A CADASTRAL WEB-MAPPING SOLUTION FOR A LIBYAN DISTRICT

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FACULTY OF COMPUTER SCIENCE AND INFORMATION TECHNOLOGY
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DISSERTATION SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF COMPUTER SCIENCE

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A Cadastral Web-Mapping Solution for a Libyan District

Field of Study : **INFORMATION SYSTEM**

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Abstract

In the 21st century with the proliferation of digital data and the availability of digital map, the use of geographic information system (GIS) technique has become the best technique to develop the cadastral information system (CIS). CIS is integrated with the land register system and cadastral mapping system. The digital cadastral database (DCDB) which shows real coordinates for the cadastral maps is hampered by the many land laws in the country. This research study examines in detail the existing structure and concepts of the cadastral mapping system. A practical and functional prototype e-tool based on A Cadastral Web-Mapping Solution for a Libyan District (CW-MSLD) has been developed to assist real estate ownership registration. CW-MSLD System prototype was developed based on a pilot case study in Tripoli which is the capital city in Libya. The prototype is developed using modern GIS techniques (Web Mapping). Web Mapping techniques make maps and geo-information available to groups of end users through a web page. The prototype tool triggers the map server software which integrates the map data stored in DCDB with the land register data stored in the MySQL database. Authorized users are able to interact with the cadastral map by using the available map tools within the system to obtain particulars pertaining to location, area and boundaries of any one parcel displayed on the map. Subsequently, the information derived can be used to register or transfer ownership for the cadastral map and further issue a cadastral certificate for the registered cadastral (real estate).

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My Allah bless all of us

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List of Acronyms

APIs	Application program interfaces
ArcIMS	Arc Internet Map Server software
Arc/Info	GIS software used to build powerful geo-processing models for discovering relationships, analyzing data, and integrating data.
ArcEditor	ArcEditor is a powerful GIS desktop system for editing and managing geographic data. ArcEditor includes all the functionality of ArcView and adds a comprehensive set of tools to create, edit, and ensure the quality of your data.
ArcGIS	ArcGIS is a complete package which integrated collection of GIS software for authoring, serving, and using geographic information when ever it is needed on desktops, servers or custom applications.
ArcView	Full-featured GIS software for visualizing, analyzing, creating, and managing data with a geographic component
ArcSDE	Incorporated into ArcGIS Server is used to access multi-user geographic databases.
ArcCadastre	A tool for handling geographic and cadastral information
MapObjects	A tool for creating specialized solutions for your desktop mapping and GIS needs. It is can work with Visual Basic programming language
ASF	Apache Software Foundation
CW-MSLD	A Cadastral Web-Mapping Solution for a Libyan District
CAD	Computer Aided Drafting

CGI	Common Gateway Interface
CIS	Cadastral Information System
DCDB	A Digital Cadastral Database is a complete digital cadastral framework visually depicted where the coordinates of each parcel corner are an approximation of the "true" or surveyed coordinates. The accuracy of the coordinates can vary greatly depending on the requirements of the user.
DBF	dBASE tabular data file stores data about geographic objects
DFD	Data Flow Diagram
DTM	Digital Terrain Model
DSMM	Department of Survey and Mapping Malaysia
ERD	Entity Relationship Diagram
EERD	Enhanced Entity Relationship Diagram
ESRI	Environmental Systems Research Institute
ESA	Egyptian Survey Authority
ECIM	Egyptian Cadastral Information Management
FIG	International Federation of Surveyors
GB	Gigabyte
GIS	Geographic Information System
GHz	Gigahertz
HTTP	Hypertext Transfer Protocol
GPS	Global Positioning System
GUI	Graphical User Interface
ICT	Information Communication & Technology

IS	Information System
ISC	Information System of the Cadastre
KM	Kilo Meter
LIS	Land Information Systems
LR	Land Register
LR&CIS	Land Registry and Cadastre Information System
MB	Megabyte
MS Access	Microsoft Access software
PHP	Hypertext Preprocessor
RDBMS	Relation Database Management System
RETD	Real Estate Taxation Department
REPD	Real Estate Publicity Department
RAM	Random Access Momery
SSADM	Structured Systems Analysis Design Method
SHP	Shapefile (stores feature geometry)
SHX	Shapefile (stores file lookup index)
SQL	Structured Query Language
TIFF	Tagged Image File Format.
UTM	Universal Transverse Mercator
UK	United Kingdom
URL	Uniform Resource Locators
USB	Universal Serial Bus
WAN	Wide Area Network
1NF	First Normal Form

2NF	Second Normal Form
3NF	Third Normal Form
3D	Tree Dimensional

Chapter One: Introduction

1.1 Background
1.2 Problem Statement
1.3 Research Objectives
1.4 Research Questions
1.5 Scope of the Research
1.6 Elements of the Research
1.7 Significance of Research / Contribution
1.8 Research Methodology
1.9 Dissertation Structure

1.1 Background

"A Cadastre is normally a parcel based and up-to-date land information system containing a record of interests in the land (e.g. rights, restriction and responsibilities). It usually includes a geometric description of land parcels linked to other records describing the nature of the interests, and often the value of the parcel and its improvements" (FIG, 1995).

Cadastral systems clearly define the limits of land parcels on the earth's surface based on laws, rights, and title/deed registration for the parcel or property. In order to do that the survey is necessary to set accurate survey data to a cadastral. The concept of cadastral information system has been simplified and shown in Figure 1.1.

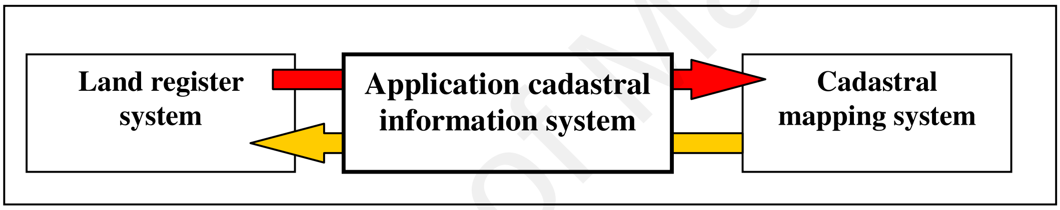


Figure 1.1Cadastral Information System Concepts

However, the standard content of cadastral data is intended to support the automation and integration of publicly available land records information. The basic spatial unit of cadastre is a land parcel. The data that may appear in a cadastre include geometric data (such as coordinates, area, perimeter, and maps), property address, land use, real property information, duration of the tenure, details about the construction of buildings and apartments, population, and land taxation values (CERCO,1995).

A cadastral map is a geometric description which shows the boundaries of land parcels, building block, position, and roads, and it is an important document required when owners need to register their property. Unlike other topographic map, the cadastral surveyor at the cadastral office updates and adds information to map daily and this update on the map leads to change in data in the land register file or new ownership file is opened. In contrast with digital map and database, the researcher can see that the hard-copy map is not an efficient method and is time consuming to execute. The possibility of using geographic information system (GIS) techniques have generated wide interest in cadastral system, and many countries have developed digital cadastral maps by using GIS techniques known as digital cadastral databases (DCDB).

However, this DCDB needs application software to add, update, delete, and search query in this database. This mean the application software will enable the map modification work to be carried out in more easily and efficient manner using DCDB.

1.2 Problem Statement

Current cadastral work in Libya is carried out manually and this has led to a number of serious problems resulting in legal battles for ownership of land titles. Title/deeds reported as being lost have been re-created resulting in having duplicate files for a signal cadastral (real estate). Furthermore, the current manual system does not support and track updates. There is a need therefore to do a piece of research in this area so that the existing system can be automated. The new computerized cadastral system would be able to resolve the current problems.

1.3 Research Objectives

Given the above problems, the research has stipulated the following objectives:

i) To identify the features of the cadastral information system (CIS).

ii) To compare the tools and techniques that have been used by some countries to develop CIS.

iii) To propose a framework for CIS based on the study of previous projects and existing system environment.

iv) To design and develop a web mapping prototype for CIS which issues cadastral certificates for the cadastral (real estate) based on the proposed framework.

1.4 Research Questions

In this research, the researcher seeks to solve the following research questions related to the system in cadastral office:

i) What is the existing situation in the cadastral office for the provision of cadastral system?

ii) What are the present tools and techniques that have been used in developing CIS?

iii) What are the new tools that can be used to improve the present situation?

iv) What are the general specifications that can be outlined in designing the new system based on analysis of the current system?

v) What are the needs of users that the system should be able to provide?

vi) How does the system work when implemented in a database and GIS?

1.5 Scope of the Research

The scope of the research would cover the following:

i) Cadastral area is about 30 km^2 from Shari Az-zawiyah district in Tripoli-Libya only.

ii) DCDB is created for the obtained area from hard-copy map with scale 1:1000 km.

iii) Registration and issue of certificates will be done only for the real estate (cadastral) that are included on selected maps.

iv) Ownership transfer will be done only for whole parcels and not for subdivided or merged parcels since the selected area is in the urban area.

1.6 Elements of the Research

The elements of this research study is elaborated at Figure 1.2

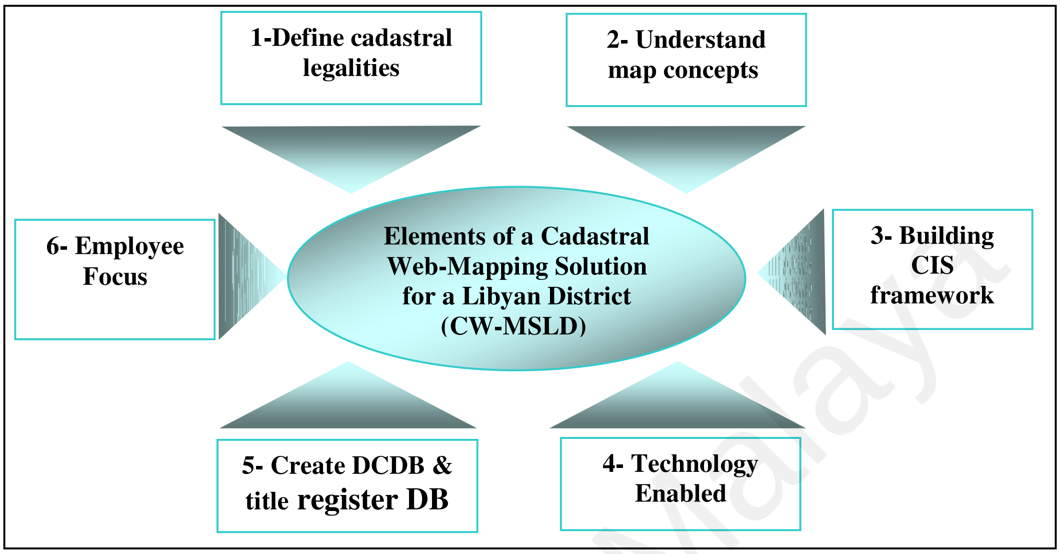


Figure 1.2 Elements of a Cadastral Web-Mapping Solution for a Libyan District (CW-MSLD)

1.7 Significance of Research / Contribution

This research will attempt to propose a framework for CIS and develop web mapping prototype for cadastral system using GIS techniques. The project will demonstrate on how to develop a computerize cadastral system based on the proposed framework, this depends on the system requirements, techniques and tools available and the prototype system will support the DCDB where each parcel on the map is linked directly to its attribute data. In addition, this project will also focuses on the framework as outlined in cadastre 2014. The cadastre 2014 vision attempts to define a general framework for cadastral system for all countries in the world. For more information about cadastre 2014 see Section (2.3.2) in Chapter Two.

1.8 Research Methodology

A research methodology defines what the activity of research is, how to proceed, how to measure progress, and what constitutes success (Effenberg & Wolfgang, 2001). The case study methodology has been applied to studies of cadastral system. Evans (1995) defined that a case study is an investigation of a specific system or phenomena from which generalisations are drawn and applied. The case study methodology in this research study does not mean given understanding a cadastral information system and analysis it but also to use a pilot study as the main input data to understand how the system interacts and operates with legal framework. The cadastral information system is developed based on GIS techniques to integrate the geographic data (cadastral map) with attribute data (land register data) where the input data is very important in the creation of any GIS application and it is the main component in GIS. Based on this reason, the case study method is selected as the main method in this research where the project's pilot area is defined.

A Cadastral Web-Mapping Solution for a Libyan District (CW-MSLD) System consists of databases with both textual and geographical data that are highly integrated and the action plan should cover the data set in Tripoli Cadastral Office and it includes the following:

i) Map digitizing (convert from Raster to Vector).
ii) Geographic referencing and non geographic locators (e.g. parcel point, parcel description).
iii) Establishment of ICT Base for Tripoli Cadastral Office.
iv) Reconstruction of cadastral records.
v) Production of digital cadastral plans.
vi) Establishment of model for the future land information system in Tripoli.

1.9 Dissertation Structure

The dissertation structure of this research study is depicted in Figure 1.3. This dissertation is written in seven chapters and the dissertation structure diagram gives a brief summary for each chapter's content and its contribution to the structure of the dissertation.

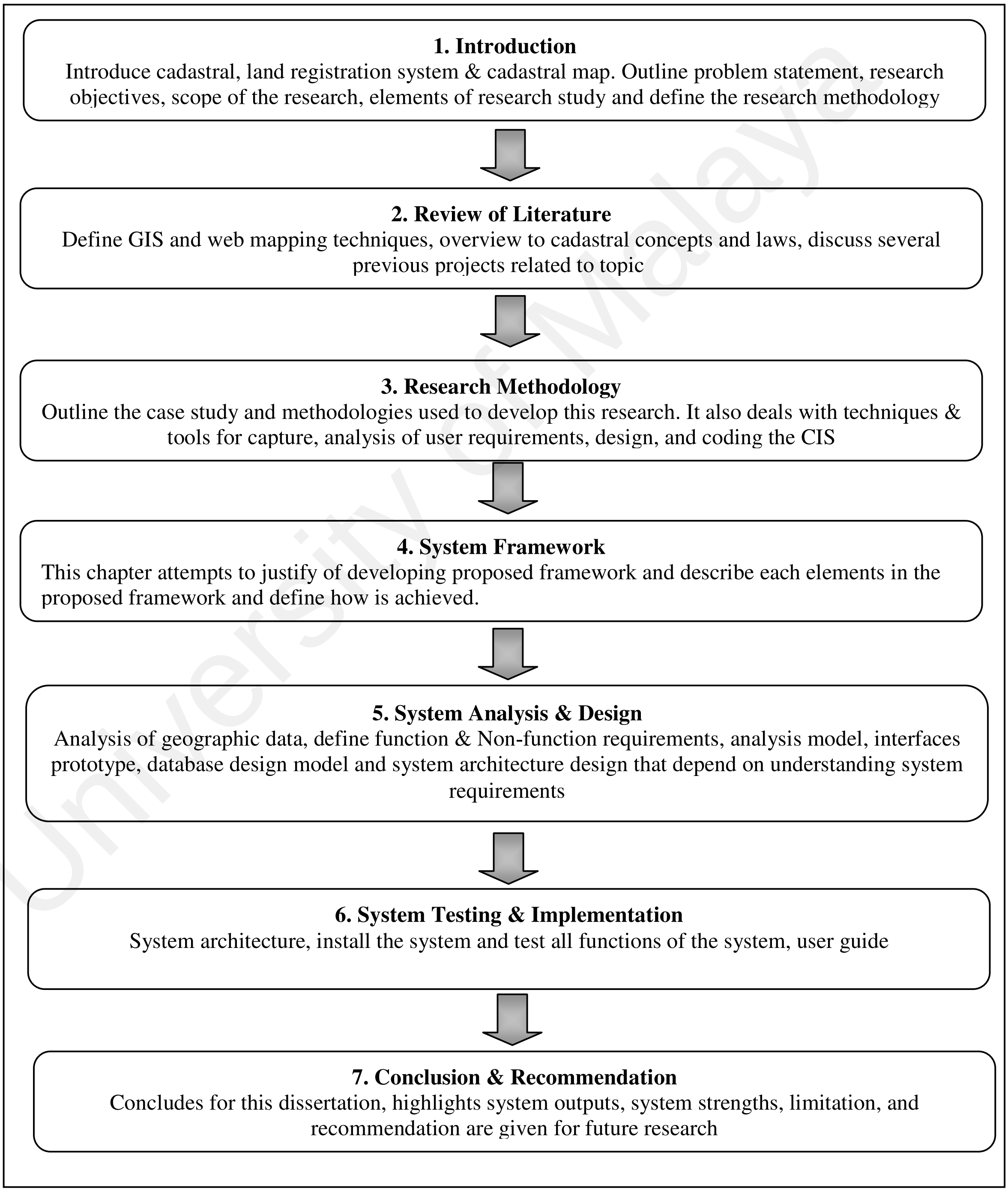


Figure 1.3 Dissertation Structure Diagram

Chapter Two: Review of Literature

2.1 Introduction

This chapter briefly introduces the concept of geographic information system (GIS), which is the best model used for developing a cadastral information system. Then, it discusses the importance of cadastre reform and digital cadastral database (DCDB). In addition to this, it explains cadastre 2014 vision issued by International Federation Survey (FIG) in 1994. The aim of cadastre 2014 vision is to define the general framework for cadastral system. Finally, it presents previous projects for some countries and summarizes the main points for them.

