



**UNIVERSITY OF NAIROBI**  
**COLLEGE OF BIOLOGICAL AND PHYSICAL SCIENCE**  
**SCHOOL OF COMPUTING AND INFORMATICS**

**Enhancing revenue collection through integrated GIS database system with property (land)  
classification using an algorithm**

By

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P58/76170/2012

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*A project submitted in the fulfillment for the Degree of Master of Science in Computer Science*

**DECLARATION**

This research project describes the work undertaken as part of the programme of study at the University of Nairobi, School of Computing and informatics. The research is my original work and has not been submitted for the award of a degree in any other University.

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This research project has been undertaken by the student under my supervision and the submission is hereby made to the University of Nairobi, School of computing and informatics with my approval as the student's supervisor.

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## **ABSTRACT**

Decentralization of revenue functions and responsibilities to county governments in Kenya has brought about new challenges in revenue mobilization. It is therefore the responsibility of the county governments to put credible measures to enable effective service and infrastructure provision. This project examines how GIS technology can enhance revenue mobilization and describes comprehensively the functionalities of a GIS application prototype developed for internal revenue mobilization. It gives detailed information of the developed functionalities of the application and the dependencies on GIS for effective revenue collection and land management. A combination of structured systems analysis and design and object oriented analysis and design methodologies were deployed to build feature rich software application prototype. The system database was designed using MySQL; PHP was used to design the user interfaces and quantum GIS was used to create the sample spatial data and was loaded.

A sample survey was carried out to determine key success factors for implementing the county revenue mobilization system (CRMS). The system was tested in a sample county whereby, the researcher demonstrates that an integrated GIS-Database application with land classification using an algorithm is capable of providing a more efficient system for collection, tracking and management of county land revenue resources.

**Keywords:** Revenue mobilization, Technology, Integrated GIS database, algorithm, Land management.

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## List of Abbreviations

<b>ABBREVIATION</b>	<b>DESCRIPTION</b>
<b>IT</b> .....	Information Technology
<b>I-Tax</b> .....	Integrated Tax Management System
<b>GIS</b> .....	Geographic Information System
<b>GUI</b> .....	Graphical User Interface
<b>LAIFOMS</b> .....	Local Authorities Integrated Financial Operations management System
<b>IFMIS</b> .....	Integrated Financial Management Information System
<b>MPOS</b> .....	Mobile Point of Sale
<b>KRA</b> .....	Kenya Revenue Authority
<b>MS</b> .....	Microsoft
<b>PDF</b> .....	Portable Document Format
<b>ICT</b> .....	Information and Communication technology
<b>XML</b> .....	Extensible Markup Language
<b>CSV</b> .....	Comma - Separated Values
<b>PHP</b> .....	Hypertext preprocessor
<b>SPSS</b> .....	Statistical Package for Social Sciences
<b>SDLC</b> .....	System Development Life Cycle
<b>RAD</b> .....	Rapid Application Development
<b>CRMS</b> .....	County Revenue Mobilization System.
<b>RC</b> .....	Revenue Collector.
<b>ME</b> .....	Medium Enterprise.
<b>POI</b> .....	Point of Interest
<b>PL/SQL</b> .....	Procedural Language/Structured Query Language
<b>API</b> .....	Application Programming Interface
<b>J2EE</b> .....	Java 2 Platform, Enterprise Edition
<b>GC</b> .....	Geo-coder
<b>LAs</b> .....	Local Authorities



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# 1 CHAPTER ONE: INTRODUCTION

## 1.1 Background to the problem

The provision of social assets and services to the people by the governments cannot be achieved without revenue. The first source of revenue for county governments is the national government. Chapter 12 of the Kenyan constitution {*Article 202 (1)*} states that revenue raised nationally shall be shared equitably among the national and county governments. For every financial year, county governments are entitled to not less than 15% of all the revenue collected by the national government.

Therefore, having significant functions to discharge the authorities are likely to structure other sources of revenue to supplement the revenue from the national kitty. Counties are expressly allowed by the Constitution to impose other taxes such as property rates, entertainment taxes and any other taxes as authorized by an Act of Parliament {*Article 209(3) of the Constitution*}. Tax is an important source of locally raised revenue in many countries, (*Bahl, 1979*). In his book “Tax Policy and Economic Development”, Richard Bird has concluded three of the main purposes for collecting revenue through taxes that are of greatest urgency in developing countries: economic growth; internal and external stability; and ensuring that incomes are distributed appropriately.

The revenue collected by county governments enables them to execute developmental projects that in turn improve the standard of living of its citizens as well as meet its recurrent expenditure. It is therefore expedient that county governments adopt suitable revenue collection models that will expand their internally generated revenue to enable effective service delivery.

Fiscal decentralization and spending powers to the county government has become the main theme of devolution in the recent past (*Fjeldstad,2005*). As part of devolution and decentralization reforms in Kenya, revenue and expenditure responsibilities are now vested in county governments, a responsibility that has come with its own challenges.

Recently, it has been revealed through the media (*Daily Nation Newspaper, January 19, 2014*) by the auditor general that the existing revenue collection mechanism has failed and the country is losing millions of shillings annually. This proposal therefore seeks to investigate and gather

information about the present method of revenue collection, processing and management at the county level and the challenges at hand.

In the process of carrying out this research, the current problems and challenges shall be investigated in detail with an aim of recommending a viable solution. This shall be realized through interviews, group discussions, direct observations and document study.

As reported by the general on media, it is palpable that a sound revenue system is essential and shall serve as a crucial tool for the successful running of county governments. In addition, local revenue mobilization has the potential to foster political and administrative accountability by empowering communities (*Shah, 1998*). Therefore, as devolution of services takes place, the creation, processing and recording of potential revenues and fast retrieval of accurate data are paramount and serves as a critical tool for the successful running of local government (*Oluwu and Wunsch, 2003*). Fairness in property valuation and taxation is also key and significant to the tax payer.

## 1.2 Statement of the problem

The current method of revenue collection in most counties is likely to be dominated by manual systems. There are many problems inherent in this method. *Byaruhanga, (2007)* asserts that tax compliance in the developing world still remains low due to key shortfalls in the manual systems which include unregistered tax payers, tax evaders, as well as delinquent tax payers. The revenue collectors are required to go to the business premises of each business operator, manually receive the money and join in the hustles and bustles of the town, hunting down sly business operators. In the process of tax collection, there are added risks and a whole basket of problems such as:

- Insecurity posed to the revenue collectors and possible theft of the revenue collected.
- Delay in remittance of the generated revenue to the county treasury as a result of the huge computation involved in bringing together all revenues collected from the sub-counties.
- Diversion of generated revenue into private pockets by the revenue collectors.

In a program recognizing innovation in tax administration (*Inter- American Centre of Tax Administration- CIAT 2012*), it was noted that the Kenya Revenue Authority currently faces a major challenge in collection of property based taxes leading to lose of billions of shillings in form of taxes due to very high levels of non -compliance and tax evasion due to lack of a system to manage the same. The records of ownership on land & development land and records of payment of taxes are not in a one comprehensive database. Data that may be used to improve the level of compliance are scattered among various arms of government.

There is no unifying database of any kind in place yet. Everything is manual, on paper maps, which is a recipe for widespread corruption and inefficient service delivery.

There is therefore a need to develop a technical solution and system that can drastically boost revenue collection. This research aims to demystify the use of GIS technology in revenue collection based on the premise that any taxpayer operates from a particular physical location (which has geospatial positional attributes) that can easily be defined, quantified, and integrated into computer-understandable format, whether those positions are static or mobile.

### 1.3 Research Justification

If the county governments are to undertake any development projects, then it is imperative that they improve on their revenue collection systems in order to increase revenue and meet targets set. Over the years, revenue collection even at the central government itself has been a challenge. The problem has inherently characterized itself at the devolved levels. Some of the challenges encountered previously by the central government in revenue collection included:

- Lack of realistic means of accessing the revenue potentials due to lack of accurate data.
- Poor tracking mechanisms of the agents or collectors.
- Evasion of property rates by property owners.
- Time consuming business licensing and permit acquisition.
- Misclassification of properties, business, and inappropriate tax assessment basis.
- Inadequate data on economic activities.

Failure to address these problems has seen them encroach into the county government level. It therefore seems that fiscal decentralization not only brought with it revenue mobilization and budgetary sovereignty but also ‘*baggages*’ of the central government.

County governments therefore need to improvise ways of dealing with the above challenges in order to embrace transparency and fairness for good governance. Automation is the best option to mitigate the challenges in the revenue collection and management process.

This paper will seek to indicate the various ways on how this can be achieved efficiently, through the introduction of a revenue collection and processing system with geographic information system (GIS) integration.

If the automated solution is ignored, the revenue generation capacity of the counties will continue to be poor, the country will be financially incapacitated and bankruptcy, unemployment, hunger, starvation and other social vices will be the result.

This paper will interrogate the surrounding issues by sifting through the available literature to emerge with a record of recommendation.

#### **1.4 Objectives of the study**

The aim of this project is:

- To develop an application system and test in a real world scenario.
- To integrate an algorithm that can enhance efficiency and fairness in property classification and valuation.
- To actualize tracking of revenue.
- To add value in digitized spatial data and operationalize.

## **1.5 Research questions**

In order for the researcher to inform the situation on the ground, the following research questions were designed and answered. Conclusions were drawn that informed even the design of the system based on the user and customer requirements.

1. Is tax/revenue collection important?
2. Are business owners faced with problems with the county governments trying to comply with the tax regulations?
3. Could tax remittance be dominated by long queues, errors and inconsistencies or inefficiency?
4. Are some citizens evading taxes, fees and land rates due to poor tracking?
5. Is proper planning and administration of revenue in place?
6. Can GIS based system improve tax collection and tracking of revenue?
7. Do county employees mandated to collect tax remit all the monies collected?
8. Should county governments improve the current mechanisms in place for planning and administration of revenue?
9. Are there Geographic Information Systems that guide on revenue collection, decision making in the counties?
10. Are there disputes relating to revenue collection between the citizens and the county governments?
11. Can automation using computerized valuation method for property rates introduce fairness and reduce disputes on property valuation, tax, rates and fees?
12. Can the prototype developed be applied in a real world problem scenario?



## 2 CHAPTER TWO: LITERATURE REVIEW

### 2.1 Introduction

The development of ICT has enormously influenced the social, economic and political life pattern in both developed and developing countries. Governance, democracy and commerce have changed due to the development of ICT (*Tony et al, 2008*). This has led to emergence of new concepts like e- Governance, e- Democracy & e- Commerce among others.

Geographical Information System (GIS) and Information Technology (IT) systems have been identified as one of the most effective tools for the administration of decentralized government models and for the mobilization and management of resources. They provide a framework for all forms of spatial data storage, retrieval, and analysis, display, reporting and modeling (*Jensen, 2001*).

Information System (IS) is an integrated set of components for collecting, storing, organizing and processing data and for delivering information. *Duff et al (1980)* defined an Information System as a collection of people, procedures, a base of data and (sometimes) hardware and software that collects, processes, stores and communicates data for transaction processing at operational level and information to support Managerial decision making. In his study, *Becta (2005)* describes an information system as a system consisting of the network of all communication channels used within an organization. Simply put, an information system is a system for accepting data/information as a raw material and through one or more transmutation processes, generating information as a product. According to *W.B. Adeoti-Adekeye (1997)*, an information system basically comprises the following functional elements which relate to the organization and its environments:

- **Perception** - initial entry of data whether captured or generated, into the organization;
- **Recording** - physical capture of data;
- **Processing** - transformation according to the “specific” needs of the organization;
- **Transmission** - the flows which occur in an information system;
- **Storage** - presupposes some expected future use;
- **Retrieval** - search for recorded data;
- **Presentation** - reporting, communication; and

- **Decision making** - a controversial inclusion, except to the extent that the information system engages in decision making that concerns itself.

In order to understand the information system concept further, *Salton (1975)* highlighted the most important computer-based information systems as follows:

- Information retrieval system (IR)
- Question-answering system
- Database system (DBS)
- Management information system (MIS)
- Decision support system (DSS).

The basic purpose of any information system is to help its users get a certain type of value from the information in the system, regardless of the type of information that is stored or the type of value desired (*Norton, 2006*).

## 2.2 Overview

The relevance of Information Systems in the public sector is that they provide administrators with a modern set of tools to assist them in performing a variety of tasks such as:

- (a) Designing appropriate fiscal and monetary responses to changing macro-economic conditions
- (b) Ensuring accountability for the deployment and use of public resources
- (c) Improving the effectiveness and efficiency of public expenditure programs
- (d) Mobilizing domestic resources and managing external resources (foreign aid and loans)

Duff et al (1980) argued that the goal of Information Systems was not only to provide citizens and institutions with a range of excellent and effective services, but to also create a new form of citizenship based on the participation of all individuals in the provision of services and the decision-making process.

Many of the functional processes in the fiscal management area, such as, revenue collection, execution of budgetary expenditures, require the processing of a large number of transactions, in limited periods of time, across a county wide network of offices. In view of the high transaction volumes and rates and the dispersed location of offices where these transactions are processed, the process of retrieving information from manual records and reclassifying it in a format or

classification scheme appropriate for management information and control can be extremely time-consuming and labor-intensive (*Ali Hashim and Bill Allan , 2007*) . In practice, without some degree of automation, the information required for economic management may simply not be available with the required degree of timeliness and accuracy. Computer-based systems that support fiscal management processes are therefore of particular interest to county governments and present them with new opportunities for the availability of timely and accurate information.

### **2.3 The role of ICT in governance-Kenya**

The role of ICT in governance cannot be trivialized. ICT in the public sector has been mainly discussed as a tool to create new and better service delivery (*Bekkers & Zouridis 1999*) by increasing efficiency and transparency and improving accountability in public administration procedures and management. Better accountability and improved transparency were the identified characteristics of good governance, and the latter became the condition for the rich states and international agencies to supply aid to developing states and countries (*UN, 2002, 2003; UNDP, 2003*).

The significance of county governments in Kenya cannot be underestimated. By providing cultural, educational, research, commerce and political services, the county governments act as engines of growth and centers of development. They also do offer employment, best health facilities and boost the country's economy (*UN-HABITAT, 2004*). It is against this background that the need for an effective information system at the county level arises.

The use of ICT in the public sector (e-government) in Kenya is playing a critical role in government's efforts to revitalize their public sectors. ICT is a significant strategic tool for lifting public sector performance, offering benefits of greater efficiencies and effectiveness in government operations and service delivery, improved communication and coordination across the two levels of government, and greater transparency and accountability in government functions. The Government has over the years initiated projects to boost the ICT infrastructure in the country.

In March 2004, the Government of Kenya launched an ambitious three year (2003-2007) E-government Strategy (*GoK, 2004*). The strategy was designed to achieve a set of goals and objectives namely:

- To efficiently deliver government information and services to the citizens.

- To promote productivity among public servants.
- To encourage participation of citizens in government.
- To empower all Kenyans in line with development priorities outlined in the 2003 – 2007 Economic Recovery Strategy for Wealth and Employment Creation (*GoK, 2004*).

In order to gain a better understanding of the revenue collection systems at the county level, it is imperative to comprehend the systems of the former local authorities from which several counties adopted their revenue systems. Previously, local governments faced a number of challenges in realizing their mandate *Mitullah et al (2005)*. The challenges included delivery of infrastructure and services, financial management, institutional and legal framework, human resource capacity and managing rapid growth. These challenges had resulted in poor service provision and management and many analysts had criticized the LAs, and questioned their role in local development.

It is as a result of this inefficiency that the Local Government Reform Programme was launched (*Waema, 2005*). The launch of the program initialized the decentralization of service provision and management, which was still in the initial stages. This was a step in the right direction since both decentralization and good governance contribute positively to the processes of community participation which are transparent, effective, responsive and accountable to the stakeholders.

In 1996, a decentralization initiative under the Local Government Reform Programme was launched focusing on improving revenue collection and mobilization in the LAs. The Kenya Local Government Reform Programme (*KLGRP*) was conceptualized by the Government of Kenya in the early 1990s and became operational in 1996. The programme aimed at the following:

- Rationalizing central-local financial relations.
- Improving LA financial management, including revenue mobilization.
- Strengthening citizen participation in planning and ownership of programmes.

The reforms also included establishing the Fuel Levy Fund, Contribution in Lieu of Rates, user charges rationalization, single business permits and most greatly Integrated Financial Management System (*IFMS*).

The main focus of KLGRP was introducing financial reforms aimed at enhancing inter-governmental fiscal transfers, improving financial management, debt resolution, streamlining budgeting system and service provision capacity building for LAs. A key instrument in this

process was the enactment of the Local Authority Transfer Fund (LATF) in 1998. The act provided 5 percent of national income tax to LAs in line with population, resource base and financial performance (*GOK, 1999*).

An analysis of the previous systems of revenue collection will inform the proposition for an automated revenue collection system using GIS Integration.

## **2.4 Previous revenue collection systems**

Alternative solutions for revenue collection, including centralized manual systems have been in existence with significance dominance for centuries before evolvement of ICT and e-government. A number of problems inherent in the system such as delay in remittance of collected revenue to treasury due to heavy computation involved in bringing together all revenues led to the automation of revenue processing system.

### **2.4.1 Local Authorities Integrated Financial Operations Management System (LAIFOMS)**

LAIFOMS is a computer- based system that integrates financial and operational activities involving business transactions in a local authority. LAIFOMS was adopted by top 26 local authorities ten years ago to fight corruption in billing for services (*Government of Kenya 2007*). LAIFOMS consists of ten interlinked modules grouped into three major components: Budget and Financial Management component, Expenditure component and Revenue component comprising of the following:

#### **Budget and Financial Management Component**

- a) Budget Preparation and Monitoring
- b) Financial Management and Reporting

#### **Expenditure Component**

- a) Expenditure Management
- b) Personnel Management
- c) Revenue Component
  - a) Single Business Permits
  - b) Property Rates
  - c) Housing and Stall Rents
  - d) Accountable Documents Management

- e) Customer Service and Billing
- f) Receipts Processing

This therefore means that any change to data on either the revenues or expenditure systems will automatically be reflected in the Financial Management modules.

The first pilot study of the LAIFOMS System was in Mavoko and Nyeri municipalities. Five of the seven modules were successfully implemented in both municipalities. The general effect of computerization of the revenue collection system was improved efficiency and increased transparency (*Waema et al 2011*).

The implementation of LAIFOMS has been not without challenges. Delays are reported to occur due to data entry mistakes rather than failure of the system .The failure to implement all modules has also reduced the level of efficiency.

According to County Budget Implementation Review Report, First Quarter 2013/2014, the county of Trans Nzoia still operates a manual management system and the former LAIFOMS in recording expenditure because IFMIS is yet to be operational due to connectivity issues. This has led to under – reporting and delay in reporting back to the County. There is therefore a need for a detailed auditing and redesign to serve counties.

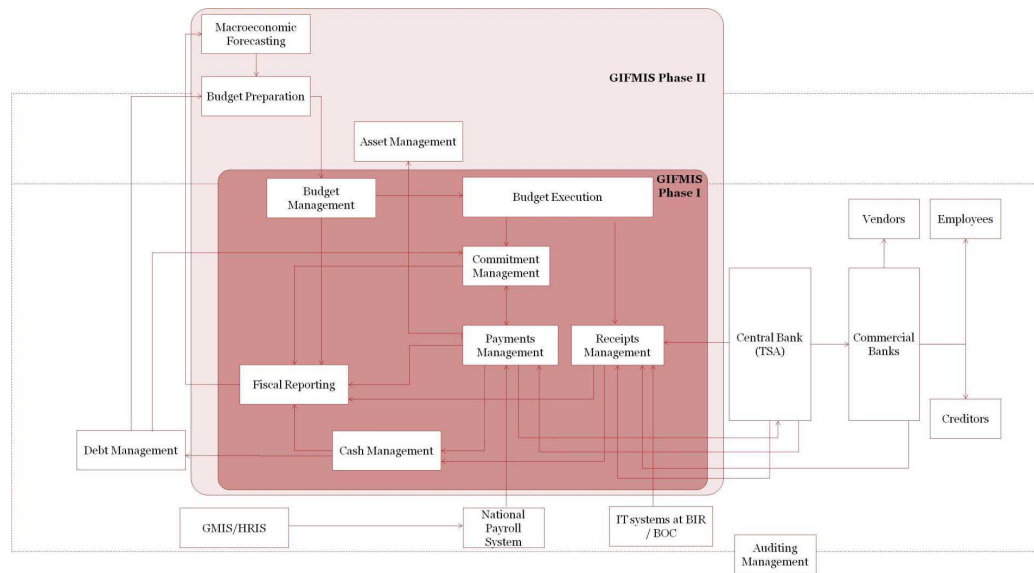
#### **2.4.2 Integrated Financial Management Information System (IFMIS)**

Integrated Financial Management Information System (IFMIS) is an automated system that is used for public financial management. IFMIS provide an integrated computerized financial package to enhance the effectiveness and transparency of public resource management and accounting system for a government.

The National Treasury introduced the IFMIS as a Public Finance Management reform initiative aimed at automating and streamlining Government’s financial management processes and procedures. The system was first rolled out to ministries department, agencies and later to all 47 counties in March 2012.The following processes have been linked and integrated with the IFMIS System: planning and budgeting, procurement, accounting, electronic funds transfer, auditing, asset management and financial reporting. (The Daily Nation, Wednesday March 12, 2014).

It consists of several core sub-systems which plan, process and report on the use of public resources. The sub-systems include: accounting, budgeting, cash management, debt management and related core treasury systems. In addition to these core sub-systems, some countries have

chosen to expand their IFMIS with non- core sub-systems such as tax administration, procurement management , human resource and pay – roll systems and other possible areas seen as supporting the core modules, (*Chene, 2009*).



