish the objectives of this project, an array of tasks were performed. Spatial and non spatial data was acquired and combined in a GIS environment. This was done through capturing Google Earth™ images of the study area, georeferencing them and then creating a geodatabase that was used to form basis of digitizing the image and creating the functional database.

Information collected from the residents of the study area was further inculcated in to the project for social consideration and aiding in making decisions on suitability of certain areas for certain land uses in socially acceptable criterion.

1.7. Limitations of the Study

The main limitation of this study was time. The time allocated to complete the project was not adequate especially considering the distance between the study area and the station of the supervisor but as much as possible, this was countered through electronic methods of communication. Other limitations include but not limited to: financial constraints, unavailability of ready data of Mwingi Town that could have been used to form basis of comparison.

1.8. Organization of the Report

This report consists of five chapters. Chapter one contains general introduction of the problem and a brief overview of the expected deliverables; Chapter two features the literature review into other similar works on the same or similar subject in other places; Chapter three outlines the methods applied in attaining the results with Chapter four shows the results attained by the project and discussion of the same. Conclusion and recommendations are outlined in chapter five.

CHAPTER 2: LITERATURE REVIEW

2.1. Structure urban plan

National Structure Planning is defined as "the integrated planning and implementation of the physical, social, economical and environmental aspects of a country" (Jayasekara, 2006). As such, a plan should formulate the spatial guidelines for utilization of land and its targeted economic growth through the provision of infrastructure network and services. It guides the development in a sustainable manner by rationalizing the use of land for each activity without disturbing the ecosystem of the country.

According to A. M. Nour (2011) in his Journal of Sustainable Development "The Potential of GIS Tools in Strategic Urban Planning Process; as an Approach for Sustainable Development in Egypt" every day, planners use geographic information system (GIS) technology to research, develop, implement, and monitor the progress of their plans. He further states that, GIS provides planners, surveyors, and engineers with the tools they need to design and map their neighborhoods and cities. Planners have the technical expertise, political savvy, and fiscal understanding to transform a vision of tomorrow into a strategic action plan for today, and they use GIS to facilitate the decision-making process.

Today, city, community, and regional planning mean dealing with constant change. Rapidly changing economic conditions have further complicated the process by threatening the funding needed to carry out these functions. To date, County Governments have been right-sized and down-sized and have had budgets drastically cut while trying to maintain service levels. Information technology, especially GIS, has proven crucial in helping County Governments cope in this environment (ESRI, 2003). GIS reduces workload and thus less personnel and time

needed to accomplish a certain planning task. GIS acts as a tool to make this achievable in the most efficient way using minimum time, financial resources and personnel.

During the last 20 years, geographic information systems (GIS) have emerged from the scientific laboratories into the heart of conventional planning practice (Nour, 2011). Planners have been in forefront in adopting and adapting GIS among other technologies in the planning practice. This is mostly so because more than mapping and production of graphical representation of planners' ideas, GIS is capable of complex and useful analyses that would have been hard and time consuming (or impossible) without the capabilities offered by GIS.

2.2. Inception of Computer Aided Design Urban Planning

As stated by Kheir Al-Kodmany *et al* (1995) "Planning and geographic information systems (GIS) have a long history together". They alluded that GIS traces its roots to early 1912, city plans for Dusseldorf, Germany, and Billerica, Massachusetts, extracted data from one map and added it to another. Today, planners of all types and in all functional areas (e.g., city planning, transportation and social services.) around the world use GIS in their daily work.

In the early 1990s, GIS began expanding into the business market, and as GIS became available on personal computers it became viable for a much broader spectrum of business users (Castle, 1993).

T. M. Harris and G. A. Elmes (1993) observed that, North America started experiencing a revolution in the linking of computer-based Geographical Information Systems (GIS) to planning issues as early as 1993. The history of application of GIS in planning and resource management in the continent dates back to the mid-1960s. They noted that, it was possible to inculcate GIS in to planning because of the growing awareness, institutional acceptance, falling system costs,

product diversity, the introduction of microcomputers and the availability of Personal Computers (PC) based GIS software in those times of early 1990's

A. M. Nour, (2011) asserts that, a professor at the University of Washington, wrote some of the earliest computer mapping software, in the 1960s that was first put in a project to map Canada's natural resources.

2.3. Application of GIS in practice

As indicated by A. G-O. Yeh, (2006), urban planning is one of the main applications of GIS. GIS in planning is used both as a spatial database and as an analysis and modeling tool. Further, he outlined that, the applications of GIS vary according to the different stages, levels, sectors, and functions of urban planning. With the increase in user-friendliness and functions of GIS software and the marked decrease in the prices of GIS hardware, GIS is an operational and affordable information system for planning. It is increasingly becoming an important component of planning support systems. GIS is increasingly accessible to planners and is now an important tool for urban planning in developed and developing countries alike (Yeh, 2006).

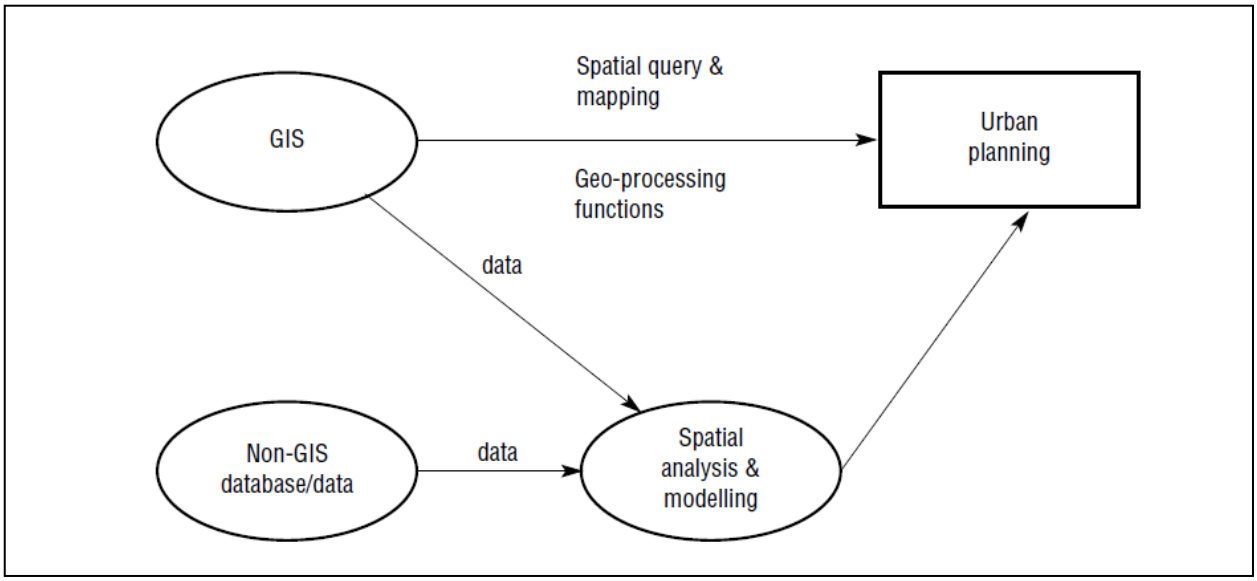

Figure 1: GIS and Urban Planning. (Source: Yeh, 2006)

GIS can be applied in many areas of urban/regional planning and management. Figure 1 above shows how GIS is coupled with other functions to add value to urban planning. GIS data is integrated with non-GIS data through modeling and spatial analysis to result in to a better and more functional urban plan.

Figure 2 (a and b) below show examples of maps produced by National Physical Planning Department (NPPD) of Sri Lanka, 2002 in preparation of the National Physical Plan for Sri Lanka.

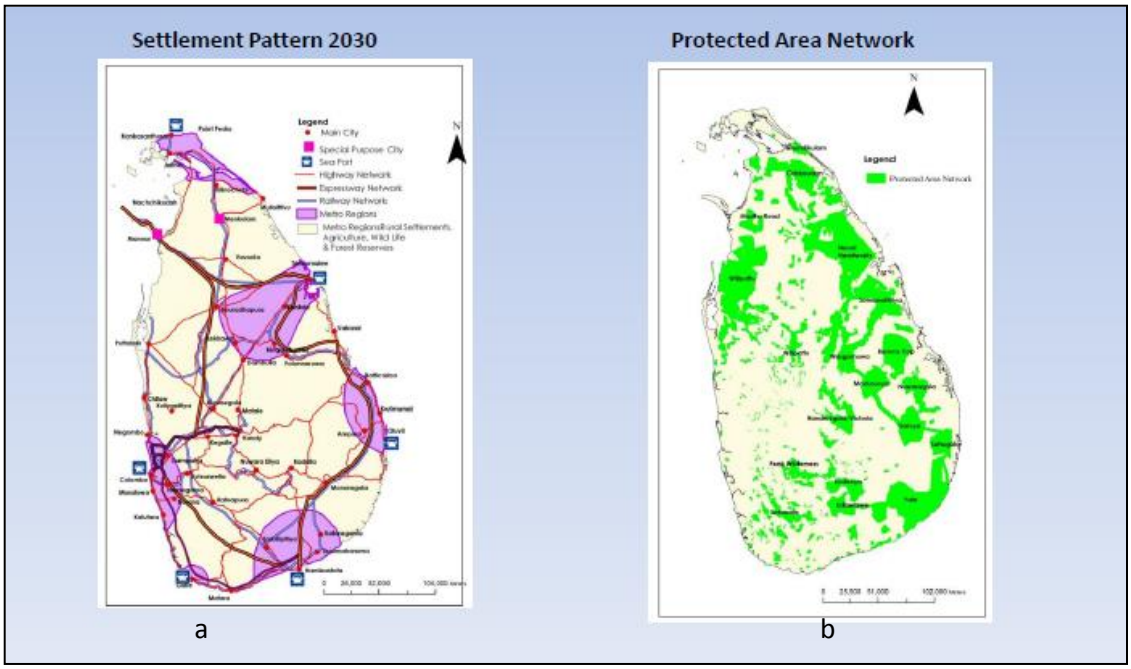

Figure 2 (a and b): Application of GIS in Land Management and Land Use Planning Issues. (Source: Jayasekara, 2006)

In figure 2 (a and b) above, settlement patterns are compared against protected areas. This helps in formulating policies that will improve environmental protection and maintenance of valuable protected national environmental assets. These maps can further be overlaid to bring out the relationship more clearly.