2.2 GIS

2.2.1 Definitions

There are many definitions for GIS. A GIS is a computerized system for storage, retrieval, manipulation, analysis, and display of geographically referenced data. The Environmental Systems Research Institute (ESRI) defined GIS as "a computer-based tool for mapping and analyzing things that exist and events that happen on earth. GIS technology integrates common database operations such as query and statistical analysis with the unique visualization and geographic analysis benefits offered by maps".

As an information system (IS), GIS is designed to work with data referenced by spatial or geographic coordinates. In other words, a GIS is both a database system with specific capabilities for spatially-referenced data, as well as a set of operations for working with the data (Star and Estes, 1990).

2.2.2 History of CIS

The development of GIS is older than you may think. It started from 1960s in Canada (Tomlinson et al., 1976). GIS developed layers, overlay calculations, data structure, scanning as data entry and so on for land resources. Furthermore during the same year, U.S. Census developed digital enumeration districts and geo-coding for address matching in commercial area, and ESRI created in 1969 as one of the most successes software company in the world. As seen by today, the use of GIS grew strongly and fast in different applications like business, government, and academic.

2.2.3 Components of GIS

The GIS consists of five components and to understand GIS, we need to look at each component of GIS and how they work together. These components are explained below:

2.2.3.1 Hardware:

Hardware consists of the technical equipment and devices needed to support the many activities of GIS ranging from data collection to data analysis. This includes a computer system with enough power to run the software, enough memory to store large amounts of data, input and output devices such as scanners, digitizers, GPS data loggers, media disks, and printers (Carver, 1998).

2.2.3.2 Software:

There are many different GIS software packages available today like ArcGIS package, ArcCadastre from ESRI and MapInfo. All packages must be capable of data input, storage, management, transformation, analysis, and output (Lo and Yeung, 2002). Extensions or add-ons are software that extends the capabilities of the GIS software package.

2.2.3.3 Data:

According to ESRI (2007), data is a key element in any GIS application. The quality of the data is very important and any error in the data set can add many unpleasant and costly hours to implementing a GIS and the results and conclusions of the GIS analysis most would likely be wrong. Geographic data comes from three forms:

i) **Map data:** It contains the location and shape of the geographic features. A map uses three basic shapes to present real-world features: points, lines, and area.

ii) **Attribute data (tabular)**: It is the descriptive data that GIS links to map features. Attribute data is collected and compiled for specific areas like states, parcel's ownership, cities, and so on. The compiled attribute are collected and subsequently added to the map.

iii) **Image data:** It ranges from satellite images and aerial photographs. Image data offers a quick way to get spatial data for a large area and is more cost- and time-effective than trying to collect layers of data like buildings, roads, lakes, etc. all one at a time.

In a GIS, the data model is an abstract representation of geographic data. The spatial components of a geographic data can be represented by three data types: points, lines and areas. Spatial data are represented in a GIS in two very different ways. They are as follows:

i) Raster data model

The raster data model is an abstraction of the real world where the basic unit of data (points, lines and areas) is represented using grid cell which is identified by rows and columns (Mitchell, 2005). Figure 2.1 shows the representation of raster data model.

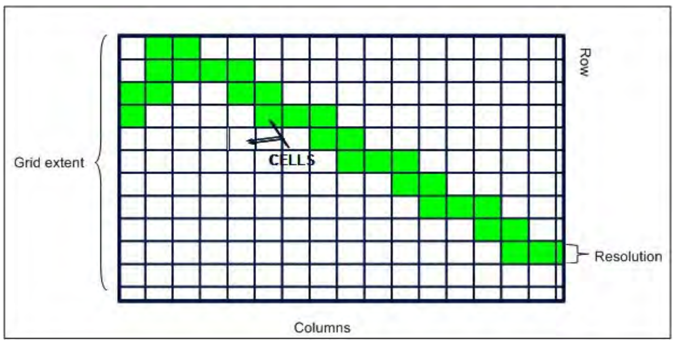


Figure2.1: Raster data model

In the simplest form, each cell contains a value for the element. Any cell not containing a feature would have the value of "0". In more sophisticated systems, the cell value is a label that links to the record as an attribute.

ii) Vector data model

In the vector data model, features are represented in the form of coordinates. The basic unit of data (points, lines and areas or polygons) is composed of a series of one or more coordinate points (Mitchell, 2005). For example a line is a collection of related points and an area is a collection of related lines. Figure 2.2 below shows the representation of raster and vector model.

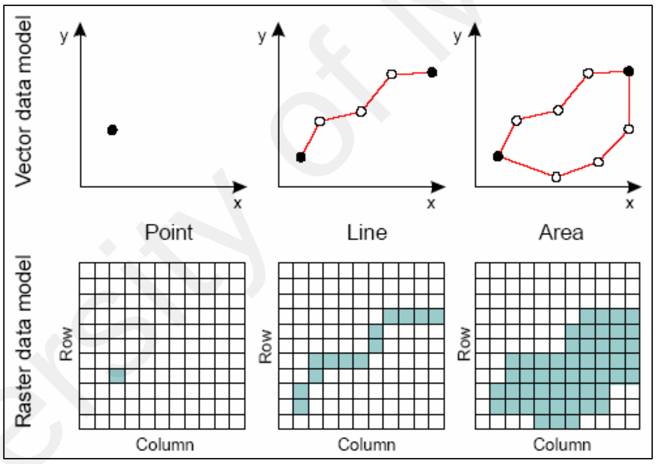


Figure 2.2: Raster and vector data model

2.2.3.4 People (stakeholders):

GIS technology should be used by people who manage a system and develop plans for applying it to solve real-word problems. Utilizing the GIS software would need skilled and trained personnel in spatial analysis and skilled. These education, career path, and networking are three factors related to people component and education is the key factors. Selecting the right type of GIS job is important. A person highly skilled in GIS analysis should not seek a job as a GIS developer if he or she had not taken the necessary programming classes. Finally, continuous networking with other GIS professionals is essential for the exchange of ideas as well as a support community.

2.2.3.5 Methods:

A successful GIS operates according to a well-designed plan and business rules, which are the models and operating practices unique to each organization.

2.2.4 Digital Mapping

The computer gives us a lot of services and this includes power processing and storage. One of these services is digital maps. Before that, people drew and colored their maps by hand and analyzing data and obtaining the result from the map was slow and costly. Digital maps can be done by a click of a mouse or doing few procedures such as computer analysis, draws, and color-theme your map data. These however require accuracy and effort when drawing the map. Very small error gives incorrect result or misleading content. A map stored in a computer file as distinct layers make it easy to modify a map without starting from scratch compared to conventional methods. The process of conventional mapping includes hand-drawn observation of the real world, transposed onto paper. If a feature changes, moves, or is drawn incorrectly, a new map needs to be created to reflect that change.

2.2.5 Web Mapping

Web mapping is a new technology in a GIS to make maps and geo-information available to groups of end users through a web page. There are two types of web mapping application:

i) **Static maps:** These are maps displayed as image on a web page and they are quite common and scanned map documents can be quickly added to your web page as static maps (Mitchell, 2005).

ii) **Interactive maps:** These types of maps are not commonly seen because they require specialized skills to keep such sites and keep it running. The user can interact with the map by selecting different map layers to view or zoom (Mitchell, 2005).

2.2.6 GIS Applications Areas

There are five major areas of a GIS application. Table 2.1 below summarizes the area and application:

Table 2.1: GIS Applications Areas[1]

No	Area	GIS application
1	Management Facilities	Locating underground pipes & cables Telecommunication network services Energy use tracing & planning
2	Environment and Natural Resources Management	Oil and gas exploration and production Agriculture lands, water resources, forestry and Wildlife...etc
3	Street Network	Car navigation (routing scheduling), Locating houses and streets, Transportation planning... etc
4	Planning and Engineering	Urban planning, Regional planning, Route location of highways… etc
5	Land Information System	Properties /Cadastre administration, Zooming of land use, Land acquisition, taxation…etc

2.3 Cadastral Information System (CIS)

Cadastral refers to a map or survey showing administrative boundaries and property lines. Cadastral information system (CIS) is a system that consists of two sub-systems i.e. cadastral map system and land register system. A land register system contains information about real property owners and other kinds of matters created outside cadastral domain such as mortgage as shown in Figure 2.3.

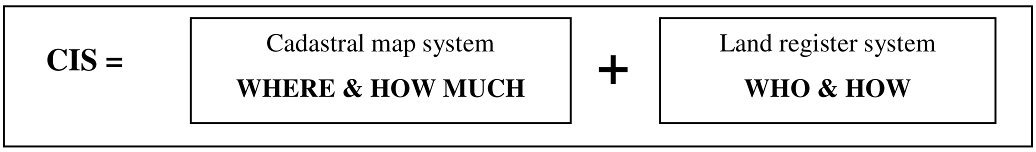


Figure 2.3: Cadastral Information System

[1] http://www.msdis.missouri.edu/presentations/intro_to_gis/pdf/GIS_intro_over.pdf

A cadastre administration is very important for the owners to register and get a certificate for their own specific property or cadastral. The government would use this information and use the outputs from cadastral and land registry system as input for other projects like water supply and highway projects. In this section, the researcher focuses on the importance of CIS concept and four successful projects are used for developing this system.

2.3.1 Cadastral Reform

Cadastral reform in a rapidly changing environment is inevitable and essential but not optional. If reform is not initiated, there are risks of a degraded cadastre, inefficient practices, overpriced surveys and an inability to fully utilise new technologies (Smith, 1990). Cadastral reform is very important for improving the operation, efficiency, effectiveness and performance of the cadastral system in a state. The word "cadastre" can have a different interpretation in different countries and states. In Libya, it refers to land registration system and cadastral surveying. In simple terms cadastral systems are based on two components which are parcel and land register which are directly linked to the property.

The most important purposes for cadastre reform are improving customer service with increased efficiency and improved cost. In additional to these, there is a need to provide better and more efficient service to the clients. "GIS based cadastral planning dissertation" dissertation discussed widely the reasons for reform (Master, 2004).

2.3.2 Cadastre 2014

International Federation Survey (FIG) has issued CADASTRE 2014 publication which is produced by Jürg Kaufmann and Daniel Steudler, the Chairperson and Secretary of working group 7.1 of Commission 7 Cadastre and Land Management on 1994.

CADASTRE 2014 presents a clear vision for cadastral systems in the future as well as being an excellent review of the strengths and weaknesses of current cadastral systems. The working group in cadastral 2014 comes with new two terms which are ‘Land Object’ and ‘cadastral 2014’. A Land object is a piece of land in which homogeneous conditions exist within its outlines (Kaufmann and Steudler, 1998). Every country has the rules to define these conditions which are normally defined by law. These rules depend of how the society understands the phenomena within the area in which he or she lives. Examples of legal land objects are private property parcels and administrative units such as states, cities, municipalities and districts. The cadastre 2014 was the first framework presented for an organized the cadastral system and creates one base for all cadastral system in the world. According to ‘cadastre 2014’, Cadastre 2014 can replace the traditional institutions of 'Cadastre' and 'Land Registration'. It represents a comprehensive land recording system. The commission group 7.1 in FIG has six important characteristics for development of cadastral for the next 20 years starting from1994. As reported by Kaufmann and Steudler, (1998), the six statements are as follows:

Statement 1: Cadastre 2014 will show the complete legal situation of land (Private and public rights and restrictions on land will be systematically documented).

Statement 2: The separation between 'maps' and 'registers' will be abolished.

Statement 3: Cadastral mapping will be dead (Long live modeling).

Statement 4: 'Paper and pencil - cadastre' will be gone.

Statement 5*:* Cadastre 2014 will be highly privatized (Public and private sector).

Statement 6: Cadastre 2014 will be cost recovering (Are working closely together).

In conclusion, the cadastre 2014 gives good guidelines to developer’s cadastral system.

2.3.3 Previous Projects on CIS

The main objective for this section is to compare various CIS projects to understand the features of CIS and to define the recent techniques and tools that are used to develop the best CIS.

2.3.3.1 Turkey

According to Ercan and Bank (2004), Turkey has developed the Turkish cadastral automation system. The most important goal for developing Land Registry and Cadastre Information System (LR&CIS) was to improve the services by computerizing the system and make land information system (LIS) to be multipurpose in order to help other organizations by given accurate and reliable data and information, this project was developed in two phases:

First phase (pilot study): This phase started in early 2001 and it was completed after 22 months after going through the process of analysis, design and development work as website into WAN environment.

Second phase (Implementation and Testing): This phase was duly tested all cadastral functions in the system.

Turkish Cadastral Automation System had been developed by using ArcIMS[2] public web services from ESRI. That system was used by the General Directorate, Ankara Regional Directorate in Turkey. Geodatabase cadastral was managed by ArcSDE[3] in Window 2000. The system has four center servers called SQL Server, Domain Controller Server, Backup Domain Server and Proxy Server. The software and data for that system needed high capacity and efficiency hardware. The cadastral model for Turkish Cadastral Automation System consists of four platform which are Central Data Infrastructure (cadastral data

[2] ArcIMS is Arc Internet Map Server software
[3] ArcSDE is technology fuses ArcGIS application logic with information management in a relational database management system (RDBMS).

model), Cadastral Process Automation (cadastral functional model), and Data Serving to external users via Internet, and System Monitoring platform for General Directorate (top hierarchy). The cadastral data definition for the system consists of two components which are

- Geometry of properties (blocks, parcels, parcel corner points, and buildings).
- Attributes of properties (owners, rights, mortgages… etc), and information about geometry.

The cadastral data process initially starts from the field by surveying. As a result, cadastral activities carried out two main products namely cadastral maps and title/deeds. The Turkish project has a big data storage. This data is categorized into two main types:

- Raster data: map sheets scanned and linked to the related parcels.
- Vector data: data converted from CAD data and field measurements[4].

Data collection and integration is done and subsequently stored into geodatabase (UTM coordinated). Cadastral data can be utilized by external users via Internet by using ArcIMS.

In conclusion, Turkey has a complete LR&CIS integrated system. This system was bought with high cost but gives a lot of services and saves time in different organization in the country. ESRI technology has been used very successfully in cadastre side, ArcSDE for managing the cadastre data at the center of system, and ArcEditor[5] for all cadastre activities in harmony with the land registry side. ArcIMS is used for serving data via Internet for external user. Thereby, the most important LR&CIS benefits are having a central database have a backup for data, easy and faster to access data via the Internet and no damages for original documents in the digital archives. External users can access the system and get

[4] Measurements data are used for calculating the coordinate values and stored in the database.
[5] ArcEditor is a powerful GIS desktop system for editing and managing geographic data.

services like zoom in, and zoom out the map, pan and access and display data. LR&CIS system is one of most important part of Turkey's e-government structure. This system is not complete yet for covering all Turkey's parcels.

