JIMMA UNIVERSITY

SCHOOL OF GRADUATE STUDIES

DEPARTMENT OF INFORMATION SCIENCE

DEVELOPING A CASE BASED REASONING SYSTEM FOR URBAN LAND DEVELOPMENT CONTROL IN ETHIOPIA: THE CASE OF JIMMA CITY

By:

WESENU MOHAMMED

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DEVELOPING A CASE BASED REASONING SYSTEM FOR URBAN LAND DEVELOPMENT CONTROL IN ETHIOPIA: THE CASE OF JIMMA CITY

A Thesis Submitted in Partial Fulfillment of the Requirements for Degree of Masters of Science in Information Science (Information and Knowledge Management)

By:

WESENU MOHAMMED

Principal Advisor: Million Meshesha (PhD)

Co-Advisor: Chala Diriba (MSc)

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As members of the board of examining of the MSc thesis open defense examination of the above title, we members of the board (listed below), read and evaluated the thesis and examined the candidate.

Name	Title	Signature	Date
Yeshihareg Temtem (MSc)	Chairperson	______________	___________________
Million Meshesha (PhD)	Principal Advisor	______________	___________________
Chala Diriba (MSc)	Co-Advisor	______________	___________________
Tibebe Beshah (PhD)	External Examiner	______________	___________________
Amanuel Ayde (MSc)	Internal Examiner	______________	___________________

DECLARATION

I declare that this thesis is my original work and it has not been presented for a degree in any other universities. All the material sources used in this work are duly acknowledged.

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Wesenu Mohammed

April, 2016

This thesis has been submitted to the department for examination with our approval as university advisors:

Principal Advisor:	Million Meshesha (PhD)	…………………….
Co-Advisor:	Chala Diriba (MSc)	…………………….

April, 2016

ACKNOWLEDGEMENT

First and for most, I would like to give all glory and honor to my Lord and savior **Jesus Christ** and his mother **Saint Mary**, who provided me the courage to finish my program of study.

I would like to extend my deepest gratitude to my advisor Dr. Million Meshesha for his unreserved and invaluable advice, encouragement and dedication throughout my thesis work. Without his contribution, this paper would not have been possible. Honestly, it is a privilege to be under his guidance.

I would also like to take this opportunity to express my appreciation to my co-advisor Mr. Chala Diriba for his commitment and patience, valuable comments and guidance from initial to the final level of the research.

My special thanks goes to Jimma City Land Development and Administration Agency domain experts who devoted their precious time for the interviews and consultation sessions throughout the research and for providing me valuable facilities and resources. Especially I give my warmest gratitude to, Mrs. Emane (Land surveyors) for providing relevant data cases, and other necessary information and encouraging me by giving necessary material for my research work.

Last but not least, not forgotten to thank all my friends who have contributed to the success of this study; directly or indirectly.

Table of Contents

Contents **pages**

LIST OF TABLES

LIST OF FIGURES

DEFINITION OF TERMS

Appropriate body: is a body of a region or a city administration vested with the power to administer and develop urban land

Knowledge engineer: the individual who acquires and represents the knowledge

Land holder: a person who owns land, especially one who either makes their living from it or rents it out to others

Land tenure: is about the ways land, resources are allocated; it define how access is granted to rights to use, control, and transfer land, as well as associated responsibilities and restraints

Lease: a system of land tenure by which the right of use of urban land is acquired under a contract of a definite period

Tender: is a modality of transferring lease of urban land to a bid winner fulfilling the competition requirements issued based on the rule of market competition of urban land tenure

Tenant: a person who occupies land rented from a landlord

Vacant land: land that has no buildings on it and is not being used

Urban land: is a land located within an administrative boundary of an urban center

User interface: interface that provide the dialogue between people and computer system

LIST OF ACRONYMS

AI	Artificial Intelligence
CBR	Case Based Reasoning
CBRSULDC	Case Based Reasoning System for Urban Land Development Control
CBS	Case Based System
FDRE	Federal Democratic Republic of Ethiopia
FUPI	Federal Urban Planning Institute
GAIA	Group of Artificial Intelligence Applications
GIS	Geographical Information System
GUI	Graphical User interface
JCLDAA	Jimma City Land Development and Administration Agency
jCOLIBRI	java Cases and Ontology Libraries Integration for Building Reasoning Infrastructures
KBS	Knowledge Based System
KNN	K Nearest Neighbor
LDC	Land Development Control
LDP	Local Development Plan
MUDC	Ministry of Urban Development and Construction
ONRS	Oromia National Regional State
ORSUPSG	Oromia Regional State Urban Planning Standards and Guidelines
SQL	Structured Query Language
TPO	Town Planning Ordinance
UN	United Nations
UPSBB	Urban Planning, Sanitation and Beautification Bureau
XML	Extensible Markup Language

ABSTRACT

Ethiopia is one of the most rapidly urbanizing countries in Africa and the challenges that come with this, especially in the provision of adequate vacant urban lands for housing is a major challenge that government faces. In Ethiopia the options available to acquire urban land to be held by leasehold include tendering and allotment. However; the focus of the study is on land acquisition through the modality of tender. Despite the various efforts of government, individuals and agencies both regionally and nationally to improve urban development and particularly those associated with urban land use conversion and management, land use problems particularly service delivery from the administration side still persist. So Case-Based Reasoning is promising to build the decision support system for urban land development control. It uses previous similar case(s) to help solve, evaluate, or interpret a new problem. The aim of this research was therefore, investigating how to develop a prototype case based reasoning system that can give decision support in urban land development control that are acquired through a modality of tender. For the development of the prototype system design science research method was performed by collecting 65 successful and unsuccessful previous cases from Jimma city land development and administration agency. The main attributes and values for the cases were identified and selected with the consultation of domain experts. After the acquired knowledge is modeled using hierarchical conceptual modeling method, cases were generated and represented with feature-value format. For the development of the prototype system, jCOLIBRI implementation tool and nearest neighbor retrieval algorithm were used. Evaluation of the system was done for both system performance and user acceptance. For testing of the prototype seven test cases and five domain experts were used. Based on the performance of the system, the average precision and recall values achieved are 70% and 83% respectively. User acceptance testing also performed by involving domain experts and an average of 83% acceptance is achieved. Although the results of this study are promising, there are challenges that need further investigation for future work. Therefore based on this challenge, efficient machine learning approach that can learn from the data after training and investigation on hybrid approach such as rule based reasoning is recommended.

CHAPTER ONE

INTRODUCTION

1.1 Background of the Study

According to the United Nations (UNO), presently more than half of the world population lives in urban areas and by 2050, this percentage will increase to 70% (UN-HABITAT, 2014). It foresees an absolute and a relative increase of urban population especially in developing countries. The chaotic growth of cities in developing countries causes different social problems, such as violence, traffic jams, visual and sound pollution, decrease of environmental quality, increase of diseases related to air pollution and depreciation of public spaces among others.

The current land policy in Ethiopia, as it is provided by Article 40 of the Constitution of the Federal Democratic Republic of Ethiopia, is that land is the property of the State and the peoples of Ethiopia and that its use shall be subject to specific regulation by law; and no land can be obtained or transferred other than on a leasehold basis (FDRE, 2011). Lease is a system of land tenure by which the right of use of urban land is acquired under a contract of a definite period.

Urban land within the administrative boundary of an urban centre is governed by the urban leasehold system (FDRE, 2011) – a means devised by the state, as the owner of land, to transfer urban land rights to the people through lease agreements with lease price payments. The price of the land to be leased is determined either through tender (auction) or allotment (leasehold right transfer without auction).

In Ethiopia the options available to acquire urban land to be held by leasehold include tendering and allotment (FDRE, 2011). Allotment of urban lands may, upon decisions of the cabinet of the concerned region or the city administration, be permitted for: office premises of budgetary government entities, social service institutions run by government or charitable organizations, public residential housing construction programs and government approved self-help housing constructions, places of worship of religious organizations, use of embassies and international organizations as per agreements entered into with the government, and projects having special national significance and considered by the president of the region or the mayor of the city administration and referred to the cabinet.

The second option is through tender process which is a modality of transferring lease of urban land to a bid winner fulfilling the competition requirements issued based on the rule of market competition of urban land tenure. In tender Process, the appropriate body will advertize lease tender and forthwith put bid documents on sale. So that the highest bidder will be declared a winner on the basis of his bid price and the amount of advance payment he/she offers (FDRE, 2011).

Land development control is the processes and procedures concerned with controlling the development of land and building (MUDC, 2012). Land development control function seeks to manage and regulate land development and ensure that all developments takes place at an appropriate time and place and in such a manner that it conforms to a pre-determined set of objectives, policies or standards. This is best done through the analysis of multiple goals and assessment of the intrinsic value of the various environmental and alternative uses of the land unit for an indication of a preferred future land use or a combination of uses. Land development control is one of the functions of urban development control department and lease office. According to the Town Planning Ordinance (TPO) of a city, the development includes "the carrying out of building, engineering or other operations in, on or over land, or the making of a material change in the use of land or building''(MUDC, 2012). Land development control is a governmental action, where its processing procedure has been stipulated by the Town Planning Ordinance (TPO).

The sustainable rapid economic growth registered across all economic sectors and regions in the country has necessitated continuously and increasingly the demand for urban land which requires such an appropriate technical support that it is efficient and responsive to land resources demand (UPSBB, 2013). While the government continued supporting individuals and corporate organizations to develop commercial and industrial sites especially residential apartments, it became clear right from the early stage that these would not meet their needs; particularly the housing needs of the people coming into most of major cities in the country on a daily basis. This initiated the need to conduct a study on the application of case based reasoning for urban land development control so as to support urban planning and related activities in the municipal government. Unfortunately, land development control is having a wide, poorly-understood, and weak domain theory, because it involves many considerations, it has a lengthy discussion time, and it does not have clear models to solve a problem (Elias, 2015). The requirement on technical support for its effective and efficient decision-making is still on high demand. On the other hand, Case-Based Reasoning has shown a high potential to solve the problems which have wide, poorly understood, and weak domain theory after its origin in the 1980s (Chang, et al., 2004). Therefore; Case-Based Reasoning is a proper technique to build the technical support for land development control, especially at the phase when a candidate passes the pre-selection stage.

In processing land development controls and set up period and cost of the four critical determinants, factors such as the government policies, the socioeconomic and environmental impacts, the traffic and infrastructural implications, and compatibility of land uses, should be taken into consideration. Moreover; when making a decision, urban development control department and lease office, comprised of different members having different backgrounds, will have different opinions, causing a very lengthy discussion. Hence, the process for land development control is complex and time-consuming (Elias, 2015). These two points implicate the necessity to seek technical support to release the burden and increase the efficiency at making a decision. Even though many studies have been conducted, the requirement on technical support for its effective and efficient decisions making is still in high demand.

Likewise, Case-Based Reasoning (CBR) is a sub-field of Artificial Intelligence (Al). Its origin is related with cognitive science and Expert System development. The philosophy of CBR is to use previous similar case(s) to help solve, evaluate, or interpret a new problem (Kolodner, 1993). The process of using a computerized CBR system to help solve a problem is very similar with that which occurs in the human brain. CBR system has a knowledge base, case library, in which concrete cases are stored. When a user inputs descriptions of a new problem into the system, the system will search for a similar case from its case library according to predefined retrieval algorithms. Cases that meet certain criteria are retrieved and their solutions are either proposed to the user or adapted to meet the new situation before being proposed. When a satisfactory solution is obtained, the newly solved problem can be stored in the case library as a new case, and the knowledge of the system increases (Kolodner, 1993).

Case-Based Reasoning has been widely used for various tasks, such as: disease classification (Pemer, 1999), motor raceway configuration (Bandini & Manzoni, 2000), mechanical design (Sycara, 1992) and building design (Smith et al., 1995), land warfare planning (Goodman, 1989) and route panning (McGinty & Smyth, 2001), air traffic control decision (Bonzano, et al., 1996), and fault prediction (Renoux & MacHattie, 1998). The successful application of Case-Based Reasoning in different tasks benefits from its problem-solving paradigm, which is quite different with other major artificial intelligence approaches.

CBR will not just tell the urban developer what he/she should do. Instead, it presents cases related to previously handled similar problem and suggests what has been done under similar situation, what the consequences of the applied solutions are and what tips the precedents can provide for dealing with the current problem (Shi & Yeh, 2001). The ability to retain cases and form new generalizations is one of the main strengths of CBR systems. This method of incremental learning results in increased efficiency in familiar situations and allows a CBR to cope with problematic situations (Kolodner, 1993). Since, the major aim of the study is to utilize the former city decisions experiences regarding to the four critical determinants and to estimate and interpret the possible incremental/minor applications of urban cases in the future by retrieving these experiences, Case-Based Reasoning (CBR) is promising to build the decision support system for urban land development control (Yeh & Shi, 1999). It uses previous similar case(s) to help solve, evaluate, or interpret a new problem (Kolodner, 1993).

At the highest level of generality, a CBR cycle may be described by the following four processes (Kolodner, 1993): firstly, the retrieve task starts with a new case description and ends when a best matching previous case has been found. The goal of the matching task is to return a set of cases sufficiently similar to the new case (similarity computing techniques are used). Secondly, the reuse of the retrieved case focuses on two aspects: the difference among the past and the current case and what part of a retrieved case can be transferred to the new case. The retrieved case is combined with the new case through reuse into a solved case. Thirdly, the revise phase consists of evaluating the case solution generated by the reuse phase. Finally retain, useful/successful experience is saved for future reuse and the case base is updated by a new learned case. It is the process of incorporating what is useful to retain from the case-solving episode into the existing knowledge (Holt & Benwell, 1996).

1.2 Statement of the Problem

Ethiopia is one of the most rapidly urbanizing countries in Africa and the challenges that come with this, especially in the provision of adequate urban lands for housing is a major challenge that government faces (FMH&UD, 2013). Attempts to meet the challenges facing the built environment in the country motivated the government to articulate and introduce some programs and policies as well as created institutions, the FUPI, to control and manage urban land use. Elias (2015) states that despite the various efforts of government, individuals and agencies both regionally and nationally to improve land development in particular those associated with urban land use conversion and management, land use problems mainly service delivery from the administration side still persist. Even though there are policies and regulations providing criteria in processing land development control, it is quite complex to consider all factors collectively. In this regard, in Ethiopia, currently Municipal Governments could not cope up with this trend in a meaningful extent with major urban service demands and population growth (Elias, 2015). Even if the demand is increasing tremendously from the client side, there is high level of involvement in an ill-timed service provision from the administration side. This is due to lack of skilled human resources which is a major constraint for most of the municipalities in the country. The relatively low status and pay, and lack of incentives offered by most local governments are principal causes for attracting and/or retaining qualified staffs to enable cities fulfill existing mandates (Solomon & Mansberger, 2003).