**Table 1: Central Government Integrated Financial Management Information System Model**

### 2.4.3 MPOs (Mobile Point of Sale)

MPOs Solution is one of the world’s leading all in one integrated system comprising of best breeds of mobile Point of Sale terminals, wireless technology and powerful back-end servers. At the back end of this system is a reporting tool, which provides seamless information at the touch of a button

This tried and tested real time revenue collection and management MPOS solution offers great benefits such as transparency and traceability for both Government and private sector businesses.

Key Systems of the MPOS solutions include:

- Financial Institutions - Revenue Collection
- Insurance Institutions - Premium collection (Life and Pensions)
- Government Revenue Collection & Management (Property rates, Hawkers fees etc.)
- Hotel and Restaurant Management System
- Mobile Ticketing Solutions for all Segments of Transportation (Buses and Toll Plaza).

#### **2.4.4 Integrated Tax Management System (I-Tax)**

On March 1, 2014, the Kenya Revenue Authority (KRA) switched the country's tax system from manual to a new electronic platform called iTax. The iTax is a web supported solution intended to deliver services to taxpayers efficiently and effectively on line, through a corporate web portal. It provides a fully integrated automated solution for the administration of domestic taxes. It enables internet based taxpayer registration, filing, payment and status inquiries with real time monitoring of accounts. Among the key compliance functions enabled by iTax is the cross validation of information for all taxpayers registered.

The system, which had been on a pilot basis, is expected to shore up revenue collection by roping in non-compliant taxpayers and those under-declaring their dues. However, this system doesn't have spatial data mapping yet. Going forward, KRA is partnering with relevant government institutions to benefit from the use of the Geographic Information System (GIS) technology/solutions on identification of spatial location of property developments. (KRA Fifth Corporate Plan 2012/13-2014/15).

#### **2.5 System development theory**

The proposed revenue collection information system with GIS integration qualifies as an information system that can be developed like any other system using the known concepts. This can be achieved through system development life cycle with a combination of some methodologies.

System development life cycle also known as SDLC is a conceptual model that guides project management in information systems development (Stazinger, J.W. 2007).

In 200, Stair stated in his publication that an information system is a set of interrelated elements or components that collects (input); manipulates (process), store and disseminate (output) data and information and provide a corrective reaction (feedback mechanism) to meet an objective. The feedback mechanism is the component that helps organizations to achieve their goals, such as increasing profits, efficiency and customer service.

In 2004, James gave a much simpler explanation and defined an information system as an assembly or integration of technology to a range of functionalities.

An information system could also be any organized combination of people, hardware, software, communication networks and data resources that collect process and distribute information in an



organization. IS are used by people to communicate using physical devices known as hardware and information processing procedures known as commands or software.

Computer networks are used as communication channels and data is stored in logical structures called data structures. The logical structures form a database and there are programs or applications with commands to organize and manage these structures. (James A. O'Brien, 2005)

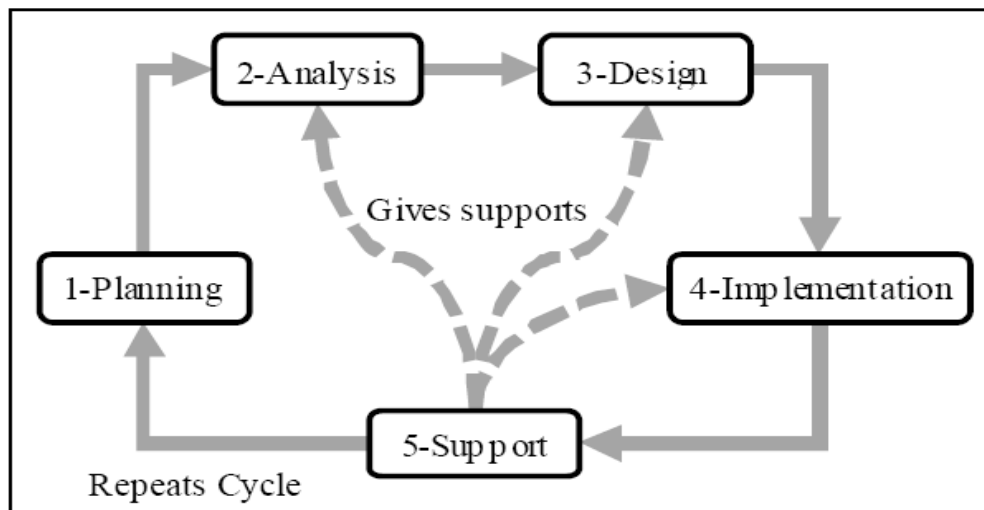
Shelly (2010) states that components of information system can be described as:-

- a) **Hardware:** this consists of everything in the physical layer of an IS.
- b) **Software:** this refers to the programs that control the hardware and produce the deserved information or results.
- c) **Data:** this is the raw that an IS transforms into useful information
- d) **Processes:** Also Known as procedures are the tasks and business functions that users, managers and ITC staff members perform to achieve some set goals.
- e) **The People:** this includes the users and the developers.

### **2.5.1 Steps in system development life cycle**

Shelly (2010) states that the basic steps of system development lifecycle are divided into five stages

- a) **Planning:** This involves conducting a preliminary investigation to determine the project feasibility
- b) **Analysis:** This involves developing a logical model of the new system.
- c) **Design:** Creating a physical model of the system.
- d) **Implementation:** deliver a functional system.
- e) **Support:** maintaining the system and protecting the integrity of the system and its data.



**Table 2: Visual demonstration of SDLC**

System management is the act of getting systems together to accomplish desired goals and objectives using available resources efficiently and effectively. Phases of system management consist of planning, organizing, activation and control (Hasab, 2007).

- ❖ **Planning:** included here are resource planning, decision making and problem identification
- ❖ **Organizing:** this includes making project planning such as building charts, work breakdown structure, and work co-ordination: also designing of systems.
- ❖ **Activation:** this is where all the previously planned and organized steps are taken into action.
- ❖ **Control:** every system needs control which includes making sure the goals have been achieved and doing system evaluations.

*Mehta, Riku (2009)* concluded that in an information system merger processes, the primary target should always be the information system planning. In a company merger there are many aspects to manage to achieve the goals; one of the most important things to manage is planning of the information systems.

## **2.6 GIS System analysis and design theory**

### **2.6.1 Introduction**

A Geographical Information System (GIS) is a computerized data management system that allows one to map, model, and query large quantities of data within a single database according to their location. GIS gives one the power to create maps, integrate information, visualize scenarios, present powerful ideas and develop effective solutions. A GIS differs from other graphic systems in that data are geo-referenced to the co-ordinates of a particular projection system. This allows placement of features on the earth's surface and maintains the spatial relationship between mapped features.

Gupta et al (2001) argues that GIS has the capabilities to provide necessary physical input and intelligence for preparation of base-maps, formulation of planning proposals and acts as a monitoring tool during implementation phase of any planning scheme. GIS systems help planners to analyze problems more quickly and thoroughly and formulate solutions to monitor processes for achieving long-term development goals. GIS also plays an extremely important role in resource management and land use planning activities (*Xinhong and Hua, 1992*).

Revenue planners can also get a broad multidimensional view of the current situation and more accurately assess the future scenarios by integrating & organizing data spatially. GIS can analyze possible planning alternatives more quickly giving decision makers better choices (*Kumar et al, 2002*)

This is one such technology that allows us to develop a non-spatial database and spatially connected database of any geographical area, which is very crucial in planning, monitoring and decision-making. The spatial data once made available up to a micro level can provide a tremendous boost to revenue budgeting, planning, and monitoring activities of collection. This micro level data also helps in monitoring developments of social infrastructure projects such as water supply projects, health, school, higher education, roads, and telecommunications.

In a bid to improve assessment of properties and efficient collection of tax, the Kanpur Municipality in India adopted GIS-based property tax system to strengthen its revenues. GIS mapping of individual properties and parcels was carried out to bring un-assessed properties under the tax net. Satellite technology was used to measure the buildings, find out the nature of the usage of the building, type of construction, number of floors and other related details. A manual door-to-door field survey was conducted after that and photos of individual properties

were taken by the municipal inspectors. This data was then correlated with the data available at the municipality headquarters (*Kumar et al 2012*).

Use of GIS has opened a whole new horizon for the Kanpur Municipality. The municipality utilized this technology for database preparation and assessment of property. The municipal areas that are using the GIS have observed major increase in revenues.

A geographic information system (GIS) integrates hardware, software, and data for capturing, managing, analyzing, and displaying all forms of geographically referenced information.

GIS allows us to view, understand, question, interpret, and visualize data in many ways that reveal relationships, patterns, and trends in the form of maps, globes, reports, and charts.

A GIS helps you answer questions and solve problems by looking at your data in a way that is quickly understood and easily shared.

GIS technology can be integrated into any enterprise information system framework.

#### Top Five Benefits of GIS

GIS benefits organizations of all sizes and in almost every industry. There is a growing awareness of the economic and strategic value of GIS. The benefits of GIS generally fall into five basic categories:

- Cost Savings and Increased Efficiency
- Better Decision Making
- Improved Communication
- Better Recordkeeping
- Managing Geographically

#### What Can You Do with GIS?

GIS gives us a new way to look at the world around us. With GIS you can:

- Map Where Things Are
- Map Quantities
- Map Densities
- Find What's Inside
- Find What's Nearby
- Map Change

### **2.6.2 The Geographic Approach**

Geography is the science of our world. Coupled with GIS, geography is helping us to better understand the earth and apply geographic knowledge to a host of human activities, (*Nicole Alexander and Ji Yang, 2011*). The outcome is the emergence of *The Geographic Approach*—a new way of thinking and problem solving that integrates geographic information into how we understand and manage our planet (*Nicole Alexander and Ji Yang, 2011*). This approach allows us to create geographic knowledge by measuring the earth, organizing this data, and analyzing and modeling various processes and their relationships. The Geographic Approach also allows us to apply this knowledge to the way we design, plan, and change our world.

### **2.6.3 Framing the Question**

Approaching a problem geographically involves framing the question from a location-based perspective. What is the problem you are trying to solve or analyze, and where is it located? Being as specific as possible about the question you're trying to answer will help you with the later stages of The Geographic Approach, when you're faced with deciding how to structure the analysis, which analytic methods to use, and how to present the results to the target audience.

### **2.6.4 Finding Data**

After clearly defining the problem, it is necessary to determine the data needed to complete your analysis and ascertain where that data can be found or generated. The type of data and the geographic scope of your project will help direct methods of collecting data and conducting the analysis. If the method of analysis requires detailed and/or high-level information, it may be necessary to create or calculate the new data. Creating new data may simply mean calculating new values in the data table or obtaining new map layers or attributes but may also require geoprocessing.

### **2.6.5 Examining the Data**

You will not know for certain whether the data you have acquired is appropriate for your study until you thoroughly examine it. This includes visual inspection, as well as investigating how the data is organized (its schema), how well the data corresponds to other datasets and the rules of the physical world (its topology), and the story of where the data came from (its metadata).

### **2.6.6 Analyzing the Data**

The data is processed and analyzed based on the method of examination or analysis you choose, which is dependent on the results you hope to achieve. Do not underestimate the power of "eyeballing" the data. Looking at the results can help you decide whether the information is valid or useful, or whether you should rerun the analysis using different parameters or even a different method. GIS modeling tools make it relatively easy to make these changes and create new output.

### **2.6.7 Sharing the Results**

The results and presentation of the analysis are important parts of the Geographic Approach. The results can be shared through reports, maps, tables, and charts and delivered in printed form or digitally over a network or on the Web. You need to decide on the best means for presenting your analysis. You can compare the results from different analyses and see which method presents the information most accurately. And you can tailor the results for different audiences. For example, one audience might require a conventional report that summarizes the analyses and conveys recommendations or comparable alternatives. Another audience may need an interactive format that allows them to ask what-if questions or pursue additional analysis.

### **2.6.8 Geocoding in GIS systems**

Geocoding is a procedure that uses postal addresses to derive geographic (longitude, latitude) locations. The Oracle Geocoder provides geocoding and reverse-geocoding services, and performs point-of-interest (POI) matching that returns complete addresses for points of interest.

The Oracle Geocoder is a geocoding engine implemented as Java-stored procedures inside an Oracle database server. In addition to geocoding PL/SQL APIs, client-side Java APIs are provided to facilitate the integration of the server-side geocoder with client-side Java applications.

The Oracle Geocoder is supported in three forms: the database geocoder, the J2EE geocoder and the Thin-Client geocoder. The database geocoder uses PL/SQL APIs to access address and coordinate information stored in database tables; the J2EE geocoder uses an XML API to provide a service that accesses the address and coordinate information stored in database tables; and the Thin-Client geocoder uses a client -side Java API to access address and coordinate

information stored in database tables. The three geocoders all access the same underlying database tables. These tables and their indexes constitute the geocoder schema. The geocoder schema is typically supplied by a data provider and is generally ready to use out-of-the-box, however, the geocoder schema can also be built by a user.

This white paper describes the geocoder schema used by the Oracle Geocoder and how data is accessed and interpreted for geocoding. It also describes how the Oracle Geocoder is configured for use. The examples in this paper are based on the United States address-format conventions, unless stated otherwise.

The features of the Oracle Geocoder that are specific to Oracle Spatial 11g Release 2 are point-based geocoding, Oracle Web Logic Server support and the Thin-Client geocoder.

### **2.6.9 Geocoder Schema**

The geocoder schema is made up of seven data tables and their indexes, and three profile tables. The data tables store address and coordinate information, and the profile tables store address-format information used by the geocoder to parse addresses entered by a user.

### **3 CHAPTER THREE**

#### **3.1 Research Design**

The target population for this study was both the revenue collector, who was basically the county government, and the tax payer. For the tax payer, randomly selected medium enterprises were interviewed as well as the officers in the revenue units/departments. This involved Chief and Senior officers in revenue, as well as the middle level staff in the revenue collection units. Random sampling method was adopted to select three counties where the questionnaires were to be administered.

#### **3.2 Sample Design**

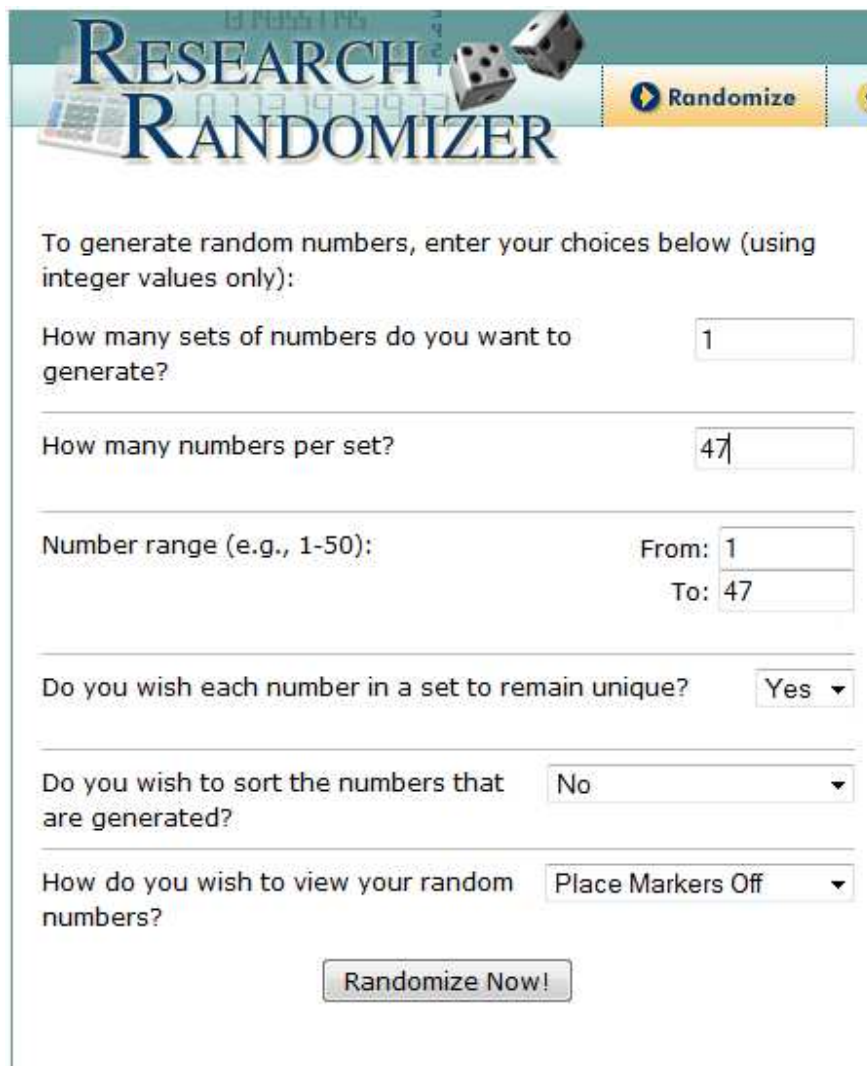
All the 47 counties were listed. Counties were assigned numbers randomly using a tool called *research randomizer*, a free service developed by *Scott Plous* and web developer *Mike Lestikoffered*, in 2007 for both students and researchers interested in conducting random assignment and random sampling.

#### **3.3 How research randomizer works**

As with most computer-based "random number generators," this program is best described as a "pseudo-random number generator" because the numbers are generated by use of a complex algorithm (seeded by the computer's clock) that gives the appearance of randomness. For most purposes this should be adequate.



### 3.3.1 Regenerating a randomized list of the counties



The screenshot shows the 'RESEARCH RANDOMIZER' website. At the top, there is a header with the title 'RESEARCH RANDOMIZER' in a stylized font, accompanied by images of dice and a calculator. A yellow button labeled 'Randomize' is visible in the top right corner of the header.

Below the header, the main content area contains the following text and form elements:

To generate random numbers, enter your choices below (using integer values only):

How many sets of numbers do you want to generate?

How many numbers per set?

Number range (e.g., 1-50):

From:   
To:

Do you wish each number in a set to remain unique?  ▾

Do you wish to sort the numbers that are generated?  ▾

How do you wish to view your random numbers?  ▾

At the bottom of the form, there is a button labeled 'Randomize Now!'.

**Table 3: Randomized list of the counties**



## Research Randomizer Results

1 Set of 47 Unique Numbers Per Set  
Range: From 1 to 47 -- Unsorted

Job Status: **Finished**

### Set #1:

18, 31, 38, 6, 2, 9, 37, 14, 29, 16, | 27, 21, 22, 7, 1, 41, 40, 47, 25, 19, 45,

---

39, 36, 24, 8, 26, 3, 32, 13, 43, 33, 5, 15, 20, 30, 17, 28, 35, 11, 44, 4, 42, 10, 12, 46, 23, 34

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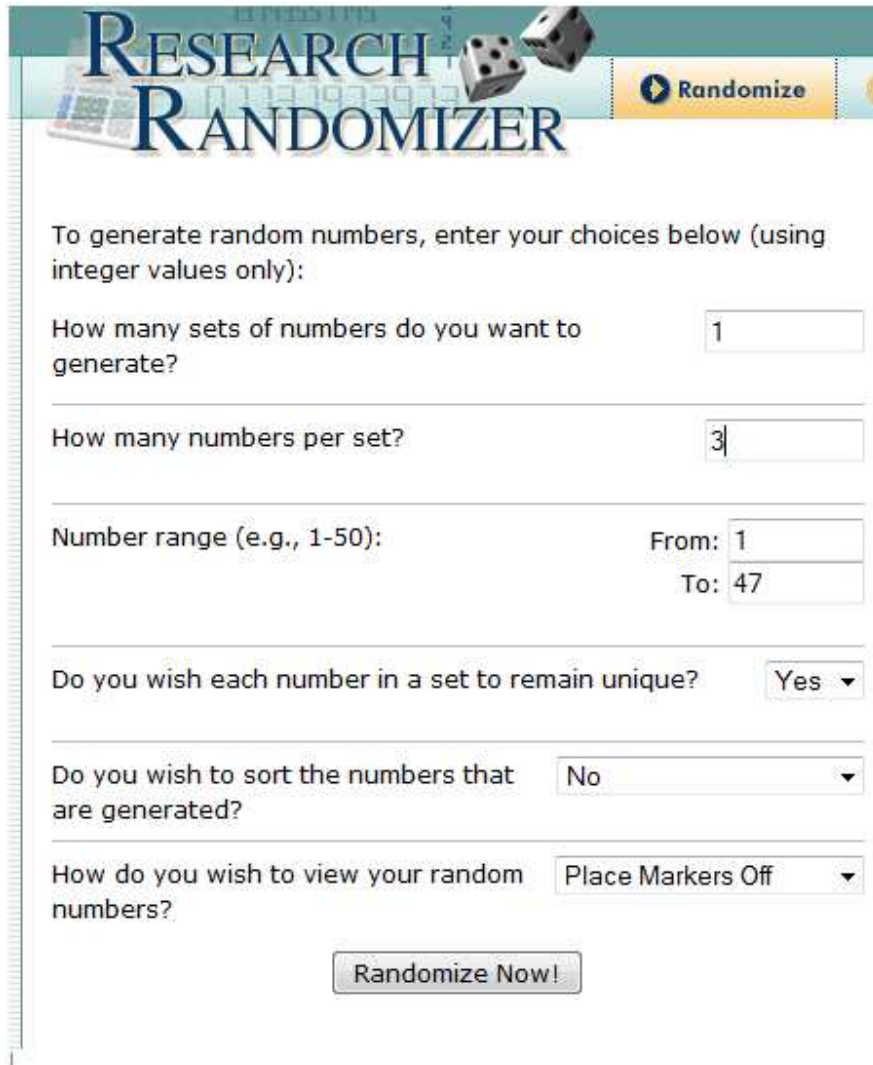
Table 4: Generation of 47 Random Numbers between 1 and 47.

