UNIVERSITY OF NAIROBI

GIS DATABASE FOR REAL ESTATE MANAGEMENT

A CASE STUDY OF KOMAROCK ESTATE

PHASE 1 INFILL

By:

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Declaration

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Student name: **Margaret N. Ndungo**

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	…….	……..

Supervisor: **Mr. Peter C. Wakoli** …….. ……

I confirm that the work contained in this MSc. project report has been composed solely by myself and has not been accepted in any previous application for a degree. All sources of information have been specifically acknowledged.

Signed …….

Date…….

ABSTRACT

Real Estate Management involves house owners, tenants, tax collectors, valuers, financial institutions, mortgage providers among others. Estate Agents deal with massive datasets from these key actors together with data from the houses and their attributes. It has been difficult to manage these datasets without a good management system. The data has been stored in paper forms that are easy to tear and misplace. These datasets are hard to manipulate, to query or even update. This has presented delay when customers are looking for houses to rent and agents have employed many workers to handle the many customers. GIS has been used as a management system that has enabled the creation of a comprehensive and complete inventory of all these datasets in a database that enabled creation of a digital interactive map of Komarock Estate Phase 1 infill that was used to display houses in their physical locations and to be integrated with their attributes for more information. This has enabled data manipulation, easy querying and updates, visualization and display. Google maps platform enabled display of houses together with the neighbourhood for even better decision making. Customization of ArcMap allowed ease of GIS software by the agents. It has been concluded that GIS is indeed a management system that has managed to integrate all the real estate datasets to allow querying, manipulation, updates, visualization and display of the houses on a map to allow customers make decisions.

Key words: Estate Management, GIS, Database

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Dedicated

To Moses, Pricilla, Sam and Sam

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ABBREVIATIONS

GMN	-	GIS + MIS + NETWORK (MIS- Management Information System).
WGIS	-	Web Geographic Information System
GB	-	Giga Byte
CD-ROM	-	Compact Disk Read Only Memory
UPS	-	Uninterrupted Power Supply
PDF	-	Portable Document Format
TIF	-	Tagged Image File Format
JPEG	-	Joint Photographic Expert Group
UML	-	Unified Modeling Language
ILRI	-	International Livestock Research Institute
IBM	-	International Business Machines

CPTER ONE

INTRODUCTION

1.1 BACKGROUND TO THESTUDY

Estate Management is defined as the direction and supervision of an interest in landed property with the aim of securing optimum return; this return may not be financial, but may be in terms of social benefit, status, prestige, political power or some other goal or group of goals (ThornCroft, 1965).

Estate Agents for a long time have encountered problems in their endeavour to serve their customers. They gather a lot of data from house owners and they have not managed to keep it in a manner as it can be easily queried, updated or shared with other key actors in the sector like investors, public and government agencies, planners, agents, professional teams etc. Customers come to them in need of houses to rent and they have never managed to satisfy these needs promptly. The agents keep their records in paper form, in files, charts, drawings and they have really generated enormous data to be able to manage without a management system. These data easily get torn, misplaced, complete loss and sometimes not easy to search. It takes along time to respond to queries emanating from customers.

The industry is affected by another problem that, the agents are not able to display the houses for customers to see and visualize on a map and instead they have dealt with data in tabular form that has proved difficult for customers to visualize. Some have used photographs to show customers what type of houses they have for them. While the photographs have tried to communicate the message, they have not effectively impacted heavily on the idea. In the absence of a suitable way of communication, the agents opted to drive their customers to the site to see the houses and on arrival; many changed their minds because what they saw on the ground did not match what was depicted in the photographs. Some of the reasons for this were that, the beautiful house was built on a hostile neighbourhood sometimes next to a slum, a quarry site, a dump site, a swamp, or next to a

commercial building. Due to lack of this communication to the customers, the agent continued to operate at a loss since he had to employ many workers to do this and he spent a lot of fuel for field visits. Lack of this information has slowed the pace at which the sector is operating and it has remained behind other sectors of the economy.

Many countries of the world had faced a similar problem and they used enabling technologies with multiple integration capacity for the geospatial data (K'onguka, 2005). Such an information system is Geographic Information System (GIS) that is capable of integrating the spatial aspects of the houses and their attributes (non-spatial data). GIS is capable of capturing the spatial aspects of the houses, keep them in the database and generate a map that can be used to display the houses to the customers. This provides the customers with graphical representation of the houses for their easy visualization. GIS has embraced the Google platforms as a means of displaying the houses in graphical form together with the entire neighbourhood where customers can clearly see what is next to the house, the road network, the position of schools, supermarkets, churches, banks and other amenities. This is a milestone in the capabilities offered by GIS in managing real estates and it will minimize chances that customers will have to change their minds after seeing the house physically for what they see in Google maps is a true representation of the reality.

House owners have benefited from the old method since their needs do not have to do with the spatial attributes of the houses but GIS offers them a golden opportunity where the agent can query the database and get all the properties owned by one owner including all the details of tenants, rent balances and maintenance waiting to be done.

Other key actors in this sector will benefit from the system in that, some of the information generated by a GIS system will enable them create value added products like the area generated from house polygons and the location of the house is vital information in calculating land rates, the amount of rent is used by tax collectors to assess tax payments etc (Wirunda, 2002).

GIS technology will lead to increased productivity in many industry operations and to greater accuracy and timeliness of information for both professionals and the general public (Thrall, 1998). New technologies are designed to make real estate operations, run more efficiently and to assist property professionals to manage their properties in a much smoother way. The need of the day is to have a streamlined system for realtors to have access to their multiple system availability of information both visually and analytically.

The approach of using GIS to manage real estate was tested on a small scale in a case study of Komarock Estate Phase 1 infill using residential rental houses. If successful, it will be employed to the whole of the city of Nairobi.

1.2 PROBLEM STATEMENT

The real estate industry lacked a management system that could be used to run the sector efficiently. This has caused many problems to the key players like landlords, tenants, estate agents, tax collectors, valuers, rate collectors etc. The estate agents who rent property on behalf of landlords had generated massive volumes of data emanating from real estate properties. Characteristics of real estate properties have both spatial and non-spatial aspects like location of the house, the architectural properties like the type, number of rooms, the area covered by rooms, the cost etc. Estate agents had not managed to integrate all these data to one common format which could be queried to generate responses. Instead they stored their massive datasets in formats that were not acceptable. They stored data in papers that were filed, in paper maps, paper photographs, paper drawings etc. These data got torn, misplaced and it was not easy to search through when confronted with queries from customers who wanted to rent houses, they could not be updated easily. This caused delays to customers when looking for houses and also caused the estate agents more expenses in terms of labour in order to cope with the customers. The agents faced the problem of not being able to display their houses on a map for customers to see the location of the house and to evaluate the neighbourhood before making decisions.

1.3 OBJECTIVES

The main objective was to create a GIS database model to be used in the management of housing units located in Komarock Estate. This was to be achieved by the following specific objectives:-

1. To use GIS to capture the spatial data about the houses and their attributes into the database.
2. To display on a map locations of individual houses and their structural attributes, such as the plan types, number of rooms, and the photographs using GIS tools.
3. To use GIS tools to query the database in order to get responses based on the customer needs.

1.4 JUSTIFICATION OF THE STUDY

Due to the fact that estate agents were unable to handle real estate data in order to respond promptly to customer's queries, there was need for a management system to help in streamlining this sector. The Geographic Information System (GIS) offered capabilities of data capture, storage, manipulation, updating, querying, visualization and display of both spatial and non-spatial data. Use of GIS enabled the agents to keep their data in digital format that was able to query and respond to their customers' queries without delay and the display of the houses on a map enabled the customers to make good decisions.

1.5 SCOPE AND LIMITATIONS OF THE STUDY

The study covered a small area in Komarock Estate Phase 1 infill due to shortage of time and limitations of resources to carry out an extensive research in the whole of the City of Nairobi. The study concentrated on residential rental houses. This would form the basis of a wider research to other towns of Kenya that experienced similar problems. The study was done in three months.

1.6 STUDY AREA

The study was conducted in Komarock Estate, one of the middle class estates in the city of Nairobi neighbouring Saika, Umoja and Kayole estates. The estate is located in Embakasi Division 15 km from the city centre and it is served by Kangundo Road and Outering road via Donholm Estate. Komarock has over 3,000 houses with an approximate population of 15, 000 people. The estate is served by Double M buses and Nissan matatus. It has a big supermarket by the name Naivas and other small ones. The area has plenty of banking services like Equity bank, Cooperative Bank, Family bank and Kenya Commercial Bank cash point. It has a post office and Nairobi Water Company office for paying water bills. Security of the estate in manned by the police officers under the area Chief who resides at Kayole 500m from the estate. The estate is served with piped water and has an efficient sewerage system. Every house is connected with electricity. Both public and private primary schools are in plenty. The study area was part of the entire estate called phase 1 Infill, with 240 housing units and with four type plans. Due to lack of information in soft copy format, it was difficult to digitize the entire estate within the given time period for the project, therefore the researcher narrowed down to phase 1 Infill that was used as a demonstration.

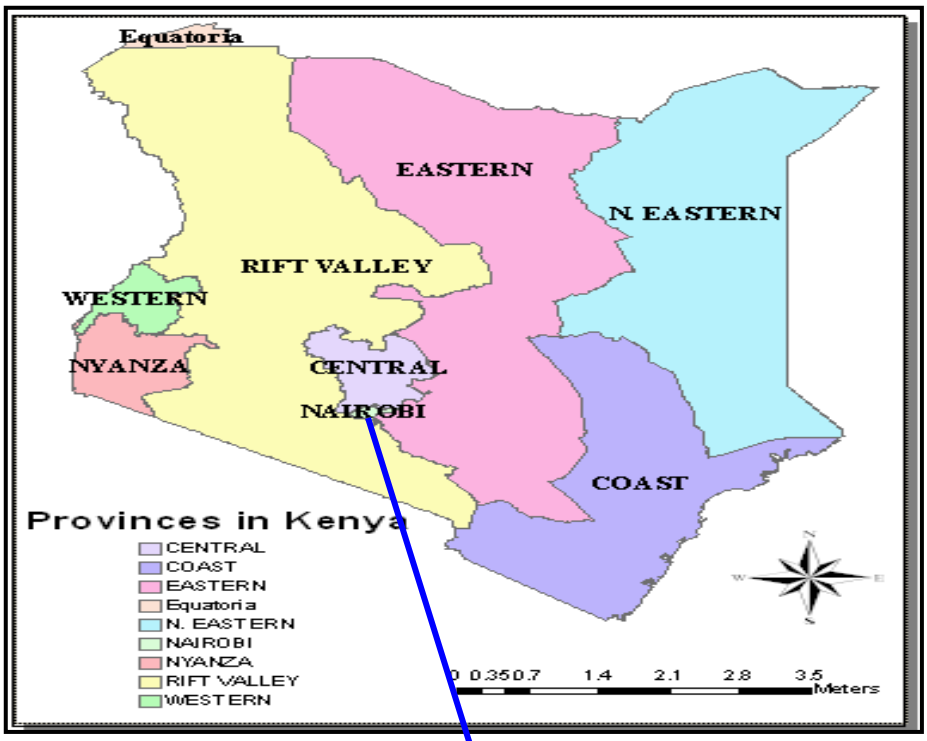


Fig. 1.1: Provinces in Kenya

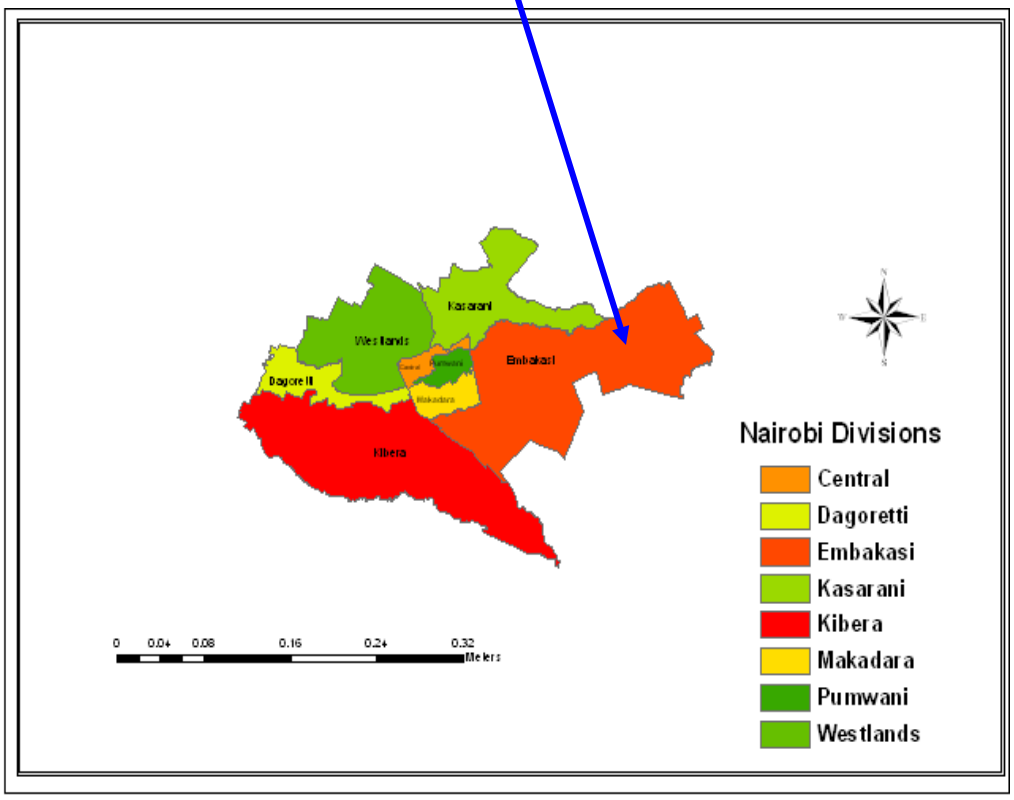


Fig. 1. 2: Nairobi Divisions
Source: ILRI data Nairobi Kenya

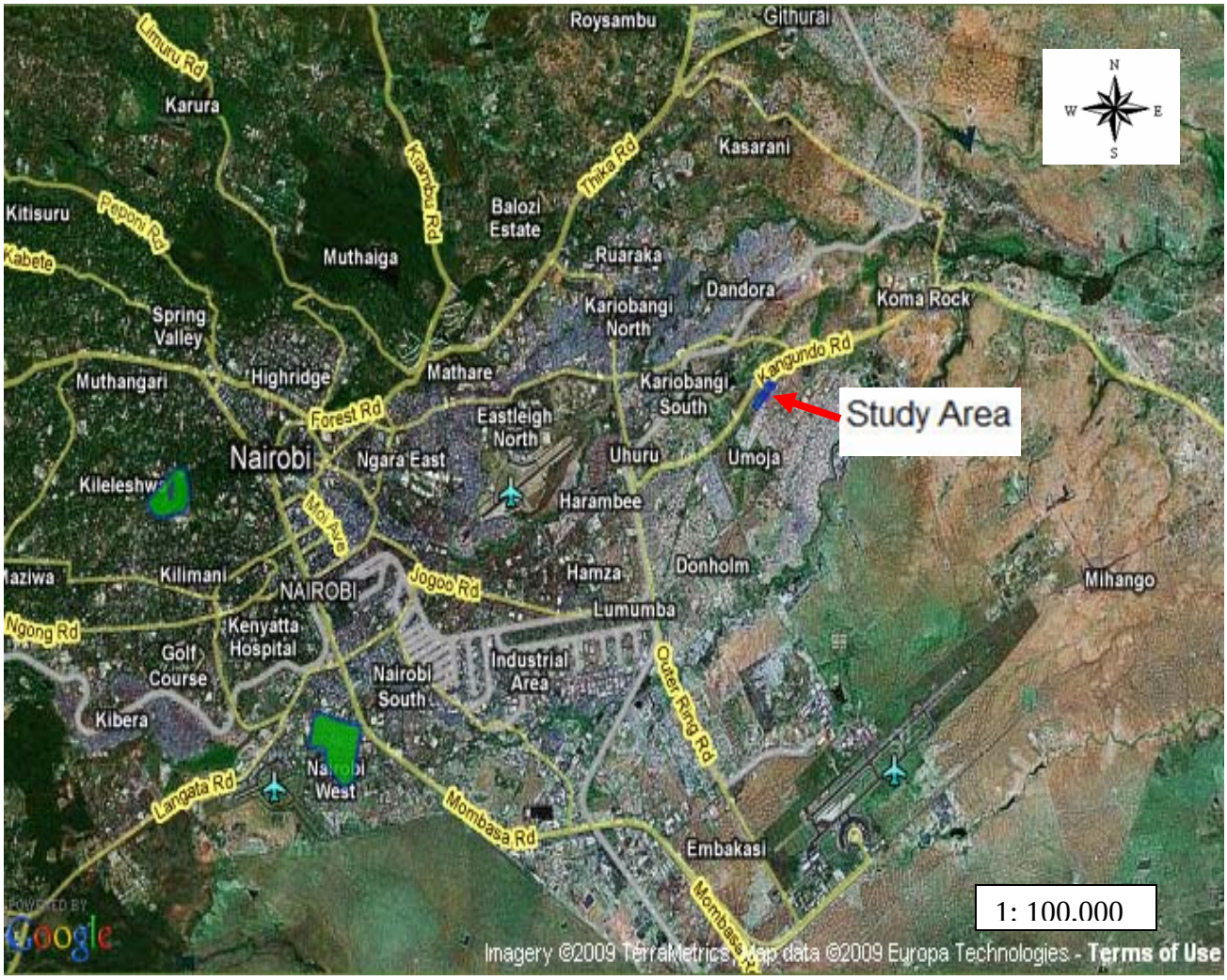


Fig.1. 3: Study area map of Komarock Estate Phase 1 Infill

Source: Google map

1.7 METHODOLOGY OVERVIEW

In order to accomplish the objective of this project, both spatial and non-spatial data for the Real Estate Database were collected from different sources and using different tools. The cadastral map of Komarock Estate Phase 1 Infill was collected from Nairobi City Council while the non-spatial data were collected from both the customers and the agents who managed these houses. Data analysis was done in order to get the required datasets that were to go into the database. The Real Estate database was developed in ArcGIS 9.2 that comprised the four stages namely; external modeling, conceptual modeling, logical and

physical modeling. In order to access information stored in different tables, tables were either joined or related in Arc Map. Google maps were incorporated in the report in order to display important things in the neighbourhood to enable customers make informed decisions. Customization of Arc Map was done in order to make Arc GIS user friendly to both the Real Estate agents as well as their employees. The analysis of the database was done to determine the capability and capacity of the database.

1.8 ORGANISATION OF THE REPORT

This report consists of five chapters:

Chapter one contains general introduction of the problem. Chapter two features the literature review. Chapter three has the methodology, Chapter four features the results and discussion and chapter five contains the conclusions and recommendations of the report.

CHAPTER TWO

LITERATURE REVIEW

2.1 INTRODUCTION

This chapter consists of a review of literature related to estate management, the role of GIS in estate management and a database system development in ArcGIS.

