WEB-BASED LAND INFORMATION MANAGEMENT SYSTEM: A CASE STUDY OF NAIROBI CITY COUNCIL

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Abstract
Reliable land information is crucial for planning and development of any country. There are various challenges that hinder proper management of land information. In Kenya rapid pace of development, coupled with high population growth rates brings with it heavy burdens on land management. Hence it is imperative that Kenya needs an effective Land Information System. Currently land information in Kenya is managed by various organizations which include the Ministry of Lands, survey of Kenya (SOK), city and county councils. This results to lack of standardized method of capturing, recording, and maintaining land-related data, resulting to duplication of information. This structure also hinders easy access to consistent, accurate, up-to-date land information in a cost-effective manner. The current labor-intensive manual processes used to collect, store and maintain this information contain a greater risk for human error. The main objective of the study was to develop a web-based land information management system with an aim of providing a proper land information collection, storage and dissemination platform for the Nairobi City Council. The proposed system is composed of three subcomponents: a single database, web-based mapping component and a website. The database provided is centralized, mapping component provides tools for data updating and visualization while the website hosts the mapping component and also provides additional information related to land management. To develop the system stable Geographical Information Systems (GIS) softwares and other Open Source softwares were used that included Quantum GIS and Mapserver. The system contained information on parcel ownership, land use, taxation, location boundary, land value, encumbrance and many more. The system offers a streamlined flow of land information within the Nairobi city council ensuring there is well structured process of collecting, storing and disseminating land information. Adoption of the system will ensures we leverage advancement in GIS technology in management of variable resources.

Key words: GIS, land information, Nairobi City Council, open source, web-based, mapping

1.0 Introduction

Land is the most valuable possession of mankind. It is also an important asset of any country. Without land, there can be no country (Amuyou *et al*, 2013). It is apparent, therefore, any information concerning land is valuable information which serves as a key to financial investments, commerce, industry and agriculture (Potdar, 2005). According to Kenya's law under RLA cap 300 land is taken to refer to surface covered in water, things growing on land and anything affixed to land. In Kenya there are various organizations mandated to manage this valuable resource and they include Ministry of Lands, Survey of Kenya and municipal, county and local councils (Gok, 2009).

In Nairobi City we have the Nairobi City council being one of the custodians of land on behalf of the city residences. Nairobi City Council refers to the body of the local government in the Nairobi city. The city is classified into 75 wards Some of the wards of Nairobi include Kangemi, South Nairobi, Ofafa, Lumumba or Hamza, Viwandani, Ziwani, Mbotela, Pumwani, Makongeni, Eastleigh North, Eastleigh, Central, Muthurwa, Kimathi, Kibera, Karen, Laini Saba, Kenyata and Mugumo-ini each of these wards has a councilor as their representative in the council.

In order to properly manage any natural resources, it is first necessary to be able to acquire and manage information about these resources. Information must be recognized as a resource which requires explicit management strategies. Land information refers to any physical, legal, economic or environmental information or characteristics concerning land, water, groundwater, subsurface resources, or air in the state (Wiegand, 2002). The operation of an land Information System (LIS) includes data acquisition, data processing, storage maintenance, analysis and retrieval of this land information.

The variety of land information necessitates development of a system capable of integrating different information and improving the flow of information between different departments. This different information can be classified into two major categories: Infrastructure/Utility information; concentrates on engineering and utility structures such as transportation and pipelines (man-made improvements to land) and Legal/Fiscal, "cadastral" information; concerned with land tenure and land use. A comprehensive city council LIS should provide a common platform for data collection, storage, authorized and secure access to spatial and non-spatial data harmonize the work flow of respective departments and disseminate information for the benefit of public at large. City council LIS will largely address the needs of various local government departments such as Local Administration, Public Works & Engineering department, Public Health Department, Water supply, Town and Country planning Department, Public Safety, Land records etc (Nikolli *et al*, 2010)