2.3.3.2 Egypt

The Egyptians had been well known for their maps in ancient times. They had drawn maps on parchment to show the gold mines at Coptes during the period of 1292 B.C. - 1225 B.C (Bernhardsen, 2002). Egypt is one of the first countries which tried to manage cadastral by enforcing rules and legalations for that.

According to Samir Elrouby and Harju (2005), the Egyptian Survey Authority (ESA) had started in 2002 to develop The Egyptian Cadastral Information Management (ECIM) project supported by the Ministry for Foreign Affairs of Finland. The most important aim for ESA/ ECIM was to have a complete computerized system which included digital LIS based on cadastral data. The ECIM project developed a system which integrated the existing ESA, Real Estate Publicity Department (REPD), and Real Estate Taxation Department (RETD). ECIM project is an automated system which enabled the monitoring of various day-to-day activities between various offices as shown in Figure 2.4.

The ArcSDE technology incorporated into ArcGIS[6] server is used to access multi-user geographic databases. The first phase finished in February 2005 where the DCDB was built for a selected pilot study. The area was chosen Damanhour district in Beheira province, and

[6] ArcGIS is a complete package which integrated collection of GIS software for authoring, serving, and using geographic information when ever it is needed on desktops, servers or custom applications.

it is a rural area which is approximately 160 km². Oracle, ArcSDE, ArcCadastre[7], and MapObjects[8] and Visual Basic were used to develop the system. After the pilot study was successfully implemented, the ESA continued to develop the system that it could be applied nationwide.

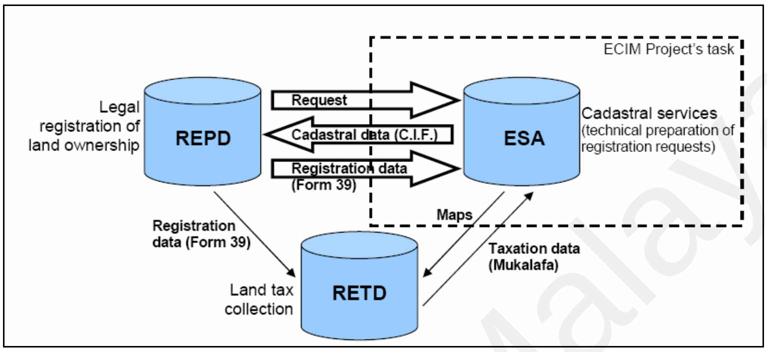


Figure2.4: ECIM Project depicting an integrated a computerized system

However, the cadastral and land registration system is in fact more complex and has unclear procedures. The ECIM project had highlighted a number of problems in the existing systems during the long analysis phase. ECIM project has worked hard to understand cadastral procedures, land registration legalities, and how to calculate tax for parcels or other objects. The biggest problem was how to integrate and connect four organizational levels and how data is transferred between them. The most important ECIM project output is the Unified Cadastral Database (UCD), which combines the map data with the attributes. UCD is designed based on user requirements. There are many functions that had been included in the system like continuous and automatic updating cadastral work, monitoring and printing out different map outputs, reports and statistics, converting data from analogue to digital, de-centralizing the system and achieving synchronization which co-ordinates between four organizational levels.

[7] ArcCadastre is a tool for handling geographic and cadastral information from ESRI.
[8] MapObject is a tool for creating specialized solutions for your desktop mapping and GIS needs.

In conclusion, ESA has developed a web application which handles the publishing of geographic and tabular information via the Internet using ArcIMS (Internet Mapping Server) from ESRI and published information could be accessed by ESA's regional offices or other stakeholders. This project brought many benefits, not only for ESA but also for the society and government. It had been tried to solve informal registration problems in Egypt. ECIM project will increase the social security by using a digital database and it is possible to standardize products in a more efficient way with lower cost. This could attract more customers and hence increase the income, and provide faster delivery services to customers. Other benefits of the ECIM project is the improved office environment, the digital storing media takes less space than the analogue environment of storing.

2.3.3.3 Bulgaria (Sofia)

According to Lazarov and Dechev (2002), GIS-Sofia Ltd in Bulgaria had developed a new cadastre and property register for Sofia Municipality in April 2000. The development of an Information System of the Cadastre (ISC) was used for the territory of the Sofia capital city.

This project had integrated the registry and cadastre offices. A prototype of the ISC project had been developed by using ArcView[9], AutoCAD Map R 4.0, and SQL Server. In order to develop any system, we first need to understand the laws and regulations in the system environment. Bulgaria had updated the rules and data exchange between registry and cadastre offices in April 2000. Bulgaria started working on developing the ISC from 1987, with digitization cadastral maps. But, the project was not completed at that time because the

[9]ArcView is full-featured GIS software for visualizing, analyzing, creating, and managing data with a geographic component

level of computer technology and work methods used was insufficient to establish a real information system. Gradually the integration between attribute database and geographic data was initiated. Sofia completed its digitization by using Arc/Info[10] 3.5 and established its attribute database in 1996. Cadastral mapping in Sofia is maintained in two scales: 1: 1 000 for urban area, and 1: 500 for the compact city only.

In 1998, GIS-Sofia started updating its digital map base starting from nationwide Sofia city and finished the task in the summer of 2001 by giving the unique identifier for each cadastre object. The project team started work on a pilot study first where property was identified. The property verification work was identified and some techniques and procedures were developed to solve these problems. Finally, the GIS-Sofia completed digitizing about 133000 properties and 242000 buildings. The next step was to link cadastral data (graphic data) to relevant data from ownership (attribute data). Input correction and carrying out information searches was done by using registration software. GIS-Sofia developed the ISC web-based system and the ISC prototype consists of three parts namely ISC center, Library of function and User Interface. SQL Server at ISC center integrated and managed the different parts.

GIS-Sofia created an efficient environment to protect information which is not only important to cadastre and registry office but useful to a lot of customers. The digital information was used to develop and build the city. The most important customers were the architects, who designed the urban planning for different parts of the city. The digital cadastre used in design works for underground project, water supply and sewerage project, and the Bulgarian telecommunication company.

[10]Arc/Info is GIS software used to build powerful geo-processing models for discovering relationships, analyzing data, and integrating data.

However, GIS-Sofia had been updating urban cadastral information system by adding 3D Visualization using remote sensing and GIS. The following data resources were required for this purpose

i) Existing topographic map at 1:5000 Scales (covers 2.50 _ 2.50 km = 6.25 km^2).

ii) Satellite image obtained from QuickBird (with 61 cm resolution, covers about 270 km^2).

iii) Digital cadastral model of Sofia.

GIS-Sofia used ArcView software for collecting data needed to obtain 3D buildings. They used specific tools to represent 3D buildings to reach the most geometrically correct and real looking three-dimensional objects. The geometrical accuracy is very important in cadastral application. The use of aerial- photo provides higher completeness of information, but is considerably more expensive (Alexandrov et al., 2002).

In conclusion, the information and outcomes from this project is very important to a lot of organization in Sofia city. GIS-Sofia did not stop at this point but they are trying to design technology and applications for furnishing information from the database via Internet and thereby increase the quality of their services.

2.3.3.4 Malaysia

As reported by Abdul Majid Bin Mohamed (1997), the department of survey and mapping Malaysia (DSMM) has been looking for other countries' experience and experimentation in developing cadastral system. DSMM started strong with cadastral reform and coordinate cadastre.

In 1986, the first pilot project was done in Johor state and it created for the DCDB at a scale of 1:4,000 and the first pilot project was successful. The next project was implemented in

Penang State in 1993. Based on both these projects, cadastral reform had been done for Peninsular Malaysia in 1995 where a connection network was implemented. Williamson (1990) states that a survey accurate DCDB and coordinated cadastre should not be created without fully understanding the place it holds and the effects it has on the operation of the cadastral system. All reforms to introduce a survey accurate DCDB and an improved cadastral surveying system (collectively a coordinated cadastral system /coordinated cadastre) go hand in hand with reforms to the wider cadastral system including reforms to the title registration system". The model proposed for coordinated cadastre is based on a complete DCDB. The implementation of the model is defined by Nordin et. al. (2006) .The accuracy of data acquisition is very important for cadastral survey. Many devices helped the surveyor in their work like Digital Theodolite, Total Station, Digital Level, Global Positioning System (GPS) and Digital Photogrammetric. Nowadays, the District Survey offices are using GPS and it increases survey accuracy, productivity, and reduces costs. The DSMM is collaboration with University of Technology Malaysia (UTM) to determine the feasibility of introducing a Coordinated Cadastral System for Malaysia, and find best techniques for integrating cadastral data with attribute data (SES et al., 1999).

In conclusion, it can be deduced that acquisitions, collection, and conversion of analog data into digital format are though very important, it is a time consuming job in building a computerized information system, DSMM has been restructured in 1994 to face new challenges more effectively by using new technology in the field of survey and mapping. It will have a strong base to develop cadastral information system by using GIS technology. To look more closely, DSMM is now better set to meet the challenges of the nation's Vision 2020 which is in the process of establishing an "Electronic Government".

2.3.3.5 Summary of the Cadastral Projects Reviewed

Table 2.2 shows the main properties for four projects which the author has investigated.

Table2. 2 Summaries of the Cadastral Projects Reviewed

country / properties	Turkey	Egypt	Bulgaria	Malaysia
Land registration	Deeds	Registration of deeds until 1975 Registration of title since 1976 (80% has been done)	Deeds	Title
Projects services	Regional Directorates land registry offices cadastre offices	Egyptian landowners and relevant authorities	Registry Office Cadastre Office	Department of Survey and Mapping (DSMM)
Survey coverage Completeness	cadastral survey of 97 % of urban areas and 77 % of rural areas end of 2005	Governorate of Beheira, Egypt 54 village	Complete digitizing about 133000 properties & 242000 buildings for Sofia city	two cities were surveyed: Johor, Penang
Technology used & Tools	ESRI technology (ArcEdit, ArcSDE ArcIMS, and ArcCatalog) SQL server VB,C++ and Delphi	Oracle, ArcSDE, ArcCadastre, and MapObjects	Visual Studio environment , Avenue language ArcSDE ,Arc/Info AutoCAD MAP SQL Server Windows NT 4.0 environment Linux Red Hat 7.1 Environment	Global Positioning System (GPS)
Method or approach	"Cadastre 2014" approach	object-relational data model	Object-relational data model	"Cadastre 2014 " approach
Significant improvement	Website design	Full integrated project, Multipurpose Connected 3 applications	Website design	Land reform & established DCDB Coordinated cadastre GPS control network
Other comments	Not complete yet	Completed in August 2006 with Project financing :1 million euros	3D Cadastre under study	The project still under development

2.4 Summary

In summary, the cadastral system is one of the GIS applications that can be successfully developed by using GIS techniques. Next, the cadastral reform procedure gives high accuracy measurement by surveying the parcels using neoteric technology such as GPS. Beside that, this chapter had elaborated vision of cadastre2014. However, this chapter had investigated some previous projects which had been highly related to the research study.

Chapter Three: Research Methodology

3.1 Introduction

The aim of this chapter is to justify a methodology for the development and documentation of this dissertation. This chapter reviews a number of system methodologies and modelling techniques utilized in CW-MSLD System.

3.2 Case study

Cadastral system is a very important system and it requires efficient data management tools. The case study has been used to understand how the cadastral system operates and interacts within the legal framework. An important objective of this research is to design and develop a web mapping prototype for CIS that will evaluate the effectiveness of DCDB and helps the author to define the strengths and weaknesses of the system before recommending any solution.

The term cadastral refers to legal, social, economic and culture in the country. The cadastral in one country may differ from another as the environment may be different. In addition, the case study in GIS application is different from other systems where about 80 % of data collocated is obtained from the map. The map type, scale and resolution should be determined based on the map features that are needed to solve the problem and develop the application or system.

A cadastral system is a big system and it has attributes and geographic data. Before starting to develop a cadastral system by using GIS techniques, one needs to convert an analogue map to a digital map for the pilot area that is chosen. The hard-map scale 1:1000 for urban area is scanned in black-white, 300 dpi resolution by A0 scanner. This scanned picture file is inserted in Arc/Info and digitized on screen and digital map will be obtained after a sequence of processing steps (digitizing steps is explained in detail on Chapter Five – Section 5.2.3). This research will not solve all cadastral system problems. The focus of this research is to develop a computerized information system prototype for the cadastral office in Tripoli- Libya. This cadastral office in Tripoli-Libya is used as a case study in this research thesis. This office presently uses a manually method to do work which leads to some of problems that the author had mentioned in the problem statement (Section 1.2).

Therefore, the author selected a subset from Tripoli city in Libya. The subset is approximately 30 km² and a pilot study was carried out in this area. The purpose of the pilot study was to develop a prototype cadastral information system that would be used in an urban environment.

3.3 Data Collection Techniques

Requirements capture or data collection techniques have been used to collect data. A technique is a set of steps and a set of rules which defines how a representation of an information system is derived and handled using some conceptual structure and related notation (Smolander et al., 1990). There are many techniques used to capture, collect, and process data to achieve all the objectives and goals of the project with clear understanding of the problem situation. The techniques used to collect data for this research are as follows:

3.3.1 Review of Literature

A literature review is very important component of any research study. It is the use of ideas in the literature to justify the particular approach to the topic, the selection of methods, and demonstration that this research contributes something new (Hart, 1999). As mentioned in

Chapter two, the legal and concepts of cadastral system and Cadastre 2014 vision have defined the basic and standard of cadastral system. Furthermore, previous projects were reviewed in order to determine suitable features and functionalities for this research. The properties for previous projects have been summarized in Table 2.3.

3.3.2 Interviews

Interview is a way of finding out is information that is needed to develop the system. The analyst discusses the system with different stakeholders and builds up an understanding of their requirements. Stakeholders must be given a starting point for discussion. This can be a question, a requirements proposal or an existing system (Kotonya and Sommerville, 1998).

In this research, a total of three interviews were held with a number of staff members which included the Head of land register department, Registration officer, Surveyor. These interviews were particularly important to collect valuable information, which enabled me to set the system requirements more clearly. These are several important questions that the author asked during the interview to open the discussion:

Q) How does the cadastral office deal with the customer?

A) The cadastral office work with the notary who applies for his/her customer. The customer comes just when the certificate is ready to be collected. The customer needs to a sign a documents before obtaining his or her certificate.

Q) What are the required documents for registering the property (cadastral or estate)?

A) The required documents to accept from the customer are as follows:

1- Original deeds,

2- Photocopy from contract between the seller (old owner) and buyer (new owner). The contract should be signed by two witnesses and notary (lawyer). The contract must be registered in courts. Many cadastral have ownership problems and it may have a “compliant file” from other person. In this case, the court does not stamp and give a register number for the cadastral to complete the ownership transfer.

3-The blueprint for deeds should be from 1/1/2000 year or above because the city has new planning and the deeds must be stamped from Urban Planning department.

5-Request letter raying the property is not mortgaged to government or a bank.

5-Application form filled by notary and it is signed by customer and Notary.

Q) What are the types of ownership transfer’s for the properties (cadastral)?

A) There are three types of ownership transfer for property (parcel/building) as shown clearly in a Table 3.1.

