Development of a Prototype Land Information Management System: A Case Study of Athi River area, Nairobi

By

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DECLARATION

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

14/03/2008

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This project has been submitted for examination with our approval as University Supervisors.

14th March 2008

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Mr. G. O. Wayumba

Dedication

§ This project is dedicated to my late mother Jane Yieya Okong'o §

Abstract

This study addresses certain aspects of data modeling with respect to Geographic information systems (GIS). The primary objective of this project is an attempt to develop an automated Land Information Management System (LIMS). In Kenya today, land information is held mostly in paper form, managed manually and even the paper records themselves are not optimally organized. The process of retrieving and disseminating this information is inefficient, time consuming and cannot support timely decision making.

This project represents the formalization of the geometrical portion of data concerning certain kinds of geographical phenomena. This formalization is modeled in unified modeling language (UML) to develop a database. The UML is used to capture both the static and dynamic components of the cadastre given its many entities and attributes.

The report develops a prototype database that is based on the Cadastre 2014 document and attempts to customize the database to suit the Kenyan environment. The project concludes that UML presents an opportunity to render the data and its processes in a manner that reduces redundancy and eliminates duplication of roles in the cadastral data recording system. Modeling presents a simpler way of presenting a standardized way for designing the database.

This study has developed a prototype LIMS using the object-oriented modeling approach. This approach provides a natural method for describing real world spatial entities, avoids data fragmentation and enables useful capabilities for managing databases. The object-oriented modeling allows better integration, data consistency, minimizes reformatting, convenient data merging and saves a lot of time. It is a feasible approach to allow data sharing among different organizations and users.

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The work submitted herein was carried out in the Department of Geospatial and Space Technology. I wish to express my sincere gratitude to my supervisors, Prof. G.C. Mulaku and Mr. Gordon O. Wayumba, for their consistent advise and guidance that greatly inspired me during the course of my project work and which led to the conclusion of the project.

I am thankful to the University for giving me the time to undertake my studies and also for giving the financial support for part of my study. My special thanks go to the former Chairman of Department Mr. Gordon Wayumba and the entire academic and technical staff of the Department of Geospatial and Space technology for their unwavering support during the time of study and preparation of this report.

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CHAPTER ONE

1. INTRODUCTION

1.1 Background

Land is critical to the economic, social and cultural development of Kenya. It is crucial to the attainment of economic growth, poverty reduction and gender equity. Its importance is recognized by various Government initiatives such as the Commission of inquiry on Land in Kenya (Njonjo Commission, 2002), the Commission of inquiry into illegally Acquired Land (Ndung'u Commission, 2004), as well as the Economic policy on the Economic Recovery Strategy for Wealth and Employment creation (GoK, 2003).

In Kenya the National Land Policy (NLP) formulation process was initiated in 2004 to address the critical issues of land administration, access to land, land use planning, restitution of historical injustices, environmental degradation, conflicts, unplanned proliferation of informal urban settlements, outdated legal frameworks, institutional framework and information management [1](GoK, 2006). It also recognizes the need for security of tenure for all Kenyans including, socio-economic groups, women, pastoral communities, informal settlement residents and other marginalized groups.

During the initial stages of the Land Policy formulation process it was agreed that a prototype Land Information Management System (LIMS) should be undertaken in parallel but by separate consultants, in order to provide a foundation upon which the comprehensive land policy would be based. Land information Management System (LIMS) is a computer – based information system that enables the capture, management, and analysis of geographically referenced land-related data in order to produce land information for decision making in land administration and management. In this regard, [2]JICA has initiated the development of a digital land information management system as part of National Spatial Data Infrastructure [3](NSDI) operations.

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[1] NLAP is the National Land Policy document being prepared by the government of Kenya.
[2] JICA – Japanese International Cooperation Agency
[3] NSDI refers to the technologies, policies, and people necessary to promote sharing of geospatial data throughout all levels of government, private sector and the non-profit sectors, and the academic society.

In this database the core land datasets that have been captured are: cadastral, topographical and boundary information.

However, these approaches are not integrated and do not provide a comprehensive Land Information Management System (LIMS) which can be used to provide a platform for poverty reduction, gender equity and economic growth as indicated above.

1.2 Problem statement

At present, land records in Kenya cover about 50% of the country in areas where land titles have already been issued. Areas for which land titles have not been issued are mainly under customary tenure of various forms, such as land under pastoralism and in informal settlements. Informal settlements are located on public or private land, sometimes registered and at other times not registered. Despite the fact that cadastral surveys in Kenya started in 1903 and whereas current estimates are that approximately four (4) million land parcels (have been surveyed and registered), the lands records system is still manual. Nyadimo (2006), and Njuki (2001), point out that the manual records system is both inefficient and time consuming.

Arising from the above, the problem statement of this project can be stated as follows:- **that currently the Kenya Government does not have an automated, digital land information management system.**

As a consequence, current Land Information system is beset with the following specific problems:

- There are no agreed standards to which land information, the systems that manage it or the people that handle it should conform.
- The manual storage and handling of data makes it prone to tampering and to enhanced wear and tear.
- There is lack of adequate storage, which hampers cross referencing of records and constrains the orderly and timely updating of the databases currently in use.

- There is lack of collaboration between the various spatial information stakeholders across the country which results into duplicated creation of Land Information datasets where each data set is being collected and or maintained by different government organizations.

This study is therefore an initiative to create a prototype of an automated, digital land information management system that is both efficient and cost effective to tackle the myriad of problems existing in the current land records as specified in the draft land policy.

1.3 Project objectives

The main objective of this study is to develop an automated land information management system for Athi River area in Kenya. The study shall principally involve the development of a scalable database for land information management, incorporating both the spatial and non spatial attributes of the study site.

The specific objectives are:-

1. To identify suitable spatial and non spatial attributes about the land parcels that should be included in the database.
2. To process the land information data so that the information is compatible with a GIS operation environment.
3. To design a suitable geo database containing the selected spatial and non-spatial attributes.
4. To implement and demonstrate the performance of the database in the study area

1.4 Justification

The development of a computerized Land Information Management System (LIMS) is a necessity for the implementation of land policies. A well-designed and functional LIMS provides information, which allows for the elaboration of tools for the implementation of the land policy and for follow-up of the results. LIMS also makes the information in land records more accessible, reliable and allows for the development of transparent procedures, which makes it possible to address fraud and other malpractices in land administration. It is also easier to identify, lobby for and protect the land interests of the poor, including women, widows and orphans because land records will be collected, updated and analyzed in time, as the need arises.

It will also be easier to identify, record and protect alienated and un-alienated public lands which include marginalized pastoral areas and the arid and semi-arid lands. This makes it easier to study and formulate strategies to provide better infrastructural and social services to such areas and to increase and diversify methods of economic production for improved livelihoods.

Furthermore, correct and comprehensive land information for these areas will help in innovating suitable methods of tenure, away from traditional individual titling which may be too slow and unsuitable for areas under informal settlements, group ranching, pastoralism and the arid north.

In order to accelerate access to land and security of tenure as instruments of sustainable development, International Federation of Surveyors (FIG) has for a number of years collaborated with the United Nations in raising awareness and developing recommendations and guidelines concerning the issue of access to land and security of tenure. Some of the major policy documents on land tenure systems include The Bogor Declaration (1996), The Bathurst Declaration (1999) and the "*Cadastre 2014*".

The Bathurst Declaration (UN-FIG, 1999) expressed the importance of open and sensitive handling of issues raised by land management and land administration. For this to be achieved, an efficient land information management system is required. *Agenda 21*[4] and the *Global Habitat II Plan of Action*[5] provide additional justifications for establishing and maintaining appropriate land information management system to serve the different needs of the nations and their populace.

[4] Agenda 21 refers to the outcome of the United Nations Conference on the Environment and Development (UNCED) dubbed the Earth Summit, in Brazil in 1992 where a number of key areas to land mangers were specified.

[5] Habitat II refers to United Nations Conference on Human Settlements that addressed "adequate shelter for all" and "sustainable human Settlements development in an urbanizing world".

The Bogor Declaration (UN-FIG, 1996)[6] recognizes that to improve an LIMS there is need to focus on cadastral processes to identify the bottlenecks, inefficiencies and duplication. It points out that once processes have been fully documented and understood, it is possible to re-engineer the system to improve the effectiveness in the delivery of services (Nyadimo, 2006).

1.5 Scope and limitation

The project is limited to developing a prototype land information management system based on cadastral survey with the land parcel as the main object and the land reference number as the primary key. It is also noted that though the land information management system is based on a specific boundary system, the information system can be used for other types of land information such as the general boundary survey, infrastructure, land use, etc.

The research has also taken into consideration the Cadastre 2014 Data Model and has developed a data model based on the same but which fits into the Kenyan context. The project implements the data model on a selected sample within the area that can eventually be extended to the rest of the country where specific boundary cadastral processes have been carried out and the data are available.

1.6 Organization of the report

This report contains five (5) chapters, a references section and appendices. Chapter 1 provides an introduction to the research defines the research problem and gives the objectives of the research. It also provides a justification for carrying out the research defines the scope and limitations and informs on the project organization.

Chapter 2 focuses on literature review and presents a global overview of land information management status shows LIMS examples from some selected countries and concludes with LIMS status in Kenya. Chapter 3 focuses on methodology, data collection methods, the study sample, questionnaire result analysis and the data model formulation. It also covers the modeling process from the conceptual model,

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[6] The Bogor Declaration refers to the affirmation made at the UN-FIG Interregional Meeting of experts on the Cadastre held in Bogor, Indonesia from the 18^{th} – 22^{nd} March, 1996.

logical model resulting in the database implementation. Some implementation results are tested in this chapter by applying some queries to the database.

Chapter 4 presents a comprehensive analyses of the database results and identifies the applications necessary for a proper implementation of the database. Chapter 5 presents the conclusions and recommendations based on the prototype LIMS. References cite the books, articles, papers and reports used in this project.

CHAPTER TWO

2. LITERATURE REVIEW

2.1. Land information Management

The International Federation of Surveyors (FIG) *Statement on the Cadastre (FIG 1995)* highlights the importance of the cadastre as part of a land information system for social economic development from an international perspective and recognizes the central role that surveyors play in the establishment and maintenance of cadastres.

A cadastre is a parcel based and up-to-date land information system containing a record of interests in land (e.g. rights, restrictions and responsibilities). It usually includes a geometric description of land parcels linked to other records describing the nature of the interests, and ownership or control of those interests, and often the value of the parcels and improvements thereon. It may be established for fiscal purposes (e.g. valuation and equitable taxation), legal purposes (conveyancing), to assist in the management of land and land use (e.g. for planning and other administrative purposes), and enables sustainable development and environmental protection (UN FIG, 1995).

Advances in Information Communication Technology (ICT) and developments in Geographic Information Systems (GIS) continue to change the way in which cadastral information is structured, stored, managed, delivered and used (Nyadimo, 2006). In this respect, Dale and McLaughlin (1988) concluded that new capabilities for data collection, storage, and processing together with the expanding requirements of users, would direct attention to the need for improved land information management strategies.

The management of land information is not a new activity and information systems about land have been in existence since people first took to sedentary agriculture (Dale and McLaughlin, 1989). The management information systems provide both the information infrastructure necessary for land allocation and settlement and the additional technical and resource information needed for resource development.

As mentioned in Section 1.2, present land records cover about 50% of the areas where land titles have already been issued. Areas for which land titles have not been issued are mainly those under customary tenure in various forms, such as land under pastoralism and in informal settlements (located on public or private land, sometimes registered and other times not registered).

The political climate in Kenya has been ripe for land policy reform for quite some time, and indeed land issues formed a large part of the constitutional debate during the referendum in 2005. Kenya has not had a clearly defined or codified national land policy since independence. The present land information system consists of land records and cadastral maps for registered rights to real property and valuation rolls for collection of land related revenues for the central and local governments. Most of this information is in hard copy format and is stored in shelves from where retrieval is a major problem, and Kenyans therefore experience a lot of difficulties accessing land information from these paper records.

The final draft National Land Policy document summarizes the problem as follows: - (NLAP, 2007)

"..to address this situation, the Government shall prepare and implement national guidelines to improve the quality and quantity of land information system by computerization at both national and local level. The guidelines will cover and address all aspects of standards, geo-referencing pre-requisites for LIMS, security, intellectual property rights, and a land information dissemination and pricing system. This system will enable the determination of the stock of un-alienated Government land and avoid malpractices in the allocation process, hasten the land delivery process, achieve equity in allocation and efficient dissemination of land information to the public."

