ADDIS ABABA UNIVERSITY

COLLEGE OF NATURAL AND COMPUTATIONAL SCIENCE

SCHOOL OF EARTH SCIENCE

3D MODELLING FOR URBAN CADASTERAL REGISTRATION, MANAGEMENT AND ADMINISTRATION; THE CASE OF BAHIR DAR TOWN ETHIOPIA

BY

AHMED HAMID

A Thesis Submitted to the School of Graduate Studies of Addis Ababa University Presented in Partial Fulfilment of the Requirements for the Degree of Masters of Science

(Remote Sensing and Geo-informatics)

ADVISOR

Dr. GETACHEW BERIHAN

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This is to certify that the thesis prepared by Ahmed Hamid entitled as 3D MODELLING FOR URBAN CADASTERAL REGESTRATION, MANAGEMENT AND ADMINISTRATION; IN THE CASE OF BAHIR DAR TOWN, ETHIOPIA is submitted in partial fulfillment of the requirements for the Degree of Master of Science in Remote Sensing and GIS compiles with the regulations of the university and meets the accepted standards with respect to originality and quality.

Signed by the Examining Committee:-

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Examiner	Signature	Date

Abstract

High rate of Population growth, coupled urbanization and industrialization results for high demand for land. In order to increase availability of land, the government of Ethiopia has introduced the construction of multipurpose buildings which allows vertical expansion rather than horizontal. Due to this mode of expansion there is a need to establish a land tenure system which considers the use and registration of multipurpose buildings in 3D environment. In Ethiopia, using aerial photography for cadastral mapping is not a new thing for the processes of extraction of 2D cadastral layer but most of the time it is not seen using for 3D cadastral registration system. Method of feature extraction in 3D environment using aerial photograph is cheaper than that of LIDAR. 2D cadastral and property registration system cannot solve the problem related to building height and was difficult to standardize building construction, even if it has been employed for a long period of time. 2D cadastral registration system is not able to clearly indicate the property right of individuals having multi-purpose buildings. Due to this it is difficult to register, manage, and visualize their institute condition for decision making and for a given applications such as infrastructure development. This study is intended to examine the applicability of Aerial photo and CGA script for automated 3D objects modeling, design cadastral information system for commonly owned residential building and commercial centers, examine legal and institutional aspects of 3D property information and representation system for land registration, management, administration, urban planning and decision making process in Bahir Dar town by applying 3D GIS techniques. The existing 2D cadastral registration system was carefully assessed and the gaps are well identified prior to propose a new registration system. The ESRI 3D city engine module was used to reconstruct the multi-purpose buildings after carried out photogrammetric processes. CGA rule was written for each textures such as wall, roof, road, façade, window and door to produce an automated 3D urban model. From the study it is found that the existing cadastral registration system in Bahir Dar land management and development office does not consider the registration of multipurpose buildings. Due to this a new registration system was proposed to incorporate multipurpose buildings in the future cadastral registration processes. It was also found that a 3D model cadaster supports better in managing increased demand of land and building constructions.

Key words: *3D model; Cadaster; aerial photo; CGA rule; Façade; Registration; Management Administration, Bahir Dar.*

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List of Acronyms

2D - Tow Dimensional

3DCDM – 3D Cadastral Data Mode

AT - Aerial Triangulation

BWUD -Bureau of Works and Urban Development

CLRAMS - Cadastral Land Registration, Administration And Management System

CGA- Computer Generated Architecture

DTM - Digital Terrain Model

ECE - Economic Commission of Europe

ECSA - Ethiopian Central Statics Agency

EMA - Ethiopian Mapping Agency

ESRI- Environmental Science Research Institute.

EO - Exterior Orientation

FDRE -Federal Democratic Republic Of Ethiopia

FIG - International Federation of Survey

FULRPRIA-Federal Land and Land Related Property Registration and Information Agency

FUPL - Federal Urban Planning Institute

GCP-Ground Control Point

GIS - Geographic Information System

GML - Geographic Marked Up Language

GPS - Global Position System

IHDP- Integrated House Development Program.

IPRR - Immovable Property Right Registration

LAS - Land Administration System

LIDAR - Light Detection and Ranging

LIMS - Land Information Management System

LOD - Level of Detail

LPO - Legal Property Object

MCA- Metropolitan City Administration

MCO - Municipal Cadaster Office

M.A.S.L-Mean Average Sea Level

OGC - Open Geospatial Consortium

PPO - Physical Property Object

RRR - Right, Restriction and Responsibility

SDI - Spatial Data Infrastructure

UML - Unified Model Language

UNDP-United Nation Development Programme.

CHAPTER ONE

INTRODUCTION

1.1 Background

Since the mid-1990s the demand for 3D city models is continuously growing and become common place. Especially Internet applications like digital globes as provided by Google Earth or Bing Maps and advanced navigation systems carry 3D city models to a huge group of potential users. The spread and wide range of applications also result in more heterogeneous demands ranging from the provision of input data for photorealistic real-time visualization of terrestrial walkthroughs to interpreted scenes for advanced search and navigation (Haala and Kada, 2010).

According to Malumpong and Chen (2008), with the rapid development of technologies in the recent years, Creation of 3D digital city model using conventional stereo images of aerial photos or satellite images is cumbersome and is a less cost-effective technique for many applications. 3D models of infrastructures are important in giving clear view of individual's and protected public properties. Using the advantage of 3D GIS, cadastral systems are upgraded to 3D cadaster in order to solve problems faced in registering complex spatial properties like tilted buildings, underground tunnels and parking, above and underground roads, condominiums, apartments, twisted buildings, over road crossing buildings etc (Kemahu Aberaham, 2015). Population density has increased significantly in Ethiopia, which results the shortage of land among the people. As a result of this the house is constructed over each other to associate the land relation with person who need in house in Ethiopia. To full fill this need The Federal Democratic Republic of Ethiopia (FDRE) constructs condominium for low income people in urban area. To secure this common building registration requires controlling the security of the land (Amezene Reda and Bekele Bedada, 2015). Transition from the existing 2D cadastral system to a 3D cadastral system; also integrate 3D representations of the physical objects with two dimensional systems in one database. The demand for 3D modeling in the field of geo-information especially in urban land management is becoming show change in developing countries. This is due to increase in number of the population in urban areas because of high fertility rate and migration of many peoples from rural areas to urban areas. It contributed to scarcity of land for building residential, commercial purpose, hotel, and industries and for other purposes. Due to the case of increase in the population number and shortage of residential for many peoples resulted in land scouting and this introduce shanti neighborhood (building small hats in groups) around the town. In the previous time a parcel of land to individual's for different purpose was possible but, starting from recent time it becomes more difficult from time to time and governments offer to solve this problem built condominium and large buildings for multi-purpose for the societies. Since it increase from time to time, so it is difficult for management and administration. The traditionally land and property information, which includes geometric, visual and legal data for each property unit, has been two-dimensional, based on 2D land parcels. The 2D description of parcel boundaries does not adequately explain the relationships among the varied parcels in buildings, especially constructions that involve below ground space. The 2D cadastral system important ground level villa type buildings, but management of modern cityscapes would benefit from a much more descriptive capacity in the land administration and tiling systems. 2D cadasters are unable to adequately reflect the spatial information about those in the 3D cadastral rights.3D cadasters needs to manage and represent stratified land rights, restrictions, and responsibilities in 3D (Aien, 2013). However, starting from recent time, urbanization, high-rise apartments and the coming of complex building structures has prompted land administrators to incorporate the third dimension into the land development cycle; the fast economic growth and rapid urbanization present a challenge to the limited urban land resources of Ethiopia. Specifically, they encourage a shift in the concentration on the surface of land parcels to the space above and below them. Recent development in land utilization in developed cities has broken the traditional frame of the parcel-based or 2D cadaster and in developing countries increasing a need for using cadastral systems which leads it in to utilizing 3D cadaster with the aim of enabling effective management and registration of 3D cadaster rights, restrictions and responsibilities.

3D urban simulation provides a virtual environment that a user can interact with an urban space as it currently exists, as it existed ten years ago, or as it might look in the future after physical changes are made. The latest simulation technology goes further, and allows a user to remove existing building and to replacing them with new developments so that the user can observe the impacts or changes from the development. Due to the unique advantages of

3D urban simulation, 3D urban simulation has been used to solve several urban planning issues for the last decades in developing countries. Several urban planners and researchers have applied 3D urban simulation to attract more community residents to public meetings, to foretaste environmental changes caused by future developments, to control urban sprawl, to analyze trends of a city's skyline and landform changes, to build a database of a city's historic buildings, to facilitate disputes related with new developments, and to study micro climate and wind tunnels of a city (Kim, D, 2010).

3D GIS technology has powerful three-dimensional visualization and 3D spatial analysis capability, which is an effective technical approach for the extraction of real estate spatial location information (Zhang, H, 2014).

The 3D modeling scenes benefit from the extensive functionality and analytical capability of GIS as well as multiple queries feature by utilizing its database structure. Development of 3D models depends on two factors: spatial information database and remote sensing technology. The rapid rate of information technology deployment suggests that these two features may become an integral part of 3D models in the near future. Consequently, a real-time, automated modeling technology will evolve such that we can automatically generate a model onsite wherever the remote sensing data are acquired by downloading them into standard packages that generate effective and useful models. The technological advancements of modeling features seem to be a matter of time, closely following the development of geographical information technologies, and the crucial factor will be the extent to which such automation will extend to bespoke applications, particularly those that address professional concerns (Shiode, 2001).

A cadaster is perceived as a systematic and official description of land parcels, which includes for each parcel a unique identifier. The description includes text records on attributes of each parcel. The prototypical (a first form from which other forms are developed or copied) means of identification is a large-scale map that provides information on parcel boundaries (Silva and Stubkjaer, 2002) as cited by Çağdaş, V. (2014).

A 3D cadaster is a cadaster which registers and gives insight in to rights and restrictions not only on parcels (a plot of land) but on 3D property units (upper and underground properties).

3D cadasters would assist management of 3D right, restriction and responsibilities. A 3D cadaster should be capable of storing, manipulating, querying, analysis, updating, and supporting the visualization of 3D land rights, restrictions and responsibilities. 3D cadaster would be able to handle such conditions as overlapped buildings and utilities that prohibit the property from being registered according to legal and organizational aspects using a 2D cadaster(Aien *et al.,* 2012).

The Open Geospatial Consortium (OGC) has defined five different levels to describe the level of detail (LOD) of the model fineness. LOD-0 model contains only simple blocks to represent terrain and images. LOD-1 model uses simple blocks that collectively represent buildings. LOD-2 model includes textures and roof structures.LOD-3 model details the building architectures specifying exterior walls and balcony. LOD-4 model describes interior architectures and objects such as inner walls, doors, windows, columns, stairs and furniture (Gröger *et al*., 2008; Elwannas, 2011) as cited by Hun-Chin Chiang(2012).

Land is at the core of a nation's economy and as such it is essential to device methods for improving its management. In this respect, the implementation of proper management tools and policies with respect to land results in efficient land transactions and land markets. However, this is only possible if the rights pertaining to different land units are well defined and properly documented. The availability of land information improves land valuation, taxation and zoning since all these operations are based on the land unit (Larsson, 1996)as cited by Kurwakumire, E (2014).

The aim of this research lies in the fast and continuous development of the legal and physical components of Bahir Dar town in a 3D environment to enable a more complete and effective land and property information registration system, which will in turn help the governing bodies for better management and decision making processes. Incorporating a 3D land and property information system becomes imperative since 2D survey plans are no longer able to represent the reality of inter-related titles and land uses with their complexities.3D architectural drawings do not deliver legal authority in land and property registration. Modeling the 3D legal world and linking this to the physical world could facilitate a 3D land development process.

1.2 Statement of the Problem

3D modeling is important in urban area cadastral system. Previously cadastral system in Ethiopia was traditional but currently two dimensional cadastral systems have been implemented and cannot solve the problem related to land property registration. This is due to the increased construction industry in Federal, regional and zonal levels. It has its own impact on individual and commercial property registration for management .However, due to lack of knowledge, skill and technological advancement of 3D modeling for urban cadastral system has been negatively affect the quality of land administration and the good governance in many sectors. Some of the reasons for this are:-

- Conventional way of land registration existed previously was not able to address the individuals property properly.
- Implementing 2D cadastral and property registration system cannot solve the problem related to building height and was difficult to standardize building construction, even if it has been employed for a long period of time.
- 3D modeling using LIDAR data from aerial laser scanner highly expensive than aerial photography In Ethiopia, the technology of using Arial photography has been introduced and being used for the rural and urban cadastral systems several years ago.

However, from the experience of 3D modeling of developed countries, it is assured that 3D modeling is most appropriate for urban cadaster system and property Registration. It is well known that 3D modeling is the most crucial to easily manage multipurpose buildings in urban areas for future implementation in Ethiopia.

1.3 Objectives

1.3.1 General Objective

The main objective of the study is to indicate application of GIS for 3D cadaster registration, management and administration system in Bahir Dar Town.

1.3.2 Specific Objectives

Specific objectives of the research are to:-

- Investigate the reliability of aerial photo integration with 3D GIS for cadastral registration processes.
- Generate 3D model for cadastral multipurpose buildings.
- To assess the existing cadaster registration, management and administration system in Bahir Dar town.
- Validate the result of 3D Cadastral model in the processes of aerial triangulation and orthophoto generation.

1.4 Significance of the Study

The study will highlight how 3D modeling is vital for cadastral management and land administration system, To examine individual properties that built in underground and upper ground buildings for Bahir Dar city administrator as casing to analyze, understand and bring to focus how 3D cadaster system is important for cadaster registration, management and administration purpose of varies decision making processes. Due to increasing demand of building construction in Ethiopia special in cities of regional capitals like Bahir Dar, requires the designing and development of advanced techniques of cadaster registration system for multipurpose buildings and skyscrapers. The techniques of registering and managing such types of buildings in a 3D environment is not yet applied in Bahir Dar town, so this study is important because it indicates how multipurpose buildings are handled in a 3D environment rather than the conventional way of cadastral registration system with minimum cost, time, labor and ready-made aerial photographs without using expensive LIDAR data. Therefore, the paper will be the base for further research. A 3D cadaster should be able to unambiguously define real property interests in land and air space. A 3D cadaster can assist management of multipurpose land, and in time will become an essential base layer for all land administration functions such as land tenure, land value, land use, and land planning (Aien, 2013).

1.5 Limitation of the Study

The gene-facade system have low qualities this is due to the photographic camera that are used during taking the photographs of the front and side of a building it impact on low resolution of images.

1.6 Thesis Organization

The overall organization of the thesis can be divided into six major parts. Chapter-1 the introduction parts describe the previous cadastral systems population situations, urbanizations and others. Chapter-2 presents the literature survey of the related work in object recognition and the technical background in land administration, tenure system ,cadastral system ,some description related to 3D cadastral system, describe about current situation of Cadastral system in Bahir Dar described, city engine, CGA rule, façade and limitation. Chapter-3.Methedology part include describes the study area, materials used for the processes of the thesis and the methodological processes start to end. In Chapter-4, Data Analysis and Result which, include the processes of photogrammetry aerial triangulation ,tie point generation, DTM, generation Ortho-photo production, 2D and 3D data capturing, taking photographs of some buildings, façade cropping, tilling ,gene façade generation ,writing CGA rule, foot printing of modeled object takes place, assigning the rule results and generation of 3Dmodelling using software's takes place. And include discussion part of a research. Chapter-5, Discussions part Chapter-6, conclusion, recommendation of the research.

CHAPTER TWO

LITERATURE REVIEW

2.1. Land Administration System

Land is the ultimate resource, without it, life on earth cannot be sustained. Land is both a physical commodity and an abstract concept in that the rights to own or use it are as much a part of the land as the objects rooted in its soil. Good stewardship of the land is essential for present and future generations. Land administration refers to the processes of recording and disseminating information about the ownership, value and use of land and its associated resources (Economic Commission for Europe, 1996).

Land administration system (LAS) should not change the land tenure relationships between people and land. On the other hand, land administration systems will enable land tenure reforms to be introduced. A land administration infrastructure provides an inventory of rights, restrictions and responsibilities in a country (Williamson, 2000).

The availability of reliable information about land and its resources emerged as a vital issue in managing these challenges. If relevant and good decisions are to be made by public authorities (private resource users or community bodies), it must be based on sound information about the land and environment in order to contribute to sustainable development. This in turn requires the articulation of principles for the development and operation of land information and cadastral systems, as well as land registration systems, which give effect to the principle of sustainable development. Land administration may be built around the concept of individual and shared, communal, commercial and private rights. The focus may be on leasehold tenures or so called freehold tenures. Lack of secure property rights in the land will inhibit investments in housing, sustainable food production and access to credit, hinder good governance and the emergence of civic societies, reinforce social exclusion and poverty, undermine long term planning, and distort prices of land and services. Without effective access to land and property, market economies are unable to evolve and the goals of sustainable development cannot be realized.

Land Registration is major component of any land administration system that are record of land ownership. Because of the uncertainties that can arise over who owns the land and under what conditions, in many societies it became based on custom rather than common low or statute to document the transfer of land rights in the form of legal deeds and certificates. To provide additional security, official copies of these records were kept in deeds registries, or what in some countries are called land books (Aien, 2013).

The International Federation of Surveyors (FIG) has defined a Land Information System (LIS) as a tool for legal, administrative and economic decision-making and an aid for planning and development. A LIS consists of a database containing spatially referenced land-related data for a defined area and of procedures and techniques for the systematic collection, updating, processing and distribution of the data.

Land management requires inter-disciplinary skills that include technical, natural, and social sciences. It also deals about land policies, land rights, property, economics, land use control, regulation, monitoring implementation and development. Land information management system a system for acquiring, processing, storing and distributing information about land. Land management must be based on knowledge the information, method of data collection and manners knowledge depends on information, and information depends on the methods of data collection and the manner in which their results are communicated.

Land-related information is an important and expensive resource that must be managed efficiently in order to maximize its potential benefits. Efficient and effective LAS that support sustainable development require a spatial data infrastructure (SDI) to operate. The SDI is the enabling platform that links people to information. It supports the integration of natural (primarily topographic) and built (primarily land parcel or cadastral) environmental data as a pre-requisite for sustainable development. The SDI also permits the aggregation of land information from local to national levels (Economic Commission For Europe, 1996).

