Journal of Communication and Computer 15 (2019) 25-37
doi:10.17265/1548-7709/2019.01.003

Building Urban Land Information Management System in PostgreSQL, for the Case of Ethiopia

Abraham Kelilo Tula[1], and Firaol Befikadu Geleta[2]

Civil Informatics Centre, Ethiopian Construction Design and Supervision Works Corporation (ECDSWC)

Along Megenagna to Bole Ring Road at Gerji Junction, P.O. Box 2561 Addis Ababa, Ethiopia

Abstract: Population growth and rapid urbanization have caused an exponential increase in urban land demand in Ethiopia. The information required for land administration and management has been tremendously increasing as well. Therefore, this paper describes the steps for a building database prototype for urban land information management system for the case of Ethiopia which results to develop an efficient and effective way of spatial and non-spatial urban land data management system. This research project will develop a central database system using a PostgreSQL software to retrieve, update and store the required data using a user-friendly graphical interface. System requirement and specification is devoted to a system design which incorporates the intended system behaviour using a use case diagram, logical design of the system using a class diagram. The design system is validated and tested via sample data which can store, retrieve, and update the required data as per the user requirement. Developing this type of urban land information management system, therefore, facilitates and increases the efficiency of land registration and related activities at the municipality level. Thence, citizens would be satisfied by the service delivery of the municipality. The land and real estate ownerships registration will also become automated. Furthermore, any spatial and non-spatial data related with the system can be stored in the database which will be ready for more analysis as to be able to use by policymakers, urban planners for the purpose of sustainable development of urban area infrastructural developments and land use policy. The research will lay ground for another task to develop CityGML 3D modelling for selected cities thereby contributes to spatial data infrastructure development to Ethiopia.

Keywords: Database prototype, PostgreSQL, programming language, urban land management system, Ethiopia.

1. Background

One of the most essential components of the socio-economic asset for Ethiopia is land, public property and not subject to sale, which is unbendingly administered and used mostly in the urban area. Land administration in Ethiopia mainly lacks capturing of basic spatial and its related data for the current update and display the information that in need of it [1]. Currently, the most practicing system to register urban land information is manual, which is hindered by enormous drawbacks for the management of the urban land administration. Application of geoinformatics in the urban development and planning are not in their position to deliver their advantage over existing land information management system. Further, there is a limitation to study on CityGML 3D modeling [20]. The basic problem in the sector must be resolved to proceed an advanced 3D modeling technologies.

During urban land ownership registration, there are spatial and non-spatial data which are required to be filled on the provided sheets by the municipality. Among the attribute data to be recorded are the identification of parcel and where it is located, landholder information, and legal rights [1]. In urban areas where land is mainly used for residential, business and investment are considered as a parcel which is the smallest unit for property register. The other property of urban area land is about leasehold right. Due to land scarcity and other reasons, most major city in the country display bid to the public to hold lease right for various purposes. However, the current urban land registration practice to lease right

Corresponding author: Abraham Kelilo Tula, Ph.D, research fields: 3D urban land modelling and artificial intelligence. E-mail: abrahamkelilo@yahoo.com.

by itself would lead to implementing an automated system that to ease the existed practical problems appeared in most major city's municipality in Ethiopia [2].

These cities in Ethiopia are currently characterized by rapid urbanization growth which results in significant demographic and spatial change [11]. The municipality of every town/cities are responsible to provide residential land for individual or private company to build residential homes. However, due to the lack of urban land information management system, problems like informal settlement hinder the growth of large cities. Thus, the municipality urban land administration department needs an effort to change the problem encountered service delivery to the citizen.

Due to rapid urbanization in Ethiopia, land datasets grow ever larger as populations expand and need for land information in support of development becomes ever more urgent. Central database to all dataset is essential for municipality and clients to have access to accurate and updated information about the urban land and land-related data. As a result, the new system should be deployed for effective and efficient data distribution among stakeholders [6]. The provision of such kind of technology would help in using the required service regards with efficiency, scalability, security, and integrity of the deploying system [5].

The existing manual urban land registration system of parcels and its related data, however, were not easily identified by a unique numbering system [5]. Because manual registration usually keeps the record to the minimum via alphanumeric order. Thus, the proposed system will use a uniquely identified number which is an essential component for the development of the database.

Due to manual record keeping of the database at the municipality record office, the administration of urban land and related activities are usually characterized by inconsistencies and irregularities among stakeholders which are a problem for the information come out from the system and a result of poor governance. More on that, the system was not transparent and did not fulfill customer demand for reliable service from the land administration authority of the municipality [5].

In many cases, an automated and reliable urban land information management system is a key for enormous public development tasks. For example, land planning, infrastructure development maintenance; environmental protection and resource management are among the areas where the geoinformatics application system is crucial at large [4].

Thus, by deploying urban land information management system at the municipality of major cities, the data would be easily manageable and applicable. Additionally, it would be useful for a policymaker to react upon the processed data derived from the system. More on that, urban land registration, retrieving, updating at the municipality (user of the system) will drastically change the service delivery that will improve the satisfaction of the citizen in this regard [3].