One of the greatest challenges facing Local Government in the 21st Century is keeping up with the demands of the citizens. This means local councils taking on efficient management of resources, planning and taking responsible decisions, and, above all, keeping the public up to date on information and opening the way to their participation. The City council of Nairobi has not been spared from these challenges especially as Nairobi city is the fastest-growing city in Kenya and this rapid pace means constantly changing data. The specific challenges facing the city council at the moment are: Currently there is no standardized method of capturing, recording, and maintaining land-related data changes as the city is growing ;to provide staff and the public with easy access to consistent, accurate, up-to-date land information in a cost-effective manner; at the moment mapping information available to decision makers, executives, and technical staff originate from many different sources due to duplication among departments; the information is sometimes obsolete, so decisions risked being based on incorrect information: the current labor-intensive manual processes contain a greater risk for human error.

The web based Geographic Information System (GIS) Services will reduce or eliminate these problems by providing a solution that included an automated index used to pull geographic information from the database. The need is to establish centralized, map-related applications for internal staff and the public covering specific programs such as the Property Lookup and Notifications and taxation system. This will help answer inquires on land availability, available business locations, and commercial/industrial buy/lease options for property, transportation options, and surrounding businesses.

The main objective of the study was to develop a web-based land information management system with an aim of providing a proper land information collection, storage and dissemination platform for the Nairobi City Council. To address these challenges highlighted above the broad objective of the research project was to develop web-based land information management system. The system would be used to address the problem of information management being experienced by Nairobi city council. This will provide a proper land information collection, storage and dissemination platform.

To be able to achieve the overall main objective, the study in particular set out to establish a centralized spatial enabled database for use by all Nairobi city council offices. The study also set out to avail a web-based mapping interface. The interface would enable the users to update the data, visualize the data and utilize other capabilities in the system including outputting maps. Also to achieve its main goal a general website was created to host the mapping interface and also be used to relay additional information related to land management and other activities related to the city council. The study covered selected areas of the Nairobi City that included Kileleshwa, Kilimani and Maziwa Figure 1. The area covered a total of approximately 3,000,000 m^2 i.e., 300 Hectares. The area has approximately 1500 plots.