2.2. Land Policy

Land policy is simply the set of aims and objectives set by governments to deal with land issues. Land policy is part of the national policy on promoting objectives such as economic development, social justice and equity, and political stability (Williamson, 2010).

Land policy consists of a whole complex of socio-economic and legal prescriptions that dictate how the land and the benefits from the land are to be allocated. A balance must be struck between the exploitation, utilization and conservation of the land as a resource in order to obtain the necessary level of sustainable development for the survival of humankind (Economic Commission for Europe, 1996).

2.3. Cadastral System and Registration

Cadasters as the engine of land administration systems while integrated with spatial data infrastructures (SDI) are required to help manage interests in land and its resources (Aien, 2012).The land registration processes is modeled, both by a static and dynamic model these includes the technical, legal and organizational aspects, and their interrelation, of such processes (Zevenbergen, 2004).

According to (Guoab *et al*., 2013), the system of land registration processes is important for the management and administration of cadastral system. Ethiopian land administration system has textual and spatial components. Textual Component includes, but not limited to, the description of the land holder, family members, and address. The property will be authorized through a process of registration in which its ownership, land usufruct, location, and area are recorded and authorized. The current 2D representation, such as plans and drawings, is not adequate to 3D reality (buildings), since it demands an additional mental process to integrate individual drawings so as envision the physical construction in grasping full property rights.

The Immoveable Property Rights Registration include:-

- Real Property Rights - records on ownership, mortgages and servitudes on land, buildings and apartments. This is a legal register
- Actors - records on private persons and legal entities (ID number, name, address, type of actor owner, possessor etc.). These actors will be linked to legal land, buildings or apartments in the Real Property Rights Register
- Buildings and apartments - records on buildings (ID number, Address, type of building, construction year, number of floors, area, etc.) and apartments (ID number location in building, number of rooms, area, etc.)
- Textual land cadaster - records on land parcels (Id number, type of land, area, etc.)

- Graphical land Cadaster - records on vector data (cadaster plans with parcel borders, roads, rivers, etc.) and raster data (Ortho-photo, digital terrain models etc.)
- Miscellaneous registers, which will store data delivered by different data providers. The model for these registers will be determined in cooperation with the providers, with the inclusion of data within the unified register (Meha *et al.,* 2004)

The main objective of any property register is to warrant legal security in property transactions. The registration is thus not an aim in itself. The primary target, from a legal point of view, is to make 3D property rights certain and transferable and, in this way, to make the multi-use of space practically possible and attractive to the market. Therefore, all the legal situations, especially those related to complex three- dimensional cases, have to be represented in the register in a correct way and the registration should provide an insight into the actual legal situation in a simple, straightforward and sustainable manner (URL[1]).

The United Nations Economic Commission for Europe held a workshop in Vienna in September 1994 which produced a number of recommendations concerning the introduction of data into a cadastral system that are relevant to land administration.

Data capture is the most expensive part of building up cadastral information systems.

To avoid redundancies and inappropriate data it is important to set up a pilot project to examine standards for quality, data exchange, data classes, attributes, updating routines, etc. It is necessary also to consider how the use and value of land will influence data accuracy

- Data concerning real property were used by a number people and organizations. To avoid double registration it is essential that regulations are set up for cooperation between public authorities on different levels and private companies.
- The Public authority should be responsible for the necessary control of data.
- To secure an optimum use of data, it is necessary to define a minimum core of common data. It is better to have a limited number of essential common data for a whole region or country than sophisticated data collections for minor areas. The different users can then supply the common data with specific data to meet their own specific needs.

URL[1] - Http: // www.ijser.org.
URL[2]- http;//www.eolss.net/EOLSS% 20publication%20Catalogue. pdf.

- To avoid double registrations of basic common data, it is important to meet the expectations of users. In this case time is a crucial parameter. The authority responsible and must consider the involvement of external producers in the conversion process from analogue to digital form for implementing the process in a shorter time.
- When data collection starts it is important that an updating process should be installed at the same time.

Ethiopian land administration system has textual and spatial components. Textual Component includes the description of the land holder, family members, address, bordering land holders, fertility status of the parcel, encumbrances if any and the like. The spatial component shows a graphical representation of the parcel together with parts of adjacent parcels and unique identifiers. The urban cadastral plans are not connected to any grid and most of them are still paper based .The cadastral mapping in Ethiopia is limited to urban areas. The urban cadastral plans are not connected to any grid and most of them are still paper based. Where as in the rural areas there are no historical maps that can be used as a base for the new cadaster bordering land holders, fertility status of the parcel, encumbrances. That is, maps can be produced using ground surveys or remote sensing tools as long as they can meet the accuracy needs of a specific holding type (Gebeyehu Belay, 2003).The information in the register is also used for valuation which is needed for compensation purposes.

Cadastral processes constitute the activities necessary for access to land and land delivery. Access to land refers to the opportunities that are available for one to acquire any form of land rights. Land delivery refers to the channels that are used to supply land for various uses and the technical and legal procedures that are necessary to support the process these are Adjudication, Demarcation, Surveying and Mapping. The significance shown in figure 1. (Amanuel Tesfay, 2008).

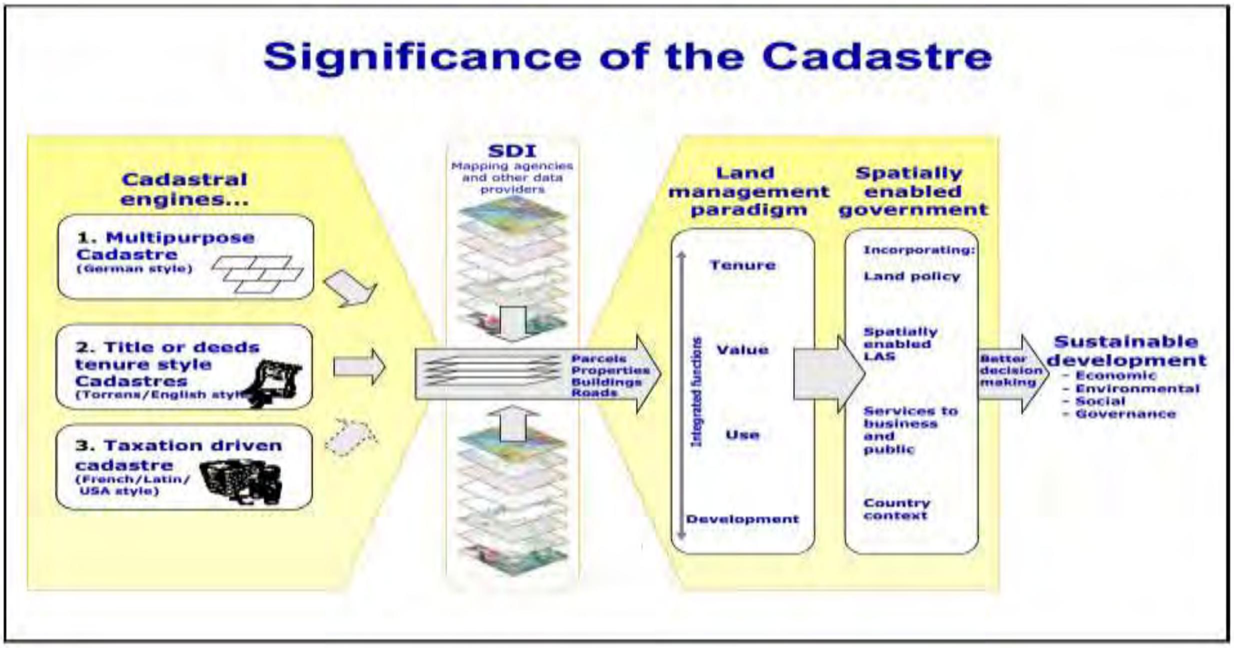

Figure 1: Significance of Cadaster (Source : FIG Congress 2010 presentation).

The FIG has published Cadaster 2014, a document that contains the development of future cadastral systems (Kaufman, 2004). Cadaster 2014 argued that, cadastral systems will show the complete legal situation on land, including all of the rights, restrictions and responsibilities. The separations between maps and registers will be abolished while traditional cadastral mapping will be replaced by modeling. The paper and pencil cadaster will have gone and been replaced by systems that will be based on cost recovery. Future cadastral systems will also be highly privatized (Abdulmajid, 2000).

2.4. Photogrammetry and Its Purpose for Cadastral System

Photogrammetry is the science, art, and technology for obtaining from imagery the position, size and shape of objects, as well as interpretation of these object features. Digital photogrammetry is now developing as a comprehensive technology for obtaining and recording 3D object model position, size and shape via real time imaging, and for reconstructing and visualizing developments in sensor and image processing technologies.[2]

URL[2]- http;//www.eolss.net/EOLSS% 20publication%20Catalogue. pdf.

2.5. GPS, Surveying Data and Its Importance for Cadastral System

Global positioning system: - The GPS consists of a constellation of 28 satellites that provide continuous instantaneous position and time information to users around the world. GPS is suitable for a broad range of surveying applications including: cadastral/engineering set out, topographic mapping, and geodetic control. It is a system for fixing positions on the surface of the Earth by measuring the ranges to a special set of satellites orbiting the Earth. The effectiveness of any surveying and mapping technique is influenced to a large extent by the conditions in the field and the capacity of existing institutions to deal with the vast amount of information that typically flows from cadastral and registration (Barnes.*et al*.., 1998).

2.6. Cadastral System and Its Classification

A cadaster is similar to a land register in that it contains a set of records about land. Cadasters are based either on 1) the proprietary land parcel, which is the area defined by ownership. 2) the taxable area of land which may be different from the extent of what is owned 3) areas defined by land use rather than by land ownership. Cadasters may support either records of property rights, or the taxation of land, the recording of land use (Economic Commission for Europe, 1996)

The cadaster is at the core of any LAS providing spatial integrity and unique identification of every land parcel. Cadasters are large scale representations of how the community breaks up its land into useable pieces, usually called parcels. Most cadasters provide security of tenure by recording land rights in a land registry. The spatial integrity within the cadaster is usually provided by a cadastral map that is updated by cadastral surveys. The unique parcel identification provides the link between the cadastral map and the land registry, and serves as the basis of any LAS and the land information it generates, especially when it is digital and geocoded. The cadaster should ideally include all land in a jurisdiction: public, private, communal, and open space (Williamson.*et al*., 2010).

Ensuring adequate resources are available to support computerization and ongoing maintenance is critical. This also requires systems be in place to integrate decentralized operations whether they are manual or automated. The cost of this reform strategy should ensure that those costs passed on to the consumer are not overly onerous. Accessible and easily adaptable information will increase demand for its use in decision making. As with first registration, during the early stages of computerization and publicly accessible data, costs should be minimized to encourage participation and increase demand for the formal system and services provided (Burns and Dalrymple, 2008).

2.7. 3D Cadaster

3D spatial modeling is an abstract representation of reality using mathematically proven relationships defined as points, lines, polygon and solids to represent man -made and natural features above, on and below the surface of the Earth (Eric *et al*.., 2013).

3D cadaster 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 realize 3D cadaster) of 3D cadaster should be considered in the implementation of 3D cadasters. The cadaster tree diagramme shown in figure 2 (Aien, 2012).

Applications of 3D cadaster are different and they require a different detail and scale of information. For example, land registrars need parcel scale information, meaning that they need to register and visualize subdivided 3D spatial objects and their associated rights. By contrast, city planning organizations need large scale and more detailed information in every unit and story of a building.

3D Cadaster is an information system, based on parcels, containing information about the ownership, use, and value of these parcels. The core urban area is the economic and social nerve center of the city, and land (space) is always in demand to support it increasing activities. The use of space under or above its surface is a rational alternative. Such space must be effectively and consistently managed to prevent legal conflict with the existing cadaster. To meet this objective, it is best to administer tri-dimensional urban space with a 3D cadastral system than with the current 2D cadastral system (Guo ab *et al*., 2013).

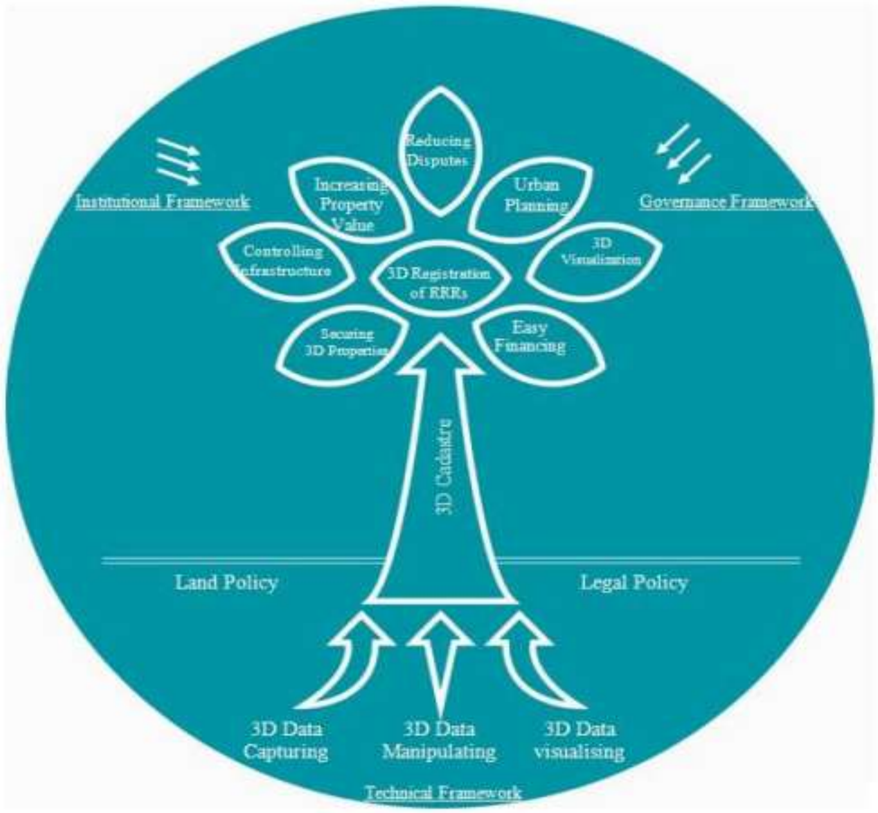

Figure 2: 3D Cadastre Tree Diagramme (Source: Ali Aien 2013).

2.8. Need for 3D Cadaster

Three-dimensional GIS city modeling with geo-informatics techniques and 3D modeling software develop three-dimensional GIS database which includes reconstruction of buildings, terrain, and other features that are relevant to a city modeling processes (Malumponga and Chen, 2008).

According to Aien (2013), Third dimension of height in land information systems facilitates subdivision of space into strata legal property objects capable of being owned by different entities and used for unrelated purposes while facilitating management of the entirety. This creates separate legal property objects above or under the original property parcel or unit. The most typical objects located above the surface are apartments or buildings registered as separate property.

2.9. Aerial Photography for 3D Modeling Cadastral Purpose

Aerial photogrammetry is able to economically the roof land scape and ground texture of a large built up area the limited resolution of 2D aerial image ,the most common of source of data however does not the detection of small roof elements. The methods used for this purpose to generate 3D city model as semi- automatic or automatic feature extraction procedure to drive the roof structure from the available data source ,texture mapping is a method of adding detail, surface texture or colour to the 3Dmodeling processes. Advantage of 3D modeling is making the 3D modeling for mobility and convincing effect on users for future decision making processes (Hamruni, 2010).

Automatic 3D building reconstruction has become increasing important for a number of applications. The reconstruction of buildings using only aerial images as data source has been proven to be a very difficult problem. The complexity of the reconstruction can be greatly reduced by combining the aerial images with other data sources. The 3D reconstruction of buildings can take advantage of the 2D maps that contain the ground plans of the buildings. It can be localized in an image, and its region of interest can be delineated in the image, the footprint can give a good hint about the structure of the building. The footprint can provide the initial values at the generation of building hypotheses It is good in order to generate 3D object modeling (Suveg *et al.*, 2004).

2.10. Cadastral System for Sustainable Development

The use of photogrammetry and remote sensing techniques has been encouraged in the cadastral system, if we want sustainable development to be achievable[3].

The Technical aspect, legal and organizational aspects also play an essential role and cannot be ignore or separated from the cadaster main body therefore, all of these aspects should work together and concurrently Choon, T.L. and Hussin, K.B. (2010).

The absence of a systematic, well-defined and public documentation system about these additional rights and restrictions creates an increasing legal insecurity. Landowners, investors and administrations are therefore confronted with additional efforts to find out what legal

URL[3] - http://www.wgbis.ces.iisc.ernet.in/energy/HC270799/LM/SUSLUP/Thema5/594/594.pdf, situation they have on their properties or in areas, where they intend to invest in. Politicians have taken up the issue and are asking for systematic registration of restrictions and rights on land. Cadaster 2014 is a concept to create a systematic documentation of the legal situation of land, using the possibilities of the GIS technology combined with the procedures used in the traditional cadastral and land registration systems (Kaufmann, 2004).

FIG has published Cadaster 2014, a document that contains the development of future cadastral systems (Kaufman, 2004). Cadaster 2014 argued that by the year 2014, cadastral systems will show the complete legal situation on land, including all of the rights, restrictions and responsibilities. The separations between maps and registers will be abolished while traditional cadastral mapping will be replaced by modeling. The paper and pencil cadaster will have gone and been replaced by systems that will be based on cost recovery. Future cadastral systems will also be highly privatized (AbdulMajid, 2000).

2.11. Urbanization and 3D Cadastral System in Ethiopia

The urban development strategy in Ethiopia is largely based on the expropriation of land from the transitional pre-urban areas located immediately beyond municipal/urban boundaries. Before the decision was made to expropriate, land in pre-urban areas was held by local and indigenous landholders and was governed in terms of a rural land-holding arrangement Urban expansion and development in pre-urban areas involve a constant change in land-holding arrangements and in the transfer of land rights to new recipients through lease contracts. Land in pre-urban areas is constantly being transferred from the original pre-urban landholders to urban leaseholders through government controlled expropriation.