2. Objectives

2.1 Main Objective

- Design a prototype for urban land information management system

2.2 Specific Objectives

- Develop a consistent framework to manage, retrieve, storing, update and display urban land data.
- Improve the management of urban lands and properties records.
- Reduce cost associated to urban land record (manual record is expensive).
- Create a user friendly interface to allow easy access to the system.
- Spatial Data Infrastructure (SDI) of Ethiopia.
- Open Geospatial Consortium (OGC) standard .
- Lay ground for CityGML 3D modelling.

3. Land Right and Urban Land Administration in Ethiopia

3.1 Land Right

The land is one of the essential components of any development activity in the urban area. In Ethiopian history, political parties mentioned the issue of land right as one of the main concern for the campaign during an election held in the past few years. The citizen, as well, was very eager to know a clear position of political parties in related to land.

In line with urbanization growth, land right for rural and urban areas is addressed separately in the constitution. However, in the Federal Democratic Republic of Ethiopia constitution Article 40 stated that land is the property of the state and the people of Ethiopia and that its use shall be subject to specific regulation by law. Due to fast growth in urbanization, the different proclamation is announced to the public. In the new urban land lease holding proclamation of Ethiopia (proclamation No. 721/2004), various terms have got definition as to fit the new proclamation.

According to lease holding proclamation of Ethiopia (proclamation No. 721/2004) the following definition are mentioned.

- "Lease" means a system of land tenure by which the use right of urban land is acquired under a contract of a definite period;
- "Urban land" means land located within an administrative boundary of an urban centre; [12].

The constitution mentioned about the right to own both urban land right. Thus, the Ethiopian constitution asserts state ownership of land; there are no private property rights in land. Article 40(3) states:

> The right to own rural and urban land as well as natural resources belongs only to the state and the people. Land is an inalienable common property of the nations, nationalities and peoples of Ethiopia and shall not be subject to sale or to other means of transfer.

It is also mentioned in the constitution about urban area residents which are included with the right to get land for residence on a 99 years lease based arrangement [13].

3.2 Urban Land Administration

Urban landholding lease system is new for Ethiopia. More attention of the government in the past year was dispensed to rural lands where most people have land ownership. This is because agriculture is the backbone of the economy and the majority of the population was living in rural areas. In the past year, urbanazation was not significant however, recently, it becomes significant. These days, people are migrating to the urban areas looking for better life and infrastructure accessibility. Thus, the government of Ethiopia introduced for the first time in 1993 about the lease system in order to administer the urban land. Since then the laser system is helping as a sole means of urban landholding.

The urban area is associated with huge infrastructure which in turn requires large income to build. Thus, the adopted proclamation also designed in order to fulfill the gap between the infrastructure development and urbanization development plan. Due to the growth of tremendous urbanization, demand for land in the urban area has been increasing and greater than the supply of land provided by the municipality. Even though the intensity of growth in urbanization are different among cities, almost all major cities are facing problem on the allocation of land.

The demand for urban land shows each year a drastic increase with price and appeal from the citizens. However, the system which leasehold right handled was not transparent and in return susceptible to corruption. Today, corruption in urban land is one of the poorest governance result and citizens are claiming the government to be fair and transparent in service delivery of urban leasehold right. If the system of the leaseholds right transparent; urban speculators and broker would have been blocked from the system. As a result, the limited resource will reach the entire citizen in a way to attain their satisfaction. The result of poor governance is also resolved through

application of modern land leasehold right [14].

4. Existing Land Information System in Ethiopia

Population density has increased in all major towns of Ethiopia. These major towns are capital cities of regional states. There are also other cities which are not capital cities of a region, however, due to business and other reasons; their population is as large as the capital city of the respective regional state. As a result, urban house construction and it's correspondent infrastructure development are major components on the usage of urban land in Ethiopia. Hence, urban house construction is pressing the available lands for rapid urbanization of Ethiopia.

Land in urban areas is an essential resource for every development activities. Its modern administration applying a spatial database system, therefore, is mandatory. Most of the time, land administration responsibilities are dealt with land delivering and transferring, building permit, and tenure administration and documentation. However, most municipalities are challenging in the administration of the land which is severely lacking consistent and automated land record systems which in turn result in a lack of transparency to the citizen. This potentially leads to corruption and informal settlement.

The existing land information management system in Ethiopia can be generally identified as follows.

- The existing manual paper land registration system does not have secured access for different types of users and the data cannot be easily processed as per the required objectives.
- Information flow among different departments is restricted to manual information. This hinders the time and manipulation of data.
- The organized data recorded on paper does not have a basic relation between different data types (spatial and non-spatial data type).
- The existing system does not allow important and immediate information retrieval and report generation.
- Paper recorded data is not organized to attain data integrity.
- Parcel identification is kept in unorganized ways which prevents the acquisition of parcel information related with other spatial and non-spatial data.
- Data exchange among different departments about land registration is not consistent and standardized.
- In general, the current system data record is kept manually and information are stored on books which are used for registering real property information and paper based archive.
- The existing system of land and real property registration is usually based on title deeds. This information is registered on several books which in turn make it difficult to update data related with the information.

