

# A Web Based Geographical Information System for Marketing of Residential Houses – A Case Study of Karen County Assembly Ward in Nairobi City County, Kenya

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**Abstract:** *Nairobi is the capital city of Kenya with about four million people which is about 10% of the total population living in the city. Because of the centralized population, many difficulties are experienced when it comes to housing. Housing in Nairobi varies from flats in developed high-rise buildings to apartments in most residential areas and to the now fast rising gated communities. With the traffic getting increasingly congested, location is becoming more and more important. Most people for instance will start by choosing a school for their children and then choosing a home not too far away. The rental housing nightmare in Nairobi will continue to be so as long as population continues to increase and also when the majority of private developers only construct to target high-end families. As such, identifying a good and affordable place to live in for a majority of the City dwellers is a daunting task. A big majority rely on estate or relocation agents, radio & television, newspapers and the internet to identify a house to live in. 'House hunting' as is commonly known can therefore be very frustrating. This is so because the standards of housing vary hugely and advertising is often quite misleading. The information provided in the adverts is usually very limited with crucial information such as the accessibility of a house and its proximity to nearby facilities (schools, highways, supermarkets and recreational facilities) usually left out. Estate agents on the other hand whose typical day involves moving customers around showing them the available houses for rent do not help matters. Infact, the act of moving customers around in itself leads to massive wastage of time and financial resources. It is therefore advisable for one to remain flexible in his requirements and calm in temper when the agent is late or doesn't completely turn up for an appointment. The study aims to combine the use of GIS technology and the web to develop a web based Geographical Information System that will serve as a platform for marketing of residential houses thereby addressing these pertinent issues.*

**Keywords:** Geographic Information Systems, Global Positioning Systems, Web GIS

## 1. Introduction

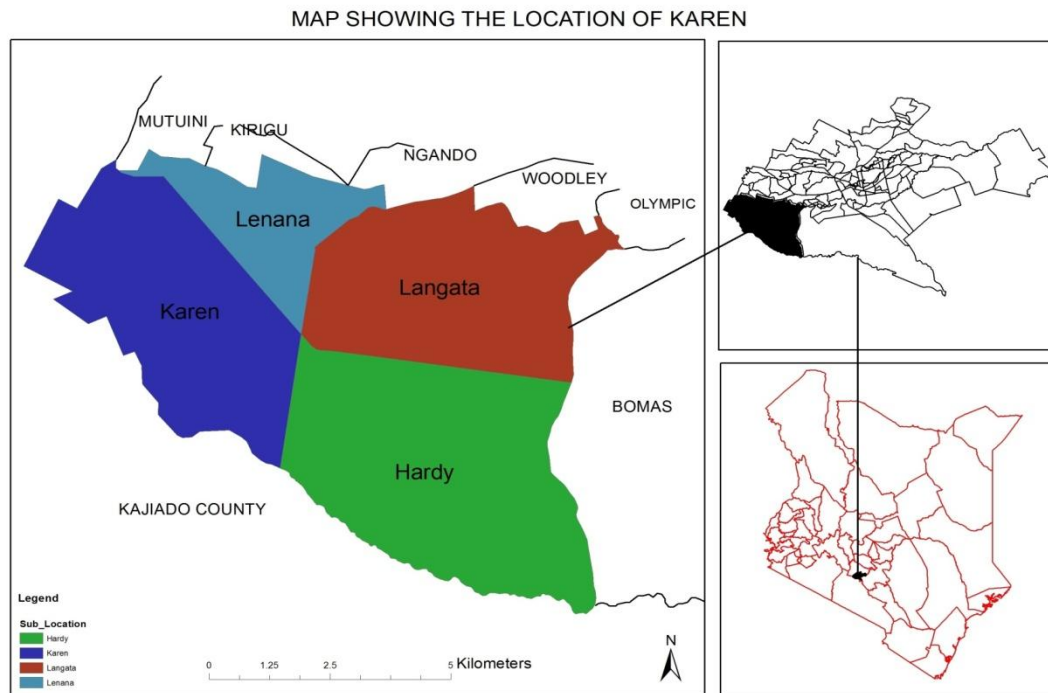
Finding a new home anywhere can be very intimidating. This is so especially if one does not know his way around the place. The traffic congestion in Nairobi seems to be going from bad to worse. This reality makes the location of one's place of work in relation to where he lives or where the children go to school become more important. Most people for instance will start by choosing a school for the children and then choosing a home not too far away.