The role of management in real estate starts even before the tenants arrive. Real estate properties are spatial in nature and their geographic characteristics are important. One of the concerns of the property manager is the selection of good tenants. The selection of customers starts with proper site selection for the property that the site is located in a good environment and one takes into consideration the catchment area of the tenants and their needs. GIS is a powerful tool that offers spatial analysis capabilities like buffering to assess the suitability of a site for the intended purpose. GIS offers a platform for data integration which make it possible for proximity analysis. While the type of soil may be an economic consideration in putting up a residential estate, proximity to services like electricity, water, sewerage, road network and recreational areas is more important to the tenants (Olaniyi, et al, 2006).

The role of the property manager is to safeguard the interests of the tenant, house owner and the society in general. He administers lease agreements, collects rents, plans for maintenance and repairs, ensures security for tenants, ensures fire prevention and protection etc. A GIS system ensures creation of a database that incorporates all these datasets that enables the manager to interact with when he needs to capture more data, update, analyse, manipulate, retrieve and display.

GIS has capabilities for displaying and visualization of data. This is important to the manager when he is displaying the location of houses and their attributes on a local computer in an internet environment. He displays maps that are interactive and customized for the purpose of marketing and leasing of space. Today it is made possible to display

properties on Google map platforms in most parts of the world. This provides means of reaching more customers and providing most of the information needed before a customer visits the agents office.

2.2 FUNCTIONS OF PROPERTY MANAGER

The roles of management may be split into two. Management prior to occupancy and management after occupancy

2.2.1 ROLES OF MANAGEMENT PRIOR TO OCCUPPANCY

The role of management begins when a development is first conceived. There are a variety of responsibilities which must be undertaken prior to occupancy and are as follows:-.

(a) Design Assistance

A property manager should be at all times present his suggestions to the Architect and should not at any time fear that his advice might not be taken seriously due to lack of architectural training. Managers as users must be incorporated in the design so as to avoid designs which are non-utilitarian (Syagga, 1999).

In a majority of cases, the manager should be encouraged to make suggestions to the designer on everything he/she is expected to comment on such matters as;-

- Where to store cleaning materials and garden tools.
- Where to locate the source of water for cleaning or lawn sprinkling.
- How to dispose of rubbish and garbage.
- How to incorporate safety security features into structure.
- Where to locate the maintenance shop and what it should contain.
- How much space is required for the various office functions of management?
- What apartment layout the occupants find undesirable and why?
- What crises are disturbing to tenants and how they can be reduced?
- What mechanical equipment has given the best service?
- How best to provide for separation of electricity and water meters as well as security alarm system.

Over all cost-in-use of building and materials used as finishes (Njuguna, 2008).

(b) Marketing and leasing space

In the case of a new building, marketing should begin just before the completion of the development. The property manager should advertise the existence of such space at his disposal using various channels of reaching the clients such: placing boards with contact details, using daily press and print media, introductory letters to various Parties likely to be interested, checking on the previous list of applicants and placing property on the web site (Syagga, 1999).

If the property is privately owned for commercial use, then the property manager needs to discussion on the type of businesses permitted in the building, before soliciting for tenants. In obtaining the rent to be charged, a market survey is used by coming up with a list of comparable (Philip, 2004) observed the most common approach of setting the rental level to be the base unit approach. This involves choosing a standard unit in a building which is substantially similar to the building in question, and then the base unit is assigned a rental figure. The base unit is then used to set the rent rates of the other units depending on their relative merits and deficiencies. (Philip, 2004).

(c) Selection of occupants

After prospective tenants have applied, it is the duty of the property manager to determine who should be allocated the premises. In the case of social housing, the occupation will be chosen from the target group while for commercial properties it depends on what the landlord requires and the ability to pay rent. (Syagga, 1990).

(d) Pre-occupancy education

It is important that tenants are educated on the rules and regulations of the management firm. It is expected that new occupants will read the lease agreements rules and regulations which pertain to their obligations and their responsibilities and maintenance and good neighbourliness. The lease agreement is drafted by the legal profession and its terms may be complex to be understood by most tenants. It is therefore advisable that the Property manager explains it to the tenants. A research carried out by (Chomba, 1990) showed that

even after the property manager has read and interpreted the lease agreement to the tenants, only 41% of the tenants understand the lease document.

(e) Preparation and interpretation of leases

With or without records, lease, the relationship between a landlord and a tenant is governed by statues and their interpretation. In Kenya this relationship is governed by two acts of parliament i.e. landlord and tenant act cap 301 which deals with business premises i.e. shops, hotels and rent restriction act cap 296 which concerns residential properties. (Magana, 1988).

(ThornCroft, 1965) defines lease as a contract giving the exclusive right of possession and use of landed property for a fixed or determinable period. The principle accomplishment of a competent property manager is the ability to advice on the preparation of leases from a commercial point of view. The manager should be sufficiently versed in laws relating to landlord and tenants so as to be able to interpret leases and advice legal consultants appropriately when the need arises. Lease include among other things the description of occupied, rental reviews, payment of premiums, provisions and restrictions as to assignment or subletting, the responsibility for maintenance, repairs and insurance and provisions in respect to proposed alterations (Syagga, 1999)

(f) Letters of offer

A letter of offer to a prospective tenant details out the main terms and conditions of the tenancy. The manager issues a letter of offer to the tenant once the tenant has met the set out conditions. A letter of offer contains the following items: actual area, the term of the lease, the rent payable, site value tax, legal fees payable and conditions of letting (Philip, 2004).

2.2.2 POST OCCUPANCY ROLES

(a) (ThornCroft, 1965), defines rent as the periodic payment made to a landlord in consideration for use granted to the tenant under the lease. Rent is payable accordance with the term of the lease agreement under which the tenant holds the property. The agreement

states the intervals at which rent is to be paid and whether it is inclusive of other charges or not (Chomba, 1990). According to (Philip 2004), the rents can be done monthly, quarterly, half yearly, and yearly or more in advance depending on the agreement set out in the lease agreement. Various methods of rent collection may be used as follows:-

- Office collection
- Door to door collection
- Payment by credit transfer and bankers order
- Check off system

All the above methods are acceptable and none of them is perfect on its own merits.

(b) Rent arrears

Rent arrears are a major problem experienced in rental houses. This is the failure by the tenant to pay rent exactly when it is due or failure to pay at all.

(c) Lease administration

A lease is a legal document in which the owner of the property transfers the right to use and occupy the property to another for a specified amount of rent (Syagga, 1999). The principal types of leases are building, occupational leases, and subleases. Leases may also be described as exclusive, inclusive, gross, or net according to who pays for repairs and utilities between the landlord and the tenant. The function of a property manager in lease administration begins when a tenant signs a lease and concludes when the tenant moves out of the building.

(d) Maintenance and repair

According to (Syagga,1979), maintenance refers to works which can be predicted and planned in advance like painting to prevent deterioration while repairs covers the remedial action such as the replacement of some defective part e.g. replacing a broken window or leaking tap. The way the management responds to tenants requests for service is instrumental in determining what kind of relationship will exist between tenants and management and therefore it is the duty of the property manager to obtain corporation of tenants in keeping the property in good condition.

(e) Security

Security of users of a property is very important. The property manager is therefore responsible for the provision of security services soon after taking over a building. He/She should assess the best security arrangements for the property, taking into account the cost of such services (Philip, 2004).

There are many types of security arrangements as follow:-

- In house security
- Security guard firms
- Alarm systems
- Fencing
- Night lighting
- Closed circuit television (CCTV)

(f) Insurance

Property manager should be familiar with insurance policies that can be applied to real estate. He should make sure that the property is insured adequately at a minimum cost. He should be knowledgeable on up to date types of insurance coverage so as to recommend the most appropriate insurer for the property. When a claim or damages or accidents arises, he/she should first investigate them and then see that the reports are filled promptly with the insurer (Philip, 2004).

(g) Fire prevention

Fire is a major risk. It is defined in terms of the damage it is likely to cause if it goes out of control. Although property manager should be concerned with security especially if there is a fire, fire prevention must involve owners of the buildings, occupants, and staff. According to (Syagga, 1999) There are a number of equipments that can be used to fight fire as follows:

- Fire extinguishers
- Fire hose reels
- Fire alarms and smoke detectors
- Sprinkler systems

(h) Service charge

These costs only occur when the premises are let in multiple occupants such as flats and offices let in suits. The items commonly included in service charges are lighting of central halls, staircase, corridors, toilets, running and maintenance of lift employment of guards, porters etc. and provision of furniture and carpets in entrance hall and other common parts.

Cleaning – The property manager is supposed to devise a method on how the common parts of a building are to be cleaned. These include lobbies, staircases, windows, basement used for parking, flower gardens among others.

(i) Management of finances

The property manager is responsible for finances generated from rent collection.

2.3 THE ROLE OF GIS IN PROPERTY MANAGEMENT

Geographic Information System (GIS) is a computer system for capturing, storing, querying, analyzing, and displaying geographically referenced data also called geospatial data. Geographically referenced data are data that describe both the location and characteristics of spatial features such as roads, land parcels and vegetation stands on the earth's surface. The ability of GIS to handle and process geographically referenced data distinguishes GIS from other information systems and establishes GIS as a technology important to wide variety of applications (Kang-tsung, 2003).

The real estate data had both spatial and non-spatial aspects that required the use of GIS in order to integrate the two to get information. GIS for real estate management utilizes the following basic functions:-

- Data acquisition and pre-processing
- Database management and retrieval
- Spatial measurement and analysis
- Graphic output and visualization (Karanja, 2007).
-

2.3.1 DATA ACQUISITION AND PRE-PROCESSING

The data sources for a comprehensive GIS are probably more numerous and of greater variety than in most other information systems (Bernhardsen, 1999)

The various sources of real estate data were;-

- Hard copy cadastral map of Komarock Estate Phase1 Infill.
- Hard copy type plans and digital photographs.
- Ground control points.
- Data from customers and from estate agents.

2.3.1.1 PRIMARY GEOGRAPHIC DATA CAPTURE

Primary geographic data capture involved the direct capturing of the ground control points using the hand held GPS for the georeferencing the cadastral map of Komarock Estate Phase 1 Infill. The digital camera was used to acquire photographs of the houses and amenities in the neighbourhood.

Together with the spatial data collected from the City Council of Nairobi, more data was obtained from the customers and the agents. The methods that were preferred were through face -to- face encounters with the respondents, observation, and use of telephones. These methods were chosen because they provided the in depth data or information. Customers were selected randomly from different classes of people in order to have a representative data for the database.

The agents were also selected based on the classes of people that they served for example those that served the highest class of people and those that served medium class of people. This was deliberately done in order to collect all the possible requirements from customers as well as all the possible interactions that were performed by the agents while serving their customers. The data that was collected from the agents was mainly done through observing how they were working and how they interacted with their customers.

2.3.1.2 SECONDARY GEOGRAPHIC DATA CAPTURE

This involved creating raster and vector files and databases in ArcGIS from the cadastral map of Komarock Estate Phase 1 Infill. An A3 flat bed Scanner was used to capture raster

data of the cadastral map followed by the heads-up digitizing. All the houses, their plots and the roads were captured into the database. The attribute data were entered using the key board in Microsoft Access before being exported to ArcGIS 9.2.

2.3.2 DATABASE MANAGEMENT AND RETRIEVAL

The real estate data sets were stored in a database where they were managed by a Database Management System (DBMS) in ArcGIS 9.2. This offered many advantages such as reducing redundancy, reducing maintenance costs due to better organization, multiple applications could use the same data source, data sharing was possible together with offering security and standards to the data (Longley, 2005).

2.3.3 SPATIAL MEASUREMENT AND ANALYSIS

Many types of interrogations in real estate would ask for measurements like the total area of a parcel, land or the distance between two points and all these measurements were done by the GIS. Before GIS was invented in Canada, it was very tendentious and error prone to carry out measurements manually. There are many types of spatial analysis and modeling like queries where no changes occur into the database, measurements, transformations which are simple methods of spatial analysis but they change datasets, descriptive summaries, optimization, and hypothesis testing.

2.3.4 GRAPHIC OUTPUT AND VISUALIZATION

Geovisualization was all about how real estate information could be presented to the customer. Using techniques of geovisualization, GIS provided a far richer and more flexible medium for portraying attribute distributions than paper maps. Through spatial query, estate agents could explore, sysnthesize, present (communicate), and analyze the data to the satisfaction of the customers. GIS based geovisualization allowed users to interact with the real world form a distance by immersion in artificial worlds (Longley, 2005).

2.4 DATABASE SYSTEM DEVELOPMENT

Real Estate database development lifecycle was inherently associated with the life cycle of the information system and involved the following steps (Thomas, 2005).

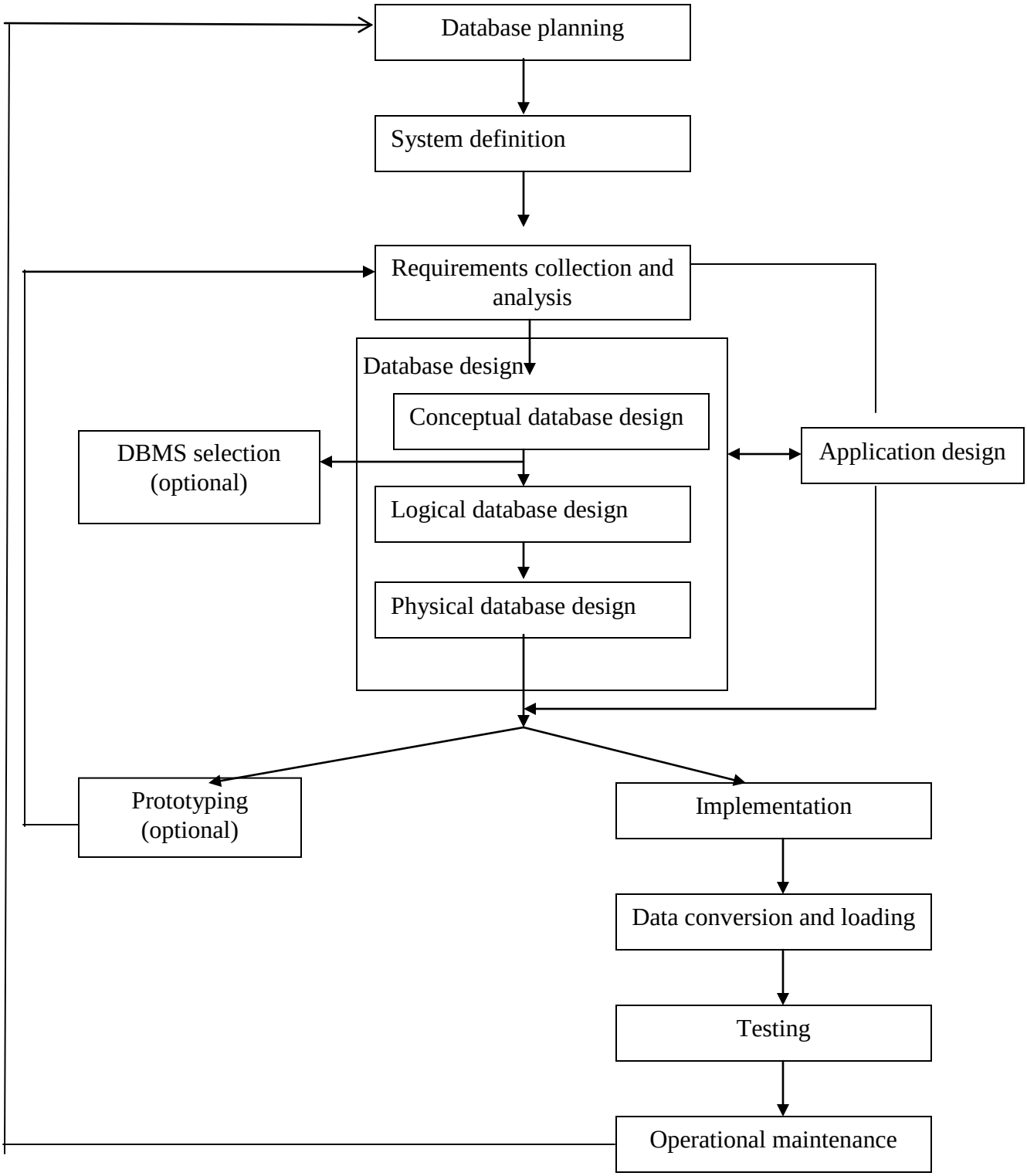


Fig. 2.1: The stages of the database system development lifecycle
Source: (Thomas, 2005)

2.4.1 PLANNING

In the recent years, there has been growing recognition that real estate data is an important corporate resource that should be treated with respect and to enable its proper management, a database was needed. To allow proper planning, a visit was made to the real estate agents to understand how they were working without a GIS and whether GIS was necessary and its implications in the real estate management. During the survey, it was evidenced that the agents were not using GIS but used databases that were not able to accommodate the spatial datasets to allow integration with the non-spatial data. A database is a tool capable of storing large amounts of complex information like those emanating from real estates in a structured way. Information in a database is organized into individual records that can be referenced, sorted, indexed, linked and queried. Databases are in principle, more robust, secure and scalable than storing information in flat files (K'onguka, 2005).

2.4.2 THE DATABASE

A database was build in order to conform to a data model, which was a set of concepts that would be used to describe a database. A data model must enable the definition of:

- The structure that would enable storage of the data. A data structure in database design refered to the way in which data were logically arranged in physical computer storage, using various mathematical structures such as arrays. Lists, queues. Trees, stacks etc. Data structures are complicated and often must be hidden from the general GIS user by the logical model.
- The integrity constraints that the data must obey.
- The data definition and data manipulation languages (DFL, DML).

2.4.3 RELATIONAL DABASE DESIGN

Database design was the process of identifying the real estate data sets that would go into the GIS database and how it would be represented. The database formed the foundation of all activities in the real estate management that would be performed using GIS, such as map creation, data retrieval and spatial analysis and modeling (Mulaku, 2007). Also according to

(Thomas, 2007), the database design was the process of creating a design that would support the real estate mission statement and mission objectives for the required database.

According to (Thomas, 2007), the most high-level data model used in database design and the one that was used in the real estate management was based on the concepts of the Entity–Relationship (ER) model. The Entity Relationship (ER) model was devised by Chen in 1976. It is a diagrammatic technique that provides a generalized approach to the representation of data and which is particularly suitable and helpful in the design of relational database systems. (Ritchie, 2003)

Database design normally consists of the following steps:

- External modeling
- Conceptual modeling
- Logical modeling.
- Physical modeling

2.4.3.1 EXTERNAL MODELING

This step is also referred to as 'user needs assessment'. It was the determination of finite potential users of the real estate database, their information needs and hence the data that was required to satisfy those needs. The data for external modeling was collected from different sources. Some were collected from the customers and estate agent firms. Interest was on what the customers looked for when looking for a house, how the agents carried out their work, how they kept their files and whether the files were easily queried, how they let the properties and the general management activities like maintenance issues, security, insurance, fire protection, and statutory responsibilities like tax payment, land rent payment (lease), payment of city council rates etc

2.4.3.2 GATHERING USER/BUSINESS REQUIREMENTS

1. The property is owned by the property owner (landlord/landlady).
2. Property owner contacts estate agent and provides details of the property.
3. Property owner and estate agent agrees on appropriate rent for the property.
4. The estate agent registers the property and signs an agreement with the property

owner.

5. After registering the property, the estate agent provides services to ensure that the property is rented out (letting process).
6. The estate agent interviews prospective renters (Tenant), organize viewing, advertise in local or national newspapers, places sign boards on site of property etc.
7. The estate agent negotiates leases with tenants.
8. Tenant signs lease agreements before occupancy.
9. After letting, the estate agent begins the role of management and re-letting.
10. Estate agent manages the property by collecting rent, renewing lease, maintaining property, ensures payments of services, cleaning premises, provide security etc.