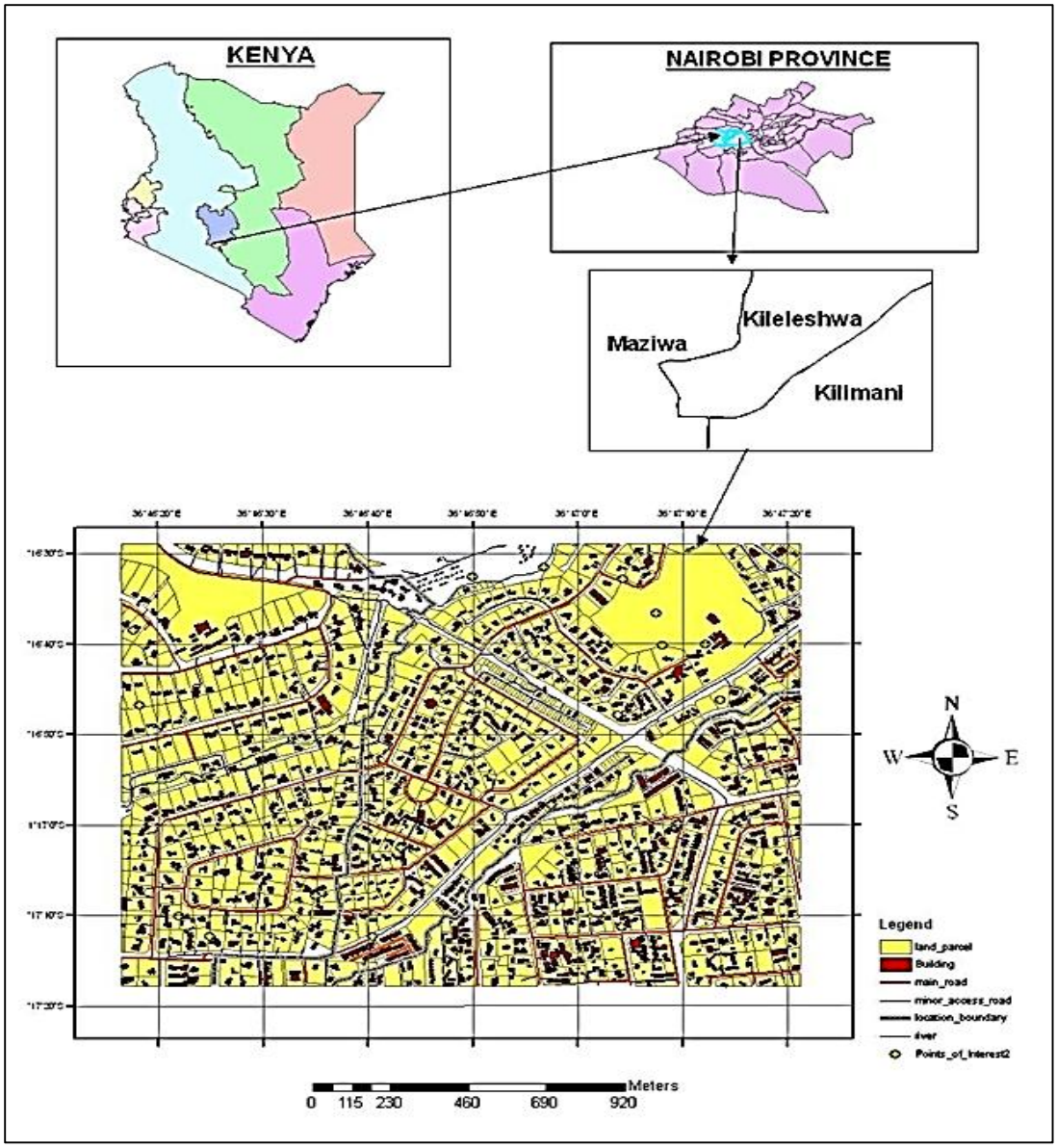

Figure 1: Location of study area showing location boundaries, land parcels, buildings and the major facilities of interest

2.0 Methodology

The approach taken to achieve the set objectives involved carrying several steps: user need evaluation and data collection, data processing, system development and system implementation Figure 2. The first phase involved the collection of relevant data as per system user need evaluation. The data was obtained from various organizations dealing with management of water resources. The data was in different formats depending on the type of data and the source or organization from which the data was obtained.

The data collected was then converted to the desired formats. The spatial data was linked to respective non spatial data. To process the data, Quantum GIS software was used. The processed data was then imported into PostgreSQL database. The data stored in the database was then used in system development. System development involved designing the database, building the web-based mapping application using Mapserver, designing a website using Joomla and integrating all this to makeup the system. The last step of the methodology

was testing the system on a local area network. This was done to evaluate the various features of the prototype against the user needs evaluation and the various refinement needed on the prototype were done. Several Open Source tools and technologies were used to develop the system. Mapserver for windows (ms4w) was used as the server on the localhost. Apache Web Server was primarily used to serve both static content and dynamic Web pages on the localhost. PHP script and Java scripts used to create web pages, application dynamic content, tools and functionalities. To create the database PostgreSQL and PostGIS were used. Quantum GIS was used to process the data and create the digital map.