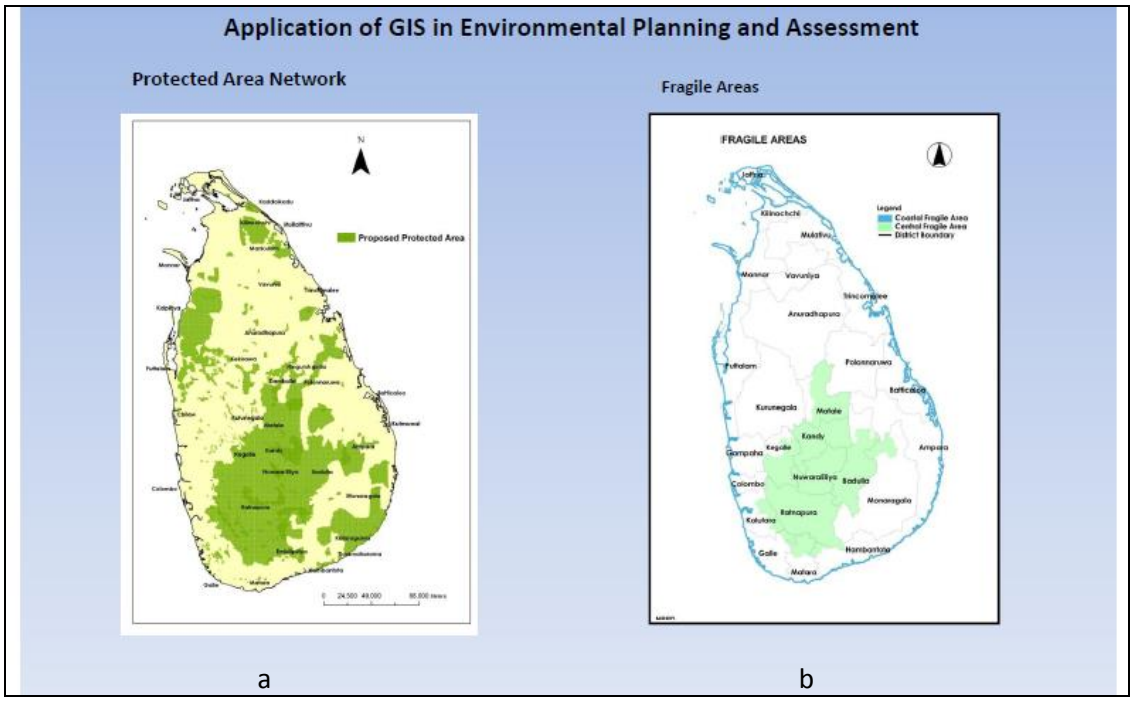

Figure 3 (a and b): Application of Planning in Environmental Planning and Assessment. (Source Jayasekara, 2006)

The figure 3a shows protected areas; figure 3b displays the fragile coastal areas of Sri Lanka. Overlaying the two datasets will bring out the areas that are fragile but not marked as protected regions or show areas that are protected but do not need to be. This information will assist the local government of Sri Lanka in making the appropriate adjustments.

2.4. Case examples

Planning like many other technical disciplines is an evolving subject, evolving both in: advancement in technical complexity and rate of adoption/application. To this effect, many planning agencies and/or planning departments of governments are adopting the use of GIS in planning. Examples of these are:

The South Carolina Department of Natural Resources (SCDNR), the University of South Carolina, Georgia Tech Research Institute, and the Georgia Wildlife Federation (GWF) were awarded a research grant by the National Aeronautics and Space Administration (NASA) office of Mission to Planet Earth (MTPE) in 1994, to research on Using Imagery and GIS for tracking urban growth along South Carolina's coast ESRI (2006). They did this using satellite imagery for studying the rate of development in the metropolitan Charleston area; South Carolina; and Savannah, Georgia. The goal of the study was to identify, document, and communicate the rate of urban change to support effective land planning decisions in the future.

They combined images of varied temporal resolution using GIS software and identified three land cover classes along the coast as: urban, water and non-urban from the images through image analysis. After this, change detection through time was done to identify change in urban growth along the coastal zone. This resulted to maps and a study report that are of use to planners in identifying land use trends and development areas; provided decision support and saved time.

Concord's WebGIS Internet mapping solution allows users to search for any property in town by address, owner name, or parcel ID. Information, such as parcel size, zoning, owner name and address, and assessed value, is available.

As per "Town of Concord Massachusetts WebGIS" website (http://www.mapsonline.net/concord/) accessed on 27th January, 2014. The Town of Concord is focused on expanding the information made available through this website using WebGIS. The planning process begun in 1995 with aerial photography project that included converting the existing assessor's tax maps from mylar to a digital parcel layer. Numerous layers of information were developed, called planimetric mapping layers, which included such layers as fire hydrants,

manholes, catch basins, stone walls, fences, wet areas, light poles, building footprints, swimming pools, and paved areas. Eventually this information was all converted to GIS format. The result was a dynamic urban plan that allows for querying by a third party remotely over the internet. See figures 4 and 5 below:

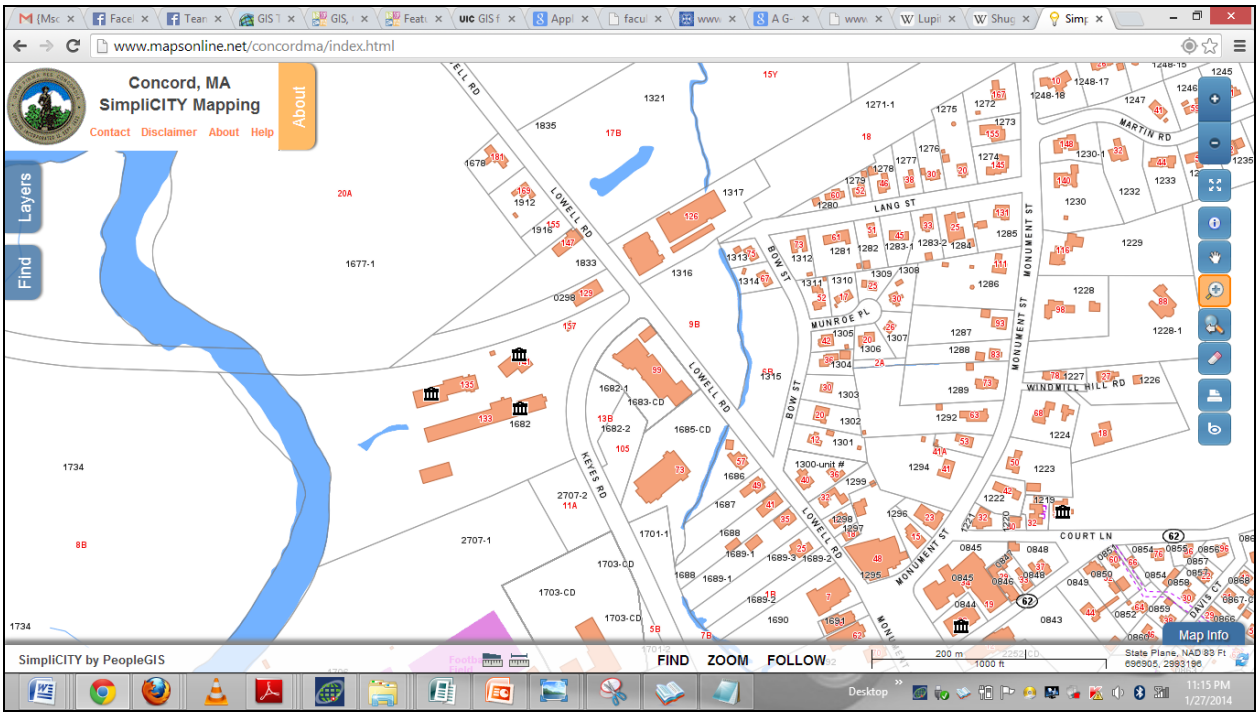

Figure 4: A screenshot of the Concord GIS powered physical structure plan.

(Source: http://www.mapsonline.net/concord/, 2014)

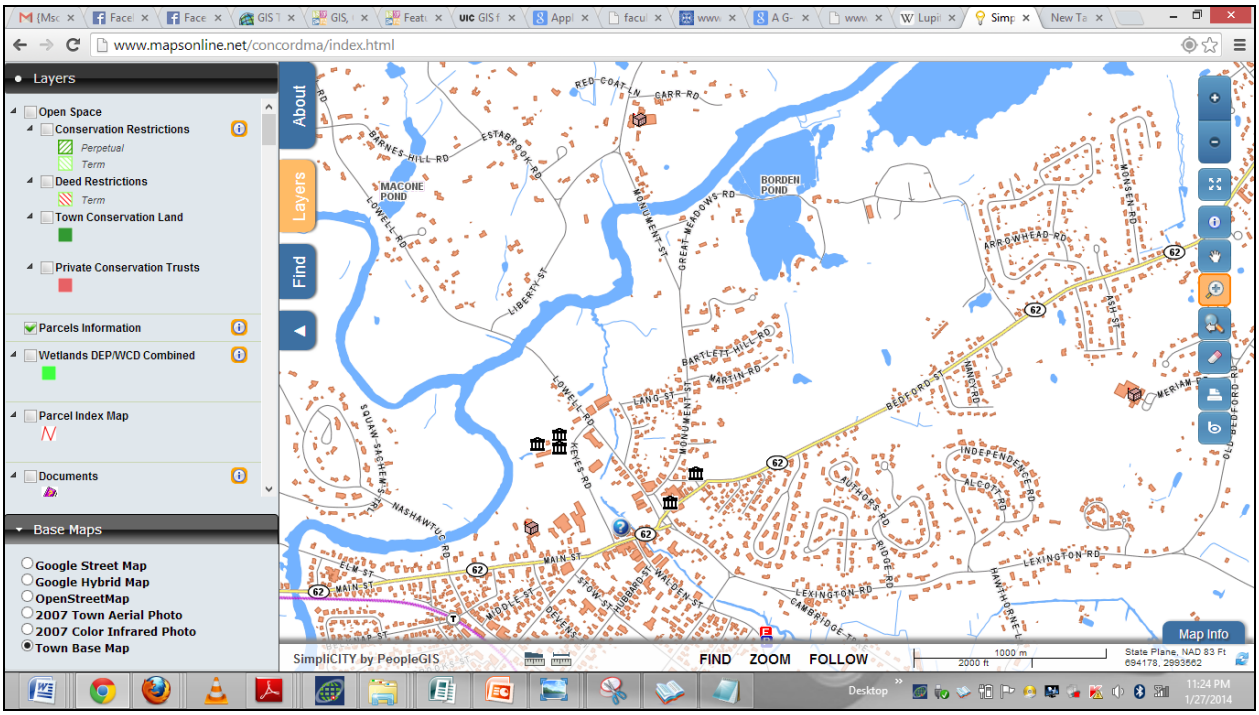

Figure 5: A screenshot of the Concord GIS powered physical structure plan with data layers. (Source: http://www.mapsonline.net/concord/, 2014)

Although it is widely agreed upon that GIS and CAD can improve the quality of planning process considerably, the current use in design of new plans of these techniques is very limited.

2.5. Importance of GIS to Urban Development

In a nutshell, benefits of using GIS in County Government for planning include the following as listed by ESRI, (2006): increase efficiency, save time, generate revenue, provide decision support, improve accuracy, manage resources, automate tasks, save money, increase access to government, enhance public participation, and promote greater collaboration among public agencies. GIS promotes a good public image of a planning department. Equipped with GIS tools from ESRI, staff members can quickly access information on parcel maps, such as

environmentally sensitive areas, and all matters concerning the implementation of zoning, permit status, and other planning information, ESRI, (2006)

CHAPTER 3: METHODOLOGY AND MATERIALS

3.1. Introduction

Application of (Geographical Information Systems) GIS in planning in this project is by using GIS as a value addition tool to the traditional planning methods. A plan is intended to guide development and control growth while ensuring sustainability economically, socially and environmentally. It (the physical development plan) ensures harmony and synchrony of activities in a subject area. When GIS is inculcated in to the plan, the usefulness of the plan in accomplishing the above mentioned is enhanced especially when applied in a digital plan presented in a soft copy.