2.4.3.3 CONCEPTUAL MODELLING

This was the first phase of database design and involved the creation of a conceptual data model of Komarock Estate Phase 1 Infill. The data model was built using the information documented in the user requirements specification (Thomas, 2005). A conceptual data model comprised entity types, relationship types, attributes and attribute domains, mappings (cardinalities), primary keys, alternate keys and integrity constraints.

2.4.3.4 RELATIONAL CONCEPTS AND TERMINOLOGY

(i) Entity – An object that has a physical (e.g. building) or conceptual (e.g. company) existence, and which is of interest to a database user.

(ii) Attributes – A set of properties associated with an entity. Each attribute may have a range of possible values; this range is called the attribute domain or value set.

(iii) Composite attributes – One that is composed of several, more basic attributes; for example address may consist of the street address, the name of the city, the postal code and the country.

(iv) Atomic attribute- One that should not be decomposed into lesser component attributes e.g. if the attribute name is atomic, then an instance of it such as John Wesonga must be treated as a single item, not splitable into John and Wesonga.

(v) Single valued attributes – One that has only one value for a given entity at any given time e.g. age of a person, area for a land parcel.

(vi) Multivalued attributes – One that has more than one value for a given entity at the same time; e.g. colour for a muiltcoloured building.

(vii) Null attribute- One that is not applicable to a given entity; e.g. area for a line.

(viii) Relationship – This is an association amongst entities. E.g.

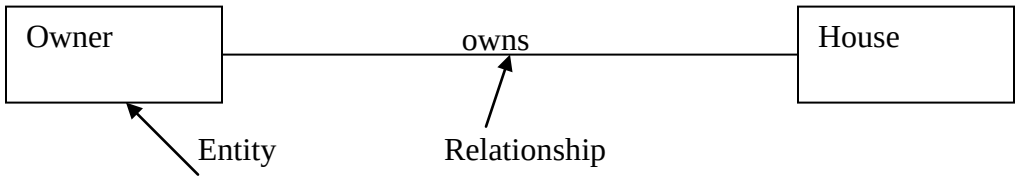


Fig. 2.2: Entity relationship diagram

A relation was said to be binary if it associated two entities or ternary if it associated three entities. The number of entities associated by a relationship was refereed to as the degree of the relationship.

(ix) Cardinalities - These were numbers that expressed the range or scope of the relationship between entities. They are expressed as four numbers defining the maximum number of entities occurring in a relationship in both the forward and reverse directions.

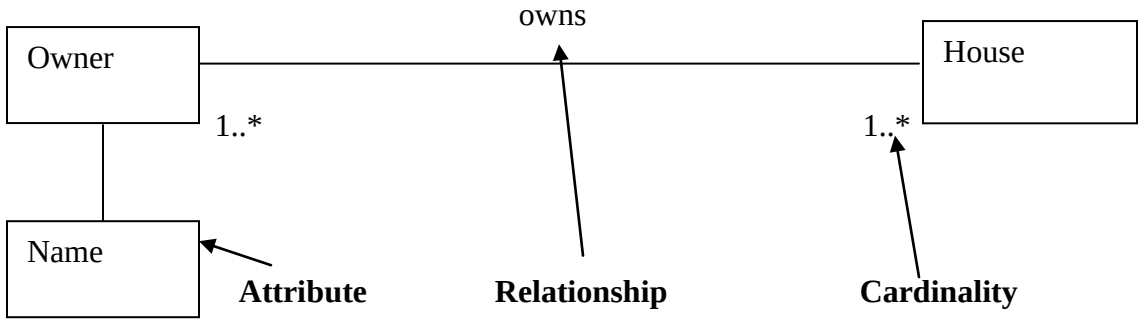


Fig. 2.3: Association of attributes, relationship and cardinality.

(x) Primary key (Pk)– This was a column (or a combination of two or more columns) that serves to identify the individual rows of the table.

(xi) Composite primary key - This was a primary key that consist of more than one column.

(xii) Foreign key (fk) – A foreign key was a column in a table where that column was a primary key of another table, which meant that any data in a foreign key column must have corresponding data in the other table where that column was the primary key. In DBMS-speak, this correspondence is known as **referential integrity**.

(xiii) Candidate Keys – They existed when it was possible to find more than one column, or combination of columns, which could serve as a primary key. These alternative primary keys were called candidate keys.

2.4.3.5 ENTITY-RELATIONSHIP (ER) MODEL

Entity Relationship (E-R) modeling was a diagrammatic technique used by analysts as a top-down method for analyzing the nature of an application system. Its objective being to help in understanding the nature and relationships that existed within the data of the system. The E-R diagrams could then be used to derive a set off relational tables that model the data of the application system. The first requirement before attempting to design an E-R diagram was a proper understanding of the problem domain in real estate.

While general and intuitive rules could contribute to the E-R design, many of the factors to be taken into account in this respect could be called 'business rules' i.e. stipulations and or/restrictions on how things would be done within the real estate. For example that *a house owner can own many houses while a tenant can rent many houses.*

(a) Entities and relationships

Entities and relationships are expressed diagrammatically in E-R diagrams, using suitable drawing conventions that distinguished clearly entities and relationships. There were several different conventions used in drawing E-R diagrams. The one that was used in this report was the (Unified Modelling Language) **UML** notation for conceptual modeling as shown in figure 2.4.

(b) Degrees of relationships

It was not enough to say that two entities were related; we needed to say to what degree they are related. There were three flavours of cardinality according to (Ritchie, 2003) as follows;-

- 1:1 One to one
- 1:n One to many
- M:n Many to many

Each of the relationships could be read in two directions.

(c) Optionality and participation

We needed some additional convention for use in E-R diagrams that allowed us to express the kind of condition since some relations were mandatory and some were optional.

2.4.3.6 LOGICAL MODELLING

This was the second phase of database design and it was based on the target data model for the database (in this case relational data model). It consisted of the mapping of the conceptual design onto the logical model DBMS. The relational model has been the most successful commercially. For relational DBMS, logical modeling comprised the design and normalization of the relational tables according to the entities, attributes and relations identified from conceptual modeling. Several iterations were necessary.

2.4.3.7 NORMALIZATION OF RELATIONAL TABLES

Normalization was a process of examining relationships between the real estate datasets. It used a series of tests described as normal forms to help identify the optimal grouping of these attributes. Normal forms identified were: First, second and third normal forms (abbreviated as 1NF, 2NF and 3NF).

2.4.3.8 PHYSICAL MODELING

While logical database design was concerned with the *what*, physical database design was concerned with *how*. It was concerned with the representation of the real estate datasets into

ArcGIS database in order to be managed by the DBMS. Knowledge on the functionality offered by the target DBMS was important.

- How to create the base relations
- Whether the system supported the definition of Primary keys, foreign keys, and alternate keys.
- Whether the system supported the definition of required data (that was, whether the system allowed attributes to be defined as NOT NULL)
- Whether the system supported the definition of domains.
- Whether the system supported relational integrity constraints.
- Whether the system supported the definition of integrity constraints.
  (Thomas, 2005)

2.5 WORKING IN ARCGIS

ArcGIS worked with the real estate geographic information managed in geodatabases as well as in numerous GIS file formats. The geodatabase was used for editing and data management of the real estate database.

The real estate datasets of various types were held in a common file system folder, a Microsoft Access database, or a multiuser relational database (such as Oracle, Microsoft SQL Server, or IBM DB2).

The geodatabase was the primary mechanism used to organize and use the real estate geographic information in ArcGIS and contained three primary dataset types:

- Feature classes
- Raster datasets
- Tables

Creating a collection of these dataset types was the first step in designing and building a real estate geodatabase. It started by building a number of these fundamental dataset types. Then addition or extension of the geodatabase with more advanced capabilities (such as by

adding topologies, networks, or subtypes) to model real estate behavior, maintain data integrity, and work with an important set of spatial relationships (ArcGIS software, 9.2).

Hyperlinks provided additional information about the houses like the type plans and photographs to the customers while using the maps with Arc Map.

geodatabase design promoted organization of the real estate database into multiple tables each focused on specific topic instead of one big table containing all the necessary fields. Having multiple tables prevented duplication of information in the database. When information was required and it was not in the current table, one could link the two tables. Arc Map provided two methods to associate data stored in tables with geographic features by use of joins and relates.

ArcGIS uses the Structured Query Language (SQL) to access information from the database. It was used in Arc Map to select features with the Select by Attributes dialog box or with the Query Builder dialog box to set a layer definition query. It was also used in geoprocessing to define a subset of features or records to perform an operation on (ArcGIS 9.2 soft ware).

2.5.1 GOOGLE MAPS AND CUSTOMIZATION OF ARC MAP

Google Earth and Google maps were vital tools that acted as platforms to show route maps as well as the location of the houses in relation to the neighbourhood. They have been used in the U.S.A by tourists to know the location of hotels. Google Earth introduced the new concept in Kenya and it is vital information for the management of real estates to show locations. This concept would go along way in assisting the citizens in identifying properties and their locations on the map.

Customization was done to Arc Map or ArcCatalog in order for the interfaces to reflect user preferences on the way they worked. The reason for this was to shield the database user from the operations of ArcGIS and instead use the interface to respond to prospective tenants queries**.** One of the principal ways one could tailor the applications to suit his/her

needs was to use the customize dialog box to change menus and toolbars (ArcGIS software 9.2).

2.6 APPLICATIONS OF GIS IN REAL ESTATE MANAGEMENT

Modern methods of Real Estate Management involved the use of enabling technologies with multiple integration for the geospatial data to support decision making by customers and to ease data handling to minimise error in transactions (K,onguka, 2005). In Kenya, the Real Estate Agents had not embraced these technologies and therefore had experienced handicaps in their transactions. They had not been able to display to their customers the vacant houses on a map and incorporating the surrounding neighbourhood for customers to judge the suitability of the house. It was on this basis that GIS in Real Estate Management was introduced in this report with an aim of introducing it to the Real Estate Industry in Kenya for informed decision making (Irimu, 2007).

In Nigeria, GIS was used for effective management of an estate and its resources in a case study of Araroni Phase IV, Oyo. GIS was used in capturing the geometric and attribute data about the estate features such as roads, parcels, buildings, electric poles, wells, land use, ownership and address. The database that was created in Arcview 3.2a was successfully used to perform spatial queries and presented results on a map which proved useful towards decision making. (Olaniyi et al, 2006).

Real Estate Industry started the implementation of the Multiple Listing Services (MLS), a computerised system that listed available properties and included the characteristics of each property including size, type, number of bedrooms, price etc. Inclusion of mapping capabilities was also started. Other applications were Estate Management Portfolio and Cooperate asset where portfolio managers managed large portfolios of Real Estate for major institutional investors such as pension funds since they used geographic data such as offices and manufacturing space (Clarke, 1995).

Sometimes back in 1980s, many municipalities made substantial investment in GIS after they recognized the importance of integrated approach to their computerized data and to the

organization of georeferenced information. Cities like Minneapolis, Minnesota; Los Angeles, California, Texas etc were using GIS to support municipal functions like property management, property appraisal permit and license issuing, sub-division planning, transportation analysis planning emergency vehicle routing, dispatching engineering design, inventory of water/sewer systems and electrical cabling and land use planning (Aronoff, 1989).

GIS has been used to do analysis in residential infill for the city of Woodstock, Ontario. The GIS was used to calculate the area of the main structure in each parcel and compared it to the parcel land area. This determined the amount of land potentially available for residential infilling. The age, size and condition information for each structure was analyzed to assess whether it was a candidate for demolition. A map was then generated showing the three infill classes required for planning and the street network and parcel boundaries (Aronoff, 1989).

GeoSpan (Minneapolis) deployed "Geovans" around the country to collect video footage and GPS registrations of real estate properties in conjunction with a GIS program. Their concept essentially amounted to replacing time-consuming drive-bys with more efficient software viewings (Daniel, 1994).

Castle Consulting (San Fransisco) had been developing PC-based GIS software to support portfolio management and property appraisal. Grant Ian Thrall of the University of Florida pursued the idea of using GIS to rate the "quality" of property tax appraisals (Daniel, 1994).

Prigmore Associates (Hull, MA) has used GIS system in conjunction with due diligence. Coopers & Lybrand and Arthur Andersen were evaluating how GIS could be used more extensively with their services. And the Castillo Company (Phoenix, AZ) was moving toward integrating GIS with a full line of real estate services including market analysis, site search, due diligence, architecture, design and construction management (Daniel, 1994).

GMN technology was a new method integrating GIS and management Information System (MIS) in the internet environment. Before its invention, real estate management software based on MIS failed to meet various requirements on the internet. GIS provided geographic information and 3D visualization capabilities to traditional real estate software systems and GMN –based Real Estate system enabled users to browse Real Estate information and conduct Real Estate business online. The actual data used was for Buona Garden Estate Real Estate in Wuhan in China (Lin et al, 2001)

Rapid development software tools have allowed some companies to develop consumer oriented real estate applications like IRIS-online parcel-based GIS software targeted to real estate professionals and consumers. With IRIS, buyers can ‘‘tour’’MLS properties by previewing them on a computer screen. Users can view full-color pictures of every property along with tax records, lot sizes, neighborhood demographics, points of interest, and even who lives next door. IRIS has a search function that allows users to input up to 14 fields of information at a time. The IRIS service includes providing a mobile crew and specially equipped van that takes photographs of the parcels. Program users can then create and print full-color brochures of each property (Thrall, 1998).

The National Association of Realtors begun work on a nationwide initiative called the Realtor Information Network (RIN) to provide real estate offices with standardized seamless computer databases and software. If fully implemented, RIN could become a de facto national MLS. A RIN-like product would enable real estate professionals to match buyers with sellers of homes more quickly and successfully. RIN data would be available in the internet and was developed by ESRI (Environmental Systems Research Institute Inc.); GDT (Geographic Data Technology) provides the geographic and demographic data (Thrall, 1998).

Data Value-Added Resellers (DVARs) purchases the property assessment files from the local government and restructures them in an easy-to-read format, such as the popular DBF file format that most GIS and spreadsheet software could read. The DVAR’s product may include a software program specific to the data, which allows the user to search and query

by data field, create subsets of data, and generate reports. DVARs provide further value by adding latitude and longitude coordinates to the data records, allowing the property assessment file to be used with a GIS software program as a fully spatial database. One example of a DVAR property assessment data file software and data product is PA-View (Property Assessment Viewer) developed for Alachua County, FL. PA-View allows the user to access the property tax roll information, perform queries on that information, produce tables of information on selected records (e.g., all single-family homes built since 1990 that sold for over $250,000 in ZIP Code 32605), and produce summary market reports by small area. (Thrall, 1998).

An example of similar products from DVARs. Multiple Choice from Multiple Choice Software Company is a product that links MLS data with electronic tax parcel maps, real property data, and other map layers via the Internet. Multiple Choice can be customized for any county. Another similar product is from Information Delivery Service (IDS of Indianapolis), which markets GIS-ready real estate data for Indianapolis. Stewart Title's BACA LANDATA is an example of an Internet-based DVAR. This is a public access site for address/parcel lookups and is a gateway to fee services offered by Stewart Title.2 Also, some large firms such as TRW are starting to provide combined local real estate transactions data and software products for multiple markets. These examples point in the direction of an emerging market for combined data and software products for using local public real estate records. These applications mostly benefit from the integrated medium GIS technology offers for spatial data management, extraction, query, and visualization. Prior to desktop GIS software, and before DVAR products, the display and analysis of information from the local tax assessment records would have been extremely time consuming, very costly, and possibly not feasible at all (Thrall, 1998).

2.7 BENEFITS OF GIS IN REAL ESTATE MANAGEMENT

Benefits of using Geographic Information System (GIS) databases in management of real estate are vast. Integration exists between digital maps and the management system.

The following are some of the benefits:

- Houses are integrated with their attributes like house type, number of rooms, area of the house, rent amount etc.
- The database provides means of displaying a map showing a particular house in relation to the entire estate, amenities in the neighbourhood, and to know whether the house is vacant or occupied.
- The database provides means of advertising the houses with much more details to enable the searcher to make decisions in a better way and to minimize the many trips that are made to the site. This is made possible by use of the Google map platform.
- By customizing the Arc map, employees who are not well versed with GIS can use the system easily and comfortably.
- Having all these information in a database enables future users to extend it to suit the circumstances.
- The house records are now very easy to query, easy to revise and update when tenants leave and others come in and when house owners stop dealing with a particular agent.
- There is possibility of value added products.
- Real Estate information can now be exchanged and shared with other key players.
- A Real Estate GIS database saves time and brings down the costs of transactions in real estate.

2.8 CHALLENGES OF A GIS SYSTEM

The following are some of the challenges of a GIS system:-

- The system is expensive and requires lots of initial capital and running costs.
- It requires skilled operators.
- Holds up due to power supplies and fluctuations.
- System is subject to security breaches (virus attacks, hacking and spying while on the internet).
- GIS system alone may not lead to organisational profitability if they have poor management (Inima K, 2009).

CHAPTER THREE

METHODOLOGY

3.1 STUDY AREA

As it was mentioned earlier, this study was conducted in Komarock Phase 1 Infill which is part of the entire Komarock Estate. It consists of 240 housing units and with four house type plans i.e.

Single storey type 3/1 - (137 units)

Single storey type 4/1 - (29 units)

Double storey type 4/2 - (63 units)

Double storey type 5/2 - (9 units)

Komarock Estate is one of the middle class estates in the city of Nairobi neighbouring Saika, Umoja and Kayole. The study area was selected since it was a residential area incorporating many house types and had different types of amenities in the neighbourhood. This made it an ideal study area whose results would be replicated to other parts of Nairobi. The estate is located in Embakasi Division 15 km from the city centre and it is served by Kangundo Road and Outering road via Donholm Estate. Komarock has over 3,000 houses with an approximate population of 15, 000 people.