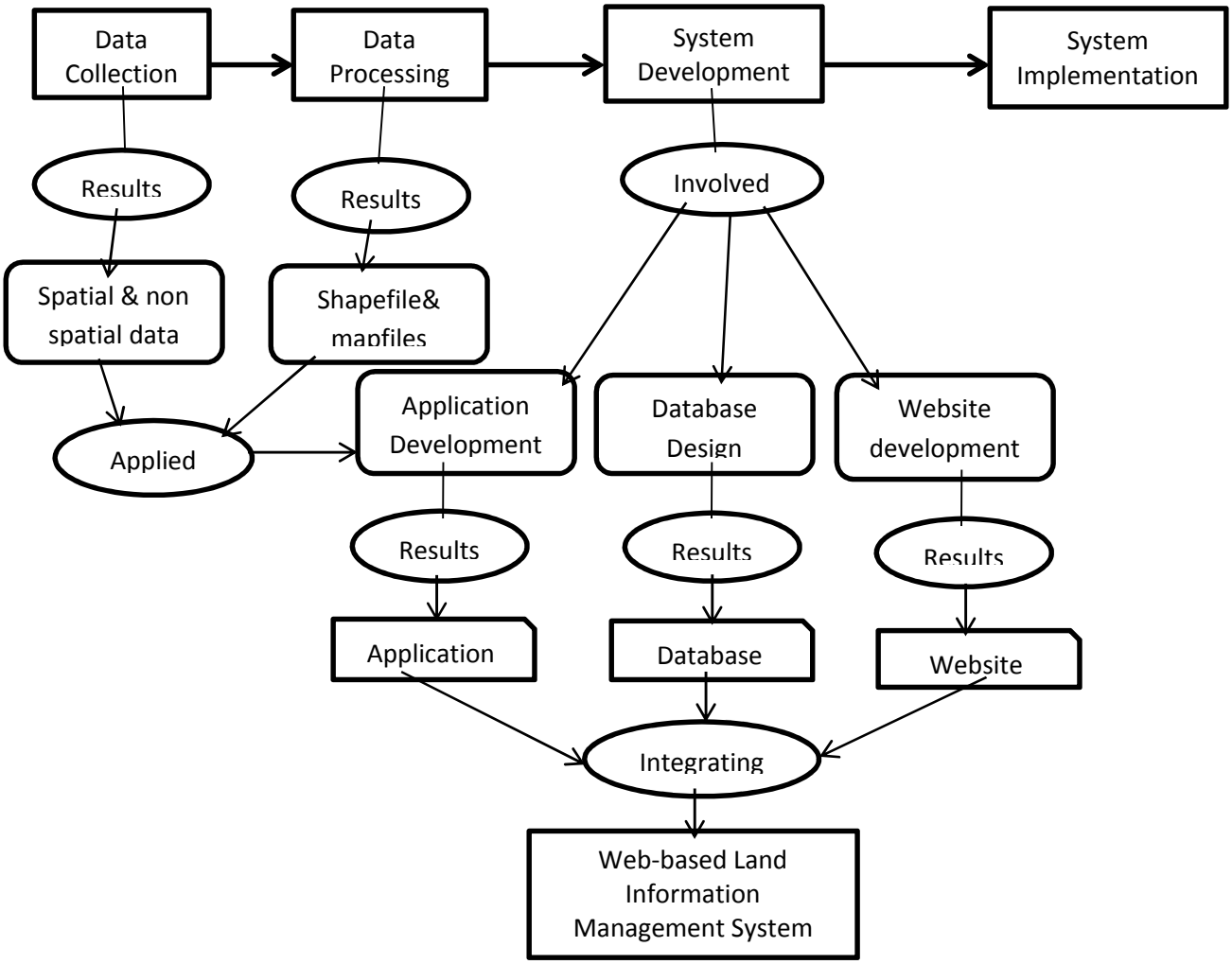

Figure 2: Work flow diagram

2.0 Results and Discussion

The result was a prototype of a web-based system of managing land information in Nairobi city. The system is centralized and hence accessible to all city council offices within the city and other stakeholders. The resulting System had three main components. First component was the spatial enabled database which was single and centralized for use by all. Several tables where created in the database and grouped into land parcels, buildings, road and points of interest. The other component was the main website. It hosted the mapping user application which was embedded on it. It also contained other information related to Nairobi city council such us detailing the various functions of city council, describing other services provided by council and also providing the instruction to various users on how to use the system. The other major importance feature on this component was the login section for the city council staff. By entering the various details required the user can access the mapping interface as illustrated by Figure 3.