Table 3.1: Types of Ownership Transfer

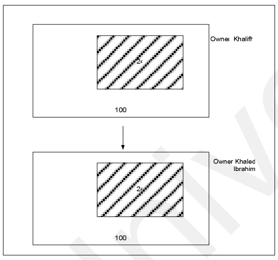
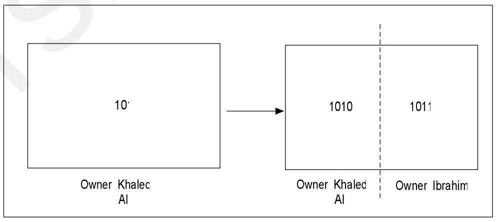
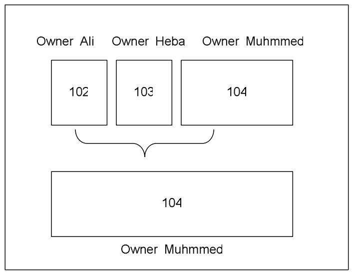
		

Figure 3.1: Whole property transfer	**Figure 3.2 :**Subdivision of property and transfer	**Figure 3.3 :** Merge a number of property and transfer

Q) What are the more recurring problems when registering real estate or a cadastral?

A) Actually, there are a lot of problems when you register some of the cadastres in the office. The first problem is parcel shifting because the old measure is done by people without referring to a surveyor and the oldest buildings in the city have been built without plan. The second problem is the boundary disputes that happen between neighbours and there are many complaints and cases on this problem. The surveyor is able to fix this problem by measuring the parcels and carrying out a field survey for them. If agreement cannot be reached then the case goes to court.

Q) What are the problems that the staffs face in their daily operation with the current system?

A) There are two types of staff, i.e. the registrar in land department and the surveyor in survey department. In the land register department, the staff felt that it is difficult to find specific file during a short time. A duplicate file for a parcel is not safe. In additional, it is very hard to produce reports for any parcel cases, because they need to go through all the files to get data or information. In the surveyor's office on the other hand it is difficult to use pencil and hard map to add and update parcel data on map. You can imagine how the map would looks like if alterations are made year after year.

Q) What are your requirements for the new system?

A) Since there are many weakness of using the manual system. The new system should address all the weaknesses in the current system. CW-MSLD System should enable the staff to search for parcel information by clicking the parcel on map or entering parcel number. The system is able to register a parcel based on a particular report from the survey department. The system should enable the staff to transfer the ownership information. Finally, the managerial staff should be able to issue a cadastral certificate for the registered cadastral.

3.3.3 Observation

An observation can give useful insight into problems, work conditions, bottlenecks and methods work (Avison & Fitzgerald, 2006).

A few visits were made to the Tripoli cadastral office concerned to make personal observation on the existing system and the process flow that occurs within cadastral surveying. Really, it is difficult to understand surveyors with out observing them through their work at office such as measure parcel area and determine parcel boundaries.

3.3.4 Searching Records and Documentation

Searching records and documentation may highlight problems, but the analyst has to be aware that documentation may be out of date (Avison & Fitzgerald, 2006). Since the Tripoli cadastral office is a service office, it has a few types of application forms to be completed by the notary and there are specific records used for storage on real estate. These application forms and records had guided the developer to design the system database and interfaces more clearly.

3.4 System Development Methodology

Methodology is defined as the analysis of the procedures used in a particular field. Avison and Fitzgerald (2006) elaborate that a methodology will consist of phases, and sub-phases, which will guide the systems developers in their choice of the techniques that might be appropriate at each stage of the project and also help them plan, manage, control and evaluate information systems projects.

It is very important to define the method which should be used to do the research in the early stage. There is a need to apply a formal systems methodology in carrying out the system development in this research. The author will follow the Structured Systems Analysis and Design Method (SSADM) with prototyping model as the main guide for development in this research.

The Research methodology defined here is based on the methods, techniques, and tools used to capture and collect analysis data from a variety of information sources. Define the system requirements by analyzing existing systems. This is done in the literature review.

3.4.1 Structured Systems Analysis and Design Method (SSADM)

SSADM – waterfall model is a conventional approach that enforced discipline and systematic manners. It is commonalty used in developing computer projects in UK. SSADM is a highly structured and documented methodology and there are five phases.

i) Feasibility Study

A preliminary study is undertaken before the start of this project. This phase looks at existing systems and highlights the main problems and presents alternative solution. Subsequently, the management studies the alternative solution from different perspective and it looks at technical, human, organization and economic cost. The project then it agree to the next stage of developments i.e. requirement analysis.

ii) Requirements Analysis

This phase looks in more detail at existing systems to determine the problems with current methods and come out with requirements for the new system. The information and data from users are obtained by using certain data collection techniques *(see Section 3.3 in this chapter).*

iii) System Specification

In this phase, the analyzer defines the user requirements and carries out the technical analysis to find out how the new system can be improved. Furthermore, the functional and non-functional requirements are defined and the data model and data structures are constructed and explained in detail.

iv) Logical System Specification

In this phase, technical system options and logical designs are defined in parallel. In technical system options, hardware and software requirements are defined pertaining to performance, security, and services level requirements that the system wishes to meet. For the logical design enquiry processing and system dialogues are defined.

v) Physical Design

At this phase, a physical database design is created by converting the logical data model to the physical data model. In additional, a set of program specification is further created.

3.4.2 Prototyping

The prototyping method was formally introduced to the information system community in early 1980 to overcome the weakness of structured analysis methods. Haag el at.(2006) state that prototyping is the process of quickly putting together a working model " a prototyping" in order to test various aspects of a design illustrate ideas or features and gather early user feedback. Prototyping is often treated as an integral part of the system design process where it is believed to reduce project risk and cost.

The main purpose for developing prototype is to help users and developers understand the requirements for the system, which are requirements elicitation and requirements validation. The analyst builds the prototype and evaluates it with the user. Next the analytic system development would to see if it fits the user requirement.

3.4.3 Justification for Using the Selected System Development Methodology for CW-MSLD System

After having studied the system development methodology and techniques which should be used for development of the system, the developer found that a combination between SSADM and prototyping is a good system development methodology. That because the user requirements are fuzzy and the system is complex.

Firstly, prototyping is used to determine the initial or basic requirements for the system i.e. the user requirements. Prototyping enables easy communication between the users and the developer and therefore it can reduce communication problem that commonly exist in requirement gathering. During this period, the user can give a feedback to the developer about their ideas and the system interfaces for the proposed system, this lead to reduce the time and costs for developing the system and improve system usability.

In this way, the delivered system will be more accurate on the user requires. One the main weakness for this method is the management problem whereby it is very hard to set deadlines for completing the system.

Secondly, SSADM becomes a structured methodology when it is combined with the prototyping model; the resulting approach on system development is more disciplined and provides more guidance. This step by step approach gives a clear vision and understanding of the various stages that we need to conduct during developing the system. SSADM allows the correction of development errors before it proceeds to the next phase and hence there will be fewer errors at the final phase. Figure 3.4 shows SSADM and Prototyping for CW-MSLD System.

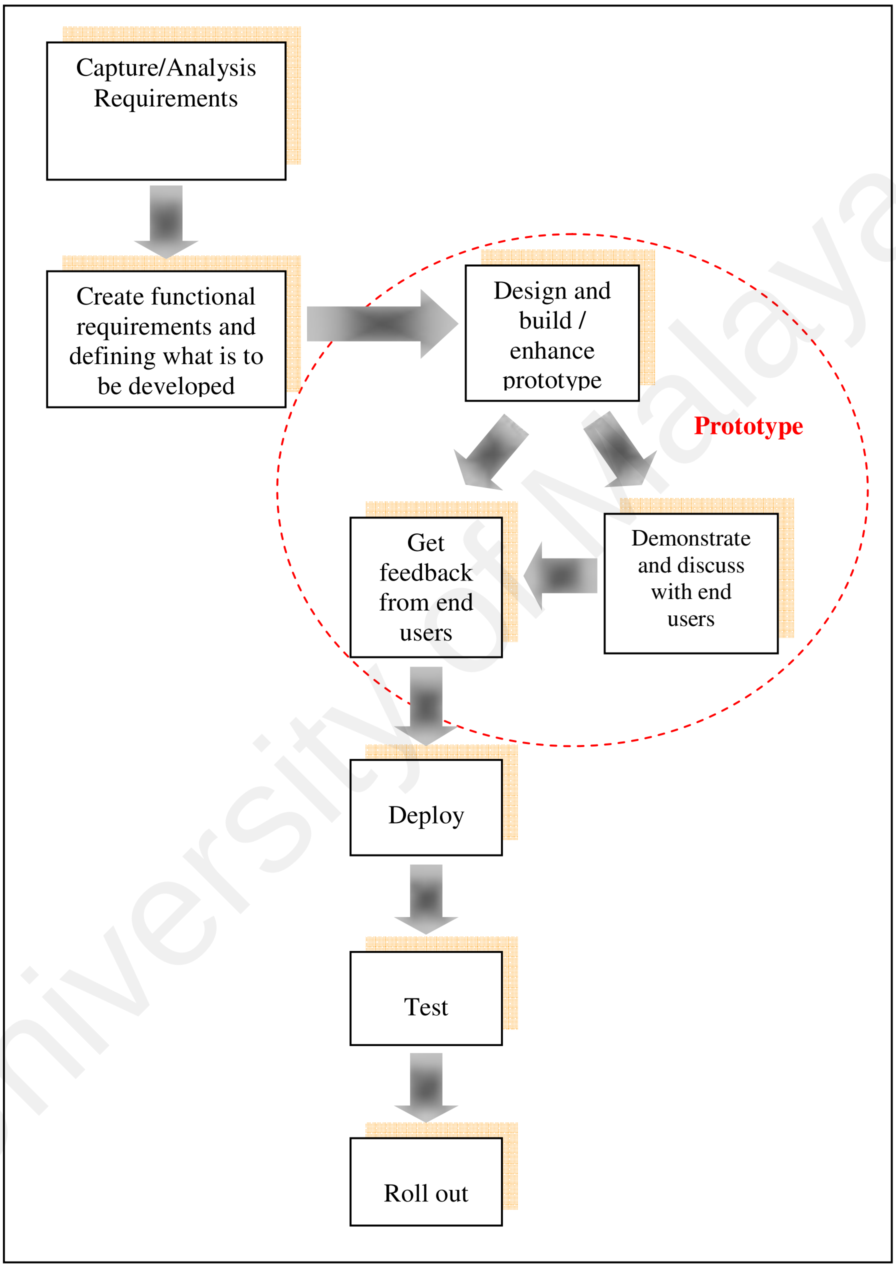


Figure 3.4: SSADM and Prototyping for CW-MSLD System

3.4.4 Map Digitizing

This research has two types of data: non-geographic data (attribute data) and geographic data (special data). Non-geographic for land registration such as owners' name, description of building, type of owner and so on which can be captured and collected by using the above technique. Geographic data can be obtained by using the map digitizing. Map digitizing is a process for converting raster data (map) into vector data (digital form) by using GIS software like Arc/Info. Map data used by GIS are collected from existing maps, aerial photos, satellite image, and other sources. The map data for this research obtained from

- Shari Az-zawiyah Street satellite image (QuikBird resolution: 60cm) from Libyan Center for Remote Sensing & Space Science.
- Shari Az-zawiyah street hard copy map scale (1:1000) from Libyan Survey Department.

This transformation from raster map to vector map allows the storage, retrieval, and analysis of the mapped data to be performed by the computer. C*hapter5 will explain more about the map digitizing and how to analyze it.*

3.4.5 Entity Modeling and Normalization

Entity Modeling or Entity Relationship Model(ER-Model) is a common technique used to model data requirements for information system in many methodologies in a top-down approach in graphical form called ER diagram (Bagui and Earp, 2003). This approach is commonly used in relational database design (RDBMS) but there are limitations to the ER model. ER model enhanced (EER) to include superclass/subclass relationships, type inheritance, specialization and generalization, and constraints. The Normalization process comes after having completed the ER-Model. Normalization is a set of rules to eliminate data redundancy and to remove potential update anomalies which arise from inserting, modifying and deleting data *(For more detail see Chapter 5- Section 5.3.1.2).*

3.4.6 Data Process

3.4.6.1 Data Flow Diagram (DFD)

DeMarco(1979) states that DFD as a network representation of a system. The system may be automated, manual, or mixed. The DFD portrays the system in terms of its component pieces, with all interfaces among the components indicated.

DFD is one of the essential techniques in structured system methodologies and adapted by others methodologies. DFD is a graphic diagram for representing data process flow in the analysis phase. It makes dissections between users and developers very easy and users can understand problem domain and clear dissections will lead to good development of the system requirements. *(For more detail see Chapter 5- Section 5.2.2.1).*

3.5 Prototype Development Tools

Olle et al. (1991) defined the tools as a computer-based application which supports the use of a modeling technique. Tool-supported modeling functionality includes abstraction of the object system into models, checking that models are consistent, converting results from one form of model and representation to another, and providing specifications for review.

i) **Microsoft Word** is main word processing software. It is used for documents.

ii) **Microsoft Visio** is a drawing software used to draw DFD of the system. Since several DFDs of the system need to be drawn, it is easier to use Visio than using the traditional way of drawing the DFD by using the Microsoft Word.

iii) **Microsoft Excel** is used in producing the bar graph.

iv) **Arc/Info** is the complete GIS product to build a comprehensive desktop GIS. As a de facto standard for GIS professionals, ArcInfo provides tools for data integration and management, visualization, spatial modeling and analysis, and high-end cartography.

It supports single-user and multi-user editing and automates complex workflows. This software is from ESRI and it used to gather, build, manage data, and analyze geographic relationships, discover new information, and produce publication-quality maps for cadastral office which can be used as cadastral index map (ESRI, 2005).

v) **MySQL** is an open source RDBMS that relies on SQL for processing the data in the database. MySQL provides APIs for the languages C, C++, Eiffel, Java, Perl, PHP and Python. MySQL is most commonly used for web applications and for embedded applications and has become a popular alternative to proprietary database systems because of its speed and reliability (Syreching, 2002). In this research, the author will use MySQL 4.1 to create non-geographic database and manage all database in the system.

vi) **PHP** is a reflective programming language originally designed for producing dynamic web pages. It is server-side application software but it can be used from command line interface or in standalone graphical applications and it is open source language (Converse, T et al.,2004).The developer selected PHP 5.0 as the main programming language to develop the prototype in this research.

vii) **JavaScript** is an interpreted programming or script language from Netscape. It is used in web site development as server side to do such things as automatically change a formatted date on a web page, cause a link to a page to appear in a popup window and cause text or a graphic image to change during a mouse rollover (Veer, 2005).

viii) **Apache 2.2:** The Apache Software Foundation (ASF) is an open-source software projects. The Apache HTTP is a project of ASF aimed at creating a robust, commercial-grade, and freely-available source code implementation of an HTTP (Web) server (Mohammed, 2002).

ix) **MapServer 4.10** is a CGI program that sits inactive on your web server. When a request is sent to the MapServer, it uses information passed in the request URL and the map file to create an image of the requested map. The request may also return images for legends, scale bars, reference maps, and values passed as CGI variables. It is open source software. It can be greatly extended and customized, and it can be built to support many different input data formats and output types. Figure 3.5 below shows a typical of MapServer application[1].

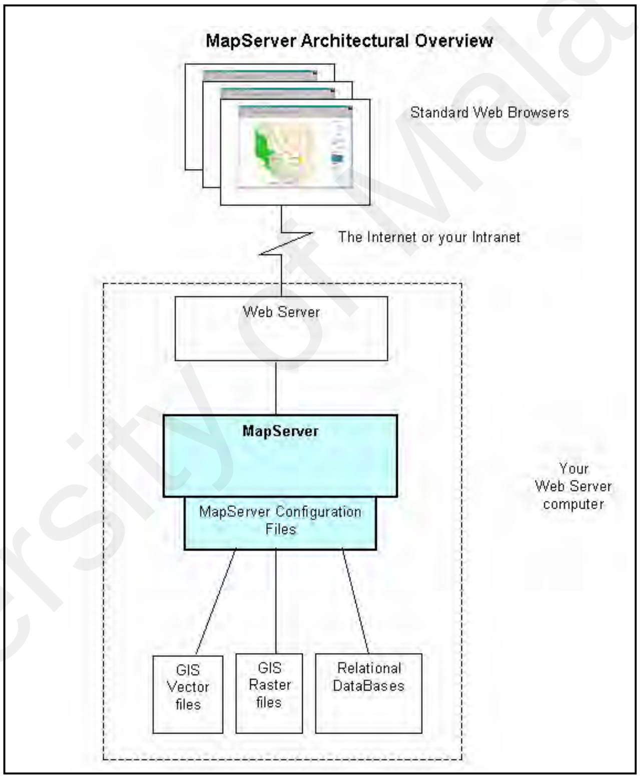


Figure 3.5 Typical of Map Server application

x) **Rosa Applet** is open source that designed with web mapping application to improve server-side web application by adding simple features on the client-side.