The rapid rate of urbanization and the resulting high demand of land for urban purposes have resulted in frequent instances of land dispossession and cases of land contestation in pre-urban areas. In addition, mechanisms to convert pre-urban land rights held by local pre-urban landholders/farmers into urban rights are non-existent in this process of urbanization. This proves that local pre-urban landholders do not benefit from the increasing value of land and urban development. Land re-assignment and allocation from pre-urban areas seem skewed in favour of urbanites. The vast majority of local pre-urban landholders, who are poorly educated and used to engage in agricultural activities, seem at great risk of losing their livelihood in the face of urbanization. Thus, the overall process and implementation of urban development has the potential to generate widespread tenure insecurity and land disputes between municipalities and local pre-urban landholders (Achamyeleh Gashu, 2014).

2.12. Current Situation of Cadastral system

The key laws relating to the integrated house development program (IHDP) are: Proclamation No. 172/2002pertains to the lease holding of urban land, with all land in public ownership. Proclamation No. 272/2003 stipulates that land is provided free of lease charge for low-cost housing developments. Proclamation No. 370/2003, The Federal Condominium Proclamation, pertains to condominium housing. It defines condominium as "a building for residential or other purpose with five or more separately owned units and common elements, in a high rise or in a row of houses, and includes the land holding of the building" Proclamation No.19/2005 deals with beneficiary eligibility criteria and selection and penalties for noncompliance. Proclamation No. 455/2005 affirmed the basis and amounts of compensation for displacement and land expropriation. That is, 90 days' notice period must be given; compensation is to be paid at market value; relocation costs incurred must be met; and rental and ownership options must be provided at fair prices, in the same or nearby location. Regulation No. 15/2004 outlines the establishment of the Addis Ababa City Government Housing Development Project office and outlines its duties and responsibilities. Regulation No. 12/2004 outlines the condominium regulations for Addis Ababa city, regulating further details to Proclamation No. 370/2003. From this historical background Ethiopia does not have 3D laws, even if the development of buildings in vertical way. The researcher recommends it needs to have 3D urban land law proclamation and regulation (Amezene and Bekele, 2015).

Since 2005, Ethiopia has been implementing an ambitious governmental low- and middle-income housing programme. The programme involves a radical shift from the single-story detached housing typology (government owned rental housing) to a new condominium typology (private homeownership). According to the programme, all slums would be cleared within ten years of the programme's introduction. To make the programme feasible, the state transferred the overall responsibility for the housing sector at the regional level to city administrations or municipalities. At the regional level, the Bureau of Works and Urban Development (BWUD) is responsible for urban management and development issues. One way to assess the government housing programme is by studying condominium commons (land or resources affecting the whole of a community). Understanding the concept of condominium commons and their management is also essential for dealing with a wide variety of issues, particularly the need for residents in condominium houses to live in peace and security (Zelalem Yirga, June 2012).

The current cadastral systems in Bahir Dar maintain 2D geometric descriptions of parcels linked to administrative boundary records. So this form of registering the cadastral information system cannot show the appropriate properties of individual identities on the underground and above the surface of the earth. In Bahir Dar town, there are houses for Keble rents, condominiums, hotels, individual properties and multi- purpose buildings, governmental and private organizations. These have overlapping property projections in a 2D cadastral system especially in highly urban expansion areas (Amezene and Bekele, 2015).

Population density has increased significantly in Bahir Dar, which results the shortage of land among the people in short period of time. As a result of this, the houses are constructed over each other to associate the land relation with person who need in house. To full fill this need the Bahir Dar city administrator constructs condominium for low income societies that are multi-purpose buildings in order to solve the problem of market areas in the center of the town in main market areas of the town. The Bahir Dar town land management and development offices on this period exercise individual property registration of land holding. In their registration processes they include full name of land holdings, existing file number, neighborhood (NH) number it represents 200 parcels in each, block no, parcel no, temporary Unique Parcel Identification Number (UPIN).

2.13. Data Model

A data model is a conceptual representation of the data structures that are required by a database. The data structures include the data objects, the associations between data objects, and the rules which govern operations on the objects. As the name implies, the data model focuses on what data is required and how it should be organized rather than what operations will be performed on the data. To use a common analogy, the data model is equivalent to an architect's building plans. A data model is independent of hardware or software constraints. It serves as a bridge between the concepts that make up real-world events and processes and the physical representation of those concepts in a database. Data modeling is probably the most labor intensive and time consuming part of the development process. The goal of the data model is to make sure that all data objects required by the database are completely and accurately represented. Because the data model uses easily understood notations and natural language, it can be reviewed and verified as correct by the end-users.[4]

Three-dimensional modeling of an object can be seen as the complete process that starts from data acquisition and ends with a 3D virtual model visually interactive on a computer. The most general classification of 3D object measurement and reconstruction techniques can be divided into contact methods using coordinate measuring machines, calipers, rulers and/or bearings and non-contact methods of using X-ray, SAR, photogrammetry, laser scanning (Remondino and El-Hakim, 2006). It is the process of developing a mathematical representation of any three-dimensional surface of an object (either inanimate or living) via specialized software.

2.14. 3D Data Modeling

3D data modeling is developing data models to identify 3D objects and their relationships.3D cadastral data modeling was enable the capture, manipulation, analysis and support visualization of 3D land rights, restrictions and responsibilities which is restricted in its cover to a few 3D objects such as volumetric lots (Aien, 2013). Cadastral data modeling potentially plays a key role in both data and business management in modern land administration systems (Kalantari.et l.., 2006).

2.15. 3D Cadastral Data Model

3D Cadastral Data Model is a conceptual data model or conceptual schema, which is a map of 3D cadasters concepts and their relationship. This data model describes the semantics of the 3D cadaster and represents a series of assertions about its nature. Specifically, it describes the things of significance to the 3D cadaster (entity classes), about which it is inclined to collect information, and characteristics of (attributes) and associations between pairs of those things of significance (relationships). 3D cadaster data model supports 3D cadaster users to

[4] http://www.gama.vtu.lt/biblioteka/Information_Resources/i_part_of_information_resources.pdf

understand the structure or behavior of the system and has a template that guides them to construct and implement the 3D cadaster (Aien *et al*., 2012).

The 3DCDM model aims to achieve a conceptual framework for 3D cadasters, represent key components and their relationships, facilitate subdivision of buildings and strata developments, and integrate physical counterparts of legal objects to support a multipurpose 3D cadaster. The 3DCDM model provides extensive information for 3D cadaster applications. Legal and physical objects are represented by their geometry and semantics (Aien, 2013).

According to (Aien *et al*.,2014), 3D Cadastral Data Model (3DCDM) was developed as a solution capable of supporting 3D data, integrating 3D physical objects with their corresponding 3D legal objects, and featuring semantically enriched objects. The data model is developed based on the ISO standards and UML modeling language is used to specify the data model. The 3DCDM model represents 3D legal objects and connects legal and physical objects together. It is equipped with the concepts of the Legal Property Object (LPO) and the Physical Property Object (PPO).The 3DCDM model supports semantics that define every aspect of legal and physical objects, and therefore, it facilitates their integration. The 3DCDM model is composed of two hierarchies: legal and physical. Legal property object, survey, cadastral point and interest holder. The physical hierarchy has the following components: Physical Property Object, Building, Land, Tunnel, Utility Network, and Terrain. The 3DCDM model supports the combination of different legal and physical components to provide more comprehensive cadastral model.

3D cadastral data models has the height value at every place of 3D cadastral map which is modeled by exact the relief of the terrain, then they display 3D buildings and underground facilities by restoring a 3D representation just above or below3D cadastral map as same as to the real world location and to the real world correspondent size. A3D cadastral data model can calculate the volumes of a building or an underground cross-section of the facility, but 2.5D operation is impossible in principle (KIM, H. M. *et al*., 2010).

2.16. City Engine

City Engine is a software application for the procedural generation of 3D city models. The core of the software is a scripting language called Computer Generated Architecture (CGA), which is used to define the rules or procedures that create 3D content. City Engine could be described as an integrated procedural modeling environment as it can be used for the whole procedural modeling development cycle. It includes tools from setting the scene up, for example pre-existing topographic data, modeling street and lot geometries, writing and analyzing the CGA script files, applying the CGA files to create 3D models, and finally exporting the derived model to desired post-processing programs (Viinikka, 2014).

2.17. The Rule Editor

The rule editor is displayed as a different tab in the same tab space as the scene editor. It is a simple text editor for creating and modifying CGA rules but can also be used to edit all text files such as .txt or .mtl.

Depending on the distance, viewing angle and potential occluders, the best source image is determined for colouring a texture pixel. Facade texture is extracted from aerial images, oblique views are necessary in order to guarantee the required visibility of the respective building facades. In highly overlapping image blocks have been captured. This is frequently realized to support image matching for elevation data generation in densely built-up areas. Even though facade texture can in principle be extracted from standard aerial images, texture mapping is frequently realized using oblique aerial photography, which of course provides a good visibility of building facades (Haala and Kada, 2010).

The user interface of City Engine consists of several windows. A typical modeling session includes (figure 3):

1. "Scene Editor" window the user can manage the scene, it is organized in layers.
2. "Rule Editor" window the CGA scripts are generated. "Rule Editor" can have a text and a graphical view.
3. "Viewport" window the generated 3D content is displayed.
4. "Inspector" window which gives a detailed view editing possibilities of selected objects.

5. "Navigator" window all the files are stored. In this section user can manage and preview files in the workspace.
6. "Log" window shows the log records. They are classified as information messages, warnings and errors.
7. "Console" window. The user interface shown in (figure 3)

(Esri 2014b)

Figure 3: The City Engine user interface (Source: Dobraja , I, 2015)

3D city model in City Engine can be done in 5 steps

- Step 1: There should be a 2D Geodatabase or 2D GIS data, CAD data or data from other formats which will be imported into City Engine.
- Step 2: After the import, GIS data can be edited and manipulated. This step includes 3D street, block and parcel creation as well.
- Step 3: includes 3D extrusion of buildings, generation of roofs, street furniture and other elements in the model.
- Step 4: When the models have been created, the refinement of the model details using procedural rules, selection of the Level of Details (LoD) and adding vegetation can be done.

- Step 5: The process is the export of the created city model to another 3D application. It can be rendered in another application, exported to a game engine and Need for 3D Cadastral Data Model at The National Level. 3D Cadastral Model Need to be developed to configure a 3D cadastral frame work and facilitate 3D Cadaster implementation (Second International Workshop on 3D Cadasters, 2011).

The needs for developing a 3D cadastral data models are described below:

- Best practice guidelines and standards for implementation of a 3D cadaster
- Establishment of conceptual framework for a 3D cadaster including the key components and their relationships that will support the subdivision of buildings and strata developments.
- Organization and provision of documents and practical guidelines for land surveying professionals.
- Promotion of standards and common language within the land administration user communities' foundation of a 3D cadaster database facilitation of the exchange of data and the integration of similar datasets, and ease data sharing.

CHAPTER THREE

MATERIAL AND METHODS

3.1 Study Area and Description

3.1.1 Location

Bahir Dar town is one of the administrative units of Amhara region. Baḥir Dar is situated southern shore of Lake Tana, source of the Blue Nile (Abay). The city located approximately 578km north-west of Addis Ababa with a latitude and longitude of 11°32′ N to 11°38′N and 37°17′ E to 37°27′E ,respectively. The is elevation of about 1,800 meters (5,906 feet) above sea level .Its total area 108.042 square kilometer and it is the capital city of the Amhara Regional state in Ethiopia. The study area shown in (figure 4).

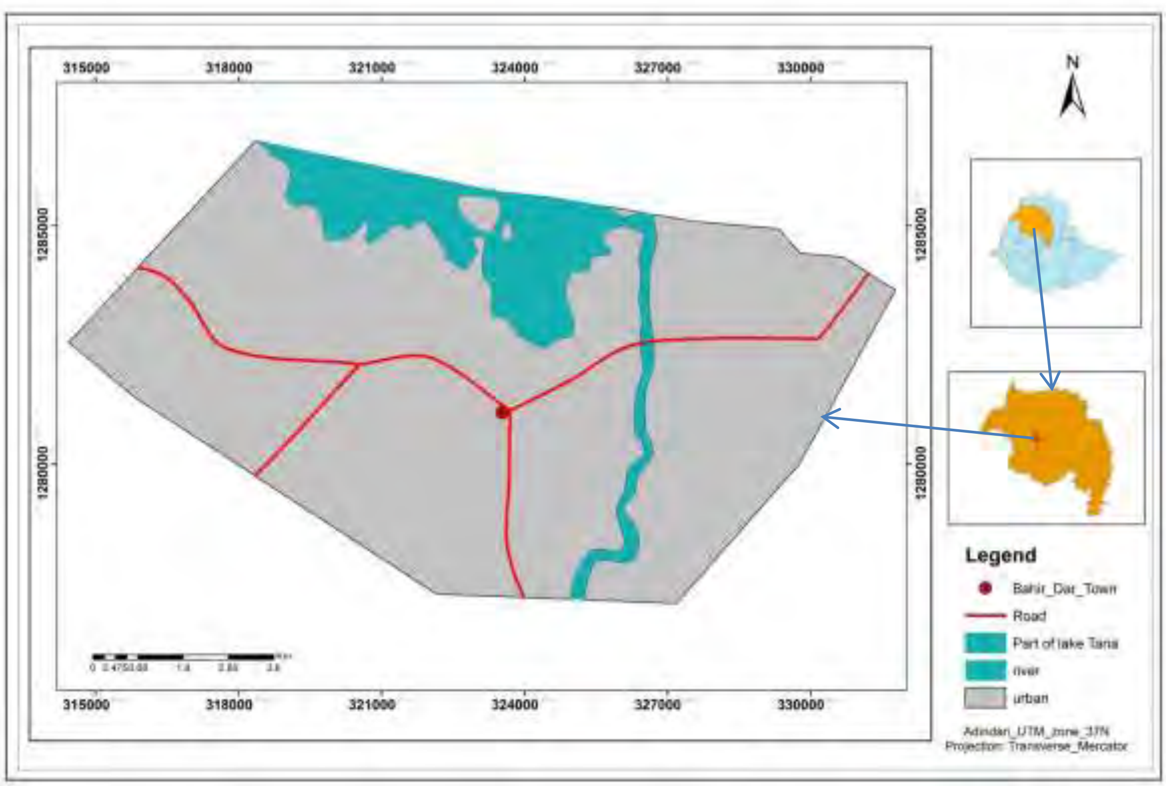

Figure 4: the study area map of Bahir Dar town (source: EMA)

3.1.2 Topography

The southern end of the Lake Tana is a relatively gulf area where the town of Bahir Dar is located. However, there are also some domes and ridges with relatively higher elevations that standout in the area, particularly to the west and south part of the town. Elevation variation in the area ranges from 1,786 m.a.s.l near the Lakeshore to 1,886 m.a.s.l at Bezawit. The town stretches over a predominantly flat land with imperceptible slope changes, except for small rises in its eastern and western peripheries. The slope varies from apparently zero to slightly over 20 percent in few places. Most parts of the town, however, stretch on areas below 2 percent slope. The natural drainage is very poor and there are also scattered and slightly depressed areas within the town's boundary, which form temporary swamps when rainwater settles for short to prolonged period of the year. FUPI and BDRMCA (2006).

3.1.3 Demography

The first national population and housing census conducted in 1984 puts the population of Bahir Dar City as 54,766. The 2nd national population housing census conducted 10 year latter in 1994 shows that the total population as 94,235 in the city. The Central Statistical Authority (CSA) in its Annual Statistical Population size 1984-54766, 1994-94235, 2005-168048, GR-5.4(1984-1994), 5.3 (1994-2005) and Projected Population of (2012) 348,429(URL[5]).

3.1.4. Land Use Land Cover

Land use practices vary considerably across the world. The United Nations' Food and Agriculture Organization Water Development Division explains that "Land use concerns the products and/or benefits obtained from use of the land as well as the land management actions (activities) carried out by humans to produce those products and benefits[6].The land use land cover shown in figure 5.

[5] - https://www.en.wikipedia.org/wiki/Bahir_Dar

[6]- https://en.wikipedia.org/wiki/Land_use

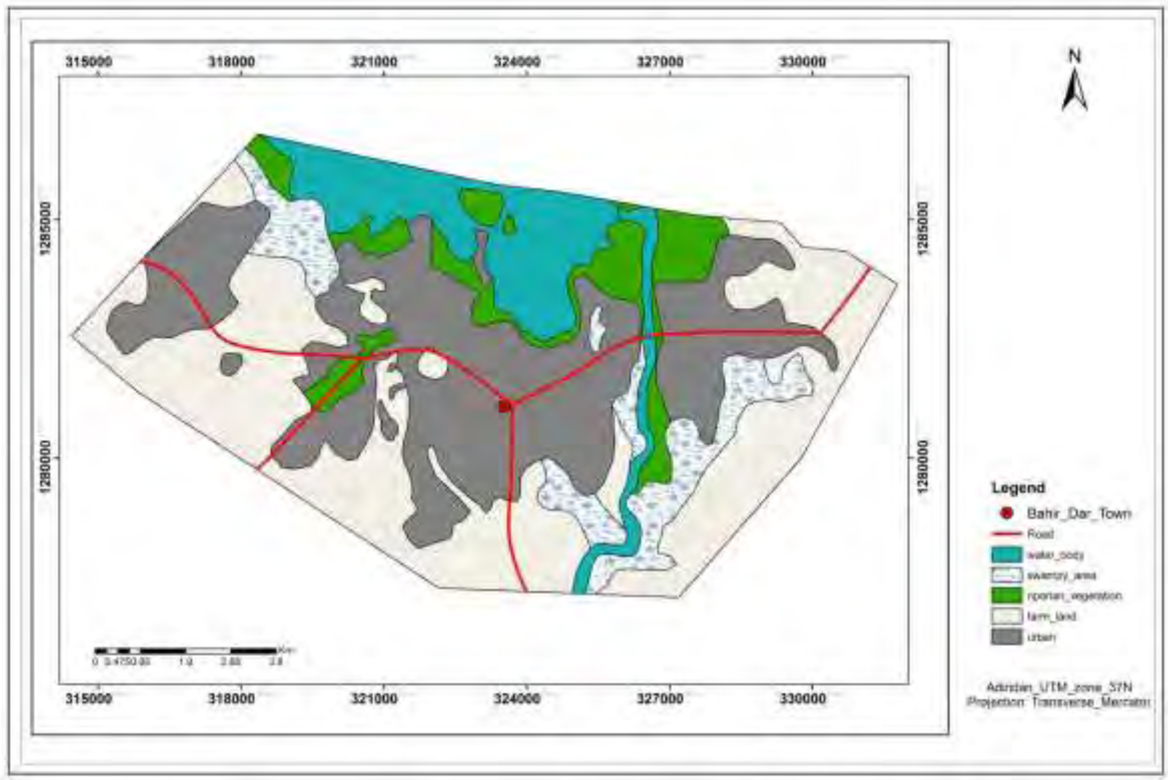

Figure 5: The land use land cover of Bahir Dar town (2015 satellite image).

