Addis Ababa University
Addis Ababa Institute of Technology
School of Civil and Environmental Engineering

3D CADASTRE MODELING

Case Studyof: - ADAMA TOWN

A Thesis Submitted to the School of Graduate Studies of Addis Ababa University

Presented in partial fulfillment of the requirement for the Degree of

Master of Science in Geodesy and Geomatics

(Specialization in Geomatics)

BY

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January/2019

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DECLARATION

I declare that, this thesis entitled "3D CADASTRE MODELING: Case study of: -ADAMA TOWN" is my original work. This thesis has not been presented for any other university and is not concurrently submitted in candidature of any other degree, and that all sources of material used for the thesis have been duly acknowledged.

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Acknowledgments

First of all, I would like to thank the Almighty God, who gave me the commitment and tolerance to pass various obstacles and come up to the accomplishment of this thesis.

I am expressing my deepest appreciation to my advisor, Mr. Andenet Ashagrie (PhD Candidate), for his valuable advice, invaluable suggestions, timely comments, and thorough guidance throughout the work of this thesis.

I would like to express my appreciation to all organizations and individuals who contributed directly or indirectly to this thesis and provided the necessary materials and support for realization of this thesis.

I would like to give my special thanks for my mother and father and all my brothers and sisters whose patience and love enabled me to complete this work.

And last but certainly not the least thanks goes to Betelihem Gadisa, my lovely wife, for her understanding, great patience, support and encouragement, and being the source of inspiration to keep me going.

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List of Acronyms

2D ----------Two Dimensional

3D ---------- Three Dimensional

3DCDM ----3D Cadastral Data Model

BA -------- -Basic Administrative

DBMS ----- Database Management System

FDRE -------Federal Democratic Republic of Ethiopia

FIG - --------International Federation of Survey

FK -----------Foreign Key

GCP ------- Ground Control Point

GIS ---------Geographic Information System

GPS ---------Global Position System

ISO ----------International Standardization Organization

LA -----------Land Administration

LADM ------Land Administration Domain Model

LAS ---------Land Administration System

LDP **---------**Local Development Plan

LIMS -------Land Information Management System

LPO --------Legal Property Object

OGC -------Open Geospatial Consortium

OOP--------Object Oriented Programming

PK –--------Primary Key

PPO -------Physical Property Object

PID –------Parcel Identification number

RRR ------Right, Restriction and Responsibility

RDBMS --Relational Database Management System

UML ------Unified Model Language

Abstract

3D cadaster is a tool in a land administration system to digitally manage and represent stratified rights, restrictions, and responsibilities (legal models) and their corresponding physical models such as buildings, utilities, on, above or under the ground surface in 3D. In Adama Town the registration of land holders in the time being cannot expresses the 3D information and the 3D cadastral data modeling application. Using 2D cadaster data model have no much more importance to clearly register and manage the property of individuals. Due to unregistered 3D objects(Building), individual property has no security, illegal settlements inside the town and around the town increasing time to time, financial institution has no grantee for mortgaging for the individual properties. The aim of this research is to develop 3D Cadaster Data Modeling in case study in Adama in order to digitally represent real property ownership rights, restrictions, and responsibilities (legal models) and their physical counterparts to secure individual property and control illegal settlements inside the town and around the town. The methodology used to develop the 3D Cadastral Data Modeling was based on the data-modelling development cycle using Entity Relationship (E-R) Model techniques/method in this research and the top down approach was also used for data modeling. The data-modelling development cycle method was, gathering the requirements of 3D cadaster data (Business Analysis) from the real world, conceptual data modeling of 3D cadaster, logical data modeling of 3D cadaster and physical data modeling of 3D cadaster. The software used in this research thesis was, ArcGIS 10.3, Visio 2016, Object oriented programming language. After the requirement gathered from real world, conceptual, logical and Physical data model were modeled for the implementation of 3D cadaster in Adama Town developed different data entry for fully implementation of the 3D cadaster.

Key words: **Cadaster**, **3D Cadaster, Modeling, Entity, ERD, Conceptual, Logical, Physical**

CHAPTER ONE

1. INTRODUCTION

1.1 Background

Urban land is one of the most scares, limited and valuable natural resources and it is related to economic social and cultural activities of the citizens. The development and management of such scarce resource requires framework of good urban land registration system that ensures optimum benefits to citizens, government and non-governmental organization, to reduce environmental and social problems and efficiency of the mobilization of this scarce and limited resources. Urban land is a driver of economic growth and development and has impact on the sustainability of this growth and development.

The current population growth, urbanization, industrialization, development and interest to social service increased the pressure on land use for different purposes. This demand to land use is forced to use land above and below the ground (underground developments, infrastructure facilities development, high-rise buildings, condominium houses building and apartments). To manage and maximize the functionality of land both horizontally and vertically complex infrastructure is being built according to the land use planning (Aein, 2013).

Cadastral Jurisdictions frame work (rule, regulation and directive for legal cadaster) introduced by Ethiopian Governments to effectively administer the urban land information system. According to (Ethiopian Federal Governmet, 2014) identify urban land resources and to create conducive situation in making decision on urban land, through having legitimate information in relation to who holds the land, when it is acquired, use of land, form of holding and for how long it has been held. This indicates that the current cadastral system is 2D cadaster which consists 2D objects and its non-spatial information system.

Current land administration systems are mostly land parcel based cadastral system. It can't properly represent the real objects of reality on the ground. The 2-Dimentional cadastral systems are not able to manage and represent land ownership rights, restrictions and responsibilities in a 3Dimmentional context. Current registration of 3-Dimmentional objects in most jurisdictions is founded on 2-Dimmentional diagrams or drawings as a footprint on deed/title plans or subdivision plans.

Obviously, the use of land involves various dimensions. However, cadasters focus on organizing 2-Dimmentional land parcels. There are a lot of reasons that why 2-Dimmentional cadasters do not accommodate 3-Dimmentional data. They are because of the lack of 3-Dimmentional data collection technique, methods and equipment (i.e. lack of information in subdivision plans and architectural maps), and the limited 3D storage and representation technologies (3-Dimmentional Data Base Management System, 3-Dimmentional topology and 3-Dimmentional visualization specifications). However, 3-Dimmentional developments under and above ground have changed the characteristics of cadasters.

Governments and authorities need to manage land by registering and securing land interests to utilize and develop them in a sustainable and efficient manner. The registration of property rights is one of the key factors around the world that determines economic performance and business activity (Kadaster, 2010).

Management of land rights, restrictions and responsibilities (3-Dimmentional RRRs) is one of the most significant challenges in the current land administration systems, which are equipped with current cadasters that are only able to maintain 2-Dimmentional spatial data information.

3-Dimmentional cadaster is an instrument in land administration system to digitally manage and represent stratified rights, restrictions, and responsibilities (legal models) and their corresponding physical models such as buildings, utilities, on, above or under the ground surface in 3D. A 3D Cadastre has the capability to capture, store, edit, query, analyse and visualise multi-complex properties and frameworks within a documented set of standards (Aien, 2013).

The ability to maintain 3D information relating to property interests and make it available through the land administration systems will provide important benefits at government levels. Its greater benefits lie at the public level where it will assist management of the economy of 3D land development, security of tenure and community engagement (Rajabifard, 2012).

3D cadasters digitally represent real property ownership rights, restrictions, and responsibilities (legal models) and their physical counterparts such as buildings, utilities, on, above or under the ground surface. They are equipped with 3D data storage, 3D visualization, and 3D spatial analysis functions. The aim of this research is to develop a 3D cadaster data modeling in case study in Adama for managing stratified and overlapping and interlocking property rights, restrictions and responsibilities and to develop a framework for understanding and organizing the management of 3-Dimmentional properties rights, restrictions and responsibilities in the way that enables the achievement of sustainable development objectives by citizens and governments.

1.2 Statement of the Problems

In Adama Town the registration of land holders in the current cannot expresses the 3D information in the town and the 3D cadastral data modeling application. Using 2D data's have no much more importance to clearly register and manage the property of individuals especially starting from recent period of time with the construction of multi-purpose buildings, high rate of urban expansion, lack of processed cadastral data, retrieving and updating of spatial information's of cadastral system in its own database administration system have impact on the management of cadastral system in Adama. One way of recording data's, with regard to multipurpose buildings and condominium houses, considers to records as ones and this affects updating, managing, collecting actual taxes from house rents, different economic activities in each buildings floor classes, to control the construction of illegal buildings inside the town and the building of illegal dwellers around the side of the town, miss use of resources but when we come to managed 3D Object information, it is possible to control the illegal settlements around and inside of the town, increasing tax collection system from the individual property.

Therefore, this research study intended to Develop a 3D Cadaster Data modeling a case study in Adama town to fulfill the gap and limitation of 2D cadaster, control illegal settlement in the city and around the side of the city, reduce conflict of neighbor boundary, increasing tax collection syste, grantee the bank collateral and well manage and secure 3D object right, restriction and responsibility in the city.

1.3 RESEARCH OBJECTIVE

1.3.1 General Objective

3D Cadaster Data Modeling and developing system in order to register real property ownership rights, restrictions, and responsibilities with their physical counterparts in Adama Town.

1.3.2 Specific Objectives

a. To model conceptual, logical and physical modeling of 3D cadaster.
b. To Develop 3D cadaster real property registration system.

1.4 Research Questions

a. What is aspects of 3D cadaster modeling?
b. What is the gap and limitation of 2D cadaster interims of accommodating 3D objects?
c. What is the importance of 3D cadaster data modeling for 3D cadastral land rights, restrictions and responsibilities?

1.5 Scope of the Research

The primary objective of this research includes an ambition to develop a 3D Cadaster Data Modeling for a solution to enhance the 3D cadaster implementation capabilities of Ethiopia. To achieves the intended objectives, the major steps was to analyses legal aspects of 3D cadaster implementation, to analyses institutional aspect of 3D cadaster implementation and to analyze Technical aspects of 3D cadaster implementation. During analysis of aspect of 3D cadaster implementation, the modeling development life cycle (Conceptual data modeling, logical data modeling and physical data modeling) was modeled using Entity Relationship (E-R) Model technics/method. At the end different data entry interfaces was designed using object oriented programming language for the modeled data. Data base designing, developing and testing was out of the scope of this research thesis.

1.6 Limitations of the Research

Even though 3D cadastral model was modeled, it is not tested using real data.

1.7 Thesis Structure

The overall structure of the thesis can be divided into five major parts/chapters. These parts are, Chapter one introduces background and objectives of the study. Chapter two deals with literature review whereas chapter three the research methodology. Chapter four result and discussion. Finally, chapter five conclusion and recommendations.

CHAPTER TWO

2. LITERATUR REVIEW

2.1 Introduction

This chapter discusses the literature related to the study in order to explain and discusses the concept, definitions and different types of cadasters. The current 2D cadastral systems and its problems regarding managing stratified rights, restrictions, and responsibilities are described.

2.2 Cadastre

A Cadastre is normally parcel based and up-to-date land information system containing a record of interests in land (e.g. rights, restrictions and responsibilities), which usually includes a geometric description of land parcels linked to other records describing the nature of the interests, the ownership or control of those interests, and often the value of the parcel and its improvements. (International Federation of Surveyors , 1995)

It is concluded from this description that cadastres keep information about:

- **land parcels** (e.g. location, boundaries, coordinates, area, value)
- **land tenure** (e.g. property rights, restrictions, responsibilities, ownership, leases)
- **land owners** (e.g. interest holder information).

Land parcels are the basic spatial entity of the cadastres. Each parcel is given a unique code or parcel identifier. Therefore, other information such as buildings, utilities, land use, and demography (such as population statistics) can also be connected to land parcels through the unique parcel identifiers in GIS systems.

Cadastres have existed for as long as land has been able to be privately held or owned. The literature supports three main classes of cadastre, being: fiscal; juridical; and multipurpose. Fiscal cadastres support a system of land valuation and land tax, and can be traced back to Egyptian times (Dale, F & McLaughlin, J, 1988). Juridical cadastres are a relatively more recent development to support ownership and interests in land (Effenberg, 2001). The fiscal and juridical systems have evolved over time beyond their initial purpose to provide the basis for general land administration systems (Williamson & Ting, 2001). This evolution has seen the establishment of the third and most recent type of cadastre, multipurpose.