In order to fulfill the objectives the National Land Policy requirements, it was recommended that the Government should accomplish following tasks:

- Re-organize, update and authenticate existing land records in terms of accuracy in readiness for the setting up of a computer based LIMS;
- Develop data standards for geo-information, to provide for standardized feature definitions, data content, data coding spatial referencing, data accuracies and metadata through the coordinated effort of all data producers.
- The cadastral parcel should be defined by surveys and the issuing of titles be based on the description of the parcel.
- Build appropriate data models and architectures which are in harmony with other systems in the country and region.

2.2 Global trends in Land Information Management Systems

Land and its resources have been the basis of wealth for most societies since the beginning of civilization. The management of such land resources, while being central to most societies, has seen many and varied approaches and systems. Traditional agrarian societies, usually based on a complex form of customary tenure, maintained a balance in the environment which sustained the food supply over generations, subject to the vagaries of nature. Examples are found in virtually every country in the developing or new world, whether they are Australian Aborigine, the North American Indians or as found in cultures of the African and Pacific island nations (*Williamson, 2005*)

Over the last hundred years or so, a number of factors have contributed to the environmental degradation of many of the rural areas. First, due to inappropriate government policies, migration and population growth, rapidly growing populations have resulted in an increase in the clearing of forests for agriculture by rural squatters and many other practices which have had an adverse effect on the environment. Secondly, the historical rural balances have changed due to the impact of efficient transportation systems, modern farming technologies and the development of international markets with a move to cash crops.

Modern cadastral and land information systems offer one possibility of help to solve some of these problems, whether in cities or rural areas, through an improvement in the management of land in general, with a particular focus on the environment. Over the last century, cadastral systems have developed in sophistication and have also developed a multi-purpose role, especially in the last couple of decades in developed countries due to the advent of computer technology. Such systems are still used as the basis for managing land ownership records as well as valuation data for land tax, but are increasingly developing into parcel based land information systems. In cities, these systems are becoming a basic framework for local government administration, city planning, collection and assessment of local government taxes and rates, and managing utilities and transport systems.

A cadastral system is an information system of land holdings and land use that revolves around four functionalities: land mapping, land registration, land valuation and land development to support sustainable development. Cadastral systems provide excellent opportunities for identifying problems associated with the development and implementation of land policies. The key processes within cadastral systems are the adjudication, transfer and subdivision (and consolidation/amalgamation) of land rights. Cadastral system comprises a land registration system and a cadastral survey and / or mapping system as the key components. Cadastres have the flexibility to record a continuum of land tenure arrangements from private and individual land rights through to communal land rights, as well as having the ability to accommodate traditional or customary rights.

Land titling, land registration and land reform projects, or projects to regularize or formalize land tenure arrangements, all require the support of or result in cadastral systems. The cadastral systems have the potential to support effective land markets, increased productivity, sustainable economic development, environmental management, political stability and social justice, although it is absolutely essential that each cadastral system be designed appropriately to serve the needs of the respective country. Cadastral systems designed for poorer countries should be simple, flexible, freely accessible and low cost, and often should have similarities with systems supporting the operation of informal land markets. The success of a cadastral system , however, is not dependent on its legal or technical sophistication, but whether land rights are adequately protected, with those rights being able to be traded where appropriate efficiently, simply, quickly, securely and at low cost. However if the resources or systems are not available to keep the cadastral system up-to-date then there is little justification for its establishment.

2.3 Land Information Management challenges in some selected countries

2.3.1 Land Information management in Fiji

With the help of the New Zealand Government, a National Land Information System has been developed in Fiji. Since LIS is a product of the industrialized world, attributes of the conventional 'western' land tenure have been incorporated without too much difficulty into the LIS. However, the major problem areas were the incorporation of the attributes of the traditional land tenure.

A land Information Management System (LIMS) provides information about the land, its resources and the improvement made on it. LIMS is defined here as being "a system for managing land information that uses modern technology to create information database and disseminate land information but it is ultimately controlled by the surrounding institutional and social framework" (Mele, et al, 1995). With its ability to quickly collate and integrate land related information from several sources and make them readily available for decision making, an LIMS provides a way of determining how Fijian land conflicts may best be resolved.

Fiji has three main types of land holdings: Freehold lands, State lands, and Native lands. These three types of land holding systems are held under two different types of land tenure systems: 'a western' land tenure system, and a 'traditional' land tenure system.

The western land tenure system is based on the European styled, capitalist oriented concepts and is intended primarily to facilitate land conveyancing and economic development. With its emphasis on individual land ownership, it applies to Freehold lands, State lands and Native leases. The system is based on the Torrens Title Registration System and is oriented towards commercial enterprises, an accurate cadastral surveying and mapping system.

Having noted the problem of the dual registration systems practiced by the Fijians, it can be concluded that their solution lies on the ability an LIMS/ GIS to integrate, reflect and analyze a variety of themes or layers of information, provide a way of efficiently documenting and displaying Fiji's land tenure related problems.

An area in which LIMS will undoubtedly be useful will be in improving the complex and confusing administration of Fiji's present land tenure systems (Mele et al., 1995). It is important, however, to remember that an LIMS is only a tool to be used by land administrators, planners, and land users to help them in planning their work/ resources.

2.3.2 Land Information Management in Ghana

Ghana has six land sector agencies involved in its land administration system. These agencies have technically been operating manually in an environment beset with conflicting and unreliable data, dubious manipulations of existing data by some recalcitrant staff and tedious retrieval of available information suggesting the need to establish or develop computer based land information systems and networks through a re-engineering process and pushing for attitudinal change (Karikari, 2006). Based on better management of information, substantial improvement within the land sector can be brought about by analyzing and costing existing procedures, abandoning unnecessary practices and making better use of existing resources through the introduction of information Technology (IT) and LIMS.

The Government of Ghana fashioned a National Land Policy (NLP) in 1999 to give effect to this reform with a view to " addressing some fundamental problems associated with land management in the country", "establishing and developing a land information system (LIS) network among related agencies in the country, linking them up with sub-regional networks; and establishing and maintaining a geo-spatial framework database in the Survey Department, requiring all thematic databases to be referred thereto".

2.3.3 Land Information Management in Uganda

Uganda is currently implementing a strategic action plan that requires a LIS/GIS system and a land information management system which can deal with both specific cadastral boundary and general boundary cadastral parcels as foundation data in the same land record system. The government is undertaking a systematic adjudication and demarcation of all parcels at the local level in terms of pilots with the idea of using the spatial information generated to supply economic and social services.

Because of Uganda's history, there are large parcels of land which have been registered, which also have many occupants who now have occupancy rights and can apply for a new form of title. This means that the land information management system has to have the information both about the registered rights under the conventional titling system and the new customary or occupancy titles which the occupants can get under the new 1998 Land Law.

Without an appropriate land information management system, Uganda will not be able to deliver the expected economic and social services to these people and it will not be able to offer sustainable and affordable security of tenure to the majority. Another key function of Uganda's land information management system will be to supply information to manage conflict and solve disputes. This implies that the system is not only useful at the local level but also to other government agencies such as local governments and the Department of Justice, which is involved in dispute resolution. Uganda, after working on this aspect will be one of the first countries to use the new LIMS/GIS products coming to the market and which are designed for this kind of problem.

2.3.4 Land information System in South Africa

In South Africa, the cadastral system covers 80-90 % of the country but 25-30 % of South Africans live outside this system. South Africa has a fully fledged Spatial Data Infrastructure (SDI), which uses cadastral data as foundation data. However, the country is still beset with the same problems as Uganda and most other developing countries. It needs to create general boundary cadastral spatial information as a foundation to adapt in the same land information system as the cadastral data to be able to undertake land management and development both in the peri-urban and rural areas of the former homelands.

Without an appropriate land information management system which can accommodate both specific boundary cadastral and general boundary cadastral parcels, the planned land use management law cannot be implemented; and the existing land use rights of inhabitants protected under law in the former homeland areas cannot be safeguarded and / or incorporated into the national planning system over time.

2.4Land Information Management Systems in Kenya

In Kenya today, land information is held mostly in paper form and managed manually. This is inefficient, time consuming and cannot support timely decision making about land. The lowest level at administration level at Kenyans can access land information is the district. Kenyans therefore currently experience a lot of difficulties and expense in accessing land information.

In addition, Kenyans often have to visit too many offices far from where they live in order to carry out a land transaction (e.g. maps of land parcels are kept by the Survey Department while ownership details are kept by the Department of Lands).

Kenya also lacks an up to date inventory of the amount of land under different uses such as, forests, water and infrastructure among others. To address this situation, the government should prepare and implement national guidelines to improve the quality and quantity of information system by computerization at both national and local authority levels. The guidelines should cover and address all aspects such as standards, geo referencing, security, intellectual property rights, and land information dissemination and pricing (NLP, 2007).

This will enable the National Land Commission determine the stock of un alienated Government land, avoid malpractices in the allocation process, hasten the land rights delivery process, generate and efficiently disseminate land information to the public. In order to enable the above process take place, the following must be taken into consideration:

- Reorganize, update and authenticate existing land records in terms of accuracy in readiness for the setting up of a computer based LIMS;
- Provide the necessary infrastructure, such as electricity, computers, and internet connection down to the district level;
- Develop a strategy to facilitate sharing of information across Government departments; and
- Encourage public-private partnerships in the setting up of the LIMS.

There is therefore, need for the government to:

i) Develop ISO standards for geo information, to provide for standardized feature definitions, data content, data coding, spatial referencing, data accuracies, and metadata, through the coordinated effort of all data producers.

ii) Establish a unitary and homogenous network of control points of adequate density preferably by use of Global Positioning Systems (GPS),

iii) Amend the Survey Act (Cap 299) to allow for the use of modern technology such as GPS and Geographical Information systems (GIS), and

iv) Implement an appropriate database models and architecture which are in harmony with other systems in the country and in the region as a whole.

2.5 Digital database development

The rapid developments in Information and Communications Technology (ICT) have increasingly resulted in the way in which cadastral information is collected, stored and retrieved. These developments are influencing countries whose digital solutions were implemented in the 1980's and forcing them to re-define and develop their cadastral systems.

In countries where manual systems are still predominant like Kenya, these developments continue to act as a drive to institute digital solutions. In the process of instituting digital solutions, it becomes appropriate to analyze the existing system so as to identify avenues for moving into a digital era. It is also significant to recognize that there are different stakeholders which are involved in generation of cadastral datasets necessary for the development of digital database.

CHAPTER THREE

3.0 METHODOLOGY

This study undertook to look at the various organs involved in the development of a Land Information Management System and carried out both individual and institutional interviews, supported by a questionnaire, to identify the various players involved in both public and private land information management sector. The interviews covered the public, who are interested in acquiring land information for various purposes, the government departments like the Department of surveys and Department of lands, who are involved in processing and management of land information datasets, and finally the institutions, who are vested with the responsibility of monitoring the professionals involved in the practice of collecting, analyzing and disseminating this information.

The datasets used in this project were collected in hard copy format from the Department of surveys. It involved a total six Folio/ Registration sheets having a total of 496 plots. The folios covered a range from F/R 339/28 – 32 and F/R 339/44. The F/ R s were then converted to digital format via digitization process using a Map Info GIS software. The coordinates system of the F/R s was in Cassini coordinate system which was acceptable to the software hence I had to transform the coordinate system into a Universal Transverse Mercator system acceptable to the GIS platform.

The digitization was done in MapInfo software due to its user friendliness. The digital data was later exported to ArcGIS to enable me carry out further analysis on the data due analytical limitations of the MapInfo software. Since there was very little time allocated for the project, it was agreed that instead of digitizing and analyzing 496 plots, I should carry out the analysis on only 92 plots available in F/R 28. The results presented in this report are therefore based on the analysis of plots belonging to F/R 339/28.

3.1 External Modeling

The way users perceive the data is called the external modeling level. The way the DBMS and the operating system perceive the data is the internal modeling level.

The external level consists of a number of different external views of the database. In this project the external modeling is based on results of a survey carried out by administering a questionnaire to a category of users using the services of a land registry system looking for relevant information. The questionnaire was administered to 50 persons in various professional disciplines and the common user who walks into a Ministry of Lands and settlement office looking for some specific information.