3.2. Study Area

3.2.1. Location

The study focuses on Mwingi Town. Mwingi Town lies on the boundary of Mwingi West and Mwingi Central Constituencies, Kitui County Kenya, It has a population: 15,970 (2009 census). The town is located along Garissa road A3 Highway between Garissa and Nairobi City, 47 kilometers north of Kitui Town and 144 kilometers east of Nairobi City (Mwingi TCM 2003-2013). Mwingi is within the latitude of (55º 59’999”S) longitude of (38º40’120”E), and an altitude of 947 meters above the sea level (TipTopGlobe.com- “www.tipglobe.com”)

Figures 6 and 7 below show the study area in the national context:

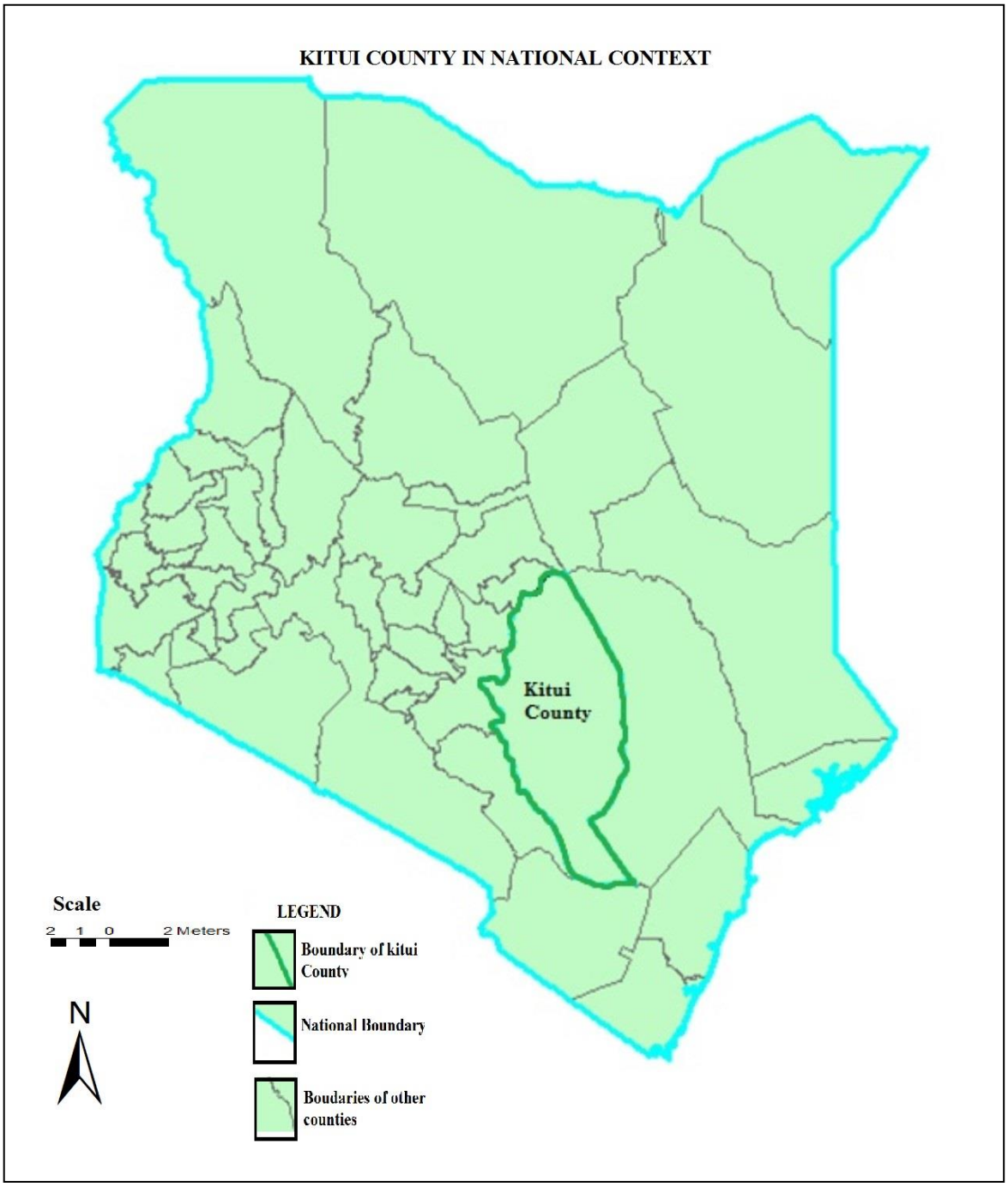

Figure 6: Kitui County in the National Context. (Shown by the green outline)

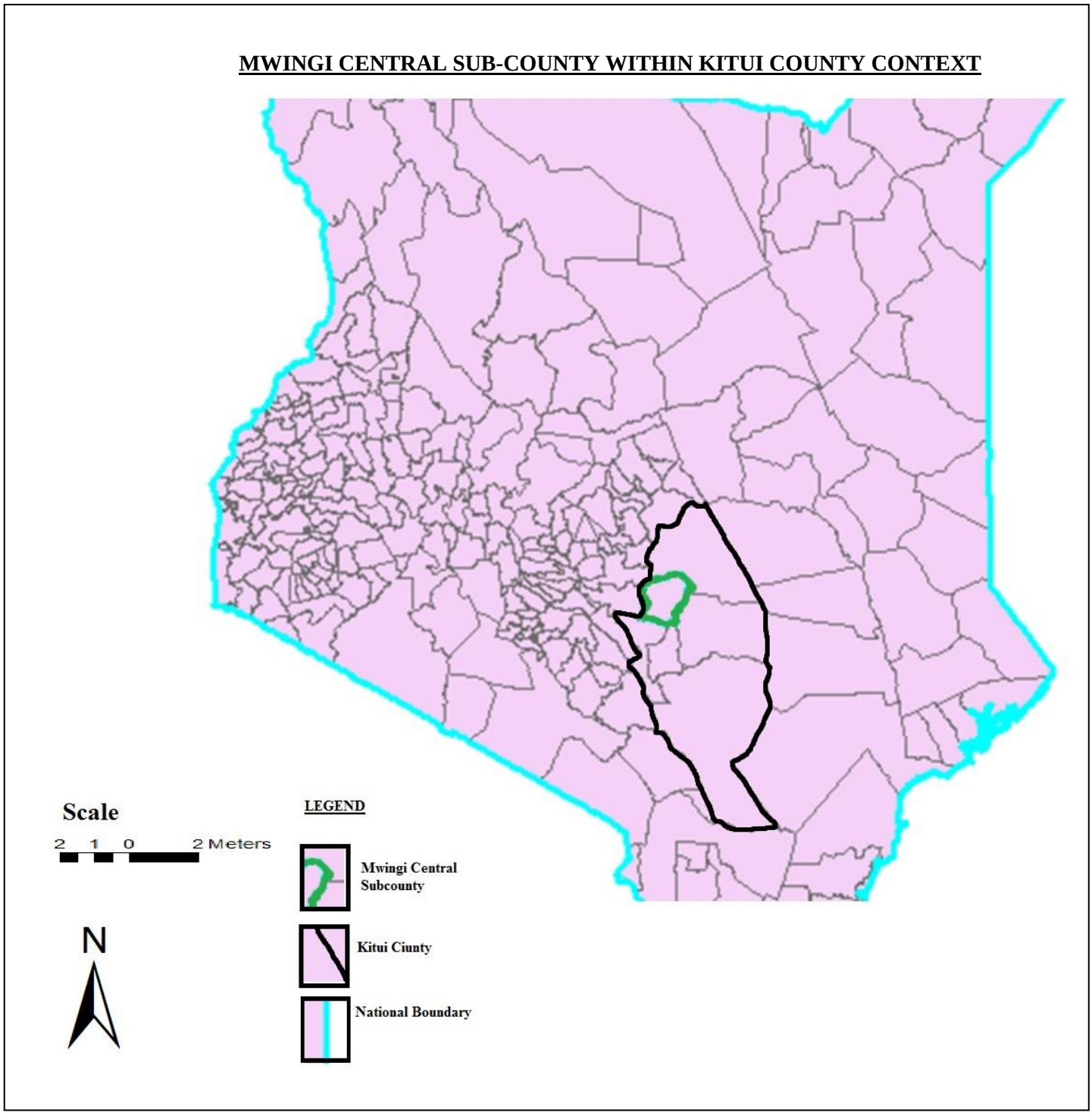

Figure 7: Mwingi Central Sub-County within the greater Kitui County (shown by the green outline)

Considerations of the project

Existing Land use

In this study, the area covered is not big enough to include all the zones. So, only a few land use zones are properly demonstrated in the project.

The study area is experiencing a rapid growth. There is a rapid change of land use from the original agricultural land use to other forms of land use mainly commercial and residential. This change occurs haphazardly without a proper means to guide it. This is because of several reasons among which are:

a. Lack of adequate technical capacity for development control in the planning department of the former town council of Mwingi.
b. Lack of an up-to-date development plan for Mwingi town.
c. Freehold land ownership whereby, the land owners feel like they have the absolute right to do with their land what they wish.
d. Poor surveying practices where surveyors provide roads of 6m all over the town without considering recommendations of planners.

The current land uses have occurred naturally shaped by the forced of capitalistic market and economics of agglomeration (Butler *et al,* 2007)

Land use- Standard as proposed in The Physical Planning Handbook (2007)

According to the Physical Planning Handbook (2007), there are nine land use zones that are included in a plan; these are as shown in the table below along with their color codes:

Table 5: Development Plan land use numbers, land use descriptions and their color codes

(Source**:** Physical Planning Handbook (2007)**)**

Zone Number	Land Use	Color Code
0	Residential	Brown
1	Industrial	Purple
2	Educational	Yellow
3	Recreational	Green
4	Public purpose	Orange
5	Commercial	Red
6	Public utility	Blue
7	Transport	Gray
8	Differed	Not colored
9	Agricultural	Not colored

Size determination

Size of land allocated for a particular land use is determined by several factors like:

The intended land use- Some land uses like agricultural, naturally require large areas for the activity to be realistically realizable. Also, other land uses dictates assignment of some functions to complement them. Like for example, an area with many educational institutions will have a bigger area under residential land use to accommodate the students from the educational institutes (Butler et al, 2007)

Available land- If the land available is not large enough, the most important land uses like residential, transport and commercial will naturally be given priority over the "auxiliary ones" like recreational and public purpose.

In the rural regions for example, land is comparatively more available than the urban centers. It is in these regions that practices like agriculture are allocated.

Location Determination

Location of a particular land use is not arbitrarily selected. A number of factors are considered, either consciously or otherwise.

Access to important facilities e.g. accommodation for educational, raw material for industrial, proximity of industrial to residential in case where polluting agents are being emitted. These are just a few examples.