Multipurpose cadastres were developed when additional registers or information were added to the base fiscal and/or legal components within a cadastre (Williamson, 1985). The term 'multipurpose cadastre' appears to have been first published in a 1980 paper by the US-based National Research Council. In that paper the need for a multipurpose cadastre was founded on the view that the parcel of property ownership should be the fundamental building block for an integrated system of land information to support a wide range of decision-making (National Research Council, 1980).

Among the three types of cadastre Ethiopian government applying legal cadastre throughout the country. There is juridical frame work for this legal cadastre.

Urban land provision has been recognized as one major component that will go a long way in promoting urban socio-economic growth in the country. Other pillars as spelt out in the current Urban Development process include expansion of microbusiness enterprises, housing development, provision of lands and development infrastructure, development of social services, and setting urban classification, urban planning and environmental protection. The lands component incorporates some principles, including real property registration provision of title deeds and enhancing real property transaction. The absence of proper real state registration system, aggravated by problem such as absence of good governance, proliferation of illegal (informal) settlements, poor urban management, outdated and/or rigid development plans, urban decay, and legal and institutional capacity problems.

The ministry of Urban Development and House with stakeholders is undertaking nation-wide remedial strategy aimed Improving the urban land management. Establishment and implementation of cadaster system and its supportive legislations is one of the strategy planned to tackle these problems. The standards prepared was to provides a general guidance with minimum requirements on cadastral surveying. mapping, and system development. It is believed to be a basic tool which will help to establish Legal Cadastre that guide and serve effective and efficient land management in the nation (Ethiopian Federal Government, 2015).

2.3 2D Cadastre

From the early stages of human settlement, land was undisputedly the primary source of wealth and power. To secure guarantee of land ownership, cadastres have been established and managed in different forms (Williamson, 1985). Their differences often depend upon local cultural heritage, physical geography, land use, technology, and etc. (Bełej, M., Źróbek, S., & Liang, L.-k., 2002).

Traditionally, cadastres were designed to assist in land taxation, real estate conveyancing, and land redistribution. Cadastres help to provide those involved in land transactions with relevant information and help to improve the efficiency of those transactions and security of tenure in general. They provide governments at all levels with complete inventories of land holdings for taxation and regulation. But today, the information is also increasingly used by both private and public sectors in land development, urban and rural planning, land management, city space management, and environmental monitoring (FIG, 1995).

2.4 Problem with 2D Cadastre.

Obviously, the use of land involves multiple dimensions. However, cadasters focus on organizing 2D land parcels. There are a number of reasons why cadasters do not accommodate 3D data. They are because of the lack of 3D data collection methods and equipment (i.e. lack of information in subdivision plans and architectural maps), and the limited 3D storage and representation technologies (3D DBMS, 3D topology, and 3D visualisation specifications). However, 3D developments under and above ground have changed the characteristics of cadastres. Developments of apartments, high-rise buildings, tunnels, and utilities involve construction of above and below ground structures (Aien, 2013).

As the economy and urbanization develop, the conflict between limited land resources and huge development demand is very serious (Guo R, 2011). As a result, the expansion of the city not only develops towards the outer space, but also towards the vertical space. However, facing the development of three-dimensional (3D) space, the traditional two-dimensional (2D) cadastral management mode cannot satisfy the need of contemporary 3D land use and urban planning, so developing a 3D cadastral management mode is very imperative (Renzhong Guo, 2014).

Most of the current cadastral systems developed in different country throughout the world are two-dimensional (2D) and land parcel based, that is, geometric and descriptive information is based on 2D land parcels, even if the properties have three dimensions. They cannot effectively represent the reality. Current 2D cadastral systems are not able to manage and represent land ownership rights, restrictions and responsibilities in a 3D context.

As humans we live in a three-dimensional (3D) world. All processes are implemented and experienced in a 3D environment; from agriculture to navigation, from recreation to consumption. We use the space for e.g. apartments and offices, and implicitly attach ownership rights and rights of use to these spaces and objects. Legislation traditionally addressed real property as two-dimensional (2D), only implying limited or ambiguous vertical aspects depending on each case. As needs of modern societies on land increased, further limitations were required to regulate overlapping private and public rights. Such complex cases cannot be accommodated through current legislation, which was based on the assumption that overlapping rights could be addressed through instruments such as condominiums, limited real rights or specific legislation (Jesper M. Paasch, 2016).

In general literature shows that, different countries including Ethiopian trying to implement 2D cadastral system. Their current cadastral data models use a 2D land parcel concept and extend it to support 3D requirements; these data models do not integrate physical counterparts of the legal objects in the model; and they are not semantically enriched. Therefore, these data models cannot adequately manage and represent the spatial extent of 3D RRRs.

2.5 3D Cadastre

Constructions below or above the surface, such as tunnels and platforms used as foundations for buildings, are also treated as separate objects in a subdivision process, and are capable of being registered as separate real property (Kalantari.m, 2008). The increasing complexity of modern cities suggests that modern land administration systems need an improved capacity to manage the third dimension (Zlatanova, S & Stoter, J, 2006).

Thus, although 3D rights over individual parcels have always existed, it is in recent years that complex structures such as buildings and infrastructure has actually necessitated the inclusion in the cadastral database as objects in their own right. Development and construction of complex structures have continued at a rapid rate and it is up to the cadastral systems to be capable of accommodating the registration of these objects.

3D cadastre is a tool in a land administration system to digitally manage and represent stratified rights, restrictions, and responsibilities (legal models) and their corresponding physical models such as buildings, utilities, on, above or under the ground surface in 3D. A 3D Cadastre has the capability to capture, store, edit, query, analyse and visualise multi-complex properties and frameworks within a documented set of standards (Aien, 2013).

A 3D cadastre is a cadastre which registers and gives insight into rights and restrictions not only on parcels but also on 3D property units (Stoter, 2004). According to Stoter conclusions the 3D cadastre should incorporate the following functionalities:

"register 3D information on rights (what is the space to which the person with a real right is entitled?) and make this information available in a straightforward way;

Establish and manage a link with external databases containing objects of interest for the cadastre (infrastructure objects, soil pollution areas, forest protection zones, monuments) and incorporate the location (and other information) of these objects in the cadastral registration; and

use the information on these objects to support registration tasks, that is, to detect and correct errors in the process of registering and viewing the legal status of 3D situations."

2.6 Applications of 3D Cadastre

Pertinent to the land administration, legal and technical aspects of 3D cadastre, (Stoter, 2004) describes the following opportunities arising from the implementation of a 3D cadastre:

"3D registration provides information on the 3D extent of rights, limited rights and legal notifications and allows integration of 3D information in the current cadastral geographical data set;

A 3D cadastre will incorporate digital information on 3D situations;

When enabling 3D registration, the parties involved have a tool to register 3D situations;

If the exact 3D location of infrastructure constructions is available within the cadastral registration (maintained in databases by holders of these objects), the cadastre can use this source for certain cadastral tasks e.g. during cleanup of registration or to support other cadastral tasks;

Holders of infrastructure constructions will benefit from a clear registration of the location of infrastructure objects; and Linking databases containing infrastructure objects with the cadastral registration can also be used for registering pipelines."

2.7 Forms of Registering 3D Cadastre

2.7.1 A Full 3D Cadastral Registration as a Final Solution

This means introduction of the concept of (property) rights in 3D space. The legal basis, real estate transaction protocols and the cadastral registration should support the establishment and conveyance of 3D rights. From a practical point of view, it seems best to maintain the 2D parcel as default; only in complex 3D situations the full 3D parcel would be used. It might also be considered if a limited definition of 3D property rights would fulfil a need (e.g. one or more property layer(s) underground or above ground level and one at ground level).

2.7.2 A Hybrid Solution

This means preservation of the 2D cadastre and the registration of the factual situation in 3D by registering 3D objects within the 2D cadastral registration. This results in a hybrid solution of 2D parcels and 3D factual objects in which the explicit relationships between the parcels and the 3D objects are maintained. Implicit relationships exist through the spatial definition of the objects and can be retrieved by spatial functions. In this case the legal and factual registrations are combined (hybrid solution). By intersection of e.g. a building plan with the cadastral parcels indications of the 3D property rights can be derived. The exact legal situation has to be derived from the official documents. These documents then have to contain precise 3D information.

2.7.3 3D Tags in The Current Cadastral Registration System

This means preservation of the 2D cadaster with references to representations of (digital) 3D situations. Complex 3D situations are registered using ad hoc solutions. This is the current situation. The reference can be made in various ways. The simplest solution is to tag 3D situations in the registration (administrative register and the cadastral index map) whereupon the user then has to consult the (digital) public registers to find the detailed information. A more advanced option is to add a reference to a 3D (digital) description in the registration. The description may be available in analogue or digital form (e.g. a CAD drawing). In the latter case the information might even be included in the database. Relevant are the possible formats (scanned, DGN, DXF, etc.). The projected contours of the 3D (physical) object could also be registered in the cadastral map.

2.8 Aspects of 3D Cadaster

2.8.1 Legal Aspects of 3D Cadaster

According to Constitution of the Federal Democratic Republic of Ethiopia article (40) the citizens can have immovable and movable properties or build any fixed asset on their own piece of land parcel. The fixed assets can be built above or below the ground in the form of 3D object. Urban land provisions have been recognized as one major component that will go a long way in promoting urban socio-economic growth in the country. Other pillars as spelt out in the current Urban Development process include expansion of microbusiness enterprises, housing development, provision of lands and development, infrastructure development of social services, and setting urban classification, urban planning and environmental protection. The lands component incorporates some principles including real property registration, title deeds and enhancing real property transactions. Recently the issue of administration of urban land establishing a cadastral system raised and different activities has been under taken by the Federal and state Governments of which are enacting laws that can facilitate in solving urban land administration and real property registration problems. Among rule and regulation proclamation 818/2014(Urban Land Holding Adjudication and Registration) currently active legal rule in urban land information registration system in throughout the country. According to proclamation 818/2014(Urban Land Holding Adjudication and Registration) land registration have the following objectives: -

To enable urban centers to identify urban land resources and to create conducive situation in making decision on urban land, through having legitimate information in relation to who holds the land, when it is acquired, use of land, form of holding and for how long it has been held.

To benefit a person who has land holding right from the economic, social and local development of urban centers by enabling him to mortgage properties built on the land.

To create conducive environment in which landholders use rights, landholding service type and transaction of immovable properties on the landholding is substantiate with acceptable evidence and thereby enable to put in place a working system that is transparent to all persons.

To create the conducive environment for the community to ascertain their landholding use right and to spend their time on development activities by enabling urban centers to provide guarantee for land right, restriction and responsibilities permitted by organ empowered to permit land use right and to reduce landholding related dispute.

2.8.2 Institutional Aspects of 3D Cadaster

Organizing, in the private or public services is the management function that usually follows after planning. And it involves the assignment of tasks, the grouping of tasks into departments and the assignment of authority and allocation of resources across the organization. In other words, organization is a planned, coordinated and purposeful action of human beings to construct or compile a common goal.

Organization design involves the creation of roles, processes, and formal reporting relationships in an organization. The purpose is the division of work among members of the organization, and the coordination of their activities so that they are directed towards the goals and objectives of the organization.

In other words, organizational structure is the pattern of relationships among positions in the organization and among members of the organization. Structure makes possible the application of the process of management and creates a framework through which the activities of the organization can be planned, organized, directed and controlled defining tasks and responsibilities, work roles and relationships, and channels of communication. Structure, though, is not an end in itself; it is a means of improving organizational performance.

The objectives of organization structure are to:

- provide effective and efficient performance of the organization and the level of resource utilization,
- efficiently monitor the activities of the organization,
- augment accountability for areas of work undertaken by groups and individual members of the organization,
- coordinate the different parts of the organization and different areas of work
- provide flexibility in order to respond to future demands and developments, and to adapt to changing environmental influences.

2.8.3 Technical aspects of 3D Cadaster

Technical aspects of 3D cadaster are the basic elements of Implementation in 3D cadaster in a given juridical frame works. technical aspects support to realise 3D cadasters (technical aspect) are basis for 3D cadaster development. During the implantations of 3D cadaster points to be considered are types of data gathered/surveyed (3D data capturing), 3D data representation, Cadastral updating and 3D data modelling. In addition to this using the appropriate software that supports 3D cadastral objects.