[1] Source: http://ms.gis.umn.edu/new_users/msappdiagram/view

3.6 Summary

This chapter has discussed the research methodology, research techniques, and research tools which are used in this dissertation. Research methodology produces the main guidelines for developing CIS in the cadastral office by using GIS techniques. The research techniques are used to collect and capture requirements from end users who were interviewed and observed during work time. Map digitizing is used for data conversion and to create DCDB. The literature review is used to study the previously related research, and other techniques for analysis and process data. The research tools are software package used to develop the computer system.

Chapter Four: Proposed Framework

4.1 Introduction

4.2 Cadastral Information System (CIS) Framework

4.2.1 Justification of proposed CIS Framework

4.2.2 Elements of proposed CIS Framework

4.2.3 Using Proposed CIS Framework for Develop CW-MSLD System Prototype

4.3 Summary

4.1 Introduction

This chapter presents the proposed Cadastral Information System (CIS) framework and it is designed to enhance the development CIS. It has proposed to define data, techniques, organizations partner and other elements. The proposed CIS framework is used to develop this project and it can be used in future to develop a complete CIS.

4.2 Cadastral Information System (CIS) Framework

The CIS framework in Figure 4.1 is based on the study of system environment. The following have been referred to in creating the framework.

i) The Turkish Cadastral Automation System in Turkey.

ii) The Egyptian Cadastral Information Management (ECIM) in Egypt.

iii) Information System of the Cadastre (ISC) in Bulgaria.

iv) Cadastral Reform Project in Malaysia.

The main information gathered from the above mentioned projects include the following.

i) Turkey project: ESRI package software (i.e. ArcInfo, ArcGIS, ArcSDE, ArcIMS and ArcCadastre) is best GIS software that can be used to develop successful CIS.

ii) ECIM Egypt project: the best type of CIS is multipurpose cadastre. It integrates between three databases which are land register database, survey data (DCDB) and taxation database. Multipurpose CIS can address electronic government services.

iii) ISC Bulgaria project: the cadastral mapping scale is very important for the accuracy of data. The compact city needs small scales (i.e. 1:500) for digitizing process.

iv) Cadastral Reform Malaysia project: accurate DCDB depends on accuracy of data acquisition for cadastral survey. The accuracy of data can be obtained by using GPS tools besides fully understanding to survey area.

Even though this framework is proposed to help in the development CIS by using GIS techniques, it can be used to develop a land register system efficiently. It can follow all the framework elements except DCDB element which is suitable for GIS techniques only. The cadastre 2014 (Section 2.3.2) portrays general framework that attempts to obtain the six statement goals for cadastral reform and cadastral system development in future (i.e. 2014). As reported by Henssen (1995) "Cadastre 2014 is a methodically arranged public inventory of data concerning all legal land objects in a certain country or district based on a survey of their boundaries. Such legal land objects are systematically identified by means of some separate designation. They are defined either by private or by public law. The outlines of the property, the identifier (i.e. the grant number) with descriptive data, may show for each separate land object, the nature, size, value and legal rights or restrictions associated with the land object". Finally, the author in this research propose CIS framework to support a developer to set the correct base to develop CIS rather than look for cadastral legislation.

4.2.1 Justification of proposed CIS Framework

In this research, as a first step in investigating trends and proposing framework, the author looked at the existing four cadastral systems project and attempts to define and organize the system requirements for developing a cadastral system. A general framework diagram is shown in Figure 4.1. It is proposed by defining the eight elements that all cadastral system shares and it further defines the recent management tools and techniques used for design and development of cadastral information system.

Basically, the framework identifies the relationships between the eight elements of the framework with one another. First, the developer needs to define the type of CIS based on user requirements and feasibility study for the project where each cadastral system mostly consists of land, people, and legal procedures that need to be followed. Second, the developer needs to select the components based on the type of CIS. For example, if the developer wants to develop the legal cadastral system, then the land register, cadastral surveying and mapping components ought to be selected. Third, the developer needs to capture the necessary data and subsequently select the appropriate software to create the DCDB by digitizing the maps data. For interface design element, the developer needs to use web mapping to fulfill sound GUI requirement. Next, management element needs to organized and next you need to establish the land register, cadastral surveying and mapping data between different departments inside the cadastral office and outside the organization.

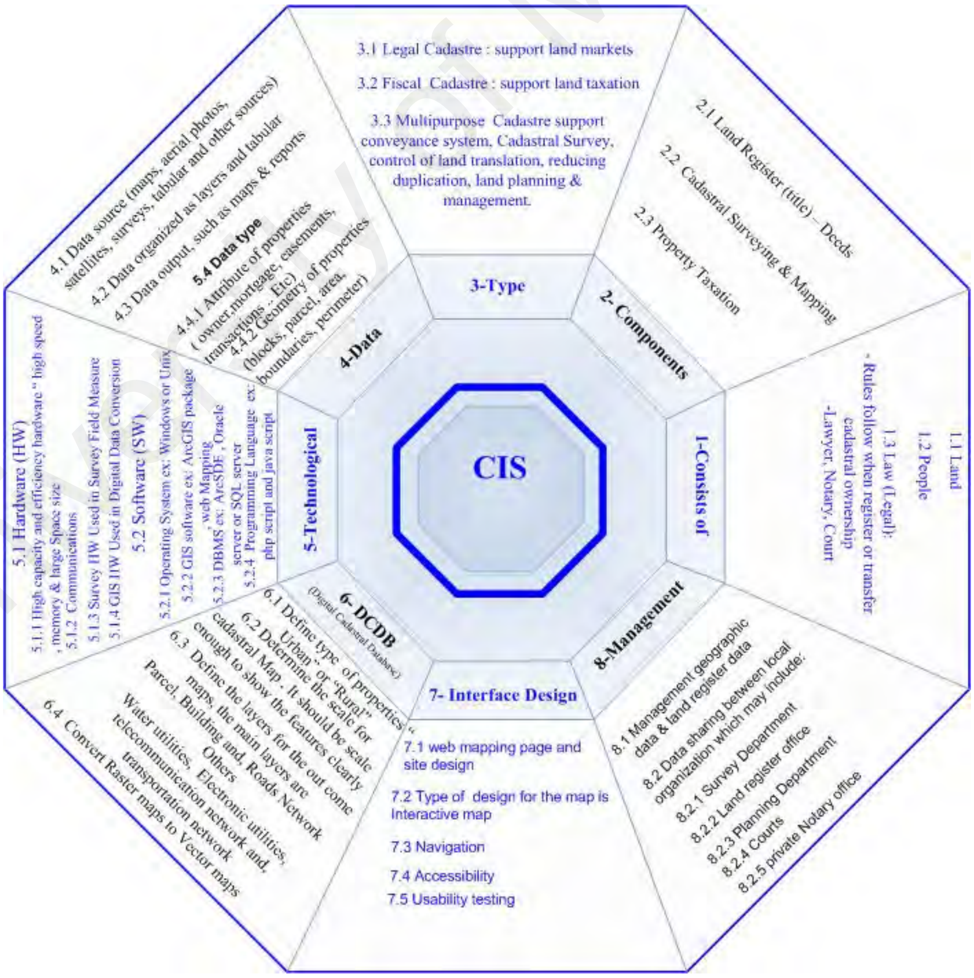


Figure 4.1: Cadastral Information System (CIS) Framework

4.2.2 Elements of proposed CIS Framework

The eight elements for the proposed GIS framework as listed below:

1. **CIS Consists of :** CIS consists of land (location), people (landowner) and law(rules to register and certify the ownership for owner). Landowners users are key components in providing data for CIS. Lawyers and notary users are responsible for certifying the ownership and survey users support the cadastral system with cadastral survey data.
2. **Components of CIS**: CIS components are land register (title/deeds), cadastral surveying and mapping, and property taxation. Each component is a subsystem in CIS and it provides the CIS with specific data. The combination between the three components is used to carry out all registration operations and contracts on land rights.
3. **Type of CIS:** There are three types of CIS namely legal cadastre, fiscal cadastre and multipropse cadastre. The type of CIS used in the early stage of development defines the system domain and services.
4. **Data :** Data requirements must be defined - thinking ahead to future policy developments. CIS includes two types of data which are land register data and survey cadastral data (spatial data). The spatial data can be captured from different resources (i.e. field survey, remote sensing, GPS, aerial photos). The output data for CIS can be maps, tables and reports.
5. **Technology:** CIS require high capacity hardware and network infrastructure (ICT) to enable CIS to be accessed by differnt users on related organizations. The required devlopment software for CIS is GIS software (i.e ArcGIS,Web Mapping, ArcIMS ..etc). The GIS software can be integrated with some programming language such as PHP and Java and the database used includes SQL Server and MySQL. This

integration between GIS software and programming lanaguage helps to develop all user requirments. The technology should support:

- Security, reliability, continuity of service.
- Distribution, publication of data.
- Use of remote access (public or private).
- Data convergence issues.

6. **Digital Cadastral Database (DCDB):** Analogue cadastral data is computerized and store as DCDB. DCDB can be created by digitizing the cadastral map (convert raster maps to vector maps). The map scale should be defined based on the features required for digital map. DCDB allows to store the maps in different layers (i.e. parcel layer, building layer … etc).
7. **Interface Design:**GIS techniques support great interface design to CIS. The users can interact with cadastral map to get cadastral information. Web mapping is a new technique that supports web map design. System accessibility and usability is tested interface design for the CIS.
8. **Management:**Management data is most important issue for CIS. DCDB would improve the management capabilities of cadastral data. The data can be shared between survey departments, land register offices and others organization based on type of CIS that is developed.

4.2.3 Using Proposed CIS Framework for Develop CW-MSLD System Prototype

In this research, the CW-MSLD System prototype is actually a legal cadastre system and the component for this system includes land register (title/deeds), cadastral surveying and mapping. The GIS technology will be used to develop this system and the interface design where web mapping occurs by using open source software. In addition to these is Arc/Info software that is used for creating DCDB.

There are two important benefits for using CIS framework. First, it is considered as a guide to developers helping them in creating a plan of development and defining the system requirements. This can be seen on design of the CIS framework as eight elements with specific properties. The developer can implement the eight element sequence to reach the desired goal. Section (4.2.2) provides more details on the elements of CIS framework.

The second benefit is the ability to define data types. As mentioned before, the cadastral system integrates between attribute data (owner data, mortgage... etc) and spatial data (parcel, area ...etc). The CIS framework defines in shortly data type, data source, and data organized in data element (Element 4) and also points the steps for creating DCDB for the spatial data in DCDB element (Element 6).

4.3 Summary

In summary, setting up the CIS framework is the most important task in developing successful CW-MSLD prototype system. It provides a great guidance to develop a CW-MSLD prototype system in this research and it can be used for developing a complete CIS. The CIS framework consists of eight elements which are type of CIS, components of CIS, data, technological, DCDB, interface design, and management. Furthermore, each element has specific properties to be looked for or gathered. However, the CIS development can provide a user-friendly system with many advantageous functions such as searching on a map to get other textual or visual information. The Common principles for proposed CIS framework will help CIS developers and ultimately staffs in cadastral office, who will be able to benefit from system in their work.

Chapter Five: System Analysis and Design

5.1 Introduction

This chapter does further study of the proposed system analysis and generate the possible models. In analysis phase, the analyzer can understand the needs of the system requirements. The analysis process has to be done properly because many errors in developing systems come from insufficient analysis. Then, it discusses data model design for the system based on the user requirements to develop the fully functional system. In the next stage, the system architecture for system prototyping will be produced.

5.2 System Analysis

The main two components in the system analysis are requirements specification and requirements structuring. Requirements specification is divided into several parts: user requirements, hardware requirements, software requirements, functional requirements and non-functional requirements.

DFD, Data Dictionary, and EERD are techniques used to represent requirements structuring and it gives a clear description of the system for both user and system developer.

5.2.1 Requirements Specification

Requirements specification is done to help the author to understand the system and it can be used as reference for developing the CW-MSLD System. Once the author can determine the requirements for the proposed system then the development of the system can be done successfully.

5.2.1.1 User Requirements

- CW-MSLD System should enable the staff to search the parcel or building by selected the parcel from map or enter Parcel ID or owner's name.

- The user interface should be simple and easy to use.
- The system is available in a website in an Internet environment.
- The system should enable the staff to register and update real estate data.
- System should enable the staff to transfer ownership.
- Staff can update the customer "owner" information.
- System should able the user to see some information on the map like parcel areas and the public places name's and area.
- System should be able to issue cadastral certificate to real estate "cadastral".
- System should be able to register the staff who issued the cadastre certificate.

5.2.1.2 Hardware Requirements

To develop the CW-MSLD System, the author recommends the following hardware to support this system. The following are the minimum requirements for this project:

- Intel Pentium IV Processor 1.7 GHz.
- 20 GB hard disk.
- 512 MB RAM.
- 4.7 GB DVD-Rom drive.
- 17" SVGA monitor (helps to do map digitizing).
- Mouse.
- Keyboard.
- Color Printer.
- Scanner for scanning the hard map.

5.2.1.3 Software Requirements

The required software for developing this system is listed in Chapter Three *(Section 3.5 Prototype Development Tools).*

5.2.1.4 Functional Requirements

Functional requirements describe what a system does or is expected to do. It is often referred as its functionality (Bennett et al., 2002). It is the activities that the system must perform. The basic functional requirements in this system are:

- Allow the registered staff to login into the system.
- Allow the staff to register building or parcel fund on the cadastral map only.
- Allow the staff to add new owner.
- Allow the staff to transfers ownership.
- Allow the staff to check registered information before issuing a certificate.
- Allow the manager of land register department to issue certificate.

5.2.1.5 Nonfunctional Requirements

Non functional requirement are those that describe aspects of the system that are concerned with how well it provides the functional requirements (Bennett et al., 2002). The basic Non functional requirements in the system are as follows:

- The user interface should be simple.
- Ease to use of the Graphical User Interface (GUI).
- Able to connect to WAN network via Internet environment.
- Security considerations: an authentication and authorization process is vital to CW-MSLD System to protect its use from unauthorized users to access the cadastral information.

5.2.2 Requirements Structure

Requirements structure is a method which structures the data and information gathered and it gives a clear description of the current system operations and the new system requirements by modeling it in diagrams form for easy determination and understanding.

The author has defined two structuring methods for this research which are process and conceptual modeling.