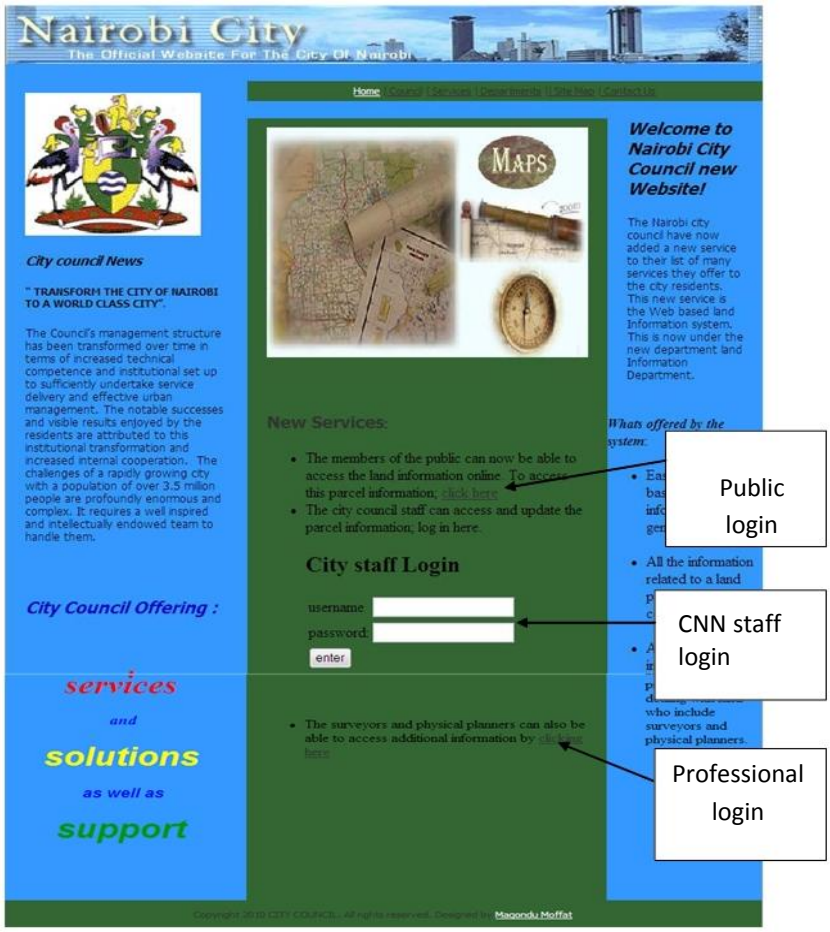

Figure 3: Website welcome page showing the login section

The mapping component had various mapping features to aid the user in map viewing and navigation that included: Zoom to full extent ; this tool was used to view the whole map at the default minimum scale, Back and forward ; these tools allowed one to move back or forward to previous zoom level and hence help to locate point of interest on the map, Zoom in and out ; these are tools to allow one to increase or reduce the scale of the map so as to ease in locating features of interest, Pan ; this tool aid in navigating on the map and refresh map too ; tool used to make the map fresh again by removing selection made earlier. Figure 4 shows the main interface of the mapping component.