According to article 12 sub-article (1) and (3) of the Ethiopian urban lands lease holding proclamation No. 721/2011 (FDRE, 2011); any lessee shall commence and complete construction within the period specified in the lease contract. Without prejudice to the provision of sub-article (5) of the same Article, where a lessee fails to commence and complete construction as well as payment within the specified period, he/she shall be liable to pay a penalty fee and as a result the leasehold contract shall be terminated; and the appropriate body shall take back the land. The tenant and/or land owner must comply with or fulfill required conditions prior to start any development on the vacant lot such as issuance of building permits, and/or final building inspection approval.

So the tenant should have to reach to an agreement with the official representative of the regional or city administration on the following four critical determinants before starting new development on a vacant land those are; construction commencement period, construction completion period, payment period and damage deposit. However; inconsistency in decision making is highly noticeable in determination of construction commencement and completion period for the same type of construction project by different construction scheduling experts due to difference in perception from one expert to the other as well as lack of skills. Therefore, construction owners always seems to complain that construction commencement and completion period which is determined by construction scheduling experts is not equivalent with the period of time required for the actual work. Because of this, owners of the land are unable to use the land for the prescribed purpose within the period of time stated in the lease contract. Pursuant to article 4 sub article (1) of the Ethiopian urban lands lease holding proclamation No. 721/2011, where a lessee fails to start and complete construction within the specified time, the lease contract shall be terminated and the appropriate body shall take back the land.

So this situation has brought high crisis and lost of valuable resource for both parties especially from the owners of the land side. Furthermore, to determine the appropriate cost that will be kept for the damage, experts are expected to physically observe the situation of the land so that it is possible to identify the infrastructural networks available around the location such as roads, water supply, sewerage disposal system, and electricity and telephone lines. However, making a physical observation on a daily basis is very enervating and boring task.

There is also absent of inter-departmental cooperation between the key departments such as mass housing, urban development control, lease office, survey & mapping and engineering services. This uncoordinated way of doing the task leads to delay in decision making since the four critical determinant decisions are prepared and forwarded by different departments. This has brought series of challenges for all the land related professionals, particularly Land Administrators/Managers, Land surveyors, Estate Surveyors and Urban planners among others (Elias, 2015).

Urban planning often involves a huge amount of data, regulations and guidelines from various sources. It also requires the experiences and expertise of planners and the assistance of planning models and analytical methods in its complicated decision-making process. But the capability of people in handling large amounts of information and the availability of experienced planners are often very limited. Therefore, computerized knowledge-based systems (KBS) or expert systems (ES) which have the capability of easy storage and retrieval of the required information and knowledge and "can reach a level of performance comparable to - or even exceeding that of - a human expert" (Turban, 1995), would be, at least theoretically, very helpful to planners in their work.

In addition, the agency is not equipped with the necessary instruments to assist in operational efficiency, hence making it ill-prepared to effectively manage the lease tenure system. There is also lack of systematic land management information system that would serve as a basis for decision making. There are also incidences in which several files with urban land management related record have been lost or could not be readily accessed, hence all this makes the grant process to be delayed. Therefore; all the afore-mentioned problems have a direct and indirect impact on urban land accessibility.

Many potential applications have been explored by researchers and a few prototypes and even operational systems have been built (Ebrahim et al., 2014). However, there are many limitations in using KBS in urban planning (Pemer, 1999; Borri et al., 1994; Perera & Watson, 1996). The two main obstacles in successfully applying KBS to urban planning are difficulties in building a practical KBS for planning and difficulties encountered to "inspiring confidence in the use of it" (Sycara et al., 1991). Some of these problems can be overcome by the use of case based reasoning (CBR) which uses previous similar cases to suggest solutions to new cases (Yeh & Shi, 1999). In contrast to rule based reasoning or model based reasoning, CBR directly uses concrete knowledge and its inference is basically the processes of retrieval and adaptation. These features make CBR able to avoid some of the problems in building KBS, such as knowledge elicitation bottlenecks, and can gain the confidence of users.

Therefore compared with other related studies, this research solution paradigm is not intended to completely simulate the whole problem solution procedure of land development control but instead provide the support in the phase of final decision making which is made prior to signing or concluding contract between tenant and the city administration. Therefore; Case-Based Reasoning (CBR) is promising to build a decision support system that helps the municipal government during decision making process for land development control (Yeh & Shi, 1999). It uses previous similar case(s) to help solve, evaluate, or interpret a new problem (Kolodner, 1993).

Finally, demand for housing is progressively growing with the growth of population. Hence, much effort should have to made in order to cope up with the situation as well as to improve the land administration system to enable it adapt to the fast growing urbanization and the ever increasing demand for land. Hence, case based system plays an important role in this regard to fulfill the function of urban land development control. In such system, CBR will provide a retrieval method (at least) by using previous experiences in proposing a solution to a new problem or providing relevant experiences to the decision makers.

To this end, this study attempts to explore and answer the following research questions:

- What are the cases suitable for developing CBS that are related to urban land development?
- How the acquired cases will be modeled and represented in developing a CBR system?
- To what extent the developed CBS learn from experience?
- To what extent the proposed system get acceptance by the City Land Development and Administration Agency staffs?

1.3 Objectives of the Study

1.3.1 General Objective

The general objective of the study is to design and develop a Case Based System for urban land development control that supports effective and efficient decisions making in Ethiopia.

1.3.3 Specific Objectives

- To review related literature so as to understand the area and identify methods, techniques and tools for developing CBS
- To identify cases suitable for urban land allocation decisions
- To model and represent the cases collected from different data and knowledge sources involved in urban land development control
- To examine the extent in which the developed CBS learn from experience
- To test and evaluate the performance and user acceptance of the proposed case based system

1.4 Scope and Limitations of the Study

The study is emphasized to develop a prototype case based system that support the final decision making process in urban land development control. The study is focused on three topics: Case-Based Reasoning techniques, urban land development control problems and their knowledge representation, Case-Based Reasoning knowledge base or case library (Intelligent Reasoner). The concept of Land management is broad and complicated which includes managing the use and development (in both urban and rural settings) of land resources. However; it is impossible to develop a full-fledged system which is capable enough to address the entire land grant process since the first phase involves a tender process that takes place in order to identify a bid winner based on the amount of advance payment and maximum bid price he/she offer for a parcel of land. Therefore; the prototype case based system only supports the decision making process of the final phase which is made by urban development control department and lease office. Even though, there are many approaches to develop the system, for instance Expert System, the investigator shall have limited to case based approach. The selection of cases for the prototype system is made based on the classifications, landholdings before and after the beginning of lease land tenure system in Ethiopia. Therefore, the focus of the study is on cases that were generated after the beginning of lease land tenure system in Ethiopia which excludes landholdings with varied land use types prior to 1994. Moreover, in Ethiopia the option available to acquire urban land to be held by a tenant includes tendering and allotment. However; cases for the prototype system has been drawn merely from landholdings that was obtained through tender land acquiring mechanism. Furthermore; among many land use types found under tendering and allotment land acquisition category, the researcher only took and generate cases from residential, commercial, industrial and mixed since they are the only land use types that could be obtained through a tender land acquisition mechanism. Finally; in developing the prototype of CBR system the four major tasks, retrieve the most similar case or cases, reuse the information and knowledge in that case to solve the problem, revise the proposed solution, and retain the parts of this experience likely to be useful for future problem solving, of CBR are applied.

Undertaking the study is not an easy task; particularly, obtaining required information for the purpose of the study has been a demanding and burdensome task owing to the tedious bureaucracy in the government organizations concerned with urban landholdings. Although urban land holdings contain many cases, it is difficult to acquire the complete coverage since there are no well documented real cases. Even some of the collected cases are ignored due to incompleteness of the cases, contains outdated information and lack of detailed analysis of the cases. The other limitation is in weighting the importance of the extracted features which needs a great care, support and deep consultation from the domain experts. Although unsuccessful cases were included during case library construction, the justification behind the failure is missed since it's difficult to get a well-documented and accessible data on the root cause of the failure.

1.5 Significance of the Study

The developed system benefits JCLDAA particularly urban development control department and lease office by means of avoiding the problem of limited number of experts and lack of coordination between departments during the final decision making process regarding to the four critical determinant which are construction commencement and completion period, payment period and damage deposit. This is because expert knowledge and experience are stored to support decision making process that leads to high accuracy and efficiency (David & Leake, 1996).

It is also believed that the developed system provides a quick and transparent access to land records on demand and anticipation. Moreover, it will reduce length of stay by the tenant until the officials/experts analyze all the possible outcomes of the solution and come up with the final decision. As a result, it accelerates efficiency in the delivery of serviced land and improve the efficiency of land market and eliminate the problem of impartiality during the decision making process. Thus using this newly system it is possible to achieve significant improvements in the level of services by eliminating old ways of doing things. The prototype case based system which was developed in this study could be helpful in a way by maintaining land and related information's for future use. Developing a case based reasoning system is the best strategies for achieving more sustainable urban land development (Yeh & Shi, 1999). Generally the prototype CBS that was developed in this study is expected to bring major advantages such as; it supports human decision making in complex city planning; working style of urban development control department and lease office, the final decision maker, could be simulated by utilizing existing knowledge; the usage of the model could reduce the time in similar situations and overcome uncertainty by avoiding to start from the beginning every time; knowledge representation logic is based on local and real past cases rather than generalized rules/guidelines which allow the solutions provided by the system to be more reliable and acceptable; experiences and lessons could be derived both from good and bad practices, and finally beside its' knowledge inference capabilities, it could be used as a digital archive, automation system and corporate memory.

1.6 Methodology of the Study

In this study design science research method was employed. The design science paradigm has its roots in engineering and the sciences of the artificial (Simon 1996). It seeks to create innovations that define the ideas, practices, technical capabilities, and products through which the analysis, design, implementation, and use of information systems can be effectively and efficiently accomplished (Brooks, 1987). The computing and information technology (CIT) field since its advent in the late 1940s has appropriated many of the ideas, concepts, and methods of design science (Hevner et al., 2004). The objective of design science research is to develop technology-based solutions to important and relevant business problems. Design science is fundamentally a problem-solving paradigm and has follows a procedure of: problem investigation, design, design validation, implementation, and evaluation (Rittel & Webber, 1984). Generally for prototype system development the following procedures were applied in the study. These were data collection and preparation, modeling and cases representation, system design and development, and finally evaluation of the system performance and user acceptance.

1.6.1 Data Source and Collection Method

In this study both primary and secondary data collection method were employed in order to collect the required domain knowledge. For this study non-documented sources of knowledge was also collected from technical staffs or experts who working in Jimma city land development and administration agency. For this reason the researcher conducted an unstructured interview schedule for acquisition of domain knowledge and critique knowledge elicitation methods to filter the acquired knowledge. The purpose of interview was to gather domain knowledge which is the expertise of the planners from their experiences in land development control decision making process.

Similarly, codified sources of knowledge were acquired by using document analysis technique. The codified domain knowledge involved in land development control includes the lease hold certificate, tender document, site plan proposing form, Jimma structure plan manual and local development plan, lease contract document, the governmental policies specially the federal democratic republic of Ethiopia urban lands lease holding proclamation and the archived cases. This previously solved cases by urban development experts, with the four critical determinant attributes those are construction startup and completion period, payment period and damage deposit and the status which indicates whether the decision was successful or unsuccessful were collected. Numbers of attributes were determined according to their importance by domain experts.

1.6.2 Study Population and Sampling Technique

According to Mack et al. (2005), a population is defined as all elements (individuals, objects and events) that meet the sample criteria for inclusion in a study. Therefore, the populations were land development technical staffs of Jimma city land development and administration agency particularly members of urban development control department and lease office who sat and carry out length discussion about the four critical determinants and come up with the final decision. Jimma city land development and administration authority is found in Oromia regional state; Jimma town. These areas were selected due to the fact that since the municipal government is pioneer and experienced organization, relatively large numbers of senior experts are available who are capable enough to provide the required tacit knowledge. Purposive sampling technique was used for selection of previously solved cases by considering the proportion from each land use types. For interviewing domain experts, five experienced technical staffs were selected depending on their immediate position, qualification and more importantly based on their year of experience from Jimma city land development and administration agency. Furthermore; the main reason for selecting five technical staffs are due to that they are the only member of urban development control department and lease office, the appointed division in the municipal government to take charge of controlling the development of land and building, who are responsible for making the final decision regarding to the four critical determinants. Even though there is no rule or standard to determine the minimum number of cases required in CBR system development; Alemu (2010), Henok (2011) and Getachew (2012) used a maximum of 51 cases for building and testing their prototype system; the main reasons they indicated for the limitation of number of cases were lack of time and cost.

Among the total number of landholders in the archive, 17653 are leaseholders who acquired urban land through a tender process over the period of 1994-2008 which was the beginning of leasing land tenure system in Ethiopia. But since the data set having different problems such as missing value of majority attributes and redundancy, the researcher selected sixty five (65) operational cases of varied tenants from total of 17653 landholders. The main reasons for selecting few cases (65) from the available cases were; landholder's file were kept in scattered places mixed with other land use types which indicated as out of the scope of the research as well as landholders prior to 1994, before the beginning of lease land tenure system in Ethiopia, were kept mixed with the relevant landholder's file. Consequently this coincidence makes the case construction task to become too difficult in order to extract and construct the case library with numerous relevant cases. Therefore; data collection was so challenging task in terms of time and cost. Finally these 65 cases represented and stored in the case base in SQL file format that was used as previously solved cases. Among 65 case used in this research for the development of the prototype system, 38 are from residential, 17 are from commercial, 7 from mixed use, and 3 from industrial land use types. Thus cases are purposively selected from the archive which was developed according to the second land acquisition mechanism, tender process, those includes residential, commercial, mixed and industry land use types. The number of sample cases collected from each land use types depends on the total number of categories in the archive so the researcher selected the case from each land use types proportionally.