The real estate industry in Kenya has become a profitable business that is growing very fast. Many Kenyans living in towns buy a house, rent a house or put up their own houses. The business of selling, buying and renting of houses is therefore very common in all urban areas. Sadly, this

lucrative business is poorly managed. Little or no proper marketing is done. If the internet, proper information and GIS technology is adopted, this problem can be easily addressed. The objective of this study is therefore to come up with a web-based online GIS system for marketing of residential houses in Nairobi.

## 2. The Study Area

The case study is Karen County Assembly Ward. Karen Ward is comprised of a number of up market estates. It is found in Langata Constituency in Nairobi County and has a human population of about 30,000. It is approximately 48 square kilometers in area and comprises of four sub counties namely Karen, Hardy, Langata and Lenana.



**Figure 1:** Study Area

### 3. Methodology

To achieve the set objectives of this study, the approach taken involved carrying out a number of steps. These steps included;

- User requirement evaluation,
- Data collection and storage,
- Data manipulation,
- Web system development and
- System implementation

#### 3.1 User requirement evaluation

The first step involved administering a questionnaire so as to identify the suitability factors that customers consider in choosing a residential house. A total of 100 respondents who were selected randomly were interviewed.

#### 3.2 Data Collection and storage

The data needed for this project was categorized into two:-

- Spatial data
- Non – Spatial data.

##### 3.2.1 Spatial Data Capturing

Housing data was obtained from the Nairobi County Council as well as from the Ministry of Land Housing and Urban Development, Directorate of Housing. Other data that was needed included roads data obtained from the Ministry of Transport, Schools Data from the Ministry of Education, and Hospitals data from the Ministry of Health. Field data collection that involved picking of the location of the houses in question using a handheld GPS and the photographs (both the interior and the exterior) using a digital camera was done.

Once the data was collected a geo database was created. Data layers on all the available public utilities/facilities were created. Another layer on the housing data was also created. This layer included the coordinates of the location of these houses as they were picked using a hand held GPS. In summary, the datasets used in the study is as shown in table 1 below;

**Table 1:** Data sets and sources

Data Set	Source
Administrative boundaries data	Survey of Kenya and through digitizing.
Health facilities data	Ministry of Health
Education data	Ministry of Education
Roads data	Ministry of Transport
Housing data	MoLHUD – Directorate of Housing
Orthophoto of Nairobi City	MoLHUD – Directorate of Housing
Data on Business Malls	Digitizing
Data on Police posts	Digitizing
Attribute data on the available houses	Field data collection

##### 3.2.2 Non Spatial data capturing

A data collection form was used to collect the non-spatial data from the house owners and from agents. The attribute data of the vacant houses was collected from the field and recorded as per the following attributes;

- The physical location of the house
- The street where the house is located
- The Number of bedrooms
- The dimensions of the rooms.
- For flats, the number of the floor
- Monthly rent
- Any deposits required
- The house owner and their contacts

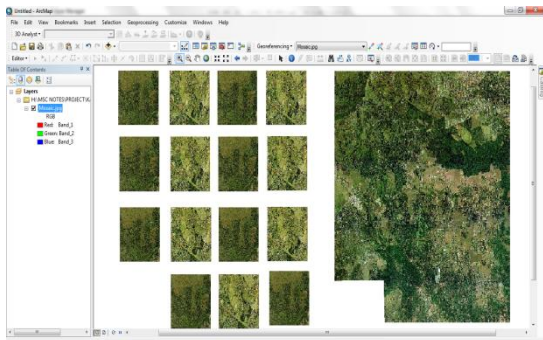
- The estate agent managing the house
- If a bungalow, the size of the land
- Other facilities available e.g. swimming pool, gym etc