3.1.4.1 Buildup Areas

The total area covered by Built-up in the city is about 37.1%. This is the second largest land use category in the city. It includes residential land, formal houses, mixed type residential land use, hotels, recreational centers, governmental bodies, private and governmental industries the road, parks, few informal settlements and other infrastructure of urban areas.

3.1.4.2 Water Bodies

The water bodies in the cities include the Tana lakes which cover (11.3% sq.km) and the river and water covers about (2.5 sq.km). This water bodies has great potential for the tourist attraction activates and to make green and smart the city for urban dwellers, Tourist and societies coming from different side of the countries .This natural gifts plays a great role for recreation, for making green the urban areas, in order to create suitable atmospheric conditions and around Lake Tana with all the facilities along its shore line, Nile River. The ecosystem in which the city is situated in general of great recreational values.

3.1.4.3 Agriculture

Agriculture is the back bone of our economy and the area covered by agricultural activities in Bahir Dar is about (38.03% sq.km) the areas different agricultural uses are notable on the city land use. In the pre-urban where the land is under the holding of peasants, crop production is widely practiced. This is however an interim period activity until the land is claimed for urban function development. These areas are mainly out of the city built up boundary. In contrary to this activities like animal husbandry, commercial flower productions and related activities predominantly found within the built up city boundary.

3.1.4.4 Riverine Tree

Although the green coverage of the city seems high, areas covered with the riverine is less than the other coverage types. The amount of coverage of trees is very small and tree covers only (9.13%sq, km) of the study area .The areas are along Lake Tana shore line and east as well as north of the textile factory along both sides of the Nile River. The areas specified here don't include the green within the public parks, churches and other institutions compounds.

3.1.4.5 Swampy Area

From all part of the region it covers about 9.8% sq.km of the study areas. This swampy areas found around the Tana Lake and border of Nile river. In the previous time larger than this but due to increase in the construction of different recreational center and resorts it decreases gradually from time to time.

3.5 Geology and Soil

The rocks types covered the Bahir Dar area mainly include basaltic lava flows (Lava outpourings and domes) and related spatter cones. Other than the rock body is covered by soils, which are dominantly clays and silts. The basaltic lava flows basically comprise porphyritic and aphanitic basalts. Most of these are believed to be fissural eruptions, although probable point sources (central vents) could be inferred to some outcrops. The overall exposed thicknesses of the flows vary from few meters to more than 100 meters at Bezawit. They seem to occur as alternate flow layers in some places and are often highly weathered and/or fractured particularly at depth, as borehole log data reveals. Generally, the rocks out cropping in Bahir Dar city administration can be categorized into three main units based on lithologic variations. These lithologic units are Aphanitic Basalt; Vesicular Basalt; and Scoriaceous Basalts/ Cinder Cones. The soils occurring in Bahir Dar area mainly represent residual fine soils (i.e. clays and silty clays) developed on basaltic bedrocks. There are no coarser soils found either in out crops or in the deep-water well logs. Two main types of soils can be specifically identified in the town and its vicinity. The first type represents red clay soils the color of which is the result of reduction of mafic minerals (FUPI and BDR MCA, 2006).

3.6 Climate

Bahir Dar has a tropical savannah climate with one distinct rainy period. This rainy period here lasts from May up to end of July and including October. During the rainy period, there are not many days with precipitation but if there is precipitation then mostly there is abundant rain fall. During the rainy period the average temperatures are somewhat lower and the average air humidity is higher. The mean annual precipitation recorded at Bahir Dar station in 37 years period from 1962 to 1999 is about 1437 mm. The monthly mean maximum and minimum temperature records of Bahir Dar in the year between 1961 and 2000 indicates that the highest mean monthly maximum temperature occurred in the months of April (29.7°c) and the lowest is in the months of July and August (23.3°c).While the mean monthly minimum temperature ranges for the lowest from 7.1°c in January to the highest 14.2°c in the month of May. Wind Speed and Directions the maximum wind speed in Bahir Dar is registered as 1.8 meter per second, which is not that much difficult to live and undertake any development activities in the town.

3.2 Materials

For the study software packages that were used for processing are ArcGIS10.3 (for data analyses), Global mapper (for the processes of base map process merging two sheets), City engine (3D Modeling processes), MICROSTATION (for digitizing), ERDAS imagine 2014 & MATCH-AT Inpho (preprocessing and photogrammetry works), LPS (for accuracy measurement), Arc scene (for 3D modelle base map with combining city engine building models) and EXCEL for preparation of graph.

3.2.1 Primary data acquisition

3.2.2.1 Aerial Photography and Satellite Image

Photogrammetry can be defined as the science of making reliable measurements by using photographs or digital photo imagery to locate features on or above the surface of the earth. The end result produces the coordinate (X, Y, and Z) position of a particular point[7]. Close-range photogrammetry is a method that allows the construction of close- and far ranges two-dimensional drawings, and after necessary orientation using special assessment software, three-dimensional models can be raised from the surface of the photographs with the help of single and dual cameras. This method is used to obtain 3D positioning information about an object (Toz and Duran, 2004) as cited by Şanlıoğlu, İ. *et al*., (2013). For these study nine scenes of high resolution aerial photography (1:20cm) covering part of Bahir Dar city will be used and with the addition of external data and satellite images from USGS. It is used for land use land cover identification.

3.2.2.2 Ground Control Point/GCP

A system of accurate measurements used to determine the distances and directions or differences in elevation between points on the Earth. A point on the surface of the earth with known location (i.e. fixed within an established co-ordinate system) is used to geo-reference Image data sources, Ground control is required to rectify (geo-reference) the imagery to its true geographical position on the earth's surface. Differential rectification is a phased procedure that uses several XYZ ground control points to geo-reference an aerial photograph to the earth, thereby creating a truly orthogonal image which can provide accurate measurement [8].The number of GCP points is Four and fairly distributed in the areas that are GCP point Cites is clearly selected for appropriate work of the processes.

URL[7] http://www.dot.state.wy.us/files/live/sites/wydot/files/shared/Highway_Development/Surveys/Survey%20Manual/Section%20VII%20-%20Photogrammetric%20Surveys.pdf
URL[8] - http://www.pasture.ecn.purdue.edu/~aggrass/esri95/to150/p124.html.

3.2.3 Secondary data

3.2.3.1 Topographic Map and written Document

Topographic maps are maps on which both horizontal and vertical features of the mapped are represented, show elevation information as contours and/or as spot elevations. From Ethiopian Mapping Agency, a) 1:2000 scale base map(prepared for the purpose of cadaster preparation) b) Digital elevation model c) Written documents of the study area. Source (EMA, Bahir Dar Town Land Management and Development Office, Ministry of Urban Development).

3.2.3.2 Block Diagramme

Block-A set of flight lines processed simultaneously to cover an area not possible with one flight line. It shows the aerial photography arrangements used for work flow of photogrammetry processes .The data source is from (EMA).

3.2.3.3 Base Maps

Base maps locate the major physical features of the landscape such as roads; water features elevation contours, fence lines, and building footprints. In some jurisdictions, they contain the fundamental information from which the cadastral maps are prepared. Base maps should be tied to the geodetic network. Base maps can be in the form of line maps (generated manually or by computer) or photographic maps. Regardless of the form, base maps are usually created from aerial photographs. Aerial photographs provide an efficient and economical means for preparing the base maps, using photogrammetry (International Association of Assessing Officers, 2004).

3.3 Methods

In this section, methods and techniques used to achieve the specified objectives are described. The 3D modeling method involves four basic steps. The first steps are photo processes and integrating GIS software. The second step is rendering the building facades to incorporate in to CGA script to generate automated 3D building model. The final step is developing a new system Architecture for cadaster registration, management and administration system. Its work flow shown in (figure 6 :).

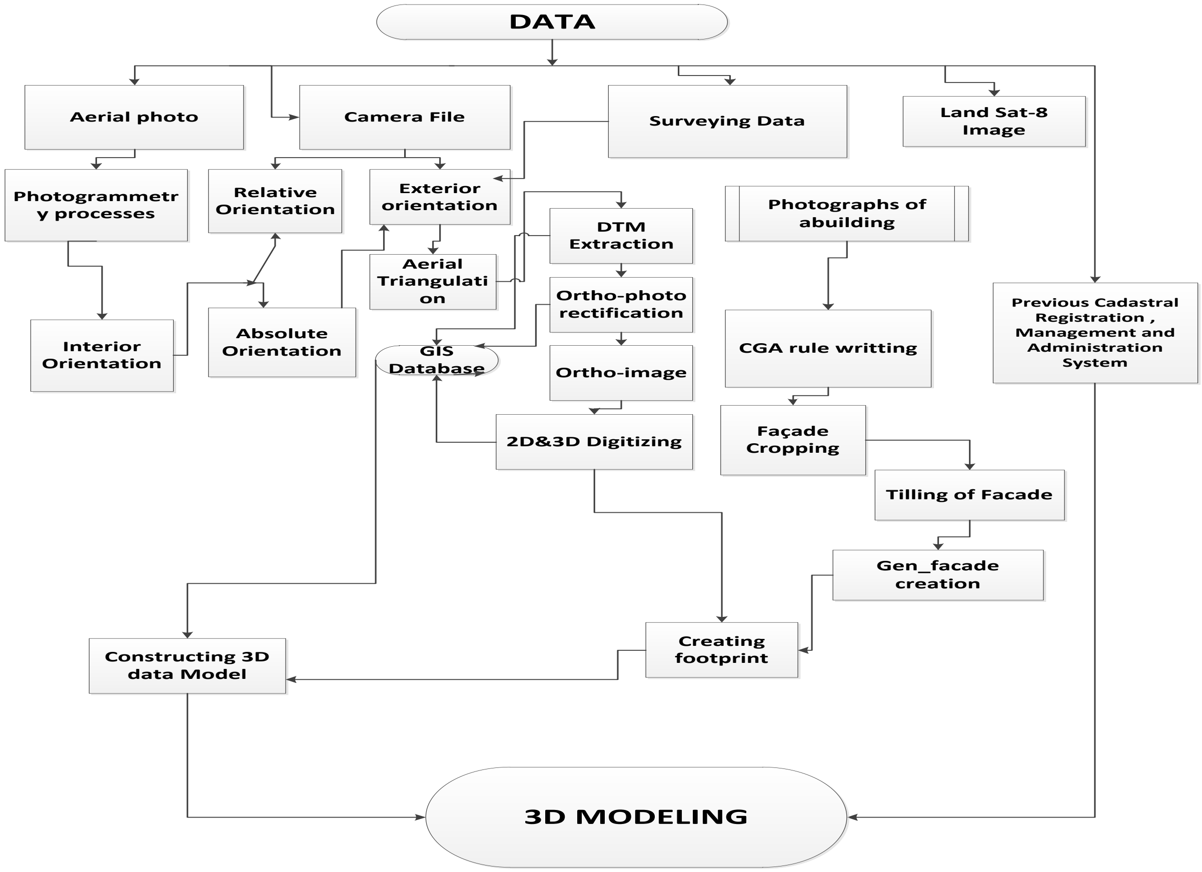

Figure 6: The work flow of the proposed photogrammetric processes and 3D objects reconstruction technique that was used in this study.

3.3.1 Pre-Processing and Data Preparation

The processes of adjusting the aerial photography, Camera file, GCP and front and side photo of a building have been done. The process of nosey reduction, geometric correction, radiometric corrections and other processes was done. This includes interior and exterior orientation, Aerial Triangulation, DTM extraction, orthophoto preparation, mosaicking, foot printing, façade creation, tiling, and Writing CGA script.

3.3.2 Interior Orientation

The interior orientation process establishes the relationship between the stage and photo coordinate systems. Accordingly, interior orientation in softcopy workstations relates the digital image coordinate to the photo coordinate system of the digitized diapositive. Interior orientation in digital copy systems is currently fully automated. The interior orientation begins with placing the diapositives on the stages. Sometimes, the accessibility to the stages is limited, especially when they are parked at certain positions. In that case, the system should move the stages into a position of best accessibility. After having set all the necessary viewer control buttons, few parameters and options must be defined. This includes entering the camera file names and the choice of transformation to be used for the interior orientation. The system is now ready for measuring the fiducial marks. Based on the information in the camera file, approximate stage coordinates are computed. After the set of fiducial marks as specified in the calibration protocol is measured, the transformation parameters are computed and displayed, together with statistical results, such as residuals and standard deviation (Schenk, T.(2005).

3.3.3 Exterior Orientation

It is a process of establishing a model is accomplished by measuring a number of conjugate points. The user clears the parallax at each point by moving one stage with respect to a locked position of the other stage. Photogrammetry finding the conjugate points automatically can be executed, especially when the operator provides good approximation and absolute orientation the relationship between the model and the object space is established. This requires the identification of ground control points. To manually identify the ground control points by human operator is a relatively easy task. However, automatic identification of ground control points is not an easy task, especially when the target has low contrast compared to the background (Hamruni, 2010). Exterior orientation is the relationship between image and object space. This is accomplished by determining the camera position in the object coordinate system. The camera position is determined by the location of its perspective center and by its attitude, expressed by three independent angles (Schenk,T. 2005).

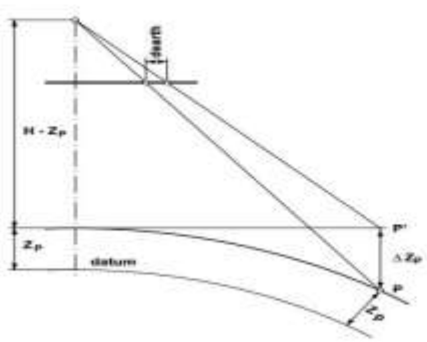

Figure 7: Interior orientation

The model expresses the condition that the perspective center C, the image point Pi , and the object point Po, must lie on a straight line (see Fig.6). If the exterior orientation is known, then the image vector pi and the vector q in object space are collinear:

$Pi = \frac{1}{\lambda} q$ ……………………………………………………………..equation 1

As depicted in Figure 6, vector q is the difference between the two point vectors c and p. For satisfying the collinearity condition, we rotate and scale q from object to image space. We have $\text{pi} = \frac{1}{\lambda} Rq = \frac{1}{\lambda!} R(P - c)$……………………………………………….equation 2

With Ran orthogonal rotation matrix with the three angles ω, φ and κ:

$R =$ cosθ cos − cosθsinK sinθ

Cos ω sin k+sin ω sin θ cos k cosωcos k-sin ωsin θsin k sin ω cos θ….equation 3

Sin ω sin k-cos ω sin θ cos k sin ω cos k +cos ω sin θsink cos ω cos θ

$$\text{x} = \frac{1}{\lambda} (xp - xc)\, r11 + (yp - yc) r12 + (zp - zc) r13$$

$$\text{y} = \frac{1}{\lambda} (xp - xc) r21 + (yp - yc) r22 + (zp - zc) r23 \quad \text{…..equation 4}$$

$$-\text{c} = \frac{1}{\lambda} (xp - xc) r31 + (yp - yc) r32 + (zp - zc) r23$$

By dividing the first by the third and the second by the third equation, the scale facto1/λ is eliminated leading to the following two collinearity equations:

$$\text{x} = -c \frac{(x_P - x_c)\, r_{11} + (y_P - y_P)\, x_P + (z_P - z_C)\, r_{13}}{(x_P - x_c)\, r_P + (y_P - y_c)\, x_P + (x_P - x_P)\, x_P} \text{…………………………equation 5}$$

$$y = -c \frac{(x_P - x_c) R_{21} + (Y_P - Y_c)\, r_{22} + (z_p - z_c)\, r_{23}}{(x_p - x_c) R_{31} + (Y_P - Y_c) R_{32} + (Z_P - Z_c)\, R_c}$$

with:

$$pi = \begin{bmatrix} X \\ Y \\ -f \end{bmatrix} \qquad p = \begin{bmatrix} x_p \\ y_p \\ z_p \end{bmatrix} \qquad c \begin{bmatrix} x_c \\ y_c \\ z_c \end{bmatrix} \text{..........equation 6}$$

The six parameters: x_c, y_c, z_c, ω, φ, κ are the unknown elements of exterior orientation. The image coordinates x, y are normally known (measured) and the calibrated focal length c is a constant. Every measured point leads to two equations, but also adds three other unknowns, namely the coordinates of the object point (x_p, y_p, and z_p). Unless the object points are known (control points), the problem cannot be solved with only one photograph. The collinearity model as presented here can be expanded to include parameters of the interior orientation. The number of unknowns will be increased by three2. This combined approach lets us to determine simultaneously the parameters of interior and exterior orientation of the cameras. There are only limited applications for single photographs. Single photographs cannot be used for the main task of photogrammetry, the reconstruction of object space. Points in object space are not defined, unless we also know the scale factor 1/λ for every bundle ray.

3.3.4 Automatic Aerial Triangulation

Automatic Aerial Triangulation (AAT) is performed on image -Z Intergraph with MATCH-AT Inpho software. The process is divided into three steps:-

- Preparation and Project Setup by operator,

- Measurement and Orientations,

- Bundle Block Adjustment.