(See fig. 3.1 for study area map)

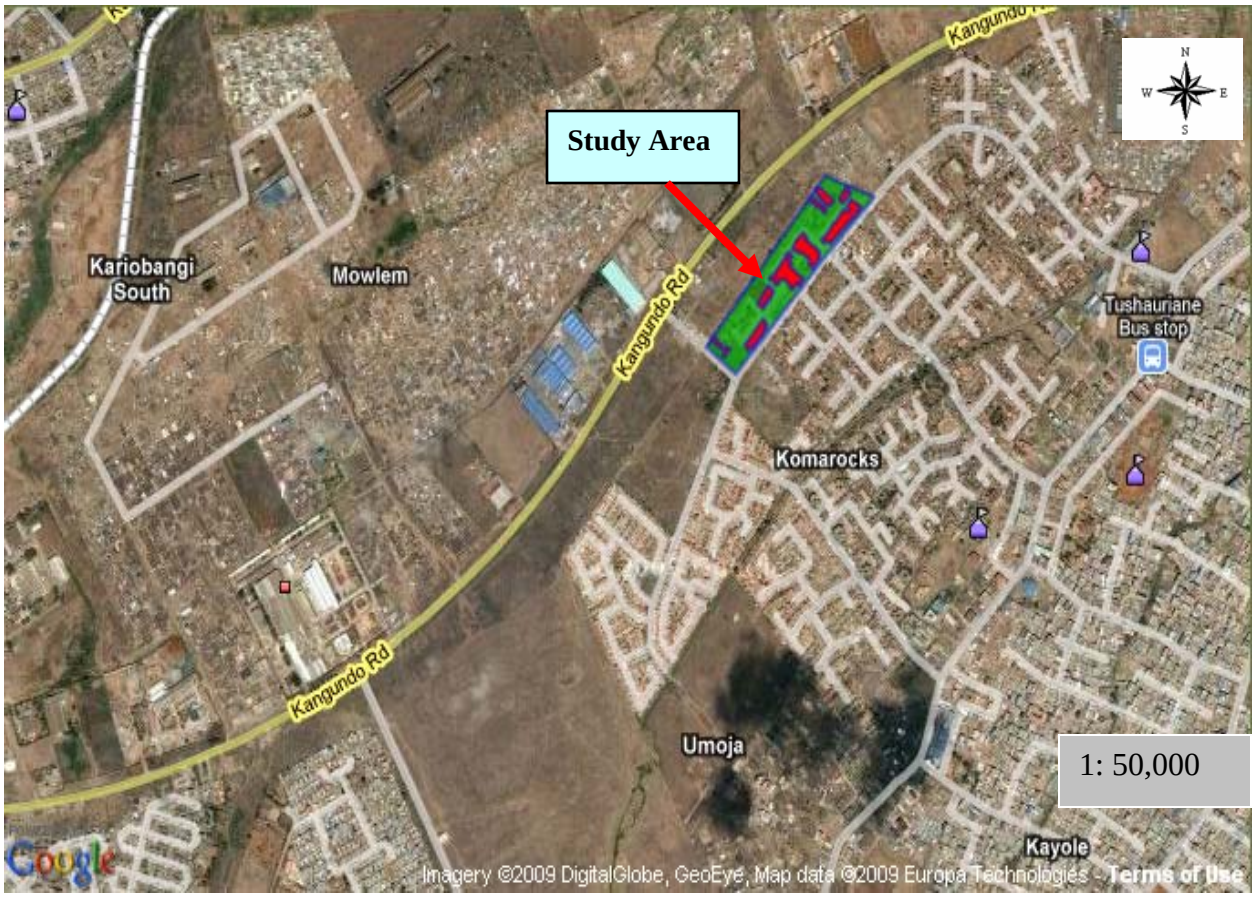


Fig. 3.1: Study area map of Komarock Estate Phase 1 Infill

Source: Google map

3.2 DATA SOURCES AND TOOLS USED IN THE STUDY

- **Hardware**

Computer hardware requirement included: Personal Computer, flush disk 2GB, Compact Disc 700 MB, scanner A3 size, printer, and plotter.

Hand held Global Positioning System (GPS) receiver (type Gamin).

- **Software**

- Adobe Reader - for opening the ArchiCAD drawing saved as PDF.
- Adobe Photoshop- for converting ArchiCAD drawings to TIF or JPEG
- ArcGIS 9.2 - for database creation.
- ArchiCAD 12 – for drawing type plans.
- TOPO - for downloading ground control points for georeferencing the cadastral map.
- Microsoft Access - for capturing the non-spatial data.
- Microsoft Word - For typing the manuscript.
- Microsoft power point - for preparing the project presentation.

3.3 DEVELOPING A GIS DATABASE FOR REAL ESTATE MANAGEMENT

3.3.1 DATA COLLECTION

This entailed identifying and collecting the datasets which were to go into the GIS database. In other words to gather all the information a customer would look for while searching for a house including all the information needed by the agent in order to serve the customers. Another set of data that was collected was to suit all possible queries that would come from house owners and the society in general.

3.3.2 DATA COLLECTION METHODS

Data to be used in the Real Estate database composed of secondary, primary, spatial and non-spatial data and it was collected from various sources.

3.3.2.1 PRIMARY DATA FROM CUSTOMERS AND ESTATE AGENTS

This data was collected from the study area, South C and Kileleshwa estates. The target population was all customers who looked for middle and high class houses in Nairobi. Twenty houses were picked from each of the three estates by use of random sampling to give a representative sample. Data collection was administered by use of interviews (see interview schedule in appendix 1). Face to face interviews were conducted.

Data from estate agents was done done by random sampling but care was taken to have a representative sample especially in the way the agents operated and the typical queries that they encountered from their customers. Seven estate agent firms were selected, three operating in the high class and four operating in the medium class houses. The estate agent firms were Frank Night, Crystal Valuers, Loyd Masika, Landmark valuers, Jokhas property managers, G-property managers and Gachwe property managers.

Data collection was administered by both face to face interviews and by observing them as they worked (see interview schedule in appendix 1).

3.3.2.2 SPATIAL DATA COLLECTION

The cadastral map of the entire Komarock Estate Phase 1 Infill of 240 housing units at a scale 1:500, their plots, including type plans (scale 1:50) were collected from the City Council of Nairobi in hard copies.

The ground control points, schools, banks, supermarket etc. were picked by a hand held GPS receiver. Photographs were also taken with a digital camera.

Location maps were obtained from ILRI in soft copy and Google maps in the internet.

3.3.2.3 DATA COLLECTED

(a) Data from customers were as follows:

- Customers specified location
- Cost of the house (affordability)
- The type of house
- Neighbourhood to the house
- Size of rooms and size of garage
- Security
- Transportation system
- Water availability

(b) Data collected from estate agents were as follows:

1. Queries that they got from customers were

   Location, cost of house, the type, the size of rooms, security, nearness to roads, shops or schools. Water availability and Neighbourhood.
2. Advertisement methods like newspapers, posters on site, information from caretakers, use of internet,
3. Data storage like excel spreadsheets, architectural type plans on walls, maps on walls, photographs in the computer or in albums
4. Contracts and lease agreements in paper form but some in digital forms.
5. Data on fire protection offered, services provided, were in paper form, but some agents put them in digital form.

3.3.2.4 ANALYSIS OF COLLECTED DATA

Many customers expressed location as a main concern while looking for a house in that the house should be near a school for the children to walk or to be driven, the nearness to the road was also a concern in order to be able to pick a bus. The type of the house was a great concern whereby some old people preferred single storey buildings while young ones preferred double storey. The cost of the house was a concern to many as they wanted what they could afford although to be of reasonable size. Security was important so as to be safe in the house and as they walked or drove home. Neighbourhood was important for it dictated the price of the house, and influenced security very much due to crime rates and proximity to nuisance.

Customers were also concerned about places to shop, collect gas, and go to worship. The road or communication network was important for customers to move easily within the estates.

To both categories of agents, the most frequently asked questions by customers were: location of the house, amount of rent, type of house, size of rooms, nearness to the road, security, water availability, transportation system (good roads), amenities in the neighbourhood like schools, supermarkets, churches etc

The registered agents mostly used the internet, newspapers and posters on the plots to advertise for the houses, however, they still received many customers direct to their offices. They kept their data in a database which were easy to query, they answered some of the customers' queries fast enough but they expressed that more often, customers could change their minds after seeing the house and these made them employ many workers. These agents did not have the means to display their houses on maps and preferred using the stand alone photographs integrated with text about the name of the location, amount of rent and contact person. No information was available about the neighbourhood which was a great concern to expatriates not familiar with the area. The security details and means of fire protection provided by house owners were readily available for some agents like Knight Frank. Most of the non-spatial data were easily captured but they did not capture the spatial data into the computer in order to integrate the two datasets.

The unregistered estate agents advertised their houses on the site by displaying posters for vacant houses. Most of their customers came direct to the offices to look for houses. Most of them had databases in excel displaying all houses from one owner, occupied versus unoccupied. They did not use photographs to advertise the houses. This category of agents faced a similar problem that customers could change their minds after seeing the house. Similarly, no information was found about the neighbourhood. These agents did not keep track of maintenance schedules and many tenants vacated the houses. Lease agreements, security and services about the house were kept in paper forms.

3.3.3 DATABASE PLANNING

Database planning allowed identification of real estate goals and plans to be identified. Evaluation of current information system to determine strengths and weaknesses was done and the need for Information Technology in real estate identified.

3.3.3.1 DATABASE DESIGN

It consists of the following steps:

3.3.3.2 EXTERNAL MODELLING

This involved conceptualizing the real-world i.e. prospective tenant needs, house owner needs and the societal needs. All these needs had to be addressed for the database to be effective.

From figure 3.2 shown below, was a summary of the particulars about the database. In other words, the capability of the database. The database has to provide for the tenant needs by providing means of locating the appropriate house for rental by considering the factors expressed by tenants.

Owners have their needs that needed to be satisfied by the database such as the need to know how much rent had been collected and when the balances were to be paid. They also needed to know whether the statutory payments like land rate, council rate insurances, government tax etc had been paid. Agents also wanted to know whether the security offered to the house was adequate, maintenance had been done, fire protection was adequate, cleaning and guarding was done.

The society needs were many and diverse. This database was to be comprehensive so as to be useful to planners and service providers like Kenya Power and lighting, Nairobi Water Company, City Council of Nairobi etc. Nairobi Water Company could use the database to re-design their outdated water systems by knowing the water demand. They could also use it for estimating the positions of the water meters. The database provided drawings for the houses and their photographs that offered vital information to mortgage

firms, insurance, and could be used by the ministry of housing to take inventory of housing stock of and how they were aging in order to plan on new houses.

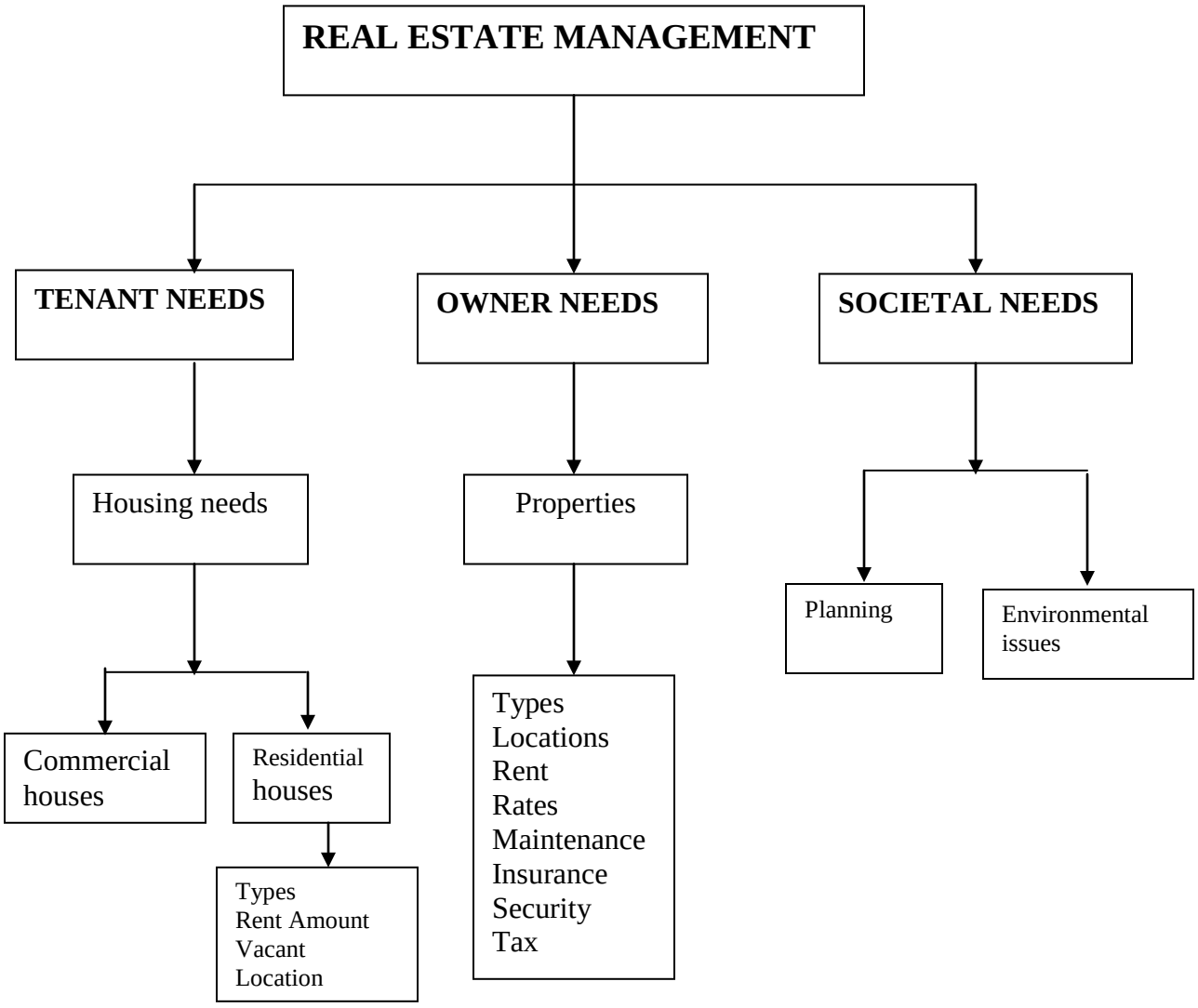


Fig. 3.2: Real Estate Management Datasets

3.3.3.2.1 USER/BUSINESS RULES

The following general business rules of the database were identified to enable the drawing of the E-R diagram.

1. Owner must sign a contract and he/she can sign many contracts for different houses.
2. Owner may own more than one house.
3. Tenant may rent many houses.
4. A house must have one tenant.
5. Tenant must sign a lease agreement for each rented house.
6. A house may have a service type.
7. Owner must sign a lease agreement for each house rented.
8. A house must be in a plot and a plot can have one or no house.
9. Plot must have a location and a plot must be in one location.
10. A house has only one house type.
11. A house may have an insurance type and must have only one insurance type.
12. A house may not have a maintenance type.
13. A house must have a fire protection type.
14. Plot must have security.

3.3.3.3 CONCEPTUAL DATABASE DESIGN

This involved the creation of a conceptual data model of the Real Estate Management of Komarock Estate Phase 1 Infill.

3.3.3.3.1 ENTITIES OF THE DATABASE

After the data collection from customers, estate agents, spatial data about the houses, ground control points and amenities in the neighbourhood, the following database entities were identified: Houses, HouseType, Owner, Plotsselected, LeaseAgreement, Leasetype, Tenant, Contract, ContractType, Location, MaintananceType, InsuranceType, ServiceType, SecurityType, FireProtectionType. The conceptual data model is supported by documentation and Entity-Relationship (ER) diagrams like the one shown in figure 2.4.

3.3.3.4 LOGICAL DATABASE DESIGN

At this stage, relational tables and their attributes were created representing the entities identified after the user needs assessment. For each table the primary key was identified and also any possible foreign keys. The primary key was underlined while foreign keys had (fk)

3.3.3.4.1 RELATIONS

1. Houses (HouseID, HouseTypeID (fk), Rooms, LRNo(fk), OwnerID (fk), TenantID (fk) Area, RentAmount, Tax, ServiveID(fk), FireprotectionID (fk), InsuranceType, MaintenanceTypeID, LocationID(fk), StatusID).
2. HouseType (HouseTypeID, HouseType).
3. Owner (OwnerID, OwnerFName, OwnerLName, OwnerAddress, OwnerTelNo. OwnerPINNO).
4. Plotsselected (LRNo, LocationID (fk), Area, OwnerID(fk), CouncilRate, Lease, SecurityID(fk).
5. LeaseAgreement (LeaseAgreementID, RentAmount, DateStart, DateFinish, TenantID(fk), OwnerID(fk).
6. LeaseType (LeaseAgreementID, LeaseType)
7. Tenant (TenantID, TenantFName, TenantLName, TenantAddress, TenantTelNO).
8. Contract (ContractID, HouseID(fk), DateSigned, OwnerID(fk),).
9. ContractType (ContractID, ContractType).
10. Location (LocationID, LocationName).
11. MaintenanceType (MaintenanceID, HouseID(fk), locationID (fk), DateReported, DateDone).
12. InsuranceType (InsuranceType, HouseID(fk), AmountInsured, DateExpiry)
13. ServiceType (ServiceID, ServiceType).
14. SecurityType(SecurityID, SecurityType)
15. FireProtectionType (FireProtectionID, FireProtectionType)

After creating the tables, they were checked to determine if they obeyed the 1NF, 2NF and 3NF.

3.3.3.5 PHYSICAL DATABASE DESIGN

This was the implementation of the Real Estate Management database in ArchGIS 9.2.

(a) Spatial data acquisition

The geodatabase by the name Komarock was created in ArcCatalogue. A dataset called parcels was also created and feature classes were created i.e. the houses, plotsselected roads and a line. The cadastral map was scanned at a resolution of 300 dots per inch (dpi) using a flat bed scanner Epson type. Georeferencing of the scanned images was done using the ground control points from Gamin hand held GPS receiver. The ground control points were downloaded from the GPS receiver using TOPO software.

(b) On-screen digitizing

This involved the conversion of georeferenced cadastral map into digital format. Various features were digitized as themes in Arc map environment. Snap distances were selected and feature outlines were followed clearly. Houses, plotsselected and roads were digitized as polygons then a line was digitised. After digitizing, spatial tables were automatically generated and other fields were added (see appendix 2). As it was not very easy to populate all the 240 records about the houses and the plots, a random sample of 49 records was picked and the respective fields and records populated accordingly. This sample represented all the house types in Komarock Phase 1 infill (see figure 3.3).

(c) Non-spatial data acquisition

Non-spatial data i.e. HouseType, Owner, LeaseAgreement, Leasetype, Tenant, Contract, ContractType, Location, MaintananceType, InsuranceType, ServiceType, SecurityType, FireProtectionType were captured using Microsoft Access. The tables were populated using simulated data and then exported to ArcGIS (see Appendix 3)

(d) Hyper linking of images and photographs

In order for the images and photographs to be attached to the individual house types, two columns were created in the housetype table one called house_plan and another one called photos. Using hyperlink, the images and photographs were linked to each of the house types.

(e) Joining and relating of tables

Joining and relating of tables was necessary in order to link information from Microsoft Access to geodatabase during querying.

3.3.3.6 GOOGLE MAPS AND CUSTOMIZING ARC MAP

The Google maps used data from the database after converting it to Keyhole Markup Language (KML) and HyperText Markup Language (HTML) and used it to display the amenities in the neighbourhood during advertisement of the houses by the agents.

Customization was done using Visual Basic for Application (VBA). Tables like houses, location, and house types were joined and coding was done to enable the user interface link with the database. These tables were the most commonly accessed during querying and therefore the coding was based on them.