### 3.3 Data Manipulation

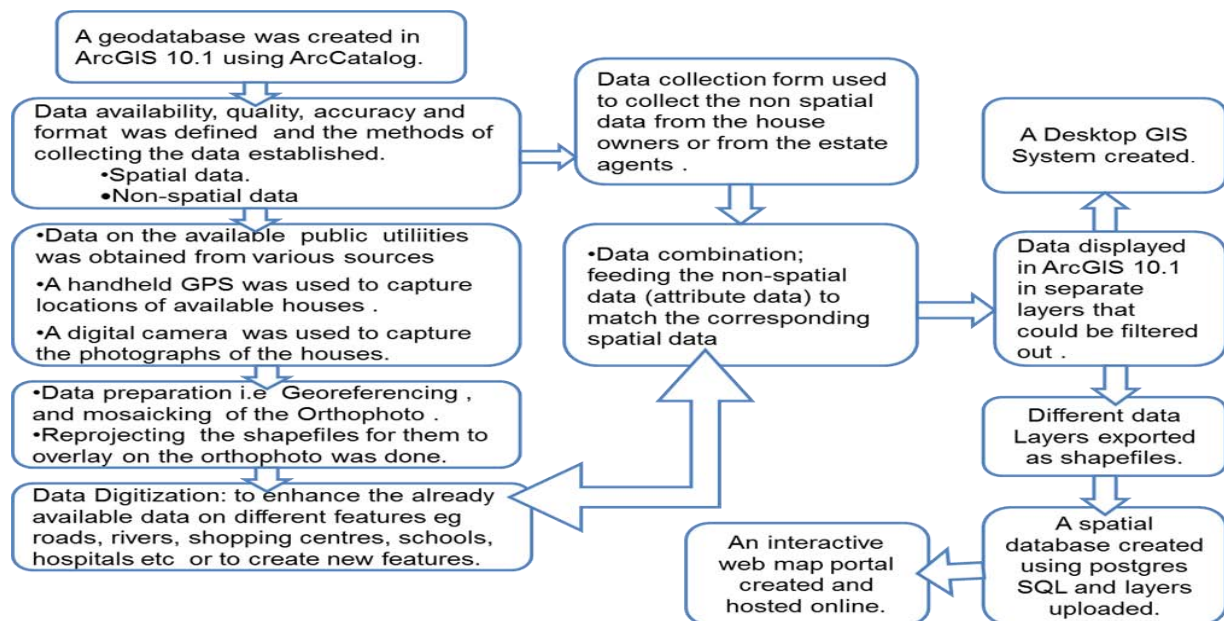
The data collected from the different sources needed to be manipulated. This was so because it was obtained in different formats, different coordinate systems and some was not geo-referenced.

#### 3.3.1 Mosaicking the Orthophoto

The orthophoto was not geo-referenced and was obtained in different sheets. Before it could be geo-referenced, the different image sheets needed to be mosaicked into one image. This was done in an ArcGIS environment as shown in fig 2 below;



**Figure 2:** Mosaicking the Orthophoto



**Figure 3:** The Workflow

#### 3.3.5 Data export

Once the desktop GIS system was complete, it was time to develop the online web based system. All the data layers were therefore exported into shapefiles ready to be uploaded in the online databases.

### 3.4 Web System Application

Client server architecture and particularly a heavy-server thin client was adopted. This is an application whereby we

#### 3.3.2 Reprojecting the shapefiles

Other data obtained in ESRI's shapefile format had to be re-projected. This was necessary so that the data from different sources could be transformed into one coordinate and reference system. This was meant to enable the different data layers created to be easily overlaid in an ArcGIS environment.

#### 3.3.3 Data Digitization

To enhance the already existing data on different features such as roads, rivers, shopping centres, schools, hospitals and to create new features for those public utilities that were missing, data digitization and extraction from the mosaicked orthophoto was done.