Some of the parameters for the block and a priori sigma naught (σ_0) value are roughly calculated. If data from differential DGPS are available then these data could be used for preparation of the block. Operator on the screen must measure GCP's. After that Block is elaborated without any interference of the operator. MATCH-AT Inpho is an automated aerial triangulation package combined with editing facilities. MATCH-AT performs hierarchical multi-image matching of cluster tie points in the standard Von Gruber locations. Point transfer and tie point measurement operations are done automatically, thereby minimizing manual work, operator errors and operator intervention. Additional information derived from navigation system installed on the aircraft and kinematics GPS positioning data can be used to compute approximate parameters with sufficient accuracy. The accuracy of automatic aerial triangulation depends on the quality and number of matched points. The point accuracy is between 0.2 -0.3 pixel sizes. MATCИ-AT provides very accurate and reliable exterior orientation parameters due to its capability of generating many redundant tie points, which make a block with better geometry configuration then semi-automatic method. The exterior orientation $m_{x0,}$ $m_{yo,}$ $m_{zo,}$ m_j, $m_{w,}$ m_c of all photographs are needed for DEM and orthophoto generation Kaczyilski, R. (2000).

3.3.5 DEM and Orthophoto Generation

The results of aerial triangulation (all research data with exterior orientation parameters) are used for DEM generation using MATCH-AT lnpho software. DEM is generated from epipolar images usually with grid 25 m x 25 m. Break lines and obscure areas are included for DEM calculation. Theoretically, DEM generated by correlation method has an accuracy of about 0.3 to 1 pixel which corresponds to 0.1 %o H do 0.2%o H. Flight height of aerial photos in the scale of 1:25 000 is H = 4400 m, therefore theoretical accuracy of DEM could be from 44 cm to 90 cm. Practical accuracy of DEM generated from double colour diapositives in the sca1e of l: 26 00 is about 1 m for open areas and up to 10 meters for forested areas. Checking and edition of raw generated DEM is done stereoscopically on the epipolar model. Some elaborated filters can also be used for filtering out high peaks. Accuracy for generating DEM for production of orthophoto can be estimated from the following formula:

mh = H [dx/x] [1: mfoto/1: morto]

Where dx -displacement on an image due to denivelation x - radial distance on an image; H - flight height; 1: mfoto -scale of aerial photos; l: morto - scale of generated orthophoto. For Phare photographs, if the maximum allowable displacement on the orthophoto is dx = 0.1 mm, H= 4500 m, 1: rnfoto = 1: 26000, 1: morto = 1: 5000 maximum radial distance on an image - x = 1 O cm, we have to generate DEM with accuracy of mh = +/-1 m. Orthophoto images are generated using DEM and all aerial photographs with exterior orientation parameters calculated during digital triangulation. The size of generated pixel on orthophoto can be calculated from the formula:

P = [8.5 x 10"5] x morto

Where morto is scale of orthophoto. It follows from this formula that orthophoto in scale of 1:5000 can be generated with pixel size P = 0.4 m. Orthophotos in 1:5000 are generated in IGiK with pixel 0.5 m x 0.5 m (which is 0.1 mm in the scale of orthophoto map) and in the scale of 1: 1 O 000 are generated with pixel size 1 m x 1 m. The accuracy of orthophotomap is about by mxy = +/-1 - 2 pixels, which is equal from 0.5 m to 1 m in the field. All generated orthophoto images are mosaicked with contrast adjustment and orhophoto map sheets are prepared according to Polish map standards Kaczyilski, R. (2000).

3.3.6 Accuracy Assessment

The first factor is the scale of the photograph determines the ground resolution. If the smallest identifiable ground feature on the photograph is a 0.1 m2 (1 ft2) object. Then, the mapping accuracy from this photograph, assuming perfect data compilation, is limited to no better than 0.3 m (±1 ft). Selecting the appropriate photo scale for a particular product depends on product specifications.

The second factor controlling the accuracy of a photogrammetric product is the total amount of errors accumulated during its derivation. In photogrammetry, as in any other surveying and mapping procedures, there are systematic errors and random errors, assuming all blunders have been removed that is the RMSE error.

Calculate the RMSE from the measurement of GCP with the 3D stereos point measurement in Inpho software in the work station and calculate the RMSE of the processed orthophoto product.

3.3.6 Foot Printing Processes

The footprint of a building is an outline of the total area of a building drawn along the exterior walls. This normally demarcates where the exterior walls intersect on the ground, but often this is not possible when extracting from imagery. According to Vicini, A. *et al*., (2014).Geospatial tools helps us to extract building footprint and homogeneous zone extraction from, imagery ,that obtained from Ortho-image acted as fundamental information for the process of digitizing information of roads and buildings through Geographic Information System (GIS). The digitizing process of a building's structure to make footprint in order to create three-dimension building model would mainly examine the building's structure and add various detail to the building that could be seen from Ortho-image. These details included the roof pattern and other features of the roof, the setting of the building's height obtained from blue print and turning it into numeral features in attribute data of each building for illustrating three-dimensional buildings.

3.3.7 Façade Building

"Façade" means all areas on the exterior of the building, except for horizontal roof areas. The façade includes all walls, windows, balconies, cornices, parapets and walls, chimneys, etc. In the formation processes single rectified façade image describe an algorithm to automatically subdivide the facade image into floors and tiles by using mutual information. A tile is an important concept from procedural modeling that denotes an architectural element such as a window or door including the surrounding wall, split detection algorithm aims at finding relevant edges closest to the boundary. The algorithm evaluates all splitting lines starting from the boundary to find the first suitable edge candidate moving inward from the left side, right side, top side, and the bottom side. Seven split type (1) vertical dual split i.e. symmetric left and right split at once, (2) horizontal dual split, (3) left split, (4) right split, (5) top split, (6) bottom split, and (7) no split. Edges cross the entire region, which initially is a tile. In order to assess the relevance of an edge, its strength needs to be compared against a threshold that takes account of the local noise level. This is quantified as the averaged gradient magnitude in a zone surrounding the boundary of the original tile (Zeng. *et al*.., 2007).

3.3.8 Tile Building

The tile UV operation rescales the texture coordinates of the selected uv-set such that the uv space gets tiled with tiles of a given width and height. The texture *Width* and texture *Height* parameters support usage of the floating and relative operators to avoid complex calculations with the texture space dimension[9].

3.3.9 CGA Rule Building

CGA Rule (Computer Generated Architecture) which the scripting language defines the rules or procedures to create a 3D content is the core of this software. City Engine can be used for the whole procedural modeling development cycle because it includes tools for setting up the scene with pre-existing data, modeling street and lot geometries, writing and analyzing the CGA script files, applying the CGA files to create 3D models and exporting the created models for further processing .Two primary attributes which connect the initial shape to the procedural generation process are “Rule file” which defines the CGA rule file assigned to the initial shape and “Start rule” which defines the production rule from which the creation process begins. Other attributes which describe the initial shape (for example, buildings heights, number of floors, roof shapes, etc.) can be used as parameters in the CGA production rules (Viinikka, 2014). The general workflow in City Engine, also used in this modeling experiment, is to draw the street network, give the street segments the desired width, adjust the block subdivision algorithm’s parameters to produce suitable lots, assign CGA scripts to the lot and street segment shapes, execute the CGA scripts, and finally to adjust the parameters of the CGA scripts until the produced geometry is as desired.

3.3.10 3D Digitizing

Three dimensional data capturing was done by using true Ortho-photo ,3D software stereo-glasses this processes was require the ability of seeing 3D objects and put exactly the point and measured objects accurately in Micro station work station machine this resulted to produce more accurate information for 3D Modeling processes rather than 2D digitizing of objects.

3.3.11 Database Management System

A database can be described as a repository for data. This makes clear that building databases is really a continuation of a human activity that has existed since writing began. it can be applied to the result of any bookkeeping or recording activity that occurred long before the

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[9] URL- http://cehelp.esri.com/help/index.jsp?topic=/com.procedural.cityengine.help/html/manual/toc.html).

advent of the computer era. A database management system (DBMS) is a collection of programs that enables users to create and maintain a database. The DBMS is a general-purpose system that facilitates the processes of defining, constructing, manipulating, and sharing databases among various users and applications. Defining a database involves specifying the data types, structures, and constraints of the data to be stored in the database. The database definition or descriptive information is also stored by the DBMS in the form of a database catalog or dictionary; it is called meta-data. Constructing the database is the process of storing the data on some storage medium that is controlled by the DBMS (Elmasri, R. and Navathe, S.B.(2011).A database management system (DBMS) is an aggregate of data, hardware, software, and users that helps an enterprise manage its operational data. The main function of a DBMS is to provide efficient and reliable methods of data retrieval to many users. Most DBMSs deal with several users who try simultaneously to access several data items and, frequently, the same data item. Manipulating a database includes functions such as querying the database to retrieve specific data, updating the database to reflect changes in the mini world, and generating reports from the data. Sharing a database allows multiple users and programs to access the database simultaneously. A DBMS must access data at a relatively high rate, such a large quantity of data need to be stored that the storage medium must be low cost. A method for structuring data in the form of sets of records or tuples so that relations between different entities and attributes can be used for data access and transformation[10].

URL[10] -(URL)http://www.cs.umb.edu/cs630/hd1.pdf

CHAPTER FOUR

RESULT AND INTERPRETATION

In this section, results of the analysis have been presented. The analysis part of this research was began at the aerial triangulation processes with the combining pre-processes of the adjustments of aerial photography, GPS data, GCP, with taking of front and side of photography of some building data running the interior orientation done automatically and the exterior orientation as input of the aerial triangulation. Then, the three dimensional reconstruction processes using city engine software new-project creation, façade processing, rule writing, generation of 3D modeling processes was takes place and discussed Finally, the cadastral system was tasted for its proper functionality and compared with the previous 2D Bahir Dar cadastral system .

4.1 Interior Orientation

The interior orientation of the processes is done automatically by the software since the overall processes of taking Aerial photography is digital system, But in analytical photogrammetry system feeding camera file and adjusting fudicial markes processes is not automatically done.

4.2 Exterior Orientation

The exterior orientation describes the location and orientation of the bundle of rays in the object coordinate system with the six parameters: projection center coordinates (X_0, Y_0, Z_0) and the rotations around the 3 axis (omega, phi and kappa). This parameters accuracy can judge the positional accuracy of the research. This process was takes place using the ground control point and the GPS points of study areas during aerial photo taken and data’s gathered from the field.

4.3. Aerial Triangulation

In Aerial triangulation system, tie Points generated first by default distribution pattern, tie Point Centre Pattern: 5 x 5, tie Point density is dense, it covers almost all part of the study sample areas that are taken as a sample of the research the final result of Modeling of the

Bahir Dar town is dependent on the accuracy of aerial triangulation. Because of this impact, more attention in the Aerial triangulation processes of area covering using GPS data and GCP data's. The software automatically generates the tie points and it was not shrinking the tie point area sizes and it has sufficient overlaps in the aerial photo. This shows the aerial triangulation processes accuracy is good A 5 x 5: is still the default tie point pattern, to obtain a denser distribution of tie points over the complete image content. Tie point result was analyzed using the standards allowable error to the software customer to use the accuracy level of Aerial Triangulation processes. Acceptable RMSE errors for different projects are different and scientifically when we take for the 1:2000 scale maps is 0.5 cm errors is allowed but the project aerial triangulation processes result is 1.31 micro and it is acceptable for the processes result. The RMSE result of the processes is shown in table one.

Table 1: Accuracy of aerial triangulation.

Parameters	**Mean standard deviation**
Omega	0.6 °
Phi	0.32 °
Kappa	0.2 °
X	0.005 [m]
Y	0.004 [m]
Z	0.008 [m]
Total positional RMSE =1.31 micron which is equivalent with 0.25 pixel.	

Figure 8: AT positional accuracy result of Bahir Dar cadaster.

The Bahir Dar cadaster RMSE of 2013 was better accuracies it shows 0.005m at x, 0.004 at y and 0.008m at z respectively when compared with the allowable error for such scale map it shows better accuracies since the aerial photograph was taken with 18cm GSD and with ultra-camera; the flight altitude would obviously be lower than the other scale maps.

4.4 Ortho-photo Generation

Several images of the same area are taken from different points Ortho-photo processes The image that used for Ortho-photo production have 60% over lap and the accuracy of the aerial triangulation of the processes is good this resulted for the production of more accurate Ortho -photo of the study area sample work. The accuracy was cheeked by the GCP points taken from the ground surface and measurements taken from the last Ortho-photo products of the study area X, Y, Z points that are taken from 3D stereo reading using L P S software and checking the errors by comparison the actual measurement in the field and result of stereo measurements in (table 2:)

Table 2: Show the GCP point and 3D measured points from Ortho-photo

GCP measured in the field				3D Point measurement using software in the Ortho-photo		
Point.	x	y	z	x	y	z
Point.1	325076.843	1280986.127	1786.994	325076.623	1280986.021	1786.831
Point.2	323453.331	1280612.4	1788.439	323453.21	1280612.213	1788.423
Point.3	323492.382	1281846.827	1790.143	323492.153	1281846.643	1790.031
Point.4	325079.43	1282593.517	1790.621	325079.23	1282593.326	1790.523

4.5 Mosaic Processes of Images

The process only done by having an exact model of the area was processed. It was contain detailed surface model used to rectify the image of the study area and it contains several images covering the study area and having sufficient overlaps of stereo images for reconstructing depth. The orthophoto was mosaicked to form a complete true orthophoto. In (figure 9 :) the resulted ortho-photos that have non-obscured data due to impact on larger buildings.

Figure 9: Processed orthophoto mosaic image of study area.

4.6 3D Digitizing

The 3D digitized datahad been captured from orthophoto by using Micro station software shown in (figure 10 :)

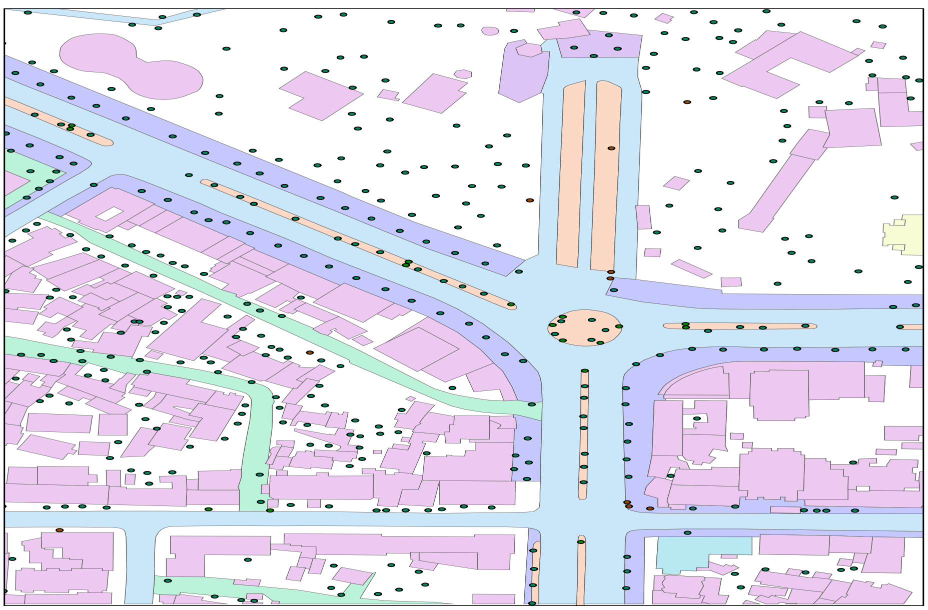


Figure 10: Data Captured using 3D software.

4.7 CGA script writing for 3D model automation

In the CGA rule the attribute was defined and can be mapped from an attribute layer of each object are used to controlling building attribute such as the building height, level of detail and others properties of a buildings. It was initialize to a specific value in the rule file and the attribute value of the building and road shape file was controlled by the rule that we define by using the inspector in the pane. In the rule, the attribute was defined using the attr. Key word height. This process was used in the Lot Rule of city engine. The rule was containing different characteristics such as width, height of roofs, door, and window of a building, roads, vegetation and others.

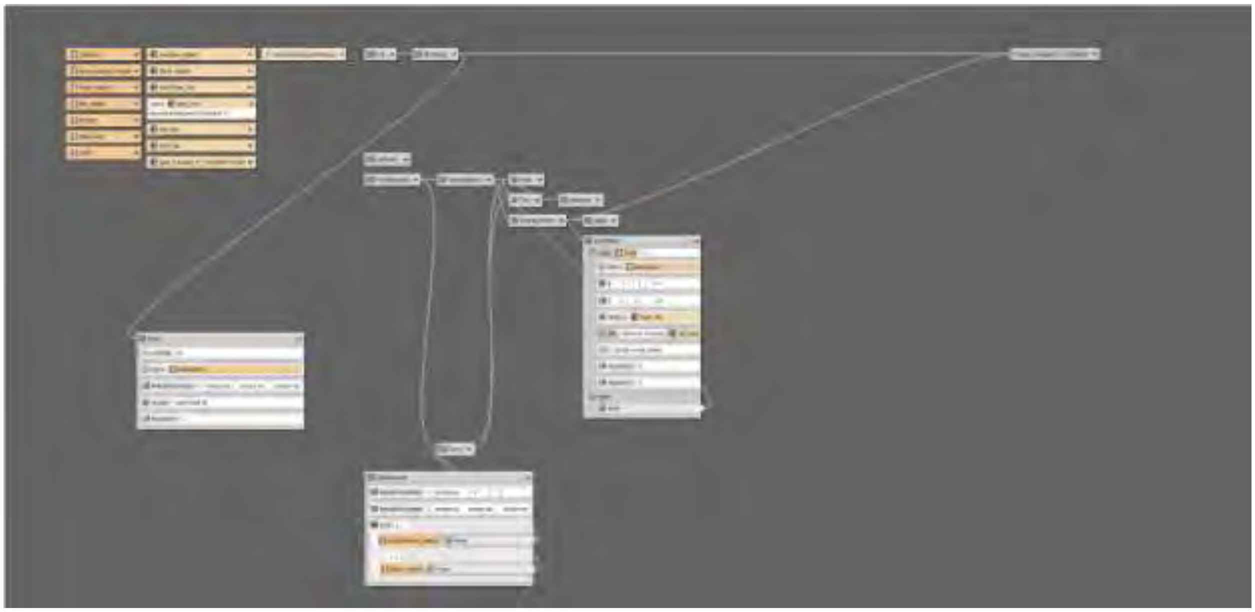


Figure 11: A graphical representation of a rule file of building in City Engine

4.8 Facade texturing

The façade producing system was start in a building Front side and side of a buildings. In flat rectangular plane surface of photo that is obtained used horizontal and vertically tilling system of a building manually mark up. A line segment on photographs that are taken from a buildings first horizontal tilling system was takes place with complete cutting system to focus for dividing the floor part of a building, the vertical tilling system was takes place colon of a building and tilling takes place for determining the door, window width of height lastly generating a texture of a buildings. There was define an offset by setting the z Adjust value per split tile to show the repetition of a building to add the number of floors in a building model. Texture image of the flat facade is computed from the multiple visible images of the façade processes had deselect the show /hide shapes .This processes was takes place for dividing the façade depending the rule of the study areas of a buildings for the processes of the production textures of a buildings .