3D data capturing: researching on what types of 3D cadastral objects need to be collected (buildings, pipelines, tunnels, etc.) and what methods of 3D data capturing can be used to capture 3D data (land surveying, aerial photogrammetry, laser scanning, etc.).

3D data representation: Visualizing 3D cadastral objects, 3D analyses and 2.5D earth surface in vector and raster formats. 3D GIS and CAD systems can provide this opportunity. 2D paper based plans are being used to represent 3D data in most cadastral systems.

Cadastral updating: updating cadastral objects in DCDB. Geometry and topology of 3D cadastral objects are complex and they need to be maintained in a 3D DBMS. Object Oriented Relational Data Base management system is the most important data base for 3D cadaster implementation. It is a hybrid database management system from ODBMS and RDBMS. An ORDBMS can be thought of as an RDBMS engine with an extensibility framework for handling objects. They can handle both the data describing what an object is (object attributes such as color, size, and age) and the behavior that determines what an object does (object methods or functions such as drawing instructions, query interfaces, and interpolation algorithms). The ideal Geographic ORDBMS is one that has been extended to support geographic object types and functions through the addition of the following: A query parser, A query, A query language, Indexing services, Storage management, Transaction services & Replication.

3D data modelling: developing data models to identify 3D objects and their relationships. 3D cadastral data modelling will enable the capture, manipulation, analysis and visualization of 3D land rights, restrictions and responsibilities. Most of the existing cadastral data models are 2D, such as the ePlan data model (ICSM, 2009) which is restricted in its cover to a few 3D objects such as volumetric lots.

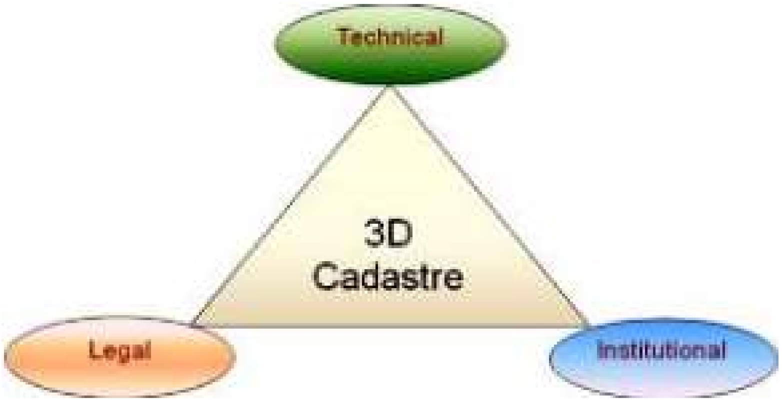

Fig 2.1 Relationship between different aspects of 3D cadastre (source Ali Aien, 2011)

2.9 3D Cadastral Data Modeling

Current cadastral data models use a 2D land-parcel concept and extend it to support 3D requirements. These data models cannot adequately manage and represent the spatial extent of 3D RRRs. As the role of cadastre has changed through the development of civilization, cadastral data models have had to develop to meet ever changing demands (Williamson, I. et al, 2010).

According to Ali Aein, three underlying principles have been proposed to develop the 3D Cadastral Data Model (3DCDM). These principles are:

Principle 1: The 2D cadastral data model is a sub-set of the 3D cadastral data model,

Principle 2: The 3D cadastral data model should not only accommodate 3D RRRs and their association with physical objects: the data model should also represent the spatial extent of 3D RRRs, and;

Principle 3: The 3D cadastre data model should cater for a broad range of land administration functions including land tenure, land value, land use, and land development with sufficient detail.

These principles are used to assess and modify the core cadastral data model. Additionally, principles related to the legal property object are also used to modify the 3DCDM. The legal property object combines interests and its spatial dimension into a single entity. This creates more flexibility and enables inclusion of complex commodities and all kinds of RRRs (Ali Aien, 2011).

2.9.1 The Core Cadastral Data Model

The Core Cadastral Data Model (Hanssen, 1995) more concerned the man that have right(steward-ship) in land object(parcel). These rights are security right (mortgages, charges(encumbrances), easements) and use right (ownership, free hold, (long term) lease hold, building right and usufruct). The 2D object(parcel) contains descriptive information that are (parcel identification, parcel address, parcel use, parcel value, parcel use, parcel nature and parcel acreage).

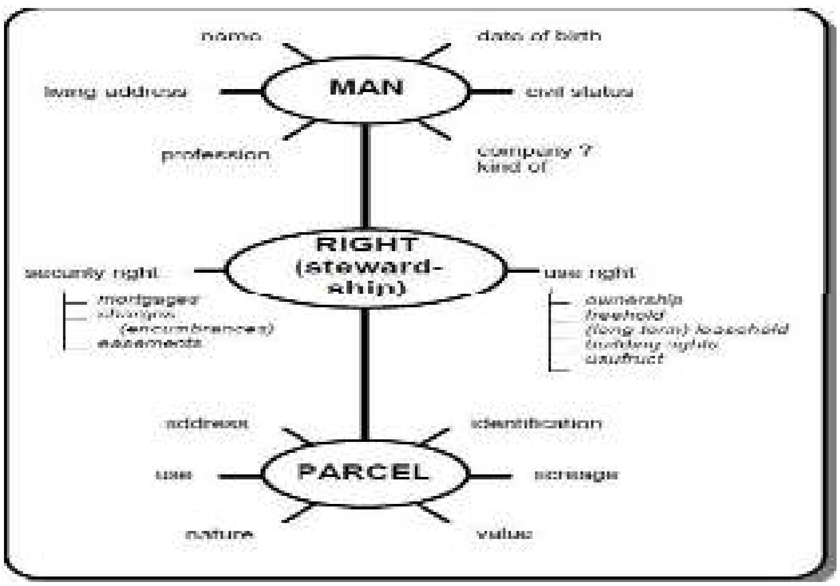

Figure 2.2 Core Cadastral Data Model (Hanssen, 1995)

In this cadastral data models there are three core objects. Thus Man, Right and Parcel. Land parcel is the only basic spatial unit of the data model. The core cadastral data model does not support 3D data. Stratified RRRs are projected on the ground land parcel and they are not rendered with 3D primitives. Land parcel is the representation of both legal and physical objects.

Overall, the core cadastral data model is a conceptual data model to explain the basic element of cadastre. Although 3D data has not been considered in this model, it is being used as a base model for developing a new 3D cadastral data model.

2.9.2 ArcGIS Parcel Data Model

The purpose of the ArcGIS Parcel Data Model is to describe parcel information to support local government and private sector decision making. Parcel managers and GIS professionals can use the model as a starting point for defining parcel information in the GIS environment and plan for migration strategies from current data designs to the new object environment. Decision makers will be able to apply the outcome of the model to integrate land ownership information with other data. Land and GIS professionals will be able to apply the definitions and structure of the model to find consistent and representative parcel information for data distribution.

Core objects of the data model are: Ownership, Encumbrances, and Separated Rights.
Ownership Parcel: a parcel is a unit of real property with rights and interests.
Encumbrances: limitations on the rights and use of the land.
Separated Rights: rights and interests in land ownership that can be disconnected from the primary or fee simple surface ownership.
Parcel is the only basic spatial unit of the data model and No other forms of spatial units are considered in the data model. The data model can be used for development of parcel level management and support parcel level functionality in the GIS environments. Types of rights are mineral rights, oil rights, grazing right, and fishing rights. Land parcel is the representation of both legal and physical objects.

Overall, the ArcGIS Parcel Data Model is a general and flexible data model that helps users to manage land parcels using GIS technology. Vertical parcels (condominium) are supported in the data model; however, 3D primitives are not used to represent the vertical parcels.

2.9.3 The Legal Property Object Model

The concept of the Legal Property Object is based on the combination of the interest and its spatial dimension. It stands on the reality that land is converted into a legal entity when an interest is attached to it. The Legal Property Object re-engineers the concept of the Core Cadastral Data Model from a land parcel-based data model to a spatially referenced data model. This new initiative is able to include all interests in land comprehensively and accommodate the increasing number of new interests on land (Kalantari, 2008).

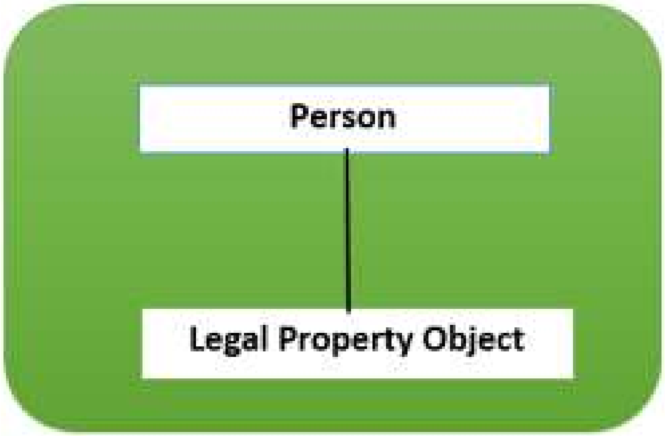

Figure 2.3 The Legal Property Object model (Kalantari et al., 2008)

Core objects of the data model are: Person and Legal Property Object.

Person: The person includes all the private, natural and non-natural individuals as well as the public.

Legal Property Object: The Legal Property Object includes a particular interest with its spatial dimensions. The Legal Property Object will be the basic building block and is the Centre of the model for organizing land information. The Legal Property Object is the only basic spatial unit of the data model. The Legal Property Object model facilitates the land administration system to be more extensible and scalable in terms of new legislations and land-related laws.

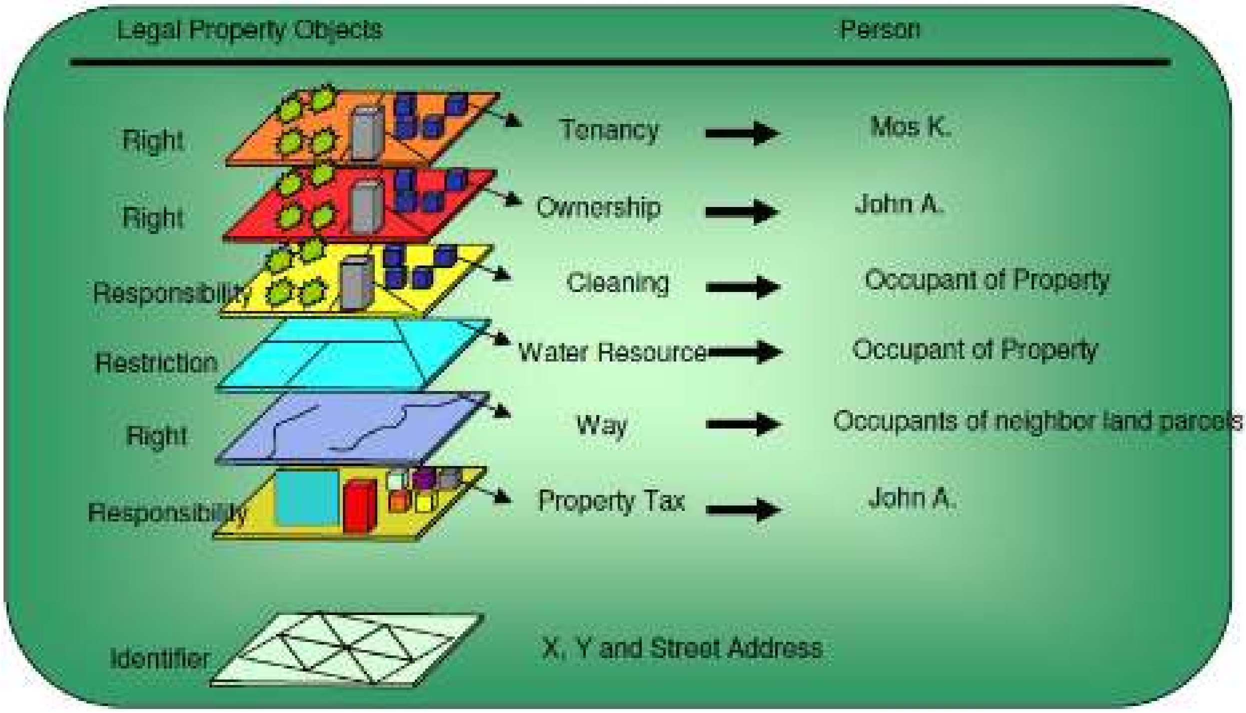

Figure 2.4 Spatially registering Legal Property Objects (Kalantari, 2008).