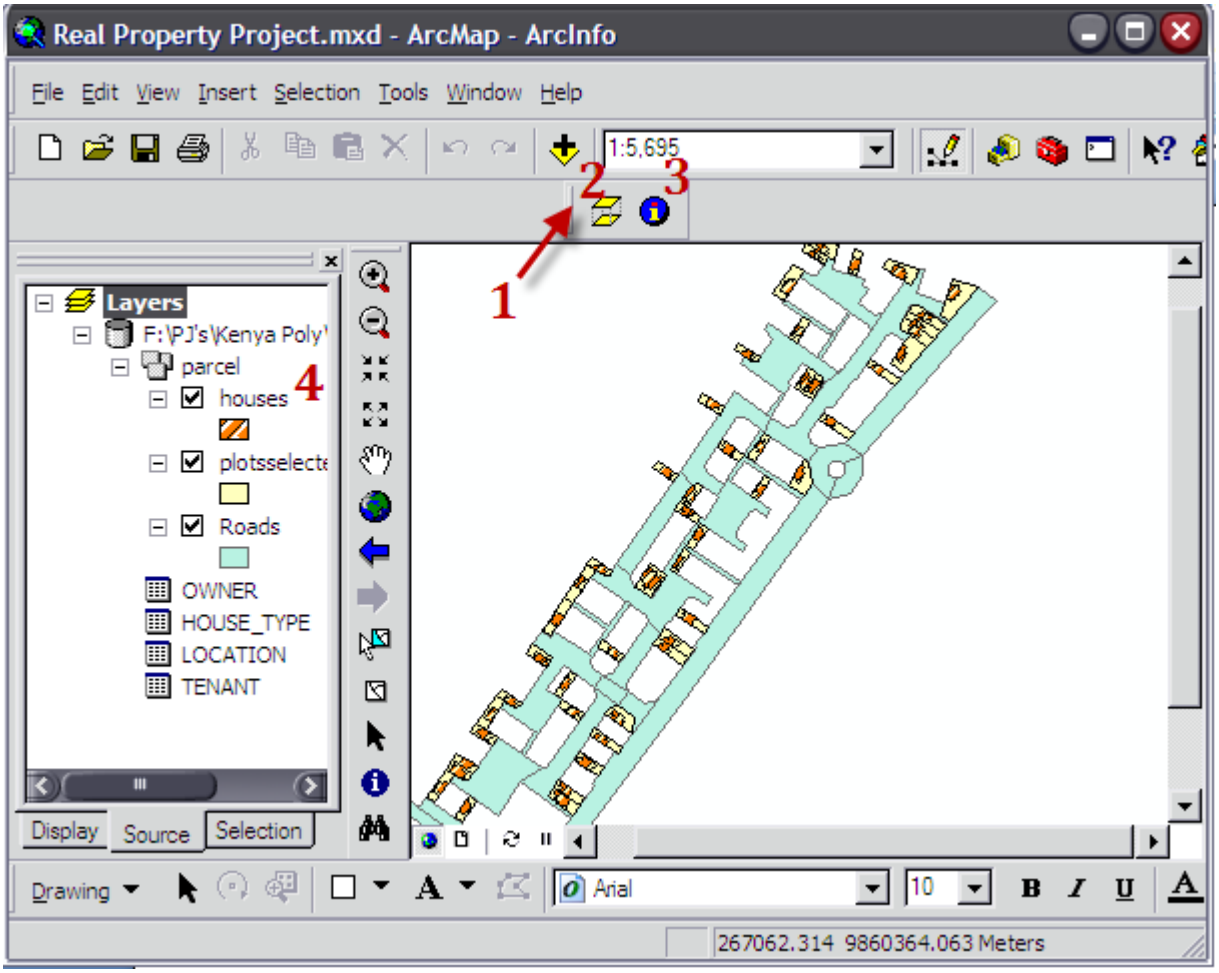
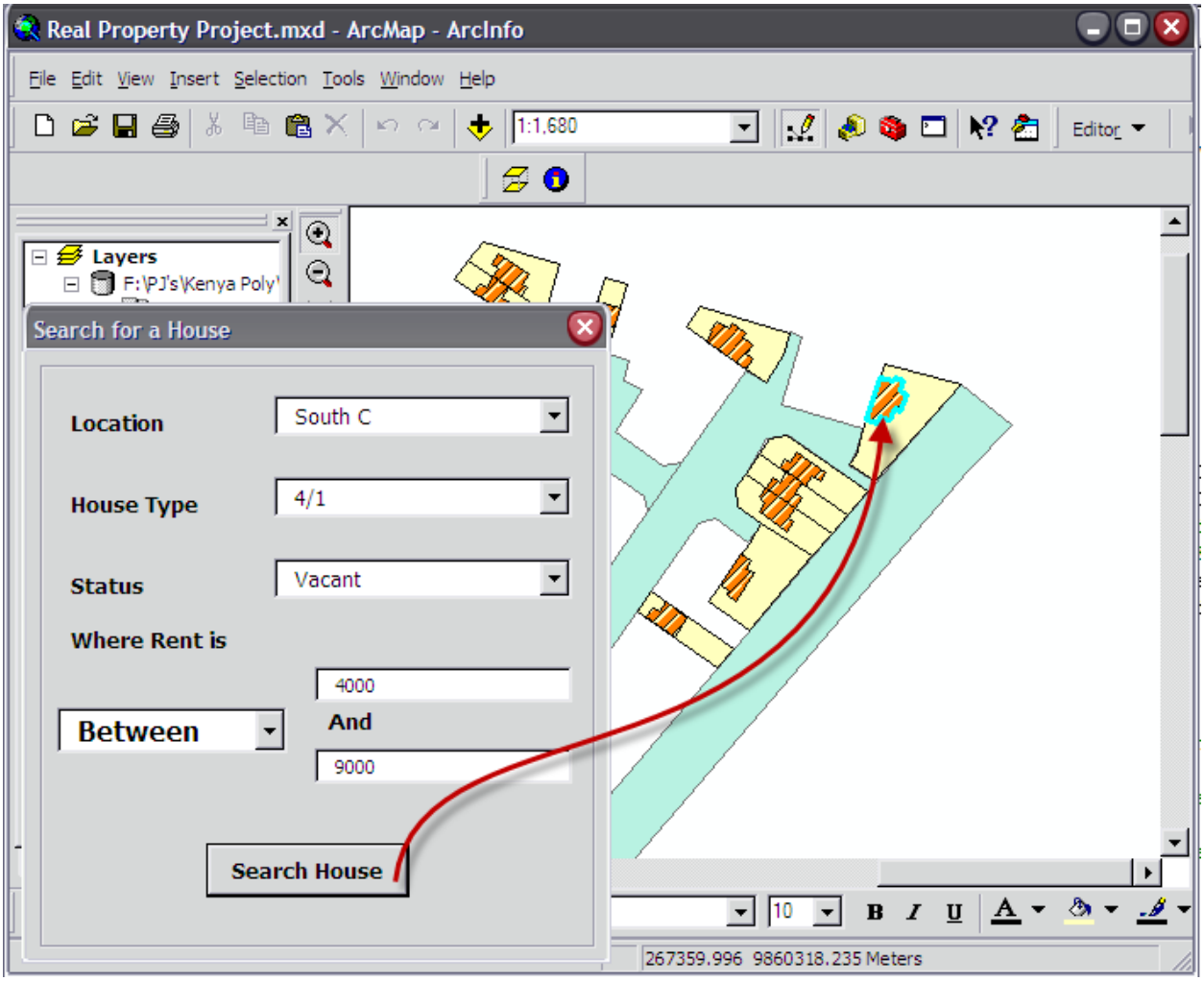


Fig.3.4: How the customized tools work

The above image is the customized ArcGIS .mxd document for real estate management. The document (Real Property Project.mxd) hosts two tools. The tools have been created and organized on a new tool bar which was added in ArcMap.

- **1** toolbar that hosted the tools
- **2** the control button to launch the custom query tool that could be used by those who did not know SQL syntax
- **3** the tool control to identify a house
- **4** ArcMap table of contents. Make sure that the first layer on the table of contents was houses feature class. Otherwise the tool will encounter an error.



NB Make sure there are no joins on the houses table before you use the custom query tool. Remove all the joins before you query.

Fig. 3.5: Custom query tool

In ArcGIS the Structured Query Language (SQL) was used for accessing data from different tables, join and relate operations were done prior to use of SQL. The query builder was used to select data from tables depending on the customer's queries BUT when using the customized window, one did not need to use the query builder but instead would use the interface dialogue box to query.

3.3.3.7 DATABASE ANALYSIS

After creating the database, it was possible to display all the houses, their plots and roads and open spaces in a digital map as in figure 3.3.

Using the query builder, it was possible to identify and display on a map all the houses of type 5/2 as shown in figure shown in figures 3.6, 3.7, 3.8 and 3.9

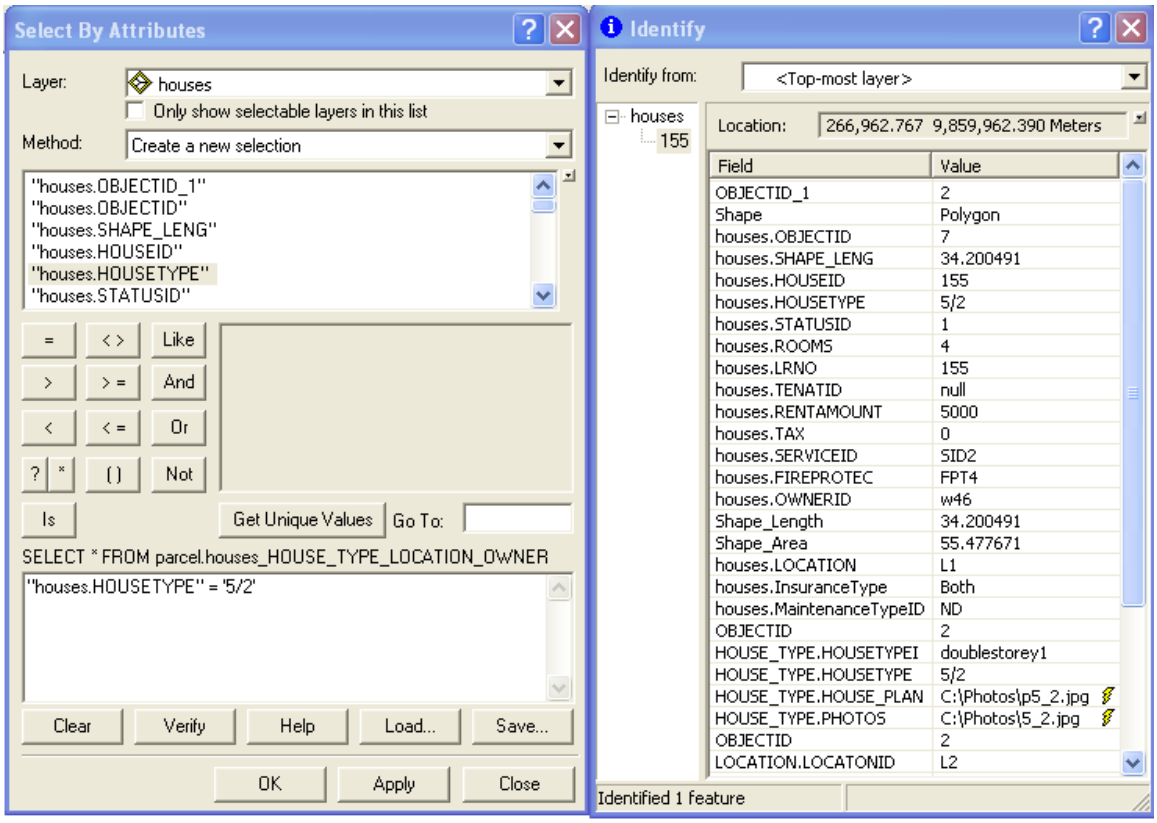


Fig. 3.6: Houses of type 5/2.

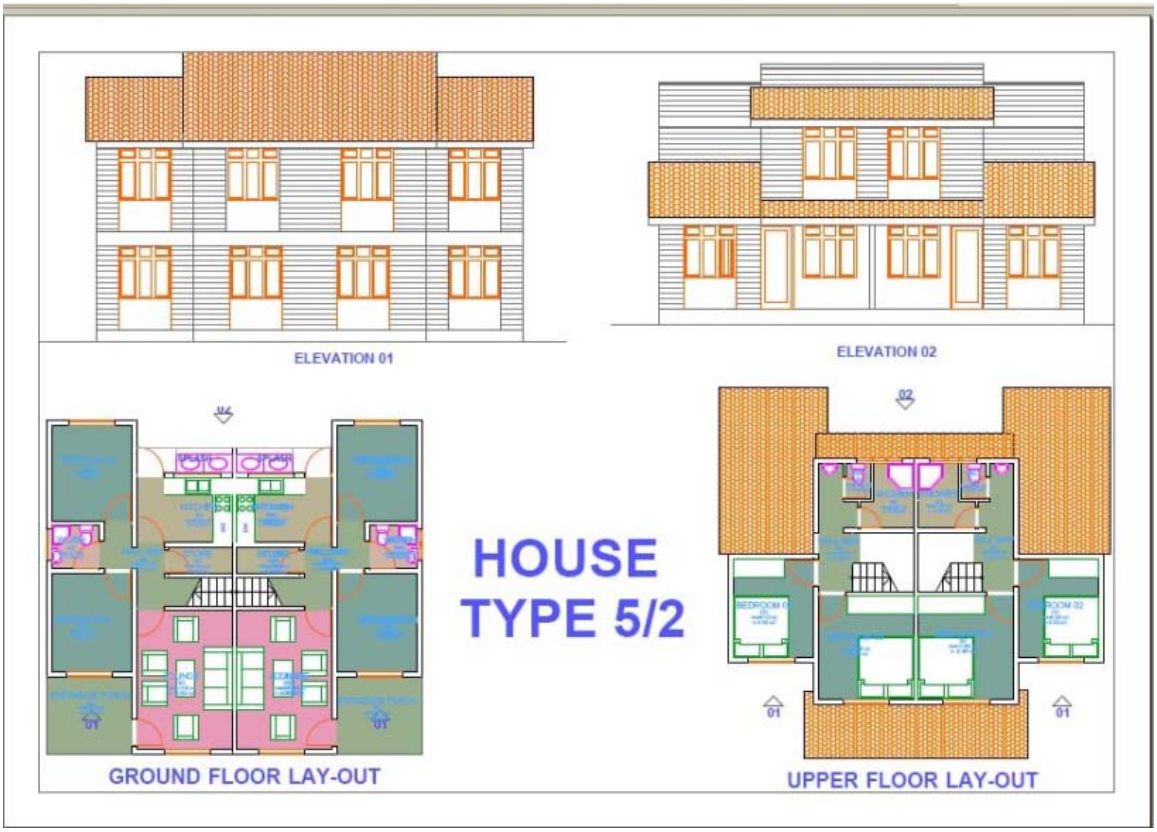
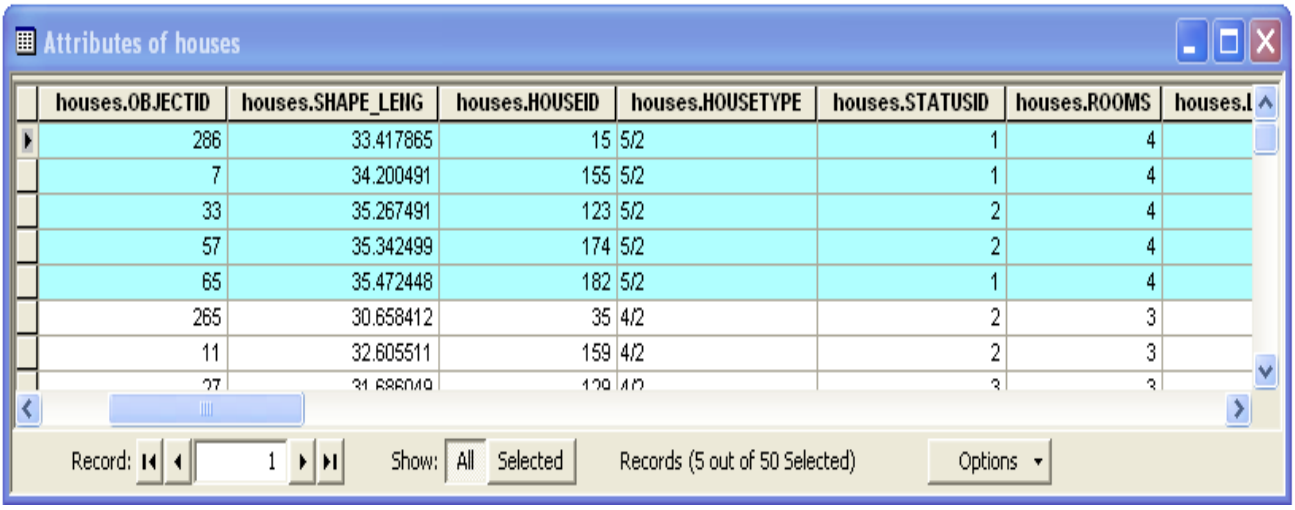


Fig. 3.7: Type plan for 5/2

Fig. 3.8: Photograph for type 5/2

It was also possible to isolate the type 5/2 houses using the table selection as in table 3.1.

Table 3.1: Selected houses of type 5/2



A query was used to extract houses of type 4/2, location L1, and statusID was 1 (vacant). The database returned one house with houseID 171, type and photograph as in figure 3.10, 3.11 and 3.12.

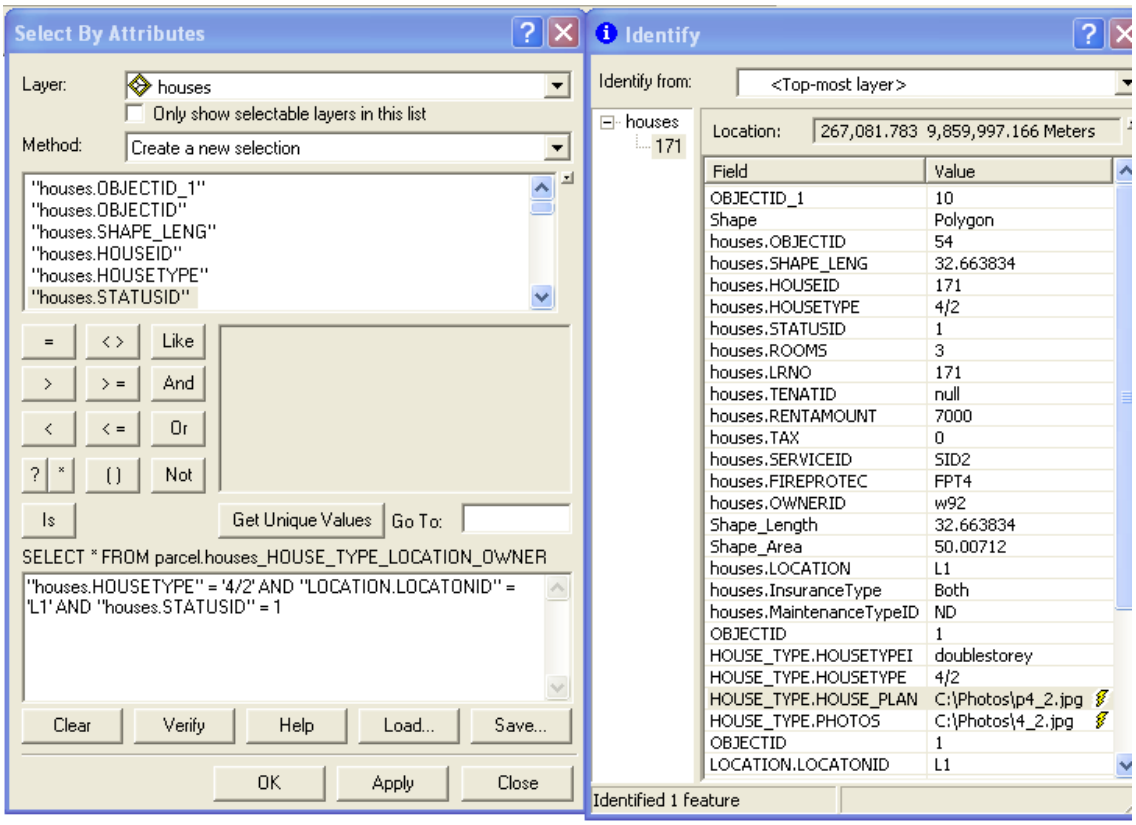
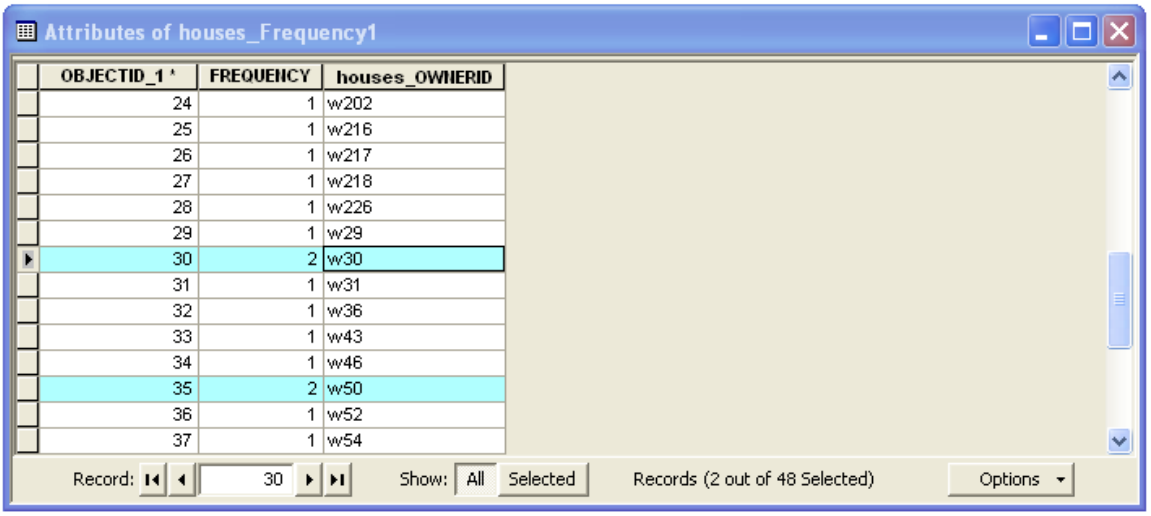


Fig. 3.10: House type 4/2 and vacant

Fig. 3.11: House type plan 4/2

It was also possible to use the frequency analysis tool to know how many houses belonged to a particular owner and then using the query builder to identify those houses as shown in table 3.2. OwnerID “w50” had two houses i.e. houseID 15 of type 5/2 and houseID 159 of type 4/2.