Figure 12: Show segmented façade of a building.

4.9 Facade texturing completion

The final facade geometry was automatically retextured from all input images. It was technical contribution for using systematic decomposition of the facade. This processes shows representing strongly architectural importance of the facades and buildings into different stages of 3D modeling processes.

Figure 13: Texture production of the façade Shown below

4.10 Foot printing processes

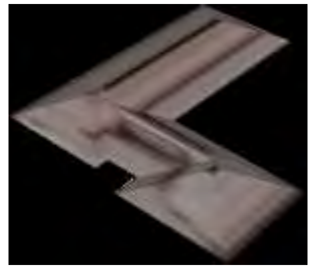
The footprint processes had been done after the 3D digitizing takes place and importing the data in to city engine software. it shows the total area of a building that holds in the surface of the earth. It extends in y axis and x axis. This normally demarcates where the exterior walls intersect on the surface and using a city engine the extraction of foot printing helps us to extrude 3D building from the data that are done in data capturing processes. The footprint processes had been done in order to create three-dimension building model. It helps to determine the design of a 3D models would mainly examine the building's structure by using the CGA rule that are prepared for the generation of 3D buildings automatically.

Figure 14: The foot printing result of the study area

4.11 Automation of 3D Modeling

The 3D modeling had been Automated using a script written based on computer generated architecture language developed by ESRI' for City engine software the script was applied to the building foot prints to generate a batch of 3D building models of sample area from Bahir Dar town. The data was used for both for foot printing processes and determining the height of a building in a model, there was no shift between roofs and base of buildings. But in the roof side when the side of a building having curves there was irregular curves have been observed some of the problems that are observed in the building formation in roofs are shown below in the figure-14.The roof shapes selected by the model processer and automatically by selecting the texture of roofs had been generated.

A



B

D

E

Figure 15: Roof and Road texture generated by CGA rules.

The researcher had taken the texture of roofs in figure 14, shows the texture of roofs, and roads taken from Google earth, the roof forms using CGA rule of built up and roads from Google earth the form of the roof is “Hip”, the size of the building roof shape determined according to the size of a building captured in 3D data capturing .the height of roofs is also determined by the height of a building during digitizing processes.

4.12 3D Cadastral Modeling

The 3D cadastral modeling of this research have been developed using the three dimensional digitized data’s. Using the roof texture, wall texture and road texture with the CGA rule written in the city engine, city engine module the models the 3D model had been generated .It looks like in (figure 13:).

Figure 16: 3D Cadastral model of the study area in city engine.

The 3D Cadastral data modeling processes in this research was also highly organized with using DTM and base map of the town changing in to raster form and with the combined processes of city engine and Arc scene generating the 3D model of the base map, the 3D model have been generated lastly by combining the 3Dmodel of building and base map using Arc scene. The 3D models are shown in (figure 14:).

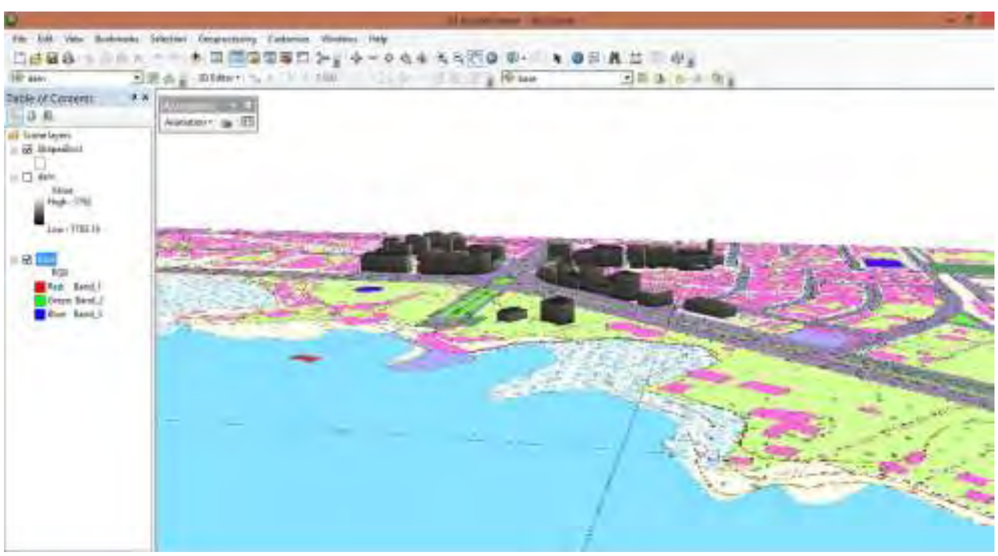


Figure 17: 3D Cadastral model of the study area city engine with Arc Scene.

Currently the Bahir Dar town land management and development office exercised registration of land holders and they are on the way of adjusting the precondition for preparing the cadastral map of the town even if there is no assumption in the preparation of the 3Dcadaster rather than 2Dcadasteral systems and in the time being the land holders registration system takes place using the following forms:-

In the table 3: form of registration for individual properties of land Field Data Recorded includes the name of land holding, Folder no, Existing file no, house number, neighborhoods no, block no, parcel no, unique parcel identification number had been recorded.

Table 3: Bahir Dar city individual property administration house field data recording *form (*Bahir Dar land management and development office).

Bahir Dar City individual property administration house field data recording
Date____________________________ page__________________________________
From 0001:____________________ Bahir Dar sub city map verification and field data collection form

No	Full name of land holding	Folder no	Existing file no	NH no	Block no	Parcel no	Temporary UPIN	Remark

Data collector name _____________signature________ Data collector _________signature________

Community facilitator _______________signature___________ field supervisor name____________

Received by data coordinator____________________________signature________________________

On the other side in the form shown in table-4 the Bahir Dar City Administration Condominium House Field Data Recording. It includes the name of land holding, house number, neighborhood no, block no, parcel no, unique parcel identification number included.

Table 4: Bahir Dar city administration condominium house field data recording form (Bahir Dar land management and development office).

<table>
<tr><td colspan="8">Bahir Dar City Administration Condominium House Field Data Recording</td></tr>
<tr><td colspan="8">Date_______________________________ page_____________________________________</td></tr>
<tr><td colspan="8">From 0001:____________________________________subcity map and field data collection form</td></tr>
<tr><td>No</td><td>Full name of land holding</td><td>House no</td><td>NH no</td><td>Block no</td><td>Parcel no</td><td>Temporary UPIN</td><td>Remark</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
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<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="8">Data collector name ______________signature________ Data collector _________signature________

Community facilitator ________________signature___________ field supervisor name______________

Received by data coordinator______________________________signature_____________________</td></tr>
</table>

According to the above processes of recording of land holder registration system takes place, but cadastral registration system is not started but it shows the preparation for it.

CHAPTER FIVE

DISCUSSION

According to Kemahu Abereham (2015) and also Genanaw Alemu and Dawit Haile (2009), the aerial triangulation positional accuracy of Adama cadaster was 0.031m in X, 0.022m in Y and 0.001m in Z. The Addis Ababa cadaster of 2010 that was done by Hansa Luftbild has achieved positional accuracy of 0.028m, 0.024m and 0.012m for the X, Y and Z respectively (Hansa Luftbild, 2010). This research resulted in 0.005m, 0.004m, and 0.008m in X, Y, and Z direction positional accuracy respectively. When comparing with these three projects, the result achieved in this research was much better accuracy in all the three directions. This 3D cadastral modeling research applied GSD (Ground Sampling Distance) of 18cm, which has direct effect on its positional accuracy. The increment of GSD in this research is due to aero-plane flying height. The Bahir Dar cadaster RMSE of 2013 was better in Y and Z direction when we compare with the Addis Ababa and the Adama Cadaster. Since, the aerial photograph was taken with 18cm GSD and with ultra-camera; the flight altitude would obviously be lower than the above listed. Flight altitude has an effect on Z accuracy because it has direct relationship with base-height ratio, i.e. the lower the flight altitude the higher base-height ratio and reverse is true, which is best for Z accuracy.

In orthophoto generation processes, the aerial photo taken from a lower altitude has an impact on resolution of the aerial photo. When we compare the GCP measurement and the Orthophoto measurement in 3D using software listed (table 2) especially in the z-value GCP point 1 the difference is 0.163, GCP point 2 the difference is 0.16, GCP point 3 the difference is 0.112 and GCP point 4 the difference is 0.098 RMSE. This shows that, the accuracy value is high because for the map with the scale of 1:2000, the allowable RMSE good. However, the positional accuracy of the final output should not exceed 40cm at scale of 1:2000 (ministry of urban development housing and construction, 2015).The buildings clearly seen in the orthophoto. This decreases the obscured areas and helps the orthophoto becomes more realistic and normal ortho rectification of the imagery and in addition detection of the obscured areas in the images. Furthermore, it is more influence in 3D vector data capturing of different features in the study area more accurately. The 3D digitizing have been taken using Micro Station software . The accuracy obtained on the orthophoto, by foot printing buildings and streets were captured effectively. With the application of the customized CGA rule, 3D model had been generated. The roof also generated by selecting Hip forms.

According the research done by Amezene Reda and Bekele Bedada (2015), the 3Dcadasteral model of Bahir Dar have been performed using the surveying data of each buildings, and the processes is so much tedious, requires much more time and the cost is expensive. To model 3D building, they applied transforming the surveying data's through digitalizing using AutoCAD software to model the 3D building. Where as in this research, surveying data and aerial photographs were used, photogrammetric processes were undertaken, and side and front view photographs of some buildings are used and finally automatically generate 3D urban cadastral data modeling within a short period of time. It focuses, not only on 3D cadastral registration but also in management and administration of 3D properties and on economic aspect on for proper tax collection and 3D models have been generated 3D using photogrammetric processes, surveying data and city Engine software.

On the other hand according to Kemahu Aberaham (2015) M-SC research of 3D cadastral data generation using surveying data and aerial photography in case of Adama town he used the methodology of point cloud generation ,segmentation with python scripting using surveying data ,Autodesk 2015 software and other Software's for generation of 3Dmodells so this processes is tedious and taking longer period of time in the processes of generation of three dimensional models when compared with using city engine 3D modeling generation processes takes place in the above processes.

In Bahir Dar the registration of land holders in the time being 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, lack of well-organized processed and recorded digital 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 Bahir Dar .The previous system of spatial information more of in hard copies and the data stored in one place, as a result, lack of recording, organizing of data and have difficulties in management and administration system. This resulted in dispute between neighboring peoples and miss use of resources. 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 cadastral digital spatial in formations the data's sited in many places, especially have one spatial database in the server that are highly secured the data are not only stored in soft copy but also in hard copies .The spatial data's that identified in each buildings with exact owner name, address, building block, type of building, purpose of a building, number of people live in each floor house, economic value of a building, legal condition of a building, situation of a building in that period and the physical aspects. The society clearly has the right, restriction and responsibilities of the properties.

3D cadasters creates a great opportunity for the geo-spatial administrators and the societies to use properly, control, continuous follow up, to easily develop any new infrastructure development, for clear decision making processes in the town. The data users or decision makers could rotate 3D models in every direction and buildings can be easily checked, analyze the characteristics of a building and it has more advantage than the 2D cadastral system. Furthermore, it is helpful to make clear and accurate decisions to decrease the economic bankrupt, social disputes, collect appropriate taxes, control illegal dwellers and buildings, to attract tourist by loading the 3D models of hotels and tourist attraction sites in to Google Earth platform. Since Google Earth have visited by many tourists before they are visiting the areas face to face, it gives the chance to view the sites online and supports the country to use the urban land resources productively to bring sustainable economic development and to evacuate from poor standard way of life to enter in to medium economic level with a short period of time and to develop stable government administration system in Ethiopia since land is the base for development.

CHAPTER SIX

CONCLUSION AND RECOMENDATIONS

6.1 Conclusion

Generating the 3D model in aerial photo needs better accuracies in aerial triangulation and orthophoto generation processes .It also requires better data capturing from orthophotos. To automatically obtain 3D building models with precise geometric position and fine details from aerial photographs, surveying data, photographs of some buildings as an input data; 3D modeling processes in relation to the accuracy value, coast, rate of speed for the formation of 3D modeling for urban areas using GIS 2D or 3D data's, by writing CGA rule systems in city engine software and façade photographs of a building techniques have been applicable for generation of urban 3D modelling. The most important revenue of this research is automatic reconstruction of 3D modeling of urban areas using aerial photographs without the need of expensive LIDAR data which reduces the complexity of 3D cadastral modeling processes, reduce human power, time, cost and improves the quality of the final 3D models, The future application of 3D cadastral information system in Bahir Dar have impact on the way of registering, managing and administrating the cadastral system more clearly, shows detail information than the traditional and the two dimensional cadastral system of the Bahir Dar town .This processes of cadastral system have an importance for the wise use of land resources, appropriate collection of tax, for reduction of dispute among the people, easily updating cadastral information, to support urban planning, land administration, land taxation, economic development and cadastral management system, to increase the land value , to increase the rate of tourist visitors for tourism industry development. Especially Bahir Dar and other many countries in Ethiopia have recent data of 2D prepared by EMA and INSA for the purpose of up grading the master plan of the town, so this data can used for the development of 3Dmodelling cadaster of towns.

6.2 Recommendations

- The Bahir Dar town has to incorporate 3D model for cadastre registration system.
- The office has to implement advanced technologies in land management activities.
- The office has to further investigate how to manage the increased demand for multipurpose buildings.
- The office has to focus on capacity building of its staff for future advancements.

References:-

Abdul Majid, S. (2000). Benefits and issues of developing a multi-purpose cadaster, *International Archives of Photogrammetry and Remote Sensing*. XXXIII: Part B4. Amsterdam.

Achamyeleh Gashu (2014). Peri-urban land rights in the era of urbanization in Ethiopia, Institute of Land Administration, Bahir Dar University, Ethiopia, and P_122-135.

Ahmed, M.H. (2010).The use of oblique and vertical image for 3d urban modeling, University of Nottingham.

Aien, A. (2012).3D cadastral data model: a foundation for developing a national land information.

Aien, A. (2013). 3D cadastral data modeling, The University of Melbourne, Victoria, Australia.

Aien, A., Kalantari, M., Rajabifard, A., Williamson, I. P. and Shojaei, D. (2012). Developing and testing a 3D cadastral data model, Remote Sensing and Spatial Information Sciences, I-4,University of Melbourne, Australia.

Ahmed, M.H.(2010).The use of oblique and vertical image for 3d urban modeling, University of Nottingham.

Amezene Reda and Bekele Bedada(2015). Development of 3d urban cadaster and property registration system, Bahir Dar University, Bahir Dar, Ethiopia. *International Journal of Research and Innovations in Earth Science*, 2: Issue 3, ISSN: 2394-1375.

Amanuel Tesfay (2008). Preparation of coordinate based cadastral map in rural Ethiopia, Department of Earth Sciences, Addis Ababa University, Ethiopia.

Burns, T. and Dalrymple, K.(2008).Conceptual framework for governance in land administration, Australia.

Barnes,G., Chaplin, B., Moyer, D. D., Roche, E .D., Eckl, M. and Sartori, M.(1998). GPS methodology for cadastral surveying and mapping in albania, Land Tenure Center, University of Wisconsin–Madison.

Çağdaş, V.(2014).Land registration and cadaster systems, Yıldız Technical University, Istanbul.

Chiang, H.C. (2012). Data modeling and application of 3d cadaster in taiwan, *3rd International Workshop on 3D Cadasters*: Developments and Practices 25-26 October, Shenzhen, China.

Choon, T.L. and Hussin, K.B.(2010). New cadastral approach for sustainable development in multilayer building, University Teknologi, Malaysia.

Dobraja, I. (2015). Procedural 3D modeling and visualization of geotypical Bavarian rural buildings in ESRI City Engine software, Technische Universität München.

Economic Commission for Europe (1996). Land administration guidelines, United Nations, New York and Geneva, ECE/HBP/96PP10-60.

Eric, E., Alias, D. and Abdul Rahman (2013). A Unified 3D cadaster data model-A Geometric Approach, Geo information Department, Faculty of Geo-information and Real Estate, University Technology, Malaysia.

Elmasri, R. and Navathe, S.B.(2011). Fundamental of database system, sixth edition, AddisonWesley, NewYork.

Gebeyehu Belay (2003). Land administration and use. Bureau of Environmental Protection, Ethiopia.

Gebeyehu Belay (2011). Cadastral Template 2010, Bureau of Environmental Protection, Land administration and Use, Ethiopia.

Guoab, R., Lia, L., Yinga, S., Luoc, P., Heb, B. and Jiang, R. (2013). Developing a 3D cadaster for the administration of urban land use, Shenzhen, China p.p. 47.

Haala, N. and Kada, M.(2010). An update on automatic 3D building reconstruction, ISPRS *Journal of Photogrammetry and Remote Sensing*, *Institute for Photogrammetry, ElsevierB.V*, University of Stuttgart, Germany, **65**: 570–580.

Hamruni, A.M. (2010). The use of oblique and vertical images for 3D urban modeling, University of Nottingham, institute of engineering surveying and space geodesy, United Kingdom.