#### 3.3.4 Data merging

After the necessary data manipulation was done, the corresponding non-spatial data was linked to the corresponding spatial data using the ArcGIS attribute tables. Once this was done, a fully operational desktop GIS system was created in ArcGIS 10.1 software. The flowchart can be summarized as shown in figure 3 below;

only have a web browser as well as a web application on the client side and then everything else is found on the server side as shown in the figure below. This kind of application has the following advantages;

- All processing to take place in the server including zooming in/out
- Requires only a standard web browser to function

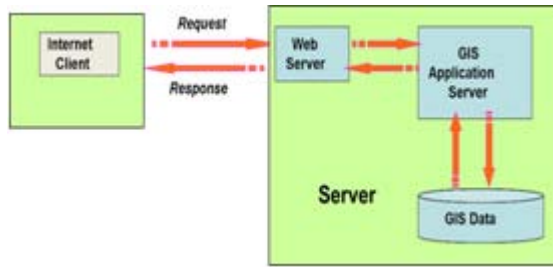


Figure 4: Client Server Architecture

A three tier system design methodology was adopted. This helped in separating the main system components into three different layers. Figure 5 below depicts the overall system architecture.

- i) Database Tier
- ii) Application Tier
- iii) User Interface Tier

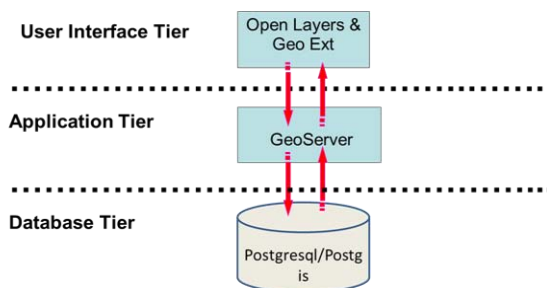


Figure 5: Three Tier Architecture

### 3.4.1 Database Tier

The raw data needed to be managed in a consistent read and write data store, a relational database was therefore the best choice. A relational database is a collection of data items organized as a set of formally-described tables from which data can be accessed or reassembled in many different ways without having to reorganize the database tables. *Postgresql* spatial database with its *Postgis* spatial extension proved sufficient in holding spatial and attributive data derived from shapefiles. The command line tool *shp2pgsql-gui* enabled the importation of shapefiles into the *Postgresql* database created. This was therefore used to import all the different data layers that were created in shapefile format into the *postgresql* database. *Pgadmin3* package was the used in administering the database, managing users and deriving SQL syntax.

### 3.4.2 Application Tier

An application server was used to enable the raw data to be accessed using web services and rendered into cartographic products. *GeoServer* web map/feature server was selected as it does an excellent job of responding to WMS/WFS requests. The difference between WFS and WMS is that data is rendered on the server in case of WMS while WFS response is rendered by the client. Both operations are standardized by OGC specifications. The other alternative to *GeoServer* is *MapServer* which however has complex configuration issues and requires consistent editing of map files, an activity not necessary with *GeoServer*.

### 3.4.3 User Interface Tier/Web Client

For the user interface framework, a user interface including an interactive map viewer and forms were generated by Javascript libraries such as OpenLayers, ExtJS and GeoExt. These libraries are freely available on the internet and their installation simply involved placing a link on a HTML document referring to their locations in the file system.

A client is a user sending request to a web server. The browser itself is a client in its relationship with the computer that is getting and returning the requested HTML file. The computer handling the request and sending back the HTML file is a server. In this project the client asks for a vacant house with specific details and the web server sends a HTML map with details.

### 3.5 Software platform: Geonode

The software platform that was used in the study was Geonode. This is mainly because it comes as a complete package which means that with a single installation all the needed software was installed. Another advantage was that the software is free and open source.

#### 3.5.1 About Geonode

GeoNode is a geospatial content management system, a platform for the management and publication of geospatial data. It brings together mature and stable open-source software projects under a consistent and easy-to-use interface allowing non-specialized users to share data and create interactive maps. GeoNode is a web-based application and platform for developing geospatial information systems (GIS) and for deploying spatial data infrastructures (SDI). It is designed to be extended and modified, and can be integrated into existing platforms [8].