5.2.2.1 Process Modeling

Process modeling represents the processes involved in a system graphically in the form diagram. Functional decomposition is the basic technique for process modeling .i.e. it breaks a complex problem into more successive layers of more manageable and comprehensive pieces, resulting in a hierarchically structured function chart that describes the problem and/or solution (Borysowich, 2007). As we have mentioned in chapter three, DFD techniques have been selected to represent process modeling for CW-MSLD System. DFDs show how data moves through an information system but does not show program logic or processing steps (Shelly et al., 1998).

i) Element of Data Flow Diagram (DFD)

There are four elements used to represent data process in DFD. These are representing processes, data flows, data stores, and external entities. There are different superficially versions of DFDs but in practice the difference are relatively miner. This research use Gane and Sarson version.

ii) DFD Level

The DFDs show the data process in different levels according to degree of abstraction required. The high DFD level is called context diagram. It is contains the main process and shows the interfaces between the system under development and the external entities. The next level called the level1 gives more details compared to high level. The Level1 process should describe only the main functional areas of the system. Next, the Level2 diagram comes to describes more details to than the level (level1). DFD has top-down characteristics.

iii) Data Dictionary

The data dictionary defines every data flow (arrow), process, external entity, and data element that the researcher has used in DFD. In other words, Data Dictionary is an organized description list or table of data elements, data structures, data flows, and data stores. *Complete DFD diagrams and Data dictionary for CW-MSLD System are stated in Appendix I and II.*

5.2.2.2 Conceptual Data Modeling

Conceptual Data Modeling is the first stage in the process of Top-down database design. This model is used to show definitions, structures and relationships between data. Data model is important and it needed for data elements in database designing, programs and even the user interfaces. It should make it easy to see the overall picture of the organization.

An Enhanced Entity Relationship model (EERD) is used in this research. That is because the cadastral system is very complex and a normal ERD can not represent the system clearly. EERD can represent such as generalizations and specializations (class hierarchies). The notation version used for this is BACHMAN notation. *To see a full EER diagram for CW-MSLD System please refers to appendix III and Table Structure appendix IV.*

5.2.3 Map Digitizing

Map digitizing is the main process used to convert an analog map into a digital form (X, Y coordinates) by geographic information system (GIS) software. At this point, the map can be stored and displayed in a computer. The real world objects are represented as shapes “Polygon”, lines “Arc”, and points “Node”. Using digitizing software requires precise pointing for selecting objects and the accuracy of work is very important in the digitizing process. The selection tools are mouse and screen for presenting map.

In this research, the developer scanned the map and is used the mouse and screen to digitize the map manually (one by one) by using Arc/Info software. The main steps for digitizing a map are as follows:

5.2.3.1 Map Layers Definition

The real world is very complex and very wide and maps in general are not able to project or describe in detail all the features found in it. Maps layers however are able to identify human problem in relation to objects and physical features. The main features in this research are parcels, buildings and roads. The roads help to describe the boundary and address of a parcel.

5.2.3.2 Map Projection Definition

According to Boslstad (2005), maps are flat, but the surfaces they represent are curved. Projection is processing to transfer three-dimensional space onto a two dimensional space. In order to transfer the information onto a flat surface one can convert the geographic coordinates into an X and Y coordinate system, where X is longitude and Y is latitude. Figure 5.1 shows the representation of map projection.

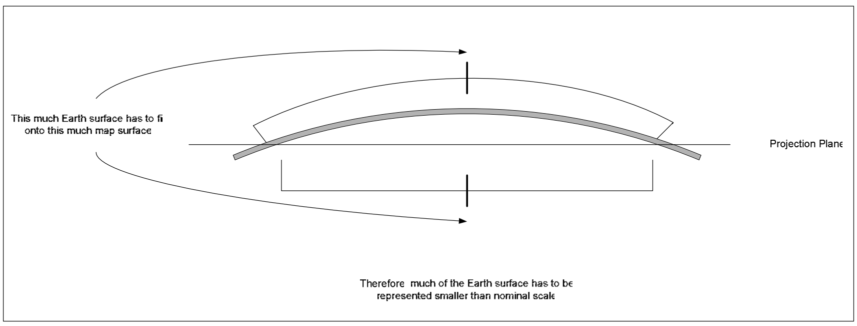


Figure 5.1: Map Projection

The coordinate system in map source is used in UTM projection. UTM is a commonly coordinate system used for large scale and it UTM divides the earth into 60 Zones and the standard line is a meridian (Mitchell, 2005), the study area "Tripoli" is in zone 32. Figure 5.2 shows the representation of UTM zone map.

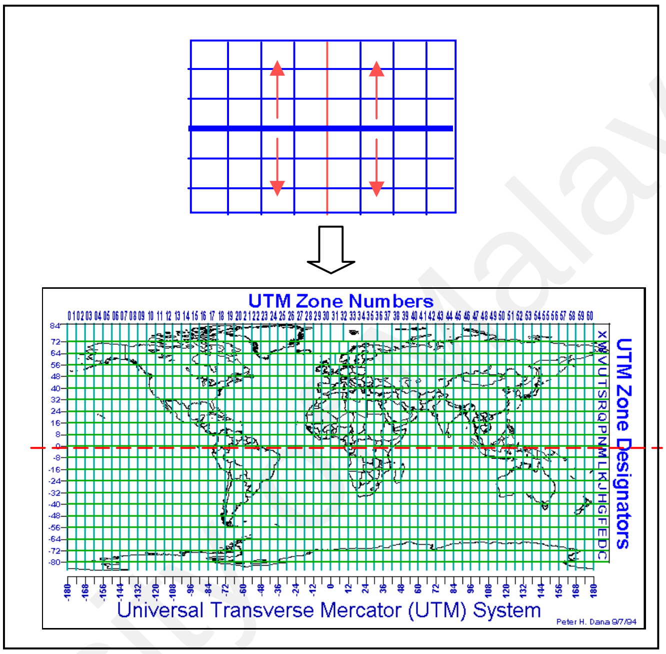


Figure 5.2: UTM Zone Map

5.2.3.3 Map Geo-referencing Definition

The first step in the digitizing process defines the geo-reference[1] point for the area since all information must be linked to the Earth's surface. The geo-reference in this study is taken from intersections of grid line for four corners of map scale 1:1000 for urban area this is appended in appendix Input Data Map (VI):

i) Identify x, y coordinates in meters.

ii) Registering a map is done by clicking on control points (TIC) on the map from screen and transfer scanned map to real coordinates. The control points refer to longitude and

[1] *Geo-reference :* The word was originally used to describe the process of *referencing* a map image to a *geo*graphic location.

latitude and this is saved in a table. Figure 5.3 shows the reference control pointes coordinate for a pilot study in this research study.

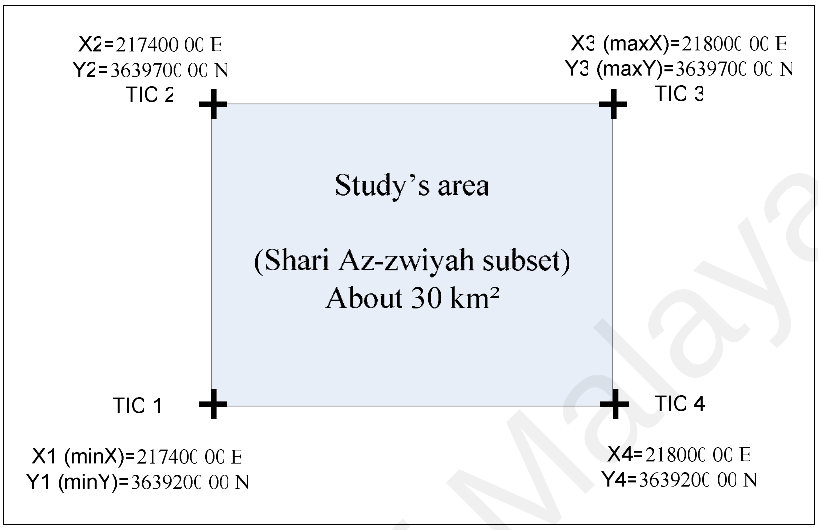


Figure 5.3: TIC points for Shari Az-zwiyah subset (Tripoli-Libya)

5.2.3.4 Digitizing and Topology

The Digitizing process starts after the user has scanned the map and registered it. The following steps are carried out:

i) Zoom in to specific areas on screen and trace the objects "features" as points, lines or polygon on the map. For example in the parcel layer (coverage file), we trace the boundary of parcel to draw line from the center of line boundary on map. The result will be a new polygon.

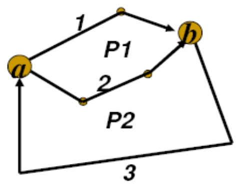
ii) Identify the ID for every parcel and building that is stored in the database.

iii) Arc/Info software allows to correct and create geographic object

iv) The topology used represents the structuring of coordinate data that answers the following questions and is explained by this example below.

- Where is it? Location (X, Y coordinate).

- What is it next to? Adjacency (line 1 goes from node a to node b, Polygon P1 is left line 2 and right line 1). Figure 5.4 shows the illustration of topology idea.
- Is it inside or outside? Containment (Polygon P1,P2).
- How far is it from something else? Connectivity (point a connect to point b).



Line	FromNode	ToNode	LeftPolygon	RightPolygon
1	a	b	0	P1
2	a	b	P1	P2
3	b	a	0	P2

Figure 5.4: Illustration of topology idea

5- The digitizing process often has errors and Arc/Info have provides help to correct error and cleaning up coverage file.

6- Ending of digitizing, result in three files. For example in Parcel layer have parcel.shp, parcel.dbf, and parcel.shx.

- shp file (geometry): stores geographic objects such as parcel shapes "polygon".
- dpf file(database): stores data about geographic objects such as Parcel ID, parcel area ... etc.
- shx file: stores index number that links parcel.shp file and parcel.dpf file.

By creating these three files, the layer will be ready to link with other attribute information like the owner data file.

5.3 System Design

In the logical design and physical phases, the author is concerned on the creation of the CW-MSLD System while implementing the requirements and constraints gathered during the analysis phase. The system design is separated into two parts:

5.3.1 Logical design

Logical design is the development of the CW-MSLD System based on understanding of how the system will operate. During this phase, the users will know how the system will look like. The author will described all the systems' inputs, outputs and interfaces that will appear in the system and display through diagram a brief view of the proposed system to the user.

In logical design, the author is only concern in designing and developing interfaces "web pages", reports, and message dialogues based on user requirements and priorities to create the interfaces, reports, and message dialogues.

5.3.1.1 System Interface Design:

The produced webpage and reports would be need in new CIS. Interface design is very important for the user because the user often judges the quality of the system with it. The system has a friendly user interface which is designed by using GIS techniques. This interface has real coordinated cadastral map that provides useful and relevant information for the users. The cadastral map is interactive map**.** The three layouts interface design is given below:

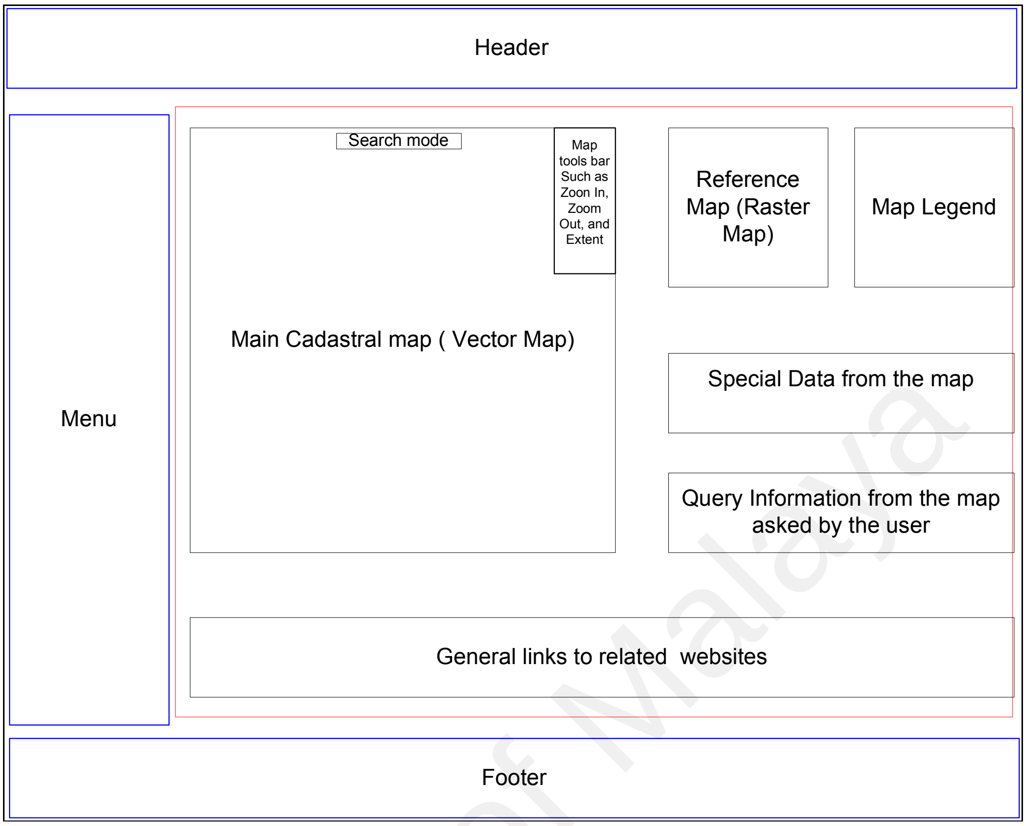


Figure 5.5: Interface layout for Cadastral Index Map web page

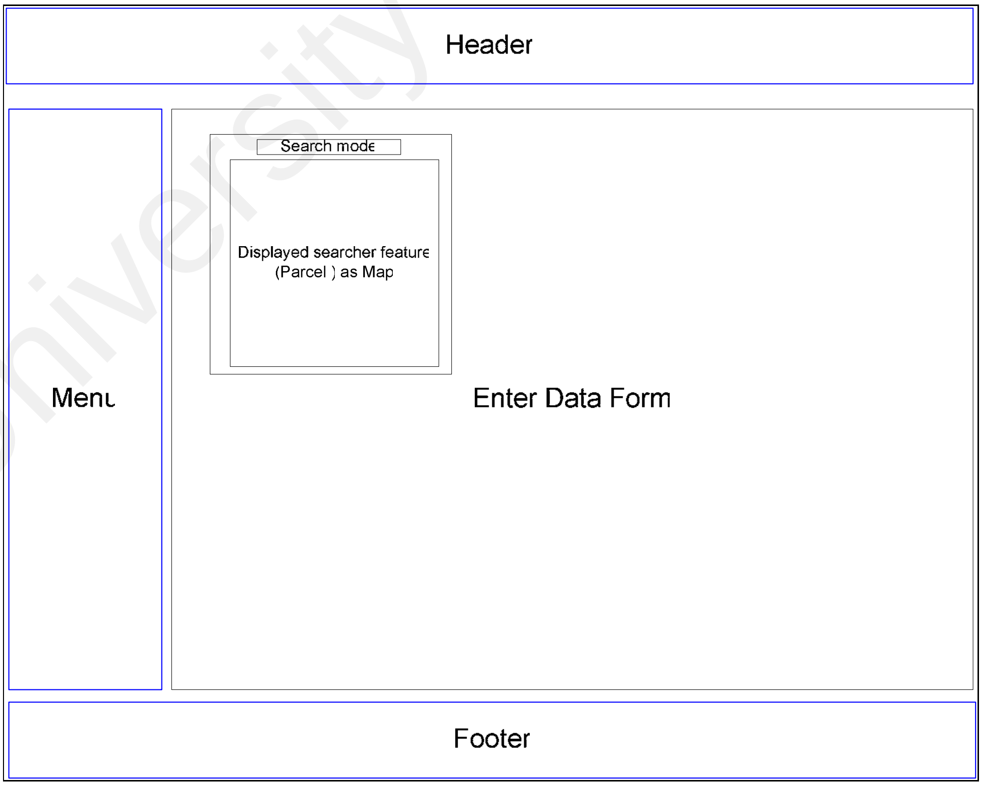


Figure 5.6: Interface layout for Register and Update Estate

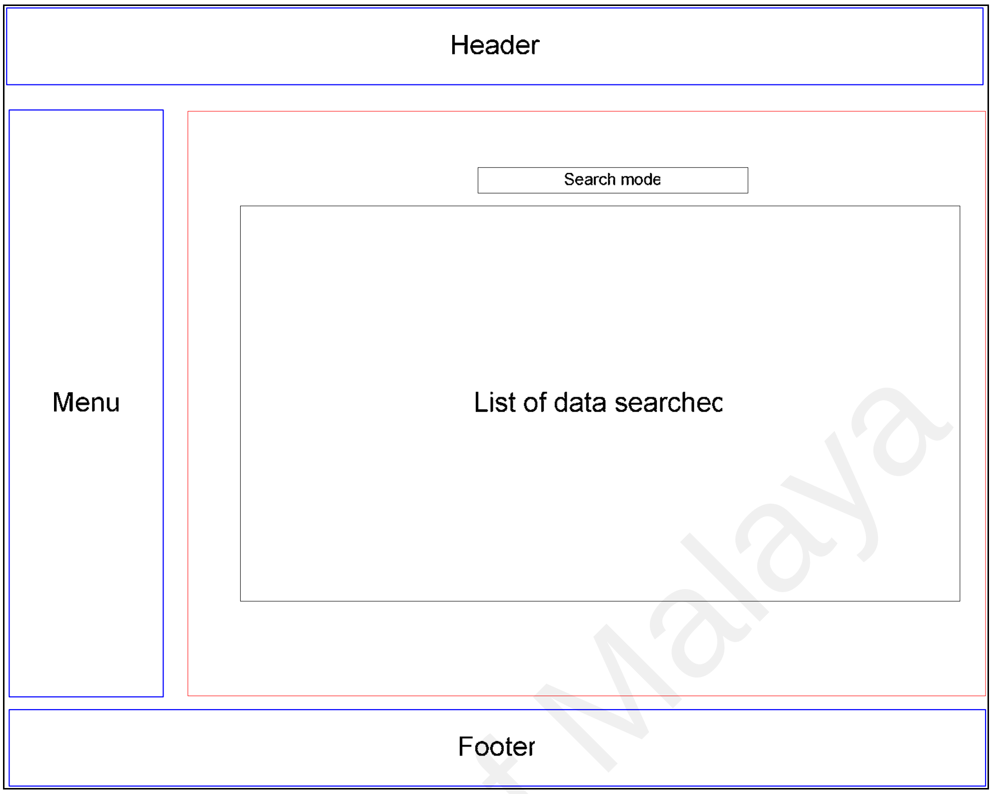


Figure 5.7: Interface layout for display list of data with research mode module

To see a full scale of User Interface Design, please refer to appendix V- CW-MSLD System User Guide.