1.6.3 Case Selection, Modeling and Representation Methods

A case is a contextualized piece of knowledge, representing an experience that teaches a lesson fundamental to achieving the goals of a reasoner (Kolodner, 1993). Accordingly previously solved cases were carefully selected by considering the proportion from each land use types found under tendering land acquisition mechanism. These cases are carefully selected in consultation with the domain expert which helps to assure their capability in representing the whole collection.

A knowledge model is a structured representation of knowledge using symbols to represent pieces of knowledge and the relationships between them. Knowledge models include symbolic character based languages such as logic, diagrammatic representations such as networks and ladders, tabular representation such as matrices and structured text such as hypertext. The model helps to ensure that all stakeholders in a proposed system understand the language and terminology being used and quickly conveys information for validation and modification where necessary. Therefore; hierarchical structure was used to model the knowledge. The prototype case based system is developed based on the model presented in these hierarchical structures. The prototype follows the procedures presented in the hierarchical structure to recommend construction commencement and completion period, payment period and damage deposit along side with status of the previous decision during urban land grant process.

Case representation is the hearth of the CBR system, so case library should correctly represent the experience and knowledge (about the domain) we obtained before. The case representation task is concerned with the selection of relevant attributes, the definition of indexes and Structuring the knowledge in a specific case implementation. There are many case representation methods such as relational database case representation, predicate based representation and soft computing case representation methods are some. For this research, among the different case representation methods feature-value case representation method is used. Feature-value case representation method is a process of representing a case as a vector of attribute-value pairs, similar to the propositional representations used in Machine Learning (ML), that support nearest neighbor matching and instance-based learning. The reason for representing the cases using feature-value representation is that this approach supports nearest neighbor retrieval algorithm and it represents cases in a simple way (Bergmann, et al., 2005).

1.6.4 Implementation Tool

A CBR tool could be used to develop several applications that require case-based reasoning methodology. There are many commercial and non-commercial implementation CBR tools used for development of KBS systems. Some of the tools such as “CaseAdvisor” were used only to suggest a previously solved case solution after once stored in a database but do not support updatability or learning (Watson, 1997). Others such as “Recall” were incompatible and do not support external databases (García, et al., 2008).

Therefore; the two most commonly used non-commercial implementation tools that are used to design any CBR system are myCBR and jCOLIBRI. However; myCBR has limitations to support full CBR cycles; it doesn’t support to use external databases and only applicable for simple CBR applications (Atanassov, 2012). Hence, in this study for the development of CBR prototype system, the researcher used jCOLIBRI which is object oriented framework and developed by Group of Artificial Intelligence Applications (GAIA). The reason for the selection of this implementation tool was the features and abilities of the tool in case based reasoning. In addition; according to Iqbal and Hassan (2006), major advantages of jCOLIBRI as compared to other implementation tools includes the following such as; jCOLIBRI supports the full CBR cycles such as (Retrieval, Reuse, Revise and Retain), jCOLIBRI is suitable for developing large scale applications, jCOLIBRI is extensible and reusable, jCOLIBRI is more user friendly than others and it works well in external database such as SQL and plain texts, jCOLIBRI is compatible with different applications so that it is possible to design an integrated system for instance ARC GIS as it is developed based on object oriented approach, and lastly jCOLIBRI have also the main function of learning ability; that means in jCOLIBRI when new cases are coming in the domain area the system have the capability to learn and update these new cases in the existing case library for the purpose of using it for the future.

jCOLIBRI stores all the configuration data using different XML configuration files. When the application is executed, the framework core reads these files to know how to configure the CBR system. Thus it is possible to write or modify this configuration files by hand, however it could be a very tedious task. XML intends to be a standard interchange language of data between computers, not to be managed directly by humans (Juan, et al., 2009). So in this research the database contained all the cases in the form of records grouped by attributes with SQL file format. These cases are used as input for the system which was collected from Jimma city land development and administration agency for decision making process.

1.6.5 Testing and Evaluation Methods

The developed prototype case based system is tested and evaluated to ensure the performance of the system whether it meets its objective or not. The evaluation processes focus on system's user acceptance of the prototype, the retrieval performance of the system, and case similarity of the system. User acceptance measurements are concerned with issues how well the system addresses the needs of the user, whereas performance measurement determine if the system perform the required task successfully. For this reason, user's acceptance testing was conducted by taking five land development technical staffs; all are members of urban development control department and lease office, from Jimma city land development and administration agency. User acceptance system evaluators use visual interaction methods together with questionnaire.

In addition to this, the standard effectiveness measures such as accuracy, precision, recall and F-measure have been used to evaluate the performance of the prototype. As retrieval task of the CBR aims to retrieve relevant cases from the case base, precision and recall are useful measures of retrieval performance in CBR (Junker, et al., 1999). Recall is defined as the ratio of the number of relevant cases returned to the total number of relevant cases for the new case in case base (Junker et al., 1999). Whereas precision is the ratio of the number of relevant cases returned to the total number of cases for a give new case (Junker, et al., 1999). For the implementation of this test, different threshold value is used to measure the similarity between the existing case and the new case. The retrieval process (i.e. recall and precision) of the prototype uses 7 sample cases that make up the case base as training and testing data. Both retrieval and reuse process uses leave-one-out cross validation testing proportion i.e. the evaluation is done for all cases by making one of the cases as a testing data and the rest of data as a training data (case base).The researcher conducted 7 experiments for both retrieval and reuse evaluation of the system. The researcher also made an experiment on case similarity testing to know how new cases are matched with the previous cases from the case base.

1.7 Organization of the Thesis

The main body of this thesis organized in six chapters. The first chapter presents the introduction part with sub headings of: background of the study, problem of the statement and its justification, objective, scope and limitation of the study, significance of the study and methodology of the study.

The second chapter presents about literature review. It introduces the available related and relevant documents to give an overview about case based reasoning, CBR techniques, case based reasoning life cycle, comparison of CBR with other techniques, advantages of using CBR, overview of urban land tenure systems, in particular on analysis of urban leasehold rights in Ethiopia, land development control, application of CBR in land development control and related works within the domain area.

The third chapter discusses about acquisition, modeling and representation of knowledge. In its sub headings, it discuss about acquisition of knowledge from different sources, conceptual modeling of the acquired knowledge using hierarchical structure and also discusses the representation of cases using feature-value for developing the prototype system.

The fourth chapter presents the architecture of CBRSULDC and its implementation. The fifth chapter discuses about analysis and interpretation on the evaluation result for the performance of the prototype system and user acceptance testing.

Finally, chapter six discuss the major findings, based on which it provides concluding remarks and recommendation for further research.

SECTION TWO

LITERATURE REVIEW

2.1 Overview of Case Based Reasoning (CBR)

CBR is a family of AI techniques which simulates behavior of human in solving a new problem. Therefore in CBR, reasoning is based on recalling. When confronted with a new problem, it is common for a human problem-solver to look into their memory to find earlier related instances for aid. The most significant reason why a person can become proficient is that they can memorize and correctly use proper cases in solving new problems (Shi &Yeh, 2001).

There are many definitions about CBR in the literature such as: to use previous similar cases to solve, evaluate or interpret a current new problem (Kolodner, 1993); CBR is an artificial intelligence (AI) technology that encodes problem-solving expertise as a database of cases, where each case encodes a solution to a previously encountered problem (Stottler Henke AI Software Solutions, 2006). Also CBR is defined as a model of reasoning which consists in solving new problems by adapting solutions that were used to solve old problems (Riesbeck & Schank, 1989). Furthermore CBR means to solve a new problem by remembering a previous similar situation and by reusing information and knowledge of that situation (Aamodt & Plaza, 1994).

CBR differs from other methods like rule/model based approaches that it allows the knowledge to be represented as an inferred case instead of generalized/abstracted rules. While most of AI technique try to make prediction, CBR tries to retrieve most relevant case(s) and utilize existing knowledge (if fits the situation). CBR systems can point to the similar cases on which the prediction is based as justification. In addition, it clearly presents and describes the internal working of the model to user when compared with the 'black box' nature of other AI methods. For instance artificial neural network method has a limitation what constitute the optimal structure of the network. Briefly, CBR only uses local information at first step instead of using deriving generalized rules or models.

In CBR approach, new problems are handled by remembering old similar ones and moving forward from there. Referencing to old cases is advantageous in dealing with situations that recur. However, CBR technique is based on two tenets about the structure of problem solving process. The first one is similar problems have similar solutions and the second one is future problems are likely to be similar to current problems (Leake, 1996). When the two assumptions hold, CBR becomes an effective reasoning strategy.

“Remembering a case” to use in “later problem solving” is a necessary learning process. According to Kolodner (1993), features of the CBR approach includes the following: learn from experiences, learning to be integrated/based on reasoning, learn from mistakes and do not repeat them, allows a reasoner to solve problems with a minimum of effort, provides a way of dealing with an uncertain world, and lastly in most cases what was true yesterday is likely true today.

By its cyclical nature, CBR is capable of ‘learning’ from previous experiences (or iterations). Thus it can adapt to both ‘good’ and ‘bad’ answers. Hammond, (1988) gives the principles of CBR as: firstly, if it works, use it again; secondly, if it works, don’t worry about it; thirdly, if it didn’t work, remember not to do it again; and finally, if it doesn’t work, fix it.

in spite of whether a case-based reasoner solves a routine or novel problem and of whether the problem solving outcome is success or failure, the system learns from its experience. The user/system learns from experience to gain prior successor and avoid prior failures (Leake, 1996).

CBR can be defined also as a model of reasoning that includes problem solving, understanding, and learning, and integrates all of them with memory processes. These tasks are performed using typical situations called cases, already experienced by a system (Pal & Shiu, 2004). CBR can be defined as the process of solving new problems based on the experience coming from similar old past problems. For instance: a mechanic who fixes a car problem may remember another car that faced similar symptoms for this problem is using case-based reasoning. Or, a lawyer who advocates a particular case may base his defense on similar legal precedents. CBR in fact is a famous way of analogy making and it is not only a famous computer reasoning technique but it is also a pervasive human problem solving technique. We can notice that the use of CBR rises in the past decade as one of the powerful AI techniques.

A case may be defined as a contextualized piece of knowledge representing an experience that teaches a lesson fundamental to achieving the goals of the system (Pal & Shiu, 2004). It can be seen that the system becomes more proficient and more competent as a result of storing the past experience of the system in the case library and then referring to earlier cases in later reasoning. Unlike traditional knowledge based systems, a CBR system operates through a process of remembering one or a small set of concrete instances or cases and basing decisions on comparisons between the new and old situations (Pal & Shiu, 2004). It has been noticed that the CBR field has appeared in a short history as one of the researches in cognitive science. During the period 1977–1993, CBR research was highly regarded as a plausible high-level model for cognitive processing. *"It was focused on problems such as how people learn a new skill and how humans generate hypotheses about new situations based on their past experiences. The objectives of these cognitive-based researches were to construct decision support systems to help people to learn* (Pal & Shiu, 2004).

2.1.1 CBR Life Cycle

Case based reasoning the name indicates, uses cases to reason about a given problem. In its problem solving process, it reuses previous old similar and related cases to understand the problem, recommend a solution, and/or to keep it from failure. A CBR technique follows four processes; retrieve, reuse, revise and retain, to accomplish its reasoning task. Figure 2.1 shows sequence of the processes and each process is described below. (Kolodner, 1993; Leake, 1996; Aamodtand Plaza, 1994; Lopez, et al., 2006) the following figure shows CBR life cycle:

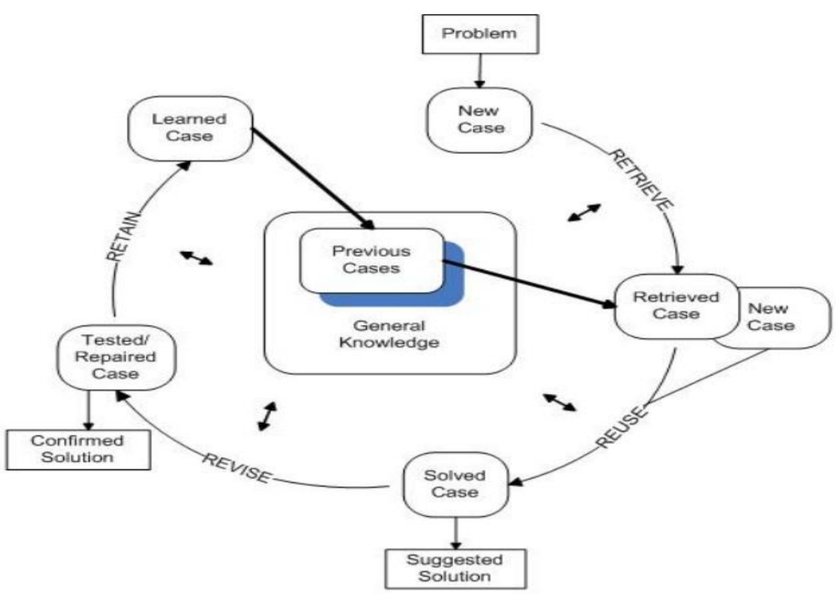

Figure 2.1 Case-Based Reasoning Cycle (Aamodt & Plaza, 1994)

- **Retrieve**

When a new problem occurs, this process tries to identify the descriptive features of the new problem and searches previous old cases that match with the new situation based on the identified features. Indentifying descriptive features involves tasks of identifying properties that describe the new problem, leave out those that don't describe it strongly and represent the descriptive features in a case format. There are algorithms which are capable of doing this kind of task. Searching similar previous cases is done by matching the new case with saved previous old cases from the knowledge base. It results in a collection of similar cases. The final step of retrieval process is to select the best matched case or a set of cases from the collection of similar cases. The degree of similarity between the old and new case is measured by using similarity assessment methods. Quality of the retrieval process depends on its descriptive feature identifying algorithm, searching algorithm and similarity assessment method.

- **Reuse**

The selected case in the retrieval process can be used to understand the new situation when it is not clear by itself, to propose a solution based on the solution taken on the selected case, or to prevent from following a wrong way of solving the problem based on the outcome of the selected case. Proposing a solution can be performed into two ways: reusing the solution as it is or by adapting it. When the s elected case and the new case do not have significant difference, the solution in the selected case will be proposed as it is for the new problem. Whereas, if there is a significant difference between them, the solution in the selected case is adapted based on the unique feature of the new case, this process is known as *adaptation*.