5. Methodology

A well-integrated and suitable database management was implemented in PostgreSQL. The selected database enables to describe the information related to land registration and management which is specified in the designed database. The designed database has a client/server architecture which would enable to access the database through a designed and well understood graphical user interface from the client side. As a result, a large number of data can easily manipulate efficiently and effectively. It is also very important in summarized report generation to users. Most importantly, land-related data are stored in an integrated way which would allow the users to retrieve information using well designed graphical user interface.

Developing a database in PostgreSQL is advantageous for a number of reasons. It is an open source object-relational database system and can run in most operating system [9]. Besides its basic data type, it supports storage of binary large object including pictures. In regards to a programming

interface, it supports with Net programming language at which the system used for a graphical user interface as a tool [6]. Fig. 1 shows the research project workflow and steps to be carried out.

5.1 System Analysis

5.1.1 Urban Land Information System and Prototyping

An urban land information system is designed in view of sustainable land use planning and management through a strengthening of urban data systems. Land and land-related data are designed to be a suite in the database which attained to have parcel based and up-to-date land information system.

Urban land information prototyping is a development process in which prototyping methodology allows developers and urban planners to create part of the solution to analyze functionality and make needed refinements before developing the final system. Thus, in order to meet the requirement analysis in developing the system, a prototyping model is applied. This system development method (SDM) defines the new requirement analysis with as much detail as possible. A thorough understanding of the system functionality is one of the main components in designing the prototype of the system. Therefore, detail requirement analysis is performed together with the system user in order to deliver a system which can accomplish user requirement. When a user is satisfied with the requirement analysis, a final prototype is constructed.

Based on the initial system requirement analysis, database and graphical user interface prototype designed for urban land information management system in client-server architecture approach. The initial user interface is designed using Visual basic.net

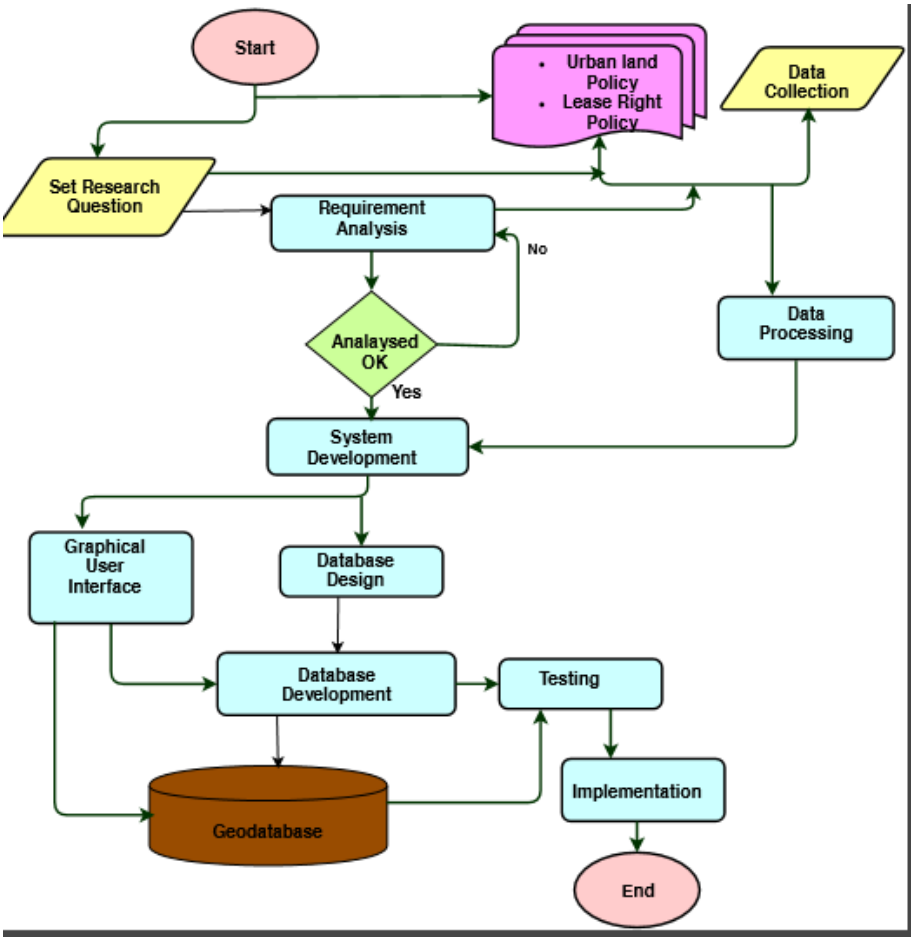

Fig. 1 Research methodology work flow.

programming language. In order to store, disseminate and retrieve spatial and non-spatial data, PostgreSQL database application is used [18].

5.1.2 Requirement Analysis and Specification

It is a pre-requisite to determining the requirement of the system before developing a model for urban land information management system (ULIMS). The model is actually in designing the relevant database system which would handle specific requirements identified during system analysis.

One of the key sources to the analysis is the existed manual system documents which have been used currently for the urban land registration system. In the following two sessions, the requirement analysis of the system can be obtained and identified. In the following use case and class model diagram, the new urban land information system prototype design allows studying the requirement analysis and specification.