Table 3.2: Owners with more than one house.



Using the summary statistic tool, it was possible to get the sum of the total number of houses based on rooms and all those houses that were vacant as in tables 3.3 and 3.4 respectivelly.

Table 3.3: Number of houses based on rooms

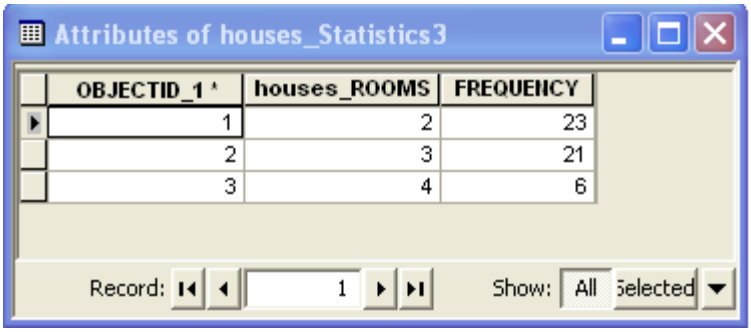
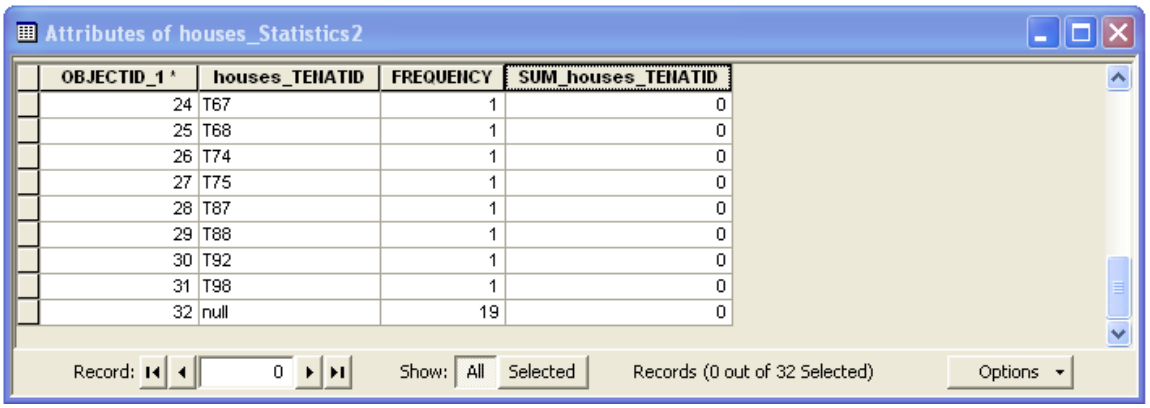


Table 3.4: All houses that were vacant or with tenant null.



It was also possible to use the measuring tools to measure for example areas of plots, house plans although they had been automatically generated but the tools could be used to measure linear distances like the with of the plots.

Sometimes it was necessary for the agent to separate the houses based on their types or number of rooms for easy selection. Using the clipping tool, it was possible for the agent to isolate the fourty- nine houses used in the testing of the model as in figure 3.13.

A buffer analysis of 3m linear was utilized to display the houses to give a rough indication of the size of the house and the available parking area. With the 3m buffer, the plots were overflowing beyond the plot boundaries as in fig. 3.14.

Google Map could display a certain house i.e. type 5/2 and the schools in the neighbourhood as shown in figure 3.15.

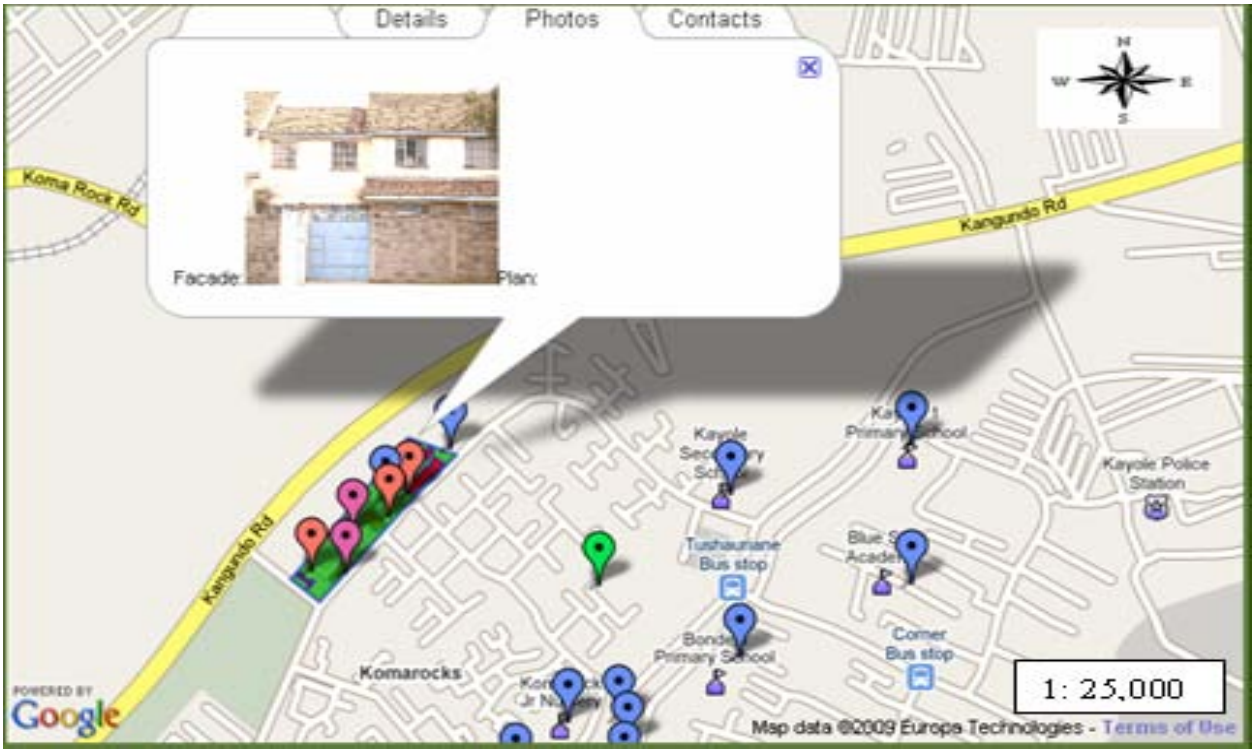


Fig. 3.15: Komarock Estate neighbourhood.

Google map displayed Naivas Supermarket in Komarock Estate and surrounding estates in figure 3.16.

Fig. 3.16: Naivas Supermarket in Komarock Estate

Google map showing Tender Care Academy in the study area and the neighbourhood in figure 3.17.

Fig. 3.17: Tender Care Junior Academy

The customized Arc Map User Interface could be used instead of the query builder to select a house type 5/2 located in Komarock, that was vacant and amount of rent was 5000 shown in figure 3.18.

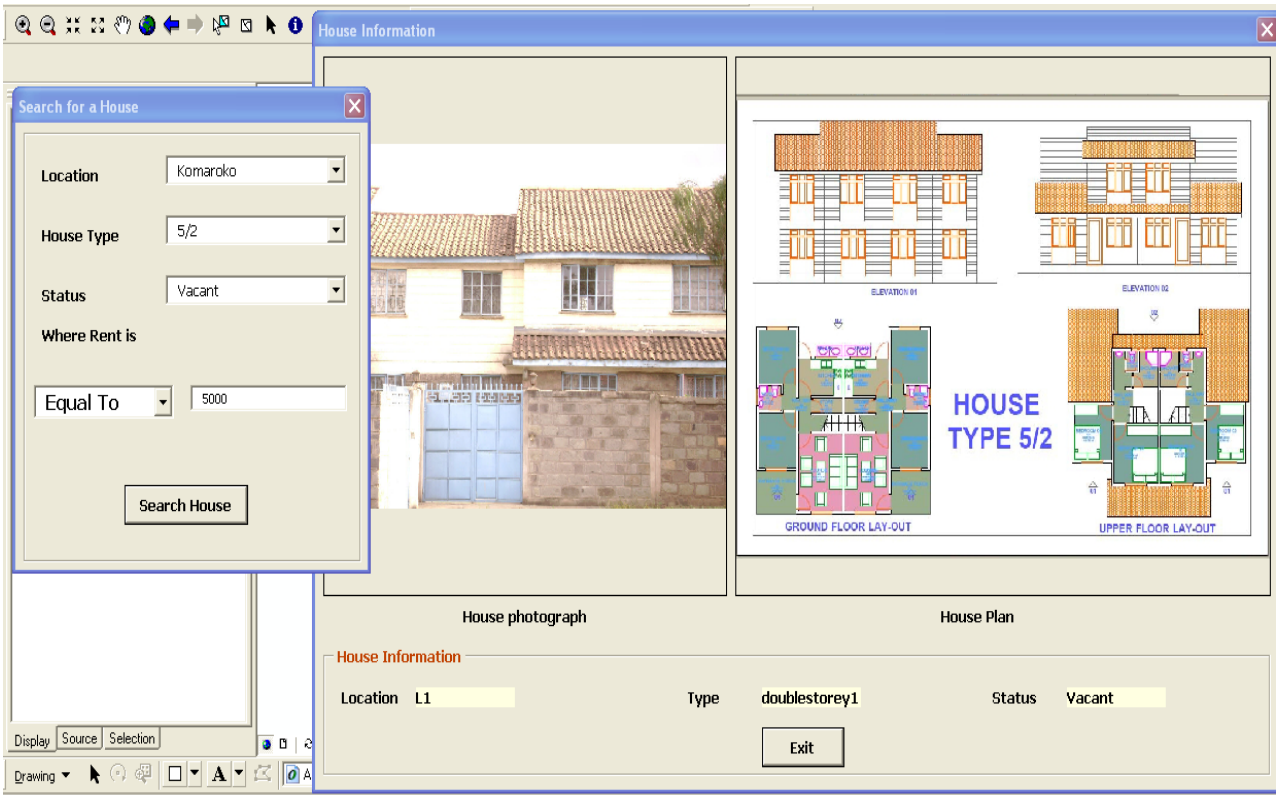


Fig. 3.18: House type 5/2 in Komarock, vacant and rent amount kshs. 5000.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 RESULTS

The results of the project was a digital map in figure 3.3, of the houses in Komarock Estate Phase1 Infill showing all the two - fourty housing units, the plots, and their physical locations.

The map displayed all the fourty - nine sampled houses named as houses together with their plots named as plotsselected. The users were able to set the map scale and coverage for display and visualization by zooming and panning in the display window, while the identifier tool enabled the display of the information required. The map also featured the easement within the estate such as access roads and car parks (open spaces).

A GIS database in appendix 5 (CD ROM) is a representation of the real world complete and comprehensive inventory of the houses and their plots. The digital map displayed all the different houses, their structural attributes (house types), and their photographs as in appendix 4. For visualization, the houses have house IDs but they have been visually displayed using their house types i.e. type 5/2. The database had comprehensive information about the houses, like the number of rooms, area, rent amount etc stored as attributes. It also stored information about house owner and the tenant details like their names and telephone numbers among others in attribute tables. Access of information from different tables had been made possible by either joining or relating all the tables where information was stored.

The agent was able to extract for example specific houses based on their type plans, that were vacant and of specific amount of rent and in a specific location like the one shown in figure 3.18. The map indicates whether the house is next to the fence, near the gate or any other location.

The database kept all records about particular houses like, the security provided, services available, means of fire protection, type of insurance and maintenance waiting to be done.

The database had records on the amount of rent payable, amount paid and amount in balance. It was possible to select all those houses without rent balances and those with balances using the statistic analysis tool. The database also provided information to be used by other actors in real estate like the public and government agencies, planners, etc.

The database provided customized maps through data manipulation, display and retrieval. The database updated records easily. The digital map provided information about houses at a click of a button and also displayed information in table form for example the statistics of all the houses based on the number of rooms as in table 3.3, statistics on all the houses that were vacant or the tenant was null as in table 3.4.

The measuring tool was used to produce the length of the plots while the 3m linear buffer analysis indicated that plots were extending beyond the boundaries. It was possible to clip all the houses that belonged to a certain category like all the houses used for testing this database.

The GIS database incorporated the Google maps platform in figure 3.15, that provided means of displaying the location of the houses in relation to not only the entire Komarock Estate but to the wider neighbourhood. The houses were displayed with their photographs. Google maps also provided comprehensive details about amenities in the neighbourhood like the road network, schools, banks, Chief,s camp, supermarket, churches etc.

The GIS database provided Arc Map customization using Visual Basic for Application (VBA). User Interface window in figures 3.4 and 3.5 could search for the houses by location, house type and the amount of rent. The search displayed the houses with both their types, photographs and with all other necessary details.

4.2 DISCUSSION

The digital map in figure 3.3 that was generated from the GIS database was a complete inventory of all the houses in Komarock Estate Phase 1 Iinfill and together with their attributes provided a platform for data integration. It was possible and easy to respond to a customer's query promptly. The customer posed a question like: 'I need a house in Komarock, the type is 5/2 (four bedrooms double storey), with 55 square meters of area, rent amount ranging from 5000-10000, and in a certain neighbourhood'. The GIS data has provided a solution to this complex query by integrating the spatial aspects of real estate (houses) with the non-spatial aspects (number of rooms). The query builder generated results from the database and the customers could see the location of the house in relation to the entire estate. This facilitated their decision making. The agent on the other hand had been able to keep all his data in a manner that was easy to search, to query, to update and to be shared with other key actors in the sector like the City Council of Nairobi could use the database as an inventory of all the houses and together with the year in which they were built would provide information on when such houses would be replaced with new ones. The government tax collectors would use the database to assess the tax from the house owners. The sizes of the plots and their locations would be used to estimate the council rates and the lease to be paid for each plot.

Keeping the data in digital form enabled the estate agent to have all the information concerning the house owners and the tenants available at the click of a button. This facilitated easy communication between them and the agents on issues concerning repairs and other aspects.

To facilitate visualization of the houses by the customer, the estate agent provided the type plans and photographs for each house. The zooming and panning tools on the display window enabled the agent to interact with the map as desired by the customer. He was able to create customized maps from the main digital map through adding of tables and manipulating all the datasets. Together with this, the customer may have wanted to know the security provided in the house by the owner and means of fire protection and escape. The agent was able to join the spatial and non- spatial tables to access this information. The agent was able to discuss the type of lease agreement the prospective

tenant was likely to sign since all this information was in the database. The house owners were also able to know the rent that had been paid and any balances waiting to be paid including any statutory payments to be paid.

The measuring and buffer analysis tools gave indications of the sizes of the plots. This provided vital information to customers who needed to know the size of parking area. For these houses, the free space could not accommodate a car, therefore customers with big cars and needed to park in the compound could not find the houses useful.

Many times the customers had liked the house, size of rooms and the parking area but it was not until they visited the site that they got to know that the house was built on a hostile neighbourhood for example next or near a dump site, a quarry site, a slum, a commercial building where people frequented the area so much that they posed dangers of carjacking etc. This lead to the customers changing their minds for another location. It become expensive for the agent in terms of man hours and fuel and it also delayed the customer in getting the right house.

Google maps have been incorporated in GIS to counteract this scenario. By providing a platform where estate agents could display their houses in the midst of the entire neighbourhood so that it becomes possible for customers to search on their own in the internet and make decisions before visiting the agents' offices. Google maps as they were used in this report, could display the houses, the road network, the schools, the supermarkets, banks, churches, Chief's camp and other desirable amenities. These maps provided an information concerning the general environment for example the areas that were not built, the crowded areas the population of schools in the surrounding and the neighbouring estates. By using these maps, the agent was able to update any new developments in the neighbourhood as they occurred. Google maps were also automatically updated by Google agents through use of more recent satellite images and this would automatically capture any new developments in the neighbourhood.

In most cases, the agent or his workers felt intimidated by the GIS system since GIS required that one was familiar with some formalities like the use of query builder and to know which information should be sought from the tables to answer specific queries from customers. The users needed not to access all the possible capabilities of the database, therefore customizing enabled them to access quickly only what they needed to serve their customers. The Visual Basic for Applications (VBA) customization made this possible. The purpose was to shield the user from the activities that took place in ArcGIS and provide a User Interface where the workers were able to query the database using location, type of house, status of house (vacant or occupied) and the amount of rent. The interface also provided the identifier tool for identifying a particular house together with any other information needed. This way made it possible for anybody with moderate computer expertise to be able to use the GIS database to serve the customers promptly.

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATIONS

5.1 CONCLUSIONS

This report has used GIS in Real Estate Management, a method that has facilitated the capture of both spatial and non-spatial attributes of the real estate. The idea was to be able to integrate the two datasets in order to get the information required by customers.

The method was tested through development of a case study in Komarock Estate Phase1infill and proved to perform well.