- **Revise**

In case based systems proposing a solution is not the only goal, it also aims to learn from the consequence of applying the proposed solution. This process evaluates how good the proposed solution is for the given problem. The evaluation is performed by using simulator, by getting feedback from a human expert of the application domain or by applying it in the real world and see the result. This process may take hours, days or months until the result is being realized. The system learns from the result whatever it is: *success* or *failure*. If it is failure, the fault needs to be repaired and explanation of why the failure occurs should be given to prevent future similar problems from such kind of failures.

- **Retain**

Case based systems upgrade their domain knowledge by learning from new experiences obtained while problems are solving. After the proposed solution for the given problem is evaluated in the revise process, the retain process identifies useful and worth remembering new experiences and decides how to merge with existing knowledge. This type of learning is known as *incremental learning* because it always adds knowledge that is new and useful in addition to the existing knowledge.

The new experience may be success or failure. If it is success, the retain process keeps how the problem is solved by modifying existing cases or by creating a new case if it has significant difference with the existing ones. The advantage of keeping failure processes is to prevent future similar problems from similar failure. The failure can be *task failure* where the solution is unsuccessful or *expectation failure* where the observed solution is different from the expected solution.

The bigger inner rounded rectangle in Figure 2.1 represents the knowledge base which is made up of cases and general knowledge. General knowledge of a case based system is domain-dependent knowledge that represents generalizations of cases, adaptation strategies and case matching procedures in order to support case based reasoning process. (Leake, 1996; Aamodt & Plaza, 1994)

2.1.2 CBR System versus Rule-Based System

In rule-based systems we have to define all rules that govern the outcomes. So we can have a set of productions in the form IF A, THEN B, where A is a condition and B is an action. If the condition A holds true, the action B is carried out and so on for all rules inside the system. Each condition can be a single premise A or a composite condition consisting of a conjunction of premises A1; A2; . . . ; An. In addition, a rule-based system has an inference engine that compares the data it holds in working memory with the condition parts of rules to determine which rules to fire, in another meaning this inference engine navigates through the decision tree till it finds the rule to be fired (Pal & Shiu, 2004). It is has been noticed that usually one of the most time-consuming tasks when developing rule-based systems is the knowledge acquisition task. Acquiring domain-specific information and then converting it into some formal representation can be a huge task and in some situations, when some of the domain info is not fully understood because of their complexity, formalization of the knowledge cannot be done at all (Pal & Shiu, 2004). It can be said that case-based systems usually require significantly less knowledge acquisition, since it involves collecting a set of past experiences without the added necessity of extracting a formal domain model from these cases and hence much less effort needed. In real life, sometimes in many domains there are insufficient cases to extract a domain model, and this is another benefit of CBR: A system can be created with a small or limited amount of experience and then developed incrementally, adding more cases to the case base as they become available and that improves the result from the system (Pal & Shiu, 2004).

2.1.3 CBR versus Human Reasoning

It can be seen that the processes which make up case-based reasoning came from reflection of a particular type of human reasoning. In many situations, the problems that human beings encounter are solved with a human equivalent of CBR (Pal & Shiu, 2004). Usually when a person encounters a new situation or problem, he or she will often try to correlate it to a past experience of a similar structure. This previous experience may be the person's experience or an experience gained by another person. If the experience originates from another person then the case will have been added to the (human) reasoner's memory through either an oral or a written account of that experience (Pal & Shiu, 2004). It can be seen also that CBR is used in other ways, most notably as an arguing point of view. For example, some students may come to their teacher with various requests. A request might be for an extension to a deadline or for additional materials. It is a common experience of a teacher that after refusing one of these requests, to have students arguing the point. One of the common techniques that students are using is to present evidence that in another course, or with another lecturer or teacher, their request has been granted in a similar situation, with similar underlying rules. Such sort of reasoning is also very common in law domains, and illustrates another way in which case-based reasoning systems can be implemented (Pal & Shiu, 2004).

CBR can also be seen in courts when an attorney argues a point in court by references to previous cases and the precedents they set. CBR systems can refer to a case base containing court cases and find cases that have characteristics similar to those of the current one. Case similarities may be a full match or only certain points that led to a portion of the ruling (Pal & Shiu, 2004). It can be concluded that the idea of CBR is intuitively appealing because it is similar to human problem solving behavior. People usually draw on past experience while solving new problems and this approach is both convenient and effective, and it often relieves the burden of in depth analysis of the problem domain. This leads to the advantage that CBR can be based on shallow knowledge and does not require significant effort in knowledge engineering when compared with other approaches (e.g., rule-based) (Pal & Shiu, 2004).

2.1.4 Guidelines for the Use of Case-Based Reasoning

Although CBR is a useful technique for solving wide range of problems domains but there are occasions that it is not the most appropriate methodology to employ. The following questions can be used to determine whether case-based reasoning is applicable technique to solve the problem or not (Pal & Shiu, 2004).

1. Does the domain have an underlying model? If the domain is impossible to understand completely or if the factors leading to the success or failure of a solution cannot be modeled explicitly then CBR cannot be used.
2. Are there exceptions and novel cases? It is advised that domains without novel or exceptional cases may be modeled better with Rule Based System where Rules could be determined inductively from past data. However, in a situation where new experiences and exceptions are encountered frequently, it would be difficult to maintain consistency among the rules in the system. Therefore, the incremental case learning characteristics of CBR systems makes it a possible alternative to rule-based systems.
3. Do Cases recur? If the similarities between cases is very low then the experience gained may not help with the new problem because they are very different and most probably adaptation to past experience may not help much, then it is better to build the domain to derive the solution.
4. Is there significant benefit in adapting past solutions? We have to consider the significance for our benefit (in terms of system development time, processing effort) when making adaptation to old solutions compared with the benefit from creating a new solution for the problem from scratch.
5. Can we record data that have the necessary and relevant characteristics of past cases? Is the solution recorded in sufficient structure with ample detail so it can guide to clear suggestion, can the solution be adapted in the future for better result?

2.1.5 Advantages of Using Case-Based Reasoning

As noted by pal & shiu (2004), case based reasoning has many advantages, and some of them are the following:

1. Reducing the knowledge acquisition task by eliminating the need to extract the full model detail or the set of rules that governs that system, as it is necessary in model/rule-based systems, the knowledge acquisition tasks of CBR consists primarily of the collection of relevant existing experiences/cases and their representation and storage.
2. Providing flexibility in knowledge modeling. When Knowledge is difficult to model or when there are incomplete date, model-based system cannot solve such problem , In contrast to that CBR using past experience as a the domain model can often provides reasonable solution to these types of problems.
3. Used with domains that have not been fully understood, defined, or modeled. In such situation where insufficient knowledge exists to build a causal model of a domain or to derive a set of heuristics for it, a case-based reasoner can still be developed using only a small set of cases from the domain. We still can operate CBR reasoner although the full domain knowledge have not yet been understood entirely.
4. Making predictions about how much the suggested solution may help. When there is stored information regarding the level of success of past solutions, the case-based reasoner may be able to predict the success of the solution suggested for a current problem. This is done by referring to the stored solutions, the level of success of these solutions, and the differences between the previous and current contexts of applying these solutions. Prediction could be better if the criteria for measuring success are defined especially quantitatively so the comparison could be better.
5. Learning over time. As CBR systems are used, the system encounters more problem situations and then after creating more solutions and retaining those into the case base the experience increases and the chance for better future solutions increases. It can be said that the more cases we have in the case base the wider the future problems the system can try to solve and the better result the system can achieve.
6. Reasoning in a domain with a small body of knowledge. We can see that in a problem domain for which only a few cases are available, CBR still can start with these few known cases and build its knowledge incrementally as cases are added. The addition of new cases will cause the

system to expand in the direction of accuracy for the suggested solutions because of better close match to the problems and with more cases added in different domain fields, the system can cover wider areas.

7. Providing a means of explanation. Case-based reasoning systems can supply a previous case and its successful solution to help convince a user of how this approach could help, or even to justify why the proposed solution could help with the current problem. In many cases there will be occasions when a user of the system wishes to be reassured about the quality of the solution provided by the system. By explaining how a previous case was successful in a situation, using the similarities between the cases conditions and the reasoning involved in adaptation, a CBR system can explain its solution to a user.

8. CBR System can be extended to serve different purposes, because the number of ways in which a CBR system can be implemented is almost unlimited. It can be used for many purposes, such as creating a plan, making a diagnosis, and arguing a point of view. Therefore, the data dealt with by a CBR system are able to take many forms, and the retrieval and adaptation methods will also vary. Whenever stored past cases are being retrieved and adapted, case-based reasoning is said to be taking place.

9. Ability to serve a broad range of domains, CBR can be practically applied to extremely diverse application domains.

10. It clearly reflects human reasoning. As there are many situations where we, as humans, use a form of case-based reasoning hence it is not difficult to convince implementers, users, and managers of the validity of the paradigm. It can be seen that humans can understand CBR reasoning and explanations and if a human user is wary of the validity of an earlier solution, they are less likely to use this solution. But we have to know that the more critical the domain, the lower the chance that a past solution will be used and the greater the required level of a user's understanding and credulity.

2.1.6 Previous Applications of CBR

CBR has developed into a mature and important field of AI and used by various researchers from various countries. Research in cognitive science and on the nature of human memory at Yale University and the works of Roger Schank on dynamic memory (Schank, 1982) form the roots of CBR. One of the earliest CBR systems to be developed was CYRUS (Kolodner, 1993) which was based on the memory organization packet concept put forward by Schank (1982). CYRUS was developed with a focus on how memory is used to answer questions of understanding (Bhogaraju, 1996). Frontier examples of CBR applications are given in Table 2.1.

Name	**Developers/Authors**	**Domain**
CYRUS	Kolodner, J., 1993	Representation in memory and understanding
MEDIATOR	Simpson, R. L., 1985	Dispute mediation
JUDGE	Bain, W. M., 1986	Subjective assessment
CHEF	Hammond, K. J., 1989	Recipe planning
CASEY	Koton, P. ,1989	Heart failure diagnostics
CLAVIER	Mark,1989; Hennessey et al.,1992	Autoclave loading designs

Table 2.1 Frontiers of CBR systems
(Source: Bhogaraju, 1996)

There are several studies have addressed specific considerations on using CBR for design issues. These design applications tried to bring new considerations to the use of CBR in design. Each implementation serves as an example for those who intend to use case-based design as a computer support system for designers. Table 2.2 lists a selection of implementations:

SYSTEM NAME	**DESIGN DOMAIN**	**REFERENCE**
Archie, Archie-II	Architecture	E. Domeshek and J. Kolodner, "The Designer's Muse," in Issues and Applications of Case-Based Reasoning in Design ,M.L. Maher and P. Pu, eds., Lawrence Erlbaum Associates, Hillsdale, N.J., 1997, pp. 11–38.
Cadre, Faming	Architecture	B. Faltings, "Case Reuse by Model-Based Interpretation," in Issues and Applications of Case-Based Reasoning in Design, pp. 39–60.
Cadsyn, Casecad	Structural Systems	M.L. Maher, B. Balachandran, and D.M. Zhang, Case-Based Reasoning in Design, Lawrence Erlbaum, 1995.

Fabel	Architecture	A. Voss, "Case Design Specialists in Fabel," in Issues and Applications of Case-Based Reasoning in Design, pp. 301–338.
Gencad	Structural Systems	A. Gómez de Silva Garza and M.L. Maher, "The Adaptation of Structural System Designs Using Genetic Algorithms, "Proc. Int'l Conf. Information Technology in Civil and Structural Engineering Design, Elsevier Science, New York,1996, pp. 189–196.
Janus	Architecture	G. Fisher, R. McCall, and A. Morch, "Design Environments for Constructive and Argumentative Design," Proc. Human Factors in Computing Systems Conf., ACM Press, NewYork, 1989, pp.269–275.
Seed	Architecture	U. Flemming et al., "Case-Ba Environment That Supports the Eased Design in a Softwarerly Phases," in Issues and Applications of Case-Based Reasoning in Design, pp. 61–86.

Table 2.2 Applications of CBR to design
(Source: Adapted from Maher & Silva-Garza, 1997)

Several recent approaches in Table 2.2 used the case based design concept for design assistance or design automation. Although practitioners have addressed these issues in developing and implementing case-based design systems, they also indicated that this aspect of case-based design has not matured enough to lead to general principles of how to represent a design case (Maher & Silva-Garza, 1997).

Additionally, the following studies were selected noteworthy samples from the related literature. Many domains used CBR for different purposes, such as software development-computer engineering (Recio-Garcia et al, 2005), electronics, robotics, mechanics (Lee D. & Lee K., 1999), urban planning (Shi & Yeh,2001), environmental planning (Kaster & Medeiros & Rocha, 2005), architectural design (Domeshek & Kolodner, 1993), architecture (Doğan, 2005), civil engineering (Dikmen & Birgönül & Gür, 2007), real estate (Pacharavanich et al., 2000), industrial engineering (Chang & Cheng & Su, 2004), farm planning (Bhogaraju, 1996), soil/landscape analysis (Holt & Benwell, 1999), medicine (Lopez & Plaza, 1993), tourism (Niknafs & Shiri & Javidi, 2003) and consumer services.

2.2 Types of Urban Land Tenure Systems

A pioneering UN study in 1973 on urban land policy and land use control measures identified a wide range of formal and customary tenure systems (Payne, 2000). As a general working definition, land tenure relates to the mode by which land is held or owned, or the set of relationships among people concerning land or its product. Property rights are similarly defined as a recognized interest in land or property vested in an individual or group and can apply separately to land or development on it. Rights may cover access, use, development or transfer and, as such, exist in parallel with ownership. Different forms of tenure may co-exist in the same country and, at times, even within the same city. Each form of tenure has its advantages and limitations. As it is stated on UNCHS (1999), the following are the most common types of tenure in developing countries:

- Customary Tenure. Customary tenure is found in most parts of Africa. It evolved from largely agricultural societies in which there was lit le competition for land, and hence land had no economic value in itself. Allocation, use, and transfer of land have been determined by leaders of the community according to needs, rather than through payment. With urban expansion, the system has become subject to commercial pressures.
- Private Tenure. This system permits virtually unrestricted use and exchange of land and is intended to ensure most intense and efficient use of land. The primary limitation of private tenure is the difficulty of access to land by lower income groups.
- Public Tenure. It seeks to enable all sections of society to obtain access to land under conditions of increasing competition. Although it has frequently achieved higher levels of equity than the private systems, it has rarely achieved the intended high level of efficiency due to bureaucratic inefficiency or systems of patronage and client age.
- Non-formal Tenure. This type of tenure allows holdings in the form of squatting, unauthorized subdivisions on legally owned land and various forms of unofficial rental arrangements with varying degrees of legality or illegality. Some of these non-formal categories, such as squatting, emanate from the inability of public allocation systems or land markets that provide for the needs of the poor. Even then, access to lower income groups

through such arrangements is becoming increasingly constrained. Despite this, informal tenure categories remain the most common urban tenure category in many countries and accommodate the majority of lower income households, often expanding more rapidly than any other tenure categories.