(1) Use Case Diagram

The use case diagram shown in Fig. 2 illustrates a methodology used in system analysis to identify the system requirement of the proposed system. Seven actors are identified such as land owner,land registrar officer, land surveyer, system administrator, land administration officer, building permit officer and mayer for the interaction among the elements in the system. Use cases are also identified for the specific roles played by the actors for the proposed system.

(2) UML Class Diagram

The unified modelling language class diagram is used to represent the logical structure of the proposed system. This system is used to verify the data requirement and the behaviour of objects within the system for the proposed database design. Fig. 3 illustrated class diagram for selected objects to design the proposed system. From class diagram shown in Fig. 3, thirteen tables are created in the database.

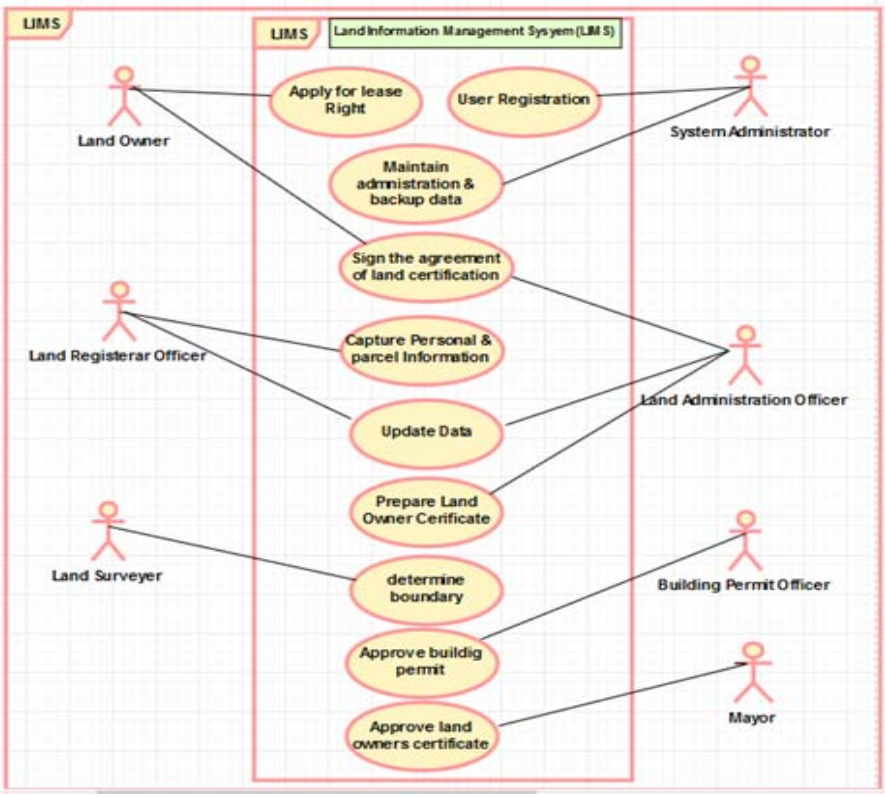

Fig. 2 Use case diagram for urban land information system.

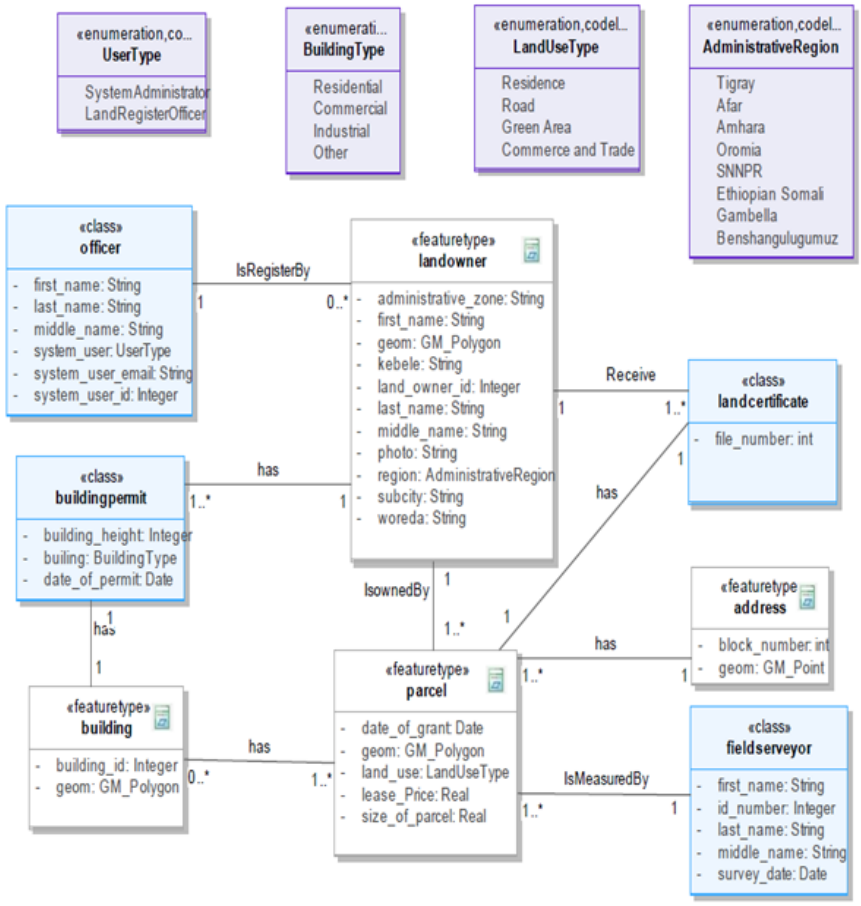

Fig. 3 Unified modelling language class diagram to urban land information system.