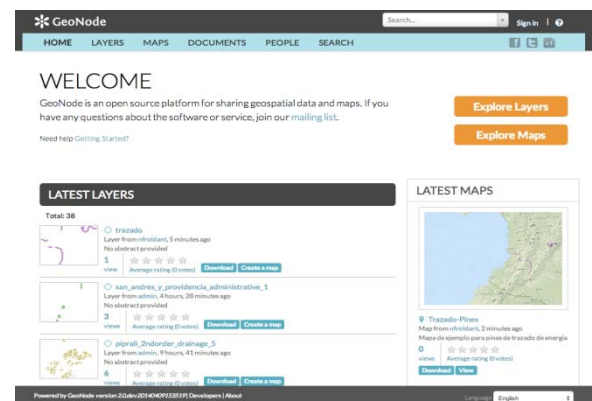


Figure 6: Geonode Homepage

#### 3.5.2 Geospatial data storage

GeoNode allows the user to upload vector (currently only Shapefiles) and raster data in their original projections using a web form. Vector data is uploaded in ESRI Shapefile format and satellite imagery and other kinds of raster data are uploaded as GeoTIFFs [8].

Special importance is given to standard metadata formats like ISO 19139:2007. After the upload is finished, the user is presented with a form to fill in the metadata and it is made available using a CSW interface. Users may also upload a

metadata XML document (in ISO, FGDC, or Dublin Core format) to fill in key GeoNode metadata elements automatically [8].

### 3.5.3 Components of Geonode

Geonode has the following as the main components

- a) Django
- b) GeoServer
- c) GeoExplorer
- d) PostgreSQL and PostGIS
- e) Pycsw

These are incorporated in an architecture as shown in the image below [8];

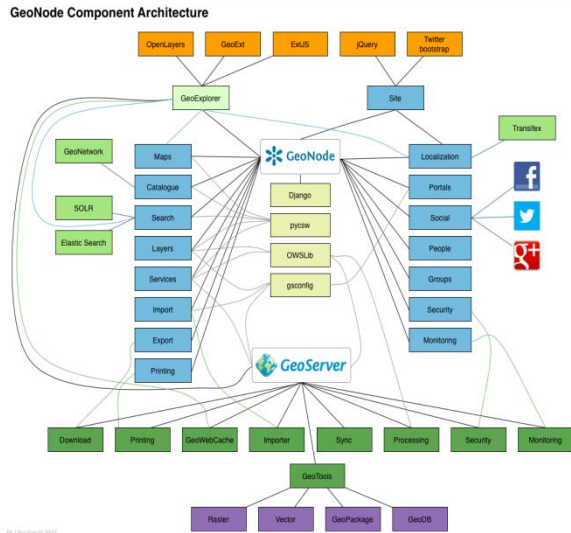


Figure 7: Geonode Architecture (source: geonode.org)

### 3.5 System Implementation

The last step in the methodology as shown on the flowchart involved getting a unique domain name and identifying a reliable server so that the developed application was hosted online.

## 4. Results and Discussion

The achieved results as discussed below shows that the objective of the study was achieved.

### 4.1 Questionnaire Results

#### 4.1.1 Suitability factors

From the administered questionnaire, the following were identified as the suitability factors that influence the choice of a residential house.

- i) Locality
- ii) Rent categories
- iii) The structure of houses
- iv) House sizes
- v) Accessibility
- vi) Size of the land.
- vii) Other available facilities e.g. swimming pool, gym etc.

Among these factors, the four most contributing factors were location, rent, size and accessibility in that order as shown in figure 8 below.



Figure 8: Questionnaire results analysis

To better analyze these four factors, four clusters of the salary scales were established as below;

- i) Those earning Kshs < 30,000
- ii) Those earning between Kshs 30,000 – 60,000
- iii) Those earning between Kshs 60,000 – 90,000
- iv) Those earning over Kshs 90,000

Among the four clusters location was the number one factor. The other three factors varied across the different clusters. In trying to analyze how these three factors varied across the clusters, further classification of the above clusters was done with clusters (i) and (ii) classified as low income earners and clusters (iii) and (iv) classified as mid and high income earners.