International federation of survey (1999).The Bathurst declaration on land administration for sustainable development, Bathurst, Australia.

International Association of Assessing Officers (2004). Standard on manual cadastral maps and parcel identifiers, United States of America.

Kim, D. (2010). 3D visual urban simulation: methods and applications, department of urban and regional planning, California State Polytechnic University–Pomona.

Kim, H. M, Tcha ,D .K, Nam, G.M. and Yang, C. S. (2010).Design and implementation of full 3d cadastral data architecture, South Korea, Sydney, Australia.

Kaczyilski, R.(2000).Digital aerial triangulation, DEM and ortho photo generation in Igiκ, institute of geodesy and cartography, Geodesy and Cartography, XXVI:, No 3.

Kaufmann, J. (2004). ArcGIS cadaster 2014 data model vision, Arc GIS Data Models.

Kemahu Aberaham (2015). 3D Objects modeling using aerial photos and surveying data for cadastral application, school of Earth Science, Unpublished MSc Thesis, Addis Ababa University, Addis Ababa, Ethiopia.

Kalantari, M., Rajabifard, A., Wallace, J. And Williamson, I. P. (2006). A New vision on cadastral data model XXIII: FIG Congress, Munich, Germany.

Kurwakumire, E. (2014). Digital cadasters facilitating land information management, Department of Geomatics, Tshwane University of Technology, South African Journal of Geomatics, Vol. **3:**No. 1, Pretoria, South Africa.

Malumpong, C. and Chen, X. (2008). Interoperable 3D GIS city modeling with geo-informatics techniques and 3d modeling software, *the International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences.* XXXVII: Part B2 Thailand

Meha, M., Llabjani, H., Bublaku, H. and Kosovo, A. (2004). Development of cadaster and land management in Kosovo, FIG, Athens, Greece.

Ministry of Urban Development Housing And Construction (2015).Urban Legal Cadaster Standard, No. 3.

Remondino, F. and El-Hakim, S. (2006). Image-based 3D modeling, Swiss Federal Institute of Technology (ETH), Zurich, National Research Council, Ottawa, Canada, The Photogrammetric Record **21**(115): 269–291.

Shiode, A.(2001). 3D urban models: Recent developments in the digital modeling of urban environments in three-dimensions Centre for Advanced Spatial Analysis, University College London, London.

Şanlıoğlu, İ., Zeybek, M. and Karauğuz, G.(2013). Photogrammetric survey and 3d modeling of Ivriz rock relief in late hittite era, Department of Geomatics Engineering, University of Selcuk, Turkey Education Faculty, University of Necmettin Erbakan, Turkey, Mediterranean Archaeology and Archaeometry, Vol. **13:** No 2, pp. 147-157 .

Suveg, I. and Vosselman, G. (2004). Reconstruction of 3D building models from aerial images and maps, The Netherlands, *ISPRS Journal of Photogrammetry & Remote Sensing* 58 (2004) 202–224, Delft University of Technology, Kluyverweg.

Second International Workshop on 3D Cadasters (2011). Advanced principles of 3D cadastral data modeling, University of Melbourne, Australia.

Schenk, T. (2005). Introduction to Photogrammetry, Department of Civil and Environmental Engineering and Geodetic Science, The Ohio State University, Autumn Quarter.

USDI Burue of land management (2001). Cadastral surveys using global positioning system method, USAD forest service.

Vicini, A., Bevington, J., Esquivias, G., Iannelli,G-C. and Wieland, M. (2014).User guide: Geospatial tools for building footprint and homogeneous zone extraction .

Viinikka, J.(2014). Adopting procedural information modeling in urban planning, School of Engineering, Aalto University.

Williamson, I. P. (2000). Best practices for land administration systems in developing countries, Jakarta.

Williamson, I., Enemark, S., Denmark and Wallace, J. (2010). Land administration for sustainable development, Australia.

Zelalem Yirga (2012). Institutional analysis of condominium management system, African Review of Economics and Finance, technical report vol. 3 No.2, June, Rhodes University, South Africa.

Muller, P., Zeng, G., Wonka, P. and Gool, L. V. (2007). Image-based Procedural Modeling of Facades, ACM Transactions on Graphics, Vol. 26, No. 3, Article 85. http://www.cis.pku.edu.cn/faculty/vision/zeng/pdf/MullerZWG07tog.pdf.

Zeng G., Wonka P. and Gool L.V., (2007). Image-based Procedural Modeling of Facades. ACM Transactions on Graphics, 26: No. 3, Article 85.

Zevenbergen, J. (2004). A Systems approach to land registration and cadaster, Section Geo-information and Land Development, Delftm University of Technology, OTB Research Institute, *Nordic Journal of Surveying and Real Estate Research* **1**, Netherlands.

Zhang, H; Li, Y; Liu, B and Liu, C (2014). The application of GIS 3D modeling and analysis technology in real estate mass appraisal, The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, **XL-4:,**2014 Suzhou, China).

URL:

http;//www.eolss.net/EOLSS% 20publication%20Catalogue.pdf. Accessed on 12/3/2016.

http://www.pasture.ecn.purdue.edu/~aggrass/esri95/to150/p124.html, accessed on, 29/2/2016.

Http: // www.ijser.org accessed on 3/2/2016

https://www.en.wikipedia.org/wiki/Bahir_Dar. accessed on 3/4/2016

http://cehelp.esri.com/help/index.jsp?topic=/com.procedural.cityengine.help/html/manual/toc.html). Accessed on 3/4/2016.

http://www.gis.esri.com/library/userconf/proc95/to150/p124.html , accessed on 9/3/2016 .

http://www.gama.vtu.lt/biblioteka/Information_Resources/i_part_of_information_resources.pdf, accessed on 19/5/2016.

http://www.dot.state.wy.us/files/live/sites/wydot/files/shared/Highway_Development/Surveys/Survey%20Manual/Section%20VII%20-%20Photogrammetric%20Surveys.pdf. Accessed on 2/3/2016

http://www.wgbis.ces.iisc.ernet.in/energy/HC270799/LM/SUSLUP/Thema5/594/594.pdf, Accessed on 12/1/2016.

Unpublished

Federal Urban Planning Institute and Bahir Dar metropolitan City Administration (2006).

Appendix

Built up rule

```
/**
 * File:    Building.
 * Created: april.25.2016  27:20:00 GMT
 * Author:  customized from andi
 */

version "2012.1"

/* Attributes *************************************/
@Range(2,6)
attr rooform = "Hip"
@Range(2,6)
attr groundfloor_height = 4
@Range(2,6)
attr floor_height              = 3.5
@Range(1,10)
attr tile_width                = rand(2.5,6)
@Range(3,50)
attr height                    = rand(3,20)
attr wallColor  =
        50% :  "#ffffff"
        50% :  "#999999"
        else :  "#444444"

@Range(LOD0=0,LOD1=1)
attr LOD                              = 0

/* Assets ************************************/

// geometries
const window_asset = "facades/window.obj"
const Roof_asset   = "roofs/roof.obj"
// textures
const frontdoor_tex            = "facades/textures/shopdoor.tif"
const wall_tex                               = "facades/textures/brickwall2.tif"
const dirt_tex                        = "facades/textures/dirtmap.15.tif"
const roof_tex                               = "roofs/roof.tif"


# this function will get one of the 9 window textures in the assets folder
randomWindowTexture = fileRandom("*facades/textures/window.*.tif")

/* Initial Shape starting rule *************/
```

```
import gen_Facade_F_FACADE : "gen_Facade_F_FACADE.cga"

Lot-->
	extrude(height) Building comp(f) { side : gen_Facade_F_FACADE.Facade }


# scale the lit to leave a small border and extrude the lot to building height
#
# inner lots are dropped
LotInner --> NIL



# split the building geometry into its facade components
Building -->
	comp(f) { front : gen_Facade_F_FACADE.Facade | side :
gen_Facade_F_FACADE.Facade | top: Roof}
# the front facade is subdivided into one front groundfloor
# and upper floors
Frontfacade -->
	setupProjection(0, scope.xy, 1.5, 1, 1) # setup 1.5m x 1m texture tiles along scopes xy
plane (and distortion in z)
	setupProjection(2, scope.xy, scope.sx, scope.sy)
	split(y){ groundfloor_height    : Groundfloor
	          | {~floor_height : Floor}* }


# a side facade is subdivided into one bottom floor
# and upper floors.
Sidefacade -->
	setupProjection(0, scope.xy, 1.5, 1, 1) # setup 1.5m x 1m texture tiles along scopes xy
plane (and distortion in z)
	setupProjection(2, scope.xy, scope.sx, scope.sy)
	split(y){ groundfloor_height    : Floor
	          | {~floor_height : Floor}* }


# a roof texture is applied to the roof face
@Location(475,538)
Roof -->
   roofHip(20)
	color(wallColor)
	setupProjection(0, scope.xy, scope.sx, scope.sy)
	texture("roofs/roof.tif")
	projectUV(0)
```

```
# each floor is horizontally split into two narrow corner areas on
# each side of the floor, and into a set of window tiles in between
Floor -->
        split(x){ 1 : Wall
                | { ~tile_width : Tile }*
                | 1 : Wall }


# similarily, the front groundfloor is horizontally split into
# two narrow corner areas on each side of the floor,
# a special entrance tile on the right
# and into a set of window tiles in between
Groundfloor -->
        split(x){ 1                  : Wall
                | { ~tile_width : Tile }*
                |~tile_width   : EntranceTile
                | 1                      : Wall }


# a tile consists of a centered window element and
# wall elements above, below, left and right
Tile -->
        split(x){ ~1 : Wall
                |  2 : split(y){ 1: Wall | 1.5: Window | ~1: Wall }
                | ~1 : Wall }


# similarily, the EntranceTile contains a centered Door element,
# but with no wall on spacing below
EntranceTile -->
        split(x){ ~1 : gen_Facade_F_FACADE.Facade
                | 2  : split(y){ 2.5: Door | ~2: SolidWall }
                | ~1 : gen_Facade_F_FACADE.Facade }


# firstly, the depth and the depth position of the future window is set
# secondly, one of nine window textures is randomly selected
# finally, the window geometry asset is inserted
Window -->
  case LOD > 0 :
        s('1,'1,0.4)
        t(0,0,-0.25)
        texture(randomWindowTexture)
        i(window_asset)
  else :
        setupProjection(0,scope.xy,scope.sx,scope.sy)
        texture(randomWindowTexture)
```

```
        projectUV(0)

# same for the door asset. Scaling, positioning, texture selection
# and geometry insert
# TODO: fix door uv bug (problem with uv handling on split?)
Door -->
  case LOD > 0 :
        s('1,'1,0.1)
        t(0,0,-0.5)
        texture(frontdoor_tex)
        i("builtin:cube")
  else :
        setupProjection(0,scope.xy,scope.sx,scope.sy)
        texture(frontdoor_tex)
        projectUV(0)

# for the wall asset, setting the texture scale params u and v
# guarantees a texture mapping that nicely fits over the whole facade
Wall -->
        color(wallColor)
        texture(wall_tex)
        set(material.dirtmap, dirt_tex)
        projectUV(0) projectUV(2)

SolidWall -->
  case LOD > 0 :
        color(wallColor)
        s('1,'1,0.4)
        t(0,0,-0.4)
        texture(wall_tex)
        set(material.dirtmap, dirt_tex)
        i("builtin:cube:notex")
        projectUV(0) projectUV(2)
  else :
        Wall
```

Street Rules

```
/**
 * File:    BDR Streets.cga
 * Created: april.30.2016. 16:12:45
 * Author:  *   Customized from Pascal

version "2012.1"


#######################
```

```
# attributes
#

# user attributes
@Order(1) @Range(0.5,1.5)
attr Walkway_Height = 70%: 1 else: rand(0.5,1.1)

# attributes which are overwritten (either by attribute layer maps or given attribute values)
@Group("Object Attributes",2) @Order(1) @Range("MINOR","MAJOR")
attr type = "MINOR"                    # for the streets



########################
# Street
#

Crossing -->
	case geometry.area < 5:          # crossings of this size must be coming from border streets (used only to determine the block borders)
		NIL
	case type == "MINOR":                        # other minor crossings are for sure walkways
		Walkway( Walkway_Height )
	case geometry.area > 54:          # crossings of this size must be over the wide waterways. ergo we do not create geometry.
		NIL
	case initialShape.name == "Waterway":  # also no crossing in case they have been manually renamed
		NIL
	else:                         # otherwise we create some bridges
		Walkway( Walkway_Height )

Junction --> Crossing

JunctionEntry --> Crossing

Street -->
	case initialShape.name == "Border" || initialShape.name == "Waterway":
		NIL
	else:
		Walkway( Walkway_Height )

Sidewalk --> NIL

Walkway -->
	Walkway( Walkway_Height )
```

```
Walkway(h) -->
	extrude(world.y,h) t(0,-h,0)
	setupProjection(0,world.xz,20,-20,4) projectUV(0)
	texture("D:/Cityengine/abdij/assets/roads/road.tif")					# a
mix between a pavement texture ..
	set(material.bumpmap,"D:/Cityengine/abdij/assets/roads/road.tif")
set(material.bumpValue,0.3)
	setupProjection(2,world.xz,5500,-3000) projectUV(2)
	set(material.dirtmap, "D:/Cityengine/abdij/assets/roads/road.tif")
	# .. and desaturated the satellite photo
```