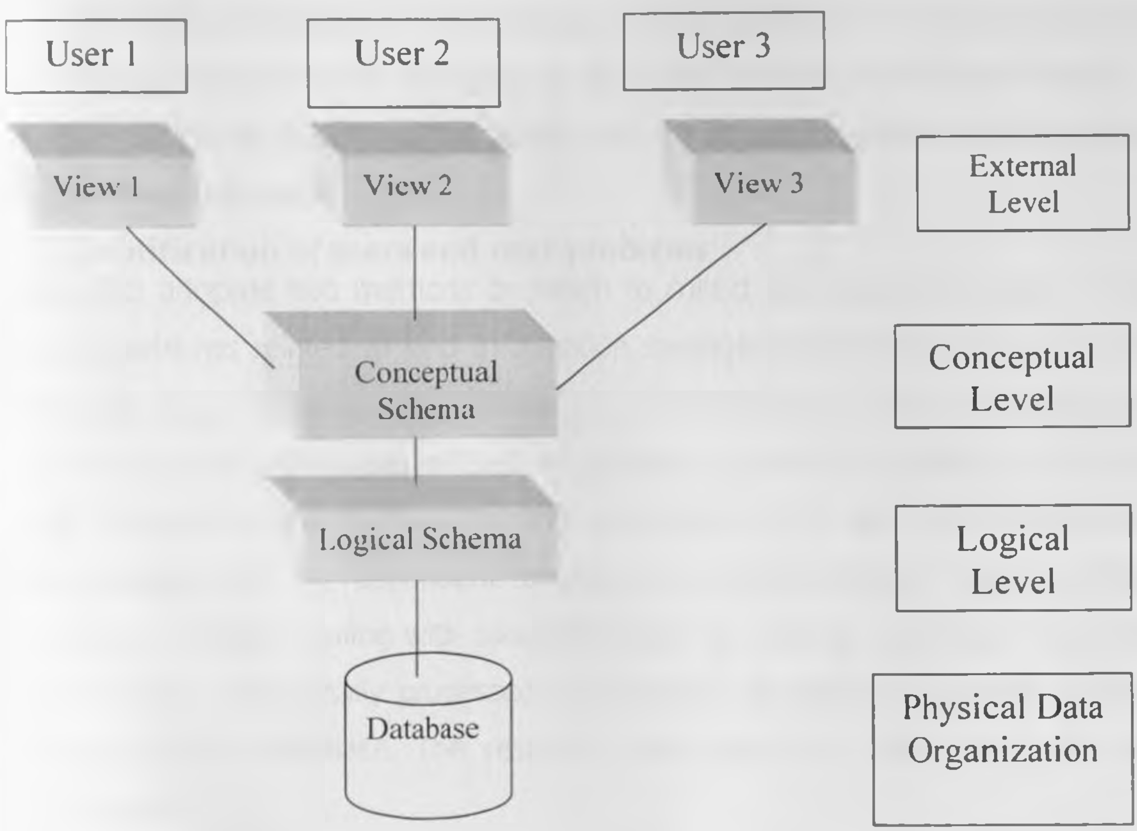


Fig 3 .1 Data models levels (source Connolly and Begg, 2004:845)

From the analysis of the fact finding interviews that were carried out on the five categories of users, it was evident that the most appropriate type of database system would be the three level architecture (distributed) system as opposed to a centralized system.

The reasons why the three-level architecture is desirable are as follows:

- Each user will be able to access the same data, but have a different customized view of the data. Each user should also be able to change the way he or she views the data and the change should not affect other users.
- Users will not deal directly with the physical database storage details, i.e. indexing, hashing, etc.
- The Database Administrator (DBA) should be able to change the database storage structures without affecting the user's views.
- The internal structure of the database will be unaffected by the changes to the physical aspects of the storage such as change over to a new storage device.
- The DBA should be able to change the conceptual or global structure without affecting the users.

3.1.1 Identification of users and user problems

This project adopted two methods by which to collect and assess the type of users and user problems related to land information management in the country. The first method was to carry out a survey based on a questionnaire. The questionnaire was based on four thematic areas related to cadastral registration systems and record keeping. The second approach was for the researcher to carry out verbal question and answer sessions with the respondent to collect relevant information from the officers and heads of sections dealing with cadastral issues on a day to day basis. The results of these surveys were finally processed and analyzed by statistical package software as an input to the database. The results of this survey are presented in the sub-sections below.

3.1.2 User needs assessment

The results of the questionnaire revealed that about 30 % of the respondents need to know about land ownership, 14 % need to know about their land title status, and about 80 % are looking for plans and maps related to their land registration area. 66 % of the respondents indicated that land registration process is very complex hence the need for its simplification. Land records are almost inaccessible to the public since only 22 % of the respondents could get access to the required information. This information is very difficult to access but when one gets access it takes close to one whole day to get especially for ownership details.

The respondents also indicated that the introduction of digital and automated records would enhance the data retrieval process. 80 % of them concurred that there is need for digital records; this implies the implementation of a land information management system.

The current reforms at the Ministry of Lands and Settlement, Departments of Survey and Physical Planning indicate that there is an on-going process of implementing a land information management system. The questionnaire results re-affirmed this necessity when 80 % of the respondents indicated that there is need for automated information in both departments. The information to be included in this database includes ownership, address (physical), land registration number (LR No.), encumbrances etc. It was also evident from the results that most of the data in our records are in analogue form hence needs conversion to digital format. The survey revealed that this conversion will make it easier to update and retrieve records in future, alleviate access problems and also solve some of the recurrent boundary conflicts if the data is linked to spatial location.

The questionnaire investigated the communication mode of most of the government offices dealing with land information and the results revealed that 20-40 % of these offices use post office mail and telephone service. 8 % are using electronic mail and data transfer and 15% courier services. Such communication processes result in unnecessary delays hence the recommendation that we have an automated land information management system. With this system in place the information transfer and retrieval will be on-line and with the core cadastral information being centralized – in the Provincial Headquarters and District Headquarters as the survey suggested – the time of data access will be greatly reduced. The data accessed should however remain selective and the necessary information retrieval and storage should be built into the database.

The land registration process, especially for new grants that this project addresses, needs to be reviewed. The survey reveals that there are in excess of 40 legislative laws dealing with land registration in the country. 60 % of the respondents suggested a reduction or amalgamation of these legislations. This will require harmonization of these legislations to address specific aspects of the land registration process.

Lastly, the questionnaire addressed the role of Geographic Information Systems (GIS) and Land Information Management Systems (LIMS) in the land administration system. 57 % respondents indicated that the role of GIS/LIMS will be central to the implementation of an automated land information system. It will, by the use if GIS, be very easy to improve data accessibility and link both the spatial and no-spatial data. Through data modeling procedures it will be easy to initiate flexible database design procedures that will enhance data access and validation procedures. The database should initially be central but be flexible enough to be transformed into a distributed system. It was also noted that access to data- especially cadastral data- should be made open to the public with some access restrictions at a minimal fee.

To fully operationalize a land information management system, the respondents indicated that the government together with private institutions need to join hands in developing the said system. The public would therefore be required to access this at in their nearest district at a small operational fee.

This project intends to incorporate the above user views in designing a prototype database which is flexible and responds adequately to the user requirements. The project fact finding process involved interviewing a cross section of users and data producers. The first category interviewed were the public who check for information concerning their individual or group land parcels (plots). Most information sought for in this category is mainly maps, title deeds and ownership details. Information to be included in the database for this category will mainly be ownership names, area, and title deed availability. The other category of users are the professional (surveyors), who actually collect and prepare this information for distribution. This category of user has basic interests in the authenticity of the allocations and the whole process of survey either for new grants, subdivision or consolidation. The vital information to be included the database for these people involve allocation procedure and the requisite legislations that legalize the allocations. If the surveyor is involved in the actual title deed preparation then he would mostly be interested in the registration and authenticity of the allocations and validity of letters of allotment.

The results derived from the survey and the questionnaire formed the basis for the database modeling and formulation of the datasets to be included in the database. Thus the database must include the name of the owner, the contact address, telephone contact and if possible the owners photograph. Other details include the surveyor, date of survey and the date the survey was authenticated amongst other details.

3.2 Cadastral data collection

The project involved the collection of cadastral data sheets from the Department of Survey offices. At the time of collection this was dataset was in five Folio number 339 and Reference numbers sheets ranging from no 339/28 - 32 and 339/44. This dataset forms part of the topographic sheet Reference/ Map / RIM / S.A 37 G.II.d.6 (148/4) within the registration district of Machakos and within the locality of Mavoko Municipality.

At the point of digitization of the dataset to vectorize, it was realized that the data was in Cassini Soldner coordinate system and would involve transformation into Universal Transverse Mercator Projection (UTM) to be accepted by the Geographic Information System software. The data was therefore converted to UTM. At this point it was agreed that the dataset be limited to one F/R sheet so as to reduce the amount of digitization. The rest of the analysis carried out in the project is therefore based on data from F/R 339/28.

The digitization was done on a MapInfo GIS software platform. This was done due to the fact that it was more flexible than the other available software. The coordinate information was in point form and these data after conversion were just imported into the system as points which were later joined to form the land parcels.

After digitization the work was imported into an ArcGIS platform to enable more elaborate analysis to be done on the data. ArcGIS has more analysis functionalities and hence is superior to MapInfo in terms of data analysis. The results of the transformation and analysis are the subject of section 4.2.

3.3 Conceptual Modeling

3.3.1 Data Model Formulation

A data model is a set of concepts that may be used to describe a database, i.e. the entities, attributes, relationships and integrity constraints that are applicable to the data. A good data model should be:

- Efficient – minimize storage needs and maximize processing speed
- Flexible – provides a complete set of tolls for the user to describe real-world objects.

Data modeling is done mainly to assist in the understanding of the meaning (semantics) of the data and to facilitate communication about the information requirements. To effectively build data models one needs to answer questions about entities, relationships and attributes. In doing this the designer discover the semantics of the enterprise's data. Entities, relationships and attributes are fundamental to all enterprises. However, their meaning may remain poorly understood until they are correctly documented. A data model makes it easier to understand the meaning of the data.

Data, therefore, is modeled to ensure the following:

- Each user's perspective of the data
- The nature of the data, itself, independent of its physical representation.
- The use of the data across application areas.

3.3.2 Data model

Data elements with different functionalities contribute to land information in land administration systems. Land information is organized by land parcels which are the basic building blocks of land administration systems.

A study of five states and jurisdictions (New South Wales, Victoria, Western Australia, Netherlands and Swtzerland) was conducted to investigate current data models showed that interest on land or property mainly include rights rather than responsibility or restriction (Kalantari, M, et al, 2006). Consequently to achieve a modern land administration, cadastral data modeling is a basic step towards efficient service delivery because data are defined in the context of business processes.

The current land information systems maintain information about parcel, owner and ownership right as well as some obligations of the owner. Therefore, the current core data model consists of the parcel/property, the owner, with rights linking these together (Fig 3.2), and this core data model includes three main data elements: land parcel/ property rights and some restrictions and interested persons. This model describes how a piece of land parcel or property is related to a person via the rights.

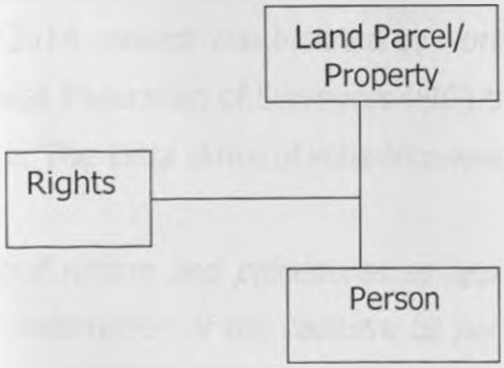


Fig 3 2 **Core Model**

However, objectives of sustainable development for a holistic management of land force the cadastral and information systems to re-engineer the cadastral data model and incorporate other information into the model such as the third dimension, both private and public interests, restrictions and responsibilities on land as well as occupancies and tenancies.

The absence of a systematic, well defined and public documentation system about these rights and restrictions creates an increasing legal insecurity. Landowners, investors and administrators are therefore confronted with additional efforts to find out what legal situation they have on their properties or in areas where they intend to invest in.

The objects of registration are in principle the land parcels, often connected with further real estate objects as buildings and apartments. This means that legal information can only be represented in connection to a certain land parcel or a piece of it. It is evident that it would be heavy work to link everything to the parcels and the maintenance of such an information system would be impossible because of the cumbersome procedures necessary to keep clean ownership records. Cadastre 2014 is a concept to create systematic documentation of the legal situation of land, using possibilities of geographic information system (GIS) technology combined with procedures used in traditional cadastral and land registration systems.