### 3.3.2 Results

RANDOM NO	NAME	CODE
18	<u>Baringo</u>	30
31	Bomet	36
38	<u>Bungoma</u>	39
6	Busia	40
2	<u>Elgeyo-Marakwet</u>	28
9	<u>Embu</u>	14
37	<u>Garissa</u>	7
14	Homa Bay	43
29	<u>Isiolo</u>	11
16	Kajiado	34
27	<u>Kakamega</u>	37
21	<u>Kericho</u>	35
22	<u>Kiambu</u>	22
7	Kilifi	3
1	<u>Kirinyaga</u>	20
41	<u>Kisii</u>	45
40	<u>Kisumu</u>	42

47	<u>Kitui</u>	15
25	<u>Kwale</u>	2
19	Laikipia	31
45	<u>Lamu</u>	5
39	<u>Machakos</u>	16
36	<u>Makueni</u>	17
24	<u>Mandera</u>	9
8	<u>Marsabit</u>	10
26	<u>Meru</u>	12
3	<u>Migori</u>	44
32	<u>Mombasa</u>	1
13	<u>Murang'a</u>	21
43	<u>Nairobi</u>	47
33	<u>Nakuru</u>	32
5	<u>Nandi</u>	29
15	<u>Narok</u>	33
20	<u>Nyamira</u>	46
30	<u>Nyandarua</u>	18
17	<u>Nyeri</u>	19
28	<u>Samburu</u>	25
35	<u>Siaya</u>	41
11	<u>Taita-Taveta</u>	6

Table 5: Assign random number to a county



**RESEARCH RANDOMIZER**

To generate random numbers, enter your choices below (using integer values only):

How many sets of numbers do you want to generate?

How many numbers per set?

Number range (e.g., 1-50):  
 From:   
 To:

Do you wish each number in a set to remain unique?

Do you wish to sort the numbers that are generated?

How do you wish to view your random numbers?

**Table 6: Randomly select 3 counties**

## RESULTS



Figure 1: Results

RANDOM NO	NAME	CODE	ORDERED	SORT BY RANDOM NO	RANDOMLY SELECT 3
18	<u>Baringo</u>	30	1	Kirinyaga	
31	<u>Bomet</u>	36	2	Elgeyo-Marakwet	
38	<u>Bungoma</u>	39	3	Migori	
6	<u>Busia</u>	40	4	Tharaka-Nithi	
2	<u>Elgeyo-Marakwet</u>	28	5	Nandi	
9	<u>Embu</u>	14	6	Busia	
37	<u>Garissa</u>	7	7	Kilifi	
14	<u>Homa Bay</u>	43	8	Marsabit	
29	<u>Isiolo</u>	11	9	Embu	
16	<u>Kajiado</u>	34	10	Turkana	
27	<u>Kakamega</u>	37	11	Taita-Taveta	
21	<u>Kericho</u>	35	12	Uasin Gishu	
22	<u>Kiambu</u>	22	13	Murang'a	22
7	<u>Kilifi</u>	3	14	Homa Bay	
1	<u>Kirinyaga</u>	20	15	Narok	
41	<u>Kisii</u>	45	16	Kajiado	
40	<u>Kisumu</u>	42	17	Nyeri	
47	<u>Kitui</u>	15	18	Baringo	
25	<u>Kwale</u>	2	19	Laikipia	
19	<u>Laikipia</u>	31	20	Nyamira	
45	<u>Lamu</u>	5	21	Kericho	
39	<u>Machakos</u>	16	22	Kiambu	39
36	<u>Makueni</u>	17	23	Wajir	
24	<u>Mandera</u>	9	24	Mandera	
8	<u>Marsabit</u>	10	25	Kwale	
26	<u>Meru</u>	12	26	Meru	
3	<u>Migori</u>	44	27	Kakamega	
32	<u>Mombasa</u>	1	28	Samburu	
13	<u>Murang'a</u>	21	29	Isiolo	
43	<u>Nairobi</u>	47	30	Nyandarua	
33	<u>Nakuru</u>	32	31	Bomet	33
5	<u>Nandi</u>	29	32	Mombasa	
15	<u>Narok</u>	33	33	Nakuru	
20	<u>Nyamira</u>	46	34	West Pokot	
30	<u>Nyandarua</u>	18	35	Siaya	
17	<u>Nyeri</u>	19	36	Makueni	
28	<u>Samburu</u>	25	37	Garissa	
35	<u>Siaya</u>	41	38	Bungoma	
11	<u>Taita-Taveta</u>	6	39	Machakos	
44	<u>Tana River</u>	4	40	Kisumu	
4	<u>Tharaka-Nithi</u>	13	41	Kisii	
42	<u>Trans Nzoia</u>	26	42	Trans Nzoia	
10	<u>Turkana</u>	23	43	Nairobi	
12	<u>Uasin Gishu</u>	27	44	Tana River	
46	<u>Vihiga</u>	38	45	Lamu	
23	<u>Wajir</u>	8	46	Vihiga	
34	<u>West Pokot</u>	24	47	Kitui	

### 3.4 Data analysis

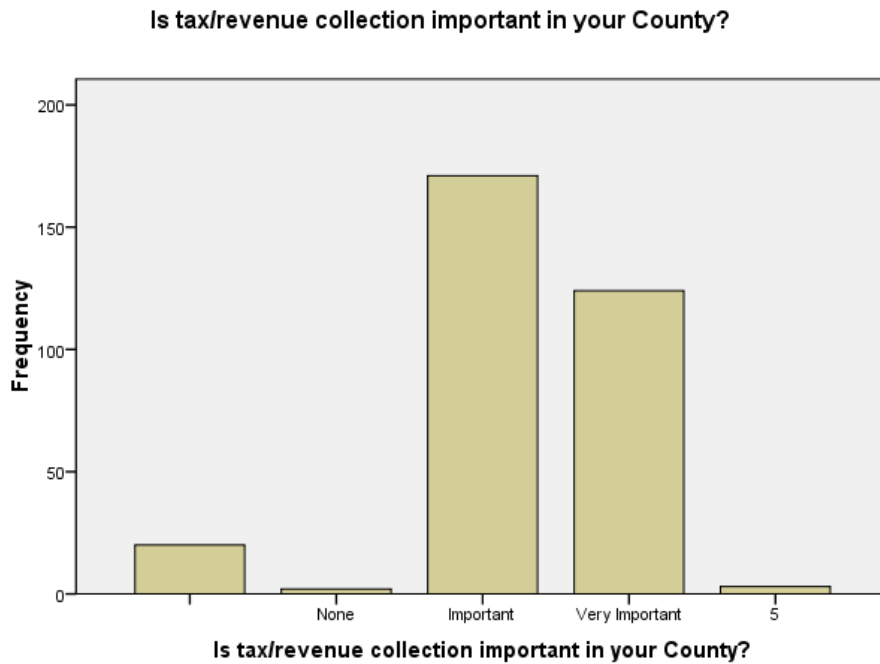
Random sampling method was used to determine the sample space from where the research data was to be collected. Three counties were selected randomly as demonstrated above using a tool called Research Randomizer. A total of 300 ME and 100 RC questionnaires were administered in the three counties. For the revenue collector, both senior revenue administration staff and middle-level management staff were interviewed in the three counties. For the medium enterprises 300 randomly selected entrepreneurs were interviewed.

#### 3.4.1.1 Analysis of the ME data and reporting

Name of County				
	Frequency	Percent	Valid Percent	Cumulative Percent
Valid	20	6.2	6.2	6.2
KIAMBU	100	31.2	31.2	37.5
MACHAKO S	100	31.2	31.2	68.8
NAKURU	100	31.2	31.2	100.0
Total	320	100.0	100.0	

A total of 300 ME questionnaires were administered in the three counties.

**Figure 2: County Cumulative percentages**



**Figure 3: Revenue importance bar chart**

As shown in figure 3 above, the majority of the people interviewed agreed that revenue collection is important/ very important in their counties.

**Business owners face problems with the county government trying to comply with the tax regulations**



	Frequency	Percent	Valid Percent	Cumulative Percent
Valid	20	6.2	6.2	6.2
Do not know	2	.6	.6	6.9
Disagree	96	30.0	30.0	36.9
Agree	69	21.6	21.6	58.4
Strongly Agree	133	41.6	41.6	100.0
Total	320	100.0	100.0	

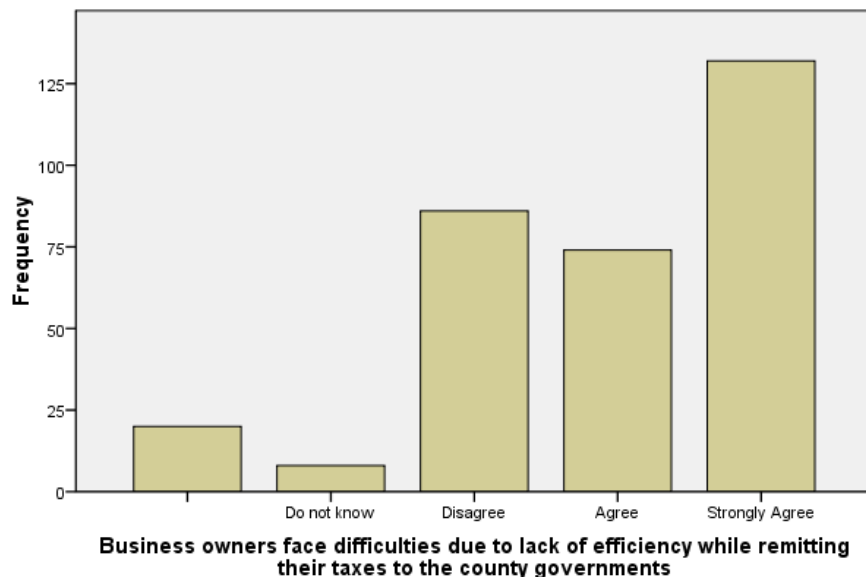
**Figure 4: tax regulation compliance**

As demonstrated in the figure above, majority agreed that business owners do face problems with the county government trying to comply with the tax regulations.

**Business owners face difficulties due to lack of efficiency while remitting their taxes to the county governments**

	Frequency	Percent	Valid Percent	Cumulative Percent
Valid	20	6.2	6.2	6.2
Do not know	8	2.5	2.5	8.8
Disagree	86	26.9	26.9	35.6
Agree	74	23.1	23.1	58.8
Strongly Agree	132	41.2	41.2	100.0
Total	320	100.0	100.0	

**Business owners face difficulties due to lack of efficiency while remitting their taxes to the county governments**



**Figure 5: Lack of efficiency**

**The process of remitting such fees is cumbersome e.g. dominated by long queues.**

	Frequency	Percent	Valid Percent	Cumulative Percent
Valid	20	6.2	6.2	6.2
Do not know	9	2.8	2.8	9.1
Disagree	92	28.8	28.8	37.8
Agree	68	21.2	21.2	59.1
Strongly Agree	131	40.9	40.9	100.0
Total	320	100.0	100.0	

The process of remitting such fees is cumbersome e.g. dominated by long queues.

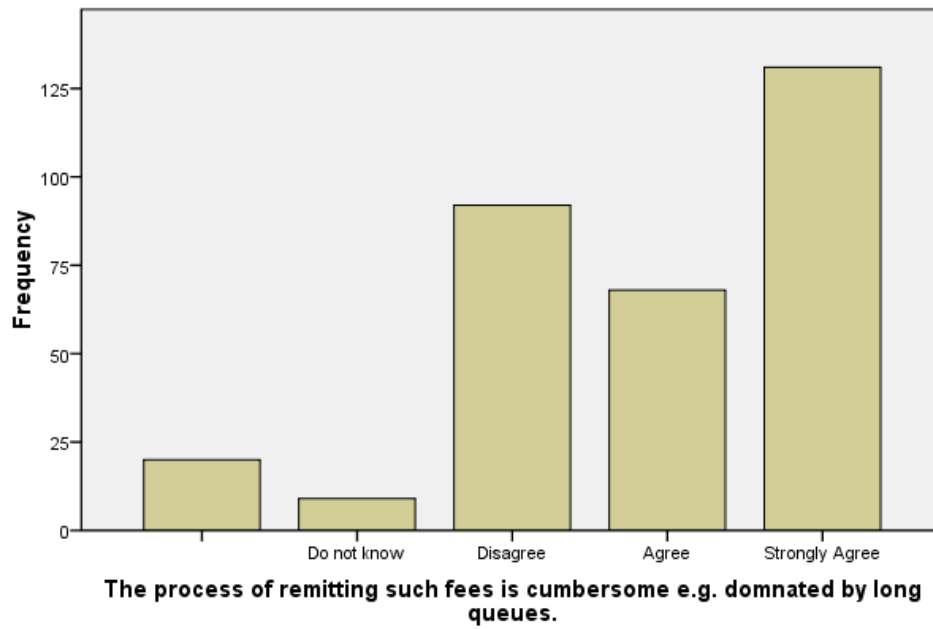
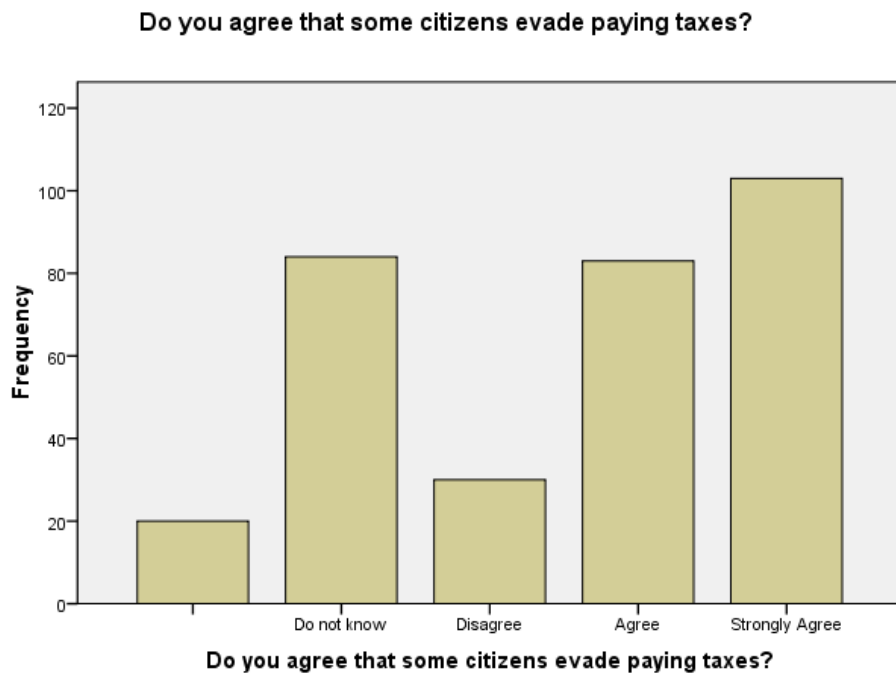


Figure 6: long queues bar chart

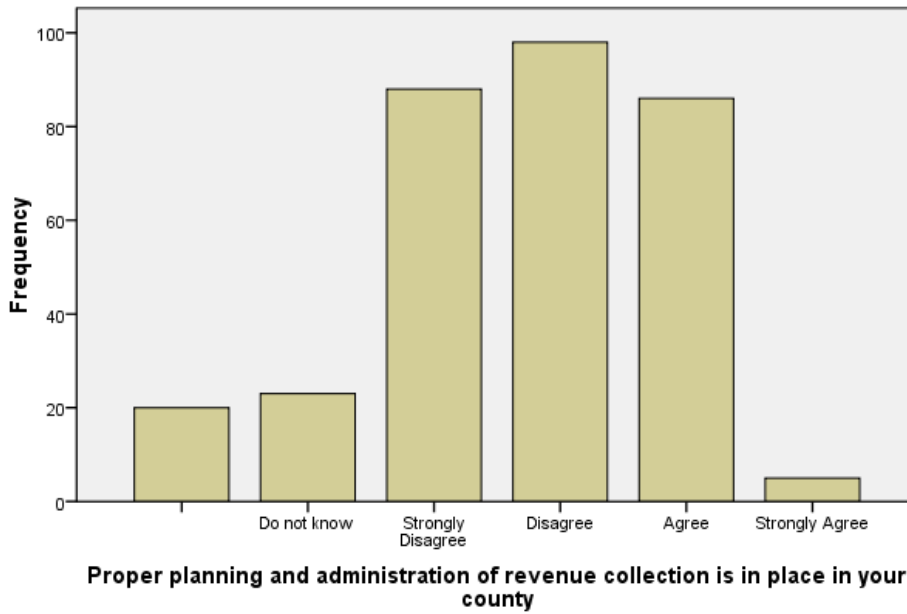


**Figure 7: tax evasion**

**Do you agree that some citizens evade paying taxes?**

	Frequency	Percent	Valid Percent	Cumulative Percent
Valid	20	6.2	6.2	6.2
Do not know	84	26.2	26.2	32.5
Disagree	30	9.4	9.4	41.9
Agree	83	25.9	25.9	67.8
Strongly Agree	103	32.2	32.2	100.0
Total	320	100.0	100.0	

**Proper planning and administration of revenue collection is in place in your county**

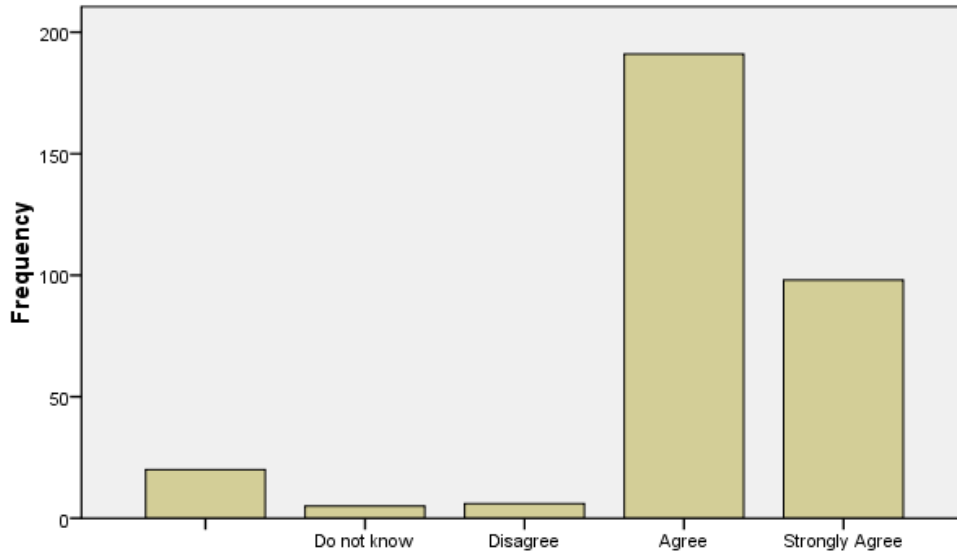


**Proper planning and administration of revenue collection is in place in your county**

	Frequency	Percent	Valid Percent	Cumulative Percent
Valid	20	6.2	6.2	6.2
Do not know	23	7.2	7.2	13.4
Strongly Disagree	88	27.5	27.5	40.9
Disagree	98	30.6	30.6	71.6
Agree	86	26.9	26.9	98.4
Strongly Agree	5	1.6	1.6	100.0
Total	320	100.0	100.0	

**Figure 8: proper planning bar chart**

**Do you agree that your county needs to improve on the current methods in place on planning and administration of revenue collection and spending budgetary?**

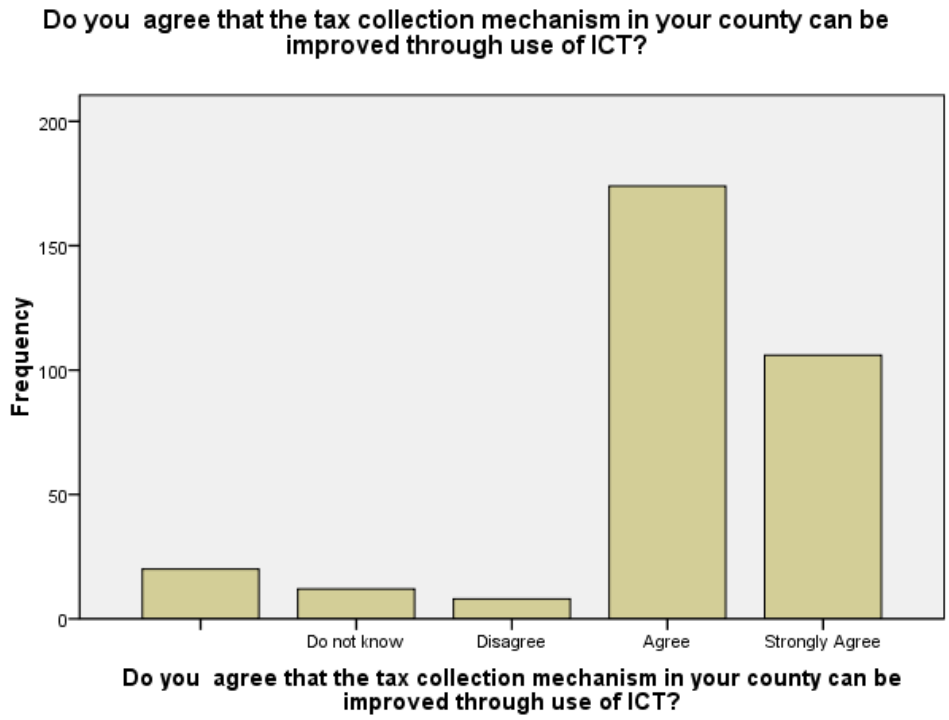


**Do you agree that your county needs to improve on the current methods in place on planning and administration of revenue collection and spending budgetary?**