There may be more than one legally acceptable system operating in many countries. The co-existence of these different tenure systems and sub-markets within most cities creates a complex series of relationships in which policy related to any one may have major and often unintended repercussions on the others. It is, therefore, vital to assess the full range of de jure and de facto tenure systems and sub-markets that exist in any city before any attempt is made to intervene in land markets.

2.2.1 Analysis of Urban Land Tenure System in Ethiopia

Modern urbanization started with the establishment of Addis Ababa Menelik proclaimed the 1908 land charter of Addis Ababa which recognizes private ownership of urban land. During the reign of Haile Sellassie, private ownership of urban land was reemphasized by the subsequent Constitutions of the 1931 and 1955 (art.43) as well as the 1960 Civil Code. The Civil code recognizes private ownership of property in general and land in particular. Urban land was controlled by few urban elites. The revolution changed the system through proc. 47/1975 Proc.47/1975 provides land to urban dwellers and such holding system was known as permit system. The right to urban land was restricted, but the right was lifetime and inheritable. No rent was paid for the land (Solomon & Mansberger, 2003).

After assuming power, in 1991, the current government passed a constitution in 1995. The much anticipated constitution once again maintained state ownership of land in Ethiopia. The right to ownership of urban land, as well as of all natural resources, is exclusively vested in the State and in the peoples of Ethiopia. Land is a common property of the Nations, Nationalities and Peoples of Ethiopia and shall not be subject to sale or to other means of exchange. The justification for state ownership of land in Ethiopia is based on two grounds: social equity and tenure security.

So currently the land needed for residential housing, business (urban agriculture, industry or services), etc. can only be transferred by tender. However, the administration of the city, based on the decisions of the regional state cabinet, may see land being awarded through the allotment (without auction) of select areas which are of paramount importance to society, such as government office premises, charitable organizations, public residential housing construction programs, places of worship or religious institutions, diplomatic missions, etc (ONRS, 2014). In addition, people who are displaced from their homes as a result of urban renewal, or expropriation for other public purposes are entitled to receive land through allotment. All recipients, except the latter, would pay the lease price based on benchmarks set by the municipality/city administration (ONRS, 2014).

Urban leaseholders who are granted land either through auction or allotment would have to conclude a contract of lease agreement with a regional state representative, most likely from city administration (FDRE, 2011). The details of the lease contract include the date of commencement of construction, the completion date, lease price per m2, grace period, and the rights and obligations of all the parties. Once the lease contract is signed between the leaseholder and a representative of the state, the leaseholder shall be issued a leasehold right certificate containing the name of the leaseholder, the size and location of the plot, the land use type, the amount of the initial lease price payment, the total amount of the lease price, the date of the final lease payment to be effected, etc.

The duration of leasehold rights varies, depending on the purpose for which the land is requested and the level of urban development. The maximum lease holding duration is 99 years for the construction of residential houses, science and technology centers, research centers, government offices, and buildings housing charitable organizations and religious institutions. There is a minimum duration of 15 years for urban agricultural land. The lease period can be renewed upon expiry, on the basis of the prevailing benchmark lease price and other requirements at that time. However, the leaseholder may not be entitled to compensation, if the lease period cannot be renewed (FDRE, 2011).

The leasehold right system defines the rights of the leaseholder over urban land, and the obligation to use the land for the prescribed purposes, within the specified time. The leasehold rights provided to the leaseholder include the right to use and develop on the land. The right to transfer leasehold right through inheritance, gift and sale is also permitted, if there is an improvement or development on the leased land. The leasehold right can also legally be used as collateral for borrowing money from the bank at least for the lease amount already paid (FDRE, 2011).

The specific rights which an urban land leaseholder is permitted to exercise, and the position of the individual leaseholder can be explained/demonstrated using the property rights analytical framework. Leaseholders, after being granted urban land through a lease agreement, have full rights in terms of exercising use, development and management rights (ONRS, 2014). More specifically, leaseholders have the right to decide what and how to build according to plan and in terms of the lease contract. Despite certain restrictions and preconditions, the permanent transfer of lease rights is also permitted under the leasehold system. That means the urban leaseholder is permitted to transfer rights through inheritance, gift and sale, if and only if there is a development or an improvement on the leased land. Therefore, the urban land leaseholders can fully exercise rights of access, withdrawal, management and exclusion, but the right of alienation only partially. Therefore, in this study the position of the urban leaseholder is categorized as that of a weak owner, due to certain restrictions on the transferability of leasehold rights.

2.3 Land Development Control

Land development control is the processes and procedures concerned with controlling the development of land and building (MUDC, 2012). According to the Town Planning Ordinance (TPO), the development includes "the carrying out of building, engineering, mining or other operations in, on, over or under land, or the making of a material change in the use of land or building". According to a recent study by Elias (2015), land development control is:

- ✓ Complex. In processing land development controls, factors such as the government policies, the socioeconomic and environmental impact, the traffic and infrastructural implications, and compatibility of land uses, should be taken into consideration. However, it is quite complex to consider all these factors collectively, even though there are policies and regulations that providing criteria on them.
- ✓ Time-consuming. To process land development control, the official in the city administration will first examine the detail of the bid winner according to the planning ordinances, regulations and plans, collect opinions about the planned construction project to be developed on a parcel of land from relevant departments, and prepare the necessary papers for urban development control department and lease office to make the decision. When

making a decision regarding to the four critical determinants, the urban development control department and lease office, comprised of different members having different professional backgrounds, will have different opinions, causing a very lengthy discussion. Hence, the process for land development control is very time-consuming.

2.4 Related Works

Edamura et al. (1995) developed a pilot system for land development control by integrating blackboard model and Case-Based Reasoning in Japan. Blackboard model is also a sub-field of Artificial Intelligence. With that particular system, the blackboard model provided system efficiency and the CBR was used for case inference. The system is intended to aid planning officials to oversee the administrative measures and to give applicants the anticipated results. Not many discussions are related with Case-Based Reasoning on the issues such as case organization, case representation, and case operations. Case referencing is only a supplementary function. On the whole, it is not a Case-Based Reasoning system but a hybrid Expert System.

Genemo (2012) investigated urban sprawl susceptibility of the town of Shashamanne using remote sensing and GIS techniques. To quantify and measure the urban sprawl, an assessment was made on the extent and rate of land use/land cover change using multi-temporal landsat images during 1986, 2000 and 2011 and Shannon's entropy index. The study employed a supervised classification algorithm to identify the major land use/land cover types in the study area and he categorized into 4 types: agricultural lands, urban/built up areas, vegetated lands and bare fields. The result of the study indicated that the study area has undergone a tremendous change in urban growth and pattern during the study period. Predominantly at the expense of agricultural lands and vegetated areas in the hinterlands, built-up area was increased from 1977 ha (in 1986) to 2677 ha (in 2000) and further rose to 4329 ha (in 2011) which implies that large areas that are currently reserved as informal green spaces, fertile farming lands and other natural resources have been threatened.

Ebrahim et al. (2014) investigates concerning urban land use planning through an integrated data infrastructure. According to their study, municipalities and provinces need to have quick access to reliable information (geographical as well as administrative) such as land purchases at what prices, land ownership, detailed information about the deeds and also historic information about land use, land values etc, and preferably in real time. Web services as data distribution and data retrieving tools can be used very effectively to obtain this information. However, usually not all information is available within one organization. Therefore, based on their finding they come to conclude that having a nationwide data infrastructure is essential for providing current data. Further, describing the data by means of metadata may improve the data usability for end-users. In addition distributing data conform users' requirements and standards can help third parties to get easy access to their needed data which is an essential factor for urban land use planning.

Shi & Yeh (2001) developed a system that integrates a CBR shell (ESTEEM) and GIS package (ArcView) to build Case Based System (CBS) in Hong Kong, China. They tried to show how CBR can be used to handle planning applications in development control. Authors state that CBR can simulate the present working style of a planner in dealing with development applications which is based on his/her knowledge of past application records. They used the previous planning application cases to support the suggestions to the decision makers rather than generalizing rules and then performing a logic inference to get the conclusion.

Kaster et al. (2005) explore a solution which couples CBR to a spatial decision support system to help planners to profit from others' experiences in Brazil. Proposed model, named WOODSS (WorkflOw-based spatial Decision Support System) is based on GIS and scientific workflows. The research describes how CBR has been used as part of WOODSS' retrieval and storage mechanism, to identify similar models to reuse in new decision processes. As a future work, authors state that retrieval scheme must be extended to handle geographic data, using GIS functions in the similarity evaluation. In addition, the implementation can be extended to single user to multi-user environment for participatory planning.

Pacharavanich et al. (2000) examined the usefulness of the CBR system for the valuation of townhouses in Bangkok/Thailand. This system should be useful as an aid for experienced valuers and a guide to assist inexperienced valuers to learn proper judgment and methodology. A CBR software shell was used a tool. A larger sample of valuers needs to be investigated when the system is developed further. The research shows that the system has potential to become a viable tool for the valuation of residential property.

Archie is the product of collaboration between architects, computer scientists, design researchers and environmental social scientists at the AI lab of Georgia Tech's College of Computing.

Archie helps architects in the high-level task of conceptual design as opposed to low-level tasks such as drawing and drafting, numerical calculations, and constraint propagation. It is a case-based design aid that provides access to past experience so that human designers can adapt the cases for use in a present situation. Firstly, the system implemented for office building design and contains several types of information like area, lighting, furniture, budget, etc. It supports architects during the conceptual design phase through three means raising design issues, proposing responses to design issues, and identifying pitfalls and opportunities. This is accomplished by not only collecting successful cases, but also by having some cases that didn't work out as was hoped for (Domeshek & Kolodner, 1993; Heylighen & Neuckermans, 2001).

Doğan (2005) investigates the possibility of predicting the cost of construction early in the design phase by using machine learning techniques. To achieve this objective, CBR prediction and artificial neural network (ANN) models were developed in a spreadsheet-based format. The study demonstrated the practicality of using spreadsheets in developing CBR and ANN models for use in construction management as well as the potential benefits of enhancing CBR and ANN models by using different weight generation methods. Conclusions mainly cover methodological contributions that include the development of ANN and CBR Excel models and their testing results of cost data.

Dikmen et al. (2007) aimed to present a DSS tool to estimate bid mark-up values for international construction projects in a more systematic way. Using the 95 cases (collected by a questionnaire), a CBR model has been developed to estimate risk, opportunity and competition ratings. ESTEEM software is used to develop CBR model. The study differs from others by searching the problem from three aspects: risk, opportunity and competition. They state that, in order to improve accuracy of the model, higher number of scenarios should be incorporated into the case base.

When we come to our country Ethiopia, as far as the researcher knowledge, there is no urban land development control decision support system developed yet. Although many studies have been conducted related to urban land management, from the review of different literature it is identified that still there is a gap on development of a decision support system for urban land development control particularly in Ethiopian urban land management context which differs from others countries experience. Many of the reviewed related work indicates that the final solutions provided by systems developed by different authors has only two states; either to accept or reject a particular applications by individuals. However; unlike other countries experience in Ethiopia the options available to acquire urban land is not through application or proposal submission rather it is through competition and negotiation followed by many other sequence of phases to reach to the final agreement with the municipal government. This indicates that there is a need to conduct further study on this area specifically in Ethiopian urban land management context.

This study differs from others by providing solutions to the problem from the following aspects: construction of case library is based on Ethiopia Urban Lands Lease Holding Proclamation, it complies with the local development plan of a city, and it addresses two unrelated aspects i.e. period and costs. In addition it supports urban land development department and lease office experts during the final decision making through the following means: (1) raising land development issues and (2) proposing responses to land development issues. This is accomplished by not only collecting successful cases, but also by having some cases that didn't work out as was hoped for. The system ought to be useful as an aid for experienced land developers and a guide to assist inexperienced land developers to learn proper judgment.

Therefore; this study distinctively investigates the application of cased based reasoning system in urban land development control in Ethiopia and try to provide recommended solution which is the newly developed prototype system that helps to solve the existing problem in the municipal government.

CHAPTER THREE

KNOWLEDGE ACQUISITION, MODELING AND REPRESENTATION

Knowledge engineering is all about build, maintain and development of knowledge based systems in the field of artificial intelligence. Knowledge engineering has phases such as elicitation, representation, design, and implementation (Ferruccio, et al., 2010). Case-Based Reasoning is a kind of knowledge engineering (Kolodner, 1993). Cunningham and Bonzano (1999) have discussed the issues to build a Case-Based Reasoning system from a knowledge engineering perspective. Makhfi (2011) also pointed that knowledge-level modeling is of eminent importance to the success of a CBR system. Knowledge engineering mainly concerns the data and knowledge representation, the encoding methodologies, the work flow management, and so forth. Two main tasks concerned are the problem analysis task to produce the problem representation and the development of the inference mechanism. As to the CBR system building, the first task concerns how to define the case to make it operable and functional as a knowledge unit, and the second task concerns how to operate case to get the useful output. Generally knowledge acquisition, modeling and representation are a key task of knowledge engineering.

3.1 Knowledge Acquisition

Knowledge acquisition is the process of extracting and organizing knowledge from human experts and other sources such as books, databases internet, research papers, documents, one's own experience and transferring to the knowledge base (Abbas, et al., 2008). It is a process used in developing problem solving model which is used for advisory or consultancy role (Birmingham & Klinker, 2009). According to Jones (2010), there are two main steps in knowledge acquisition process which are accompanied by knowledge engineer. These are: knowledge elicitation- extracting tacit and explicit knowledge and knowledge structuring - using the concepts discovered during knowledge elicitation phase to build a model.

The process of knowledge acquisition in this research encompasses some basic activities such as gathering the required knowledge, analyzing that knowledge, identifying important concepts (urban land development control) and finally modeling them in using hierarchical structure.