3.3.3 Cadastre 2014

The cadastre 2014 concept was initiated by working group 7.1 of the Commission 7 of the International Federation of Surveyors (FIG) to reflect on the future of development of the cadastre. The initial terms of reference were:

"study cadastral reform and procedures as applied in developed countries, take into consideration automation of the cadastre as part of a larger land information system, evaluate trends in these fields and produce a vision of where cadastral systems will be in the next twenty years, show the means with which these changes will be achieved and describe the technology to be used in implementing these changes".

The working group was commissioned in 1994 hence the term cadastre 2014 means 1994 + 20 = 2014.

One of the major aims of the cadastre 2014 proposal is to improve the information about the legal situation of land and thus strengthen legal security. Cadastre 2014 defines a 'legal land object as a piece of landing for which homogeneous conditions, defined by a law or regulation, exist within its unit lines. Typical legal land objects are defined by zoning areas. Cadastre 2014 talks about other aspects of cadastral systems, namely about organizational aspects, data modeling and use of IT.

Even though all aspects carry significant weight, the data modeling aspect can be singled out as the most crucial one, which has the potential to make or break the implementation of all recommendations. Data modeling influences the way that data and information are acquired, administered, handled and distributed, which then also impacts on the organizational and institutional structures.

3.3.4 Principle of land object

Cadastre 2014 builds upon the established principles of traditional cadastres but extends the definition of the basic cadastral unit – the land ownership parcel – to also include land objects such as zones. The cadastral system therefore would include and administer all land objects, which have some legal or economic relevance, the land ownership parcel of course being the most basic one.

Land Parcel	Land object
A land parcel is a piece of land with defined boundaries, on which property rights of an individual person or a legal entity exist.	A land object is a piece of land in which homogeneous conditions exist within its outlines. Legal land objects are described by the legal content of a right or restriction and the boundaries which demarcates where the right or restriction applies.

Table 3.1 **Land object**

Cadastre	Land object
Cadastre is a methodically arranged public inventory of data connecting properties within a certain county or district, based on a survey of their boundaries.	Cadastre 2014 is a methodically arranged public inventory of data concerning legal land objects within a certain country or district, based on a survey of their boundaries, the right or restriction.

Table 3.2 Modern Cadastre definition

3.3.4 Conceptual data modeling

The initial step in database design is to build one (or more) conceptual data models of the data requirements of the enterprise. A conceptual data model comprises:

- Entity types
- Relationship types
- Attributes and attribute domain
- Primary keys and alternate keys
- Integrity constraints

The following tasks were be involved in coming up with a conceptual model:

- Identify the entity types
- Identify relationship types
- Identify and associate attributes with entity or relationship types.
- Determine attribute domain
- Determine candidate, primary and alternate key attributes.
- Check for model redundancy
- Validate conceptual model against user transactions.
- Review conceptual data model with the user.

Entity types

The entities are identified by examining the user's requirements specifications. From these specifications, we identify noun or noun phrases that are mentioned (parcel no., owner, owner Id, area, value, location, etc.). Here it is important to look for major objects such as parcel no., area, owner, or other concepts of interest, excluding those nouns that are merely qualitative of other objects. These are then grouped as parcel ID, Parcel Owner, Parcel Area, Parcel Value, etc).

Identification of relationship types

Having identified the entities, the next step is to identify all the relationships that exist between the entities. Here I used the nouns in the user's requirements specification

e.g. Parcel is owned by Owner(s)

Parcel ID belongs to one parcel only.

Great care is taken to ensure that all the relationships are either explicit or implicit in the user' requirements specification are detected. However, missing relationships should become apparent when the model is validated against the transactions that are to be supported.

3.3.5 Modeling in Unified Modeling Language

Unified Modeling Language (UML) is a notation that combines elements from three major strands of Object- Oriented design. Rumbaugh's OMT modeling, Boochs's and Jacobson's objectory (Connolly, T., Begg, C., 2004).

There are three primary reasons for adopting the UML notation:

i. UML is becoming an industry standard, the Object Management Group (OMG) has adopted the UML as a standard (ISO 19109) notation for object methods.
ii. UML is arguably clearer and easier to use.
iii. UML is now being adopted within the academia for teaching object oriented analysis and design, and using UML in a database module provides more synergy (ibid).

3.3.6 Object Oriented Data Models

Object-Oriented (OO) technology concepts were developed in the 1080's and have become popular since early 1990's (Nyadimo, 2006). Object oriented data modeling is based on the premise that the world is divided into objects that have properties, behavior and relationships with other objects (Burke 2003). Virtually all the basic concepts of the object –oriented approach were introduced in the *simula*[7] programming language developed in Norway in the late 1960's. (Connolly and Begg, 2004).

Object-oriented modeling resembles our real world experience. In this case objects are modeled after real world entities and are given behaviour that mimics or models some relevant aspect of their behaviour in the real world (Tomlinson, 2003). The OO data models thus allow for rich and complex descriptions of the real world and the ability to set up a data structure that users find easy to understand.

3.3.7 Object modeling concepts

Object-Oriented data models have several concepts which include:

Classes: A class is an element that defines the attribute and behaviors that an object is able to generate (Fowler, M., 2000). The behavior is described by the possible messages the class is able to understand, a long with operations that are appropriate for the message.

Encapsulation: the concept of encapsulation in OO means that an object contains both the data structure and the set of operations that can be used to manipulate it (Connolly and Begg, 2004). Encapsulation therefore means that the data within an object can only be accessed in accordance with the objects behavior thus serving to protect it from corruption. Encapsulation enables information hiding which means that one can separate the external aspects of an object from the internal details, which are hidden from the outside world.

Relationship: relationships describe how objects are associated with each other and define the rules for creating, modifying and removing objects (Tomlinson, 2003). There are several types of relationships that are used in the object- oriented data models and these include *associations* and *multiplicity*.

An association is a structural relationship that specifies how objects of one class are connected to objects of another class. The connector may include named roles at each

[7] Simula is a computer language developed in the 1960's at the Norwegian Computing Centre for the purpose of simulating real-world processes. Simula pioneered the concepts of classes, objects and abstract data types as well as providing object based support for parallel processing.

end, cardinality, direction and constraints. There are three (3) basic cardinalities and these include: one to one (1:1), one to many (1: m), and many to many (m: m).

The figure below exemplifies an association and multiplicity between two (2) objects, the owner class and the Land Parcel class.

Fig 3.3 Association / Multiplicity

In the above case an owner can own more than one land parcel and one land parcel can be owned by more than one owner.

Aggregation and composition are special types of the association relationship. Aggregations are used to depict elements which are made up of smaller components. Aggregation relationships are shown by a white diamond-shaped arrowhead pointing towards the target or parent class.

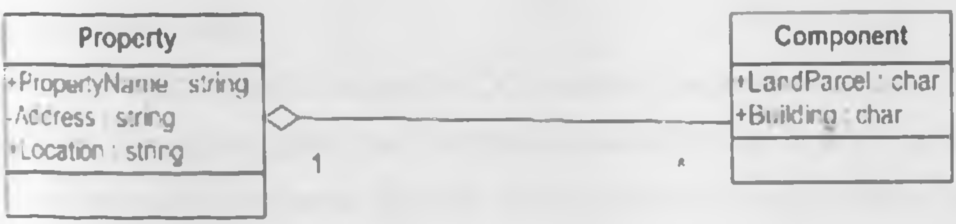


Fig 3.4 Aggregate Relations

A stronger form of aggregation – a composite aggregation - is shown by a black arrowhead and is used where components can be included in a maximum of one composition at a time. If the parent of a composite aggregation is deleted, usually all its parts are deleted with it.

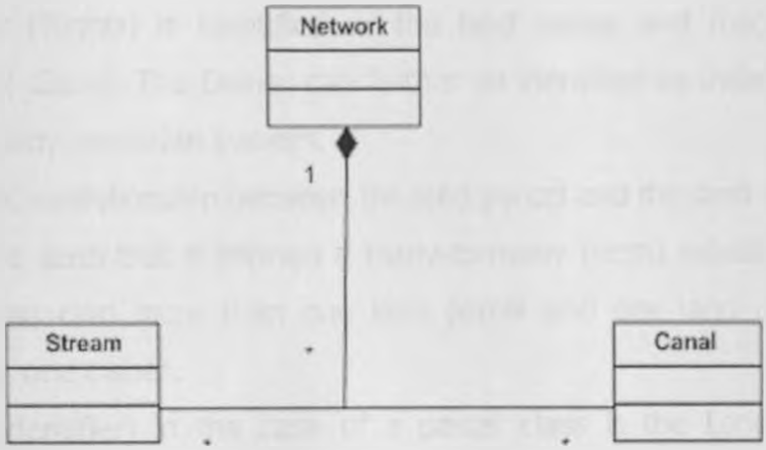


Fig 3. 5 Composite aggregate

In the diagram above, the network feature class contains two subordinate feature class stream and canal. If the network feature class is deleted, then the canal and stream that compose it are also deleted.

Inheritance: Inheritance refers to the ability of one class (subclass) to inherit the identical functionalities of another class (super class), and then add new functionality of its own (Bell, 2003). Hence inheritance is the automatic passing of all super class characteristics to all related sub classes and their sub classes e.g. of a building has a "name" as part of its state, the all buildings must have names (note that the converse is not necessarily true).

Inheritance is a powerful concept in OO modeling because it reduces data redundancy and computer coding since the essential properties of an object are defined once and are automatically inherited at all lower levels at which the object takes part

3.3.8 Modeling Land Parcels Database

In the scenario depicted in Fig 3.6 the relationship between the *LandParcel*, *RightsOfOwner*, the Proprietor is modeled.

The *LandParcel* is modeled as a polygon feature represented in a class diagram (LandParcel Class), including its attributes and the operations that can be performed on it.

The *RoghtsOfOwner* (Rights) is identified as the land owner and modeled into an *Proprietor* (Proprietor Class). The Owner can further be identified as individual owners, group owners, and body corporate owners.

In the model there is a relationship between the land parcel and the land owner. In the relationship it can be seen that it defined a many-to-many (m:m) relationship since a given land owner can own more than one land parcel and one land parcel can be owned by more than one owner.

The Primary Key (identifier) in the case of a parcel class is the Land Registration Number (LR No.). It is also important to note that Kenya has two predominant land registration systems – The Registered Lands Act (RLA) and the Registration of Titles Act (RTA). This results in two different registration numbers depending on the system used - The Parcel Number (Parcel No.) and the Land Reference Number (LR No.). This study has been restricted to LR No which has been adopted as the unique identifier since the area under study falls under RTA.

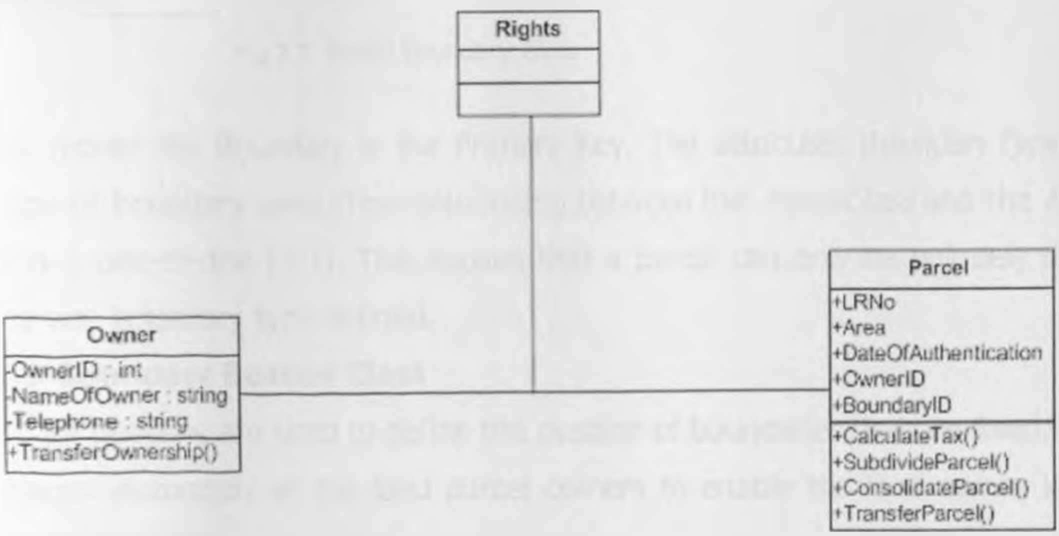


Fig 3.6 The Land Parcel and the Proprietor.

3.3.9 Boundary Class

Boundaries are the exterior lines used to define a parcel as a linear feature. In Kenya we have in existence two types of boundary systems, the fixed boundary system and the general boundary systems. Both of them operate under different legislative laws.