2.9.4 LADM (ISO 19152)

The Land Administration Domain Model (LADM) is now the ISO standard and most recognizable data model in land administration discourse. This data model has been under development since the early 2000s. The LADM provides a conceptual description for a land administration system. The model aims to provide an extensible basis for the development and refinement of efficient and effective land administration systems and to enable involved parties, both within one country and between different countries, to communicate, based on the shared vocabulary implied by the model (ISO19152, 2012).

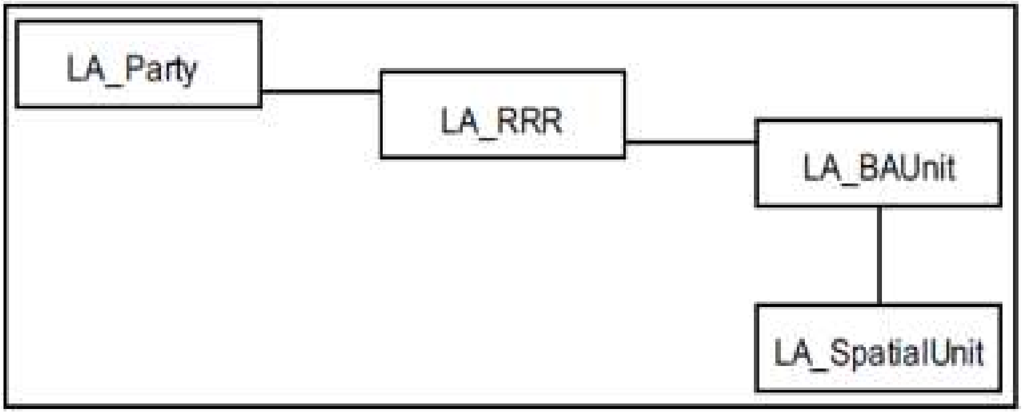

Figure 2.5 Basic classes of LADM (ISO19152, 2012)

LADM has four basic classes (Figure 4.4). They are LA_Party, LA_RRR, LA_BAUnit, and LA_SpatialUnit.

LA_Party: A person or organization that plays a role in a rights transaction.

LA_RRR: Right (action, activity or class of actions that a system participant may perform on or using an associated resource), Restriction (formal or informal obligation to refrain from doing something), Responsibility (formal or informal obligation to do something).

LA_BAUnit: A Basic Administrative Unit is an administrative entity, subject to registration (by law), or recordation consisting of zero or more spatial units against which (one or more) unique and homogeneous rights, responsibilities, or restrictions are associated to the whole entity, as included in a land administration system.

LA_SpatialUnit: A single area (or multiple areas) of land and/or water, or a single volume (or multiple volumes) of space. Spatial units are structured in a way to support the creation and management of basic administrative units. LA_SpatialUnit is the basic spatial unit of the data model. The data model can be used for a number of land administration applications.

LADM has a solution to represent stratified interests and 3D parcels using Class LA_BoundaryFace. However, the LADM does not use solid geometry (GM_Solid) to represent 3D parcels.

CHAPTER THREE

3. STUDY AREA

Adama was selected as the jurisdiction to undertake the case study due to its lead in 2D cadastre implementation and the accessibility to case study data. The case study performed an in-depth analysis of the current cadastral systems and explored the institutional and technical 3D cadastral issues.

3.1 Physical Character

Adama is situated within the Wonji Fault Belt, in the main structural systems of the Ethiopian Rift Valley. Geological studies indicate that the present physiography of the area is the result of volcano-tectonic activities occurred in the past and thus deposition of sediment largely of fluvial and lacustrine origin. Therefore, the main landscape in Adama and its surrounding consists of fault scraps and fault controlled depressions covered with sediments and volcanic domes and cones. The study further points out that the major proportion of the City lies in a relatively low lying flat land (within 1 to 10% slope) between two mountain ridges, at an average altitude ranging between 1600 and 1800 meters above sea level (msl) (AdamaCityAdminstration, 2017).

3.2 Location and Climate

Adama City is located at some 100 kilometers from Finfinne, on the southeast along the main road to Harar. Its grid references point that the City stretches between 80 33' to 80 36' North latitude and 390 11' 57" to 390 21' 15" East longitude. Adama lies in somewhat warm and lower climate. Hence, it enjoys hot and dry weather for the greater part of the winter and warm and sunny climate in summer. Thus, the area is generally, known for its attractive weekends and summer resort release. References to its temperature points that Adama has a minimum annual temperature falling between 190 and 220C. Its yearly minimum rainfall is reported to be 760 mm. According to NUPI (1995: 38), the humidity record based on 39 years' period (i.e., 1953-1991), points that, the mean annual precipitation of the City was 822.5 mm.

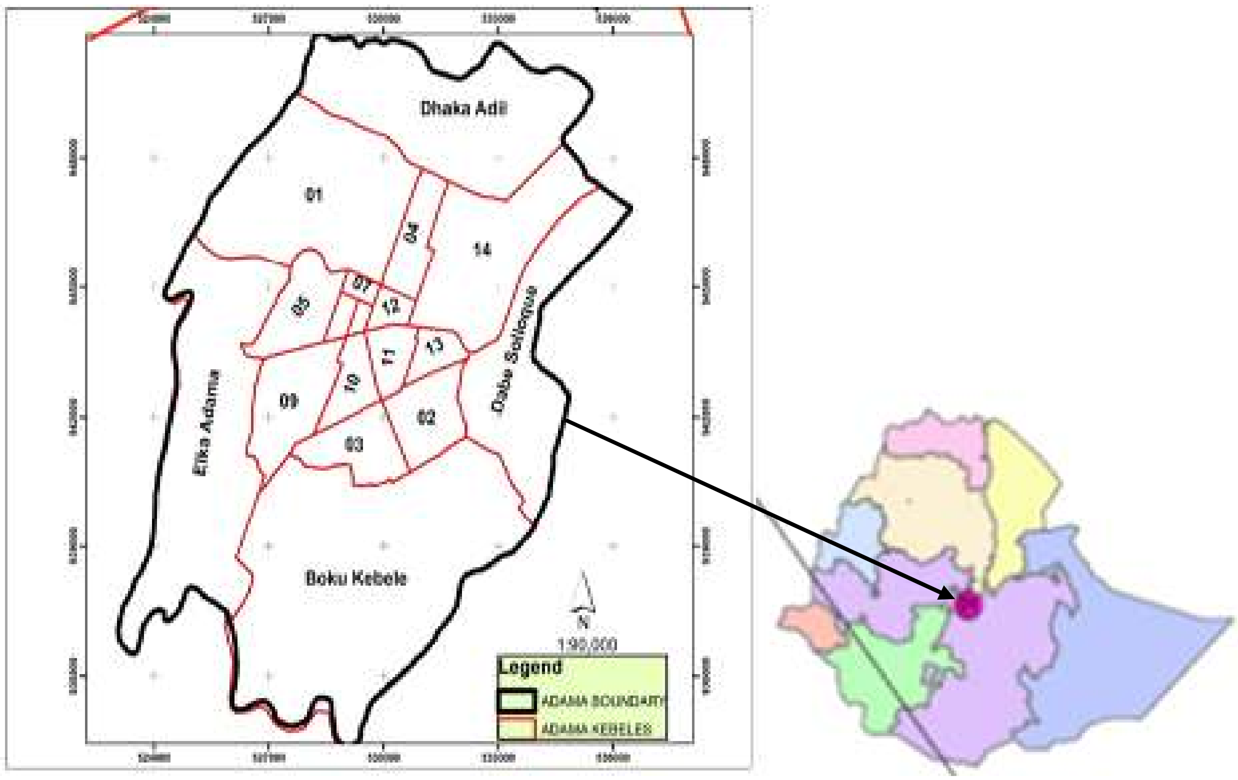

Figure 3.1 Adama City Map

3.3 Population and Language

Estimates based on CSA's 2015 Population and Housing Census and National Labor Force Survey (NLFS), indicate that there were about 324,000 people living in Adama. Afan Oromo is the working language (official language) of the city Administration and spoke majority of the city communities. Amharic and English are also spoken by societies living in the City Administration. However, other local languages, particularly Gurage, somali, Silte Harari, Tigre, etc. are also widely spoken in the city. This implies that, so many different ethnic group leaving in the city. Therefor the city is home to of various nations and nationalities of Ethiopia.

3.4 Aspects of the 3D Cadaster

3.4.1 Legal Aspect of 3D Cadaster

Proclamation number 818/2014 includes only the registration of interest holders (owner of the land) and 2D land parcels. Regulation 323/2014 states that the way urban land adjudicate and ready for land registration. It addresses the two types of adjudication (systematic adjudication and sporadic adjudication). Directives 44/2015 outlines the procedure and frame work which urban land adjudicated. The major objective of Standards 03/2015 standard is to Create a data standard for cadastral surveying and mapping used to stablish legal cadaster. Specifically, the standard has been created for Provide a way to express standards and practices that eliminate discrepancies and inconsistencies in the accuracy, quality, scale, projection system, storage and overall content of the cadastral surveying and mapping datasets and Formulate an integrated and compatible standards and procedures for the components of a Legal cadaster and related records that guide federal and regional towns. From these historical background there is no any rule and regulation that support 3D objects in the country. Therefore, Ethiopia hasn't 3D laws, even if the development is in vertical. The researcher recommends it needs to have 3D urban land cadaster implementation law, proclamation, rule, regulation, directives and standards.

3.4.2 Institutional Aspect of 3D Cadaster

The primary objective of Urban land holding adjudication and registration Agency is adjudicating and registering urban land parcels. After that it will implementing and establishing the 2D cadaster throughout the country. So that this institution has only the privilege of implementing 2D cadaster within the given scope and mandates. From this background of study there is no any institutions responsible for implementing 3D cadaster in the urban. Therefore, the researcher recommends it needs to have 3D urban land implementing institutions that implements 3D cadaster in Ethiopia. This institution can be recommended through two options: -

A. Restructuring the current institution that establishing 2D cadaster throughout the country according to proclamation 818/2014 or

B. Establishing new institution with full mandate composed of (structure, strategy and system) that can implement 3D cadaster from the scratch.