5.2 System Design

5.2.1 System Development Model

System development technique applied in designing land information management system is the incremental build model which is a method of software development where the model is designed, implemented and tested incrementally (a little more is added each time) until the product is finished. It involves both development and maintenance. The system is defined as finished when it satisfies all of its requirements stated in the system requirement specifications. This kind of model is implemented and used iterative waterfall model.

Each phase in the development of the system is decomposed in to a number of components, each of which are designed and built separately. When the database designed and implementation steps is complete, the system partially used by the user. Thus, it will create acquaintance by system users. When deploying any new system, there is always a gap of misunderstanding the system. However, this kind of model is important to fill those barriers to deploy and use the system [15].

5.2.2 System Development

In building urban land information management system, a database design is the main part of the system development lifecycle. To this end, the following major activities in the development of the database design is crucial to meet the requirement of the users and high performance of the system that to be develop as shown on Fig. 5.

One of the main objectives in the database design are to perform the model of logical and physical designs in the logical database design; the activities which is to be decide how to arrange the attribute of the

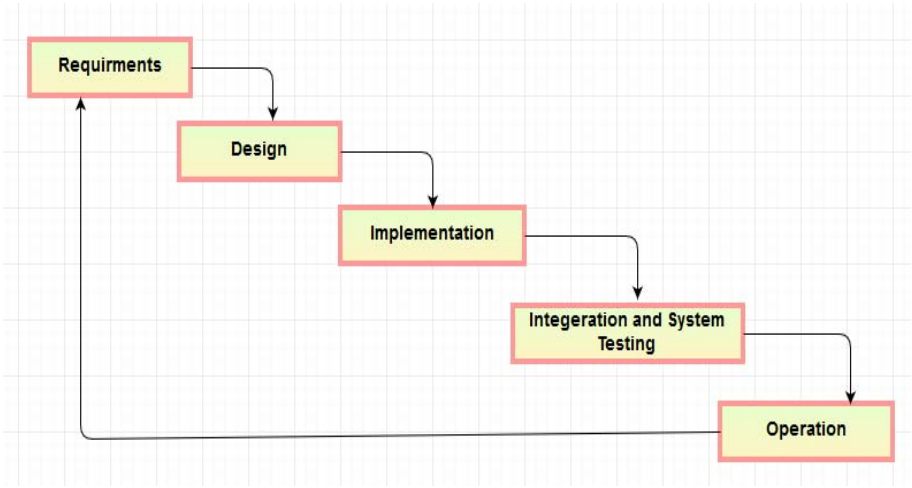

Fig. 4 Incremental life cycle model.

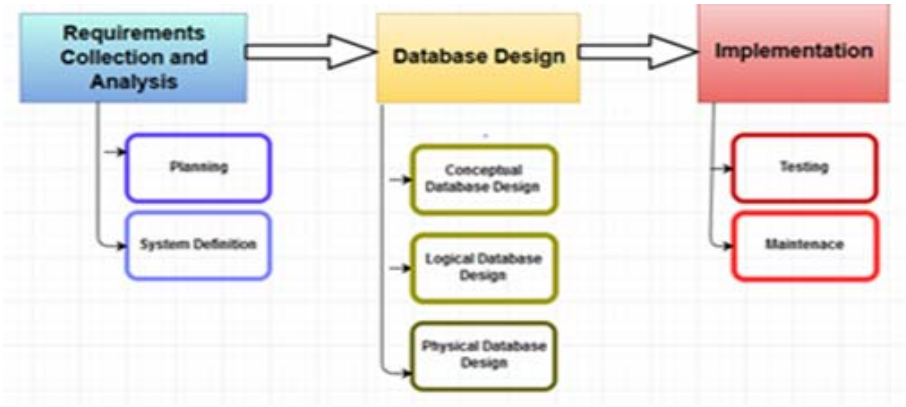

Fig. 5 Database development life cycle.

entities in urban land information system in to a database structure. As specified in system requirement and analysis, a central database system is created for the new automated system [5].

Hence, the following database development lifecycle diagram (Fig. 5) shows the flow and steps to design a database system development in a way to attain the requirement by selected Database Management System (DBMS) [10].

The database used for the project land information management system is developed based on object relational database principles. Through database development life cycle procedure, database management system was implemented as to be able to interact with both spatial and non-spatial data by using postgreSQL.