**Do you agree that the tax collection mechanism in your county can be improved through use of ICT?**

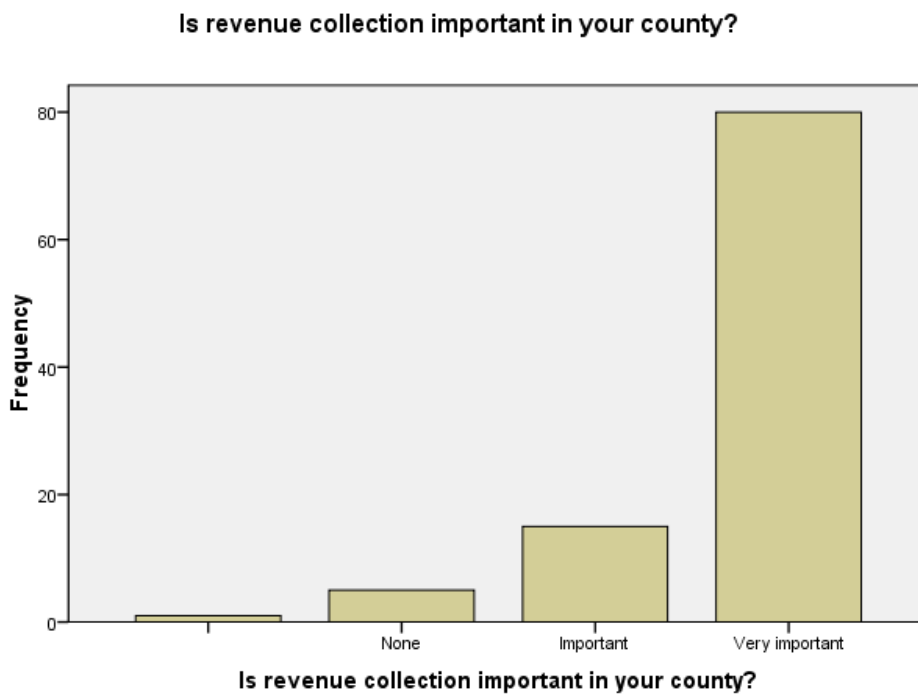
	Frequency	Percent	Valid Percent	Cumulative Percent
Valid	20	6.2	6.2	6.2
Do not know	12	3.8	3.8	10.0
Disagree	8	2.5	2.5	12.5
Agree	174	54.4	54.4	66.9
Strongly Agree	106	33.1	33.1	100.0
Total	320	100.0	100.0	

**Figure 9: Need for improvement**



**Figure 10: Use of ICT recommended**

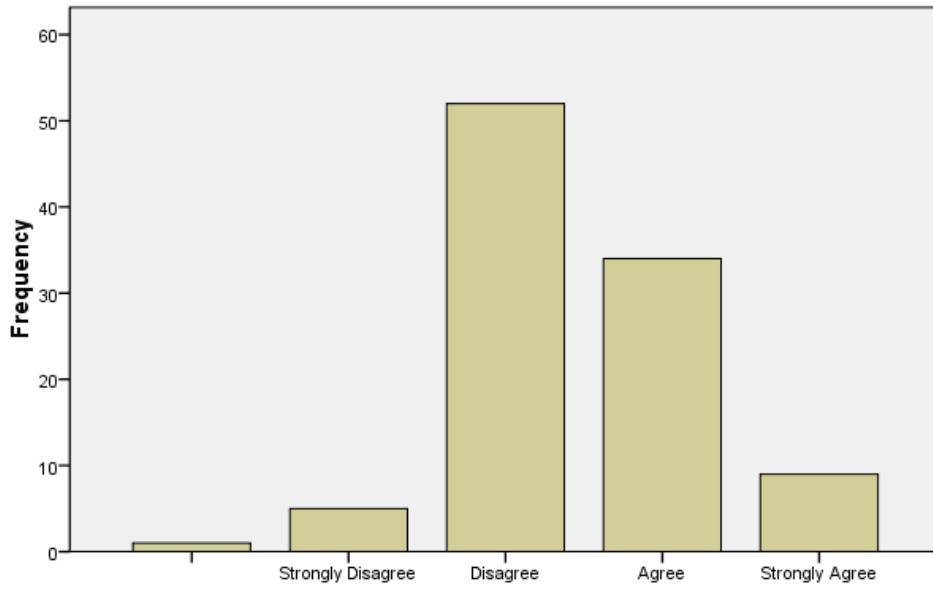
*3.4.1.2 Analysis of the RC data and reporting*



**Figure 11: importance of revenue**

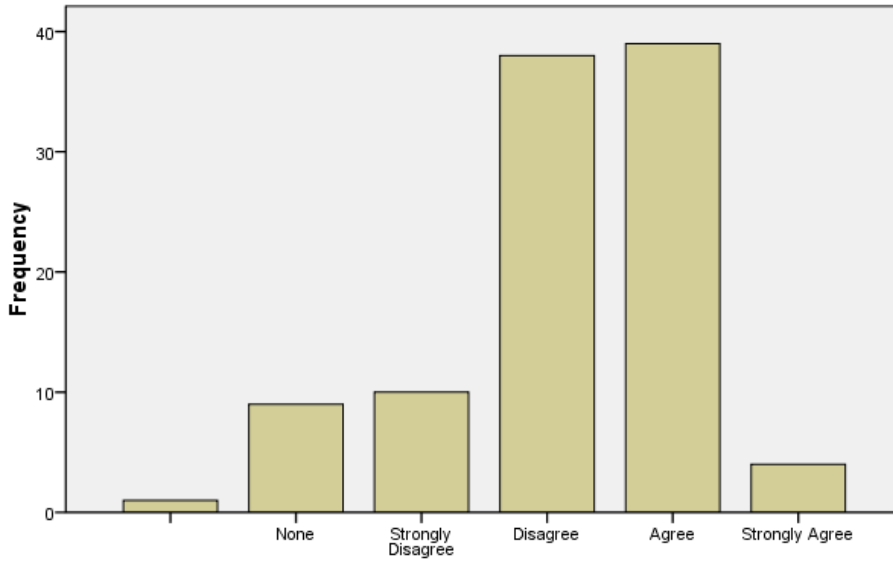


**The amount of revenue collected in my county is satisfactory.**



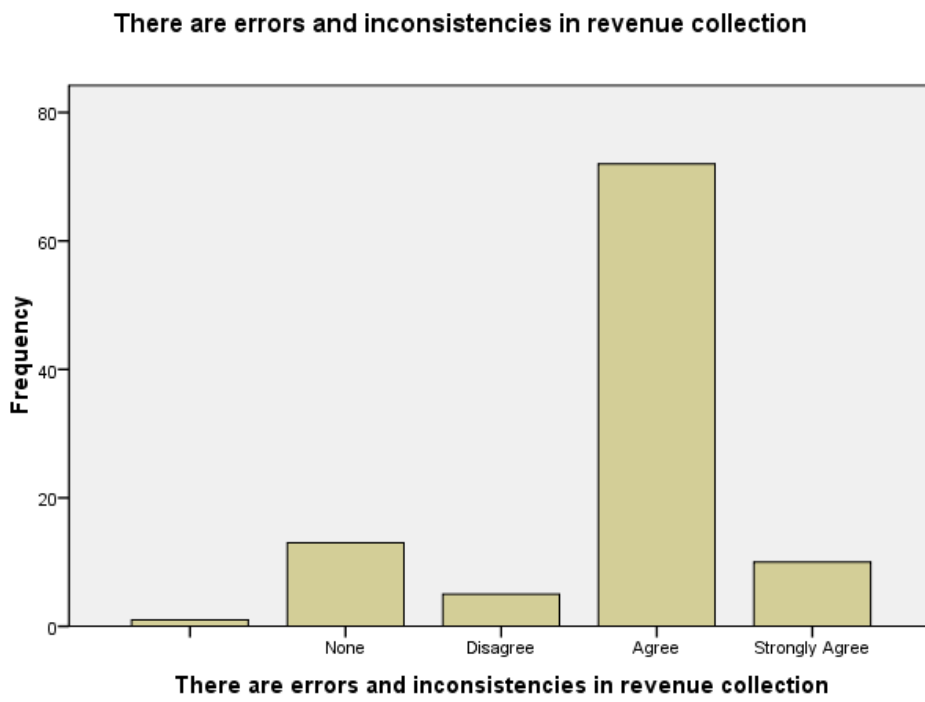
**The amount of revenue collected in my county is satisfactory.**

**The current revenue collection mechanisms in my county are automated**



**The current revenue collection mechanisms in my county are automated**

**Figure 12: automation in place**



**Figure 13: Errors in revenue collection**

### **3.4.1.3 Summary of the results**

Based on the results from this research, it is evident that the medium size business entrepreneurs feel that there is a strong need for improvement in terms of revenue administration and also the need to have efficient means of tax compliance. As desired by the tax payers, a new way of doing business is highly on demand and therefore this will obviously improve the situation.

1. ***Is tax/revenue collection important?*** Out of the 300 persons in small and medium enterprises interviewed, 53% (percent) agreed that this was an important exercise while 38% (percent) as very important. Cumulatively this is more than 90% of the persons interviewed. The response was slightly the same for the revenue collector with also more than 90% of the persons interviewed indicating that it is important.

2. **Are business owners faced with problems with the county governments trying to comply with the tax regulations?**

More than 60% of the persons interviewed, (ME) agreed that they do face problems related to tax compliance and regulations. This is a clear indicator that something should be done to create a platform of ensuring that business owners comply without much hustle.

3. **Could tax remittance be dominated by long queues, errors and inconsistencies or inefficiency?**

Out of the 100 persons interviewed, approximately 70% of the respondents from the county secretariats concurred that there do exist long queues, errors and inconsistencies in the revenue collection and processing and that there is need for improvement. This is a significant variable since it is from the revenue collector himself as well as representing the various processes involved in revenue collection. This is also a clear indicator that there is need for improvements of not a complete changeover.

4. **Are some citizens evading taxes, fees and land rates due to poor tracking?**

This view is significant and imperative especially getting to understand it from the respondent. 67% of the tax payers generally agree that it is possible to evade county fees due to poor or lack of a tracking mechanism.

5. **Can the prototype developed be applied in a real world problem scenario?**

More than 70% of the persons interviewed both ME's and RC's clearly indicated that integration and use of ICT can improve the processes and compliance and they felt that it is

strongly necessary and applicable. This is a clear indication that the current system isn't up to their expectations both ME owners and the revenue officers

#### **3.4.1.4 Conclusion and recommendations**

According to the analysis, it is evident that the current system is inefficient and is dominated by manual processes. Also through the observation on the services point, long queues are a characteristic of inefficiency that might open up corruption and office malpractices.

At this point the researcher has found it wise to have the whole business process redesigned. A business process design model needs to be adopted and employed in order to intervene the situation on the ground.

Chapter four of this report will demonstrate the whole idea of introducing a new way of doing business using a new model proposed by the researcher named as the county revenue mobilization system (CRMS).

#### **4 CHAPTER FOUR: RESEARCH METHODOLOGY**

The research methodology employed to design the system included a combination of structured systems analysis and design and object oriented analysis and design methodologies. The system database was designed using MySQL database and PHP was used to design the user interfaces. Quantum GIS was used to create the sample spatial data and was loaded. Automated valuation methodology was adopted from the Moore's 2005 Computer assisted mass appraisal methodology whereby algorithms were designed and implemented.

##### **4.1 Analysis and design**

In the analysis and design, the researcher introduces a new business process idea in tax collection and administration using the CRMS model proposed. This model was designed in a MYSQL database and the spatial data was converted using a special open source spatial software called quantum GIS. The graphical user interfaces were designed using both java and PHP.

The proposed system was intended to support a full range of business processes on revenue mobilization ranging from land parcel and revenue zones management, land rates calculation and collection of generated revenue, creation and administration of revenue zones, easier reporting and audit of land and other revenue collection points. A menu based graphical user interface (GUI) was developed to enable easy and friendly user-system interaction. This is expected to increase acceptability and utilization of the system among planners and decision makers and shall enhance the efficacy of revenue planning and budgeting. The variables in this system include; system inputs and outputs, user interfaces, specified software, database and data communication facilities, personnel and procedure components.

The system has the following set of modules: *Identity and personnel information module, Lands/property information module, Revenue collection point module, Land parcel management module, Revenue zones management module and the Reporting module.*

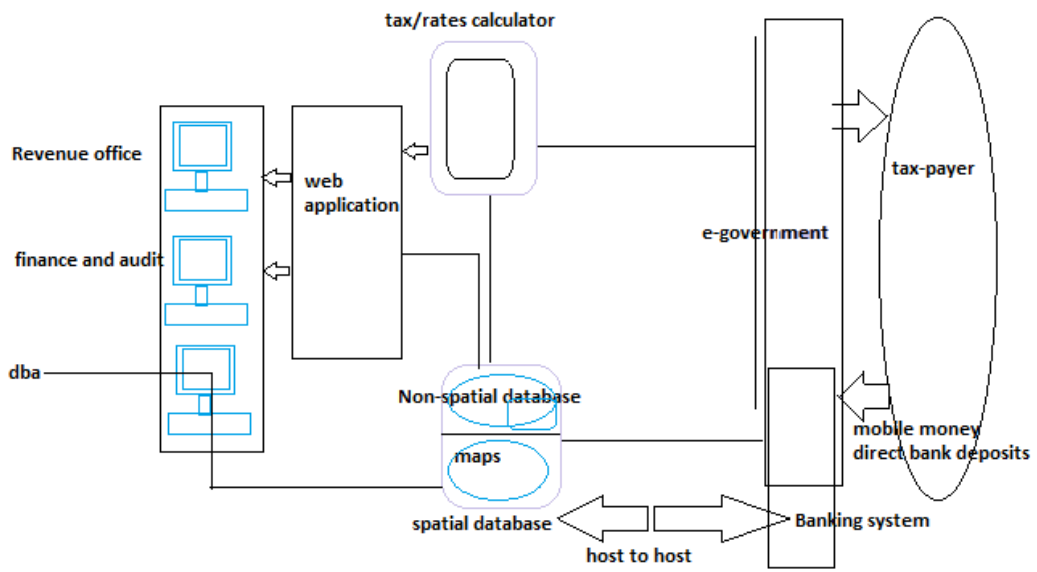
Apart from the above listed modules, the system has the capability to store and operationalize geospatial data using mathematical functions and in this case an algorithm has been implemented to ease land classification using classification functions. This brings about fairness in land rates

calculation and distribution. This is a big milestone for national land administration and the researcher will embark on this as the next project to actualize a system for lands management.

## 4.2 The Business Model



Figure 14: model



### 4.3 Data and work flow





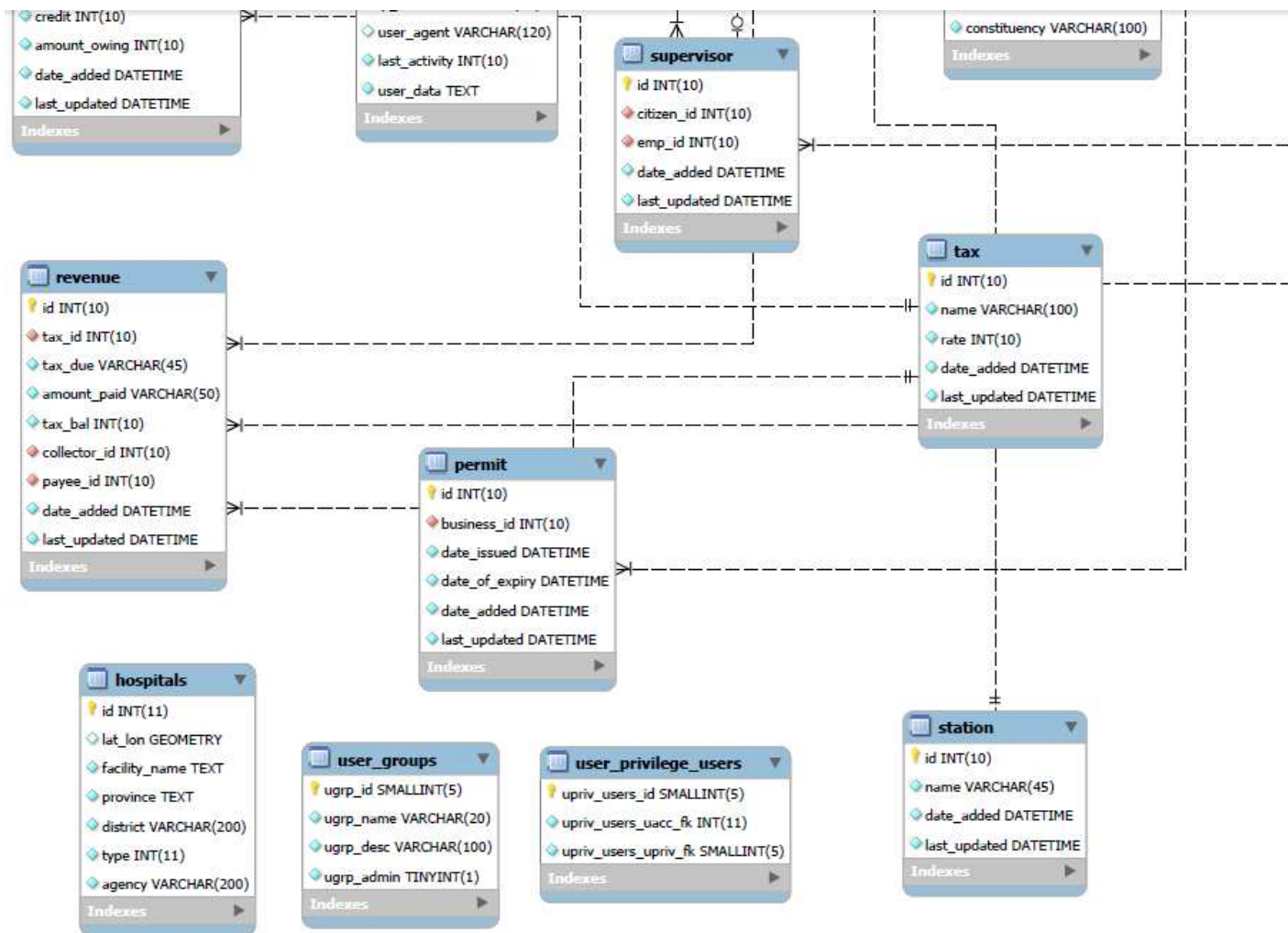


Figure 16: ER diagram cont.

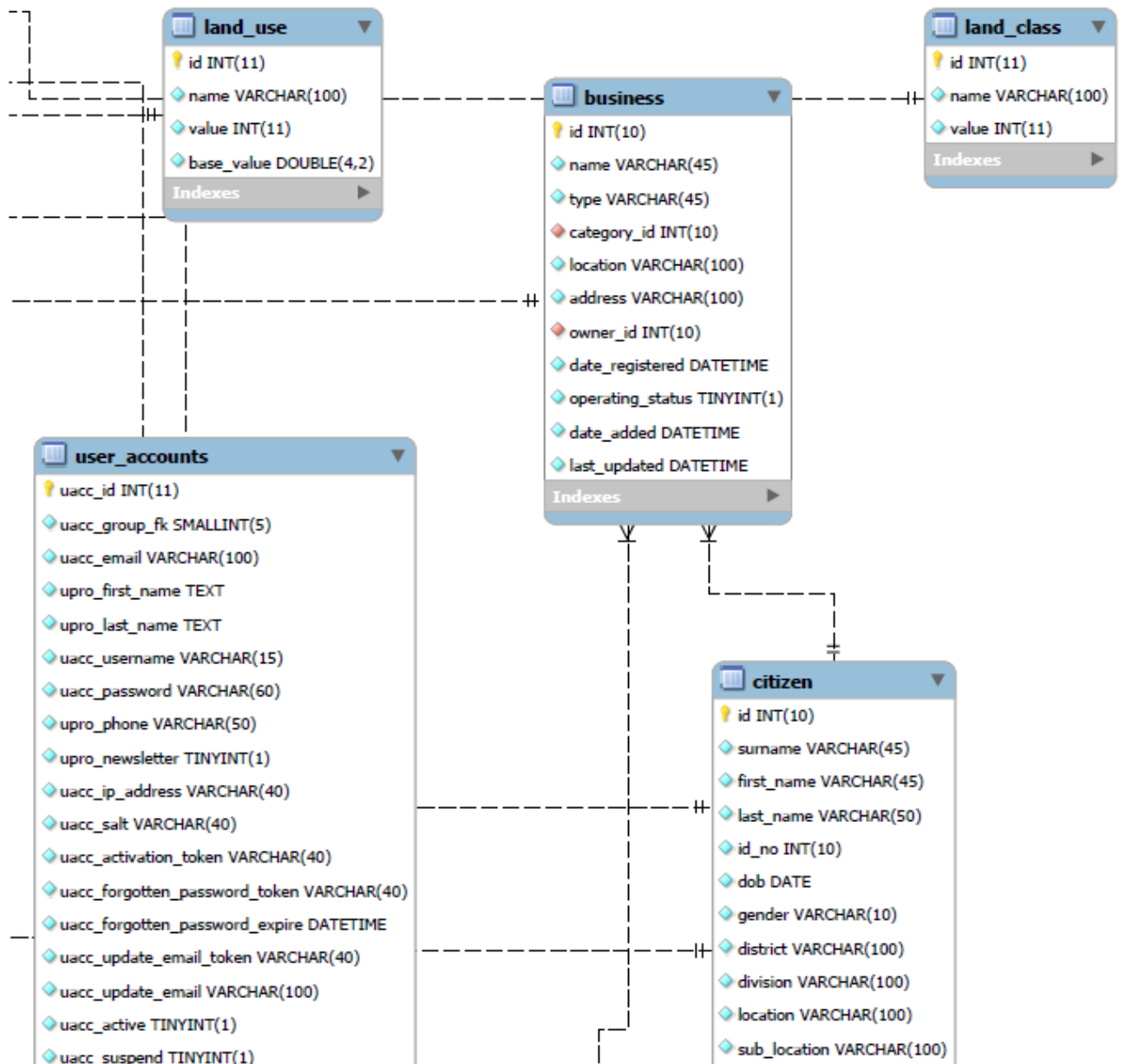


Figure 17: ER diagram cont.