gen_Facade_F_FACADE.cga

april.15.2016.

```
// this file was automatically generated by the facade editor.


version "2012.1"


attr LOD = 2
# LOD 0 generates the original texture
# LOD 1 generates flat splits
# LOD 2 generates splits with depth as defined in Facade Wizard


#! SIZE 30.0 32.74474

const n = 5

Facade -->
	case LOD <= 0:
		texture("/abdij/assets/facades/textures/F_FACADE.tif")
		alignScopeToGeometry(zUp, 0, world.lowest)
		setupProjection(0, scope.xy, '1.0000, '1.0000)
		projectUV(0)
	else:
		texture("/abdij/assets/facades/textures/F_FACADE.tif")
		alignScopeToGeometry(zUp, 0, world.lowest)
		split(y, noAdjust) { 6.34: Facade__1(0) | ~7.08: Facade__1(1) | ~6.69:
Facade__1(2) | 6.03: Facade__1(3) | ~6.60: Facade__1(4) }


Facade__1(i) -->
	case i == 0: Facade__1_1
```

```
        case i == 1: Facade__1_2
        case i == 2: Facade__1_3
        case i == 3: Facade__1_4
        case i == 4: Facade__1_5
        else: Facade__1_1

Facade__1_1 -->
        split(y, noAdjust) { ~6.34: Facade__1_1_1 }*

Facade__1_1_1 -->
        split(x, noAdjust) { ~6.30: Facade__1_1_1_1 | 0.83: Facade__1_1_1_2 | ~14.83:
Facade__1_1_1_3 | 0.65: Facade__1_1_1_4 | ~7.39: Facade__1_1_1_5 }

Facade__1_1_1_1 -->
        setupProjection(0, scope.xy, '4.7586, '5.1656)
        projectUV(0)

Facade__1_1_1_2 -->
        setupProjection(0, scope.xy, '36.3062, '5.1656, '-7.6296, '0.0000)
        projectUV(0)

Facade__1_1_1_3 -->
        setupProjection(0, scope.xy, '2.0235, '5.1656, '-0.4810, '0.0000)
        projectUV(0)

Facade__1_1_1_4 -->
        setupProjection(0, scope.xy, '46.1184, '5.1656, '-33.7532, '0.0000)
        projectUV(0)

Facade__1_1_1_5 -->
        setupProjection(0, scope.xy, '4.0579, '5.1656, '-3.0579, '0.0000)
        projectUV(0)

Facade__1_2 -->
        split(y, noAdjust) { ~7.08: Facade__1_2_1 }*

Facade__1_2_1 -->
        split(x, noAdjust) { 1.85: Facade__1_2_1_1 | ~3.37: Facade__1_2_1_2 | 1.91:
Facade__1_2_1_3 | 1.89: Facade__1_2_1_4 | ~3.48: Facade__1_2_1_5 | 2.24:
Facade__1_2_1_6 | 1.78: Facade__1_2_1_7 | ~3.80: Facade__1_2_1_8 | 2.15:
Facade__1_2_1_9 | 1.76: Facade__1_2_1_10 | ~3.37: Facade__1_2_1_11 | 2.39:
Facade__1_2_1_12 }

Facade__1_2_1_1 -->
        setupProjection(0, scope.xy, '16.2343, '4.6234, '0.0000, '-0.8951)
        projectUV(0)
```

```
Facade__1_2_1_2 -->
	split(y, noAdjust) { 1.61: Facade__1_2_1_2_1 | ~4.02: Facade__1_2_1_2_2 | 1.45:
Facade__1_2_1_2_3 }

Facade__1_2_1_2_1 -->
	setupProjection(0, scope.xy, '8.9033, '20.3449, '-0.5484, '-3.9386)
	projectUV(0)

Facade__1_2_1_2_2 -->
	setupProjection(0, scope.xy, '8.9033, '8.1420, '-0.5484, '-1.9764)
	projectUV(0)

Facade__1_2_1_2_3 -->
	setupProjection(0, scope.xy, '8.9033, '22.5645, '-0.5484, '-8.2487)
	projectUV(0)

Facade__1_2_1_3 -->
	setupProjection(0, scope.xy, '15.6801, '4.6234, '-2.7270, '-0.8951)
	projectUV(0)

Facade__1_2_1_4 -->
	setupProjection(0, scope.xy, '15.8641, '4.6234, '-3.7708, '-0.8951)
	projectUV(0)

Facade__1_2_1_5 -->
	split(y, noAdjust) { 1.83: Facade__1_2_1_5_1 | ~3.80: Facade__1_2_1_5_2 | 1.45:
Facade__1_2_1_5_3 }

Facade__1_2_1_5_1 -->
	setupProjection(0, scope.xy, '8.6251, '17.9240, '-2.5938, '-3.4699)
	projectUV(0)

Facade__1_2_1_5_2 -->
	setupProjection(0, scope.xy, '8.6251, '8.6073, '-2.5938, '-2.1465)
	projectUV(0)

Facade__1_2_1_5_3 -->
	setupProjection(0, scope.xy, '8.6251, '22.5645, '-2.5938, '-8.2487)
	projectUV(0)

Facade__1_2_1_6 -->
	setupProjection(0, scope.xy, '13.4068, '4.6234, '-5.5862, '-0.8951)
	projectUV(0)

Facade__1_2_1_7 -->
	setupProjection(0, scope.xy, '16.8158, '4.6234, '-8.2609, '-0.8951)
	projectUV(0)
```

```
Facade__1_2_1_8 -->
	split(y, noAdjust) { 1.94: Facade__1_2_1_8_1 | ~3.80: Facade__1_2_1_8_2 | 1.34:
Facade__1_2_1_8_3 }

Facade__1_2_1_8_1 -->
	setupProjection(0, scope.xy, '7.8858, '16.9174, '-4.3429, '-3.2750)
	projectUV(0)

Facade__1_2_1_8_2 -->
	setupProjection(0, scope.xy, '7.8858, '8.6073, '-4.3429, '-2.1751)
	projectUV(0)

Facade__1_2_1_8_3 -->
	setupProjection(0, scope.xy, '7.8858, '24.3915, '-4.3429, '-8.9976)
	projectUV(0)

Facade__1_2_1_9 -->
	setupProjection(0, scope.xy, '13.9550, '4.6234, '-9.4550, '-0.8951)
	projectUV(0)

Facade__1_2_1_10 -->
	setupProjection(0, scope.xy, '17.0141, '4.6234, '-12.7469, '-0.8951)
	projectUV(0)

Facade__1_2_1_11 -->
	split(y, noAdjust) { 1.72: Facade__1_2_1_11_1 | ~4.02: Facade__1_2_1_11_2 | 1.34:
Facade__1_2_1_11_3 }

Facade__1_2_1_11_1 -->
	setupProjection(0, scope.xy, '8.9033, '19.0579, '-7.1936, '-3.6894)
	projectUV(0)

Facade__1_2_1_11_2 -->
	setupProjection(0, scope.xy, '8.9033, '8.1420, '-7.1936, '-2.0034)
	projectUV(0)

Facade__1_2_1_11_3 -->
	setupProjection(0, scope.xy, '8.9033, '24.3915, '-7.1936, '-8.9976)
	projectUV(0)

Facade__1_2_1_12 -->
	setupProjection(0, scope.xy, '12.5449, '4.6234, '-11.5449, '-0.8951)
	projectUV(0)

Facade__1_3 -->
	split(y, noAdjust) { ~6.69: Facade__1_3_1 }*
```

```
Facade__1_3_1 -->
	split(x, noAdjust) { 1.96: Facade__1_3_1_1 | ~3.26: Facade__1_3_1_2 | 1.78: 
Facade__1_3_1_3 | 2.02: Facade__1_3_1_4 | ~3.37: Facade__1_3_1_5 | 2.35: 
Facade__1_3_1_6 | 1.78: Facade__1_3_1_7 | ~3.70: Facade__1_3_1_8 | 2.26: 
Facade__1_3_1_9 | 1.76: Facade__1_3_1_10 | ~3.26: Facade__1_3_1_11 | ~2.50: 
Facade__1_3_1_12 }

Facade__1_3_1_1 -->
	setupProjection(0, scope.xy, '15.3324, '4.8954, '0.0000, '-2.0065)
	projectUV(0)

Facade__1_3_1_2 -->
	split(y, noAdjust) { 1.59: Facade__1_3_1_2_1 | ~2.93: Facade__1_3_1_2_2 | 2.16: 
Facade__1_3_1_2_3 }

Facade__1_3_1_2_1 -->
	setupProjection(0, scope.xy, '9.2001, '20.5645, '-0.6000, '-8.4290)
	projectUV(0)

Facade__1_3_1_2_2 -->
	setupProjection(0, scope.xy, '9.2001, '11.1576, '-0.6000, '-5.1158)
	projectUV(0)

Facade__1_3_1_2_3 -->
	setupProjection(0, scope.xy, '9.2001, '15.1468, '-0.6000, '-8.3024)
	projectUV(0)

Facade__1_3_1_3 -->
	setupProjection(0, scope.xy, '16.8341, '4.8954, '-2.9277, '-2.0065)
	projectUV(0)

Facade__1_3_1_4 -->
	setupProjection(0, scope.xy, '14.8352, '4.8954, '-3.4613, '-2.0065)
	projectUV(0)

Facade__1_3_1_5 -->
	split(y, noAdjust) { 1.59: Facade__1_3_1_5_1 | ~3.15: Facade__1_3_1_5_2 | 1.94: 
Facade__1_3_1_5_3 }

Facade__1_3_1_5_1 -->
	setupProjection(0, scope.xy, '8.9033, '20.5645, '-2.6775, '-8.4290)
	projectUV(0)

Facade__1_3_1_5_2 -->
	setupProjection(0, scope.xy, '8.9033, '10.3881, '-2.6775, '-4.7630)
	projectUV(0)
```

```
Facade__1_3_1_5_3 -->
	setupProjection(0, scope.xy, '8.9033, '16.8402, '-2.6775, '-9.3424)
	projectUV(0)

Facade__1_3_1_6 -->
	setupProjection(0, scope.xy, '12.7857, '4.8954, '-5.2811, '-2.0065)
	projectUV(0)

Facade__1_3_1_7 -->
	setupProjection(0, scope.xy, '16.8158, '4.8954, '-8.2609, '-2.0065)
	projectUV(0)

Facade__1_3_1_8 -->
	split(y, noAdjust) { 1.70: Facade__1_3_1_8_1 | ~2.93: Facade__1_3_1_8_2 | 2.05:
Facade__1_3_1_8_3 }

Facade__1_3_1_8_1 -->
	setupProjection(0, scope.xy, '8.1177, '19.2504, '-4.4706, '-7.8904)
	projectUV(0)

Facade__1_3_1_8_2 -->
	setupProjection(0, scope.xy, '8.1177, '11.1576, '-4.4706, '-5.1529)
	projectUV(0)

Facade__1_3_1_8_3 -->
	setupProjection(0, scope.xy, '8.1177, '15.9487, '-4.4706, '-8.7949)
	projectUV(0)

Facade__1_3_1_9 -->
	setupProjection(0, scope.xy, '13.2834, '4.8954, '-8.9518, '-2.0065)
	projectUV(0)

Facade__1_3_1_10 -->
	setupProjection(0, scope.xy, '17.0141, '4.8954, '-12.7469, '-2.0065)
	projectUV(0)

Facade__1_3_1_11 -->
	split(y, noAdjust) { 1.70: Facade__1_3_1_11_1 | ~2.93: Facade__1_3_1_11_2 | 2.05:
Facade__1_3_1_11_3 }

Facade__1_3_1_11_1 -->
	setupProjection(0, scope.xy, '9.2001, '19.2504, '-7.4334, '-7.8904)
	projectUV(0)

Facade__1_3_1_11_2 -->
	setupProjection(0, scope.xy, '9.2001, '11.1576, '-7.4334, '-5.1529)
```

```
        projectUV(0)

Facade__1_3_1_11_3 -->
        setupProjection(0, scope.xy, '9.2001, '15.9487, '-7.4334, '-8.7949)
        projectUV(0)

Facade__1_3_1_12 -->
        setupProjection(0, scope.xy, '11.9995, '4.8954, '-10.9995, '-2.0065)
        projectUV(0)

Facade__1_4 -->
        split(y, noAdjust) { ~6.03: Facade__1_4_1 }*

Facade__1_4_1 -->
        split(x, noAdjust) { 1.96: Facade__1_4_1_1 | ~3.26: Facade__1_4_1_2 | 1.78:
Facade__1_4_1_3 | 2.02: Facade__1_4_1_4 | ~3.37: Facade__1_4_1_5 | 2.35:
Facade__1_4_1_6 | 1.68: Facade__1_4_1_7 | ~3.70: Facade__1_4_1_8 | 2.37:
Facade__1_4_1_9 | 1.87: Facade__1_4_1_10 | ~3.15: Facade__1_4_1_11 | ~2.50:
Facade__1_4_1_12 }

Facade__1_4_1_1 -->
        setupProjection(0, scope.xy, '15.3324, '5.4275, '0.0000, '-3.3333)
        projectUV(0)

Facade__1_4_1_2 -->
        split(y, noAdjust) { 1.43: Facade__1_4_1_2_1 | ~3.04: Facade__1_4_1_2_2 | 1.56:
Facade__1_4_1_2_3 }

Facade__1_4_1_2_1 -->
        setupProjection(0, scope.xy, '9.2001, '22.9773, '-0.6000, '-14.1115)
        projectUV(0)

Facade__1_4_1_2_2 -->
        setupProjection(0, scope.xy, '9.2001, '10.7591, '-0.6000, '-7.0760)
        projectUV(0)

Facade__1_4_1_2_3 -->
        setupProjection(0, scope.xy, '9.2001, '20.9291, '-0.6000, '-15.7098)
        projectUV(0)

Facade__1_4_1_3 -->
        setupProjection(0, scope.xy, '16.8341, '5.4275, '-2.9277, '-3.3333)
        projectUV(0)

Facade__1_4_1_4 -->
        setupProjection(0, scope.xy, '14.8352, '5.4275, '-3.4613, '-3.3333)
        projectUV(0)
```

```
Facade__1_4_1_5 -->
	split(y, noAdjust) { 1.43: Facade__1_4_1_5_1 | ~3.15: Facade__1_4_1_5_2 | 1.46: 
Facade__1_4_1_5_3 }

Facade__1_4_1_5_1 -->
	setupProjection(0, scope.xy, '8.9033, '22.9773, '-2.6775, '-14.1115)
	projectUV(0)

Facade__1_4_1_5_2 -->
	setupProjection(0, scope.xy, '8.9033, '10.3881, '-2.6775, '-6.8320)
	projectUV(0)

Facade__1_4_1_5_3 -->
	setupProjection(0, scope.xy, '8.9033, '22.4916, '-2.6775, '-16.9573)
	projectUV(0)

Facade__1_4_1_6 -->
	setupProjection(0, scope.xy, '12.7857, '5.4275, '-5.2811, '-3.3333)
	projectUV(0)

Facade__1_4_1_7 -->
	setupProjection(0, scope.xy, '17.9068, '5.4275, '-8.7968, '-3.3333)
	projectUV(0)

Facade__1_4_1_8 -->
	split(y, noAdjust) { 1.43: Facade__1_4_1_8_1 | ~3.15: Facade__1_4_1_8_2 | 1.46: 
Facade__1_4_1_8_3 }

Facade__1_4_1_8_1 -->
	setupProjection(0, scope.xy, '8.1177, '22.9773, '-4.4412, '-14.1115)
	projectUV(0)

Facade__1_4_1_8_2 -->
	setupProjection(0, scope.xy, '8.1177, '10.3881, '-4.4412, '-6.8320)
	projectUV(0)

Facade__1_4_1_8_3 -->
	setupProjection(0, scope.xy, '8.1177, '22.4916, '-4.4412, '-16.9573)
	projectUV(0)

Facade__1_4_1_9 -->
	setupProjection(0, scope.xy, '12.6734, '5.4275, '-8.4949, '-3.3333)
	projectUV(0)

Facade__1_4_1_10 -->
	setupProjection(0, scope.xy, '16.0262, '5.4275, '-12.0067, '-3.3333)
```

```
	projectUV(0)

Facade__1_4_1_11 -->
	split(y, noAdjust) { 1.43: Facade__1_4_1_11_1 | ~3.15: Facade__1_4_1_11_2 | 1.46: Facade__1_4_1_11_3 }

Facade__1_4_1_11_1 -->
	setupProjection(0, scope.xy, '9.5173, '22.9773, '-7.7242, '-14.1115)
	projectUV(0)

Facade__1_4_1_11_2 -->
	setupProjection(0, scope.xy, '9.5173, '10.3881, '-7.7242, '-6.8320)
	projectUV(0)

Facade__1_4_1_11_3 -->
	setupProjection(0, scope.xy, '9.5173, '22.4916, '-7.7242, '-16.9573)
	projectUV(0)

Facade__1_4_1_12 -->
	setupProjection(0, scope.xy, '11.9995, '5.4275, '-10.9995, '-3.3333)
	projectUV(0)

Facade__1_5 -->
	split(x, noAdjust) { 2.07: Facade__1_5_1 | ~3.04: Facade__1_5_2 | 2.02: Facade__1_5_3 | 1.89: Facade__1_5_4 | ~3.37: Facade__1_5_5 | 2.35: Facade__1_5_6 | 2.00: Facade__1_5_7 | ~3.26: Facade__1_5_8 | ~2.61: Facade__1_5_9 | 1.96: Facade__1_5_10 | ~2.83: Facade__1_5_11 | ~2.61: Facade__1_5_12 }

Facade__1_5_1 -->
	setupProjection(0, scope.xy, '14.5255, '4.9603, '0.0000, '-3.9603)
	projectUV(0)

Facade__1_5_2 -->
	split(y, noAdjust) { 1.26: Facade__1_5_2_1 | ~3.15: Facade__1_5_2_2 | 2.19: Facade__1_5_2_3 }

Facade__1_5_2_1 -->
	setupProjection(0, scope.xy, '9.8572, '25.9569, '-0.6786, '-20.7240)
	projectUV(0)

Facade__1_5_2_2 -->
	setupProjection(0, scope.xy, '9.8572, '10.3881, '-0.6786, '-8.6940)
	projectUV(0)

Facade__1_5_2_3 -->
	setupProjection(0, scope.xy, '9.8572, '14.9676, '-0.6786, '-13.9676)
	projectUV(0)
```

```
Facade__1_5_3 -->
	setupProjection(0, scope.xy, '14.8372, '4.9603, '-2.5267, '-3.9603)
	projectUV(0)

Facade__1_5_4 -->
	setupProjection(0, scope.xy, '15.8641, '4.9603, '-3.7708, '-3.9603)
	projectUV(0)

Facade__1_5_5 -->
	split(y, noAdjust) { 1.37: Facade__1_5_5_1 | ~3.37: Facade__1_5_5_2 | 1.86:
Facade__1_5_5_3 }

Facade__1_5_5_1 -->
	setupProjection(0, scope.xy, '8.9033, '23.8978, '-2.6775, '-19.0800)
	projectUV(0)

Facade__1_5_5_2 -->
	setupProjection(0, scope.xy, '8.9033, '9.7179, '-2.6775, '-8.1654)
	projectUV(0)

Facade__1_5_5_3 -->
	setupProjection(0, scope.xy, '8.9033, '17.5893, '-2.6775, '-16.5893)
	projectUV(0)

Facade__1_5_6 -->
	setupProjection(0, scope.xy, '12.7857, '4.9603, '-5.2811, '-3.9603)
	projectUV(0)

Facade__1_5_7 -->
	setupProjection(0, scope.xy, '14.9893, '4.9603, '-7.3636, '-3.9603)
	projectUV(0)

Facade__1_5_8 -->
	split(y, noAdjust) { 1.48: Facade__1_5_8_1 | ~3.15: Facade__1_5_8_2 | 1.97:
Facade__1_5_8_3 }

Facade__1_5_8_1 -->
	setupProjection(0, scope.xy, '9.2001, '22.1414, '-5.1334, '-17.6777)
	projectUV(0)

Facade__1_5_8_2 -->
	setupProjection(0, scope.xy, '9.2001, '10.3881, '-5.1334, '-8.7630)
	projectUV(0)

Facade__1_5_8_3 -->
	setupProjection(0, scope.xy, '9.2001, '16.6190, '-5.1334, '-15.6190)
```

```
	projectUV(0)

Facade__1_5_9 -->
	setupProjection(0, scope.xy, '11.5075, '4.9603, '-7.6716, '-3.9603)
	projectUV(0)

Facade__1_5_10 -->
	setupProjection(0, scope.xy, '15.3204, '4.9603, '-11.5449, '-3.9603)
	projectUV(0)

Facade__1_5_11 -->
	split(y, noAdjust) { 1.80: Facade__1_5_11_1 | ~3.15: Facade__1_5_11_2 | 1.64:
Facade__1_5_11_3 }

Facade__1_5_11_1 -->
	setupProjection(0, scope.xy, '10.6155, '18.1414, '-8.6924, '-14.4840)
	projectUV(0)

@Location(1527,7405)
Facade__1_5_11_2 -->
	setupProjection(0, scope.xy, '10.6155, '10.3881, '-8.6924, '-8.8665)
	projectUV(0)

Facade__1_5_11_3 -->
	setupProjection(0, scope.xy, '10.6155, '19.9148, '-8.6924, '-18.9148)
	projectUV(0)

@Location(1171,7599)
Facade__1_5_12 -->
	setupProjection(0, scope.xy, '11.4995, '4.9603, '-10.4995, '-3.9603)
	projectUV(0)
```

D E C L A R A T I O N

I hereby declare that the thesis entitled "3D MODELLING FOR URBAN CADASTERAL REGESTRATION, MANAGEMENT AND ADMINISTRATION IN THE CASE OF BAHIR DAR TOWN, ETHIOPIA" has been carried out under the supervision of Dr. Getachew Berhan in School of Earth Sciences, Addis Ababa University, Addis Ababa during the year 2016 as a part of Master of Science program in Remote Sensing and GIS. I further declare that this work has not been submitted to any other University or Institution for the award of any degree or diploma

Ahmed Hamid

Signature: _____________

Place: Addis Ababa

Date: June 2015

CERTIFICATION

This is to certify that the thesis entitled as “3D MODELLING FOR URBAN CADASTERAL REGESTRATION, MANAGEMENT AND ADMINISTRATION IN THE CASE OF BAHIR DAR TOWN, ETHIOPIA” is an authenticated work carried out by Ahmed Hamid under my guidance and supervision. This is the actual work done for the partial fulfillment of the award of the Degree of Master of Science in Remote Sensing and GIS from Addis Ababa University. Addis Ababa.

Dr. Getachew Berhan

Signature___________________________

Department of Earth Science

Addis Ababa University

Addis Ababa

Date: June 2016