The situation on the ground in Kenya confirms that the two systems of registration are predominantly used and there might not be in major changes in this trend in the foreseeable future. The adoption of a particular system will be based on entirely the dataset available for processing. This study therefore will adopt the fixed boundary system since the data collected was based on the same system. The model will however allow room for any future changes and will try to accommodate either of the systems.

Model for Boundary Class.

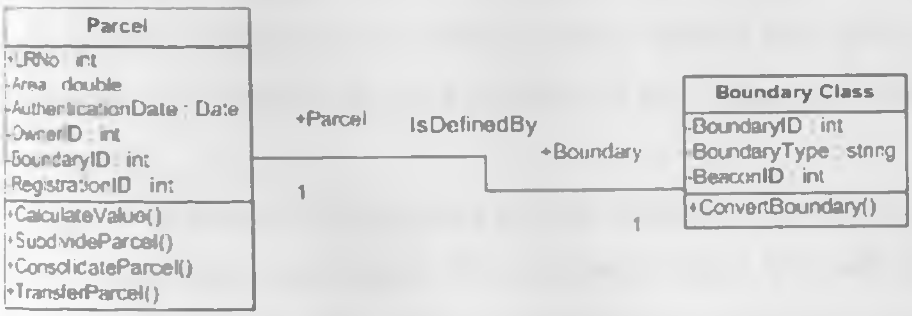


Fig 3.7 Model Boundary Class

In this model the Boundary is the Primary Key. The attributes B*oundaryType* defines the type of boundary used. The relationship between the *ParcelClass* and the *Boundary Class* is a one-to-one (1:1). This implies that a parcel can only be uniquely defined a having one boundary type defined.

3.3.10 Boundary Beacon Class

Boundary beacons are used to define the position of boundaries that are fixed. Beacons are placed accurately at the land parcel corners to enable the land owner know the extent of his parcel.

There are many different types of boundary beacons in use to define the land parcel boundary. The most commonly used are Angle Iron in Concrete (AIC) or the Iron Pin in Concrete (IPC).

Boundary beacons can be modeled as point features. In Fig 3.8 Boundary Beacons class area modeled. Here the Boundary Beacon is also related to the Boundary Class.

The relationship defined is a one-to-one (1: *), where one boundary can be defined by many boundary beacons.

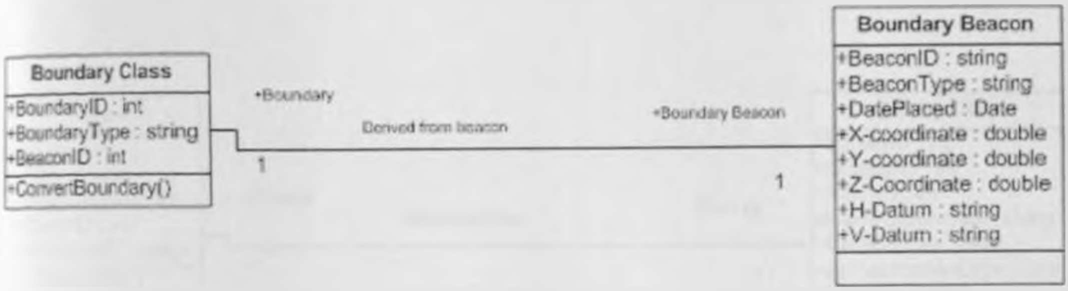


Fig 3.8 Model of the boundary Beacon

In this case the Primary Key is the *BeaconID*. Beacon types define whether the beacon is constructed with Iron Pin in Concrete (IPC). Beacon date gives information on when the beacon was established. The positions of the beacon are defined by its x, y. and z coordinates.

The datum information is necessary to help establish the reference datum on which the beacon coordinates are based. The horizontal datum will define the spatial x and y coordinates reference frame while the vertical datum will define the datum on which the height values are based (z- coordinates).

3.3.11 Modeling the Survey Class

In order to relate the computations and the drawn survey plan to the land parcel, it is necessary to have a model of the survey class. The survey class will include the name of the surveyor, date of entry, type of survey and the Preliminary Development Plan (PDP) number where applicable. These records will then form the basis of the land information management system dataset for the development of the database.

Model of the Survey Class

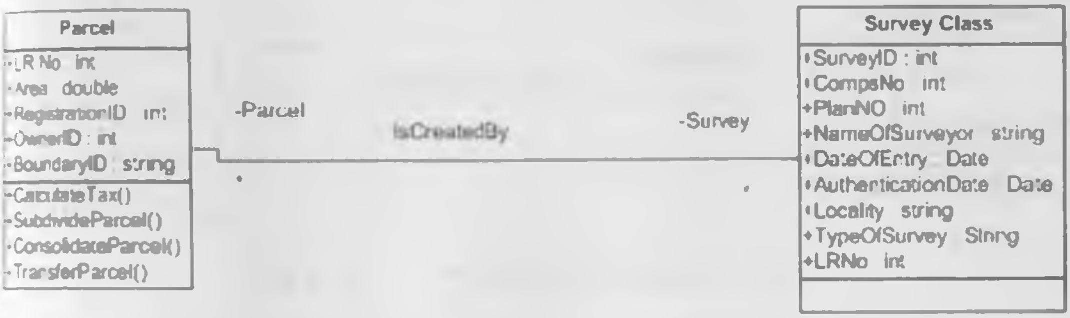


Fig 3.9 Model of the Survey Class

In this model the Primary key is the *SurveyID*. Attributes like *CompsNo* traces the serialization of the survey computations. Name of the surveyor who executed the survey is captured by the *SurveyorName* attribute. Type of survey defines the purpose of the survey e.g. consolidation, subdivision, change of user etc. the *DateOfEntry* traces the date when the survey was submitted for registration at survey records office. Authentication date gives the date when the survey was authenticated. Locality gives the location of the survey the *LRNo*. Is the link between the Parcel Class and the Survey Class.

3.3.12 Modeling the Registration Class

Kenya uses five (5) systems of registration (Nyadimo, 2006). The most common registration systems are, however, only two (2); the Registration of Titles Act (RTA) and Registered Lands Act (RLA). A model for Registration Class should thus provide for the option to register in either of the Acts. The model for the Registration Class is shown in

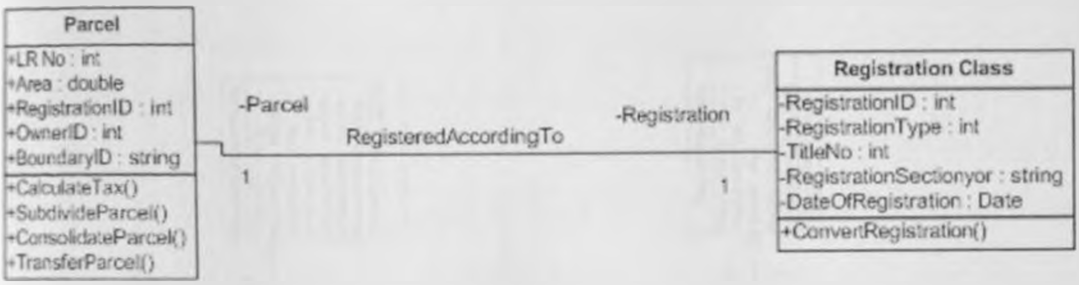


Fig 3. 10 Model for the Registration Class

In this model the relationship between the *ParcelClass* and the *RegistrationClass* is a one to one (1:1), meaning one parcel can only be registered under one Act. The *RegistrationID* is the Primary Key linking the Parcel Class to the Registration Class. The attribute *RegistrationType* indicates the Act under which the parcel is registered. The attribute *TitleNo* gives the title deed number of the parcel. The *RegsitrationSection* identifies the registration section whereas *RegistrationDate* gives the date when the registration was effected.

An operation *ConvertRegistration* enables the conversion of the registration type from one Act to another.

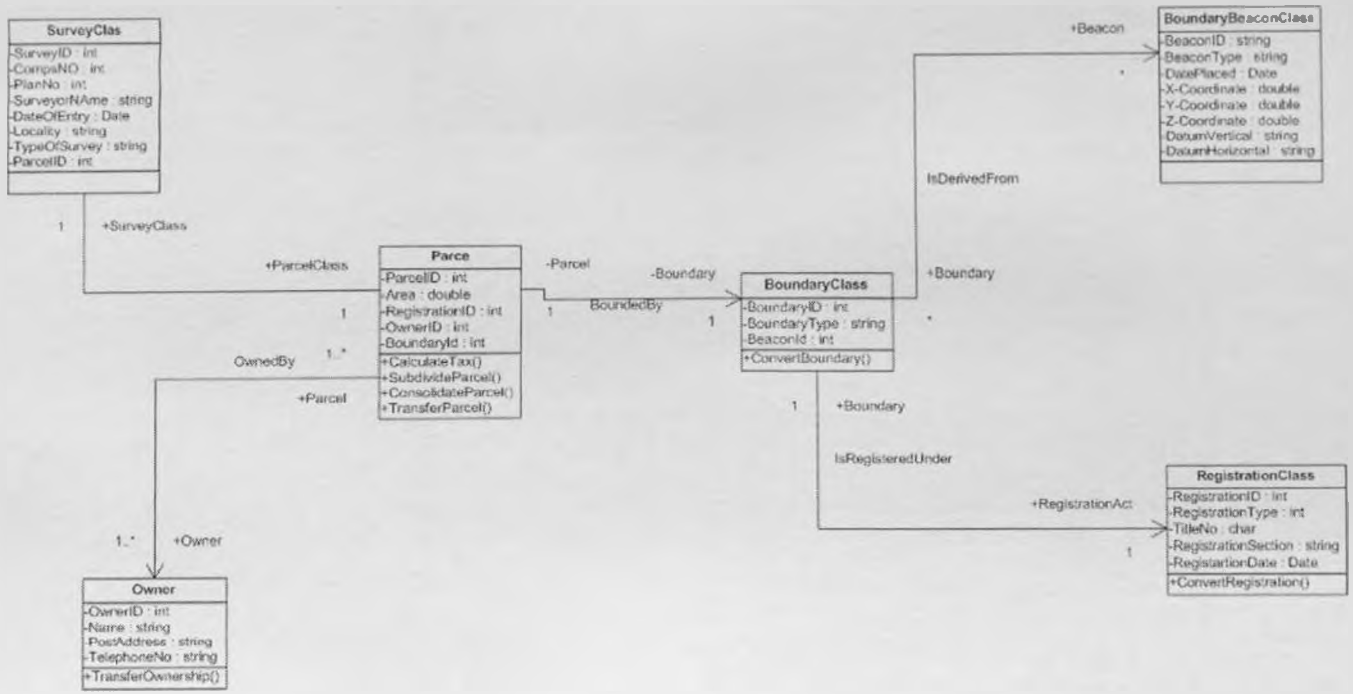


Fig 3. 11 Model of the Database

3.4 Logical Modeling

The implementation of the database involves the actualization of the logical design process. The logical design was done in Unified modeling Language (UML) and its implementation will be done on Entity – relationship tables due system restriction.

A UML class (ER:Entity) is nay 'object' in the enterprise that is to be represented in this database. Each class is uniquely defined by its set of attributes (UML or ER). Each attribute is one piece of information that characterizes each number of this class in the database. Together they provide the structure for the database tables or code objects.

Class Diagram

Relation Schema

In Object Oriented programming, each class is instantiated with *objects* of that class. In building a relational database, each class is first translated into a relational model scheme.

Schema name ....Parcel

Attributes Name ....

ParcelID	OwnerID	Address	telephone

In the relational model, a scheme is defined as a set of attributes, together with an *assignment rule* that associates each attribute with a set of legal values that may be assigned to it. These values are called *domain* of the attribute e.g. address.

Rows and Tables

Each real-world individual of a class (e.g. a parcel) is represented by a row of information in a database table. The row is defined in the relational model as a *tuple* that is constructed over a given scheme. Mathematically, the tuple is a function that assigns a constant value from the attribute domain to each of the scheme.

Schema name ....Parcel

ParcelID	OwnerID	Address	telephone
001001	George	0724268997	318262

Attributes Name ......

Row (tuple)

Tables

A database *table* is simply a collection of zero or more rows. This follows from the relational model definition of a relation as a set of tuples over the same scheme.

PK				
parcelID	Name	Phone	Address	code
001001	Wafula	0724268997	31136, nbi	00100
001002	Odera	0733835780	2070, njoro	60102
001003	Njoki	0726246777	222, ksm	60200

Table name (relation) – parcel

Primary (PK) attribute

Columns (attribute) names

Rows (tuples)

Knowing that the relation (table) is a set of tuples (rows) tells us more about the structure:

- Each tuple / row is unique, there is no duplicate
- Tuples / rows are unordered, can be displayed in any way without changing the meaning.