#### 4.1.2 Low income earners

The priority of the four factors was the same i.e. the first was location followed by rent then size of the house and finally accessibility. The only varying thing was their percentages; Location: 50%, rent: 30% and size and accessibility 10% each as shown on the pie chart below. The explanation is that when one identifies an estate where he or she wants to stay which is influenced majorly by the place of work, the next thing on his or her mind is the amount of rent per month to be paid. At this point, he or she is not bothered with the size of the house or its accessibility. The question of size only arises if he identifies two or more houses of the same rent but of varying sizes in which case the accessibility factor comes into play.

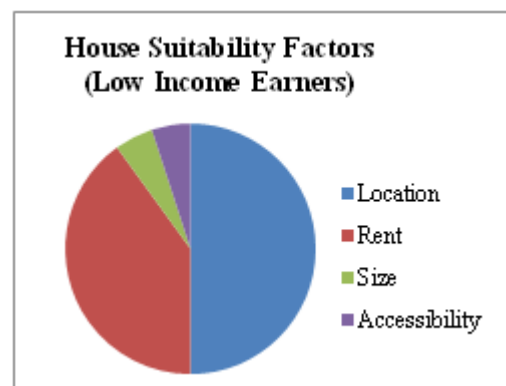
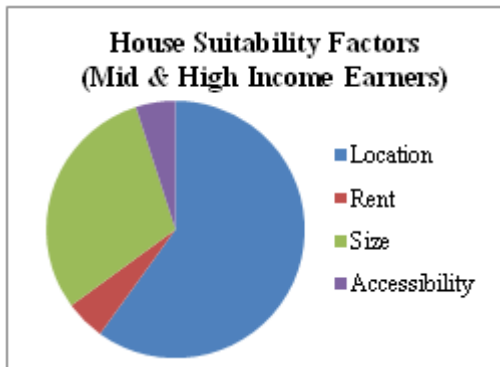


Figure 9: Low Income Earners

#### 4.1.2 Mid & high income earners

Among the mid & high income earners, location remains the number one factor at 65% with the size of the house as number two at 25%. Rent and accessibility were at 5% each

as shown in the pie chart below. The explanation for this was that, among the mid and high income earners the location of the house which is majorly driven by prestige of an estate where a house is located becomes the first factor to consider. Once they are satisfied with the location (estate), the size of the house which is determined by the size of their families now comes into play. Both rent and accessibility comes last both at 5%. This is so because affordability of a house in the estates of their choice is not a big issue because they are sure they will afford any house. Accessibility is on the other hand almost guaranteed and therefore a non issue in as far as the choice of a house within such estates is concerned.