3.3. Data

3.3.1. Spatial Data

Spatial data is data that identifies the spatial location of a feature. It can also be referred to as spatial information or geographical data. This form of data can be manipulated in a GIS environment and be used to create maps and also be used to support decision making. (Ormsby et at 2001)

For the purpose of this project, geographical data is obtained from a georeferenced Google Earth Image that is digitized to give various types of data sets.

Physical collection of geographical data from the field was done using a GPS Android application “Polaris Navigation” in an android phone: Samsung S2. This was used to collect Ground Control Points (GCPs) that were used in georeferencing the image used to obtain data layers.

GPS coordinates for ground control points were collected with phone with an error of approximately ±5m which is adequate for planning.

The Collected GCPs collected are shown in the table below and the description of the physical location is also provided.

Table 6: Ground control points as collected using a GPS phone

Point	Eastings	Northings	Location description
1	395344.00 m E	9896708.00 m S	*Kimangau* Building
2	395027.00 m E	9896487.00 m S	Opposite *Tahidi* Hospital
3	394859.70 m E	9896762.95 m S	*Usalama* apartments
4	395437.89 m E	9896490.54 m S	*Ngumu* Apartments
5	395852.01 m E	9896703.59 m S	*Silingi* Homes
6	395805.96 m E	9896417.05 m S	*Bajaber*- Opposite Kitui Millers

3.3.2. Non-Spatial data (Attribute data sets)

Non spatial data gives description of a feature without giving location information. This data is stored in tables and linked to the features being referred to using unique identifier. Some of the non-spatial information used was: current land use, street names, preferred land use zones and parcel owners (Ormsby et at, 2001).

This is information that further describes the geographical data. This information was collected using questionnaires and from the records of the former Town Council of Mwingi (TCM).

3.4. Software and equipment

A collection of software and equipments was used to complete the project. These are shown in the table 3 and 4 below respectively.

Table 7: Equipment used, their make, model and what they were used for

Equipment	**Make and model**	**Used for**
Laptop	Samsung 300E7C	-Typing the report -Manipulating data in a GIS environment. Data storage
GPS	Samsung S2 GT-I9105	-Collection of GCP coordinates.
Printer	Hp 510 plotter and Hp All-in-one 2280	-Printing the report. -Printing maps. -Printing photos.
Digital camera s2	Samsung S2 GT-I9105	-Taking photos of the study area.

Table 8: Software and applications used in the project

Software/application	Version	Used for
Arc GIS	10.0 (1999-2010)	-Creation of Geodatabase -Spatial data analysis and. -Storage of spatial data.
Ms. Excel		-Analysis of questionnaires.
Ms. Word		-Word processor for typing the report.
Global Mapper	11.02 Copyright 2002-2010	-Georeferencing. -Geo-correction
Paint	6.2 (build 9200) 2012	-Basic image editing -
Publisher	12.0.641501000 (2007)	-Creating the flow chat
Snip	6.2 (build 9200) 2012	-Capturing snap-shots from still screens
Polaris Navigation	2.5.2	-Collection for collection of coordinates with android phone
Google earth	4.1.7076.4458 (beta) May 6 2007	-Obtaining aerial satellite images

3.5. Methodology

The methods applied are summarized in the flow chart below:

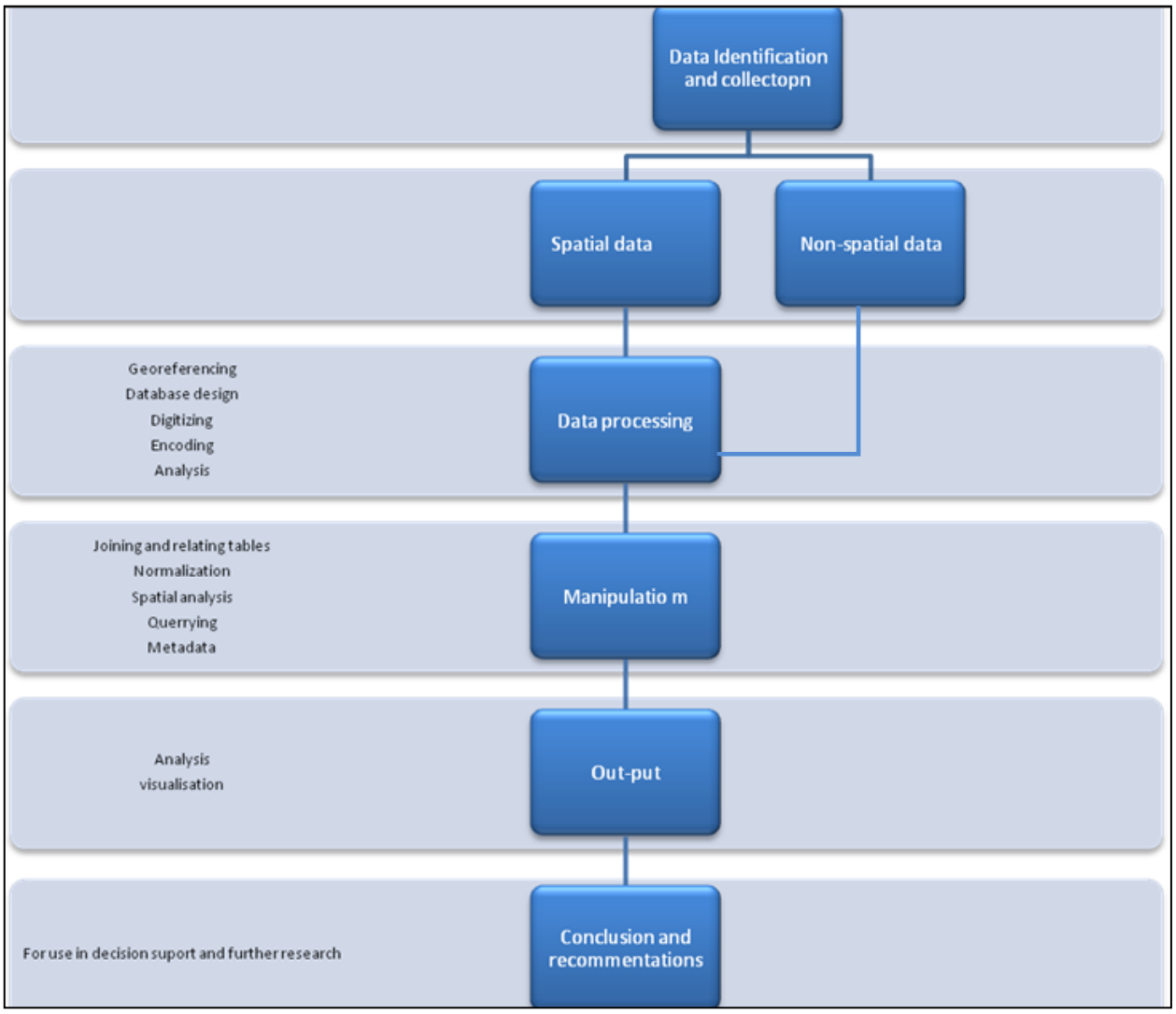

Figure 8: A flow chart showing a summary of the methodology applied

3.5.1. Identification of the Study Area

The area of study was identified and the boundary area determined the images of the area identified were captured from Google Earth using the "Snipping Tool™" software. The images were then loaded in to ArcGis 10™ and georeferenced using the points collected from the ground The Ground Control Points.

The two images are georeferenced to form a mosaic that is then used to for digitization

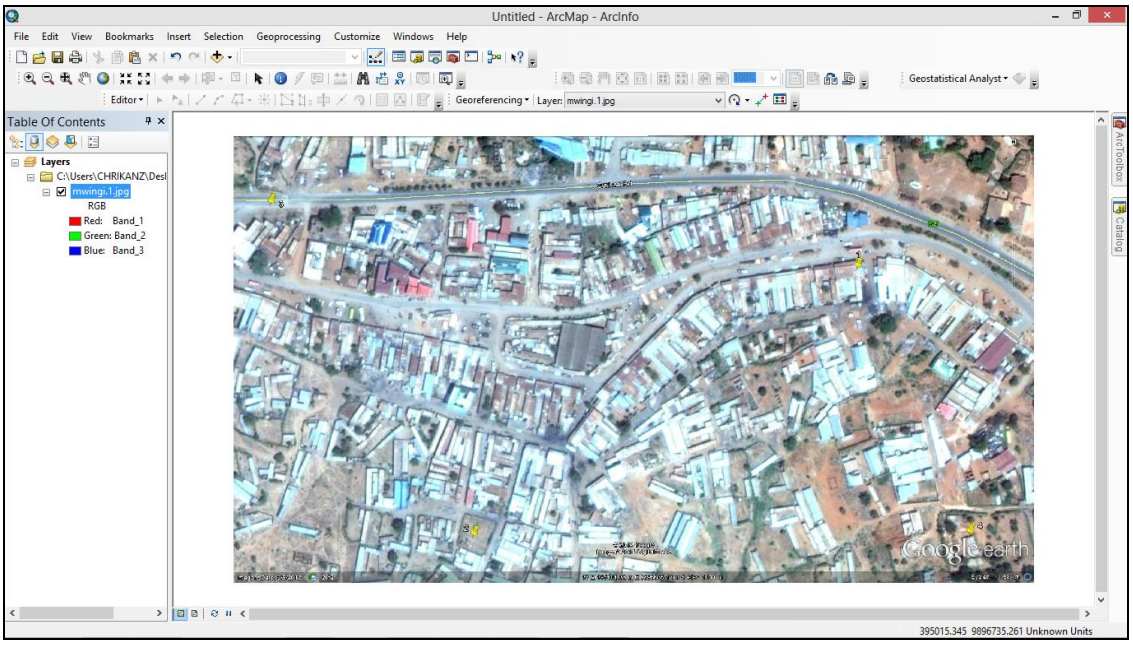

Figure 9: Snapshot of An image loaded in to ArcGIS for georeferencing

Figure 9 above shows a screen shot of one of the image that was georeferenced to create the mosaic for digitization and creation of the geodatabase.