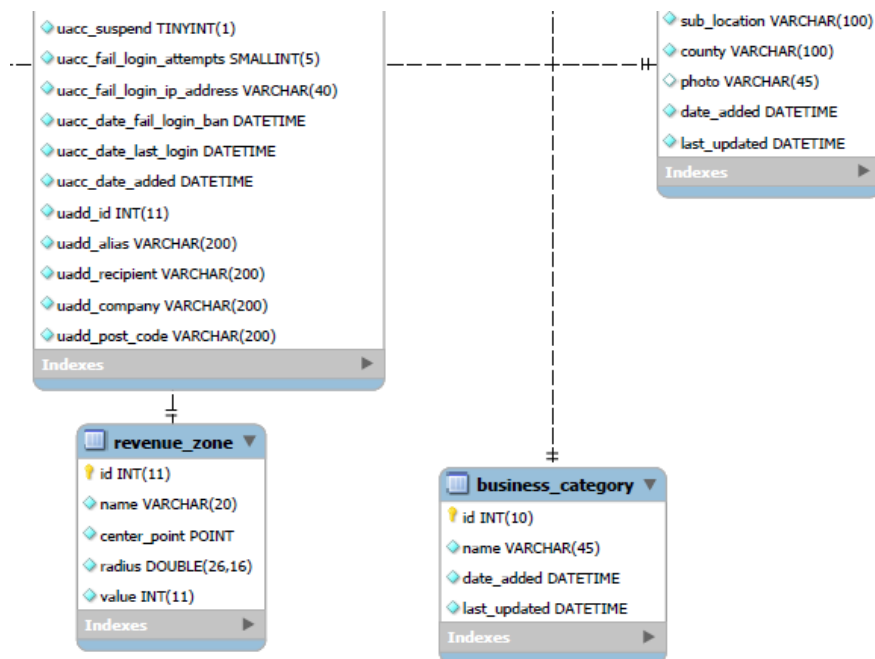


Figure 18: ER diagram cont.

### 4.3.1 Identity and personnel information module

This module shall contain complete employee information, which acts as a central employee database. This enables revenue administrators to utilize all employee information productively.

Features:

- Populate and manage the employee's personal information in a centralized location, thus preventing data loss.
- Manage & update your employees contact & travel information within the employee's record itself.
- Manage job information by selecting the relevant roles and responsibilities.
- View employee details in the employee list and search using different employee information.
- Generate employee reports.

### **4.3.2 Identity Model**

The security of this system is very crucial and therefore usage and access shall only be authorized. End users shall be given credentials and access shall only be given on verification. Front end users shall be granted roles by the database administrator and roles performed on the system shall be logged using audit trail tables. Guests shall be required to registers by creating account that shall be verified using their national identity numbers. A biometric authentication function shall be deployed where necessary and host to host encryption incorporated for host to host transmission.

### **4.3.3 Lands Property information module**

This module shall carry a complete map interface with all functional map tools for geographical navigation and tracking. By default, the module shall have special data, a legend pane and a preview of the attribute pane. The build-in tool-bar buttons allows printing and navigation through the spatial data.

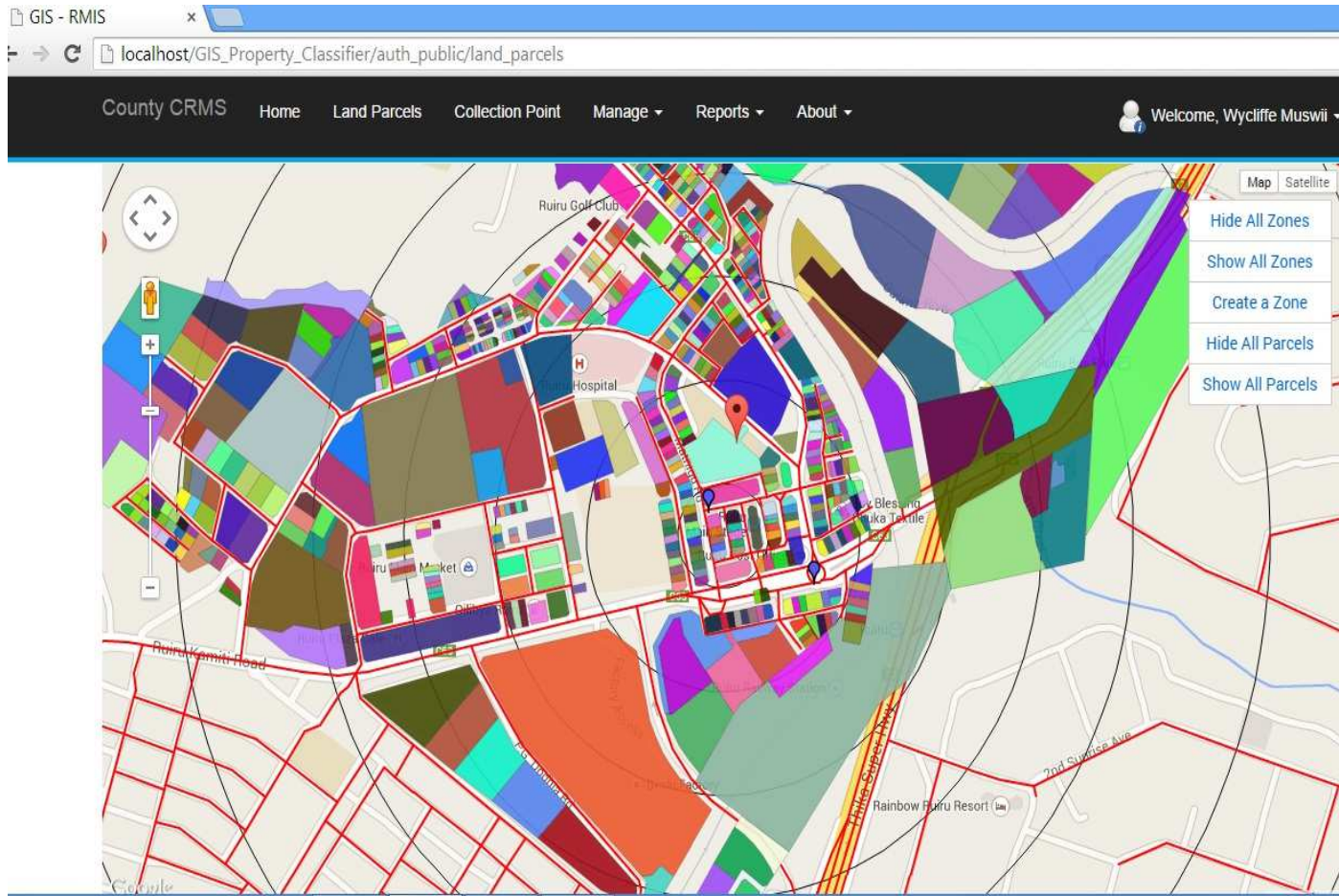
The module shall also contain a search tool and a button for editing the details of a particular selected property. This shall also have functionality for property valuation based on market value and user specified criteria as well as provide for the appropriate adjustments. This module shall be linked to the revenue management module for the billing and collection operations. It shall have a facility for producing billing and monitoring of property payment collected in the revenue collection system.

From this module, the revenue collection and land administration departments shall be able to administer related information using a special spatial data navigation panel. New zones and demarcations can be added in the system to create new parcels. Through a search space provided, the user can search the real geographical location of a parcel and query related (attribute) data as well as financial status. The algorithm integration shall actualize property classification and valuation using the computer assisted mass appraisal methodology, (Moore, 2005).

#### 4.3.3.1 The Data capture table

Attribute Name	Data Type	Size
Land_ID(PK)	Number	10
AL_NO	Number	10
TitleD_NO	Number	10
Region	Varchar2	64
Area_Name	Varchar2	64
Category	Varchar2	64
Size	Number	10
Location_ID	Number	10
Location_Name	Varchar2	64
Geometry	SDO_GEOME	Polygon
County	Varchar2	64
City	Varchar2	64
Country	Varchar2	64
Address	Nvarchar2	64
Value	Math	
Station_Name	Varchar2	64
Date_Stump	date	

**Table 7: Land parcel management module**



**Figure 19: Lands/Property Information Module Window**

#### 4.3.4 The revenue zones management module

This module shall form the system’s attribute database with all the relevant information pertaining to an item such as; item description, statistical data such as item profile, item location, zone and class, link to the owner, registration date, rate, amount due, payee, person posting the data, date of payment ,etc.

It shall also provide an inventory of land, business base and property of the county. It shall also contain information of the people in charge of the property and their status. It shall also contain functions that give jurisdiction the ability to register, consolidate and track information. The module shall allow printing of reports and query information retrieved. This module shall contain a valuation and billing functions.

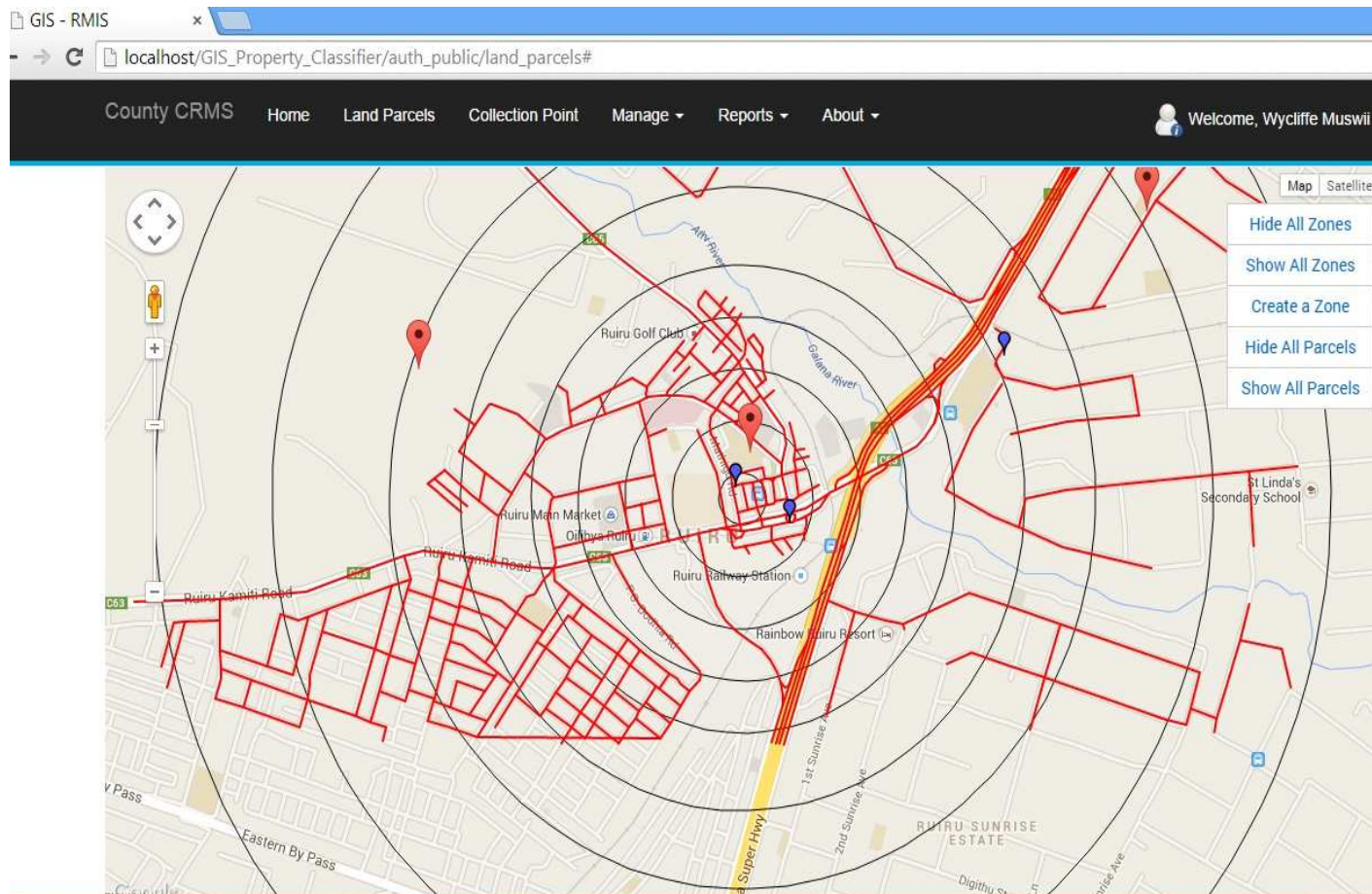
This is a flexible invoicing of collection system that shall be used to invoice property rate billing, service charges etc. This function shall be used to print all bills on user commands, update the revenue accounts receivable database, calculate financial and past due account charges and keep track of the revenue accounts.

The billing function shall link the bills to property and businesses to individuals (owners or managers), in order to facilitate different types of billing. A crystal-reporting tool shall also be provided for easy generation of reports. It shall allow the users to query view and print customized reports. The reports shall be exportable to PDF, MS excel, XML, CV among others.

Attribute Name	Data Type	Size
<b>Tax_ID(PK)</b>	Number	10
Levy_Type	Varchar2	64
Tax_due	Varchar2	64
Amount_paid	Varchar2	64
Tax_balance	Varchar2	64
Location_ID	Number	10
Collection_ID	Number	10
Business_ID	Number	10
Owner_ID	Number	10
Item_Name	Varchar2	64
Item_ID	Number	10
Tax_rate	Varchar2	64

Process ID	Number	10
Business Name	Varchar2	64
Payee Name	Varchar2	64
Category	Varchar2	64

**Figure 20: Revenue item data model**

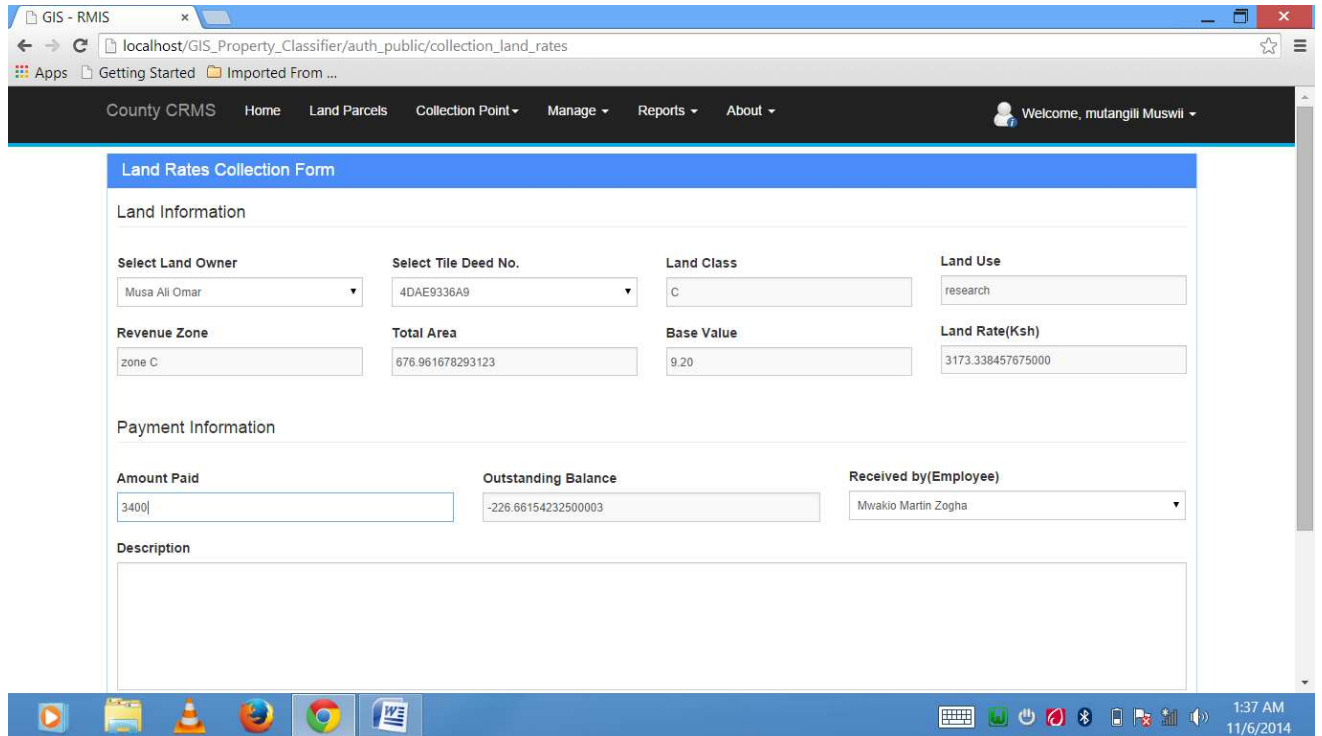


**Figure 21: Revenue zones**

#### 4.3.5 Revenue collection point module

This module shall be used for collection of revenue ranging from parking fees, land rates, license fees, transfer fees and any other.





**Figure 22: Collection point for other levies**

At the collection point, data on land rates and other revenue collections like parking and business permit fees shall be captured here and all the transaction information captured and stored.

Land rates shall also be automatically computed and invoiced. Where payment is made, payment status shall be reflected, showing the received amount and the outstanding balances.

From this point, it will be possible to generate customized business and asset reports and this shall make it possible for the revenue collector to track revenue.

### 4.3.5.1 Land management window

County CRMS Home Land Parcels Collection Point Manage Reports About Welcome, Wycliffe Muswii

#### Land Parcels

Add New Parcel Tools

records Search:

ID	Class	Zone	Used for	Allocation No.	Title Deed No.	Owner	Area (Sq Meters)	
1	C	Zone A	research	--	--	Unknown	563.809445001580	View Edit Delete
2	B	Zone A	hospital	--	--	Unknown	658.708195313764	View Edit Delete
3	A	Zone A	research	--	--	Unknown	2310.940099259742	View Edit Delete
4	C	Zone A	research	--	--	Unknown	676.961678293123	View Edit Delete
5	A	Zone A	factory	--	--	Unknown	758.035500329908	View Edit Delete
6	A	Zone A	factory	--	--	Unknown	1744.296966067523	View Edit Delete
7	B	Zone A	factory	--	--	Unknown	737.761196824367	View Edit Delete
8	C	Zone A	research	--	--	Unknown	461.239404240438	View Edit Delete
9	B	Zone A	research	--	--	Unknown	3932.188511677467	View Edit Delete
10	A	Zone A	school	--	--	Unknown	490.866494948182	View Edit Delete

Figure 23: Parcel management window

### 4.3.6 Revenue tracking and reporting module

This module shall have the capability to query and track information related to revenue item with a flexible database design that can be tailored to specific requirements. This module shall enable the system to have the capability to show the payment status of each and every parcel and other related attribute data. It shall be able to link the reporting module in order to track land rate payment status.

Attribute Name	Data Type	Size
Employee_ID(PK)	Number	10
Transaction_ID	Number	10
Transaction_type	Varchar2	64
Levy_Type	Varchar2	64
Status_report	Varchar2	64
Transacton_date	Date	
Date_ID	Date	
Next_pay_date	Date	
Debits	Varchar2	64
Credits	Varchar2	64
Amount_owing	Varchar2	64

**Table 8Table 9: Revenue tracking and audit model**

This module shall also capture each and every transaction and shall include data like levy type, transaction type, amount, date, day and time of a transaction.