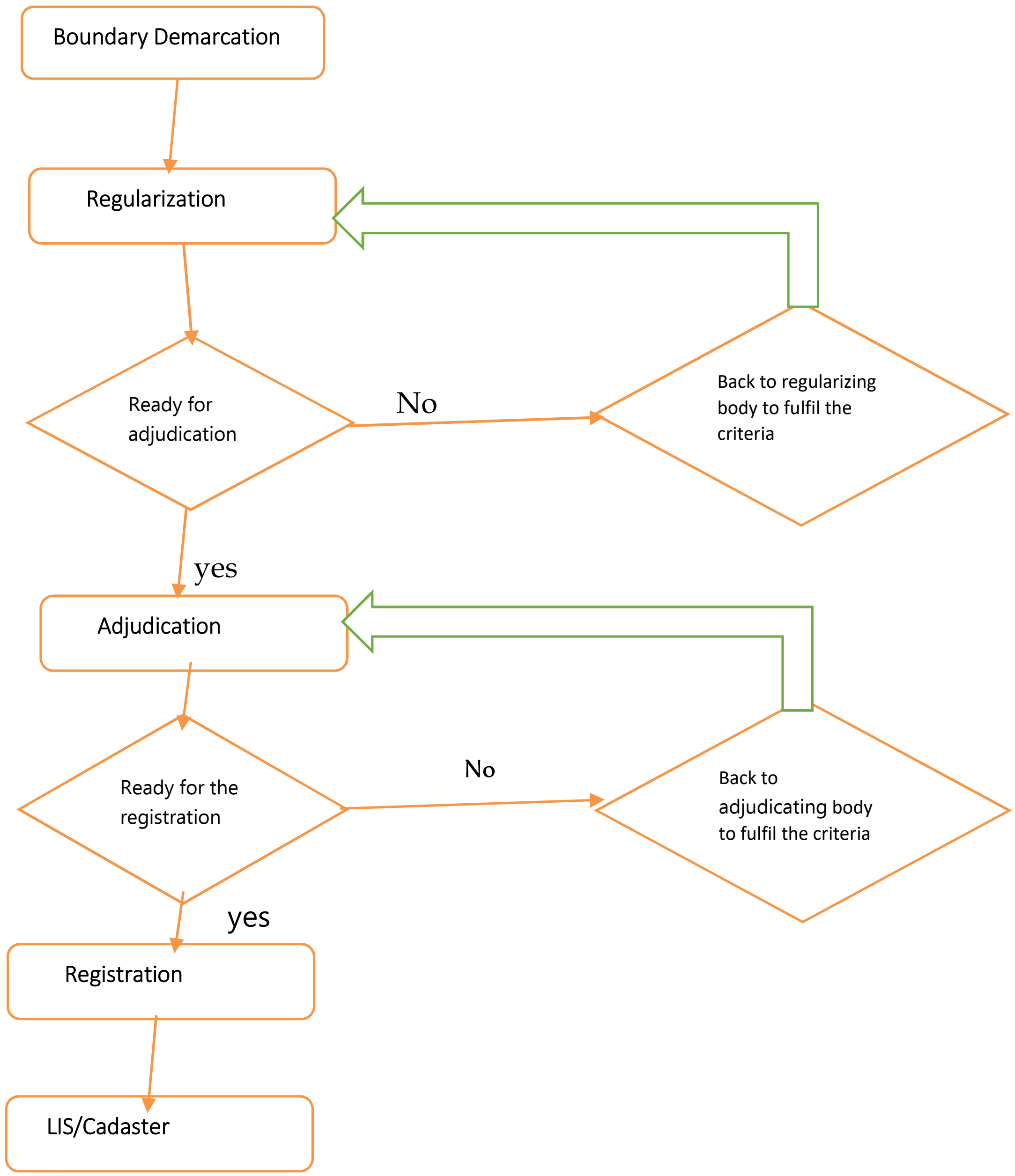

Figure 3.2 Current 2D land Registration System Process

The current land registration process(steps) fig 4.1 above shows only 2D objects collected during the implementation of legal cadaster. This indicates that 3D cadastral land object right, restriction and responsibilities are not included in this land registration process. Currently this process is functioning for urban legal cadstre system (only 2D land parcel information) in Adama Town. So the city administration must take into consideration 3D property object right, restriction and responsibilities registration data collection method. While collecting the 3D objects, taking consideration of logical designed of building fig 4.3 will be facilitate the registration.

CHAPTER FOUR

4. DATA AND METHODOLOGY

4.1 Source of Data and Data Collection Methods

Different data was used to conduct the research thesis. These include aerial photo, auto cad software generated floor plan of the building, coordinate of the parcel and building. In addition to this different literatures, proclamations, rules, regulations, directives, standards of urban land administration and workshop presentations, seminars and reports were used as a primary and a secondary data to complete this researches. To obtain the coordinates of the 3D objects(building) and parcel ground surveying data collection method using EDM was used.

4.1.1 Software Used

In addition to data, different software's were used to analysis different data to finalize this research thesis. ArcGIS 10.3 used to analysis and interpret aerial photo. From aerial photo using ArcGIS possible to get area and coordinate of the parcel. Auto cad software was used to generate the 3D object (Building) floor plan. Using this software possible to calculate the area of the building floor and measure height of the building. After this, Visio 2016 used to model conceptual, logical and physical model of 3D cadaster. At the end, Object oriented programming language used to design different data entry interfaces of the identified attribute data.

4.2 3D Cadaster Data Modeling Methodology

The methodology used to develop the 3D Cadastral Data Modeling was based on the data-modelling development cycle using Entity Relationship (E-R) Model techniques/method in this research. The top down approach also used to complete this research thesis. The data-modelling development cycle for 3D cadaster consisted of five steps. The first step is gathering requirements of 3D cadaster (business analysis), The second step is developing conceptual data modeling for 3D cadaster, the third step is Developing a logical data model for 3D Cadaster, the fourth step is Developing a Physical data model for 3D Cadaster, the fifth step is designing a 3D Cadastral database. The fifth step (designing a 3D Cadastral database) is out of the scope of this research.

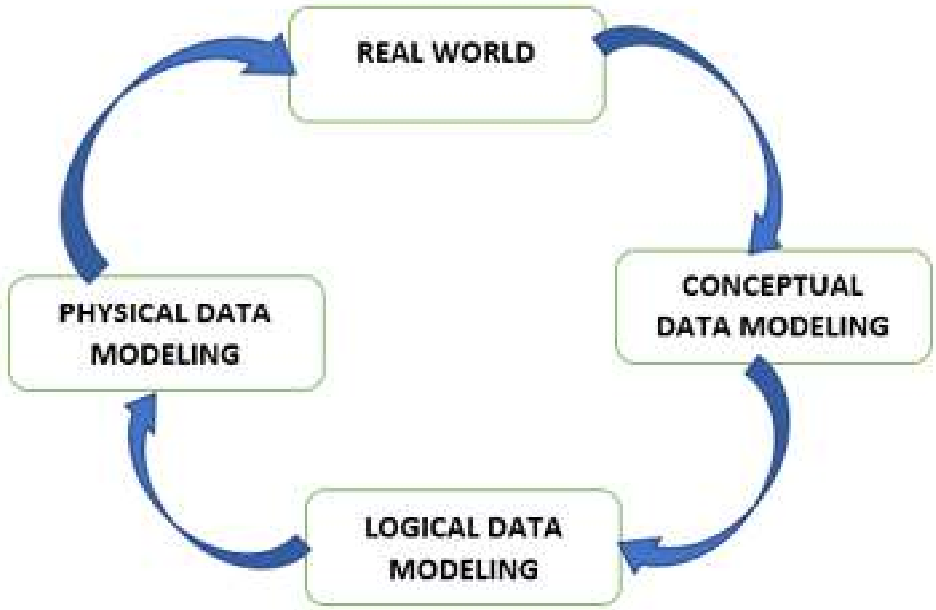

Figure 4.1 Data modelling development cycle

3D data modelling is developing data models to identify 3D objects and their relationships. 3D cadastral data modelling will enable the capture, manipulation, analysis and visualization of 3D land rights, restrictions and responsibilities. Most of the existing cadastral data models are 2D models.

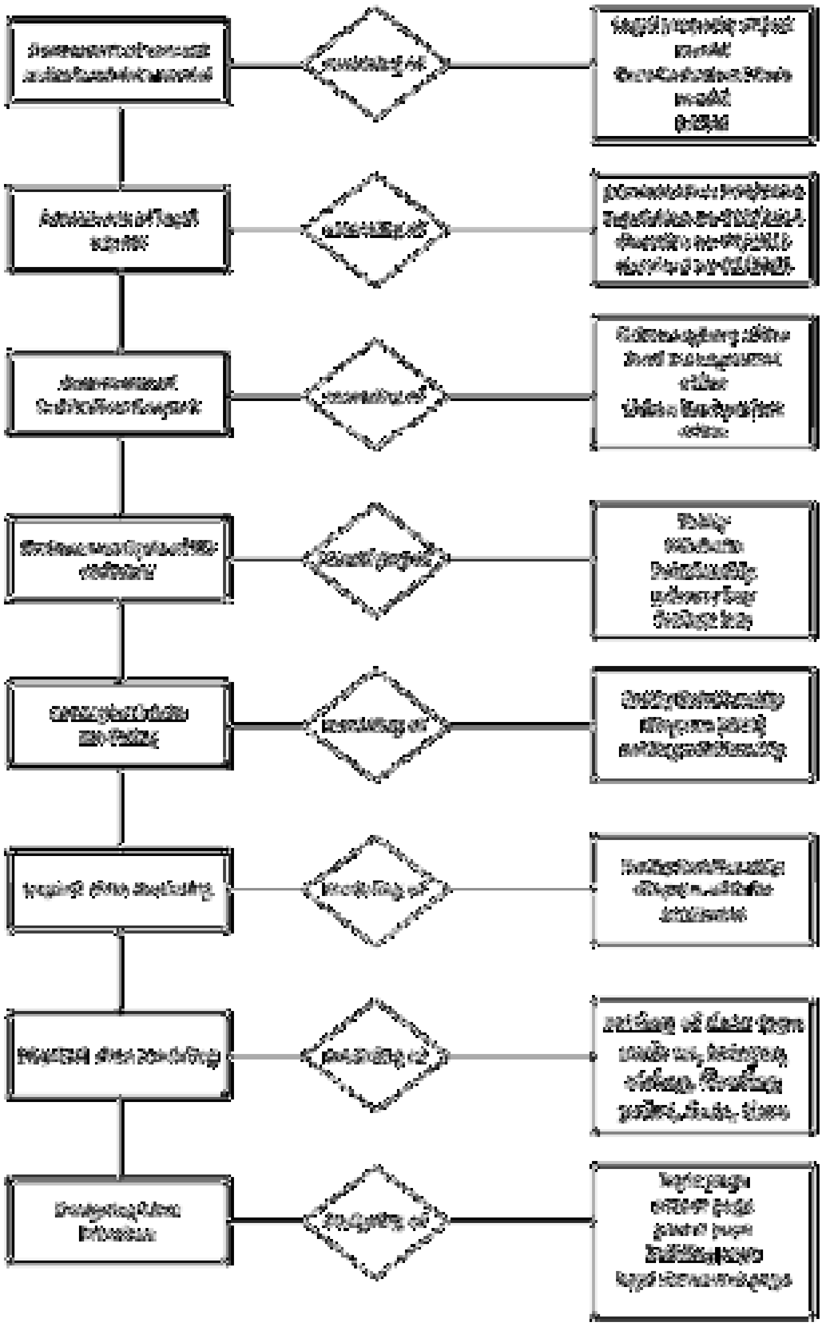

Figure 4.2 General 3D Cadaster Data Modeling Methodology

The above figure 4.2 shows the general work flow 3D Cadaster Data Modeling Methodologies. The result of all above methodology was shown in chapter four. From the above methodology the conceptual 3D cadaster modeling, logical 3D cadaster modeling and physical 3D cadaster modeling life cycle shown in the figure 4.1.

4.3 3D Cadastre Modeling

4.3.1 Gathering requirements of 3D cadaster (Business Analysis)

Business analysis is an important step defining requirements in the data modelling and database development cycle. The first step is to assess the needs of the users (gathering user's requirement). This step is conducted by interviews and discussions with both the developers (producers) and end users. The basic objectives of business analysis involve: gathering and defining basic Entity/objects and data Attribute/elements; describing the information about the data elements and the relationships among them; and comprehensively documenting all of the requirements. The followings are Entities, Attributes and Relationships of the 3D Cadaster Modeling that was identified.

Entity is real-world object or thing with an independent existence and which is distinguishable from other objects. In this research the Entities of the 3D Cadaster modeling identified was **Interest Holder**, **Parcel**, **Building** and **Legal Documents**.

a. **Interest Holder: -** it can be a person, Group or organization. The interest holder has (RRR) over parcel and buildings.
b. **Parcel: -** it is a piece of land owned by the owner or interest holders.
c. **Building: -** it is a physical object that has been built on the parcel.
d. **Legal document: -** it can be Title/Deed, Mortgage and Caveat/court case applied to parcel or building.

Attribute: an entity is represented by a set of attributes (its descriptive properties), e.g., name, age, salary, price etc. Attribute values that describe each entity become a major part of the data eventually stored in a database. The followings table shows Entities and Attributes of the Entity that was identified during gathering the requirements.