- Tuples / rows can be included in a relation / table set if they are constructed on a schema of that relation.
- We can define subsets of the rows by specifying criteria for inclusion in the subset (SQL query)
- We can find union, intersection, or difference of the rows in two or more tables as long as they are constructed over same scheme.

Insuring unique rows

Since each row in a table must be unique, no two rows can have exactly the same values for every one of their attributes. There exist, therefore, a set of attributes in each relation whose values, taken together, guarantee uniqueness in each row. Any set of attributes that can do this is called a *super key* (SK).

In the database design one picks the possible super key attribute to serve as the *primary key* (PK) of the relation (note that PK is an SK but not all SK are PK). The primary key is also sometimes called a *unique identifier* for each row of the table.

3.4.1 Logical Model Schema

The main database developed for Athi River area defines those entities that are of interest to the users. The model was then further defined into specific relations in the database. Relation 3 captures all the elements in the database and what could, in future, be added when the information on them is availed.

The logical model schemas defined for the land parcel and ownership can be described as follows:

1. Parcels (ParcelNo, Location/District, Area, Registration Act, Value)
2. Proprietor/Ownership (ParcelNo, OwnerID, Name, Sex, Address)

Relations (Tables)

Relation 1 - Parcels

Parcel No	Location/District	Transaction No.	Area	RegistrationAct	Value

Relation 2 – Proprietors

Parcel No	Owner ID	Name	Sex	Address

Relation 3. Survey/Registration

Parcel No	Computations	Surveyor	Type of survey	Folio	Register	PID	Authentication Date	Letter of Allotment

3.5 Database Implementation

The database developed in this study is a geodatabase which supports a model of topologically integrated feature classes, similar to the coverage. It also extends the coverage model with the support for complex neworks, relationships among feature classes, and other object oriented features. The data was imported into ESRI ArcGIS, whose applications like ArcMap, ArcCatalog, AcrToolbox work with geodatabases as well as shapefiles.

Since the ArcInfo geodatabse is implemented on a standard relational databases withArcSDE application server, it allows ArcInfo to manage geographic information on a variety of different common database platforms including Oracle, MicrosoftSQL server etc. The geodatabase model supports object oriented vector data model. In this model the entities are represented as objects with properties, behavior, and relationships. Support for a variety of different geographic object types is built into the system. These object types include simple objects, geographic features (objects with location), network features (objects with geometric integration with other features), annotation features and other more specialized feature types. The model allows one to define relationships between objects, together with rules for maintaining the referential integrity between objects.

3.5.1 Data preparation for digitization

This data set was provided in Cassini coordinate system. It is good for testing of data accuracy but had to be transformed into Universal Transverse Mercator system in order for it to be used in a MapInfo GIS software system which was the system I used for digital data conversion. The data conversion involved the choice of at least three points in both Cassini coordinate system and UTM coordinate system that are easily identifiable in the map sheet. These points were used to generate transformation parameters to enable the rest of the points to be transformed into UTM.

3.5.2 Coordinate Transformation

In this study, two dimensional transformation equations were used to determine four transformation parameters (Translations in N and E directions, a uniform scale factor and one rotation angle about Z- axis). Three primary triangulalation (control) points: SKP208, SKP216, and SKP 218 with coordinates in both systems (local UTM and Cassini) covering the area of interest (Athi river) were used.

The basic linear model for this transformation is given as,

$$N = aN' - bE' + \Delta N$$
$$E = aE' + bN' + \Delta E$$

where,

a is the scale factor,
b is the rotation angle in radians,
ΔN is the shift in Northern direction,
ΔE is the shift in Eastern direction,
N and E are the local UTM coordinates,
N' and E' are the local Cassini coordinates.

The determined parameters given in Table 1 were then used to transform the Cassini coordinates into the local UTM (Arc - Datum 1960) coordinates.

Table 3 3 Transformation Parameters

Parameter	Value	Units
a	0.9999981	-
b	-0.0009019	rads
ΔN	10,000,167.509	m
ΔE	277,427.317	m

The above parameters were then used to transform the rest of the Cassini coordinates resulting in the table below.

Table 3 4 Transformed UTM coordinates

Sheet 28

STATION	Y Northings	X Eastings
PW	9844963.80	273343.26
QQ4	9844558.92	273232.07
QQ5	9844685.44	273172.09
QQ6	9844774.44	273297.61
QQ7	9844891.93	273241.91
PW1	9844992.42	273383.62
CT24	9845079.20	273506.00
Q35	9844595.28	273262.58
Q41	9844574.44	273224.71
Q43	9844594.44	273323.74
Q46	9844623.26	273324.11
Q47	9844636.71	273275.14
Q50	9844646.76	273190.43
Q51	9844683.37	273242.05
Q52	9844655.17	273186.44
Q52a	9844644.08	273269.92
Q53	9844709.46	273263.00
Q54	9844736.38	273243.91
Q56	9844753.33	273340.72
Q57	9844704.50	273340.12
Q58	9844656.37	273272.23
Q67	9844832.55	273329.34
Q68	9844801.10	273284.97
Q69	9844809.36	273281.05
Q70	9844834.69	273316.78
Q71	9844883.65	273282.07
Q73	9844922.58	273285.13
Q74	9844898.10	273292.47
Q75	9844903.31	273309.83

Q79	9844881.50	273294.64
b12	9844620.89	273237.52
b14	9844616.40	273232.15
b32	9844741.59	273251.27
b39	9844714.66	273270.36
Q55	9844688.57	273249.40
V1	9844875.41	273423.70
V15	9845017.45	273491.54
V17	9844974.12	273482.64
V19	9844936.25	273509.49
V22	9844970.58	273469.85
V23	9844975.77	273443.35
V24	9844984.50	273445.06
V31	9845010.25	273408.76
V32	9844978.09	273431.57
V33	9844804.96	273397.70
V34	9844793.24	273381.15
V48	9844968.80	273429.76
S3	9845038.12	273518.60
S4	9845025.38	273500.63
S6	9845034.20	273494.34
S7	9844992.73	273435.91
S10	9845017.20	273418.55
S18	9844984.19	273529.84
S21	9845018.04	273505.83
S22	9845030.79	273523.81

These coordinates were used to plot the boundaries of the cadastral plots resulting in digital cadastral plan in Fig. 4.1

3.6 Query demonstration

To look at the data in our database, I used the select (SQL) statement. The result of this statement is always a new drawing that is viewed using our database client software. It is also possible to programming languages like XML or KML to build dynamic web pages or desktop applications. The result of thequery is not stored in the database but used specifically to view some selected queries.

The basic syntax consists of the following basic clauses:

Select *< attribute names>*
From *< table names>*
Where *<condition to pick rows>*

e.g **Query 1** **Query 1: Select** *from* **ParcelBnd**

Parcels *Where* *Area* > **0.09 Ha**

This syntax requires that the table ParcelBnd be used to investigate the parcels whose areas are greater then 0.09 Ha.

Query 2 **Select** ***from*** **ParcelBnd**

Where AUTHENTICA = 0

This syntax exploits the table ParcelBnd to check those parcels whose survey were not authenticated.

Chapter 4: Results and Analysis

4.1 Results

Table 4 1 **Database implementation output**

Attributes of Mavoko_ParcelBnd_region

Shape*	LR_NO	AREA	OWNERSHIP	ADDRESS	AUTHENTICA	AUTH_DATE	DATE
Polygon	29699/448	0.0638	Joel Mbugua Maina	34136, Nairobi	1	11/08/2006	08/11/2006
Polygon	29699/452	0.0844	Mwangi Ngando	227, Nyeri	1	19/08/2006	12/11/2006
Polygon	29699/451	0.08	Thomas N. Kiea	3346, Nakuru	1	11/08/2006	08/11/2006
Polygon	29699/450	0.08	Benjamin Kisielu Logedi	4478, Kisumu	1	19/08/2006	12/11/2006
Polygon	29699/449	0.075	A. N Muragun	2289, Nairobi	1	11/08/2006	08/11/2006
Polygon	29699/442	0.0614	Margaret Wanyiku Njongom	3341, Nairobi	0	11/08/2006	08/11/2006
Polygon	29699/441	0.0914	Ruth Kabiti Mwora	2213, Nairobi	0	11/08/2006	08/11/2006
Polygon	29699/437	0.0718	Naftali Muthuri Iougu	2234, Kisumu	0	19/08/2006	12/11/2006
Polygon	29699/454	0.075	Nyaga Eliab Munyi	2235, Nyeri	0	19/08/2006	12/11/2006
Polygon	29699/453	0.0843	Paul Katusya Nyumbu	335, Nyeri	1	11/08/2006	08/11/2006
Polygon	29699/440	0.0704	Anicetus Wilys N. Obuya	678, Nakuru	1	11/08/2006	08/11/2006
Polygon	29699/439	0.0765	Anicetus Wilys N Obuya	3358, Kisumu	0	19/08/2006	12/11/2006
Polygon	29699/438	0.0771	David Tito Kimayo	1234, Nairobi	1	19/08/2006	12/11/2006
Polygon	29699/436	0.0974	Julius Musili	2345, Nakuru	1	19/08/2006	12/11/2006
Polygon	29699/443	0.0785	Peter N. Oluech	890, Mombasa	1	19/08/2006	12/11/2006
Polygon	29699/444	0.0753	Peter N. Oluech	2234, Nakuru	1	11/08/2006	08/11/2006
Polygon	29699/446	0.081	Farida Mahgoub Asindua	2985, Nairobi	0	11/08/2006	08/11/2006
Polygon	29699/447	0.818	Lydia Njeri Kiarie	3345, Nairobi	1	11/08/2006	08/11/2006
Polygon	29699/445	0.0718	James Kiarie Wangombe	4567, Nairobi	0	11/08/2006	08/11/2006
Polygon	29699/432	0.0784	Prutus Ojwang Bwire	6789, Nakuru	0	11/08/2006	08/11/2006
Polygon	29699/433	0.0847	Anne Kiptuiya Baringo	224, Kitengela	0	19/08/2006	12/11/2006
Polygon	29699/436	0.0921	Agnes Mweni Mwendo	345, Kitengela	0	19/08/2006	12/11/2006
Polygon	29699/434	0.0959	Pauline A Ekhesa	567, Athiriver	1	19/08/2006	12/11/2006
Polygon	29699/407	0.0742	Agnes Nyambeku Henry	3358, Nairobi	1	19/08/2006	12/11/2006
Polygon	29699/406	0.075	Denson Mwendia Mwangi	7890, Mombasa	1	19/08/2006	12/11/2006
Polygon	29699/405	0.0744	Luka Gachoki Kanaru	675, Meru	1	19/08/2006	12/11/2006
Polygon	29699/404	0.0751	Erustus Masweche	342, Isiolo	0	19/08/2006	12/11/2006
Polygon	29699/403	0.0754	Keneth Kaunda Wagunda	55443, Nairobi	1	19/08/2006	12/11/2006
Polygon	29699/402	0.751	Alice Esther Adhiambo Manyonge	765, Nairobi	1	11/08/2006	08/11/2006
Polygon	29699/401	0.075	Stephen Maina Mwangi	9876, Athiriver	1	11/08/2006	08/11/2006
Polygon	29699/400	0.136	George Kennedy Muthemba	4321, Athiriver	0	19/08/2006	12/11/2006
Polygon	29699/398	0.075	Norah Kemunto Otwoma	8643, Kitengela	0	19/08/2006	12/11/2006
Polygon	29699/397	0.075	Machiel Oyoo Nyagunda	456, Athiriver	0	11/08/2006	08/11/2006
Polygon	29699/396	0.075	Lawrence Muya Kavabi	890, Kitengela	0	19/08/2006	12/11/2006
Polygon	29699/395	0.075	Antony Obare Opwaka	8769, Nairobi	0	11/08/2006	08/11/2006
Polygon	29699/[illegible]	0.075	Dr Mbula Pamela	4512, Nairobi	0	19/08/2006	12/11/2006
Polygon	29699/393	0.075	Musyoka Nzioka Musyya	675, Nyeri	1	11/08/2006	08/11/2006
Polygon	29699/392	0.075	Oscar Mwale Onyango	981, Kisumu	1	11/08/2006	08/11/2006
Polygon	29699/391	0.075	Kapha Kimoli Nyamaka	789, Kericho	1	11/08/2006	08/11/2006
Polygon	29699/390	0.19	Teresa N Nyamaka	321, Kisii	0	11/08/2006	08/11/2006