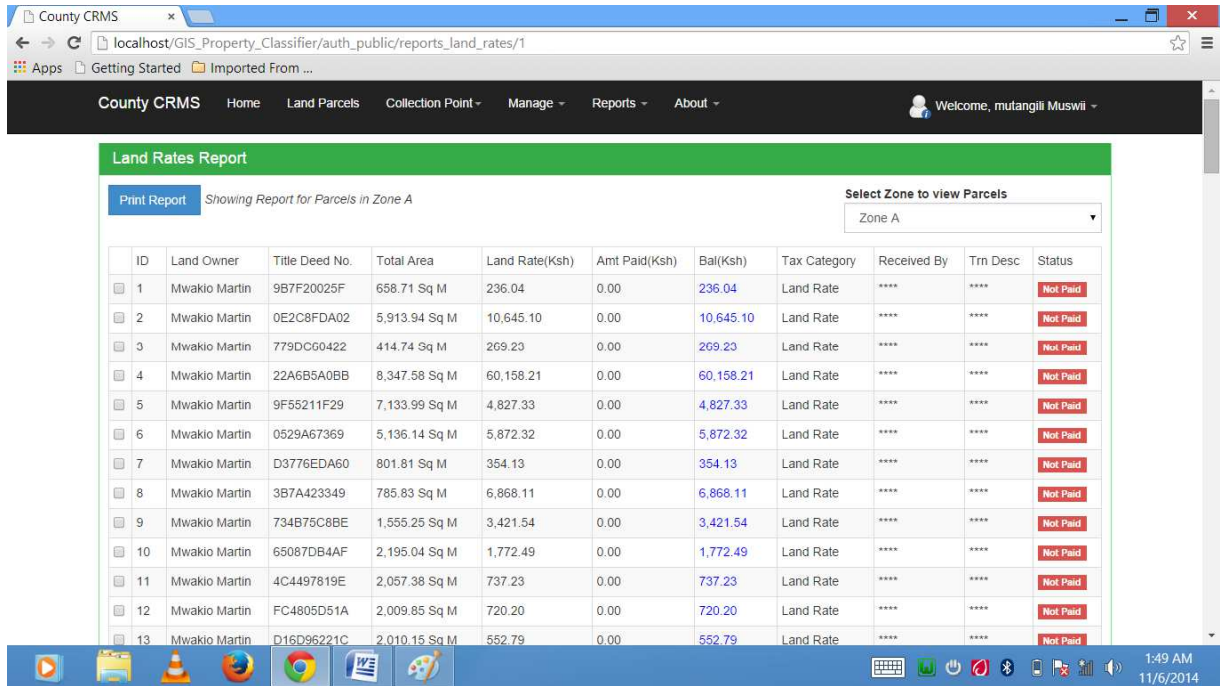


Figure 24: Payment status report

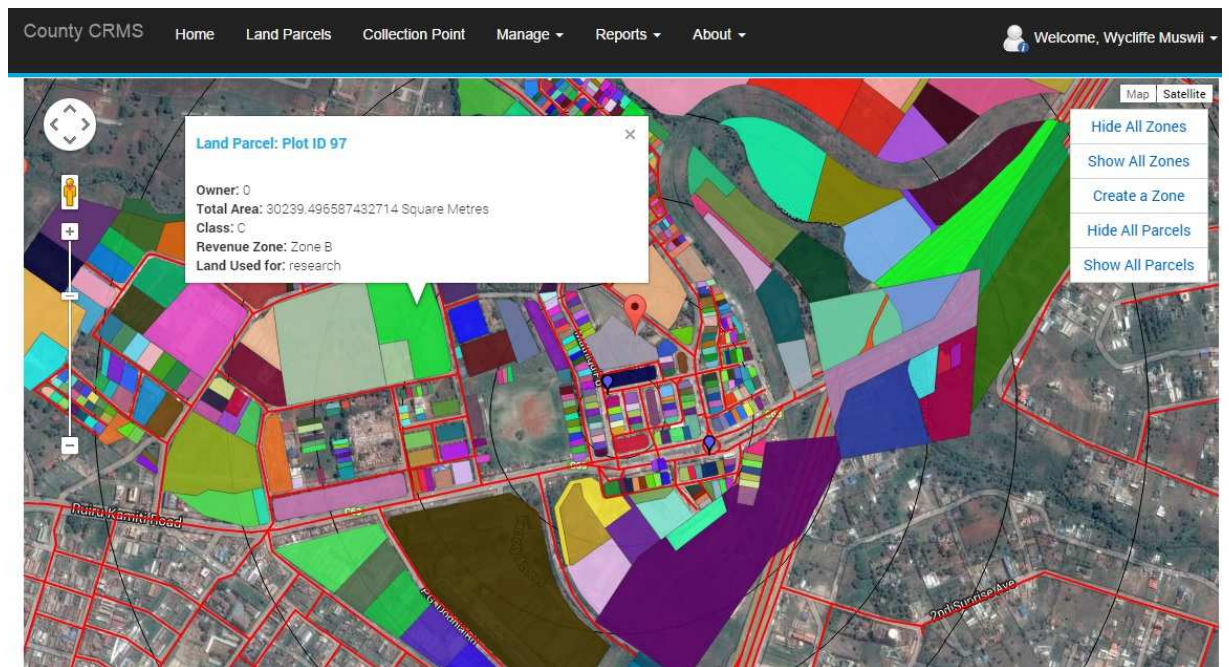


Figure 25: GUI navigation menus and property attribute window.

#### ***4.1.1.1 Querying profile table***

The following steps were performed to install and query the Oracle-supplied profile tables.

- 1 Logged on to the database as the geocoder user. The geocoder user is the user under whose schema the geocoder schema will be loaded.
- 2 Created the GC\_COUNTY\_PROFILE, GC\_PARSER\_PROFILES and GC\_PARSER\_PROFILEAFS tables by calling the SDO\_GCDR.CREATE\_PROFILE\_TABLES() procedure:

```
SQL>CALL SDO_GCDR.CREATE_PROFILE_TABLES();
```

- 3 Populated the GC\_PARSER\_PROFILES and GC\_PARSER\_PROFILEAFS tables by running the sdogcprs.sql script found in the \$ORACLE\_HOME/md/admin subdirectory:

```
@$ORACLE_HOME/md/admin/sdogcprs.sql
```

- 4 Queried the parser profile tables to determine if parser profiles for the counties of interest are supplied:

```
SQL>SELECT DISTINCT(country_code) FROM gc_parser_profiles;
```

```
SQL>SELECT DISTINCT(country_code) FROM gc_parser_profileafs;
```

#### ***4.1.1.2 Using the Database Geocoder***

The database geocoder is ready for use once the geocoder schema has been loaded into the database. Addresses are then geocoded by calling subprograms of the SDO\_GCDR PL/SQL package. The addresses are entered into these subprograms using specific geocoding data types

and the geocoded results are also returned in these data types. There are three data types that must be understood in order to enter addresses and extract and interpret geocoding results.

The SDO\_GEO\_ADDR type, the SDO\_KEYWORDARRAY type, and the SDO\_ADDR\_ARRAY type are the data types used in database geocoding. Addresses to be geocoded are represented either as formatted addresses or unformatted addresses. The SDO\_GEO\_ADDR type is used to describe formatted addresses, while the SDO\_KEYWORDARRAY is used to describe unformatted addresses. The SDO\_ADDR\_ARRAY type stores multiple SDO\_GEO\_ADDR objects and is used when multiple addresses are returned. A description of these data types and the SDO\_GCDR PL/SQL package follows.

#### **4.3.7 Computer assisted Valuation using an algorithm**

Efforts by previous researchers on property valuation and classification for taxation purposes have been explored. Nevertheless, it is necessary for assessors to prepare value estimates for huge numbers of properties. Computer assisted programs using Automated Valuation Models (Moore, 2005) have been built. A process called Computer Assisted Mass Appraisal (CAMA) that has evolved for the past four decades can handle the logistic challenge presented by the task. Computer –assisted mass valuation methodology are quite useful for property taxation purposes, where the main interest is not to obtain a market value for each and every property in the jurisdiction but to obtain an equitable and fair distribution of individual property values to establish an appropriate tax base.

Fairness is an important consideration when dealing with taxation issues therefore is ensured because exactly the same valuation criteria are applied to the characteristics of every property (Kelly et al, 2001). Moreover, the same bases values are used for similar land locations and building classes. Additionally if a computer assisted mass valuation methodology is used, the possibility of erroneous calculations are reduced.

In this approach , revenue items are given relative values compared to any other item in the jurisdiction, calculated on a common base value for the item in question and then modified by the set of co-efficient taking into account specific criteria's such as Type, Use, Class,

Categorizations and Revenue Zones. From the replacement cost formula for valuation the final taxable value is multiplied by the tax or levy rate to equal the Annual Property Tax.

Below is the valuation methodology algorithm implementation.

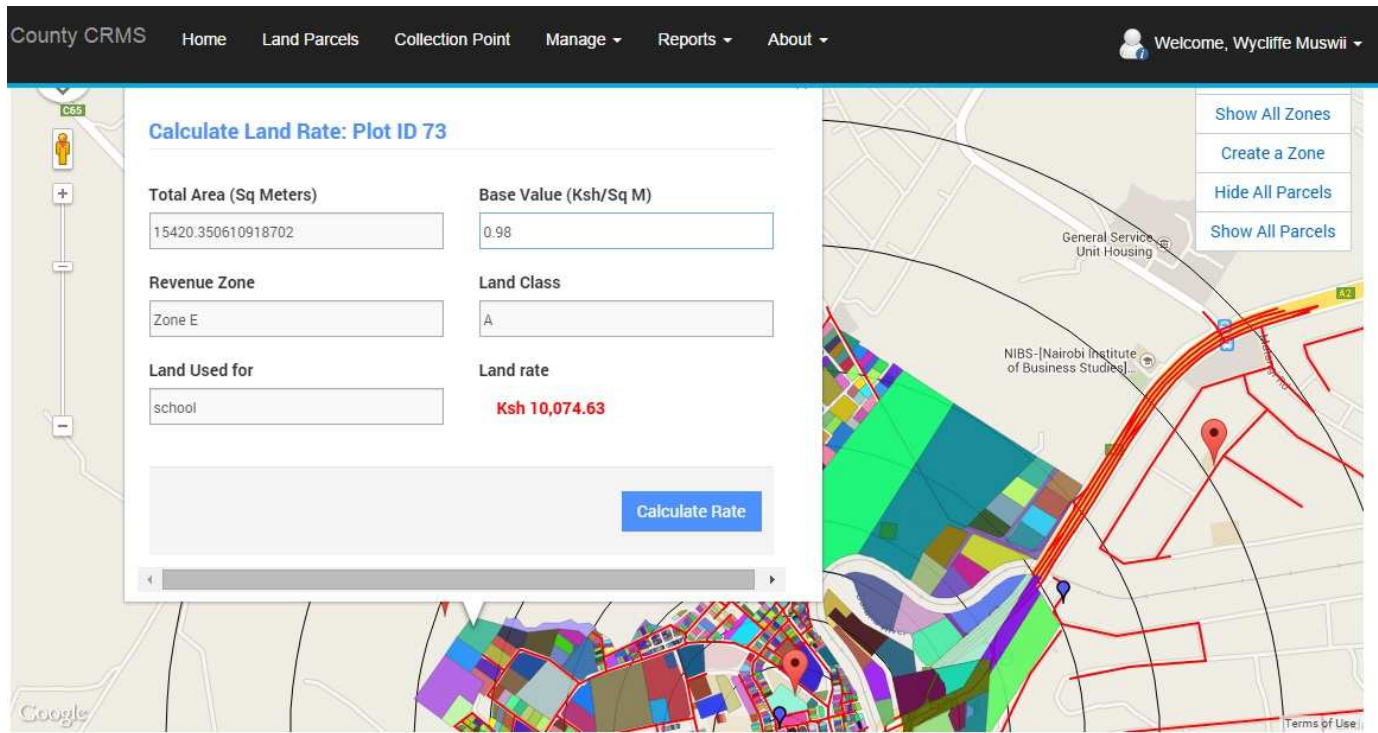


Figure 26: Business Valuation Window (computer assisted appraisal function)



Table 10: Map showing the spatial pointer



### 4.3.8 Implementation

The implementation of the system involved the selection and use of one of the system conversion methods that consist of four major techniques for implementation, (Sarkis, 2000). Namely:

- a) **Parallel conversion:** The existing system and the new system operate simultaneously until there is confidence that the new system is working properly.
- b) **Direct conversion:** the old system is removed totally and the new system takes over.
- c) **Phased conversion:** Modules of the new system are gradually introduced one at a time using either direct or parallel conversion.
- d) **Pilot conversion:** The new system is fully implemented on a pilot basis in one segment of the organization.

Sarkiset *et al* stated that determining the most appropriate implementation method is dependent on how much risk a company is willing to take. For this case, the researcher has chosen the Parallel conversion method. Changeover can be rapid or slow, depending on the method (Gary, B. Shelly, 2010). The system changeover explanation is expressed in the diagram below:

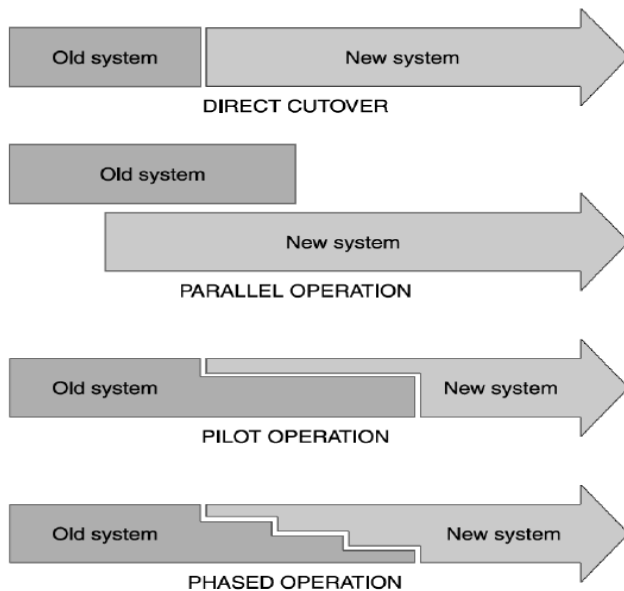


Figure 27: System conversion methods

#### **4.3.9 Testing**

The success of any revenue system requires a number of institutional issues to be addressed. It was therefore essential to focus on the needs of the users of the system and to analyze the existing operational procedures of the revenue mobilization process. Kiambu County was chosen as a case study for testing. The primary objective of the study was to identify common operational and administration procedures. It is also to identify opportunities for improvement within the scope of the revenue administration, not only in relation to current practices, but also in anticipation of future developments such that information and recommendations gathered in this process will provide a framework suitable for any selected local assembly.

Sample revenue registers obtained from the County Office were in tables in hard formats having field names such as Reference, Name of owner, address, property analysis, valuation amount and the gross value. The data was field validated and exported into the database in the Server Engine. Other information needed to complete revenue item's profile was as well collected during the field validation. In the ArcGIS, attributes were created to contain all the relevant information about all the spatial data captured.

Further research will be conducted to ascertain the impact analysis of the system and further collect views from the users of the system for further improvement.

## **5 CHAPTER FIVE: CONCLUSION AND RECOMMENDATION**

### **5.1 Conclusions**

Computerized County Revenue mobilization System (CRMS) is a feature rich application system designed to meet world class service requirements of the mission critical operations of the County governments. The application was tested with respect to the problems identified with the existing system of operations and therefore if adopted the governments will perform excellently. The deployment of this application will enhance the revenue generation capacity of the revenue collectors, pluck all leakages in the revenue collection and management process and put the country in a better position to meet her obligation to citizens hence contributing to the achievement of the vision 2030.

Also in this study, a better implementation of the CAMA algorithms has been implemented by addition of new mathematical functions to automate land valuation. This will contribute to better land assets management and therefore if adopted by any organization or government it can reduce manual computation hence contributing to efficiency. With this system, tracking of revenue using spatial data has been realized and this has contributed a lot in addition of value to spatial data which has basically not been widely operationalized. This summarizes the objectives set by the researcher and have all been met.

### **5.2 Recommendations for future work**

Further research should focus on enhancing the system to include other modules like for disaster management. Since the system has spatial data that shows land information and cadastral layouts, transport and agricultural information can also be loaded. This shall be critical especially determining the cost of agricultural land.

### 5.2.1 Work Plan and Timeline

The proposed study will take 6 months. The Gantt chart in table 5.11 below is a tentative study schedule.

ACTIVITY	TIME IN MONTHS					
	2	2	2	2	2	2
Designing data collection tools						
Data collection						
Analysis of the data						
Design of the proposed model						
Developing the model prototype						
Testing the prototype						
Designing the implementation strategy						
Report writing and submission						

Figure 28: Gantt chart showing the work schedule.

### 5.2.2 Resources and Budget

The table below shows the resources required and the cost of the project.

ITEM	QNTY	UNIT COST (KSHS)	APPROXIMATE COST (KSHS)
Laptop Computers and software	1	72,000.00	72,000.00
A GSM Modem	1	3,500.00	4,000.00
Printing questionnaires	200 X 4 pgs	10.00	2,000.00
Data collection		20,000.00	20,000.00
Printing report		500.00	1,000.00
Stationeries and consumables		1,000.00	1,000.00
Contingencies		2,000.00	2,000.00
<b>Total</b>			<b>102,000.00</b>

**Figure 29: Resources and Budget**

### 5.3 5.3 Appendixes

#### 5.3.1 Appendix I: Declaration of Originality Form

This form must be completed and signed for all works submitted to the University for Examination

Name of Student \_\_\_\_\_

Registration Number \_\_\_\_\_

College \_\_\_\_\_

Faculty/School/Institute \_\_\_\_\_

Department \_\_\_\_\_

Course Name \_\_\_\_\_

Title of the work \_\_\_\_\_

#### 5.3.2 Declaration

1. I understand what Plagiarism is and I am aware of the University's policy in this regard
2. I declare that this \_\_\_\_\_ (Thesis, project, essay, assignment, paper, report, etc) is my original work and has not been submitted elsewhere for examination, award of a degree or publication. Where other people's work or my own work is used has been properly acknowledged and referenced in accordance with the University of Nairobi's requirements.
3. I have not sought or used the services of any professional agencies to produce this work
4. I have not allowed, and shall not allow anyone to copy my work with the intention of passing it off as his/her own work
5. I understand that any false claim in respect of this work shall result in disciplinary action, in accordance with University Plagiarism Policy.

**Signature:** \_\_\_\_\_

**Date:** \_\_\_\_\_

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**5.4.1 Appendix B: Questionnaires**

**5.4.1.1 ME**

**KEY SUCCESS FACTORS FOR IMPLEMENTATION OF A REVENUE COLLECTION SYSTEM USING GIS**

This questionnaire is designed to collect data from the tax payer in order to establish the key success factors for implementation of a revenue collection system using GIS. The data shall be used for Academic purpose only, and will be treated with strict confidence. Your participation in facilitating this study is highly appreciated. All information in this questionnaire will remain absolutely confidential and will be seen only by academic researchers involved in this study.

**SECTION I: Respondent's Demographic Details**

1. Gender

Male

Female

2. Age group

18-25

25-35

35-45

45 and above

4. Name of County.....

5. Type of business .....

<b>Section II: General questions to medium enterprises</b>
--

On the scale of (1-5), please indicate by ticking.

Questions		Very Important	Important	Not Important	None
		(4)	(3)	(2)	(1)
1.	Is tax/revenue collection important in your County?				

Questions		Strongly Agree	Agree	Disagree	Strongly Disagree	Do not Know
		(5)	(4)	(3)	(2)	(1)
2	Business owners face problems with the county government trying to comply with the tax regulations.					
3	Business owners face difficulties due to lack of efficiency while remitting their taxes to the county governments.					
4	The process of remitting such fees is cumbersome e.g. dominated by long queues.					
5	Do you agree that some citizens evade paying taxes?					
6	Proper planning and administration of revenue collection is in place in					

	your county.					
7	Do you agree that your county needs to improve on the current methods in place on planning and administration of revenue collection and spending /budgetary?					
8	Do you agree that the tax collection mechanism in your county can be improved through use of ICT?					

Thank you for taking your time to fill this questionnaire

5.4.1.2 RC

**KEY SUCCESS FACTORS FOR IMPLEMENTATION OF A REVENUE COLLECTION SYSTEM USING GIS**

This questionnaire is designed to collect data from the revenue collector (county governments) in order to establish the key success factors for implementation of a revenue collection system using GIS. The data shall be used for Academic purpose only, and will be treated with strict confidence. Your participation in facilitating this study is highly appreciated. All information in this questionnaire will remain absolutely confidential and will be seen only by academic researchers involved in this study.

**SECTION I: Respondent's Demographic Details**

1. Gender

Male

Female

2. Age group

18-25

25-35

35-45

45 and above

3. Highest Education Level

University

College

High School

Primary School

4. Name of County.....

5. Occupation.....



**Section II: Questions to tax collection authority and policy makers**

On the scale of (1-5) please indicate by ticking.

Questions	Very Important	Important	Not Important	None
	(4)	(3)	(2)	(1)
1. Is revenue collection important in your county?				