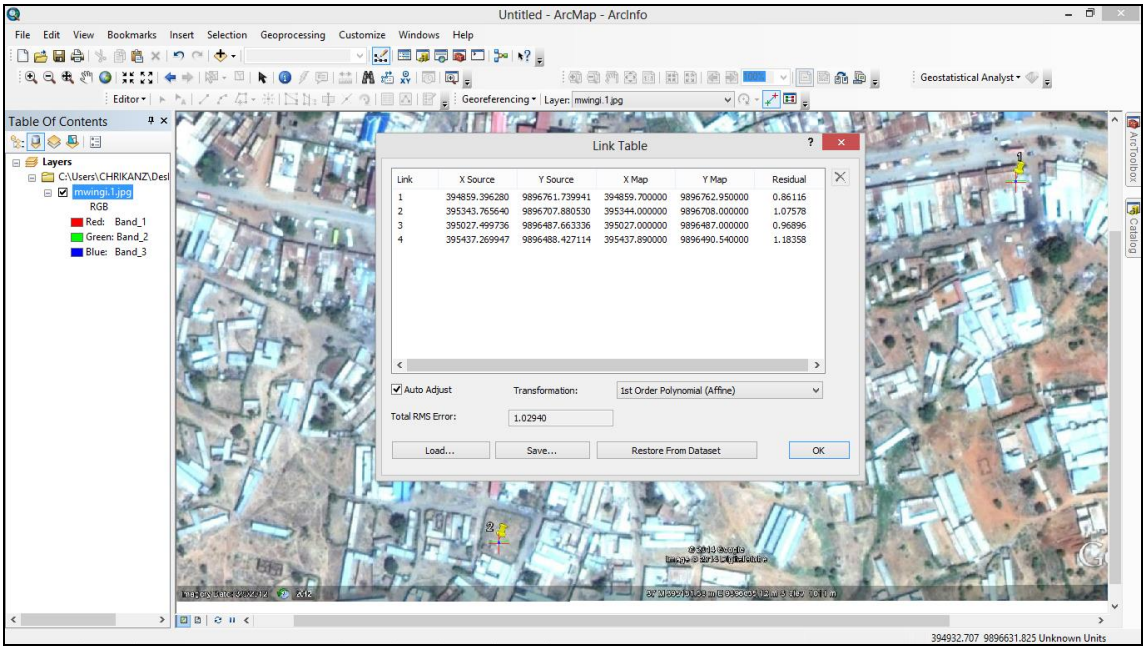

Figure 10: Georeferenced image in ArcGIS

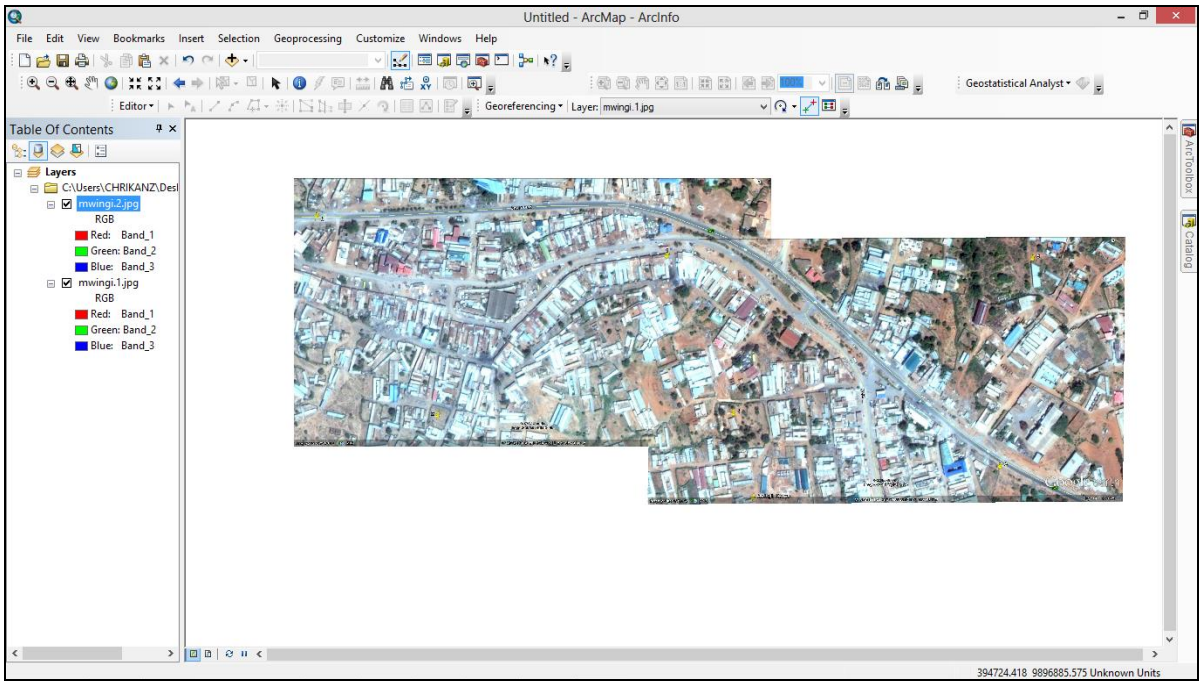

Figure 11: A mosaic of two georeferenced images ready for digitization

3.5.4. Creation of a geo-database

Database Design

The database was designed to hold data digitized from the mosaic. The information was held in a File Geodatabase called “Mwingi Digitization” in this File Geodatabase, there were two Feature Datasets titled: “Land_use_zones” which has ten feature classes, “points_of_interest” with three feature classes and the entire feature classes had their attributes included.

Hierarchy showing details of the database design is shown in the appendix II.

Geo-Database Design Screenshots

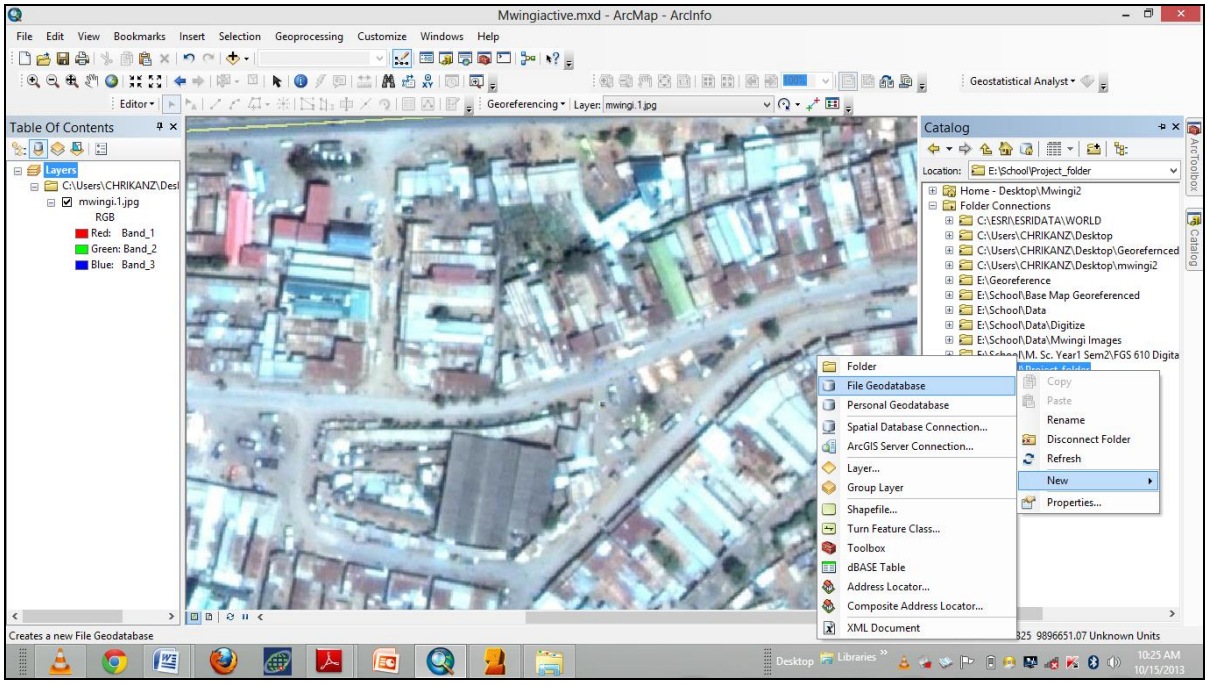

Figure 12: Creation of a file geodatabase

In the ArcCatalogue, a new file geodatabase was created to contain all data generated for the project. The figure above outlines the process of creation of the File Geodatabase.

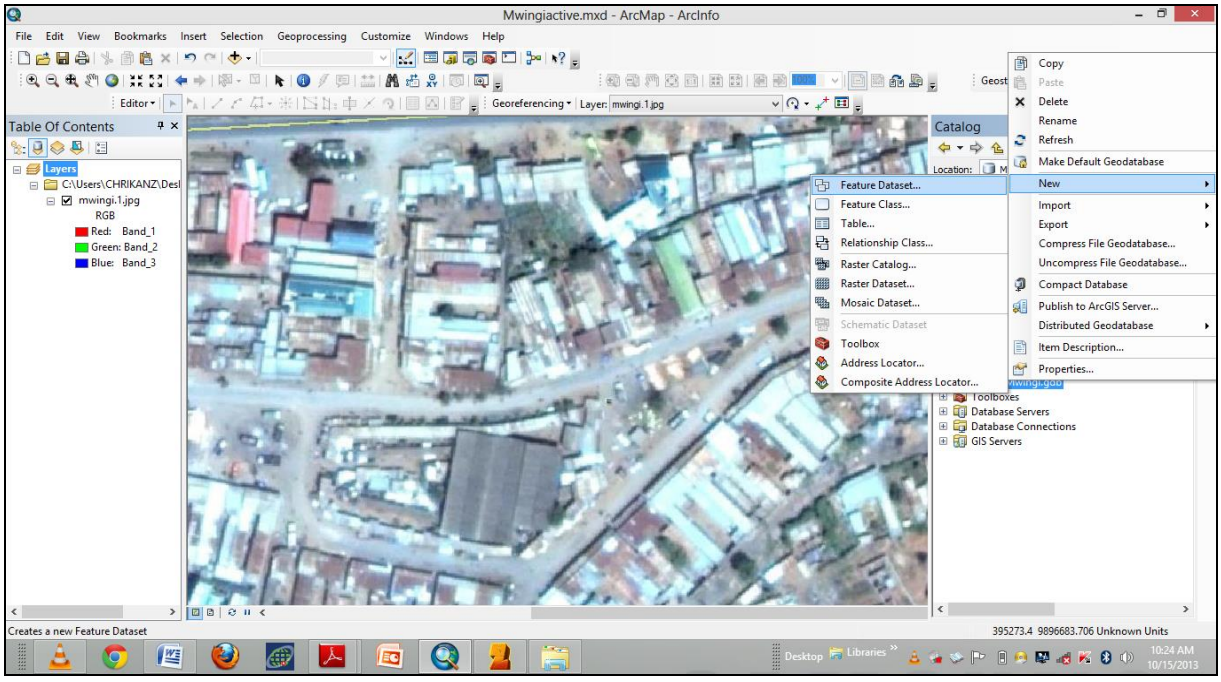

Figure 13: Creation of a feature database

The above figure shows how the two feature classes were created. These are the ones that contain the datasets for the project.