3.1.1 Knowledge Acquisition from Domain Experts

Primary sources of knowledge were collected from domain experts in JCLDAA. To gather the required knowledge semi-structured interview technique has been employed. Since one of the main focuses of this chapter is eliciting relevant tacit knowledge from the domain experts, five domain experts from members of urban development control department and lease office were selected using purposive sampling technique. As a result, urban land planners from this department have been interviewed to obtain the required knowledge on the domain area. The expertise of a planner is usually not written down on paper and remains within their brain. The planner can form opinions with his/her working experience increasing about which aspects should be intensively considered, and which aspects should be slightly considered. These opinions and experience are important knowledge sources.

The domains of interview with expert covered issues such as how the expert interact with their client, what are the criteria's to be considered in order to assign construction commencement and completion period, payment period and damage deposit for the new development. What additional factors considered between different land use types which includes commercial, mixed, residential and industrial.

During the extensive discussion, the researcher acquired the relevant tacit knowledge which is significant to generate the proposed cases. In addition the domain experts were actively participated throughout the research work and they are consulted to confirm the correctness of the acquired knowledge. During face to face communication, the acquired knowledge from domain experts has been recorded manually by using pen and paper sheet.

According to the domain experts' response, the investigation regarding to the four critical determinants started by collecting some relevant information such as initial lease price, highest bid price, advance payment, total lease amount, basemap number, plot size (land holding size), building height, land grade and land use types. Besides they also stated that the period of commencement and completion of construction determined depending on the complexity of the construction. In order to reach to the final decision members of urban development control department and lease office requires detail information regarding to the construction project that is expected to be developed in the near future. Planning department is the one who is responsible to collect and prepare the necessary information for urban development control department and lease office to make the decision which includes height of the building, basemap number, land holding size and built up area, land use types and building type. In addition, in the case of any damage that will happen on infrastructural networks such as roads, water supply, sewerage disposal system, electricity and telephone lines caused by the newly development carried out on a particular parcel of land, the owner of the land expected to deposit amount of money or a compensation in a blocked bank account for the purpose of maintaining the damaged infrastructure network as it is determined by the appropriate body. But in order to assess and confirm the environmental situation of the bare land, experts are expected to physically observe the place so that it is possible to determine the appropriate amount of deposit reserved for the damage. According to their response, basemap number could easily substitute the activity of this task since it consist details about the location and infrastructural networks available around the land. Furthermore, the experts explained that payment period is determined by considering the total lease amount as well as advance payment paid by the tenant prior to finalizing the agreement with the municipal government.

Since the main goal of this research is to identify the factors that affect the decision making process of urban land development, the researcher asked questions to domain experts about "what are the main attributes having effect on the decision making process of urban land development? ". The researcher also asked the effect of some attributes that found from different secondary sources to get confirmation from domain experts whether it has effect or not; particularly on their level of importance that each attribute had individually and collectively on the four critical determinants. Also among the total number of collected attributes, urban land experts was consulted in order to identify and exclude attributes with no importance or less level of significance on the final decision making process. For instance plot number, period of lease, kebele, built up area, registration number, block number, site corner coordination, approximate construction cost and date of agreement attributes are rejected by discussing with urban land experts due to less level of importance they had on land development control decision.

3.1.2 Knowledge Acquisition from Relevant Documents

Document analysis involves gathering knowledge from existing documentations. Hence, document analysis has been carried out to acquire explicit knowledge which is found in various secondary sources of knowledge. In order to elicit knowledge for this research relevant documents which are related to urban land development control have been reviewed. The documented knowledge involved in land development control includes the governmental policies, articles that are published in different journals, research papers, Manuals and Guideline that are used in land development control decision making process. Specifically lease hold certificate, site plan proposing form, bidding documents, lease contract document and the archived cases was the major source of document since they consisted valuable inputs for the prototype system. The governmental policies are the paper-based publications. They can be further classified into the following: Ethiopia Urban Lands Lease Holding Proclamation, Town Planning Ordinance (TPO), Oromia Regional State Urban Planning Standards and Guidelines (ORSUPSG), Jimma structure plan manual and local development plan, and the Town Planning Board Guidelines (TPBG). These five subtypes are issued by different governmental departments and have different usability with respect to land development control. Ethiopia Urban Lands Lease Holding Proclamation is prepared and issued by the FDRE government which is the highest level among the policies related with town planning and land development control. As the result, relevant and technical knowledge were extracted and structured in a manner that suitable for knowledge modeling and finally knowledge representation.

The archived cases, both successful and unsuccessful landholder's, which were collected from Jimma city land development and administration agency record and archive office is the main sources used to develop CBRSULDC are also another relevant document. In the archival office, all the cases that passed the first phase and come to the second step to make the final decision; either approved or rejected by urban development control department and lease office have been archived. Furthermore; unsuccessful land development cases, landholder's whose leasehold contract was terminated and took back the land by the municipal government because they fail to start and complete the construction within the period specified in the contract, is important source of documents which creates a conducive environment for the experts to learn from such previous mistakes and prevent future failures. From the archived cases, it is possible to get some implicit factors and tendency about the processing of urban land development. And also the list of available land use types, lease period for each type of land use, a generic guideline to period of payment, the benchmark price for each land grade, the type of building allowed to be constructed depending on location of the plot and minimal amount of advance payment for a particular land grade have been collected from Urban Lands Lease Holding Proclamation and guidelines at regional and city administration level. The detail of this knowledge acquired from different sources that focus on land development control is discussed, structured and conceptually modeled in section 3.2.

3.2 Conceptual Knowledge modeling

Once the required knowledge is acquired from pervious tenant cases, urban land experts and other relevant documents, the next step is modeling the knowledge. During the knowledge modeling phase, the acquired knowledge (elicited by various techniques) is represented in a knowledge model. A knowledge model is a structured representation of knowledge using symbols to represent pieces of knowledge and the relationships between them. Knowledge models include symbolic character based languages such as logic, diagrammatic representations such as networks and ladders, tabular representation such as matrices and structured text such as hypertext. The generation and modification cycle of a knowledge model is an essential part of the knowledge modeling phase. The model helps to ensure that all stakeholders in a proposed system understand the language and terminology being used and quickly conveys information for validation and modification where necessary (Makhfi, 2011).

During the knowledge acquisition stage, knowledge engineer collects both tacit and explicit knowledge. The knowledge engineer tries to understand both the tacit and the explicit part of the knowledge and then use simple visual diagrams to stimulate discussion amongst users and knowledge experts. Then knowledge engineer has to construct the conceptual model from what has been discussed during the knowledge acquisition stage. This communicates the knowledge to the knowledge engineer who transforms the model into workable computer programs or codes.

There are different conceptual modeling techniques and for this study hierarchical structure is used to model how decision will be made in the process of urban land development control. To make the acquired knowledge reasonable for knowledge representation it is modeled using hierarchical structures. The context of this hierarchical structure is used to demonstrate clearly the decision making process of urban land development control which are implemented by using jCOLIBRI programming tool.

The model was built by the knowledge engineer after the core concepts are extracted from domain experts and secondary source of data (document analysis). After acquiring the required knowledge, the knowledge engineer makes a discussion with domain experts to validate the reliability of the knowledge that acquired from different source for urban land development control. Mainly urban land allocation is done in taking consideration of the attributes such as initial lease price, highest bid price, advance payment, total lease amount, basemap number, plot size (land holding size), building height, land grade and land use types. In this study, the conceptual modeling technique is used to show how urban land development control is held on.

Hierarchical structure was used to model the knowledge. The hierarchical structure as shown in figure 3.1 is derived from the knowledge acquired from the consultations of experts and secondary sources. These hierarchical structures are the base for the prototype knowledge based system development. The prototype case based system is developed based on the model presented in this hierarchical structure. The prototype follows the procedures presented in the hierarchical structure to recommend construction commencement and completion period, payment period and damage deposit along side with status of previous decision during urban land allocation process. In the following hierarchical structure figure 3.1 the main factors of urban land allocation decision and the fundamental procedures during urban land development control are structured.

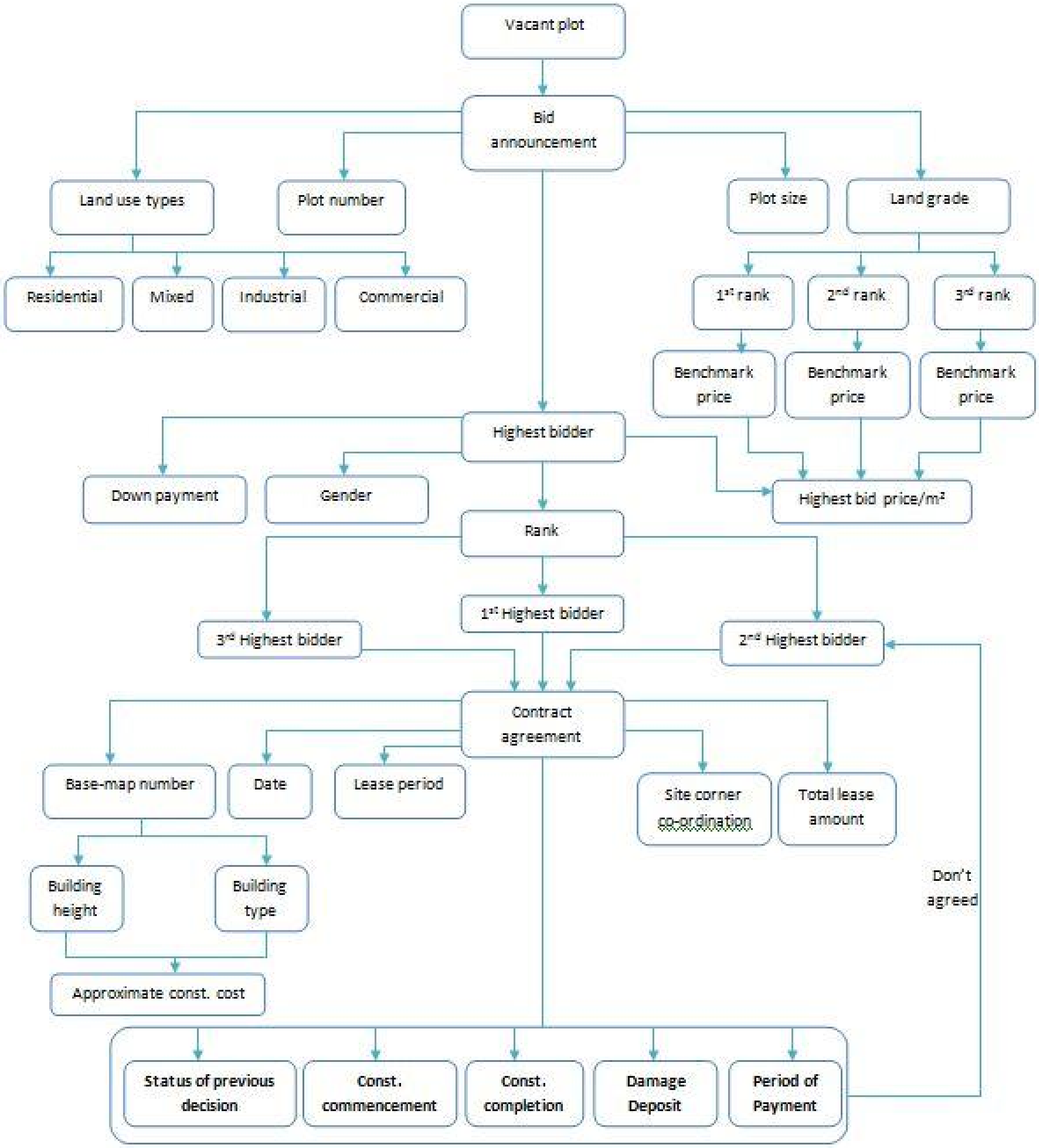

Figure 3.1: hierarchical structure of urban land development control

3.2.1 Processing Procedure of Urban Land Development Control

Land development control function seeks to manage and regulate land development and ensure that all developments takes place at an appropriate time and place and in such a manner that it conforms to a pre-determined set of objectives, policies or standards. Urban land development control is the procedure to ensure that the development follows the structural and local development plan (LDP) of a particular city. Moreover urban land development control is a process which is considered on a small site to evaluate a kind of development by taking the factors such as the government policies, the socioeconomic and environmental impacts, the traffic and infrastructural implications, and compatibility of land uses, into consideration. The main purpose of land development control is to ensure the orderly, rational and efficient development of land to create sustainable human settlements. Development control is the most critical step in urban land management.

Previously before the beginning of lease tenure system in Ethiopia, land used to be acquired through five methods: Auction, Negotiation, Assignment, Lot and Award. Now, since most of them open door for corruption and "rent seeking" behaviors, only Auction (tender) and Allotment (land transfer without auction) are recognized (art.7.2). The current land policy in Ethiopia is that land belongs to the state and the people as it is provided by Article 40 of the Constitution of the Federal Democratic Republic of Ethiopia that land is the property of the State and the peoples of Ethiopia and that its use shall be subject to specific regulation by law; and no land can be obtained or transferred other than on a leasehold basis. Lease means a system of land tenure by which the right of use of urban land is acquired under a contract of a definite period. Regions and city administrations shall have the powers and duties to administer land in all urban centers in accordance with the Proclamation (FDRE, 2011).

In Ethiopia the options available to acquire urban land to be held by leasehold include tendering and allotment. Allotment of urban lands may, upon decisions of the cabinet of the concerned region or the city administration, be permitted for (FDRE, 2011):

a) office premises of budgetary government entities;

b) social service institutions run by government or charitable organizations;

c) public residential housing construction programs and government approved self-help housing constructions;

d) places of worship of religious organizations ;

e) use of embassies and international organizations as per agreements entered into with the government;

f) projects having special national significance and considered by the president of the region or the mayor of the city administration and referred to the cabinet.

The second option is through tender process which is a modality of transferring lease of urban land to a bid winner fulfilling the competition requirements issued based on the rule of market competition of urban land tenure. Regions and city administrations based on the demand for urban land and development priorities shall prepare in advance plots of urban land and publicize their annual plans indicating the quantity of urban land to be presented for tender, for higher education institutions, hospitals, health research institutions, four star and above hotels and mega real estate developments, to be undertaken by the private sector. In tender Process, the appropriate body will advertize lease tender and forthwith put bid documents on sale. The information relating to urban land prepared for tender shall contain the land grade, the lease benchmark price and other detailed relevant data's. The sale of bid documents should be in a manner accessible to anyone willing to bid; provided, however, that no single bidder may be allowed to buy more than one bid document for the same plot. The highest bidder will be declared a winner on the basis of his bid price and the amount of advance payment he offers. Any person permitted urban land lease holding in accordance with the Proclamation be obliged to conclude a contract of lease with the appropriate body. The lease contract will include the construction start-up time, completion time, payment schedule, damage deposit, the rights and obligations of the parties as well as other appropriate details (FDRE, 2011).