Through creating this database, GIS successfully provided a complete and comprehensive inventory of all the houses and their attributes stored in attribute tables. This was evidence that the Estate Agent was able to keep all his records in a manner that would facilitate easy manipulation, fast querying and more important allow for updating of the records. Digital data stored in different tables allowed easy integration for the purpose of getting information. Integration also allowed visual interpretation of data inform of maps for good decision making by customers.

Identification of individual houses on their physical locations on the ground was evidenced. It was possible to see that the house available was near the fence, near the gate or whichever position when related to other houses. This has been facilitated further by integrating attribute tables which stored information about security offered to the house, means of fire protection and the rent payable for that house. This seemed to provide the most sought for information needed by customers while looking for a house. The question of which house was vacant was no longer a big issue. SQL could solve this problem through the query builder and other spatial analysis tools like the summary and frequency statistic tools. Customers could physically see the things in the neighbourhood including neighbouring estates. This database could also be used by the agent to keep track of the maintenance schedules so as to satisfy the tenants and to communicate to

house owners about their transactions on rent amounts, maintenance expenses and the statutory payments

Storing data in digital format allowed the data to be used in the internet and especially on Google map platform where a wider audience visualize it, to analyze and make decisions before visiting the agent's offices. This saved the agent time to search for others who did not use the internet.

Creating a database enabled the data to be stored in a format that was acceptable for sharing with other key actors in Real Estate. Through value added products, the database provided vital information for example to the government tax collectors, estimation of land rents, mortgage providers, financial institutions among others.

Real Estate practitioners could now use the GIS system without necessarily having to acquire very high level education in GIS. Customization has demystified all the myths about GIS and it could now be used by the common person with reasonable computer knowledge.

The results of this project confirmed that GIS is indeed a cutting edge technology in the management of a real estate and as its full potential is realized, the real estate market would move to higher levels of efficiency which would bring down the cost of real estate transactions while enhancing customer service. This study was necessitated by the fact that customers spent a lot of time while locating houses to rent and estate agents dealt with large volumes of data in searching for houses for customers to rent.

5.2 RECOMMENDATIONS

- Due to the fact that real estate properties were scattered all over the world and these data may be required to be accessed by people from different locations of the world, it is recommended that this database be re-designed using the Object Oriented (OO) Data Model. This would save the database the problem of slowing down when subjected to queries in a distributed environment.

- The database should also be housed in client server architecture to allow creation of user views to suit the various operational functions in a real estate management.

- For the purposes of proper record keeping and transparency, It is recommended that, this database be extended to incorporate a system that could automatically generate the amount of rent that has been collected for a particular period. This would enable the database be able to generate forms and reports for the house owners records on how his/her money has been spent. This is important since there are deposits to be refunded, deposits to be paid in, maintenance costs to be incurred and statutory payments to be made.

- This report has used Google maps to show amenities in the neighbourhood but it is recommended that these maps be used for the purpose of calculating distances to the estates from a central place like for example the city centre and the travel times also calculated.

- In the era of internet, and with the arrival of the fibre optic cable, much more transactions should be done online to minimize labour expenses for the agent.

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Fig. 2.4 UML (refer E-R DIAGRAM)

Fig. 3.3: Map showing all houses

Layout 11 (refer A3 maps)

Fig. 3.9: A map of all houses of type 5/2.

Layout 5-2 (refer A3 maps)

Fig.3.12: A map of house of type 4/2 and vacant

Layout 4-2 (refer A3 maps)

Fig. 3.13 clipped houses (refer A3 maps)

Fig. 3.14 buffered (refer A3 maps)

APPENDICES

Appendix 1: Interview schedule for customers and Estate Agents

Appendix 2: Spatial tables

Appendix 3: Non-spatial tables

Appendix 4: Type plans and photographs

Appendix 5: Compact Disc for the Real Estate Database

APPENDIX 1

INTERVIEW SCHEDULE FOR CUSTOMERS

1. What do you look for when looking for a house to rent?.....
   ……
2. When you talk of location, what is it that you consider in order to arrive at a particular location? ……..
   ……..
3. Apart from location, what else is important to you as you look for a house?
   …….
4. You talked about accessibility to the road, what about it?.....
   ……
5. You mentioned security, what about it……

INTERVIEW SCHEDULE FOR ESTATE AGENTS

1. What role does your company play in building the nation?
   …….
   …….
2. What activities are concerned in real estate management?
   ……
   ……
3. Who are your customers? ……..
   ……
4. How do you get to know that some houses are ready to let?.....
   ……
5. How do you acquire the houses from house owners?.....
6. After acquiring the houses from house owners, what is the first thing that you should do?
   ……
   ……
7. What means of advertisement do you provide to the houses and what do you include in the advert? ……
   …….

8. After visiting the houses? How do you store the data in your offices?
   ……

9. After the advertisement, customers call or come to your offices, what common questions do they pose to you? …….
   ……

10. After a customer has posed a query to you, how easy are you able to search through your records. How long does he/she has to wait for the response?
    ……
    ……
11. How do you describe the property in detail to the customer?
    ……
    ……
12. After the customer is satisfied with information from the office, what is next?
    ……
    ……
13. After visiting the site where the house is, how often do the customers change their mind. …….
    ……..
14. What are the major reasons for changing their mind? ……..
    ……

15. What alternatives do you give them when they decline to take the offer?.....

16. Currently, what are you doing to minimize the chances that a customer changes his or her mind? ……..
    …….....

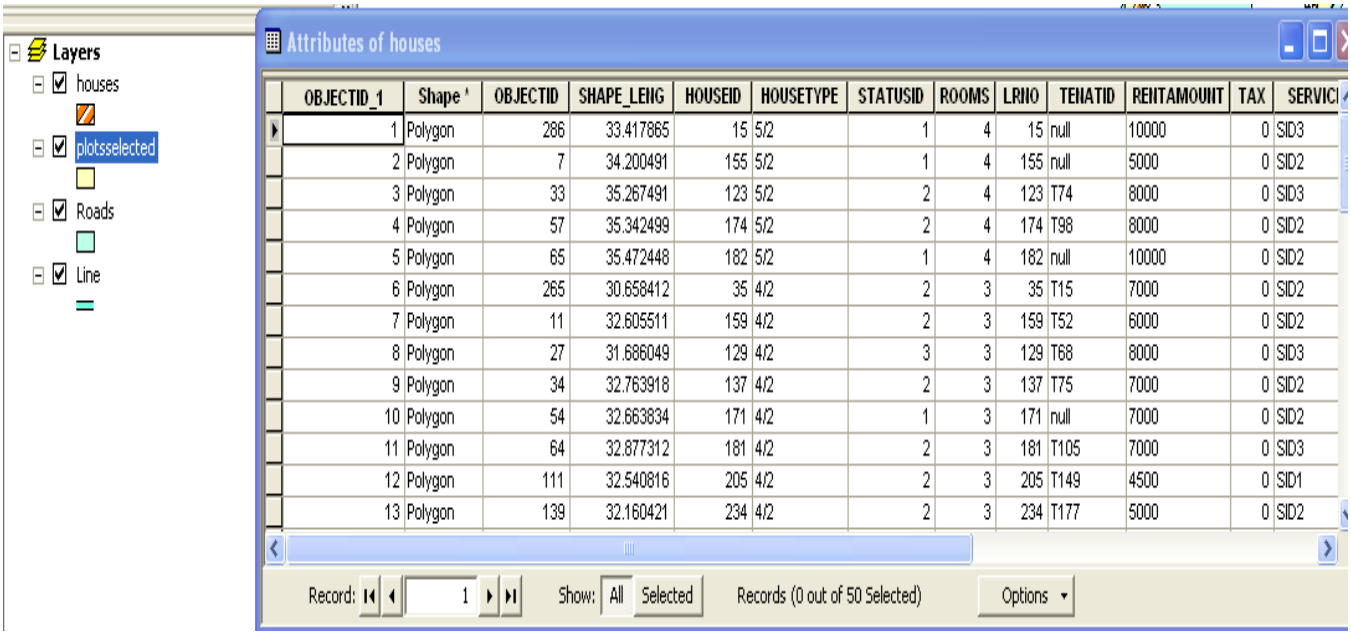
17. Once the customer has become a tenant, what is next?.
    ……

18. What is the responsibility of the tenant once he/she is in the house?
    …….

19. What interactions are there between tenants and you agents? ……

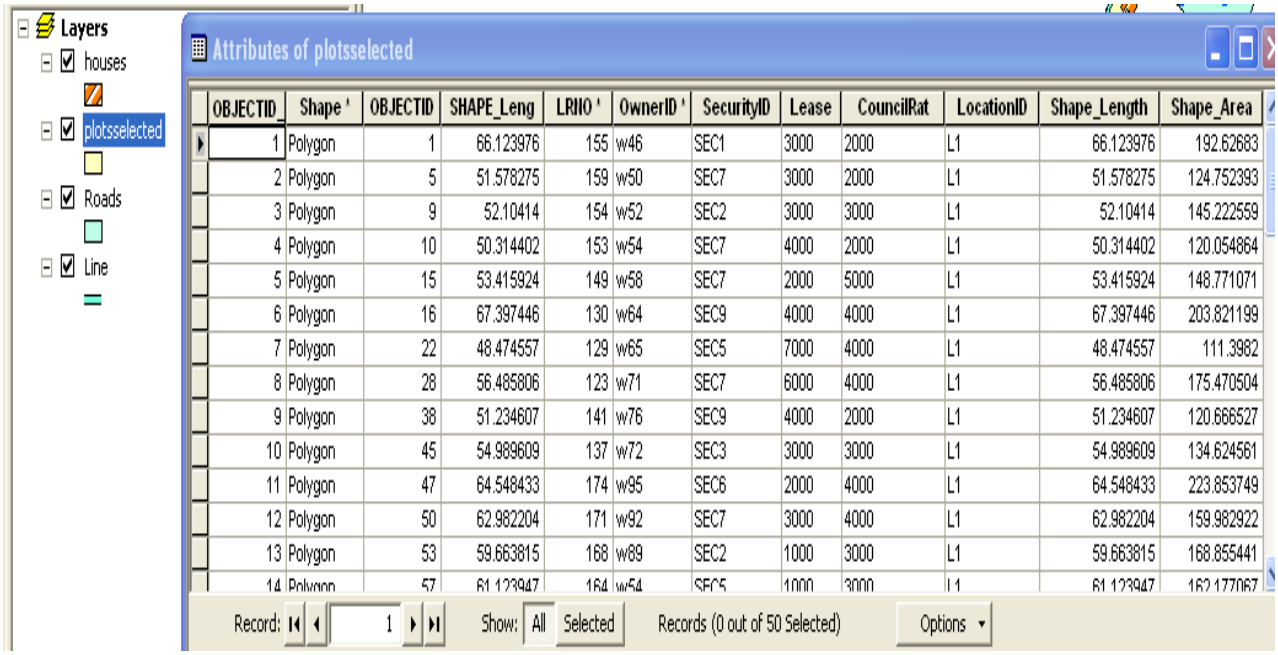
20. How do you take care of the house owners interest in the real estate management?
    ……

APPENDIX 2: SPATIAL TABLES



OBJECTID_1	Shape *	OBJECTID	SHAPE_LENG	HOUSEID	HOUSETYPE	STATUSID	ROOMS	LRNO	TENATID	RENTAMOUNT	TAX	SERVICI
1	Polygon	286	33.417865	15	5/2	1	4	15	null	10000	0	SID3
2	Polygon	7	34.200491	155	5/2	1	4	155	null	5000	0	SID2
3	Polygon	33	35.267491	123	5/2	2	4	123	T74	8000	0	SID3
4	Polygon	57	35.342499	174	5/2	2	4	174	T98	8000	0	SID2
5	Polygon	65	35.472448	182	5/2	1	4	182	null	10000	0	SID2
6	Polygon	265	30.658412	35	4/2	2	3	35	T15	7000	0	SID2
7	Polygon	11	32.605511	159	4/2	2	3	159	T52	6000	0	SID2
8	Polygon	27	31.686049	129	4/2	3	3	129	T68	8000	0	SID3
9	Polygon	34	32.763918	137	4/2	2	3	137	T75	7000	0	SID2
10	Polygon	54	32.663834	171	4/2	1	3	171	null	7000	0	SID2
11	Polygon	64	32.877312	181	4/2	2	3	181	T105	7000	0	SID3
12	Polygon	111	32.540816	205	4/2	2	3	205	T149	4500	0	SID1
13	Polygon	139	32.160421	234	4/2	2	3	234	T177	5000	0	SID2

Record: 1 Show: All Selected Records (0 out of 50 Selected) Options



OBJECTID_	Shape *	OBJECTID	SHAPE_Leng	LRNO *	OwnerID *	SecurityID	Lease	CouncilRat	LocationID	Shape_Length	Shape_Area
1	Polygon	1	66.123976	155	w46	SEC1	3000	2000	L1	66.123976	192.62683
2	Polygon	5	51.578275	159	w50	SEC7	3000	2000	L1	51.578275	124.752393
3	Polygon	9	52.10414	154	w52	SEC2	3000	3000	L1	52.10414	145.222559
4	Polygon	10	50.314402	153	w54	SEC7	4000	2000	L1	50.314402	120.054864
5	Polygon	15	53.415924	149	w58	SEC7	2000	5000	L1	53.415924	148.771071
6	Polygon	16	67.397446	130	w64	SEC9	4000	4000	L1	67.397446	203.821199
7	Polygon	22	48.474557	129	w65	SEC5	7000	4000	L1	48.474557	111.3982
8	Polygon	28	56.485806	123	w71	SEC7	6000	4000	L1	56.485806	175.470504
9	Polygon	38	51.234607	141	w76	SEC9	4000	2000	L1	51.234607	120.666527
10	Polygon	45	54.989609	137	w72	SEC3	3000	3000	L1	54.989609	134.624561
11	Polygon	47	64.548433	174	w95	SEC6	2000	4000	L1	64.548433	223.853749
12	Polygon	50	62.982204	171	w92	SEC7	3000	4000	L1	62.982204	159.982922
13	Polygon	53	59.663815	168	w89	SEC2	1000	3000	L1	59.663815	168.855441
14	Polygon	57	61.123947	164	w54	SEC5	1000	3000	L1	61.123947	162.177067

Record: 1 Show: All Selected Records (0 out of 50 Selected) Options

APPENDIX 3: NON-SPATIAL TABLES

Attributes of HOUSE_TYPE

OBJECTID *	HOUSETYPEI *	HOUSETYPE *	HOUSE_PLAN	PHOTOS
1	doublestorey	4/2	C:\Photos\p4_2.jpg	C:\Photos\4_2.jpg
2	doublestorey1	5/2	C:\Photos\p5_2.jpg	C:\Photos\5_2.jpg
3	singlestorey	3/1	C:\Photos\p3_1.jpg	C:\Photos\3_1.jpg
4	singlestorey1	4/1	C:\Photos\p4_1.jpg	C:\Photos\4_1.jpg

Record: 1 Show: All Selected Records (0 out

Attributes of TENANT

OBJECTID *	TENANTID *	TENANTFNAM	TENANTLNAM	TENANTADDR	TOWN	TENANTTELN
1	T105	Margaret	Mwangi	568	Embu	723454763
2	T106	Zacharia	Sigoro	765	765Bondo	723495767
3	T109	Francis	Muthoni	785	Karatina	722485269
4	T118	John	Njoki	896	Kiriaini	722158763
5	T12	Jeremy	Okoth	234	Mbaruku	723475767
6	T121	Reuben	Njeri	587	Kangema	722325489
7	T127	Michael	Waceke	158	Kiru	712548963
8	T133	Rechael	Mwangi	465	Kanjama	721478569
9	T139	John	Wafula	678	Karatina	723475767
10	T140	Mathew	Wandati	456	Garisa	723437368
11	T149	Meg	Ndirangu	456	Ndakaini	723495768
12	T15	Peter	Mbau	453	Bundalangi	723495464
13	T151	Mark	songoro	765	Tala	723495765

Record: 1 Show: All Selected Records (0 out of 49 Selected)

Attributes of OWNER

OBJECTID *	OWNERID *	OWNERFNAME	OWNERLNAME	OWNERADDRE	TOWN	OWNERTELNO	OWNERPINNO
1	w102	Moses	Kanyari	123	Maua	723876432	355
2	w103	Joseph	Nyaboke	356	Banana	721987456	349
3	w106	Jame	Waititu	569	Egerton	721587963	256
4	w115	Mary	Kamau	487	Turi	710458789	359
5	w117	Susan	Onyango	569	Elburgon	733258698	369
6	w12	George	Wesonga	856	Thika	733256932	361
7	w123	Sarah	Wamaitha	236	Molo	733145896	249
8	w129	Reuben	Kerubo	245	Kericho	722158963	589
9	w135	Ann	Gitau	896	Mwala	786453098	368
10	w136	Susan	Njoroge	589	Kitui	745764544	370
11	w145	Jaddiel	Lugaho	326	Meru	745098765	356

Record: 1 Show: All Selected Records (0 out of 49 Selected) Options

Attributes of LeaseAgreement5

HOUSEID	LeaseAgreementID	RentAmount	DateStart	DateFinish	TenantID	OwnerID
15	LA3	7000	1/2/2004	1/2/2007	T184	w102
205	LA2	10000	2/1/2004	3/4/2007	null	w147
163	LA3	8000	3/2/2005	3/2/2009	T98	w20
130	LA2	5000	4/5/2004	4/5/2006	null	w36
89	LA1	7000	6/4/2004	6/4/2007	null	w84
80	LA3	7000	3/5/2004	3/5/2007	T222	w85
55	LA3	7000	1/3/2005	1/3/2009	T221	w89
196	LA2	7000	8/7/2005	8/7/2009	T220	w92

Record: 1 Show: All Selected Records (0 out of 49 Selected) Op

Attributes of CONTRACT

CONTRACT.ContractID	CONTRACT.HouseID	CONTRACT.OwnerID	CONTRACT.DateSigned	OBJECTID	CONT
CT01	102	w180	4/6/2006	1	CT01
CT02	103	w129	3/7/2004	2	CT02
CT01	11	w36	6/12/2009	1	CT01
CT02	114	w117	6/5/2007	2	CT02
CT01	122	w123	2/7/2006	1	CT01
CT02	123	w71	2/4/2005	2	CT02
CT02	129	w65	8/7/2008	2	CT02
CT01	130	w64	3/5/2009	1	CT01

Record: 1 Show: All Selected Records (0 out of 49 Selected) Options

Attributes of MaintenanceType57

MaintenanceTypeID	HouseID	LocationID	DateReported	DateDone
ND	102	L1	2/3/2005	null
ND	103	L1	3/6/2006	null
D	11	L1	3/6/2005	12/6/2005
D	114	L1	6/2/2004	2/15/2004
D	122	L1	6/5/2001	5/16/2001
ND	123	L1	1/3/2005	null
ND	129	L1	2/5/2006	null
D	130	L1	2/5/2004	2/25/2004

Record: 1 Show: All Selected Records (0 out of

Attributes of SERVICE_

OBJECTID *	SERVICEID	SERVICETYP
1	SID1	Electricity
2	SID2	Water
3	SID3	Sewarage
4	SID4	All

Record: 4 Show:

Attributes of Leaset...