6. User Interface

In order to interact with the database, a graphical user interface (GUI) approach is selected for a number of reasons. A graphical user interface is a program that uses the graphical capability of a design system to understand and improve the usability of the system interacts with. A graphical user interface usually uses visual elements (commands) method that present information stored in a database with simplicity. These buttons make easy for system users to interact with and can use urban land information management system. A GUI uses windows, icons, menus, and submenus to perform commands, such as registering, updating and related functionalities of the system information into the database and vice versa. GUI

application is much easier to use and understand than command line application since there is no need to type in and memorize every command. As a result, for this particular research project,Visual Basic.NET programming language is selected [7].

6.1 Graphical User interface Design in Visual Basic NET

Once the database is designed and ready for use as an information system, there should be an application to link the user and the database. Therefore, the design of the user interface and the application programs that will use the processed data are defined and designed in the application design. Thus, as mentined above, VB. Net is used as a front end program as it is feasible and easy to develop a graphical user interface and to connect them to handler functions provided by the application [7]. Moreover, user can query or search the information with spatial and non-spatial data from the database [9].

The prototype can be continuously tested and modified as per the feedback from previous version, like incorporating multilingual. This favours to increase its applicability. This will be more suitable for users in their own language, i.e., Amharic (Official National Language of Ethiopia) and Afaan Oromoo, the largest language spoken in the region. The link bteween the commands in GUI forms are illustrated in Fig. 7.

6.2 User Friendly Interface Design to the Urban Land Information Management System (ULIMS)

Fig. 8 shows land owner registration display, as an example, of graphical user interface. It displays graphical user interface design approach and shows the land owner registration form that allows to use the system and link the postgreSQL database server.

7. System Prototype Validation

System prototype validation includes the steps from system development to delivery of that system into practical production for the intended purpose. A number of techniques are incorporated in the validation. These systems are designed for the purpose and use of an automated land information management system to the municipality. Therefore, the installation phase of the system to the respected municipalities is also part of system implementation and testing.

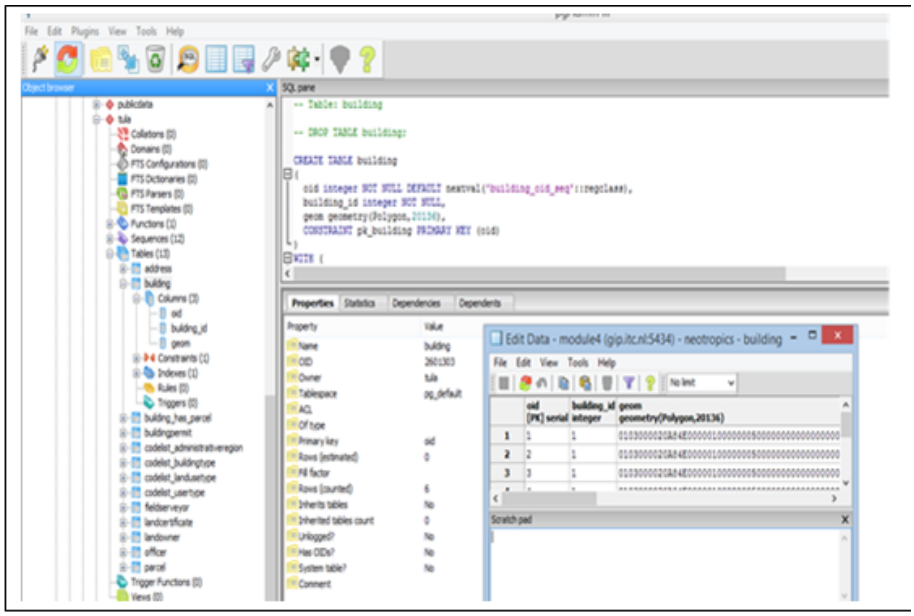

Fig. 6 Database of land owner registration for land information management system.

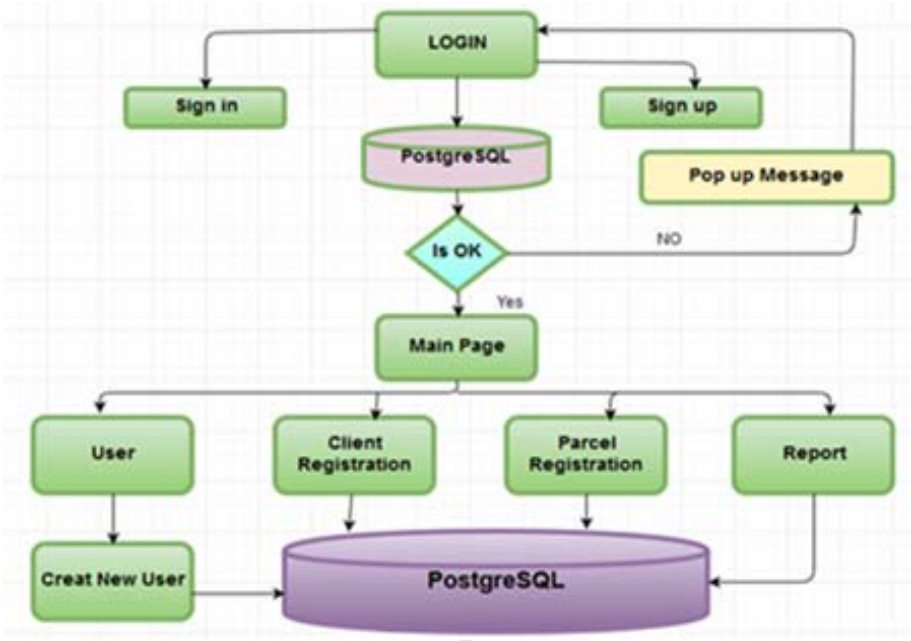

Fig. 7 Flow diagram of the application development method.