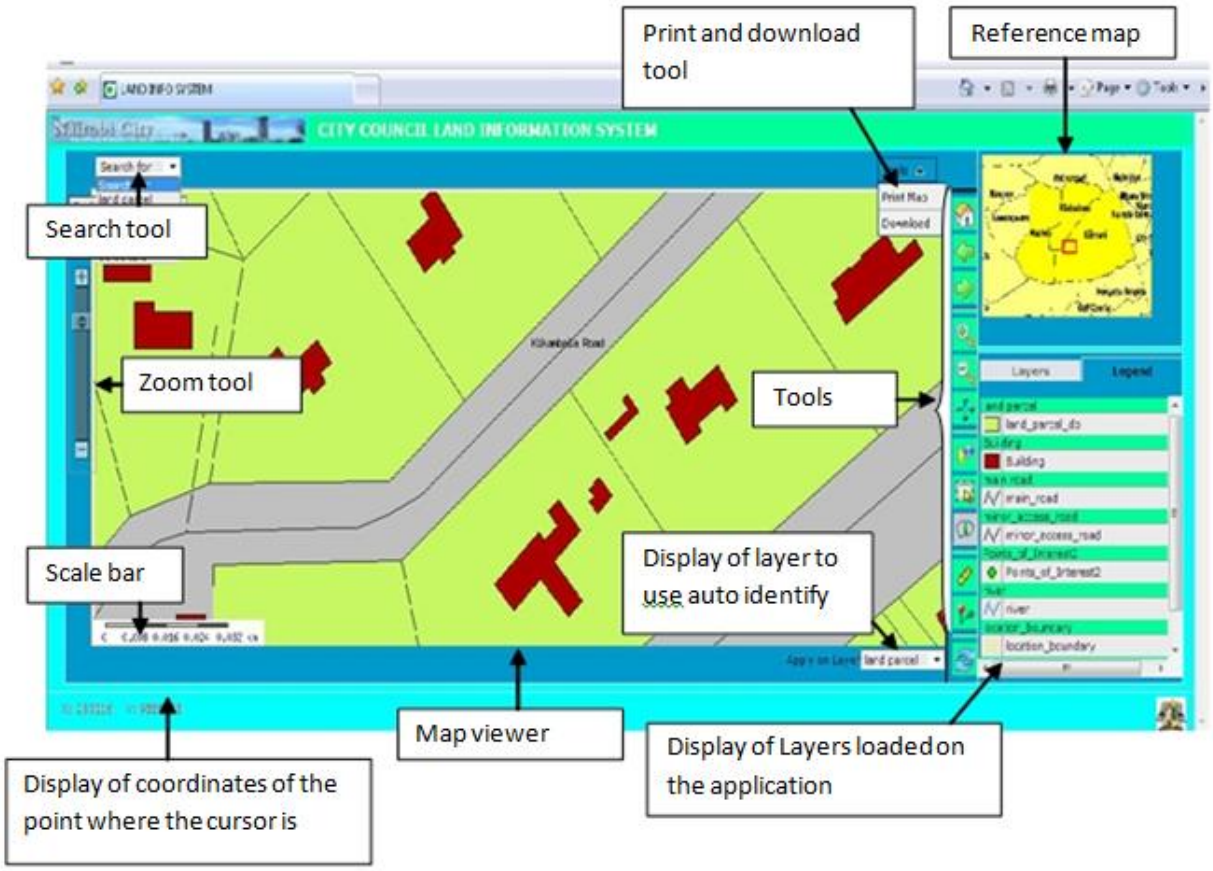

Figure 4: Mapping interface showing map viewer section, various tools and map layers

On the mapping component also we had various capabilities that were added according to evaluation of user needs. Data retrieval capability enables the user to obtain the information associated to various land parcels and buildings shown on the map. User is able to use the search tool extract specific data related to a given feature. This illustrated by Figure 5.

Figure 5: Using the search tool to retrieve parcel specific data

Segregation of users was also incorporated on the system. This was availed through the website whereby we had various access levels depending on the amount of information availed to the user. Using this functionality the general public and any other user of the system can only be able to obtain the basic information regarding a parcel of land. This includes parcel number, LR number, acreage, estate, if they is electricity connection, water supply and the type of waste disposal method used by owners of the parcel. For additional information they would have to contact the Nairobi city council Figure 6. There is a reserved login for the for the city council staff who deal with land information. They can access detailed information of a given parcel of land which include; owner, tax arrears, value of parcel, encumbrance Figure 7. Additional information is provided to the professional dealing with land that include the surveyors and physical planners. This additional information include; the name of surveyor who did the original survey, the name of beacons on the parcel and the survey plan number Figure 8.