Urban development control department in collaboration with lease office are responsible parts to set appropriate values for the four critical determinants in urban land development and administration agency. The bid winner cannot declared as owner of the land unless and otherwise he/she reach to an agreement with the municipal government. The pre-selection stage by itself cannot make the bid winner holder of the land. The bid winner is expected to accept and sign what is determined by the experts. Among many competitors, only top three of them will be chosen to join the second phase. If the highest bidder could not reach to an agreement on the four critical determinants which is determined by urban development control department and lease office experts, the chance will be given to the second winner to conclude an agreement with the municipal authority. This process will repeat itself and the chance goes to the third winner unless one of the highest bidders agrees and concludes a contract with the appropriate body (MUDC, 2012).

There are respective experts available in the departments who are in charge of determining the required values regarding to the four critical determinants. The involvement of various experts in particular Land Administrators/Managers, Land surveyors, Engineers, Estate Surveyors and Urban planners among others is essential to come with the final decision. After isolated analysis by individual experts, they come and sit together and held lengthy discussion in order to reach to mutual agreement. Based on their experience and analysis of legal framework including review of proclamation as well as other necessary documents that helps to ensure whether or not the new development project should carried out in conformity with the urban plan guidelines, they determine the period of time required to start and complete a specific construction on a parcel of land, the period of time required to complete lease payment and the amount of money required to maintain any damage that will happen on the surrounding infrastructural networks (UPSBB, 2013).

A person who has signed a lease contract will going to receive a lease holding certificate prepared in accordance with Article 17 of the FDRE Urban Lands Lease Holding Proclamation No. 721/2011 and shall receive the plot of land by personally appearing on site. The leasehold certificate contains the following particulars such as: full name of the lessee including grand father's name, size and location of the plot, the type of service, land grade, plot number, the total lease amount and down payment, the amount of the annual lease payment and the time of the final lease payment to be effected, and the lease period. Beside; regarding to period of urban land lease, it varies depending on the level of urban development and sector of development activity or the type of service and should have the ceiling of: 99 years for residential housing, science and technology, research and study, government offices, charitable organizations, and religious institutions; 15 years for urban agriculture; 80 years for industry; 70 years for commerce; and 70 years for others (FDRE, 2011).

Any person permitted urban land lease holding is allowed grace period depending on the type of the intended development or service. Once the lease hold certificate prepared and issued to the tenant, the municipal government have the responsibility to follow up and ensure that the urban land handed over pursuant to Article 16 sub article (4) is developed in accordance with the lease contract and that the annual lease payment is effected timely. Therefore; any person permitted urban landholding fails to commence construction within the specified period, the tenant shall be liable to pay a penalty fee and the municipal government can take back the land. In addition a lessee permitted urban land leasehold in accordance with sub-article (1) of Article 12 of the FDRE Proclamation fails to complete construction within the period specified in the contract, the leasehold contract will be terminated; and the appropriate body will take back the land. The person, whose lease contract is terminated have to, at his own cost, remove his property from the land within six months. However; the person fails to remove his property, the municipal government can transfer it through open tender to a person who can complete and use the building; or clear the land at its own cost and recover such cost from the lease down payment or from the damage deposit in his blocked bank account (FDRE, 2011).

Regarding to period of payment, the proclamation states that failure to pay the annual payment in time as originally scheduled will result in penalty fee equivalent to the rate of penalty fee imposed by the Commercial Bank of Ethiopia on defaulting debtors. However; a lessee has failed to make payments within the specified time limit and accumulated arrears for three years, the municipal government have the power to seize and sale the property of the lessee to collect the arrears (FDRE, 2011).

3.2.2 Factors That Influence Urban Land Allocation Decisions

In processing land development, many factors such as government policies, socioeconomic and environmental impacts, traffic and infrastructural implications, and the compatibility of land uses should be taken into consideration. However, it is quite complex to consider all these factors collectively, even though there are policies and regulations like the FDRE urban land lease holding proclamation and Guidelines providing criteria on them.

Land development should have to be done with the aim to promote the health, safety, convenience and general welfare of the community (UPSBB, 2013). Before making the decision examining each factors that have impact on land allocation decision is an essential mechanism for plan implementation to ensure that development conforms to planning policies, land use zoning provisions and related environmental performance standards while safeguarding the land available to satisfy future needs. Without considering all the factors it might be difficult to bring the desired outcome which is creating conducive environment to live for the surrounding community.

The four critical determinants of a particular land vary from one to another depending on the location of the vacant land to be developed. For instance a given construction that will going to be carried out in central zone or downtown should be completed more faster compared to transitional or peri-urban area since most of the time the density of the population in such area is very high; consequently this might affect activities of the local community.

So the major factors that influence urban land allocation decision are initial lease price, highest bid price, advance payment, total lease amount, basemap number, plot size (land holding size), building height, land grade and land use types. So all this factors has had a tremendous impact on the physical development of the city. The detail of each factor is discussed below:

- **Initial Lease Price**

As it is indicated below on figure3.2, a lease benchmark price or initial lease price is explained as a threshold price determined by taking into account the cost of infrastructural development, demolition cost as well as compensation to be paid to displaced persons in case of built up areas, and other relevant factors; the price differs depending on the grade of the land that is 1st, 2nd and 3rd rank. Every plot of urban land has a benchmark lease price. The benchmark lease price required to be updated at least every two years to reflect current conditions. Lease benchmark price is one of the information that will be announced for the bidders during preparation of urban land for tender. In addition with lease benchmark price, bid documents should have to contain the land grade and other detailed relevant data's. The valuation method shall be determined on the basis of the objective conditions of each urban center in accordance with regulations issued by the respective regions and city administrations.

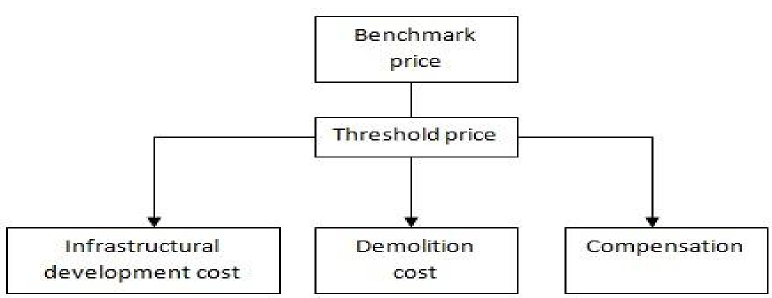

Figure 3.2: benchmark price determinates

Lease benchmark price = compensation for land + demolition cost + infrastructure (water…). The idea is that government calculates the cost of developing land to be leased out.

- **Highest Bid Price**

Highest bid price is the price which is given for a particular square meter plot. The benchmark price announced first Before the tender process starts which is the threshold price determined by taking into account the cost of infrastructural development, demolition cost as well as compensation to be paid to displaced persons in case of built up areas, and other relevant factors. The benchmark price differs depending on the grade of the land which comprises three different levels. As it is stated above during the pre-selection stage there are only two criteria that made a person win to acquire a particular urban land. The first one is the amount of down payment of the lease price to be paid by the winner at one time and the second is the highest bid price offered for one square meter plot of land. Accordingly the highest bidder will be declared a winner on the basis of his bid price and the amount of advance payment he offers. As it is indicated on figure3.3, in bidding process out of many competitors, only top three of them will be chosen to join the second phase. If the highest bidder could not reach to an agreement on the four critical determinants which is determined by urban development control department and lease office experts, the chance will be given to the second or third winner to conclude an agreement with the municipal authority. However; still the pre-selection process doesn't provide full guarantee to the winner until he/she proved his capability to accept and implement the intended project which is verified by the appropriate body. In the second phase experts examine the capabilities of the candidate by looking at different factors such as the project design corresponding to its approximate construction value which is required to finish the planned project, the construction completion period as it is planned by the candidate with the actual period needed to complete the project and other necessary details. All these factors examined according to the rules and regulations of the authority by the right expert before they reached to an agreement (FDRE, 2011).

Figure 3.3: highest bid price factor on a bid winner

- **Down Payment**

Down payment is any initial or partial payment as to reduce one's indebtedness. The highest bidder shall be declared a winner on the basis of his bid price and the amount of advance payment he offers. The amount of down payment, to be determined in accordance with the prevailing factors of the region or the city administration, may not be less than 10% of the total lease amount of the urban land, but it also can go higher. The amount of advance payment can be determined, as shown in the figure3.4 down payment derivative and its minimal requirement, by calculating the percentage of the down payment from the total lease amount which is computed by multiplying the highest bid price with the total land size. So a person permitted urban land lease holding will be made aware of the contents of the lease contract and have to effect the down payment of the lease price prior to signing the contract (FDRE, 2011).

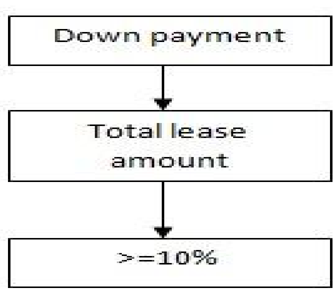

Figure 3.4: down payment derivative and its minimal requirement

- **Land Grade**

Among much information's that will be announced for the bidders relating to urban land prepared for tender which contain the lease benchmark price and other detailed relevant data's, land grade is the one that provides detail information about the quality and level of a particular plot. As it is indicated on figure 3.5 land grade category and its determinant, there are three basic land grade categories for a particular parcel of urban land. Lease price of urban land have a strong relation with land grades (grades 1 up to 3), and location (central zones, transitional zones, and expansion zones). A given land pegged at grade one class should fetch the highest price in the city (FDRE, 2011).

The prices of plots of urban land decrease as the distance from the centre increases. Grades are determined by the proximity of a particular plot of land to main roads. The land lease policy value in the city varies depending up-on the specific location of a site (which is graded on the level of infrastructure development supplies such as road, water, telecommunication, and education facilities).

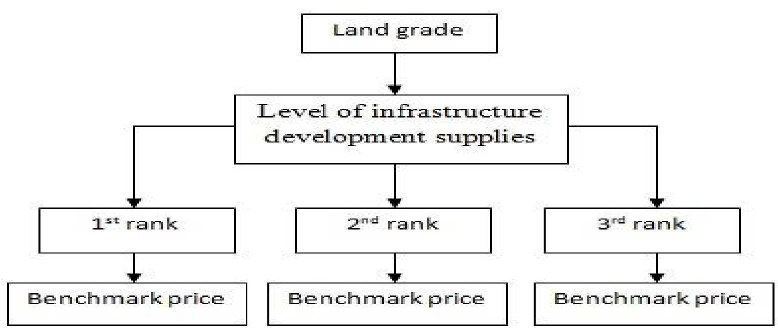

Figure 3.5: land grade category and its determinate

- **Land Use Types**

Land use is general term with a somewhat obvious meaning. It is what the land is used for by humans. That is, humans take the natural environment and change it for their own purposes. In the urban area, land is used in different ways. As shown in figure 3.6: broad category of land use types; these land use types include residential, institutional, mixed, commercial, industrial, transport, recreational, social service and forestry. These broad categories can be subdivided. For example residential land use can involve single-family dwellings on large or small plots, or large groups on estates of semi-detached or terraced houses. Institutional land uses are mostly occupied by public buildings such as schools, universities, government office buildings, and museums and hospitals. These facilities are most commonly located in urban or suburban areas.

As it is stated above, in Ethiopia the options available to acquire urban land to be held by leasehold include tendering and allotment. Tendering is a modality of transferring lease of urban land to a bid winner fulfilling the competition requirements issued based on the rule of market competition of urban land tenure. Even if a lot of different land use types are there, the focus of the study is towards land use types acquired through a tender process which includes residential, mixed, commercial and industrial (FDRE, 2011).

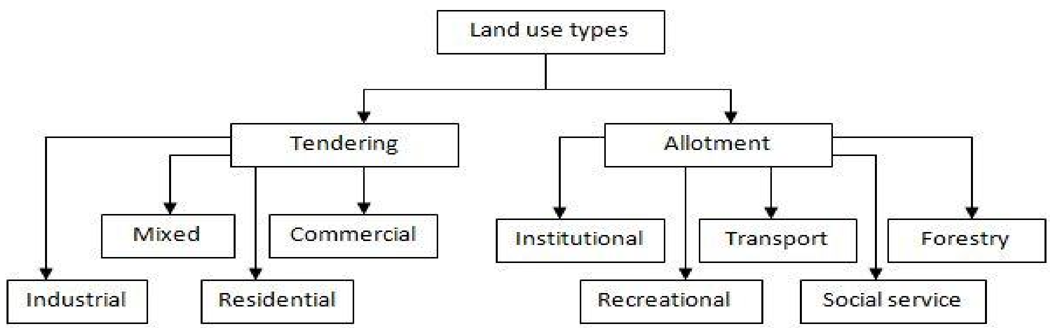

Figure 3.6: broad category of land use types

- **Commercial Land Use**

Commercial areas in a city can take up about 5% of a city's land. It is used for commercial activities. These activities include the buying and selling of goods and services in retail businesses, wholesale buying and selling, financial establishments, and wide variety of services that are broadly classified as "business". Even though these commercial activities use only a small amount of land, they are extremely important to a community's economy. They provide jobs and bring money into the community. A commercial area is real estate intended for use by for-profit businesses, such as office complexes, shopping malls, service stations and restaurants. Practically every incorporated city uses a zoning system to regulate the use of property within its jurisdiction. In order to grant permission to build a new office complex or other profit-making business, the city government must determine that the chosen area is indeed commercial area. The zones which separate commercial, industrial, and residential area are clearly marked on city maps. If the proposed business is clearly in an area zoned for commercial use, then the city will allow the sale to proceed for the stated use. If any part of the property extends into a residential or industrial zone, however, then the buyer must seek a 'variance', special permission to cross over a zone boundary (FDRE, 2011).

- **Mixed Land Use**

Mixed use classifications are intended to accommodate several compatible land use categories, including most residential uses, neighborhood retail, service commercial, institutional uses, and light industrial activities. Mixed land use classifications are promote smart growth principles and are subdivided into the following categories and administered primarily through zoning district classification.