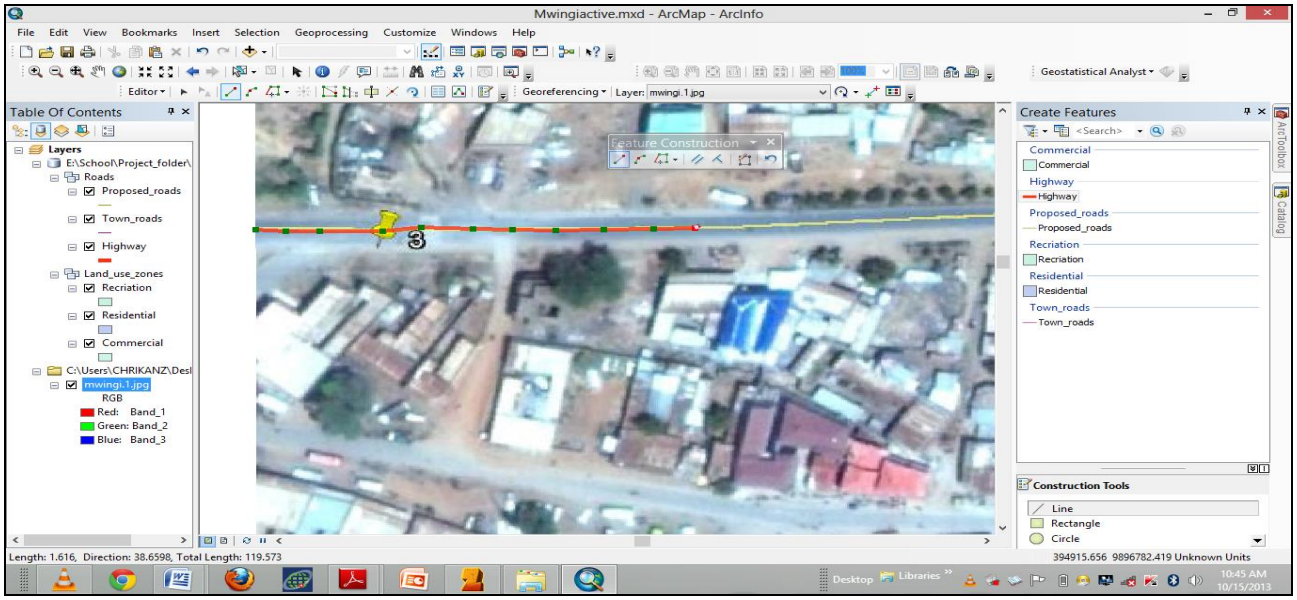

Figure 14: Digitization of highway feature

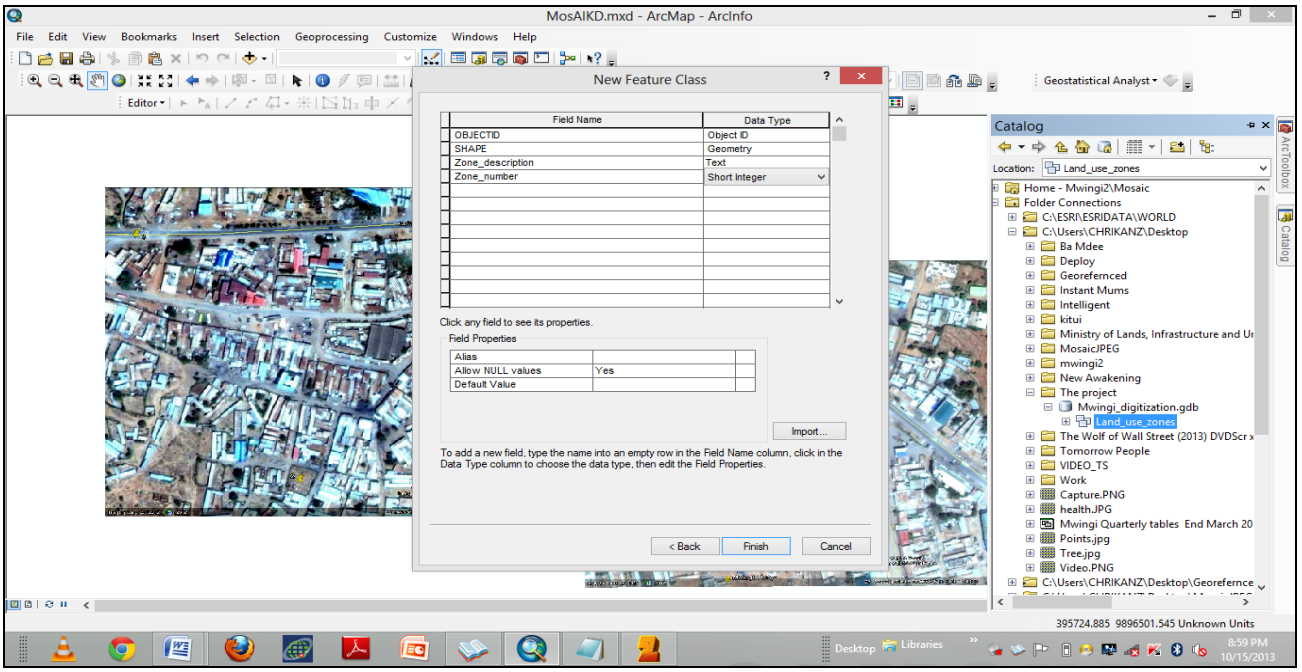

Figure 15: Adding attributes of a feature class

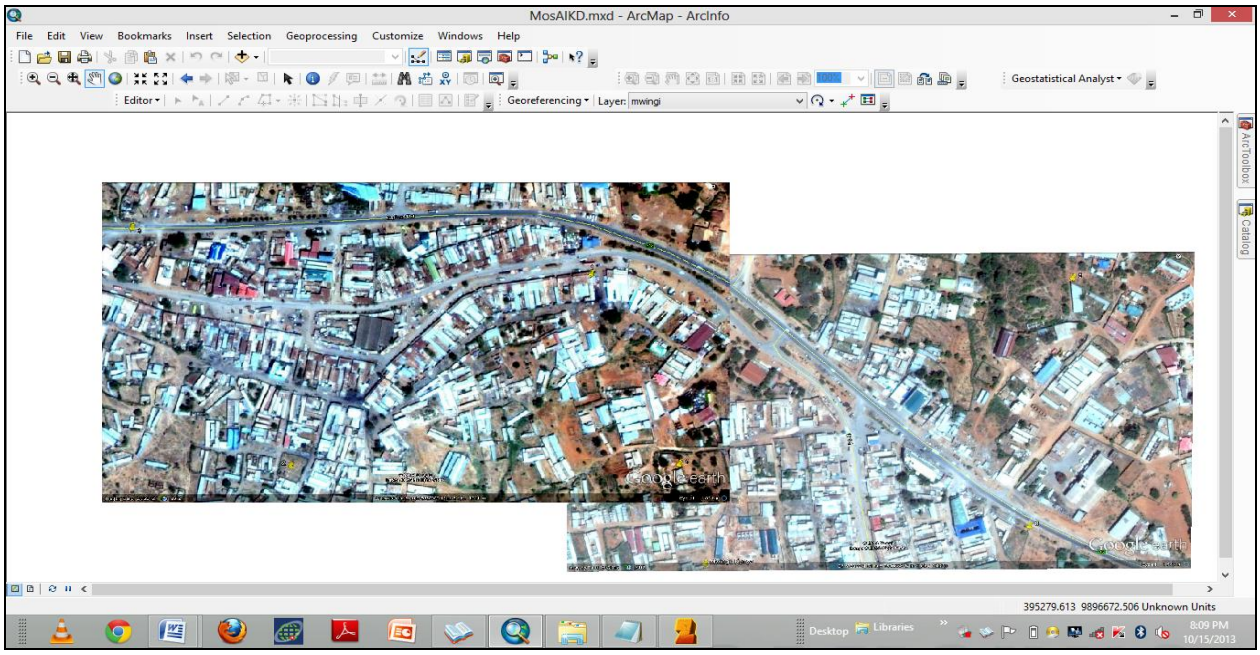

Figure 16: A mosaic of two georeferenced Google earth images

3.5.5. Data analysis and processing

3.5.6. Output

Land use map

For the purpose of this project, digitization was done to an extend that is enough to display the functionalities of GIS that adds value to preparation of a Development Plan. The figure 17 below shows a digitized part of Mwingi town with the various land uses.

The land uses shown are both the existing and proposed.

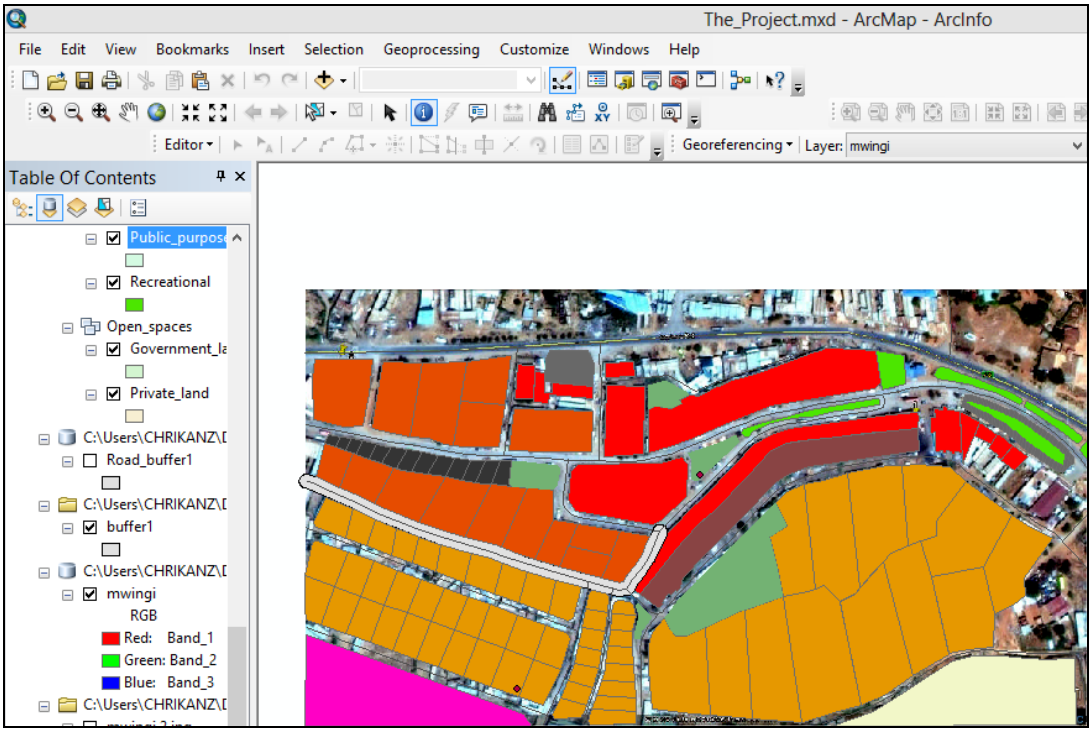

Figure 17: Digitized image of Mwingi town showing several land use zones

Cadaster Plan of a Focus Area

Maps and records showing boundaries, ownership and attributes of real properties for planning, zoning, permit granting, it is an integrated database of land description, value, ownership and socio-economic data.

This was used to show how GIS can be used in physical planning but also in lands records management that shall allow application of the records in all other areas concerning land e.g.: valuation, taxation, disaster management.

The figure below shows an image from the project showing information about a property in a cadastral plan in the urban plan.