Record: 2 Show: All Selected Records (0 out of 96 Selected) Options

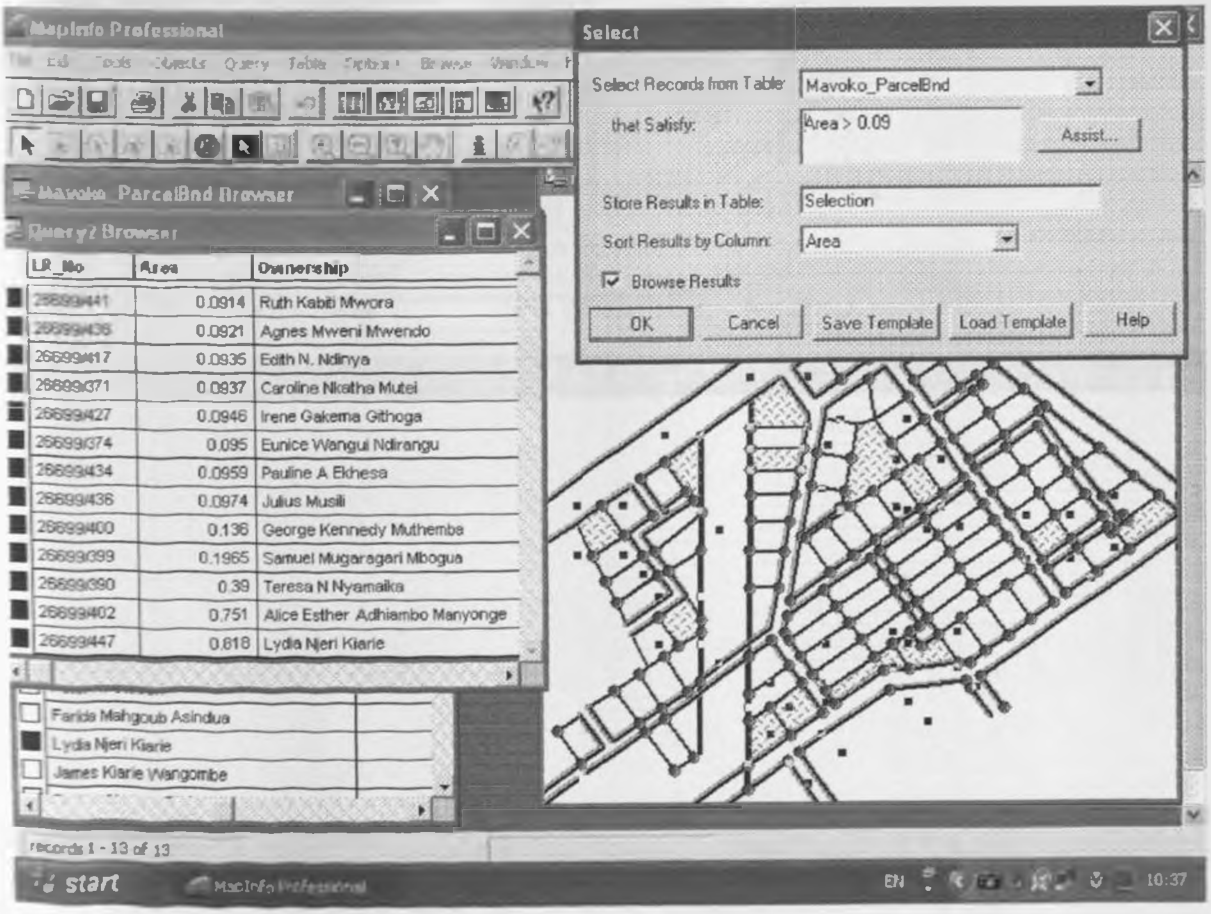
start | My Documents | Mavoko - ArcMap - Ar... | 17:38

The database abstract in Table 4.1 is a result of the development of the spatial database of the information extracted digitally from the F/R Sheet no. 338/28. The process involved digitization of the parcel details and converting the information into an ArcGIS software platform. The developed database was developed based on the information analyzed from the user needs assessment extracted from the interviews and the questionnaire. This information was organized into classes /entities that formed the backbone for the database.

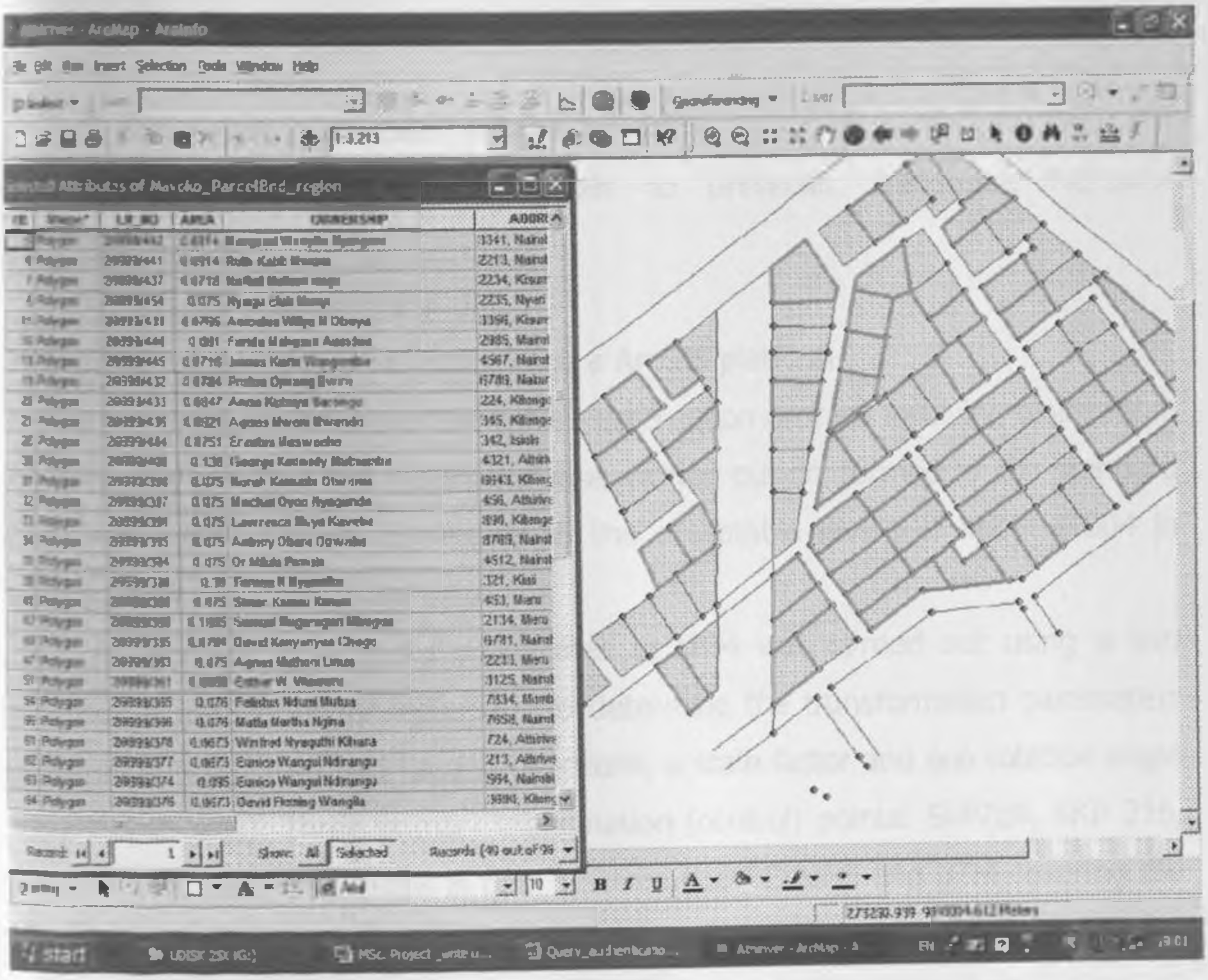
To demonstrate the effectiveness of the database a SQL query procedures were carried out on the database with the graphic results shown below.

Query 1: Select *from* **ParcelBnd**

Parcels *Where* *Area* **> 0.09 Ha**



Query 2 **Select** ***from*** **ParcelBnd**
Where AUTHENTICA = 0



4.2 Analysis of results

The results presented in this report are as a result of processing of spatial datasets performed in four steps:

- Analogue data conversion to digital format
- Conversion of Cassini coordinates to Universal Transverse Mercator coordinates.
- Design of the database in UML
- Implementation of the database on a ArcGIS platform

The data conversion was done through a vectorization process involving digitization. The accuracy at which the digitization was carried out conformed to the standard RMS error checks. These conformed to the acceptable levels of about 0.004 in depending on the scale of the map.

The conversion of the Cassini coordinates to UTM was carried out using a two dimensional transformation equations to determine the transformation parameters (translation in Northing and Easting directions, a scale factor and one rotation angle about the Z- axis). Three primary triangulation (control) points: SKP208, SKP 216, and SKP 218, with coordinates in both systems (local Cassini and UTM covering the area of study (Athi River) were used. The transformation process resulted in the following transformation parameters which were then used to transform the rest of the Cassini coordinates to local UTM coordinates. The following parameters were derived:

$a = 0.9999981$

$b=-0.0009019$ rads

$\Delta N= 10000167.509$

$\Delta E= 277427.317$ m

Where

a – the scale factor

b - the rotation angle in radians

ΔN- the shift in North direction

ΔE – the shift in East direction

The transformed coordinates were then used to plot the parcel boundaries which were later used to define the plot extent and compute the areas of the parcels. The computed areas checked well after comparison with the original areas from Cassini coordinates.

From the above demonstration queries, it is evident that the database is properly designed and carries out its intended purpose effectively. It must, however, be mentioned that the database is not exhaustive and that only the data that was available at the period of the project were uploaded onto the database. Being flexible and expansible the database can take more datasets and could also accomplish more complex tasks depending on the amount of information stored in the database.

4.4 Data Model Analysis

The data models were developed using UML class diagrams. To determine precisely whether a data model is correct or complete is difficult. However, an indication is given if the answer is yes to the questions: Does the logical data model represent all data without duplicate? Does the logical data model support an organizations business rules? Does the logical data model accommodate different views of data for distinct groups of users?

The data model developed in this project has attempted to represent data without duplication. The data model supports the organization's functions and accommodates different views of data from distinct groups. This data model, while addressing a particular land registration system i.e. fixed boundary survey system, has room for any other data type to be accommodated, though this will require further technical considerations for which a solution can be developed.

The parcel is the main object in the database design. The attributes assigned to the parcel were based on the user needs assessment survey carried out during the data collection stage. Examples of classes derived from the survey include *SurveyClass, ParcelClass, OwnerClass, RightOfOwnerClass, BeaconClass* and *RegistrationClass.* The attributes attached to these classes include *ParcelID, OwnerName, BeaconID, OwnerAddress, RegistrationAct etc.*

After the database design was been the entire geodatabase was implemented on an ArcGIS software platform. This procedure involved invoking of the in-built ArcSDE server which automatically allows the importation of the data through the use of the ArcCatalog, ArcToolbox and Computer-Aided software Engineering (CASE) tools. The CASE consists of tools and techniques that automate the process of developing software systems and database design. The CASE tools were used to create new custom objects and generate a geo database schema from UML diagrams.

The results of the developed database of the prototype LIMS is illustrated in the query test results in Section 4.1.

Chapter 5: Conclusions and Recommendation

5.1 Conclusions

Taking and implementing decisions about the acquisition, development and conservation of land resources is generally referred to as land administration and management. For land resources to be properly identified, used without waste and also without degrading of the environment, it is important to manage them properly. Land administration systems in any country usually have five pillars: the first four are survey, registration, valuation, and control and regulation. All these produce and use information which is managed by the fifth pillar land information management.

In order to efficiently and effectively administer land, it is necessary to manage the information on land property. Land information management is the effective use of land information to achieve the goals of land administration.

In Kenya today, land information is held mostly in paper form, managed manually and even the paper records themselves are not optimally managed. This is inefficient, time consuming and cannot support decision making.

The implementation of the database design in this study led to the following conclusions;

- It is essential and necessary to understand the enterprise's objectives in order to integrate them in the data models.
- It is critical to identify the roles provided by the different stakeholders.
- Spatial data modeling necessitates a clear understanding of the real world objects and their representation in a GIS environment.
- The need for standardization of geo-information processing is very crucial to avoid the current heterogeneous data processing.
- Though the study area used data from fixed boundary survey, there is room for other data sets once data standardization process is achieved.