5.3.1.2 Databases Design (Logical Data Modeling):

In the first stage of logical modeling the conceptual schema will map the logical schema. The conceptual schema done in the analysis phase and the author designed EERD data model is capture the essential data that needed to be stored and the relationships between elements. But this is not the final phase for database design. The logical schema becomes to a normalized representation of the conceptual schema by minimizing redundancy in the data and leveraged relational concepts.

i) Normalization

"Normalization is a formal technique used to evaluate the quality of a relational database schema. It usually determines whether a database schema contains any of the "wrong"

kinds of redundancy and defines specific methods to eliminate that redundancy", (Satzinger et al., 2004).

The 1NF, 2NF, 3NF, and BCNF steps of Normalization were applied onto data model relations whenever necessary. The database relations, attributes, and primary keys were determined at the end of this operation. Therefore, the tables are normalized.

ii) Table Structure

Table structure contains information of the fields and data type of each table. Besides that, it also shows the relations between each table and the access type, size, record description, data type and range of each data used in the database. *A full scale of table structure can be referred in appendix IV.*

5.3.2 Physical Design

Physical design is often concerned with databases, programming and development of the system environments. During this time, the author tries to design the most appropriate design that will satisfy the requirements gathered by the users and their system internal and external environment.

5.4 CW-MSLD System Architecture

The selection of system architecture or development approach can be critical in ensuring that a system will meet changing demands of an organization. Therefore, scalability and the total cost are important factors which should be considered here.

The system architecture for implementing this project is web mapping client/server application system. This system architecture is chosen based on system analysis and CIS framework understanding. The CW-MSLD System Client-Server architecture is depicted in Figure 5.8.

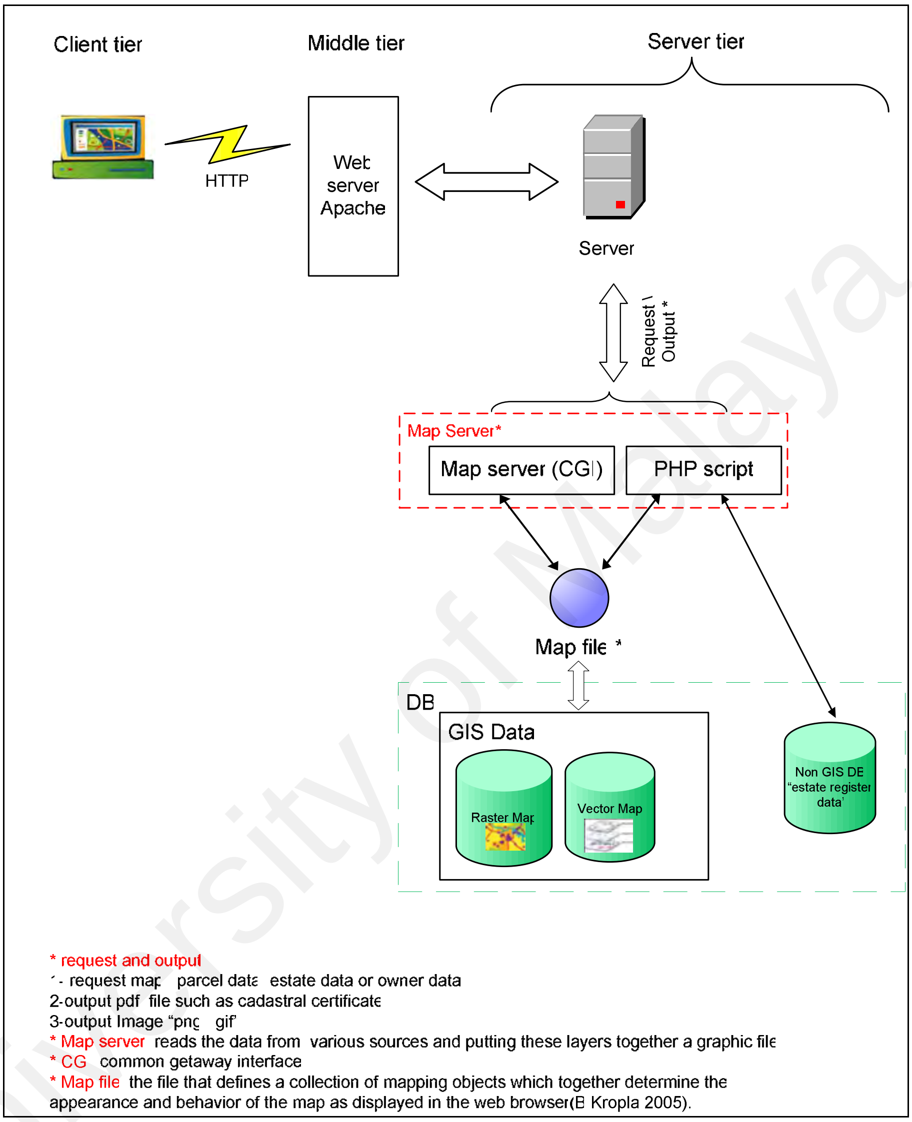


Figure 5.8: CW-MSLD System Architecture

CW-MSLD System architecture consists of three main tiers that show the interaction between application function that is transmitted. The tiers are client side (users), web server apache (middle tier), and server side (information management tier). The server side manages all system parts which are map server (CGI), PHP script, map files and database (GIS data and Non GIS data).

5.5 Summary

In this chapter, the researcher has defined and specified the data requirements, structure, and system design. Requirements structure has been defined by DFD, data dictionary and EERD techniques. Besides that, the map layers have been defined and digitized. By setting a clear requirement for the system it can prevent determine the scope in future and it can be used to measure the performance of the system and find out of the system developed had met with the previous planned or set requirements.

Chapter Six: System Testing and Implementation

6.1 Introduction

This chapter illustrates the system testing and implementation phases. The testing phase involves some modification to the pervious design phase and system testing has been done to minimize the programming and system error. At the implementation phase, system requirements such as hardware and software will be defined. Besides that, the system prototype interfaces and functionalities (module) will be fully demonstrated to users.

6.2 System Testing

Testing the system is a very important stage to ensure that all system requirements have been developed without errors. System testing can be done through some stages. The first stage is called unit testing or component testing and this testing done during the development of the system. Each component, script or module test isolates from other component or unit by checking the input and output for it.

The second stage is called integration testing. The integration between components will be tested and in case there are any errors the components will be tested again. The third stage is called user acceptance testing and this testing done by users who request to develop the system. The third stage is called security testing. The final stage is called user acceptance testing and this testing done by users who request to develop the system.

6.2.1 Unit Testing

Unit testing focuses on testing module, script or component that has been designed by PHP, JavaScript, or Rosa Applet. For example, the developer tested the map tools button functionality such as Zoom in on a map or obtain information when clicking on the map by using Identify button that is designed by using Rosa Applet.

6.2.2 Integration Testing

After the unit testing has been done with satisfaction for each component or script, the integration testing is started to ensure the CW-MSLD System components worked together smoothly. The functional and non-functional requirements were tested in this stage. One example for integration testing is to search the parcel model by entering the parcel ID and if the GIS database has the parcel requested, the system will display it and it can use the data given to register new real estate.

6.2.3 User Acceptance Testing

User acceptance testing is the final stage of testing before CW-MSLD System begins to be implemented by the user. The potential users evaluate the system to reveal the errors and omissions of system requirements that were defined in early stage developing the system. A total of 10 questionnaires were given out in Tripoli Cadastral Office to evaluate all the functions available in the system. The questionnaires were distributed to the staffs in early March 2007 and collected after test the system. The completed questionnaires revealed valuable information that enabled to evaluate the functional and nonfunctional requirements for the CW-MSLD system. User Acceptance Questionnaire is appended in appendix (VII).

6.2.4.1 User Testing and Analysis of the Questionnaires

The user guide was submitted to the users with the evaluation questionnaires after the users had used the system**.** The system was tested by six users and analyses of the questionnaires were done.

i) Analysis of User Interface Evaluation

Working with user interface any system is dependent on users' computer background and understanding of the system environment. Based on the evaluation, the system was found to be easy to use. The highest rating mean of 4.2 indicates that searching on the map to get information is easy. The results were converted into a bar chart in Figure 6.1 to show more clearly.

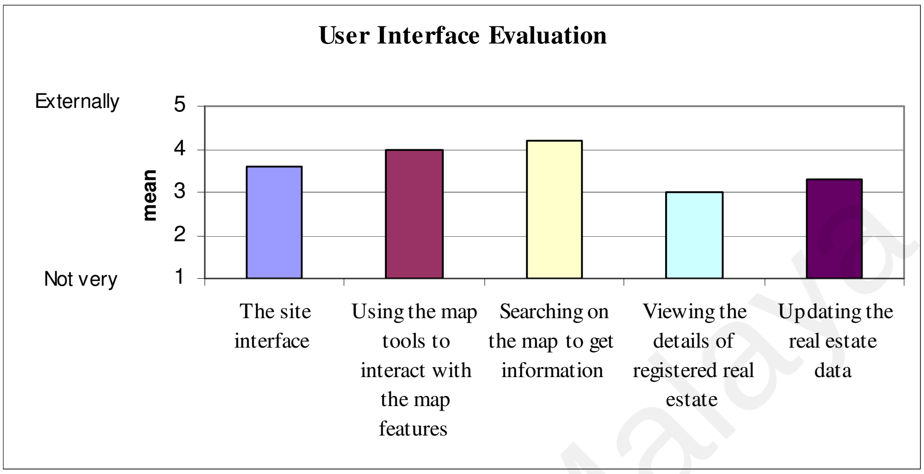


Figure 6.1: User interface evaluation bar chart

The bar chart in Figure 6.2 shows the evaluation for user interface satisfaction. The bar chart clearly indicates that the users are satisfied by with using the help tools.

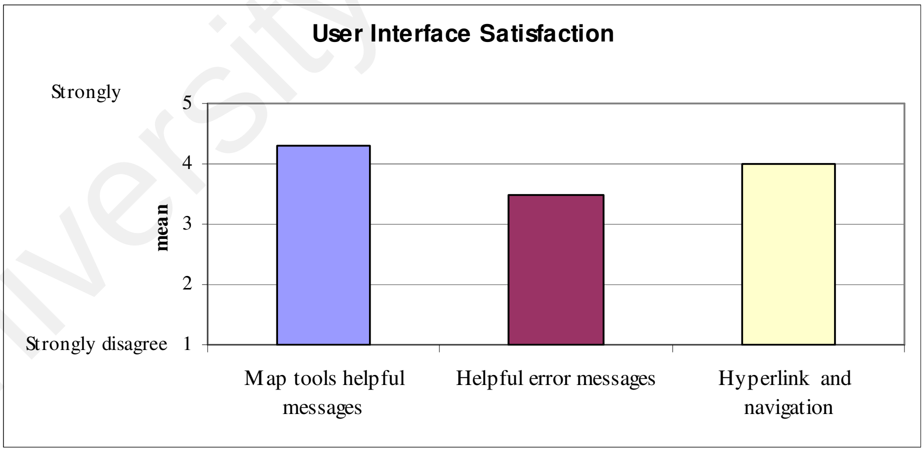


Figure 6.2: User interface satisfaction bar chart

ii) Analysis of Evaluation Pertaining to Features

Figure 6.3 shows the evaluation of testing the accuracy of geographic data (map) as the data accuracy is the most important part of a successful GIS application. The bar chart indicates a good frequency for testing the accuracy for the parcel's area, boundary, and location.

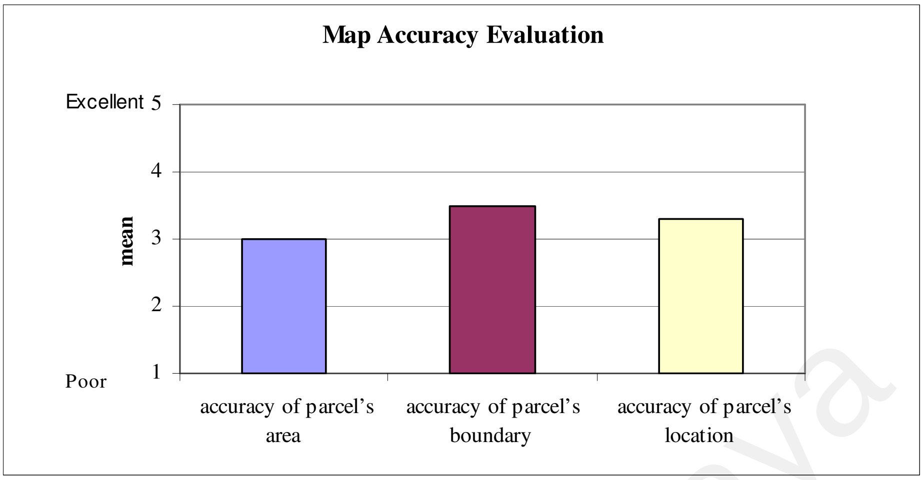


Figure 6.3: Map accuracy evaluation bar chart

The results obtained from analysis of available features on the system is depicted in Table 6.1

Table 6.1: Available features on the CW-MSLD System

No	Statement	Available
1	Administrator able to add new user to login to the system	√
2	Access control for authorized user to login to the system	√
3	Administrator able to monitor the login users to system	√
4	Working with real coordinates map	√
5	Use the map to get requested parcel	√
6	The system able to register the parcel not included on the map	
7	Updating certificate information before issuing certificate	√
8	The system able to register a whole cadastral (parcel/building)	√
9	The system able to register subdivides cadastral (parcel/building)	
10	The system able to transfer ownership for registered real estate	√

6.3 System Implementation

System implementation describes the development tools that have been used in developing this system. The guidelines for using the CW-MSLD System will be given.