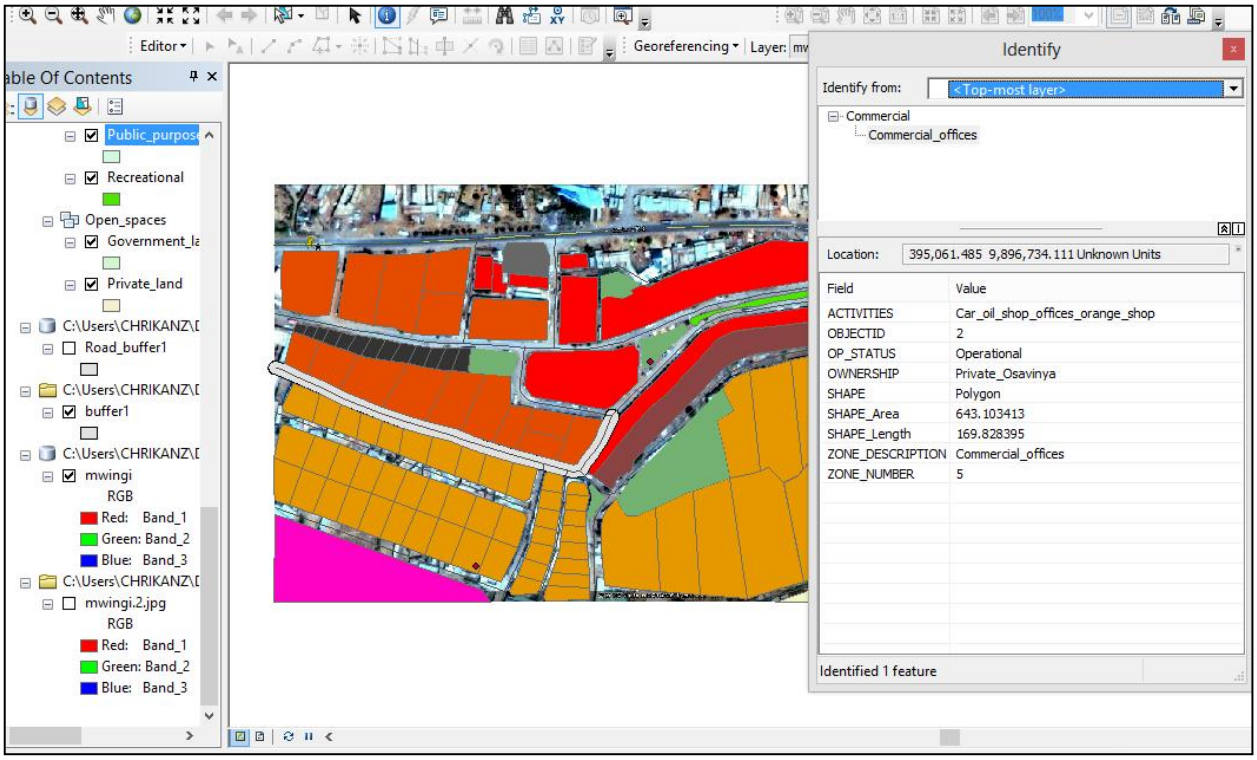

Figure 18: Information about a property of interest in a cadastral plan.

Contents of a cadastre map

- Parcel boundaries, dimensions and areas
- Parcel identifiers.
- Geographical division.
- Transport network.

GIS connects a database of non spatial information to a map (spatial information). It combines layer of information about where things are located with descriptive data on these things and the surrounding.

This helps in:

- Using analytical tools on the spatial data.

- Prioritization of issues.
- Better understanding of spatial phenomenon.
- Help in making viable conclusions.

CHAPTER FOUR: RESULTS AND DISCUSSIONS

In this chapter key findings are presented from the conducted research in the Mwingi Town. The research intended to: show how GIS can be used in land use mapping by production of various thematic maps generated from the compiled database; to demonstrate ways in which planning decision making is improved using GIS as a decision support tool and finally, to see how GIS can be useful in zoning. That is how GIS can be used to determine the various land use zones to be set out in any development plan.

The above is achieved through various means some of which includes "non-GIS" methods like public consultation and in this case, this was done through administration of questionnaires.

4.1. GIS in Land Use Mapping;

The database created was used to create thematic maps which are produced according to the users' preferences. These maps are dynamic and changes within them can be made fast without much cost implications as with the orthodox paper maps.

4.2. GIS as a planners' decision support tool

4.2.1. Buffers

A buffer is a region around a geographical feature or a phenomenon. A buffer can be one ring or multiple rings,

Also called proximity analysis, buffer analysis can be used to depict spheres of influence, areas that are more impacted on by a given phenomenon than others on the outside. Zones of protected areas and areas protected from impacts of a given phenomenon.

Figure 19: A buffer showing encroachment index on the A3 highway in Mwingi town.

In this project, a buffer of 30m was run on the A3 highway. A highway of class A is supposed to have a road reserve of 60m width. This buffer was used to show the encroachment index on the A3 highway and help the planner in making decision on the best way to deal with the menace.

The buffer is made to be transparent so that the affected properties can be seen thorough the output layer.

4.2.2. Query by location

This is a search of a point within a polygon or a radius search from a specific point. For example identify all parcels of more than one acre. This was used to determine which area was sub-divided the least for allocation of functions that need lager tracts of land with low density.

This helps planners to decide on locating land uses that complement each other. An example from the project is water points and residential areas. An area designated for residential land use needs to have adequate water supply within a convenient proximity. A planner may query all

properties of sizes between 250m2 and 700m (ideal for residential land use) that are within 500m from a water point. This is then recommended for high-density residential area.

Figure 20 below shows an example of a Part Development Plan developed using GIS

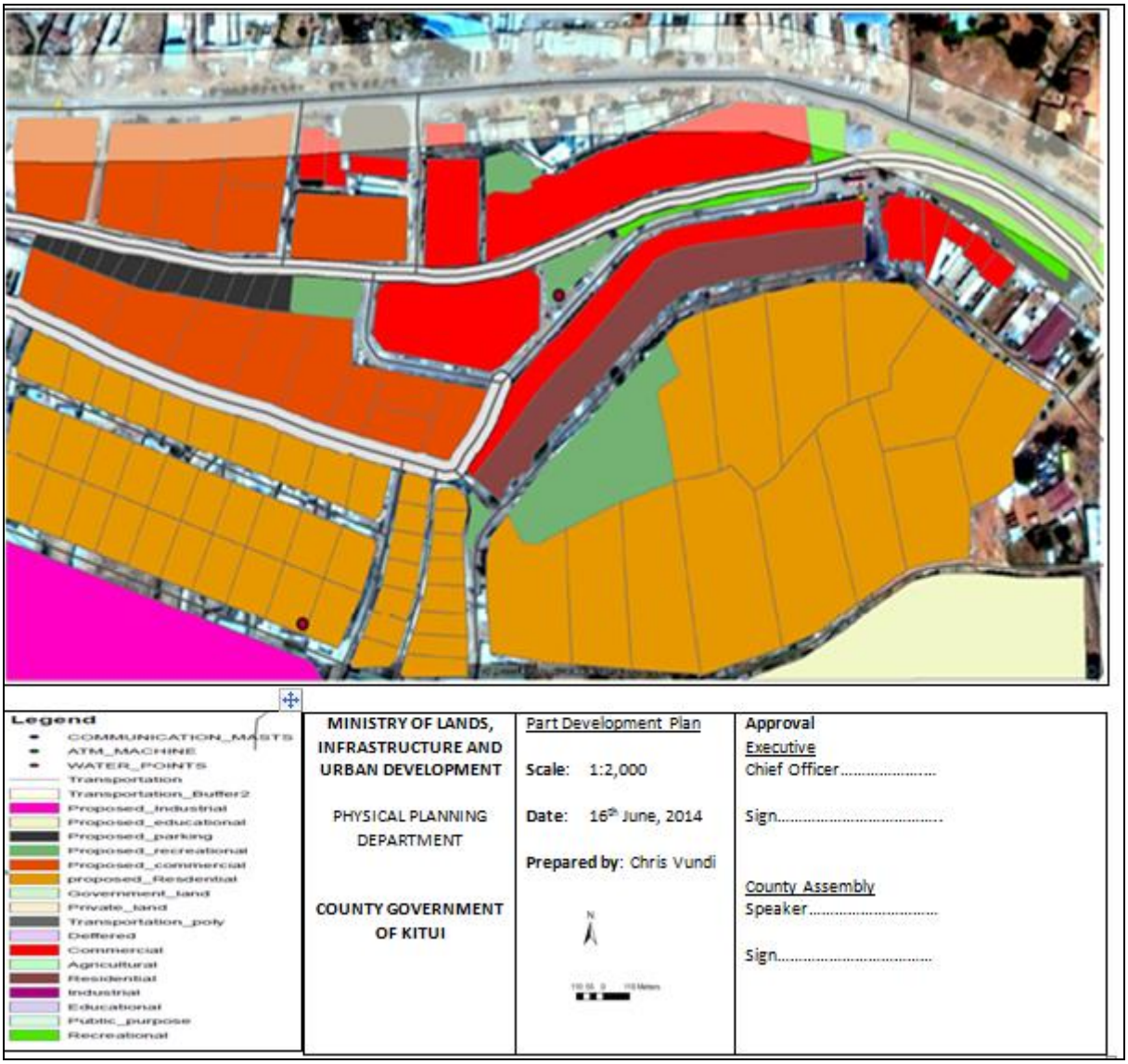

Figure 20: Part Development Plan of the study area

4.3. GIS in land use zoning

To determine what land use goes in to what section, a number of considerations are done. These are but not limited to the following:

4.3.1. Land size versus use

As shown below, land uses can be determined by the size of the land available. Land size in this case is used to refer to the level of subdivision and ownership not the size of undeveloped land available.

Residential- This is the land use type that can be accommodated by the smallest units. This can be as small as 200m^2 to 2,500m^2. This range can also accommodate other land uses like: light industries and small recreational grounds, small-scale commercial entities.

Agricultural- As much as it is possible to practice agriculture in any size of land, the most productive and cost effective is done on land not below 2,500m^2. Also applicable within this bracket is educational and heavy industry zones.

The database was queried with the above limiting parameters and the resulting parcels put under further investigation through public participation where questionnaires were administered to limit the selections determined through querying.

4.4. Administration of the questionnaires

50 respondents were randomly picked through the area of study and administered with the questionnaire in Appendix I. Only 47 responses were considered because 9 were people who had stayed in the area for less than two weeks and so, their opinion is not well informed, 1 was filled by a child below the age of 12 and it was not properly filled up so it was also discarded.

Not all questions were considered for analysis; those considered were the ones for zoning, the others were used as a guide the researcher in determining validity of the responses given by the respective respondent.