Fig. 8 Land owner registration form.

Before implementing the system, building and testing a functional system that fulfils the system design requirement should be the first steps which also in turn create an interface between the new system and the existing land administration system. Because, real accomplishment of the system should be

verify in the final stage of system development. Physical system design of the implementation also should be analysed before deployment in a number of ways. The implemented system has to be ensuring well operational in line with usage and to make sure that the system is designed for the intended purpose. Thus, to meet the quality standard, in this phase the system quality is measured and defined based on the following measuring parameters.

7.1 Correctness

Correctness from system prototyping perspective can be defined as the dedication to the requirement specification that determines how system users can interact with the database and how the system should act and behave when it is used correctly. For example, if the system user enters wrong data type in the database, the designed system should notify the user a pop-up message to correct the entry again which can achieve via developing an algorithm which can handle all possible errors in the system prototype design and then the program logic. Repeated use of the system can also lead to verify the completeness quality parameter. Therefore, the system performs the required functions accurately which are in determining, recording, dissemination of spatial and non-spatial data.

7.2 System Compatibility

In this designed prototype system uses both spatial and non-spatial data types. To interact with the database, a user-friendly graphical interface is also designed as per the user requirement specification. Therefore, communication compatibility is one of the parameters to test system compatibility between the database and graphical interface design. In line with communication compatibility, data compatibility and hardware compatibility is also checks as a quality parameter.

7.3 Consistency

Each tasks and activities are performed in the same procedure each time while entering and retrieving the required data. Consistency can achieve throughout the life time of the system by making procedure and data consistency in the system which helps us to know errors that is caused by space utilization in and damage to data stored in the database.

7.4 Efficiency

This is one of the most important quality parameter of the designed system prototype. It includes enormous efficiency parameters among which efficiency process, efficiency communication and efficiency storage are those suitable to test the quality regards with the designed prototype for urban land information management system. Under each efficiency type, a number of efficiency measures have been tested for the quality measures which are processing, data usage, and communication and storage effectiveness measure. Therefore, it will help to verify the minimum requirement of the computer resource to which system has to be uses.

7.5 Integrity

Land and land related information is too sensitive and susceptible to misuse by unauthorized person. Therefore, access to the database by unauthorized person is controlled and the security of the system should be maintained. To make sure for this kind of quality parameter to the system, a quality criterion has to be implemented which is performed through audit ability, instrumentation and security. As a result the confidentiality of the data is achieved through these quality parameter techniques.

7.6 Testability

This quality parameter is also performed in line with integrity. When this new system introduced, it should be verified and ensure that intended functions and tasks achieved as per the requirement sketched. The criteria to verify for these quality parameters are audit ability, complexity, modularity,

self-documentation and simplicity. Thus, this quality measures also very important in the implementation of the designed system.

7.7 User-friendliness

The interaction between user friendly interface and the database should be a kind of interaction to perform the required functions without difficulty. This designed prototype database system is now functioning in its first version. Through time, new updates can be made. Therefore, a well-structured document about the system should be available which would help to correct errors with relative ease.

Therefore, based on the above listed quality measure parameters, the designed prototype urban land information management system fulfils all basic necessary of the benefit which is also solve the current existing real problem in the municipality particular in urban land management and information system [16, 17, 19].

8. Conclusion & Recommendation

This research project consists entirely of the prototype design for urban land management information system. This project reveals the existing urban land information system and problem encountered in urban land administration. In order to review the existing urban land information system and urban land right in Ethiopia, literature was reviewed to observe the basic stand of urban land system and land use right. The design of a prototype for urban land information management is carried out in order to alleviate the problem appeared due to lack of automated urban land information system. A software system development approach has been implemented to design a prototype based on identified system requirement analysis outcome and using incremental build model which is a method of software development where the model is designed.

In order to use the system, a well-designed user-friendly graphical interface designed by visual basic.net programming language which is used to interact with the database. It is a suitable method to assist the system in determining, recording and dissemination of spatial and non-spatial data of urban land.

The development of this prototype for an urban land management system in urban land ownership right can ease and serve as a tool to store, retrieve and disseminate integrated information related to urban land management information system. This data includes information about landowner, parcel, building permit, land certificate address, building, surveyor and system user. All this information can ease the service delivery by the municipality where urban land leasehold right is taking place.

After successive uses of the system, accumulation of data through the system can emerge. As a result, these data can serve policy makers and urban planner to react and sketch a nationwide urban land management plan.