6.3.1 System Development

This section describes the programming language and tools that have been used to develop CW-MSLD System. The system developed as web mapping page makes use of the map server and PHP as the core programming language techniques. Besides that, the JavaScript and Rosa Applet have been used to help the system interfaces become more interesting and easy to use. For example the Rosa Applet tools used image button tools that help the user interact with the map in easy ways such as ZOOM IN, ZOOM OUT …etc.

The RDBMS used to build attribute data for this system is MySQL and for the map data (geographic data) are stored in three types of files that relate with each other to produce the vector map such as parcel layer. The merge between the attribute data and map data is done by using map server techniques.

6.3.1.1 Coding

Coding is the process of turning design of the web mapping for cadastral information system into specific instructions that the computer system can understand and execute (Gary et al., 2001). The initial unit testing and integration testing for a functional prototype model was done after having written the codes. As mention in Section 6.2.1, the system has been written using PHP script, MapServer, JavaScript, Rosa Applet and MySQL database management.

In this section, the author will present some parts from a mapfile. The mapfile defines a collection of mapping objects that together determine the appearance and behavior of the map as displayed in the web browser (Kropla, 2005).

In the code snippet below, the first line sets the name of the map to cis; the keywords UNITS define map unit where the map size that is displayed is defined in pixels by using keywords SIZE. Similarly, the keyword EXTENT sets the extent for the whole map (Xmin, Ymin, Xmax, Ymax). The IMAGECOLOR keyword line 5 defines the background for the map image and the image format defines using IMGETYPE keywords line 6. The keyword SHAPEPATH line 7 tells MapServer where to find the shpefiles data.

```
1.   Name "cis"
2.   UNITS METERS
3.   EXTENT 217400.00 3639200.00 218000.00 3639700.00
4.   SIZE 400 300
5.   IMAGECOLOR 255 255 255
6.   IMAGETYPE GIF
7.   SHAPEPATH "/ms4w/var/www/htdocs/data/"
8.   FONTSET "/ms4w/var/www/htdocs/etc/fontset.txt"
```

In the code snippet below, the lines from 94 to 99 define query map object which highlights the special results on the map image when querying special database so that the user is able to see the query result highlighted by using different colours. As seen on line 98, the query map is highlighted using yellow color.

```
94.  # Query Map
95.  QUERYMAP
96.  STATUS on              # draw query map
97.  STYLE HILITE           # highlight selected feature
98.  COLOR 255 255 0        # in yellow
99.  END
```

In the next code snippet, in lines 103 through 131define the parcel layer which starts with Layer keyword at line 103 and finished with END keyword at line 131; the NAME keyword at line 103 sets parcel's name that is used in MapServer; the METADATA defined in lines 105 through 108 allows the data to be stored as name value accessible by template tags file in line 129.

A polygon layer name parcel line 103 is specified in lines 109 through line 111. It retrieves its spatial data form a shapefile named parcel. The "PARCEL_ID" item in data set will be used to label the feature. The label properties are defined in lines 119 though 128 under

CLASS object. The layer style is defined using STYLE object in lines 155 through 188 which sets the filling colour and outline colour for parcel layer.

```
103. LAYER
104. NAME "parcel"
105. METADATA
106.      "ESCRIPTION"   "Cadastral"
107.      "RESULT_FIELDS" "PARCEL_ID AREA PERIMETER"
108. END

109. STATUS on
110. TYPE polygon
111. DATA "parcel"

112. LABELCACHE on
113. LABELITEM "PARCEL_ID"
114.
115. CLASS
116.     STYLE
117.         COLOR 238 232 170
118.         OUTLINECOLOR 222 184 135
119.     END # end style

120.    LABEL
121.        TYPE truetype                  # use truetype font
122.        FONT "arial"                   # use arial bold
123.        SIZE 6                         # use 6 point szie
124.        COLOR 0 0 0                    # color text black
125.        BACKGROUNDCOLOR 255 255 255    # render text on white background
126.        MINDISTANCE 50                 # labels > 50 pixels apart
127.       POSITION cc                     # labels in center of feature
128.       ANTIALIAS true                  # antialias the text
129.    END # end label

130.   TEMPLATE "/ms4w/var/www/htdocs/templates/parcel.html"
131. END # class
132. END  #Layer
```

6.3.2 System Security

The system security is very essential to this system especially when the system is running on the internet environment network. Users are grouped into three groups. At the highest level is the system administrator and second level or group is the manager and the last group members are the registered staff users. Valid user ID and password are required whenever a user access the system. This is to prevent unauthorized users from using the system. The specific models for each group are explained in the user guide appendix on Page 106.

6.3.3 CW-MSLD System Implementation

This section presents the system interfaces for each module and the functionality for it. The system actually has three types of users which are manager, staff and administrator. The Figure 6.4 shows the system modules tree based on user's type

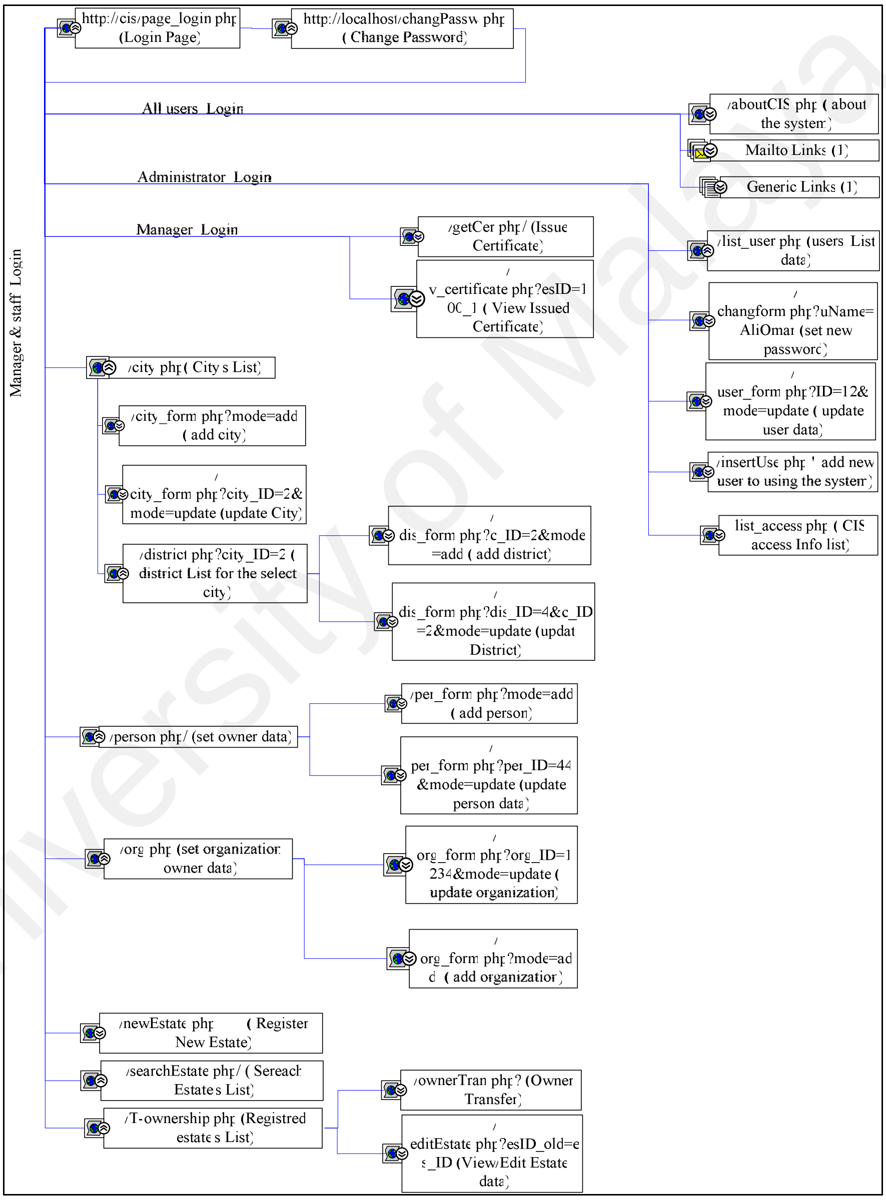


Figure 6.4: System Modules Tree

To see the implementation function for each model, please refer to *appendix V: CW-MSLD System User Guide.*

6.4 Summary

In summary, this chapter investigated the system testing and implementation. It presents the basic types of testing suitable for this system. The system testing started with test unit, followed by testing component or module. Next, integration testing between units or a component was done and finally the system test by the potential users to evaluate the system acceptance was carried out. The end phase in the system development is implementation where the user guide for the modules is shown step by step.

Chapter Seven: Conclusion and Recommendations

7.1 Introduction

This chapter will further discuss the research contributions by determining how CW-MSLD fulfilled the objectives as identified. Next, the system strengths and limitation will be defined. Finally, the recommendation for future enhancement will be proposed.

7.2 Fulfillment of the Objectives

Chapter one presented the research objectives for this research (Section 1.3). In addition, it presented six research questions that were used to guide in achieving the research objectives. This section will answer the research question (Section 1.4) which will aid in fulfilling the objectives.

Objective 1: ***To identify the features of the cadastral information system (CIS).***

Question 1: What is the existing situation in the cadastral office for the provision of cadastral system?

This objective was fulfilled by understanding the cadastral system environment and the system information was gathered by interviewing and observing the staffs in Tripoli Cadastral Office. The interview sessions were presented in Chapter Three (Section 3.3). Next, the developer digitized the map and created the DCDB based on observation of the survey staff during their work. Further discussion on identifying the requirements for survey of cadastral map is made in Sections (3.3.2, 3.3.4). Besides that, the developer created DFDs based on the procedure for registration and transfer of ownership for the cadastral (real estate). Some forms are used to fulfill this requirement in the cadastral office (Section 3.3.4). In addition, EERD model and database design were done to obtain the user requirements (Section 5.3.1.2). Finally, the developer came out with system architecture for development of the prototype (Figure 5.8).

Objective 2: ***To compare the tools and techniques that have been used by some countries to develop CIS.***

Question 2: What are the present tools and techniques that have been used in developing CIS?

Question 3: What are the new tools that can be used to improve the present situation?

The objective is fulfilled by studying the previous studies in CIS and the techniques and tools that were used to develop their projects based on the studies conducted, the author has came out with summary table and this is depicted in chapter two (Table 2.2). The fulfillment of this objective helped the author to identify the tools and techniques for developing the system prototype based on feasibility study and recent techniques available and discussed in Chapter Three (Section 3.4 and 3.5).

Objective 3: ***To propose a framework for CIS based on some existing CIS frameworks.***

Question 4: What are the general specifications that can be outlined in designing the new system based on analysis of the current system?

The proposed framework is obtained by studying the cadastral features, cadastral reform and cadastre 2014 vision which gives a general framework for cadastral. The proposed framework depicted in Figure 4.1 of Chapter Three proposed many options to computerize the day to day cadastral work at cadastral office and it further proposed a secure way of keeping the database up-to-date. The CW-MSLD System prototype measured by the CIS framework includes the following:

i) The CW-MSLD System must consist of land, people and law (legal) partners.

ii) The type of CW-MSLD System is Legal cadastre which supports the land markers such as register and transfers the cadastral by issuing a cadastral certificate for the owner.

iii) A component of the system consists of land register (attribute data) and mapping (special data). Attribute data is ownership data and special data is parcel survey data.

iv) Data for the system uses satellite image (QuickBird resolution: 60 cm) with hardcopy map scale (1:1000) for the study area (Section 3.4.4).

v) Technology: hardware and software requirements are documented in Sections (5.2.1.2 and 5.2.1.3)

vi) DCDB created for the urban area studied are created in three layers which are namely parcel layer, building layer and street layer (Section 5.2.4).

vii) Interface design as web mapping for system included search map and search text queries and the exhibited map is interactive. The system's website supported great image tools that make the system gives clear information from map that are interactive (Section 5.3.1.1).

viii) The system manages geographic data and land register data in the Land Register and Survey Office.

Objective 4: ***To design and develop a web mapping prototype for CIS which issues cadastral certificates for the cadastral (real estate) based on the proposed framework.***

Question 5: What are the needs of users that the system should be able to provide?

Question 6: How does the system work when implemented in a database and GIS?

This objective is fulfilled by developing the web mapping prototype to provide a better computerized solution for the cadastral office in Tripoli-Libya. This system was developed based on the proposed CIS framework. The system requirements and functionality for the web mapping prototype are explained in details in Chapter Five (Section 5.2.2). The interface design and system architecture for CW-MSLD System prototype are explained in detail in Chapter Five (Section 5.3 and 5.4).

CW-MSLD System prototype was developed to increase the efficiency and effectiveness of the daily work on Tripoli Cadastral Office by using the modern GIS techniques (Web Mapping). The current system in office is a manual system. CW-MSLD System works with DCDB and the system can give the location, area, boundaries for any parcel included on the map. The user is able to interact with the cadastral map by using available map-tools on the system.

The search model in the system is not like any other search engine whereby it searches the map to get information. These are the two search models that can be used to get information about the requested parcel. The user can click on a parcel in the map if he or she knows the parcel location. Alternatively, the user can enter parcel ID and click the “Search” button to get the parcel location and other information.

Based on GIS techniques, the system is able to register real estate (cadastral) and transfer the ownership for the registered cadastral. Besides that, the system is able to issue cadastral certificate to the owner and complete the registration without any problem. In addition, the system is able to provide security and save information of the authorized users. The issue of the certificate and the system implementation are discussed in detail in Chapter Six (Section 6.3).

7.3 Significance of the study

This research should have some interest to both researchers and developers of cadastral systems. It has significantly contributed and enriched the body of knowledge in the context of GIS techniques and cadastral survey procedures.

7.3.1 Theoretical Contribution

In order to develop the theoretical framework for the study, several theories and framework had been refereed to. In addition to these, the study and findings obtained from Cadastre 2014 vision were later applied to construct a theoretical framework for CIS. This framework would have tremendous impact on the study of cadastral systems in Middle East countries notably Libya.

7.3.2 Practical Contribution

Approximately two years of research study has resulted in the creation of CW-MSLD prototype system which is web mapping. This prototype tool when refined could be used to replace the archaic manual cadastral that is currently in use. The new computerized cadastral system would put to right the unsound filing practices and resolve the numerous problems pertaining to title deeds.

7.4 System Strengths

CW-MSLD System is a common integrated system that takes into account the land register and cadastral map. The main benefits of the system are listed below:

i) The system is developed based on web mapping techniques to support DCDB as interactive map.

ii) The database is designed to be available to upgrade the modules to merge and subdivide parcels.

iii) The system allows only authorized users to login and use the system.

iv) The system helps the cadastral office to manage daily work and store data on the computer which will lead to better land management and minimize land disputes.

7.5 System Limitation

A few limitations encountered in this research study are listed below:

i) The development of CW-MSLD System prototype has been implemented based on proposed CIS framework. However the measurement of CIS framework validation has not been done in this research. Measures like easy-to-use, satisfaction and accuracy for the framework can be enabled in further research.

ii) The system does not support merge and subdivide parcels because these two modules need to edit the map directly using a GIS software like Arc/Info.

iii) The system does not support upload for building description architecture or map that describes the building design to store in a database.

iv) The data used in this system is based on digitizing the hard-copy map scale 1:1000. To obtain more accurate map data, the digitizing map should be support with the GPS points taken by survey field.

7.6 Recommendation for the Future Enhancement

The following recommendations are forwarded to facilitate and overcome some of the constraints and limitations indicated above in future study:

i) Future studies should create DCDB to cover all Tripoli city area in Libya.

ii) The system should link with other GIS software such as ESRI package like Arc/Info for editing the cadastral map. It should further link with ArcSDE which is used to manage and maintain cadastral database and ArcIMS to manage cadastral data on the internet which would enable subdivision and merging of parcel.

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