Questions	Strongly Agree	Agree	Disagree	Strongly Disagree	None
	(5)	(4)	(3)	(2)	(1)
2. The amount of revenue collected in my county is satisfactory.					
3. The current revenue collection mechanisms in my county are automated.					
4. There are errors and inconsistencies in revenue collection.					
5. The tax payers in my county have ways of evading taxes, fees, rates, licenses or rent.					
6. The county employees mandated to collect tax remit all the monies collected (100%).					
7. My county is losing revenue from tax that goes					

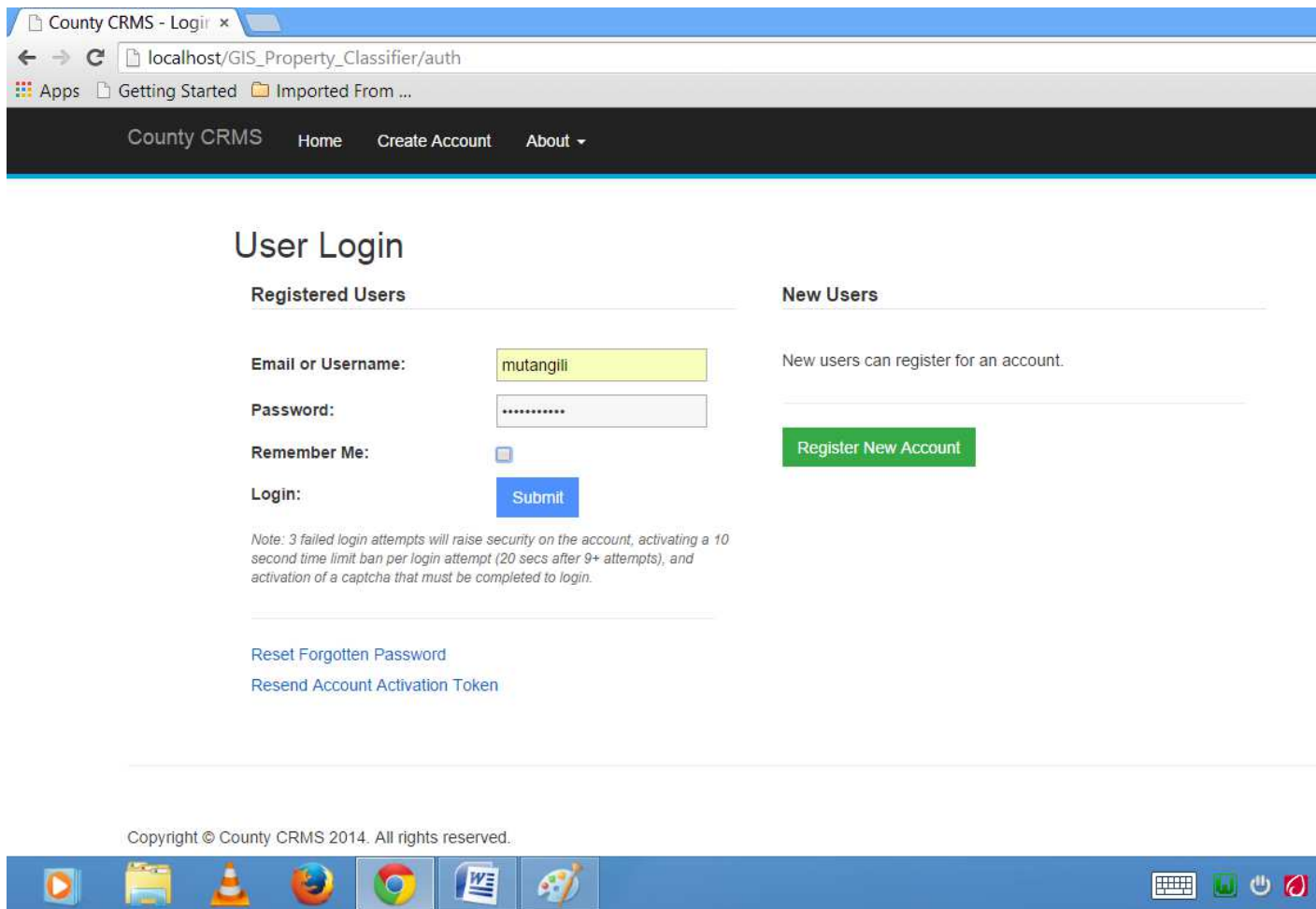
	uncollected.					
8	There is proper planning and administration of revenue in my county.					
9	The county government should improve on the current mechanisms in place on planning and administration of revenue.					
10	There are effective plans to improve on the current revenue collection mechanisms.					
11	There is awareness of the laws governing revenue collection and mobilization.					
12	My county is fully compliant with the said laws.					

13	There are sound mechanisms for tracking revenue collection and audit my county.					
14	The use of computerized geographical data and maps for my county can improve on revenue collection.					
15	There is a Geographic Information System (GIS) in my county that guides on revenue collection, decision making etc.					
16	There are disputes relating to revenue collection between					

	the citizens and the county government.					
17	It takes an unnecessary long amount of time for one to get a license, building or business permit in county					
18	The automation using computerized valuation methods for property rates can introduce fairness and reduce disputes on property valuation, tax, rates and fees.					

Thank you for taking your time to fill this questionnaire

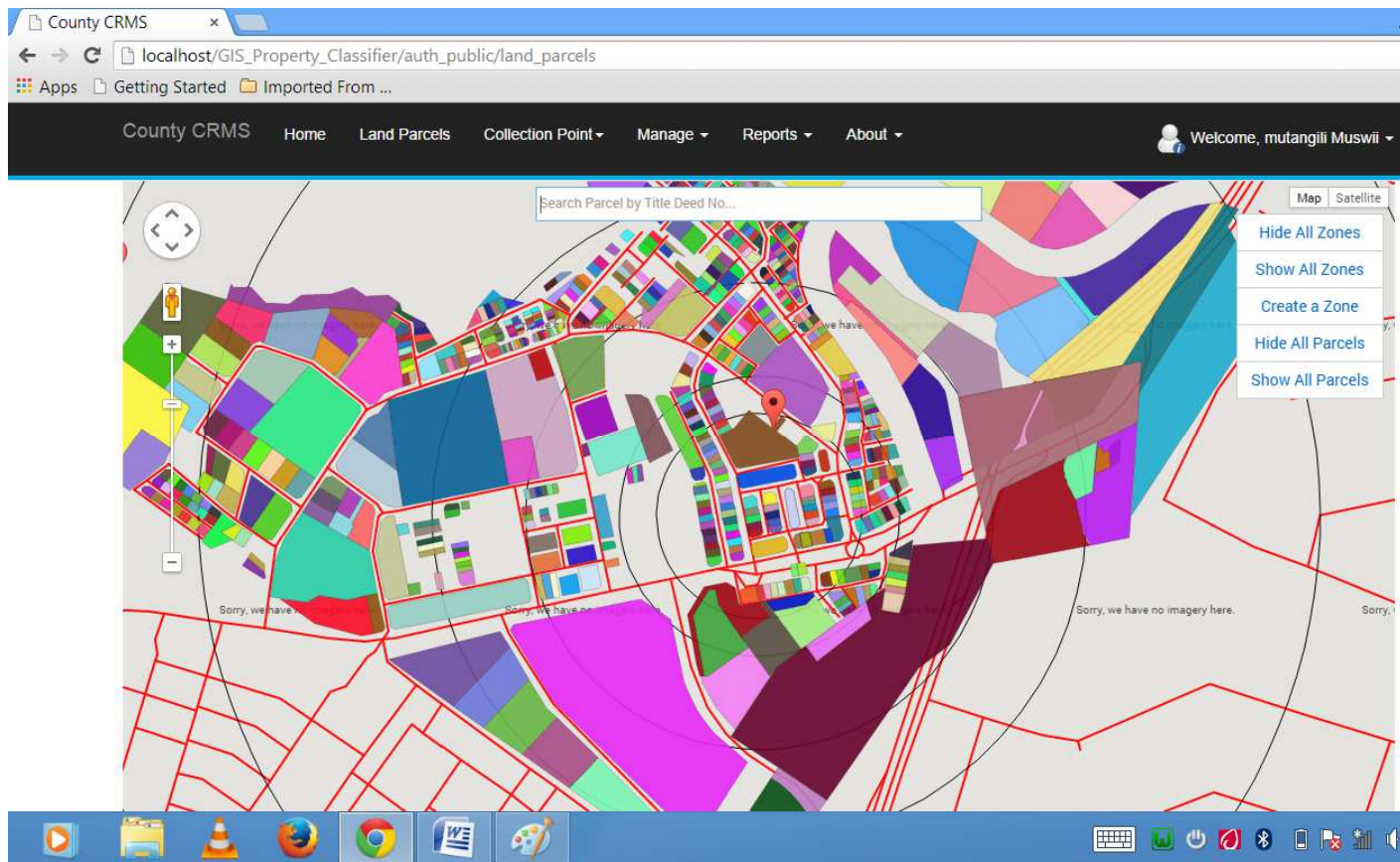
## 5.4.2 Appendix C: User manual



**Figure 30: Login Screen**

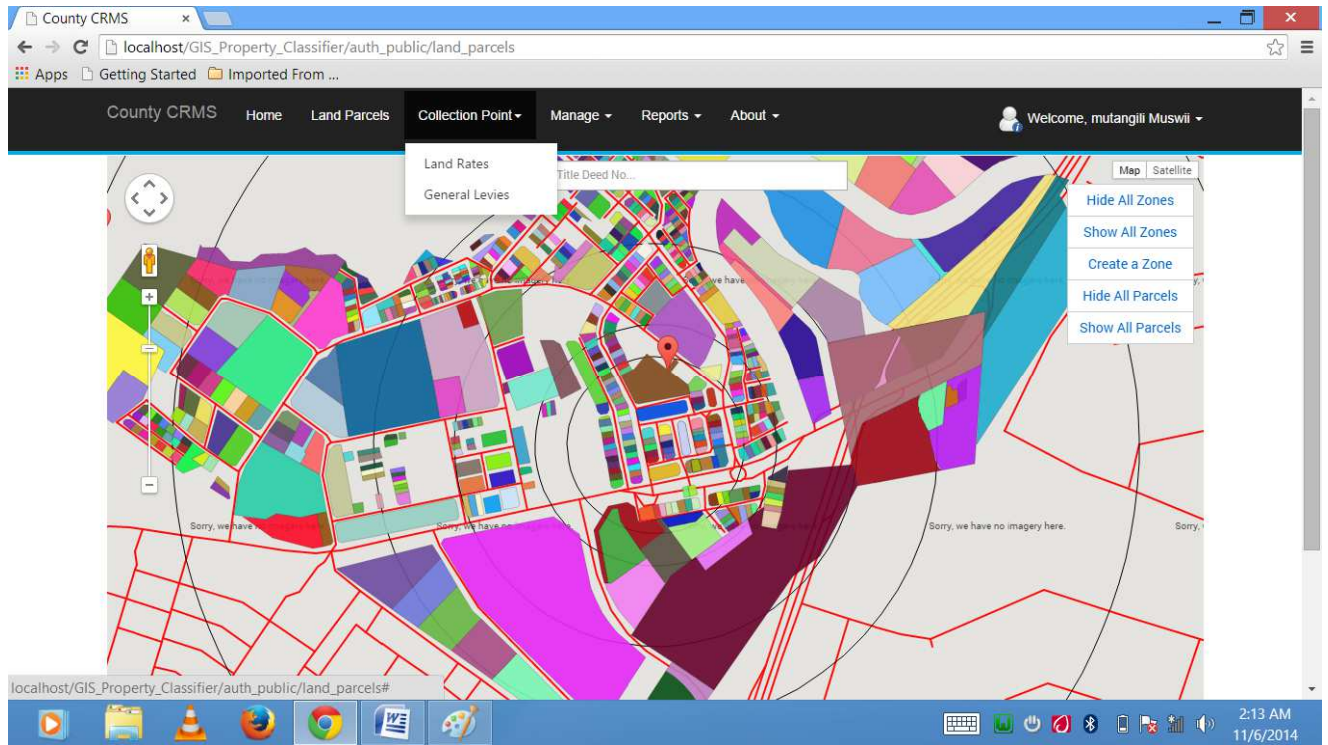
### 5.4.2.1 Description

This window shows how users shall register and authenticate to use the system. Due to the sensitivity of the system, users shall be granted access by the authentication module. The database administrator shall define the roles in the system. Guest users shall be required to register in order to view required information.



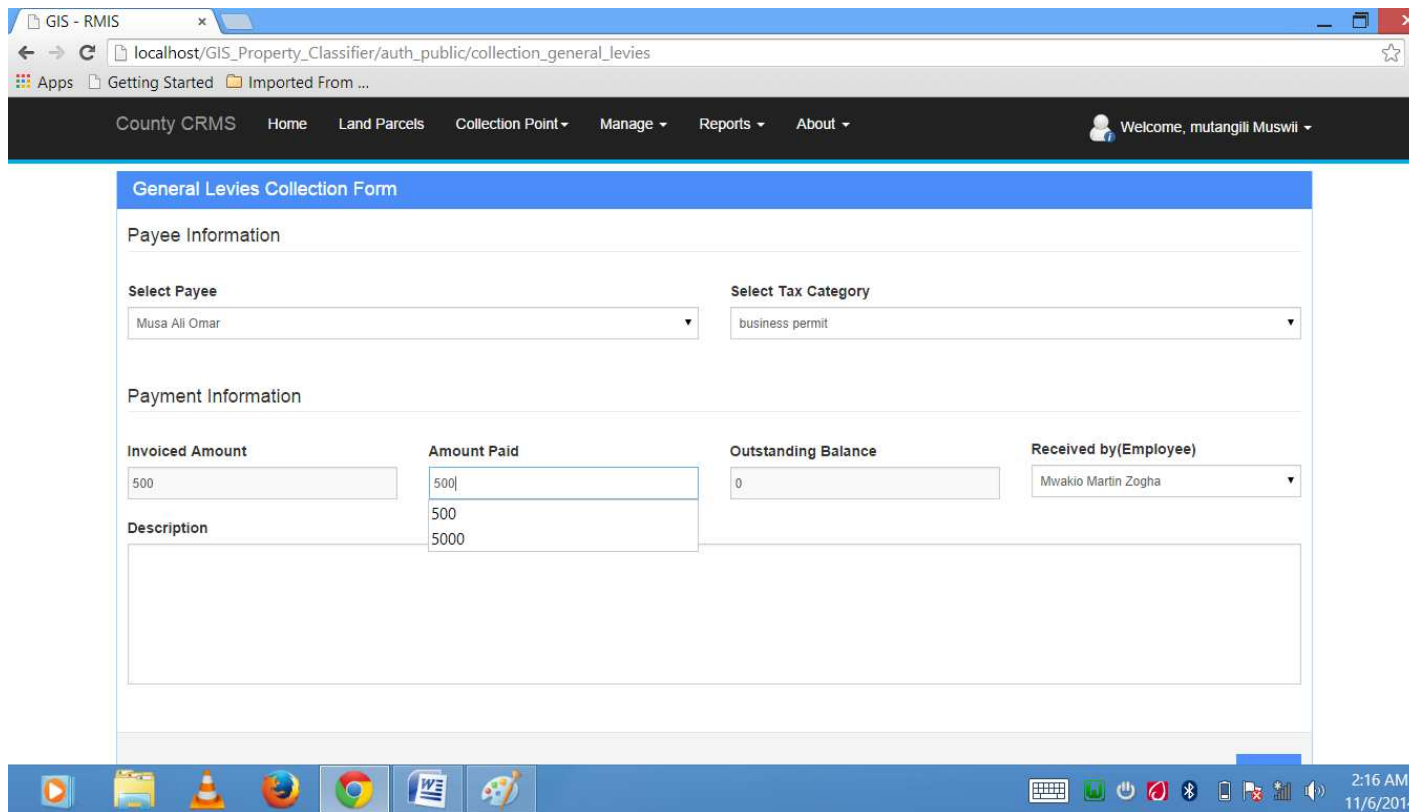
**Figure 31: Land parcels in Ruiru**

The revenue and land administration departments shall work through this interface. This window shall make it possible to administer revenue zones and add new parcels as well as generate reports from the system regarding the same.



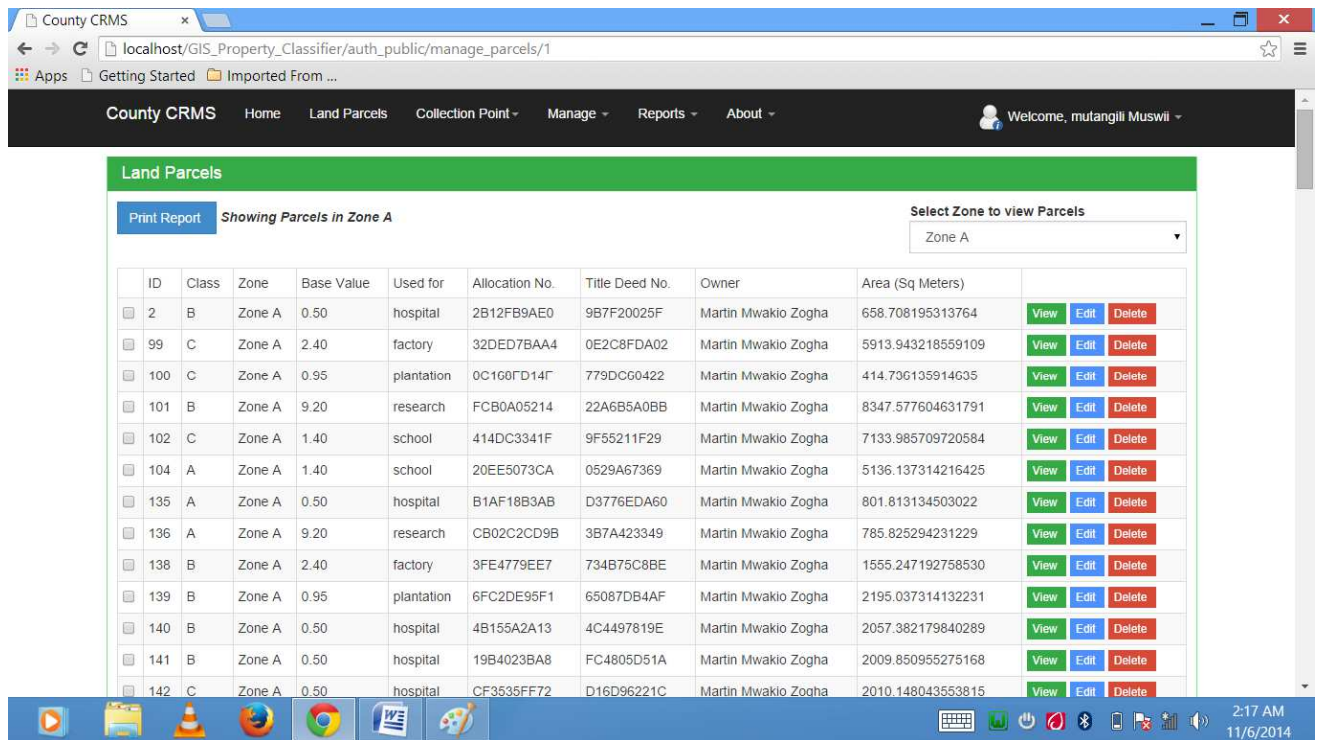
**Figure 32: Land rates and general levies collection window**

At this window, the revenue collector shall capture land rates and general levies including parking fees, business permit fee and other collections not specified and all the transaction data shall be stored in the system.. From this point, it shall also be possible to generate customized reports from the system on day to day transactions and other activities from the system.



**Figure 33: Rate determination function**

Land rates shall be automatically computed and invoiced as displayed in this window. Transaction status showing amount received and outstanding amount shall also be displayed.



**Figure 34: Land parcel management window**

As seen in this window, transaction reports can be generated based on zones or any other criteria as defined and therefore making reporting easy and efficient.



The screenshot shows a web browser window titled 'County CRMS' with the URL 'localhost/GIS\_Property\_Classifier/auth\_public/reports\_land\_rates/1'. The navigation menu includes 'Home', 'Land Parcels', 'Collection Point', 'Manage', 'Reports', and 'About'. A user profile 'Welcome, mutangili Muswii' is visible in the top right.

The main content area is titled 'Land Rates Report' and includes a 'Print Report' button and a dropdown menu 'Select Zone to view Parcels' set to 'Zone A'. Below this is a table with 13 rows of parcel data. Each row has a checkbox in the first column. The 'Status' column for all rows contains a red 'Not Paid' button.

ID	Land Owner	Title Deed No.	Total Area	Land Rate(Ksh)	Amt Paid(Ksh)	Bal(Ksh)	Tax Category	Received By	Trn Desc	Status
1	Mwakio Martin	9B7F20025F	658.71 Sq M	236.04	0.00	236.04	Land Rate	****	****	Not Paid
2	Mwakio Martin	0E2C8FDA02	5,913.94 Sq M	10,645.10	0.00	10,645.10	Land Rate	****	****	Not Paid
3	Mwakio Martin	779DCG0422	414.74 Sq M	269.23	0.00	269.23	Land Rate	****	****	Not Paid
4	Mwakio Martin	22A6B5A0BB	8,347.58 Sq M	60,158.21	0.00	60,158.21	Land Rate	****	****	Not Paid
5	Mwakio Martin	9F55211F29	7,133.99 Sq M	4,827.33	0.00	4,827.33	Land Rate	****	****	Not Paid
6	Mwakio Martin	0529A67369	5,136.14 Sq M	5,872.32	0.00	5,872.32	Land Rate	****	****	Not Paid
7	Mwakio Martin	D3776EDA60	801.81 Sq M	354.13	0.00	354.13	Land Rate	****	****	Not Paid
8	Mwakio Martin	3B7A423349	785.83 Sq M	6,868.11	0.00	6,868.11	Land Rate	****	****	Not Paid
9	Mwakio Martin	734B75C8BE	1,555.25 Sq M	3,421.54	0.00	3,421.54	Land Rate	****	****	Not Paid
10	Mwakio Martin	65087DB4AF	2,195.04 Sq M	1,772.49	0.00	1,772.49	Land Rate	****	****	Not Paid
11	Mwakio Martin	4C4497819E	2,057.38 Sq M	737.23	0.00	737.23	Land Rate	****	****	Not Paid
12	Mwakio Martin	FC4805D51A	2,009.85 Sq M	720.20	0.00	720.20	Land Rate	****	****	Not Paid
13	Mwakio Martin	D16D96221C	2,010.15 Sq M	552.79	0.00	552.79	Land Rate	****	****	Not Paid

Figure 35: Land rates reporting window

### 5.4.3 Sample Code (data tables)

The data tables, GC\_ROAD\_SEGMENT\_<suffix>, GC\_AREA\_<suffix>, GC\_ROAD\_<suffix>, GC\_INTERSECTION\_<suffix>, GC\_POSTAL\_CODE\_<suffix>, GC\_POI\_<suffix> and GC\_ADDRESS\_POINT\_<suffix> store address and coordinate information for a single country or group of countries of interest. The mandatory suffix for these tables is data-provider- or user-specified and is typically used to identify the country or group of countries to which the data belongs, for example, “US” for the United States or “EU” for Europe. However, any 5-characters-or-less can be used for the table-name suffix and the same suffix must also be used in the creation of indexes on these tables.