Figure 6: Land parcel information availed to the members of the public

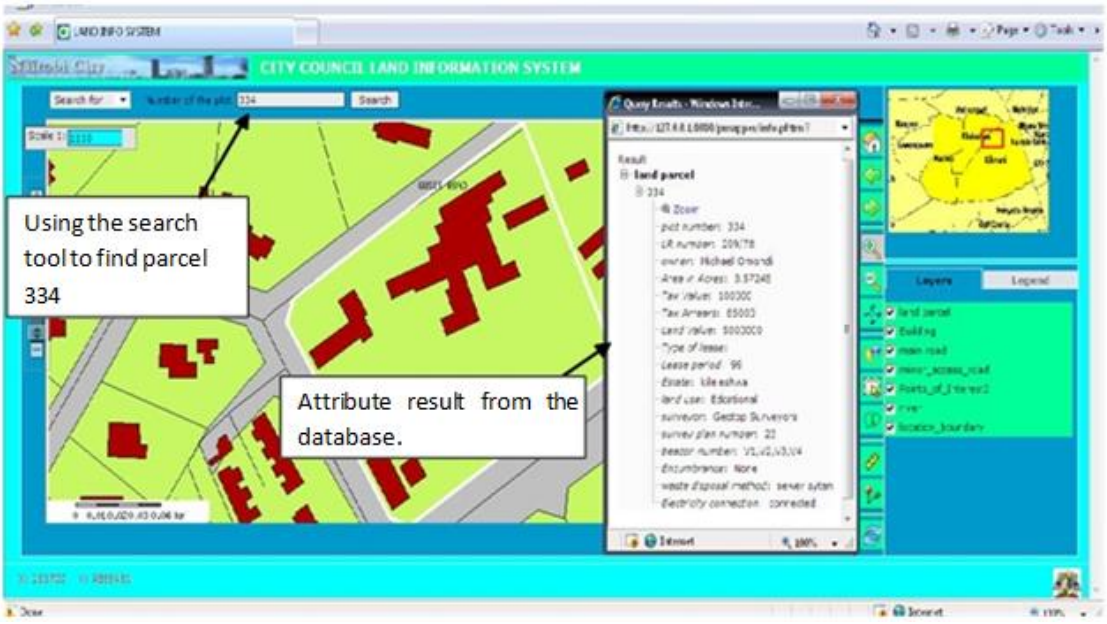

Figure 7: Land parcel information availed to the city council staff

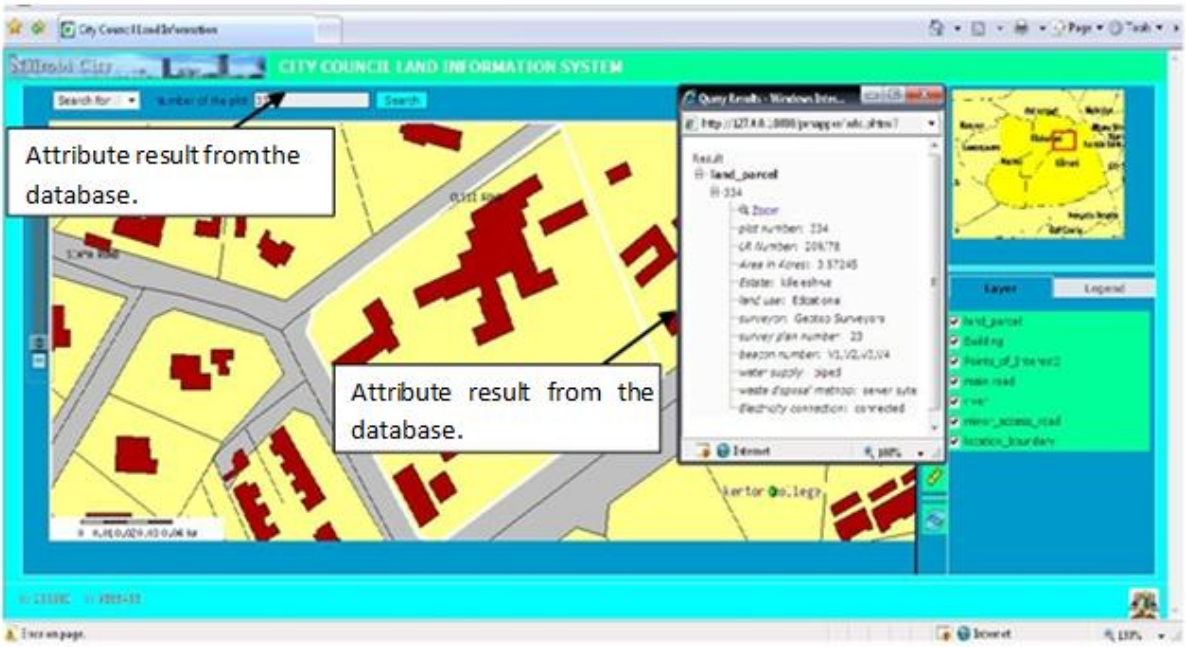

Figure 8: Land parcel information availed to the professionals

The city council staff can also be able to download and print maps. To produce the maps the user has to have logged in as staff. They then use the print and download map tools that are activated Figure 9.

Figure 9: Using the print and download tools

The system also allows the user to easily navigate through the map by using the search tool to find a point of interest, a building or a road. This eases the work of the user who may not be sure of the land parcel number hence by using the search function he/she can be able to locate the parcel of land easily hence be able to obtain the information required. This can be by searching using the nearest main road to the parcel, the name of the building on the parcel or by searching using the points of interest in the area like schools Figure 10 and 11.

Figure 10: Using a point of interest to navigate to a land parcel of interest

Figure 11: Using a road to navigate to a land parcel of interest

The system also includes updating capability. The system administrators can be able to login into the system and update the database. This ensures that the information relayed to the users can be kept up to date by having the administrators of the system effecting any changes on the parcel and other features. Using the system the city council staff are able to located defaulter in case of tax arrears. This is made possible by using the search tool where by all the parcels whose owners have arrears are given a code and on searching using the code the defaulters parcels are highlighted. From these the city staff can use either the auto identify tool or select too to identify other details of the parcel.

3.0 Conclusion

The study leads to the development of a prototype of a Web-based Land information management System. The system offered a solution to land information, by providing one shared database hence reducing duplication and lowering maintenance cost. It also offered a mapping interface that ensures Nairobi City council leverages advancement in GIS technology in its service delivery. The system also offers a streamlined flow of information by having one system accessible to all city council offices hence ensuring there is well structured process of collecting, storing and disseminating land related information.

From the study one can draw conclusions that Web-based GIS is a prospective application in GIS and represents an important advancement over the traditional desktop GIS. Its application eliminates duplication and inconsistency and makes location information conveniently and intuitively accessible across organizations, at a lower cost per user. Internet provides a medium for processing geo-related information and spatial information to users at an amount larger than traditional GIS.

The study lays the foundation of proper management of the land resources. It aids in realization of the The Kenya Vision 2030 as land reforms is cited as one of the foundations of vision 2030. . This project can be extended to create land information management system that can provide services for a wide range of users, starting with government institutions and ending with private individuals. Further improvements of the system could be made to include more land resources information and also capabilities improved to carry out analysis using the available data. Also the systems functionality can be improved such that it supports all of the procedures that are involved in the allocation of land and issuing of land titles.

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