It do therefore conclude that the prototype land information management system developed in this project will help in giving guidance for a more comprehensive process to store data in a simple, easy to access and retrieve manner.

5.2 Recommendations

The study set an initial goal of developing a prototype land information management system which was achieved based on the available land registration data. The following recommendations are made from the study:

- That land information should be computerized and made available in the language that most citizens can understand.
- Standards to guide the generation and dissemination of land information should be developed, relevant professionals trained and public awareness of the public on the existence of the data.
- The current land information management system needs to include more data sets than currently available. It could also be possible incorporate other data sets than cadastral data such as buildings, infrastructure and informal settlements.
- The current system covers only a few selected areas of the country, specifically selected urban and peri-urban areas. It is my recommendation that this system be extended to include other rural areas in order to cover areas governed by customary land tenure systems. For the formal and customary tenure systems the integration is achievable by conversion of the current cadastral registration records including the provisional maps used under general boundaries system into digital land records. The system can also be improved by incorporating ancillary data like the Global Positioning system information into the reference information.
- There is need to review the Kenyan legal framework. Measures should be taken to harmonize the various legislations dealing with land registration process.

- The database should be initially located in a central place e.g. Provincial Survey office but should later be decentralized to take the information closer to the public. With proper planning and good management of resources the database should ultimately be on line via the National Spatial Data infrastructure network for easy access countrywide over the internet.
- More is needed to address the issue of modeling various data sets into a standardized format. Most datasets without geo-referenced boundaries are difficult to model into objects which can be accepted by the existing object-relational database management systems (DBMSs).

References

1. Bell, D (2003). **UML Basics Part III, The Class Diagram**, Rational Edge. At http://www.therationbaledge.com/content/nov-03/t_modelinguml-db.jsp
2. Burke. R. (2003), **Getting to know Arc Objects, Programming ArcGIS with VBA**, ESRI Publication, California, USA
3. Connolly, T. M and Begg C. E (2004), **Database Systems; A practical Approach to Design, Implementation, and Management**, 2nd Edition, Addition-Wesley.
4. Dale P.F and J.D McLaughlin (1988), **Land Information Management**. Clarendon Press.Oxford.UK.
5. *Dale, P & McLaughlin J. D* (1989), **Land Information Management**, An Introduction with special reference to cadastral problems in Third World countries
6. FIG (1995), **Statement on the Cadastre. Report prepared for the International federation of Surveyors by Commission 7 (Cadastre and Land Management)**, FIG Publication No. 11
7. Fowler, M and Kendall Scott (2000), **UML Distilled**, Addison Wesley, 2000.
8. GoK (2002), **Report on the Commission of Enquiry into the Land Law System of Kenya (the "Njonjo Commission") on the Principles of national Land policy Framework, Constitutional position of Land and New Institutional Framework for Land Administration.**
9. Government of Kenya (2003), **National Economic Plan 2003- 2004, Ministry of Planning and National Development**, June 2003.
10. GoK (2004). **Report on the Presidential Commission on Illegal and Irregular Allocation of Public Land (Ndungu Commission).**
11. Government of Kenya (2006), **National Land Policy Formulation Programme Framework**. 2006 -2009.

12. GoK (2007). **National Land Policy Document,** May 2007

13. Kalantari. M., Rajabifard. A. Wallace. J. and Willamson, I. P (2006). **A new vision on cadastral data model.** Shaping the Change. XXIII FIG Congress. Munich. Germany, October 8 -13, 2006.

14. Karikari. I. B (2006), **Ghana's Land administration Project (LAP) and Land Information Systems (LIS) Implementation: The Issues.** International Federation of Surveyors, Article of the Month. February, 2006.

15. Mele, E. T Rakai, I.C Ezigbalike and I.P Williamson (1995), **Traditional Land Tenure Issues for LIS in Fiji.** Survey review, 33, 258.

16. Nyadimo. E (2006). **Cadastral Data and Process Modeling Using the Unified Modeling Language: A Case Study of Kenya.** Master of Science Thesis, Technical University of Munichen. Germany.

17. Njuki, A. K (2001), **Cadastral Systems and their Impact on Land Administration in Kenya.** Paper presented at the 'International Conference on Spatial Information for sustainable Development, Nairobi, Kenya.

18. Syagga. P. T. Osterberg. & I. Mwathane (2006). **Draft Kenyan Implementation Framework for the Land Reform Support Programme.** August 2006 – May 2009.

19. Tomlinson, R. (2003), **Thinking about Geographic Information System planning for Managers.** ESRI Press, California, USA.

20. UN-FIG (1996), **The Bogor declaration: United Nations Interregional Meeting of Experts on the Cadastre,** Bogor, Indonesia, 18-22 March. 1996.

21. UN-FIG (1999), **The Bathurst Declaration: The Bathurst Declaration on Land Administration for Sustainable Development.** FIG Publication No. 21

22. Williamson. I (2005). **A land Administration Vision.** Expert Group Meeting on Incorporating Sustainable development Objectives into ICT Enabled Land administration Systems, 9-11 November 2005, Center for Spatial Data

Infrastructure and Land Administration, The University of Melbourne. Australia.

APPENDICES

APPENDIX 1 : Questionnaire cover letter

Dear Respondent,
I am a graduate student in the College of Architecture and Engineering, School of Engineering, University of Nairobi, pursuing a Master of Science degree in Geographic Information Systems (GIS). In partial fulfillment of my M.Sc.(GIS) I am conducting a Land Information Systems survey on a project paper titled:

DEVELOPMENT OF A PROTOTYPE LAND INFORMATION SYSTEM:
A CASE STUDY OF ATHI RIVER

I do seek for your participation in this research project and the information obtained in this questionnaire will be treated as confidential and in no instance will your name be mentioned in this research except with your permission. The information collected will be for the sole purpose of this academic endeavor.

Your assistance in facilitating this research will be highly appreciated. I will be following up this questionnaire in person or by telephone call in due course. Your response will be highly appreciated since the research work must be submitted by 7th September 2007

Thanking you in advance for your support,

Yours Faithfully

....

George Ted Osewe Odero

MSc (GIS) STUDENT.

Appendix 2: Questionnaire Form

Questionnaire for a research Project on Development of a Prototype Land Information Management system: A Case study of Athi River Area, Nairobi.

Part I

1. Have you ever visited the Ministry of lands office?

   □ Yes □ No

   a) What information were you seeking from the Lands office?

      □ Ownership details □ Maps □ Encumbrance details

      □ Land Transfer □ title deed □ others (specify) ……

   b) How did you find the land registration procedures?

      □ clear and simple □ complex □ other …………

   c) How accessible were the land records?
      □ Very accessible □ accessible □ not accessible □ hardly accessible

   d) How long did it take to get information?
      □ immediately □ < 1 hour □ 1-2 hours □ 2 -4 hours

      □ 4 – 8 hours □ > 1 day

   e) Did you have to pay to get this information?

      □ Yes □ No

      a) If yes how much? (in Kshs.)

         □ < 500 □ 500 – 1000 □ 1000 – 2000

   f) What is your view on the costs?

      □ Appropriate □ Inappropriate □ Not sure

2. What impact can internet and e-mail facilities have on information access?
   □ Great □ Little □ Not sure
3. Do you have access to internet and e-mail facilities?

   □ Yes □ No

4. What reforms would you like to see in the cadastral and land registration system in Kenya?

   □ Digital records □ internet solutions □ Education

   □ Clear procedures □ Decentralization □ No Idea

   □ Others (specify)

Part II

1. What information needs to be added to the existing cadastre and land register?

□ Street Address □ Telephone contacts □ Others ....

g) How should this be done?

□ Incrementally □ Immediately □ Other ....

b) Does the cadastre cover areas currently under customary land tenure?

□ Yes □ No

i) How are the interests in land recorded?

□ Maps □ Digital □ Tapes □ Others (specify)

ii) What problems are prevalent?

---

2. How is the cadastral and registration work (process) shared between the Head office, Provincial office, and District office?

a. How do these offices communicate?

□ Mail □ Telephone □ Fax □ courier delivery

□ Other ....

b. What problems do exist?

□ Delays □Lack of coordination □ Other ....

c. How can these problems be addressed?

□ Decentralization □ Centralization □ Other ....

d. Should the cadastral registration process be decentralized?

□ Yes □ No

i) What should be the basis of the decentralization?

□ Provincial □ District □ Division □ Location □ Other

ii) What should remain centralized?

□ Policy formulation □ Geodetic control □ Regulation □ Title Deeds

3. Have you documented your cadastral and / or land registration procedures?

□ Yes □ No

Part III

1. What are the bottlenecks with the current land registration process?

□ Missing records □ improper storage □ Slow updates

□ cumbersome procedures □ Bureaucracy □ Other ....

h) Are there any delays?
□ Yes □ No □ Other ....

i) What are the causes of these delays?

□ Bureaucracy □ Officers □ Lack of resources □ Other ....

c) How can the delays be prevented?

____

2. To what extent do the existing legislations on land play a role in the cadastral process? How do these affect information management?

____

____

Part IV

1. How can GIS technology be implemented to enhance land information management process?

□ Multiple access □ Ease of updates □ Hyper linking records

□ Internet map service □ Storage □ Other...............

2. What role would data modeling play in the development of a Land Information Management System?

____

____

3. How should the database be managed?

□ Distributed database □Centralized database □ Other ....

4. What factors hinder the development of an automated database management system?

□ Lack of knowledge □ Resistance to new technology □ Lack of policy

□ Bureaucracy □ Other .....

5. What are the possibilities of Public/Private Partnership in the development of a land information management system?

□ High □ Low □ None

6. How should the development of a land information management system be financed?

□ Government □ Private sector □ Users □ Banks □ Loan □ Other (Specify)

7. What percentage of your work force is IT / GeoIT compliant?

□ 10% □ 10 – 20% □ 20 – 40 %

□ 40 -60% □ 60 – 80 % □ 80 – 100 %

8. What is the level of computerization of your cadastral records?

□ 10% □ 10 – 20% □ 20 – 40 %

□ 40 -60% □ 60 – 80 % □ 80 – 100 %

Part V

1. What restrictions exist in the use of cadastral data?

□ Confidentiality □ Other .....

a) Should cadastral records be made public?

□ Yes □ No □ Other

b) Who should have access to this data?

□ Public □ Lawyers □ Professionals

c) What information should be made available and in what format?

□ All records □ Selected records □ Digital □ Analogue

d) What security measures need to be put in place?

□ Access protocols □ Backup □ Other ....

Appendix 3: Sheet 339/28 Coordinates

STATION	Y Northings	X Eastings
PW	155202.01	4209.81
QQ4	155606.72	4321.36
QQ5	155480.16	4381.21
QQ6	155391.29	4255.63
QQ7	155273.77	4311.21
PW1	155173.43	4169.43
CT24	155086.78	4046.99
Q35	155570.39	4290.82
Q41	155591.19	4328.7
Q43	155571.29	4229.67
Q46	155542.47	4229.27
Q47	155528.98	4278.22
Q50	155518.85	4362.91
Q51	155482.3	4311.26
Q52	155510.44	4366.89
Q52a	155521.61	4283.44
Q53	155456.23	4290.29
Q54	155429.3	4309.35
Q56	155412.44	4212.54
Q57	155461.26	4213.19
Q58	155509.32	4281.11
Q67	155333.22	4223.85
Q68	155364.63	4268.24
Q69	155356.37	4272.15
Q70	155331.07	4236.4
Q71	155282.09	4271.06
Q73	155243.17	4267.97
Q74	155267.65	4260.65
Q75	155262.46	4243.29
Q79	155284.25	4258.5
b12	155544.76	4315.85
b14	155549.25	4321.22
b32	155424.1	4301.99
b39	155451.04	4282.93
Q55	155477.1	4303.91
V1	155290.46	4129.46
V15	155148.51	4061.5
V17	155191.82	4070.44

V19	155229 71	4043.63
V22	155195 35	4083 23
V23	155190.14	4109.72
V24	155181 41	4108.01
V31	155155 63	4144.28
V32	155187 81	4121.5
V33	155360.87	4155.53
V34	155372 58	4172.08
V48	155197.09	4123.32
S3	155127 87	4034.43
S4	155140.59	4052.41
S6	155131.77	4058.69
S7	155173.17	4117.15
S10	155148.69	4134.48
S18	155181.8	4023.24
S21	155147.93	4047.21
S22	155135.2	4029.23