In general, building a spatial database for urban land management information system provides for the municipality with the visualization of land related information and ready to use and implement land related municipal service delivery. This helps the municipality in providing better service delivery and as well helps for urban planners in making prominent and better decision making regards to modem urban land management system. This research project is also open a door for 3D urban data modeling using CityGML for the city Addis Ababa as a next research modeling. Most importantly, it would also contribute for national spatial data indrastructure modeling using the open geospatial consortium(OGC) standard.

Acknowledgements

We would like to express our sincere gratitude to Andre Da Silva Mano and Demo Todorovski, University of Twente, for their valuable comments, support, and guidance to this research project work.

References

[1] Melkamu, B., and Shewakena, A. 2010. "Facing the challenges in Building Sustainable Land Administration Capacity in Ethiopia." Accessed June 16, 2016. https://www.fig.net/resources/proceedings/fig_proceedings/fig2010/papers/ts08a/ts08a_abab_moges_4051.pdf.

[2] Cadastral Template 2010. "Country Report." Accessed June 16, 2016. http://www.cadastraltemplate.org/version1.0/countryreport/Ethiopia-19Apr2011.pdf.

[3] Land Information System (LIS). Accessed June 16, 2016. http://www.compass.ie/applications/lis/.

[4] Stephen J. Ventura 1997. "Land Information Systems and Cadastral Applications, NCGIA Core Curriculum in GI Science." Accessed June 17, 2016. http://www.ncgia.ucsb.edu/giscc/units/u164/u164.html.

[5] Tarek, Z., and A. B. Zerihun 2012. "Addis Ababa: The Road Map to Progress through Securing Property Rights with Real Property Registration System." *Annual World Bank Conference on Land Poverty*, The World Bank-Washington Dc, April 23-26, 2012. Accessed June 17, 2016. http://www.landandpoverty.com/agenda/pdfs/paper/zein_full_paper.pdf.

[6] Dale, P. F., and Mclaren, R. A. *GIS in Land Administration*. Chapter 61, 859-875. Accessed June 17, 2016. http://www.geos.ed.ac.uk/~gisteac/gis_book_abridged/files/ch61.pdf.

[7] Utley, C. 2001. "A Programmer's Introduction to Visual Basic.NET." Accessed June 19, 2016. http://www.interplat.com/vbnet.pdf.

[8] Designing Databases. Accessed June 19, 2016. http://www2.amk.fi/digma.fi/www.amk.fi/opintojaksot/0303011/1142845462205/1142847774995/1142849037295/1143037341377.html.

[9] PostgrelSQL homepage. Accessed June 19, 2016. https://www.postgresql.org/about/.

[10] Introduction to Database Design. Accessed June 19, 2016. http://www.guru99.com/database-design.html.

[11] Aleme, B. J., Zevenbergen Jaap, and Bennett, R. 2016. "Assessing Land Governance in Ethiopian Cities (2002-2011): Lessons for the Implementation of the 2011 Urban Land Management Policy." In: *From the Wisdom of the Ages to the Challenges of the Modern World*, Sofia, Bulgaria, and 17-21 May 2015. Accessed June 21, 2016. https://www.fig.net/resources/proceedings/fig_proceedings/fig2015/papers/ts06b/TS06B_alemie_zevenbergen_et_al_7477.pdf.

[12] New urban land lease holding proclamation of Ethiopia (Amharic and English), Proclamation Number 721/2004. Accessed May 12, 2016. http://www.waltainfo.com/index.php?new-urban-land-lease-holding-proclamation-of-ethiopia.pdf.

[13] A report, Ethiopian Land Policy and Administration Assessment, Accessed July 12, 2016. http://www.globalprotectioncluster.org/_assets/files/field_protection_clusters/Etiophia/files/HLP%20AoR/Ethiopia_Land_Policy_Administration_Assessment_2004_EN.pdf.

[14] Ambaye D. Weldegebriel 2007. "Land Rights in Ethiopia: Ownership, Equity, and Liberty in Land Use Rights." In: *FIG Working Week 2007 May, Knowing to Manage the Territory, Protect the Environment, Evaluate the Cultural Heritage*, Rome, Italy, 6-10 May 2012. Accessed June 22, 2016. https://www.fig.net/resources/proceedings/fig_proceedings/fig2012/papers/ts02d/TS02D_ambaye_5521.pdf.

[15] "Testing Excellence, Incremental Model." Accessed June 16, 2016. http://www.testingexcellence.com/incremental-mode.

[16] "System Implementation, Testing, and Support." Accessed August 10, 2016. http://www.cga-pdnet.org/Non_VerifiableProducts/CourseNotes/2010/ms2/module05.pdf.

[17] "System Implementation." Accessed August 11, 2016. http://web.simmons.edu/~benoit/lis486/SystemsImplementation.

[18] "What Is Prototyping Methodology?" 2009. Accessed August 22, 2016. http://www.information-management-architect.com/prototyping-methodology.html.

[19] Ming-Chang, L., 2014. "Software Quality Factors and Software Quality Metrics to Enhance Software Quality Assurance." *Journal of Applied Science and Technology* 4: 3069-3095.

[20] CityGML official web site. http:// www.cityGML.org.