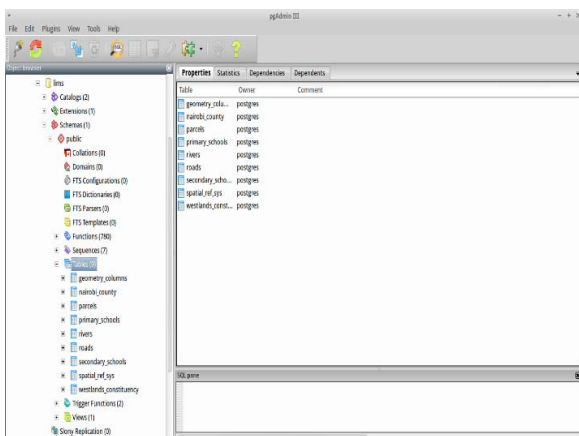


**Figure 10:** High income earners

## 4.2 Web Application

### 4.2.1 Database Management

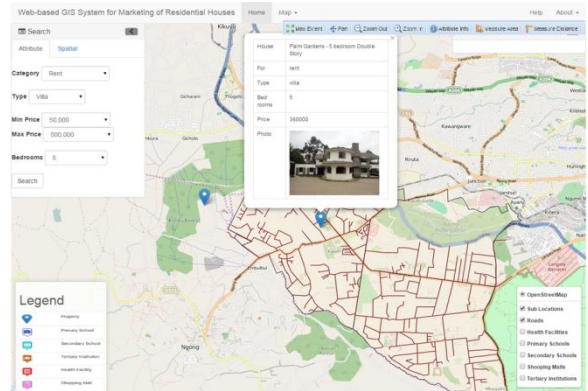
The database was composed of tables created using PgAdmin III. These included tables for each of the exported layers from the desktop GIS system. The database and the application were connected such that any update by the admin of the database would automatically update on the application.



**Figure 11:** PgAdmin III Database

### 4.2.2 Online Web-GIS

An online web geographic information system that was to be used to display the spatial map of the area and also provide the non-spatial data of the features in the area of interest to the clients was developed as shown on figure 12 below.



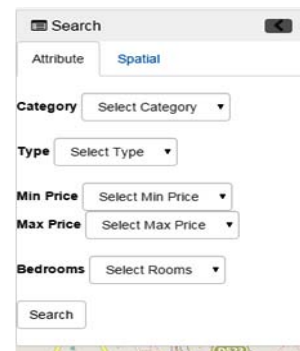
**Figure 12:** Online Web GIS

## 4.3 Functionalities of the system

### 4.3.1 Viewer Interaction and Display

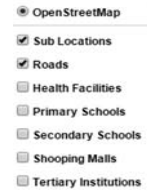
The system has various capabilities which were in build in the system using the various developed tools and windows and include:

#### a) Spatial and attribute search window



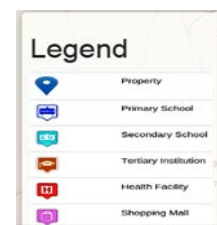
**Figure 13:** Search Window

#### b) Layers that can be easily filtered out



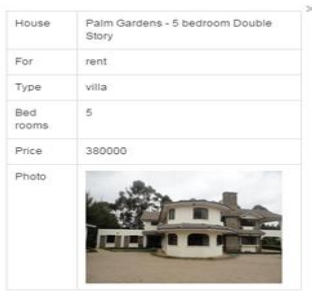
**Figure 14:** Layers Filter

#### c) The legend

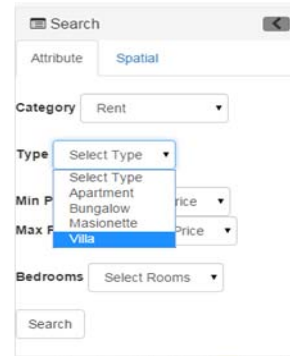


**Figure 15:** Legend

**d) Results display window**



**Figure 16: Results Window**



**Figure 19: House Type**

**e) Toolbars**



**Figure 17: Tools**

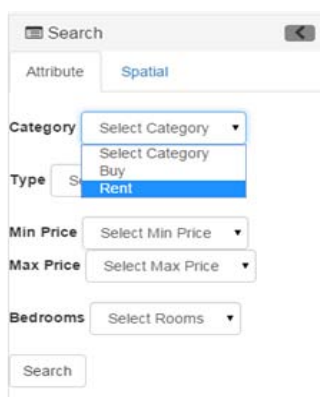
The toolbar as shown in figure 17 above has the tools for:

- Zoom to full extent ;
- Back and forward : used to locate point of interest on the map
- Zoom in and out ;
- Pan ; to ease navigation on the map
- Identify tool; used to obtain attributes of a feature which is clicked.
- Select ; used to find a feature of interest
- Measure; used to carry out measurements on the map.
- Distance measurement.
- Area measurement.
- Add point of interest; used to add temporary points on the map by the user when using the map.
- Refresh map; used to make the map viewer reload again.
- Reference map for easier navigation.

**4.3.2 Using the System for Property search**

On the attribute search window, a customer just selects from the drop down list.