#### 4.1.1.3 Storing and Retrieving spatial data in a table

Creating tables for special data was done using CREATE TABLE statement.

```
SQL> CREATE TABLE outbreaks
```

```
(OID integer NOT NULL, address nvarchar2(120), city_code integer, locsde.st_geometry);
```

<i>OUTPUT</i>		
	<b>Outbreaks</b>	
	Address	nvarchar2 (120)
	City_Code	integer
	Location	sde.st_geometry

**Table 11: Table outbreaks**

```
SQL> CREATE TABLE sensitive_areas (
area_id integer primary key autoincrement not null,
name text(128),
area_size float,
type text(10)
);
```

<i>OUTPUT</i>	<b>Sensitive_areas</b>	
	Area_ID	integer(PK)
	Name	text(128)
	Area_size	float

Type	text(10)
------	----------

**Table 12: Table sensitive\_areas**

Table sensitive\_areas

```
SELECT AddGeometryColumn(
null,
'sensitive_areas',
'zone',
4326,
'polygon',
'xy',
'null'
);
```

*Data was loaded in using INSERT statement*

```
INSERT INTO OUTBREAKS (OID, address, city_code, loc)
VALUES (1,
'1420 Eastleigh',
43,
sde.st_geometry (0.00003, 0.00051, null, null, 4326)
);
```

```
INSERT INTO OUTBREAKS (OID, address, city_code, loc)
VALUES (2,
'638 Muthini',
10,
sde.st_geometry (0.00020, -0.00029, null, null, 4326)
);
```

```
INSERT INTO OUTBREAKS (OID, address, city_code, loc)
VALUES (3,
'5579 Katelembu',
96,
sde.st_geometry (-0.00048, -0.00009, null, null, 4326));
```

OID	Outbreaks	
1	1420, Eastleigh	43
2	638, Muthini	10
3	5579, Katelembu	96
4		

### Table 13: Data insertion table

#### Data insertion table

When using ST\_Geometry functions in Oracle, you must qualify the functions and operators with sde. For example, ST\_Buffer would be sde.ST\_Buffer. Adding sde. indicates to the software that the function is stored in the schema of the sde user.

#### 4.1.1.4 Constructor functions used

Constructor functions create geometry from a well-known text description or another data format, such as well-known binary or shape files.

When you provide a well-known text description to construct a geometry, the measure coordinate must be specified last. For example, if your text includes coordinates for x, y, z, and m, they must be provided in that order, not x, y, m, z.

Geometry can have zero or more points and is considered empty if it has zero points. The point subtype is the only geometry that is restricted to zero or one point; all other subtypes can have zero or more.

The following sections describe the geometry superclass and subclass geometries, and lists the functions that were used to construct each one of them.

#### ❖ The geometry superclass

The ST\_Geometry superclass cannot be instantiated; although you can define a column as an ST\_Geometry type, the actual data inserted is defined as either point, linestring, polygon, multipoint, multilinestring, or multipolygon entities.

The following functions can be used to create a superclass to hold any of the aforementioned entity types.

- ST\_Geometry;
- ST\_GeomFromShape;

- ST\_GeomFromText;
- ST\_GeomFromWKB;

❖ **Subclasses**

You can define a feature as a specific subclass, in which case only the entity type allowed for that subclass can be inserted. For example, ST\_PointFromWKB can only construct point entities.

❖ **ST Point**

AnST\_Point is a zero-dimensional geometry that occupies a single location in coordinate space. An ST\_Point has a single x,y coordinate value, is always simple, and has a NULL boundary. ST\_Point can be used to define features such as oil wells, landmarks, and water sample collection sites.

❖ **Functions that create a point are as follows:**

ST\_Point;

ST\_PointFromShape ;

ST\_PointFromText;

ST\_PointFromWKB;

ST\_MultiPoint;

AnST\_MultiPoint is a collection of ST\_Points and, like its elements, has a dimension of 0. AnST\_MultiPoint is simple if none of its elements occupy the same coordinate space. The boundary of anST\_MultiPoint is NULL. ST\_MultiPoints can define such things as aerial broadcast patterns and incidents of a disease outbreak.

❖ **Functions that create a multipoint geometry are as follows:**

ST\_MultiPoint;

ST\_MPointFromShape;

ST\_MPointFromText;

ST\_MPointFromWKB;

❖ **ST LineString**

AnST\_LineString is a one-dimensional object stored as a sequence of points defining a linear interpolated path. The ST\_LineString is simple if it does not intersect its interior. The endpoints (the boundary) of a closed ST\_LineString occupy the same point in space. AnST\_LineString is a ring if it is both closed and simple. Like the other properties inherited from the superclass ST\_Geometry, ST\_LineStrings have length. ST\_LineStrings are often used to define linear features such as roads, rivers, and power lines.

The endpoints normally form the boundary of anST\_LineString unless the ST\_LineString is closed, in which case the boundary is NULL. The interior of anST\_LineString is the connected path that lies between the endpoints unless it is closed, in which case the interior is continuous.

Functions that create linestrings include the following:

ST\_LineString;

ST\_LineFromShape;

ST\_LineFromText;

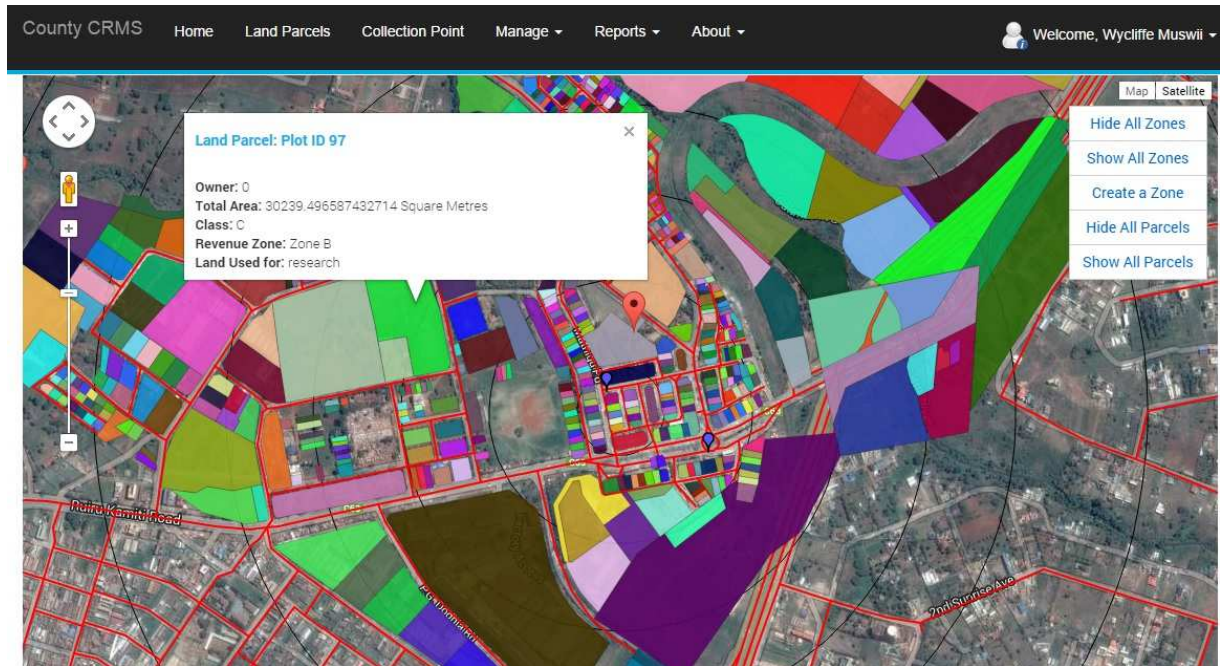
ST\_LineFromWKB;

ST\_Curve;

- ❖ **ST\_Polygon**: AST\_Polygon is a two-dimensional surface stored as a sequence of points defining its exterior bounding ring and more interior rings. ST\_Polygons are always simple. ST\_Polygons define features that have spatial extent, such as parcels of land, water bodies, and areas of jurisdiction.

#### **5.4.4 ST\_Polygon objects Query.**

This graphic shows examples of ST\_Polygon objects with the boundaries defined by rings.



**Figure 36: Land output as ST\_Polygon objects**

#### 4.1.1.5 Geospatial functions employed

##### 5.4.4.1.1 Function for creating and querying revenue zones

```
function get_zones() {
    // Start XML file, create parent node
    $dom = new DOMDocument("1.0");
    $node = $dom->createElement("zones");
    $parnode = $dom->appendChild($node);

    $query = $this->db->query('SELECT id, name, radius, X(center_point) AS lat,
Y(center_point) AS longi FROM revenue_zone ORDER BY radius DESC');
    $result = $query->result_array();
    if (!$result) {
        die('Invalid query: ' . mysql_error());
    }
    header("Content-type: text/xml");
```

```

    foreach ($result as $row) {
// ADD TO XML DOCUMENT NODE
        $node = $dom->createElement("zone");
        $newnode = $parnode->appendChild($node);

        $newnode->setAttribute("id", $row['id']);
        $newnode->setAttribute("name", $row['name']);
        $newnode->setAttribute("lat", $row['lat']);
        $newnode->setAttribute("lng", $row['longi']);
        $newnode->setAttribute("radius", $row['radius']);
    }
    echo $dom->saveXML();
}

```

#### 5.4.4.1.2 Function for querying specific objects from database

```

function get_roads() {
    // Start XML file, create parent node
    $dom = new DOMDocument("1.0");
    $node = $dom->createElement("roads");
    $parnode = $dom->appendChild($node);

    $query = $this->db->query('SELECT id, AsText(line_path) AS points FROM roads');
    $result = $query->result_array();
    if (!$result) {
        die('Invalid query: ' . mysql_error());
    }
}

```



```

header("Content-type: text/xml");
foreach ($result as $row) {
    // ADD TO XML DOCUMENT NODE
    $node = $dom->createElement("road");
    $newnode = $parnode->appendChild($node);
    $poly_arr = $this->convert_wkt_to_poly_arr($row['points']);
    foreach ($poly_arr as $poly) {
        $coords = explode(',', $poly);
        $total = count($coords);
        for ($i = 0; $i < $total; $i++) {
            list($lon, $lat) = explode(' ', $coords[$i]);
            if ($i == 0) {
                $lon = -abs($lon);
            }
            $coordnode = $dom->createElement('coordinates');
            $coordnode = $newnode->appendChild($coordnode);
            $coordnode->setAttribute("lat", $lat);
            $coordnode->setAttribute("lng", $lon);
        }
    }
    $newnode->setAttribute("id", $row['id']);
}
echo $dom->saveXML();
}

```

```

function slice_points_from_kml() {
    $file = base_url() . 'assets/secondary_schools.kml';
    $xml = simplexml_load_file($file);
    $childs = $xml->Document->children();
    $id = 1;
    foreach ($childs as $placemark) {

```

```

$coordinates = $placemark->Point->coordinates;
$data = strtr($coordinates, array(',' => ' ', ' ' => ','));
$values = explode(',', $data);
$coords = "";
$total = count($values);
for ($i = 0; $i < $total; $i++) {
    $args = explode(" ", $values[$i]);
    $lat_long = $args[1] . ' ' . $args[0];
    if ($i < $total - 1) {
        $lat_long.=' ';
    }
    $coords.=$lat_long;
}
echo $coords . '<br>';
$sql = 'UPDATE secondary_schools SET lat_lon=(GeomFromText('\POINT(' . $coords .
')\')) WHERE id="' . $id . "'";
$query = $this->db->query($sql);
$id++;
}
}

```

#### 5.4.4.1.3 Parsing KML files to polygons

```

function slice_polygons_from_kml() {
    $file = base_url() . 'assets/parcels.kml';
    $xml = simplexml_load_file($file);
    $childs = $xml->Document->children();
    foreach ($childs as $placemark) {

```

```

$coordinates = $placemark->Polygon->outerBoundaryIs->LinearRing->coordinates;
$data = strtr($coordinates, array(',' => ' ', ' ' => ','));
$values = explode(',', $data);
$coords = "";
$total = count($values);
for ($i = 0; $i < $total; $i++) {
    $args = explode(" ", $values[$i]);
    $lat_long = $args[1] . ' ' . $args[0];
    if ($i < $total - 1) {
        $lat_long.=' ';
    }
    $coords.=$lat_long;
}
$query = $this->db->query('INSERT INTO plot (shape) '
    . 'VALUES (PolygonFromText('\POLYGON((' . $coords . ')))\')');
}
}

```

#### 5.4.4.1.4 Updating user accounts

```

/**
 * update_account
 * Manage and update the account details of a logged in public user.

```

```

*/
function update_account() {
    // If 'Update Account' form has been submitted, update the user account details.
    if ($this->input->post('update_account')) {
        $this->load->model('demo_auth_model');
        $this->demo_auth_model->update_account();
    }
    // Get users current data.
    // This example does so via 'get_user_by_identity()', however, 'get_users()' using any other
unique identifying column and value could also be used.
    $this->data['user'] = $this->flexi_auth->get_user_by_identity_row_array();
    // Set any returned status/error messages.
    $this->data['message'] = (!isset($this->data['message'])) ? $this->session-
>flashdata('message') : $this->data['message'];
    $this->load->view('demo/public_examples/account_update_view', $this->data);
}

```

#### 5.4.4.1.5 Function for revenue zone management

```

function insert_zone() {
    // Gets data from URL parameters
    $name = $_GET['name'];
    $radius = $_GET['radius'];
    $center = strtr($_GET['center'], array(',') => ' ');
    $query = $this->db->query("INSERT INTO revenue_zone (name, center_point, radius,
value) VALUES ( '" . $name . "',GeomFromText(\POINT(' . $center . ')\', ' . $radius . ',1)");
    echo $query;
}

```

#### 5.4.4.1.6 Function for calculating the land rate for a given plot

```
/**
 * calculates the land rate for a given plot/parcel of land
 * @return float The levy rate in KSh
 */
function calculate_land_rate() {
    //get the plot id, zone id and base value from URL parameters
    $plot_id = $_GET['plot_id'];
    $zone_id = $_GET['zone_id'];
    $base_value = $_GET['base_value'];
    //get the plot from the database that we want to calculate its land rate
    $this->db->select('l.class_id, l.use_id, l.zone_id, l.total_area AS total_area');
    $this->db->from('land AS l'); // I use aliasing make joins easier
    $this->db->where(array('l.id' => $plot_id));
    $query = $this->db->get();
    $total_area = null; //total area of the plot in square meters
    $land_class_id = null; //the id of the class in which this plot belongs to
    $land_use_id = null; //the id the use category in which this plot belongs
    $land_zone_id = null; //the id of the zone in which this land belongs
    foreach ($query->result() as $row) {
        $total_area = $row->total_area;
        $land_class_id = $row->class_id;
        $land_use_id = $row->use_id;
        $land_zone_id = $row->zone_id;
    }
    //calculate the taxable value = tototal area X base value(price in Ksh per square Metre of
land)
    $taxable_value = $total_area * $base_value;
```

```

    $rate_due_to_use = $this->get_land_use_coefficient($land_use_id); //get the land use
coefficient
    $rate_due_to_class = $this->get_land_class_coefficient($land_class_id); //get the land class
coefficient
    $rate_due_to_zone = $this->get_land_zone_coefficient($zone_id); //get the land zone
coefficient
    //calculate levy rate(average property tax rate); LR = Taxable Value * {rate due to use +
rate due to class + rate due to zone}
    $levy_rate = $taxable_value * ($rate_due_to_use + $rate_due_to_class +
$rate_due_to_zone); //add adjustments
    echo $levy_rate;
}

/**
 * calculates the rate due to land use as a coefficient R(U)
 * @param number $use_id The id of the land use
 * @return float The coefficient R(U) as a fraction
 */
function get_land_use_coefficient($use_id) {
    $query = $this->db->get('land_use');
    $res = $query->result_array();
    $total = 0;
    foreach ($res as $row) {
        $total = $total + $row['value'];
    }

    $query = $this->db->get_where('land_use', array('id' => $use_id));
    $res = $query->result_array();
    $value;
    foreach ($res as $row) {
        $value = $row['value'];
    }
}

```

```

    }
    $coefficient = ($value / $total);
    return $coefficient;
}

/**
 * calculates the rate due to land class as a coefficient R(C)
 * @param number $class_id The id of the land class
 * @return float The coefficient R(C) as a fraction
 */
function get_land_class_coefficient($class_id) {
    $query = $this->db->get('land_class');
    $res = $query->result_array();
    $total = 0;
    foreach ($res as $row) {
        $total = $total + $row['value'];
    }

    $query = $this->db->get_where('land_class', array('id' => $class_id));
    $res = $query->result_array();
    $value;
    foreach ($res as $row) {
        $value = $row['value'];
    }
    $coefficient = ($value / $total);
    return $coefficient;
}

/**
 * calculates the rate due to land zone as a coefficient R(UZ)
 * @param number $zone_id The id of the land zone

```

```

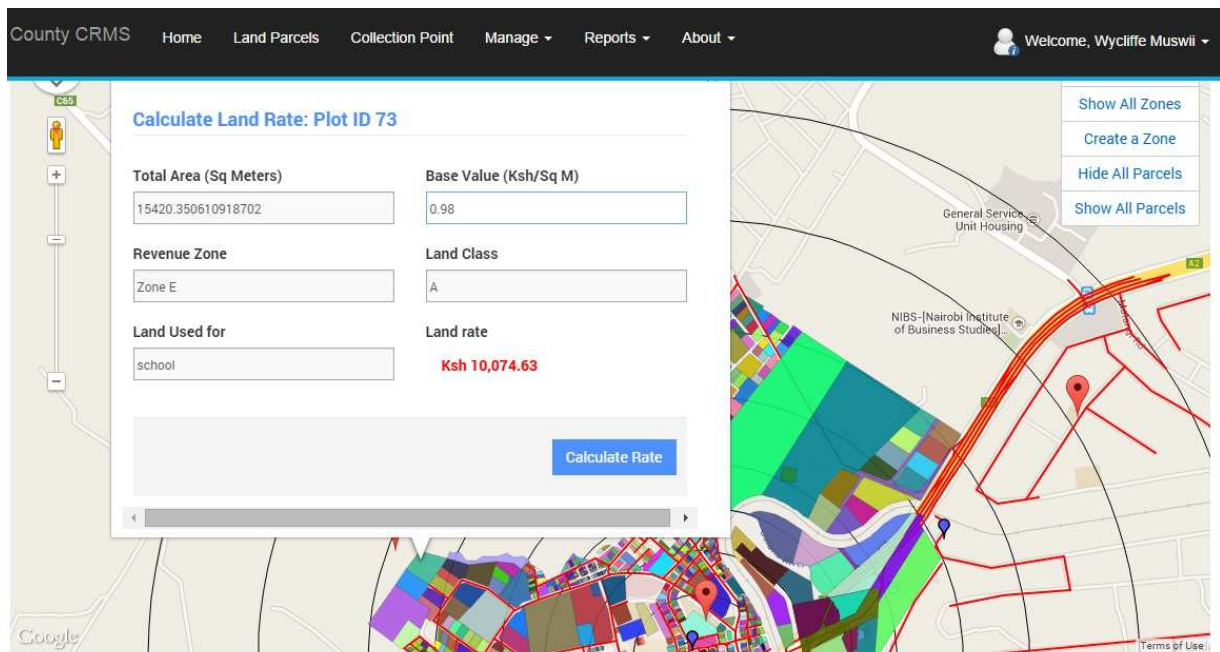
* @return float The coefficient R(Z) as a fraction
*/
function get_land_zone_coefficient($zone_id) {
    $query = $this->db->get('revenue_zone');
    $res = $query->result_array();
    $total = 0;
    foreach ($res as $row) {
        $total = $total + $row['value'];
    }

    $query = $this->db->get_where('revenue_zone', array('id' => $zone_id));
    $res = $query->result_array();
    $value;
    foreach ($res as $row) {
        $value = $row['value'];
    }
    $coefficient = ($value / $total);
    return $coefficient;
}

```



### 5.4.4.1.7 Output



### 5.4.4.1.8 Function for managing land parcels

```
function manage_parcels() {
```

```
    $query = $this->db->query('SELECT land.id, owner_id, revenue_zone.name AS zone_name, '
```

```
        . 'land_use.name AS use_name, land_class.name AS class_name, rate, base_value, '
```

```
        . ' allocation_no, title_deed_no, total_area FROM land INNER JOIN revenue_zone
```

```
ON land.zone_id=revenue_zone.id'
```

```
        . ' INNER JOIN land_use ON land.use_id=land_use.id '
```

```
        . 'INNER JOIN land_class ON land.class_id=land_class.id ORDER BY land.id ASC');
```

```
$result = $query->result_array();
```

```
if (!$result) {
```

```
    $data['parcels'] = null;
```

```
} else {
```

```
    $data['parcels'] = $result;
```

```
}
```

```
    $this->load->view('manage_parcel', $data);  
}
```

#### 5.4.4.1.9 Function for managing revenue zones

```
function manage_revenue_zones() {  
    $query = $this->db->query('SELECT id, name, radius, value, X(center_point) AS lat,  
Y(center_point) AS longi FROM revenue_zone ORDER BY id ASC');  
    $result = $query->result_array();  
    if (!$result) {  
        $data['zones'] = null;  
    } else {  
  
        $data['zones'] = $result;  
    }  
    $this->load->view('manage_zones', $data);  
}  
  
public function land_parcel() {  
    $this->load->view('land_parcel');  
}  
  
public function revenue_zone() {  
    $this->load->view('revenue_zone');  
}  
  
public function collection_point() {  
    $this->load->view('collection_point'); }  
}  
  
/* End of file auth_public.php */  
/* Location: ./application/controllers/auth_public.php */
```