Table 4.1 shows the relationship between Interest holders(owner) and its attribute

No	Entity	Attribute	Description and Source of Attribute
1	INTEREST HOLDERS	Interest Holder ID	unique identification number of the legal document which given for each Legal document
		Name	the date which the document was produced
		Address	Location of the owner(Region, City, Kebele, Block number)
		Owner types	The types of owner(Private, Group, Organization)

Table 4.2 shows the relationship between Parcel and its attribute

No	Entity	Attribute	Description and Source of Attribute
1	PARCEL	Parcel ID	unique identification number of the parcel which given for each parcel on aerial photography
		Area	area of the parcel which calculated using ArcGIS from aerial photography
		Land use	service of the parcel that was identified by LDP
		Coordinate	X,Y coordinate collected using ground survey method
		Address	Location of the parcel(Region, City, Kebele, Block number)

Table 4.3 shows the relationship between Building and its attribute

No	Entity	Attribute	Description and Source of Attribute
1	BUILDING	Building ID	ID of the building
		Building Type	types of building (Condominium, Apartment, Real state and Villa).
		Area	Built up area of the building calculated from floor plan using auto cad software
		Height	Height of the building calculated from floor plan using auto cad software
		Basement	Height of the Building below the ground
		Coordinate	X, Y, Z value of the building
		Bed Type	numbers of the room the building has
		Floor No	the floor of building above or below the ground

Table 4.4 shows the relationship between Parcel and its attribute

No	Entity	Attribute	Description and Source of Attribute
1	LEGAL DOCUMENT	**Document_ID**	unique identification number of the legal document which given for each Legal document
		Produced Date	the date which the document was produced
		Document type	types of documents (Mortgage, Caveat, Deed, Title
		Volume	The size of the document / numbers of the document pages

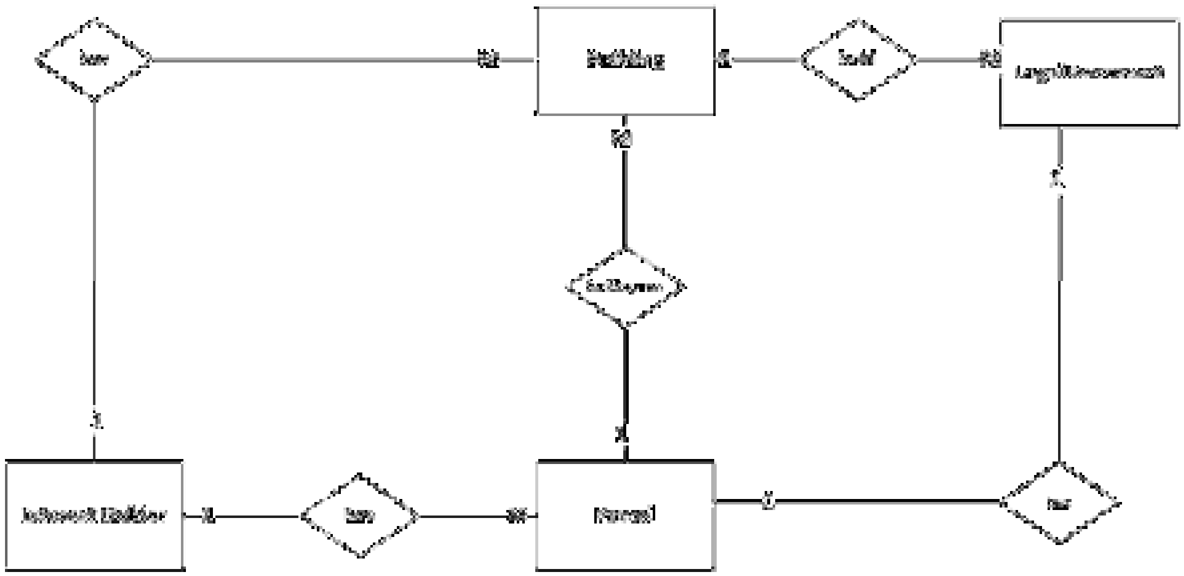

Figure: - 4.3 Entity Relationship Diagram

The above entity relationship diagram has four different entities that has a relationship with each other. Interest holders has many building/ many building belongs to a single interest holder. The relationship type was one to many (1 to m). in addition to this an interest holder have many land parcels. Many land parcels belong to a single interest holder. The relationship type was one to many (1 to m). a building may have restricted by many cases (court case and bank collateral). The relationship type was one to many (1 to m). if the cordiality(relationship) doesn't defined here, the above entity cannot able to store in a single data base.

4.3.2 Conceptual Data Modeling for the 3D Cadaster

Conceptual design is the process of constructing a model of the information used in an enterprise, independent of any physical considerations. Conceptual data model is built using the information in users' requirements specification. The following figure shows the conceptual design of 3D cadaster data Modeling in this research study.

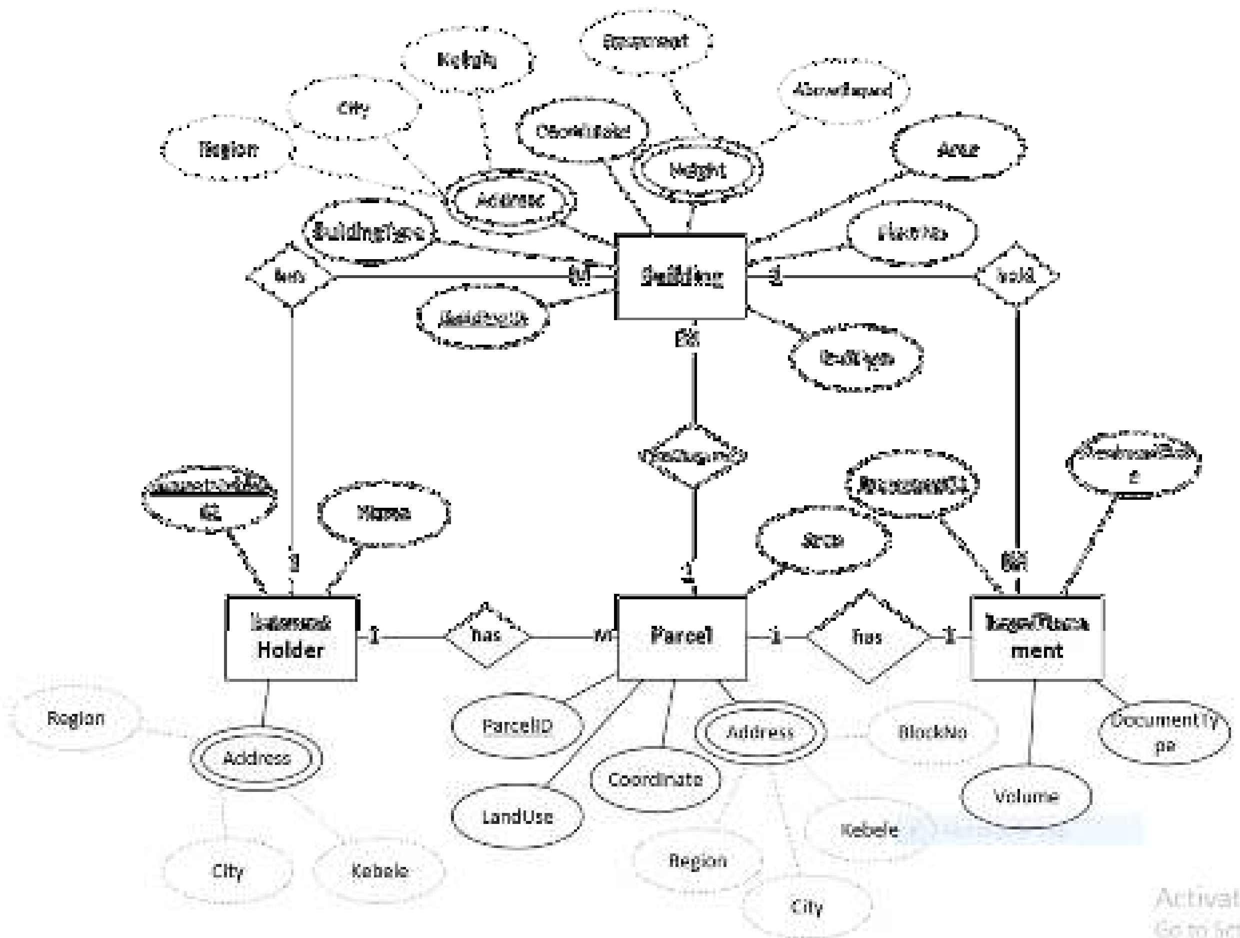

Figure: - 4.4 Conceptual Design of 3D Cadaster Modeling

In the above Conceptual Design of 3D Cadaster Modeling, the attributes of all entities were identified during the investgation. Ammong the above attribuite address of interest holder, parcel and building were multi-valued attributes. The height of the building also multi-valued attributes. The rest attributes are single-valued attributes.

4.3.3 Logical Data Modeling for the 3D Cadaster

Logical data modeling is a higher level conceptual abstraction with selected specific data model to implement the data structure. Logical design is the process of constructing a model of the information used in an enterprise based on a specific data model (e.g. relational, hierarchical or network or object), but independent of a particular DBMS and other physical considerations.

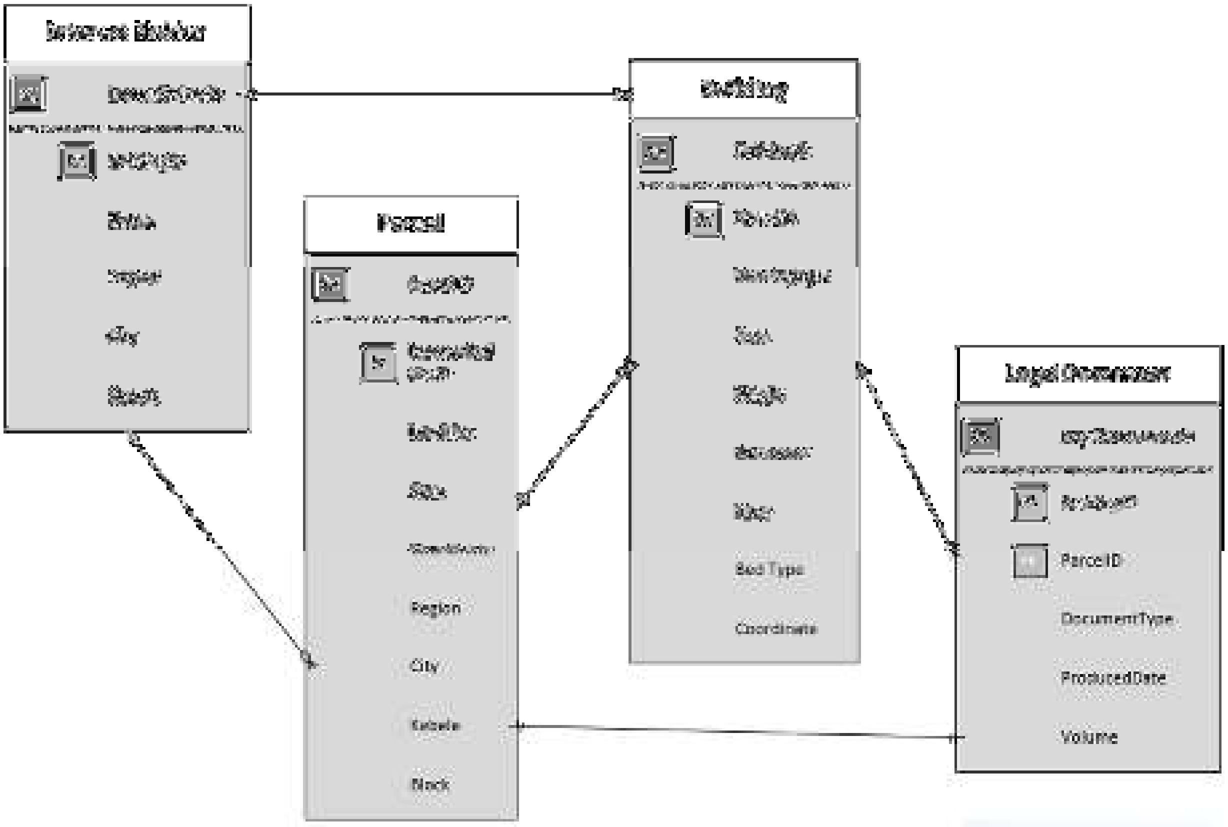

Figure: - 4.5 Logical Design of 3D cadaster Modeling

In the above Logical Design of 3D cadaster Modeling, primary key and foreign key was identified and used. A primary key is a field in a table which uniquely identifies each row/record in a database table. Primary keys must contain unique values. Interest holder's ID, parcel ID, building ID and legal document ID were the primary ID'S that uniquely identified and used in this model. A foreign key is a key used to link two tables together. This is sometimes called a referencing key. Foreign Key is a column or a combination of columns whose values match a Primary Key in a different table. The relationship between two tables matches the Primary Key in one of the tables with a Foreign Key in the second table. building ID was a foreign key in the interest holder column, Interest holder ID was a foreign key in the parcel column, parcel ID was a foreign key in the column of building and legal document.