LeaseAgreementID	LeaseType
LA1	Exclusive
LA2	Inclusive
LA3	Gross

Record: 1

Attributes of CONTTYPE

OBJECTID *	CONTRACTID *	CONTRACTTY
1	CT01	Letting
2	CT02	Lettingandmanagement

Record: 2 Show: All ect

Attributes of LOCATION

OBJECTID *	LOCATONID *	LOCATIONNA *
1	L1	Komarock
2	L2	SouthC
3	L3	Buruburu

Record: 1 Show:

Attributes of FIRE

OBJECTID *	FIRETYPEPR	FIREPROTEC
1	FPT1	Sprinkler systems
2	FPT2	Fire hose reel
3	FPT3	Fixed extinguishers
4	FPT4	Fire alarms and smoke detectors

Record: 1 Show: All Selected ecords

Attributes of InsuranceType5

InsuranceType	HouseID	AmountInsured	DateSigned	DateExpiry
Building	102	5400	6/8/2007	6/8/2006
Both	103	6000	12/2/2005	12/2/2006
Both	11	5000	3/8/2008	3/8/2009
Building	114	3000	4/2/2006	4/2/2007
Building	122	2000	3/2/2006	3/2/2007
Both	123	6000	4/6/2006	4/6/2006
Both	129	4000	5/4/2005	5/4/2006
Both	130	5000	3/12/2006	3/12/2007

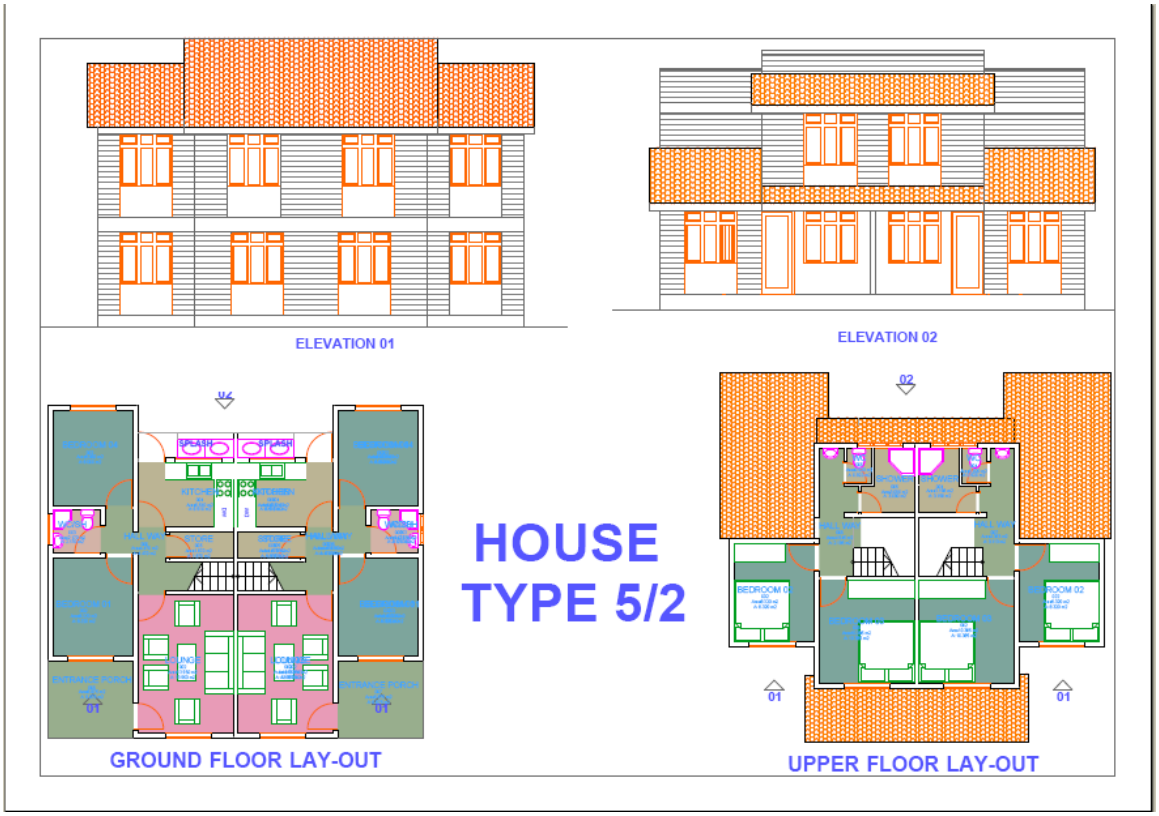
Record: 1 Show: All Selected Records (0 out

Attributes of SECURITY

OBJECTID *	SECURITYID	SECURITYTY
1	SEC1	Inhouse
2	SEC10	GuardFencing
3	SEC2	Guardfirm
4	SEC3	Alarm
5	SEC4	Fencing

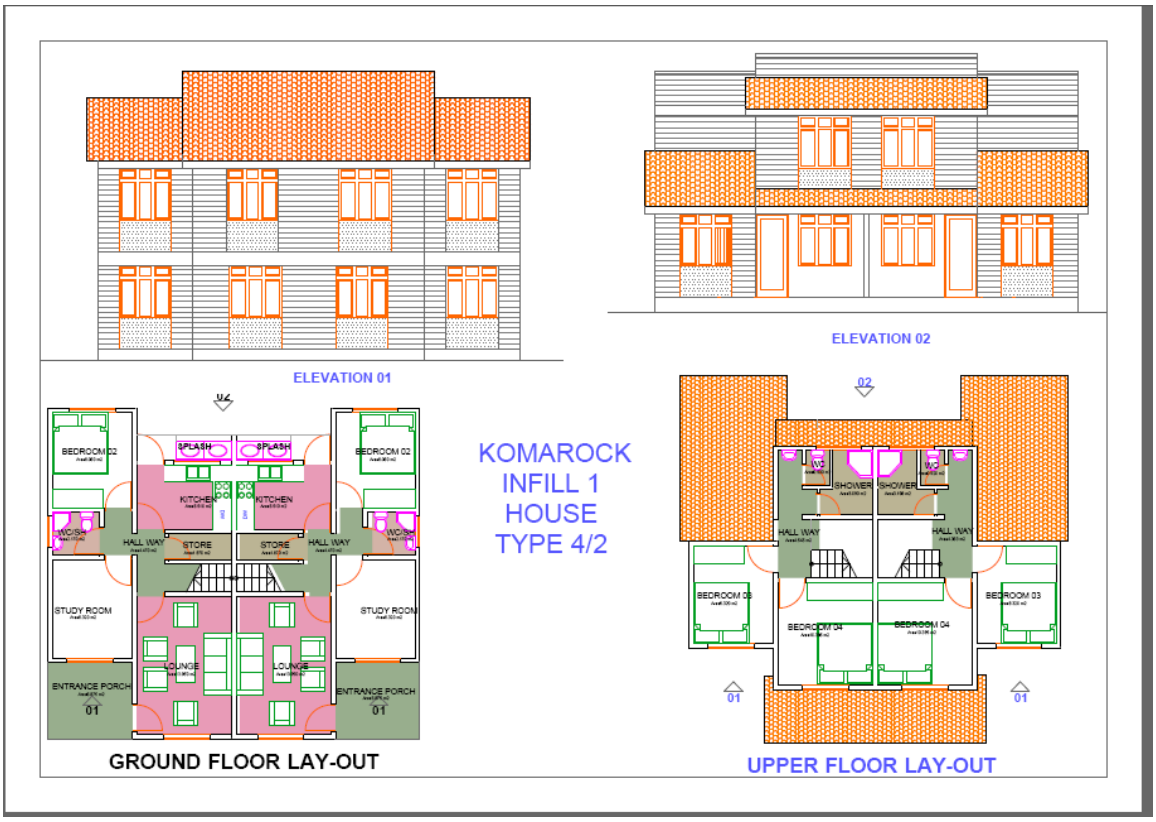
Record: 1 Show:

APPENDIX 4: TYPICAL HOUSE PLANS AND THEIR PHOTOGRAPHS



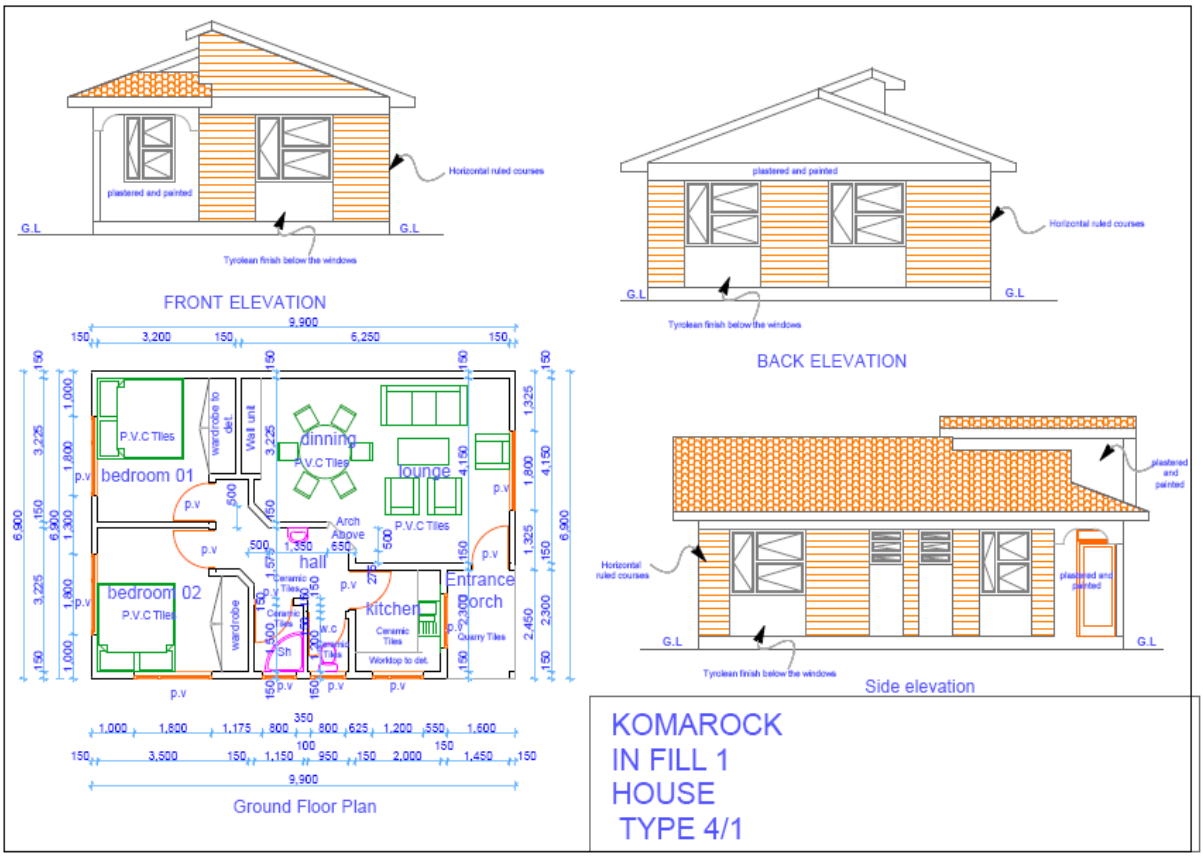
TYPE: Double storey 5/2

Type 5/2



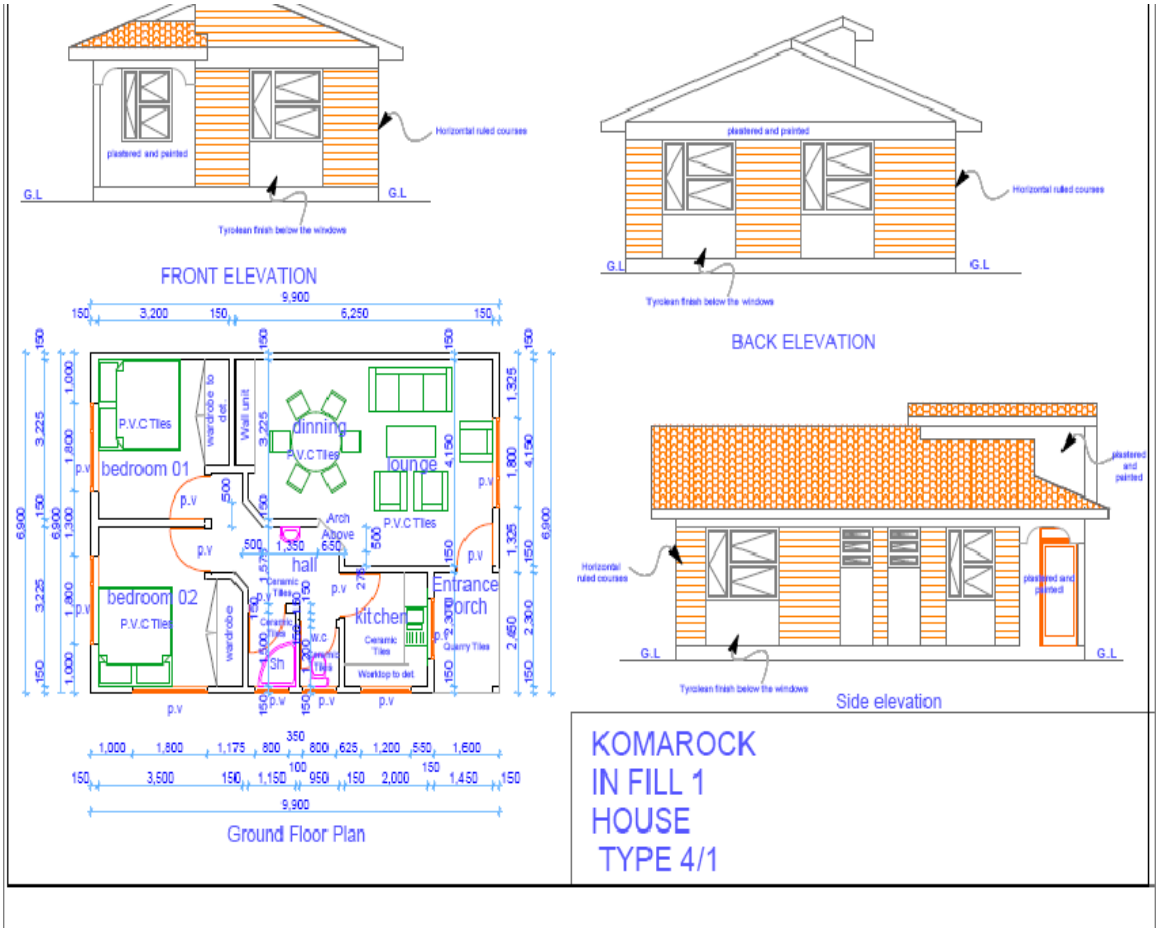
TYPE: Double storey 4/2

Type 4/2



TYPE: Single storey 4/1

Type 4/1



TYPE: Single storey 3/1

Type 3/1

(DATABASE) CD

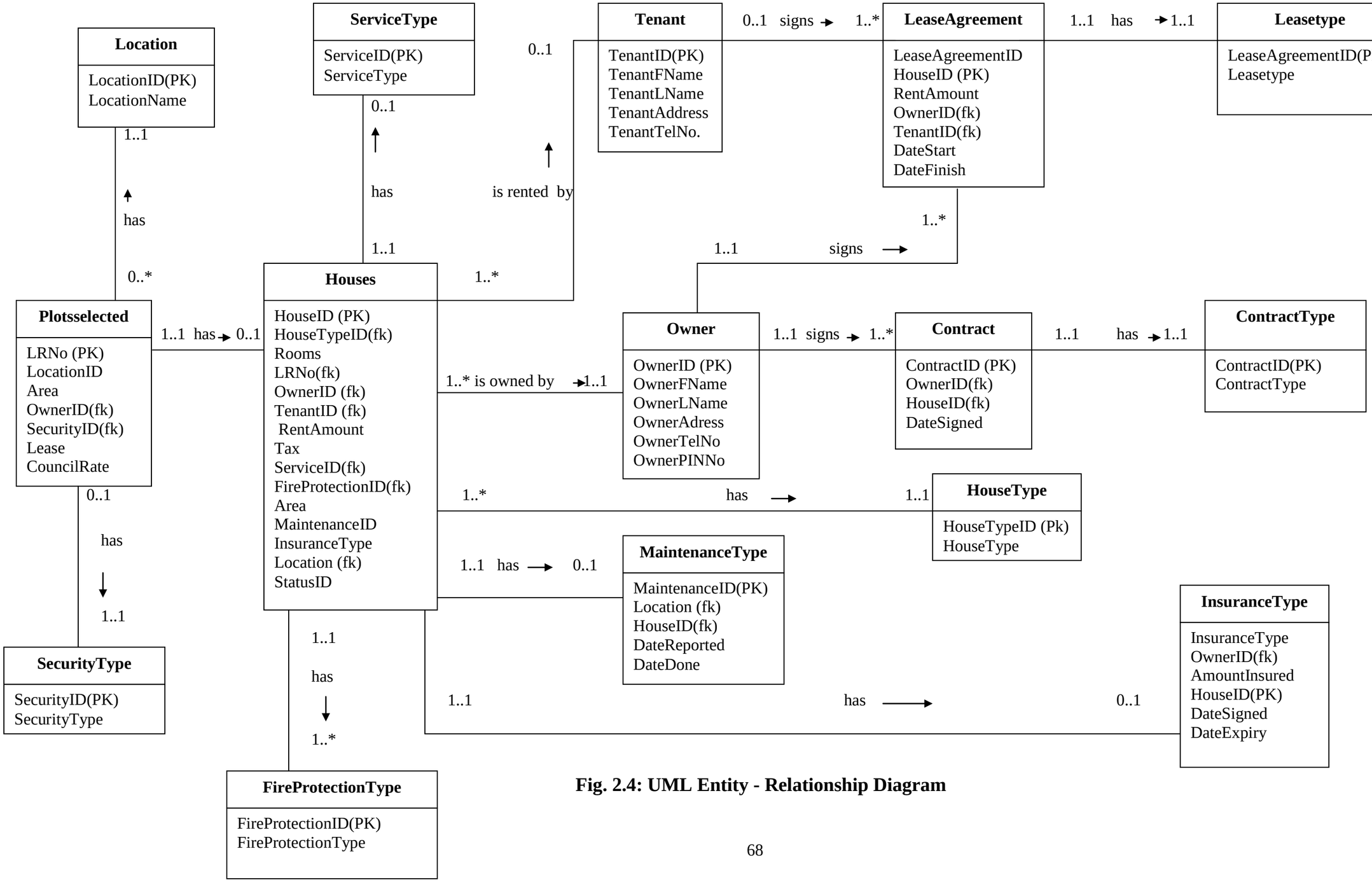


Fig. 2.4: UML Entity - Relationship Diagram

CADASTRAL MAP OF KOMAROCK ESTATE PHASE 1 INFILL

FIG.3.3: CADASTRAL MAP OF KOMAROCK ESTATE PHASE 1 INFILL

MAP OF HOUSES OF TYPE 5/2

Fig. 3.9: MAP OF ALL HOUSES OF TYPE 5/2

MAP OF HOUSE TYPE 4/2 AND VACANT

1:1,750

Fig. 3.12: MAP OF HOUSE TYPE 4/2 AND VACANT

CLIPPED HOUSES

Fig. 3.13: CLIPPED HOUSES

BUFFERED HOUSES

Fig. 3.14: BUFFERED HOUSES