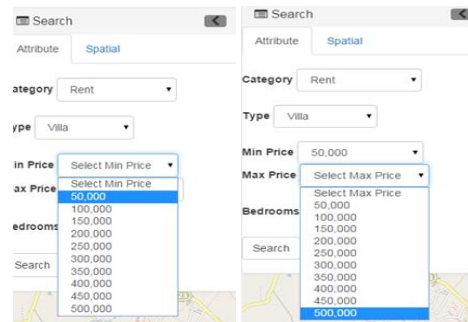
Under “Category;” The choices are either buying or renting as shown below;



**Figure 18: Category**

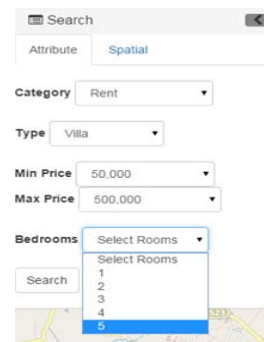
Under the “Type of the house,” the options are apartment, bungalow, maisonette or villa.

The customer has to then select the range of the rent i.e. the minimum and the maximum rent;



**Figure 20: Minimum and Maximum Price**

Finally, the customer selects the number of rooms of the intended house as shown below.



**Figure 21: Number of Rooms**

On clicking search, all the properties that meet the specified conditions are displayed on the map display. The properties that meet the specified conditions for instance are two as shown below;

Category: Rent  
 Type: Villa  
 Minimum price: 50000  
 Maximum price: 500000  
 Number of rooms: 5

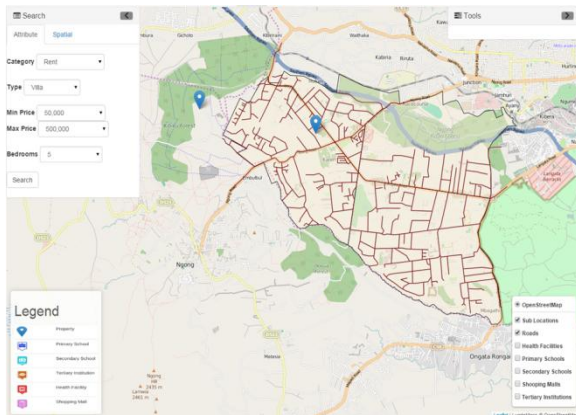


Figure 22: Selected Properties

On hovering the mouse on a selected property, the attribute information of the house in question which includes photographs and a link to a video are displayed.

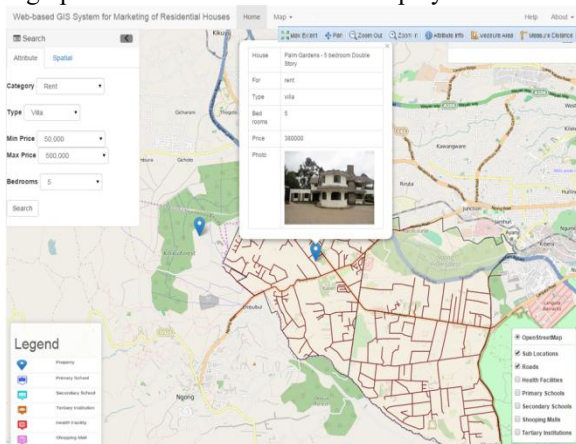


Figure 23: Search Results

## 5. Conclusion

The study was successful as the intended system was developed and hosted online. With the system now in place, customers looking for a house are in a position to do so at the comfort of their homes and this will lead to a reduction of the time and financial resources that they spend while looking for a house. Private developers, brokers and estate agents will also have a platform on which to market their houses to the potential customers. Unlike the advertisements they make on newspapers which has to be done on a daily basis, their houses will remain on the system for as long as they are available for rent or for sale. This will not only improve on the marketing but also reduce the costs.

## 6. Recommendation

The system can be further enhanced and a mobile application that can be installed on mobile devices developed. More functionalities arising from user needs can also be added to the system. Similarly, the system should be further developed so that it can incorporate spatial search queries. Finally, the scope can be extended to cover the whole of Nairobi or the whole of the Country and incorporate other types of houses such as offices or business premises.

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