4.3.4 Physical Data Modeling for the 3D Cadaster

In the following Table 4.6 Interest Holder Physical Data Modeling, Table 4.7 Parcel Physical Data Modeling, Table 4.8 Building Physical Data Modeling and Table 4.9 Legal Document Physical Data Modeling were described with their data type and storage. Because, Physical design is the process of producing a description of the implementation of the database on secondary storage. It defines specific storage or access methods used by database. The physical design of the database specifies a description of the physical configuration of the database, such as the tables, file organizations, indexes, security, data types, and other parameters in the data dictionary.

Table 4.5 Interest Holder Physical Data Modeling

Nos	**Attribute**	**Data Type**	**Storage(Unit)**
1	**(PK)InterestHolder_ID**	*Integer*	15
2	**Name**	*character*	50
3	**Address**	*character*	20

Table 4.6 Parcel Physical Data Modeling

Nos	**Attribute**	**Data Type**	**Storage(Unit)**
1	**(PK) Parcel ID**	*Integer*	15
2	**Area**	*double*	15
3	**Land Use**	*Character*	30
4	**Coordinate**	*Float*	15
5	**Address**	*Varchar*	20

Table 4.7 Building Physical Data Modeling

Nos	**Attribute**	**Data Type**	**Storage(Unit)**
1	**(PK) Building_ID**	*Integer*	15
2	**Bulding_type**	*Varchar*	20
3	**Area**	*Double*	15
4	**Height**	*Double*	15
5	**Basement**	*Double*	15
6	**Coordinate**	*Float*	15
7	**Floor_no**	*Varchar*	15

Table 4.8 Legal Document Physical Data Modeling

Nos	Attribute	Data Type	Storage(Unit)
1	**(PK)LegalDocument_ID**	*Integer*	15
2	**Produced_date**	*Varchar*	15
3	**Volume**	*Double*	50

CHAPTER FIVE

5. RESULT and DISCUSSION

5.1 Designing of Different 3D Cadaster Data Entry User Interfaces

For the implementation of 3D cadaster designing the interface of a 3D cadaster is a basic component and the important parts of this thesis. At this stage different interfaces were identified and designed. Such that login page interface, interest holder data entry interface, building attribute data entry interface and legal document data entry interface was designed.

5.2 Designed Data Entry Interfaces

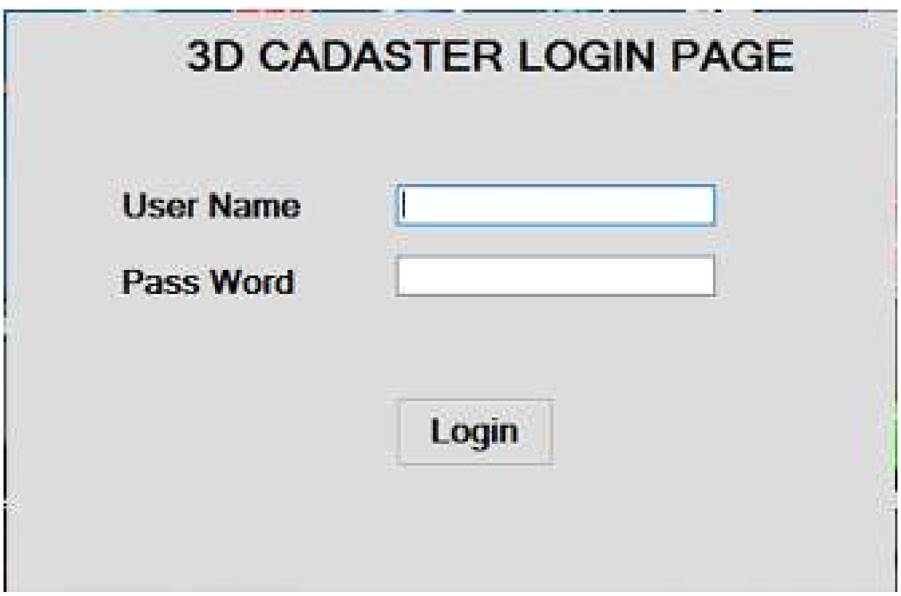

Figure 5.1 Login Page

The user logged into the system through this page. A password was used to gain access into the system to avoid unnecessary interference by unauthorized people.

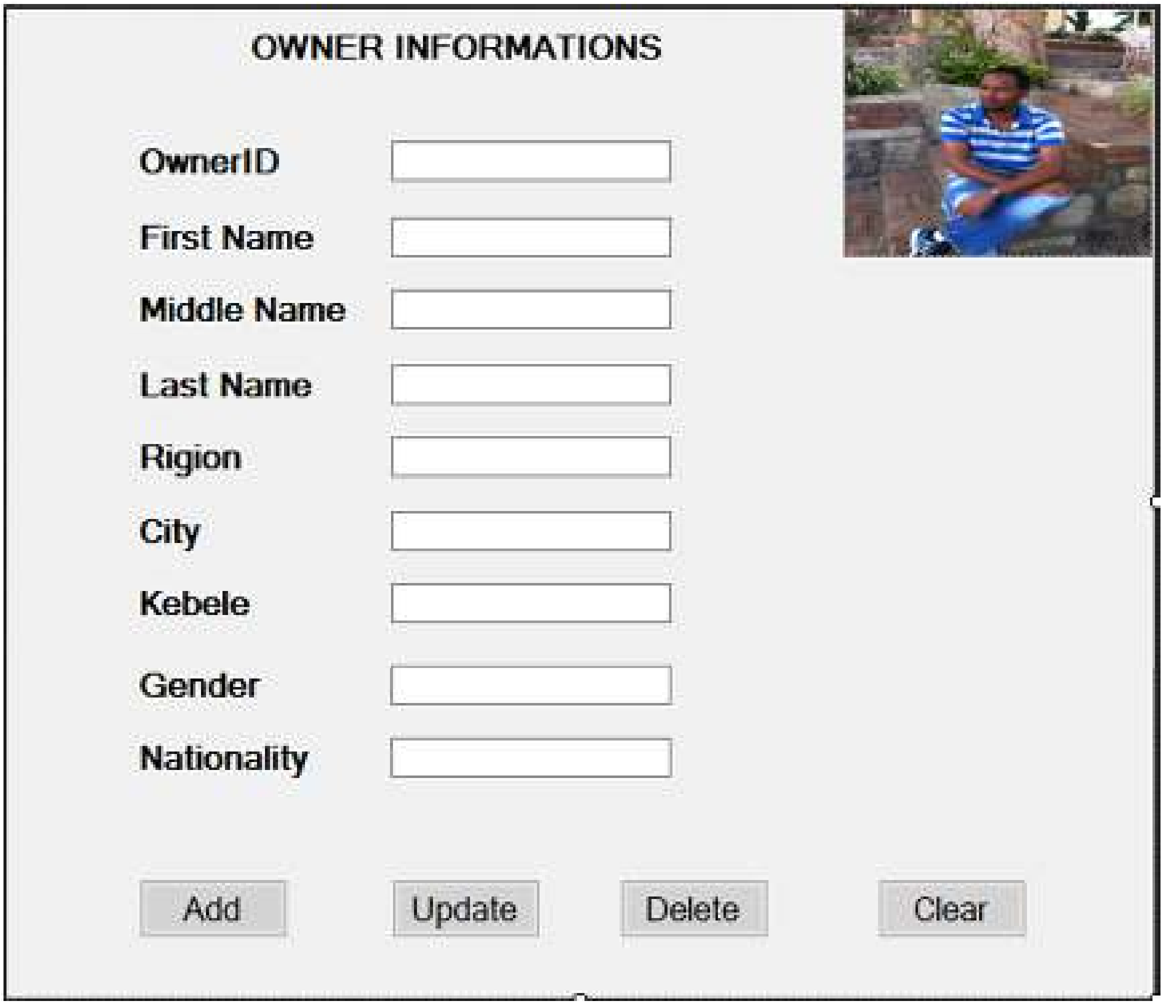

Figure 5.2 Owner information data entry interface

Owner Data for the system was entered through the designed interfaces with a carefully selected coloration to add to its esthetic quality.

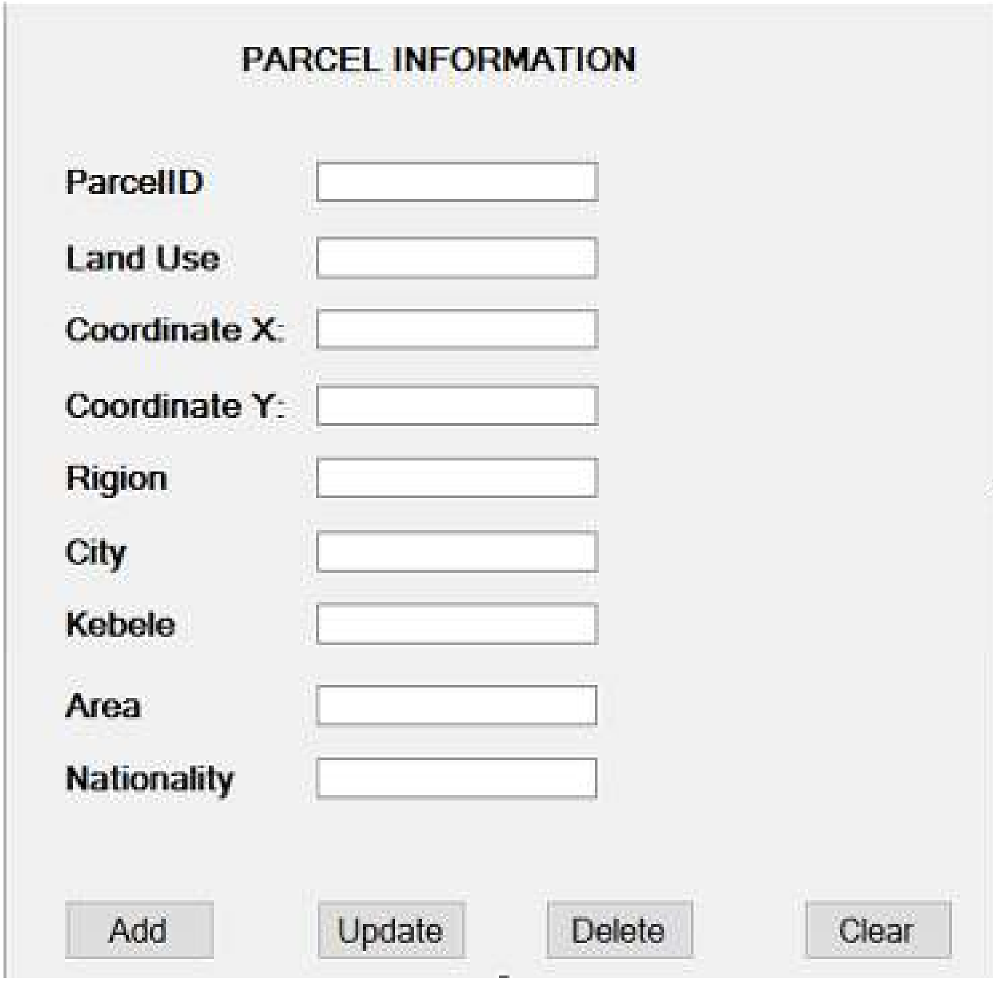

Figure 5.3 Parcel information data entry interface

Parcel information for the system was entered through the designed interfaces with a carefully selected coloration to add to its esthetic quality.