Analysis was done using MsExcel and the following findings were come up with:

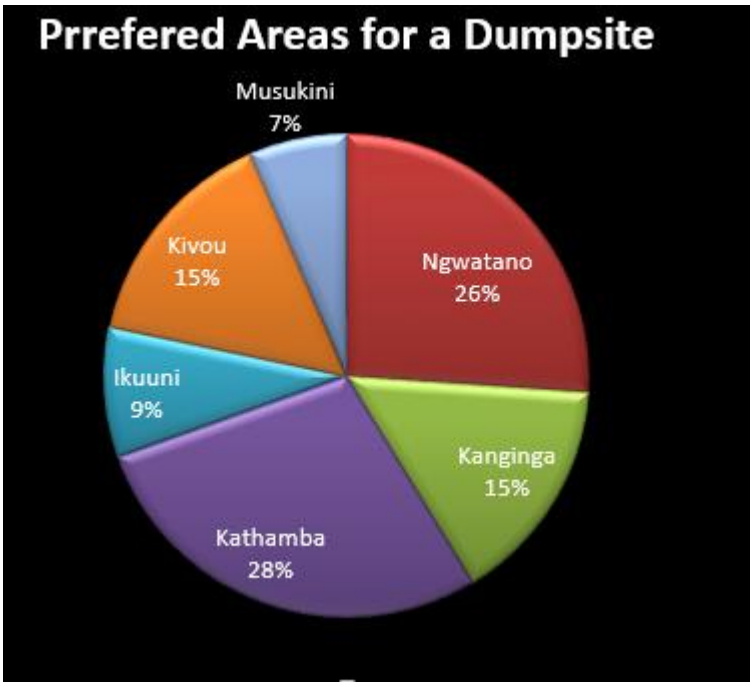

Figure 21: Pie chart showing respondents' suggestions for a preferred dumping site location.

From the above chart (Figure 21) Kathamba was found to be the most preferred location for a dumpsite with a 28% vote against Ikuuni, Kanginga, Ngwatano and Musukini with Ngwatano following closely at 26%.

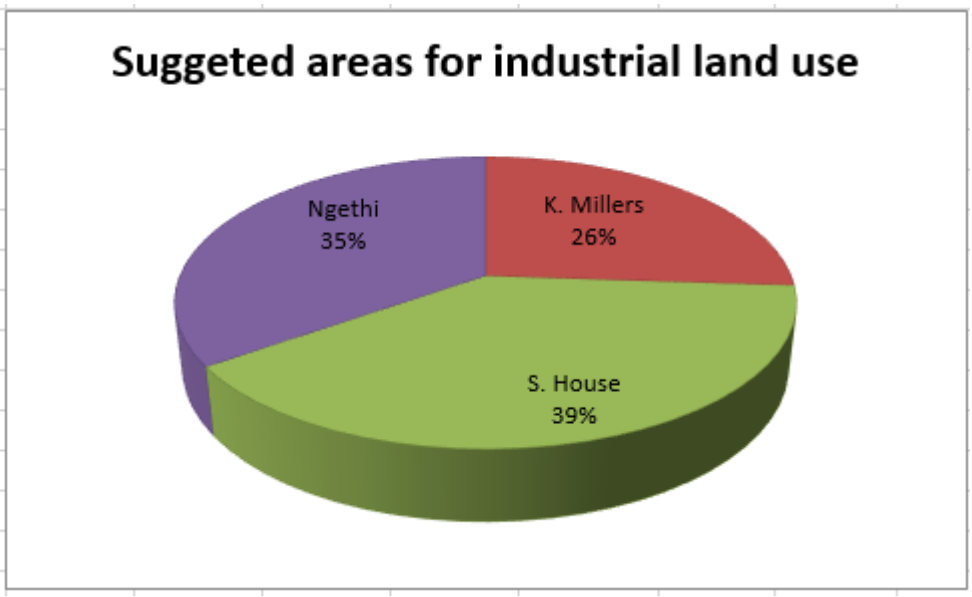

Figure 22: Pie chart showing responses on the preferred location for industrial land use zone

Slaughterhouse region was the most preferred with 39% of people suggesting the region as the best for industrial land use. Ngethi No'Undu were and Kitui Millers followed closely with 35% and 26% respectively.

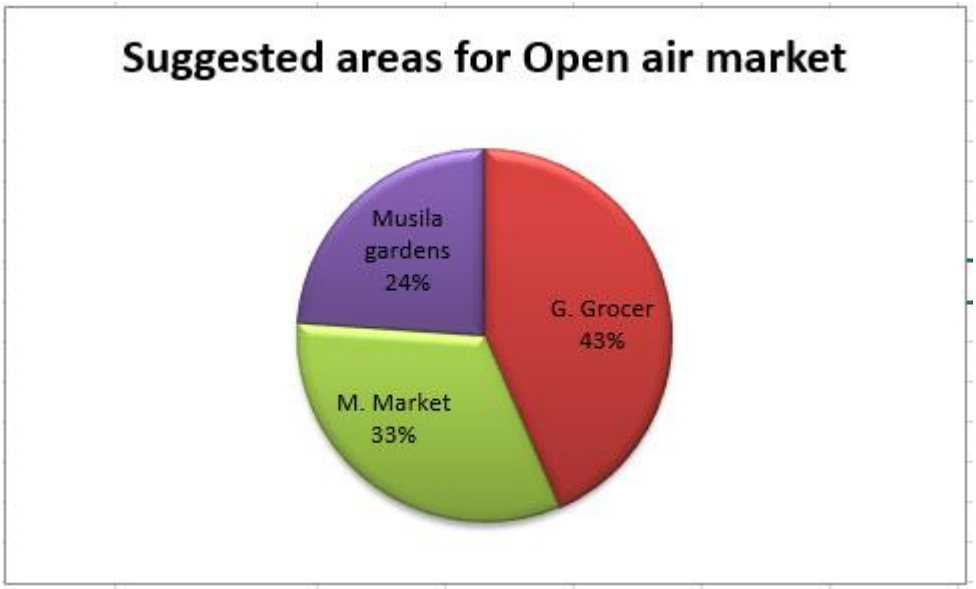

Figure 23: Pie chart showing responses on the preferred location for open air market.

The existing open-air market was selected as the most preferred location for an open air market with 43% against 33% and 24% of Modern Market and Musila Gardens respectively.

CHAPTER FIVE: CONCLUSION AND RECOMMENDATIONS

5.1. Conclusion

From the research, it is evident that, GIS is a very vital tool that can be used to take planning to the next level in terms of time saving in plan preparation process, making of optimum decision that will respond the best to the situations requirements and needs and in creation of dynamic maps that can be produced custom to the users need.

5.2. Recommendations

So as to attain maximum benefits of the GIS in planning, the following are recommended:

- Inculcate GIS as part of Urban and Regional planning educational curriculum.
- Add value to the planning process by hosting digital development plans online and make them accessible to the public more easier and also be able to include public participation in that forum.
- Speed up digitization of the existing maps and development plans so as to enable tap the strengths of GIS in planning of these areas during planning or re-planning of the areas.

REFERENCES

1. **Castle**, G. H. (Ed.) (1993). "Profiting from a geographic information system". Ft. Collins, CO: GIS World.
2. **ESRI**, (2003) "Spatial Data Standards and GIS Interoperability" White Paper
3. **ESRI**, (2006) "GIS Solutions for Urban and Regional Planning Designing and Mapping the Future of Your Community with GIS".
4. **Government of Kenya**, (2007), "Physical Planning Handbook", Ministry of Lands.
5. **Government of Kenya**, (2012) "County Governments Act No. 17 of 2012 Revised Edition 2012", Kenya Government Printer.
6. **Jayasekara** J. M. K., (2006) "Use of GIS in Preparation of the National Physical Plan for Sri Lanka" National Physical Planning Department
7. **Judith** V. B., (1994) "Use of GIS and CAD in National Physical Planning, University of Utrecht Faculty of Geographical Sciences", Post Bus 80.115,3508 TC Utrech, EGIS (1994) Copyright EGIS Foundation.
8. **Kheir** A., **Kerry** B., **Zorica** N., **Gary** H., **Mark** S., **Michael** S., **Lyna** W., and, **Nancy** O. (1995), "GIS for Planning Prospectus", Indiana State University.
9. **Nour** A. M, (2011), "The Potential of GIS Tools in Strategic Urban Planning Process; as an Approach for Sustainable Development in Egypt" Vol. 4, No. 1; February 284 *ISSN 1913-9063 E-ISSN 191*.
10. **Ormsby** T., **Eileen** N., **Robert** B., **Carolyn** G., **Laura** F., (2001) "Getting to Know ArcGIS™ Desktop", ESRI Press, Redlands Califonia.
11. **Republic of Kenya** (2013), "Mwingi District Environment Action Plan, Ministry Of Environment and Mineral Resources": National Environmental Management Authority.

12. **Stimer** F. and **Buttler** K., (2007), "Planning and Urban Design Standards Students edition" University of Texas at Aston, American Planning Association, 2007

13. **TipTopGlobe**.com- (2014) " www.tipglobe.com " accessed on 26th January, 2014

14. **Town of Concord Massachusetts** WebGIS (2014) "http://www.mapsonline.net/concord/. accessed on 27th January, 2014

15. **Town Council of Mwingi**, (2007) "Mwingi Town Strategic Plan"

16. **Trevor** M. H. and **Gregory** A. E., (1993) "The application of GIS in urban and regional planning": a review of the North American experience. Department of Geology and Geography, 425 White Hall, West Virginia University, Morganto wn, WV 26506, USA

APPENDICES

Appendix I: Non-Spatial data questionnaire

Appendix II: Geodatabase design

Appendix I: Non-Spatial data questionnaire

A questionnaire collecting non-spatial information to aid in planning of Mwingi Town

***Note**: The information provided here will strictly be used for academic purpose only and ultimate confidentiality shall be maintained on the personal information provided.*

Non spatial information Questionnaire

Name	
Age	
Home	
Residence(Village)	

1. How long have you lived there? (Mark appropriately)

<1 year	
1-3 years	
4-6 years	
7-9 years	
>10 years	

2. In a scale of 1 to 10, rate the condition of the following in your immediate locality (Mark appropriately)

Scale	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Roads										
Waste disposal system										
Security										
Pollution										

3. What are other challenging issues in your neighborhood?

……....

……....

……....
……....
……....
……....

4. What recommendations for corrections of the above mentioned problems can you propose?

……....
……....
……....
……....
……....
……....

5. Indicate the area you would recommend for the following

Dumping site	
Heavy industries	
Open air market	
Sewer treatment plant	

Appendix II: Geodatabase design

Mwingi Digitization.gdb - (File Geodatabase)

Land_use_zones - (Feature dataset)

Transport	Grey	
		Size
		Condition
		Zone_description
		Zone_number
		Local_name
Recreational	Green	
		Zone_description
		Zone_number
		Op-Status
		Activities
Public_purpose	Orange	
		Zone_description
		Zone_number
		Condition
		Local_name
		Occupation
Educational	Yellow	
		Zone_description
		Zone_number
		Ownership
		Op_status
		Local_name
Industrial	Purple	
		Zone_description
		Zone_number
		Ownership
		Op_status
		Local_name
		Activities
Residential		
		Zone_descrigption
		Zone_number
		Ownership

Occupation

Agricultural No color

Zone_description
Zone_number
Ownership
Activities

Differed

Zone_description
Zone_number
Activities

Commercial Red

Zone_description
Zone_number
Ownership
Op_status
Activities

Transportaton (poly)- To contain transpiration features that are in polygon form like bus park, car parks, petro stations etc

Zone_description
Zone_number
Condition
Op_status
Local_name
Activities

Points_of_interest- No standard color (Feature dataset)

Water_points

Description
Use
Condition

ATMs

Description
Use
Condition

CDMA masts

Description
Use
Condition