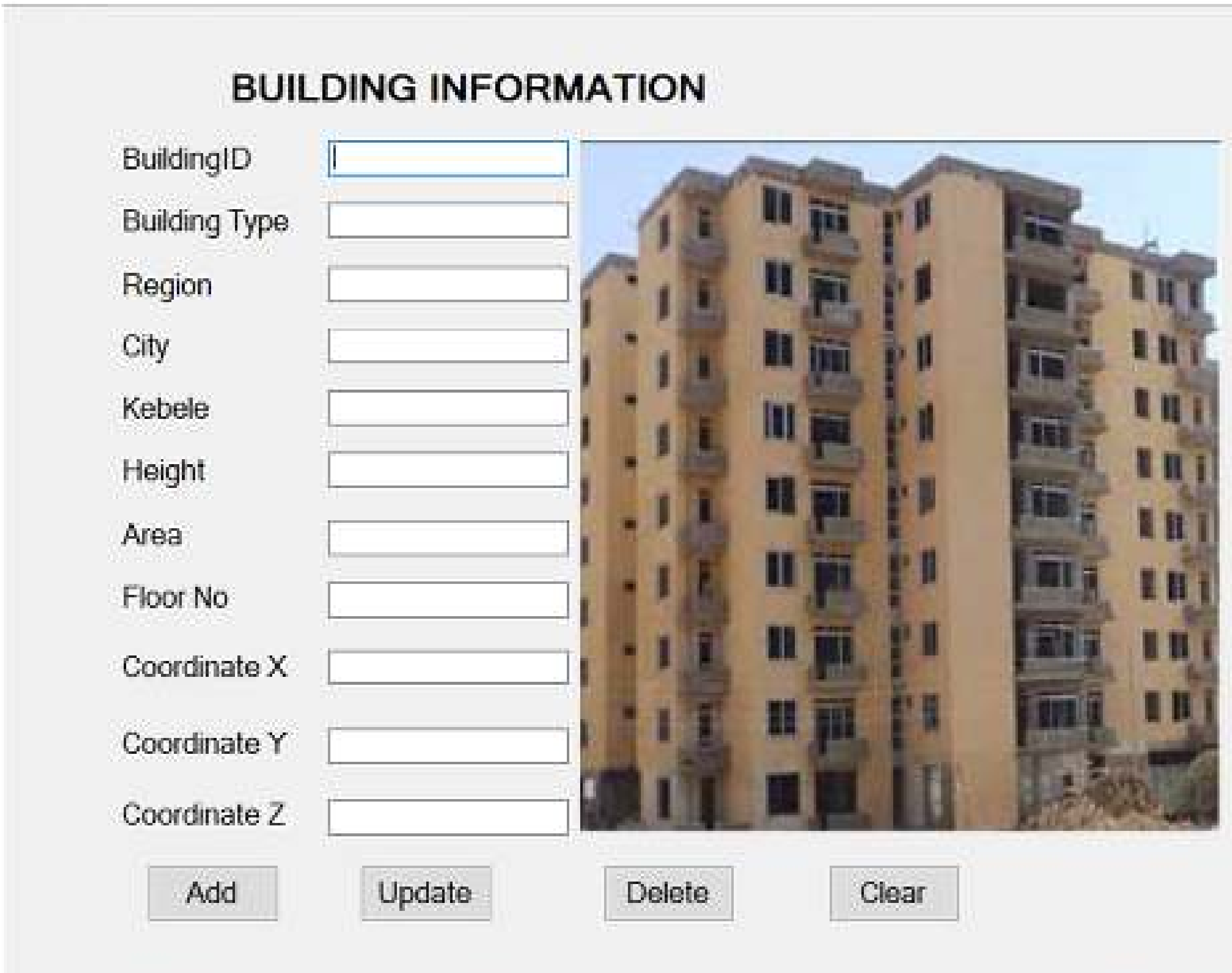

Figure 5.4 Owner information data entry interface

Building information for the system was entered through the designed interfaces with a carefully selected coloration to add to its esthetic quality.

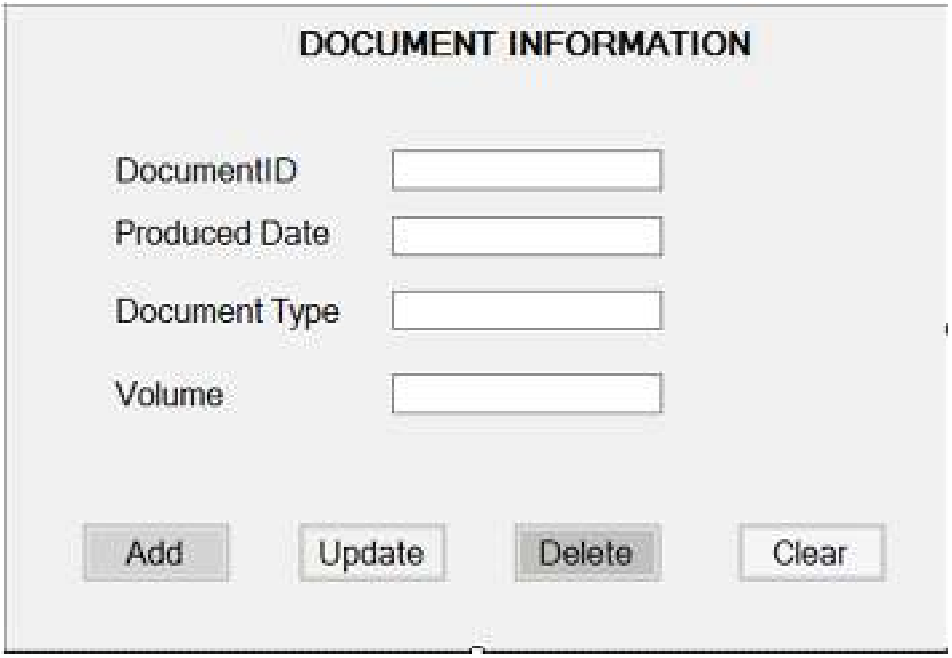

Figure 5.5 Legal document information data entry interface

Legal document information for the system was entered through the designed interfaces with a carefully selected coloration to add to its esthetic quality. This legal document may be mortgage, court case, title or deed.

5.3 Discussion

According to the research thesis done by Ahimad Hamid (2016) 3D modeling for urban cadastral registration, management and administration, case of Bahrdar Town have been performed using the surveying data of each buildings and aerial photographs were used, photogrammetric processes were undertaken, and side and front view photographs of some buildings are used. This method of using aerial photography demands high cost. Interns of cost benefit analysis it is not visible or advisable. The second drawback of this research thesis was taking side and front view photography doesn't show the inner part of the building and consumes high memory space and also the probability of image redundancy was happening. Where as in this research surveying data collection method using EDM method and Autodesk technology software generated floorplan ware used. This method saves time, memory usage and cost. In addition to this, the redundancy of data cannot be happening.

The real property registration system done by information network security agency(INSA) for Adama city urban land administration office cannot included the 3D objects. The other system Solution for Open Land administration(SOLA) done by Oromia Urban land holding Registration office cannot incorporate the 3D Object right restriction and responsibility. Where as in this research the 3D objects incorporated in the 3D cadaster modeling process.

According the research done by Amezene Reda and Bekele Bedada (2015), the Development of 3D Urban Cadastre and Property Registration System of Bahir Dar have been performed using the surveying data of each buildings to model 3D building, they applied transforming the surveying data through digitalizing using AutoCAD software to model the 3D building. In addition, this, they accessed the legal aspects of 3D cadaster implementation in Ethiopia. But the institutional aspects of 3D cadaster implementation didn't address. Where as in this research method the three pillars of 3D cadaster implementation (technical, legal and institutional aspects were addressed). Many scholars agree with the three pillars of the 3D cadaster implementation. Implementation of 3D cadaster needs different components that support to realization of 3D cadaster in any circumstances. These components are Technical, Legal and Institutional aspects of 3D cadaster (Fig 2.1 shows the relationship between different aspects of 3D cadastre). These aspects should be considered in 3D cadaster developments for each jurisdiction while 3D cadaster will be implemented. If one of the components or aspects missed or fully not functioning, it cannot fully implement 3D cadaster for the intended applications. So any governmental or non-governmental organizations that want to implement the 3D cadaster for the registration of right, restrictions and responsibilities of 3D objects must give attention to these aspects of 3D cadasters.

There are two approaches commonly used to build data models. Top down and bottom up approaches. In this research thesis the Top Down approach was used. Because,

The top down approach begins with identifying the entities within the business. Entities are the major items which the users identify or work with. For each entity identified, create a list of attributes which make up that entity. Review the attributes to be sure that they cannot be broken into smaller pieces of data, i.e. they may be entities themselves. In this way, start at the highest level and fill in the details below.

The bottom up approach begins with identifying all the elements in the system. This is a very long and difficult process of attempting to identify all the pieces of information the user comes in contact with. Once the elements are identified, they are grouped together to create entities.

The top down approach is recommended because it more closely relates to how the users define their business. Following the top down approach may also prevent from falling into the trap of physical modeling rather than logical modeling.

CHAPTER SIX

6 CONCLUSION and RECOMMENDATION

6.1 Conclusion

3D cadaster is a best tool for land administration system properly to digitally manage and represent stratified rights, restrictions, and responsibilities (legal models) and their corresponding physical models such as buildings, utilities, on, above or under the ground surface in 3D. A 3D Cadaster has the capability to capture, store, edit, query, analyses and visualize multi-complex properties and frameworks within a documented set of standards. The aim of this research were 3D Cadaster Modeling case and Develop 3D cadaster real property registration system case study in Adama in order to digitally represent real property ownership rights, restrictions, and responsibilities (legal models) and their physical counterparts. To overcome the statement of the problem of this research study, two objectives were analyzed in detail. To model conceptual, logical and physical modeling of 3D cadaster and to Develop 3D cadaster real property registration system. In order to implement the 3D cadaster different topic ware covered, different proclamations, rules, regulations, directives and standards were assessed in detail. From all rule and regulation historical background Ethiopia has not 3D laws, even if the development is in vertical. The researcher recommends it needs to have 3D urban land law proclamations, rules, regulation, standards and directives. The second point of this research study was, to analyses institutional aspect of 3D cadaster implementation**.** Different institutions Urban Land Development and Management, Urban land Holding Adjudication and Registration, Urban Planning Institute and Urban Land Information Project Coordination Office were discussed. Among these institutions none of them have the responsibilities of implementing 3D cadaster in the cities. The primary objective of Urban land holding adjudication and registration is adjudicating and registering urban land parcels for the implementation of legal cadaster. So that this institution has only the privilege of implementing 2D cadaster within the given scope and mandates. Therefore, the researcher recommends it needs to have 3D urban land implementing institutions that implements 3D cadaster in Ethiopia. This institution can be recommended through two options: - Restructuring the current institution or Establishing new institution that can implement 3D cadaster. The other point of this research study was, to model conceptual, logical and physical modeling of 3D cadaster implementation. This was the technical aspects of 3D cadaster. Business analysis is an important step defining requirements in the data modelling and database development cycle. The first step is to assess the needs of the users (gathering user's requirement). The basic objectives of business analysis involve: gathering and defining basic Entity/objects and data Attribute/elements; describing the information about the data elements and the relationships among them; and comprehensively documenting all of the requirements. The followings are Entities, Attributes and Relationships of the 3D Cadaster Modeling that was identified. In this research the Entities of the 3D Cadaster modeling identified was Person, Parcel, Building and Legal Documents. The attribute and relationships of these entity were discussed in detail using ER-diagram in chapter four. At the end of this research thesis Conceptual, logical and Physical 3D cadaster data modeling was modeled for the implementation of 3D cadaster and different interfaces were identified and designed. Such that login page interface, interest holder data entry interface, building attribute data entry interface and legal document data entry interface was designed.

6.2 Recommendations

In this research the Entities of the 3D Cadaster modeling was identified. Interest Holder, Parcel, Building and Legal Documents are the entities of 3D cadaster. The attribute and relationships of these entity were discussed in detail using ER-diagram, Conceptual and logical designing of 3D cadaster modeling. Therefore, it is possible to implement 3D cadaster by using conceptual, logical and physical modeling modeled in this research thesis.

Different land proclamations, rules, regulations, directives and standards were assessed in detail. From this all historical background Ethiopia has not 3D laws, even if the development is in vertical. The researcher recommends the governments, it needs to have 3D urban land law proclamations, rules, regulation, standards and directives for the implementation of 3D cadaster in the country.

Different institutions Urban Land Development and Management, Urban land Holding Adjudication and Registration, Urban Planning Institute and Urban Land Information Project Coordination Office are not having the responsibilities of implementing 3D cadaster in the cities. Therefore, the researcher recommends it needs to have an institution that implements 3D cadaster in Adama City. Such institution can be recommended through two options: - Restructuring the current institution or Establishes a new institution that can implement 3D cadaster.

This research defines a 3D cadastre as a tool in a land administration system that enables better management and registration of multiple stratified land rights, restrictions and responsibilities in 3D space. Furthermore, it is indicated that legal aspects (legislation to support 3D property registration), institutional aspects (relationships between involved parties), and technical aspects (technical support to realise 3D cadastre) of 3D cadastre should be considered in the implementation of 3D cadastres.

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