Mixed-Use Categories:

A. City Center – Suitable for a wide range of residential and commercial land uses, including vertical and horizontal mixed uses, attached single-family and multifamily housing, community and neighborhood retail, professional offices, services, hotel-motel, entertainment, cultural, and civic uses. The primary goal of this classification is to create a mixed use pedestrian area. Highly automobile dependent uses and surface parking lots are generally discouraged in the core area of this classification.

B. Traditional Neighborhood – Suitable for a blend of medium and high density residential, small scale commercial, entertainment, educational, office, and open space uses that are geared to serve residents within a one-mile radius. The purpose of this designation is to create a centralized, pedestrian-oriented, identifiable focal point for neighborhood districts. The residential density range shall be at least six (6) units per gross acre but not exceed twenty (20) units per gross acre.

C. Highway Corridor – Suitable for a blend of highway oriented commercial uses, business parks, limited light industrial uses, educational, office, and high density residential uses. The purpose of this designation is to identify key areas along a highway corridor which are highly visible or transitional in nature. Development in this area should occur in a manner that does not disrupt the function of the highway system. The residential density range shall be at least six (6) units per gross acre but not exceed forty (40) units per gross acre.

- **Residential Land Use**

In some areas, many houses and buildings are built for people to live in. This type of land use is called residential use. Residential land uses range from high density, represented by the multiple-unit structures of urban cores, to low density, where houses are on lots of more than an acre,, on the periphery of urban expansion. Linear residential developments along transportation routes extending outward from urban areas should be included as residential appendages to urban centers, but care must be taken to distinguish them from commercial strips in the same locality. The residential strips generally have a uniform size and spacing of structures, linear driveways, and lawn areas; the commercial strips are more likely to have buildings of different sizes and spacing, large driveways, and parking areas. Residential development along shorelines is also linear and sometimes extends back only one residential parcel from the shoreline to the first road.

Residential Categories:

A. Residential Estate – Suitable for the promotion of low-density residential uses of a semi-rural character. This classification is intended to protect and enhance single-family living areas that are rural in character or otherwise transitional in relationship to more urbanized residential areas of higher density. Residential units may be clustered into multiple building styles. Such areas may not necessarily have a full range of urban utilities and services contingent upon topography, density, lot size, and development designs. The residential density range shall not exceed two (2) dwelling units per gross acre.

B. Low-Density Residential – Suitable for single-family residential neighborhoods, to include churches, schools, neighborhood parks, comparable public facilities, and essential utility locations. The residential density range for a single-family residential subdivision shall not exceed three (3) dwelling units per acre. A planned-unit development with mixed uses, such as duplexes, townhouses, and compatible non-residential uses, may be permitted at a residential density of not more than six (6) dwelling units per gross acre.

C. Medium-Density Residential – Suitable for infill development or a transitional district to include a mixture of dwelling choices (attached and detached), churches, schools, group day care facilities, public facilities, and limited neighborhood commercial uses. Manufactured home parks and manufactured home subdivisions may be located in designated and selected medium density areas. The residential density range shall not exceed four (4) dwelling units per gross acre for a single-family residential subdivision and shall not exceed ten (10) dwelling units per gross acre for a mixed use (planned unit development) site.

D. High-Density Residential – Suitable for more intense land uses and as a transitional district to include: multi-family housing such as apartments, townhouses, condominiums, and manufactured home parks. This classification is also suitable for professional office development and limited neighborhood commercial uses, public and semi-public uses, and compatible institutional uses. The residential density range shall not exceed twenty-five (25) units per gross acre and it shall not exceed thirty-five (35) units per gross acre for a mixed use (planned unit development) site.

- **Industrial Land Use**

This type of land use is relating to factories that actively make different product. This type of land use is called industrial use. Industrial classifications are intended to accommodate a wide range of industrial uses including manufacturing, processing, warehousing, wholesaling and limited commercial and office uses. Industrial land use areas are classified as "industrial" on the Comprehensive Plan map, but divided into three (3) sub-categories that are administered primarily through zoning district classification.

Industrial Categories:

A. Industrial Park – Suitable for corporate offices, office parks, and light industrial uses planned, designed and constructed on a coordinated basis.

B. Light Industrial – Suitable for the manufacturing, processing, assembling, packaging or fabricating of previously prepared materials; research and development activities; and warehousing. Also suitable for limited commercial activities involving large areas for storage/display and limited residential uses such as manufactured home parks.

C. Heavy Industrial – Suitable for light industrial uses, manufacturing and processing of products predominately from extracted or raw materials; wrecking; and storage activities.

- **Plot Size (Land Holding Size)**

Plot is a parcel of land meant to be owned by some owner(s). Possible owner(s) of a lot can be one or more person(s) or another legal entity, such as a company/corporation, organization, government, or trust. Figure 3.7 clearly depicts that plot size alongside with highest bid price and lease period, are the major determinant which plays a key role in determining land values. The task of vacant land preparation including grade, size, and other detail for tender is accomplished by the city administration. Plot size multiplied by highest bid price and lease period yields the total lease amount. A leasehold certificate that will be issued to a person to whom an urban land lease holding is permitted should have to contain information regarding to size of the plot.

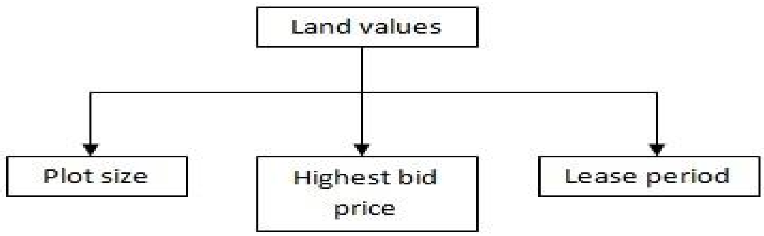

Figure 3.7: land value determinants

- **Basemap Number**

The term basemap refers to a collection of GIS data that form the background setting for a map. Basemap number is one part of a comprehensive plan which specifies in considerable detail what may be constructed in each zone and to what uses structures may be put. The function of the basemap is to provide background detail necessary to orient the location of the map. There are two types of physical plan: structure plans and land use plans. A land use plan has a legal status and indicates what is (not) allowed on a parcel of land, whereas a structure plan is only indicative for possible future land use development. In urban land grant process, the appropriate body authorizes the proposed land use where it ascertains that it is in conformity with the land use plan of the urban center, which is determined by the basemap number.

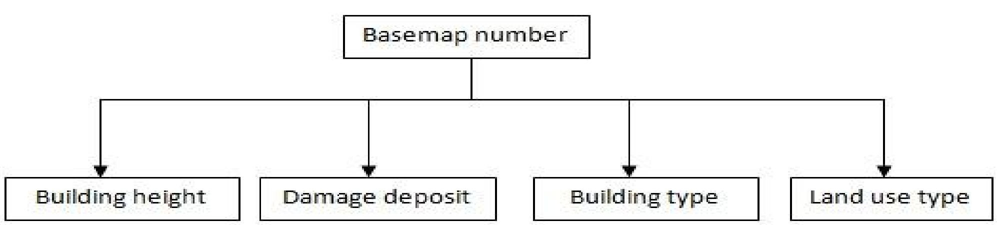

Figure 3.8: list of attributes determined by basemap

Basemap displays play an important role in the communication of physical planning information. Physical planning maps play an important role in the realization of land use plans, but also in the communication of information about what is and what is not allowed in geographical space or on specific land parcels. This basemap, a part of LDP which is designed by the authorized body should fit into the physical planning policies of the government at a higher level in the hierarchy (the state). Future land use basemaps describe the future land use plan. It is a long-range plan intended to guide the growth and development of a community. Future land use is tracked and rendered on each parcel. Different part of the basemap distinguished by a basemap number which indicates what kind of new development should be established on a particular parcel such as the building type, height of the building, land use types and also different infrastructural network available on a bare land which helps to compute the cost required for damage deposit as it is illustrated in figure 3.8.. The basemaps found on Jimma city master plan accounts a total number of around 92 distinguished basemap numbers as it is indicated on the diagram found below. In general, the four critical determinants varied depend on different basemap numbers which indicates whether the new development is going to carried out around central, transitional and expansion or peri-urban areas. New development around central zones should be completed more faster than transitional or expansion zones since it might bring a negative impact on activities of the local community. So the basemap number helps to crosscheck whether the construction is carried out according to the LDP as well as to take appropriate measure on new development depending on the location of the construction (FDRE, 2011).

Figure 3.9: Jimma city partial basemap

Source: Adapted from Jimma structure and local development plan manual (UPSBB, 2013)

❖ **Building Height**

Height of buildings is to be regulated and there is some kind of height restriction depending on different factors. For instance some restrictions limit the height of new buildings so as not to block views of an older work decreed to be an important landmark by a government. Other restrictions are because of practical concern, such as around airports to prevent any danger to flight safety. Also the type of soil that the foundation will sit on is important for two reasons: first it should be able to bear the weight (load) of the foundation and the extension - different soils have different load bearing capabilities. Second the way it reacts to variations in moisture content (such as in prolonged rainy or dry seasons) can lead to the soil expanding or contracting. This is a particular issue with some clay soils. So building height of a particular project can be determined based on the above factors and beside as illustrated on figure 3.10, it also allows to determine construction startup and completion period as well as approximate construction value. Building regulations provide standards related to size of rooms, height of buildings, openings for light and ventilation, and type of materials used, as well as other aspects of construction. As it is stated previously basemap number contains such details alongside what is allowed or not allowed on a parcel of land (FDRE, 2011).

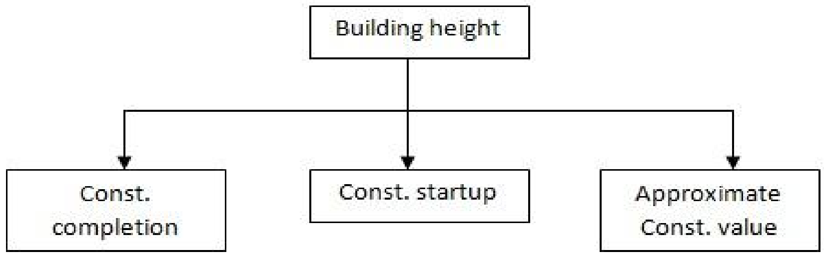

Figure 3.10: attributes affected by building height

- **Total Lease Amount (Lease Prays)**

Total lease amount is a price offered by a tenant for a specific square meters parcel of land. Figure 3.11 below shows that total lease amount is computed by multiplying the three attributes which is highest bid price, lease period and total land size. So a person permitted urban land lease holding will be made aware of the total lease amount and have to start the payment prior to signing the contract. Furthermore a person allowed to hold urban land will be given a period of lease payment taking into account the payback period of the investment. The remaining balance of the lease amount will be paid on the basis of equal annual installments during the payment term (FDRE, 2011).

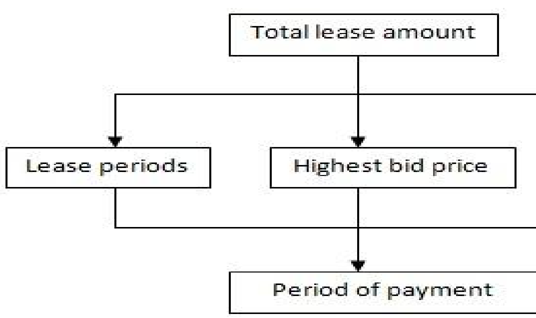

Figure 3.11: total lease amount factor on payment period

3.2.3 Building Permit

Building permit is the final formal permission to begin the construction. Any new developers required to obtain permits to ensure safe building, coordinated development, effective land use, and high-quality site planning. In Ethiopia as part of the building permit process, urban land development and lease office in collaboration with building permit and control authority staffs must review the owner plans to ensure they comply with the structural and local development plan, city building code, and other applicable law. Building permits regulate the type of construction allowed in a community and ensure that minimum building standards are met. The permit process protects the owner's interests, the community, and helps to ensure that any new construction is appropriate and safe.

After a careful assessment of the newly construction design by experts, upon consensus the authority will issue plan agreement to developers to whom land has been allocated or legal possessors of land to build in accordance with the structural and local development plans as well as levels of the construction. The evaluation is determined by experts and includes investigating and approving construction designs, analyzing quality control of the building, investigating the row material for the construction which should be pure and qualified. In addition, the approximate construction value indicates the extent of the bid winner by which he/she capable of implementing the intended project. Before they reached to an agreement, a certificate which shows the amount of his deposit in a blocked bank account should have to be submitted in the name of the project owner. Finally In order to get a building permit, the developer should have to conclude an agreement with the city administration on the four critical determinants which includes construction startup period, construction completion period, payment period and damage deposit (FDRE, 2011). The detail of the four critical determinants is discussed below:

3.2.3.1 Construction Commencement Period

Construction start-up means the construction of at least the foundation and erection of re-enforcement bars to cast columns of the permitted construction or building on the place. Any lessee expected to commence construction within the period specified in the lease contract. Notwithstanding the provisions of sub-article (1) of Article 22, the period of commencement of construction could be extended depending on the complexity of the construction and in accordance with regulations to be issued by the concerned region or city administration. Pursuant to article 22 of the urban landholding lease proclamation, where a lessee fails to commence construction within the period specified on the contract, the tenant will be liable to pay a penalty fee beside, the leasehold contract also could be terminated; and the municipal government shall take back the land. Therefore, experts who determine the startup period of the construction should come up with proper commencement period by considering the capability of the tenant as well as by examining all the possible factors that affect the startup period (FDRE, 2011).

3.2.3.2 Construction Completion Period

Completion of construction means the full completion of a building and makes it ready for use by installing basic utilities in accordance with the issued construction permit on a land permitted by lease. Most construction contracts set a date by which the works described in the contract must be completed. This is not the date by which all obligations under the contract have to be discharged, but the date by which practical completion must be certified. A lessee of urban land has to use the land for the prescribed purpose within the period of time stated in the lease contract. Pursuant to article 23 of the urban landholding lease proclamation; any lessee shall complete construction within the period specified in the lease contract following the time line which is determined by responsible experts who works in the municipal government. However; where a lessee fails to complete construction within the time limit specified under sub-article (1) of the Article specified above, the lease contract shall be terminated and the municipal government shall take back the land. Therefore, the lessee have to complete the intended construction project within the specified completion period as it is stared in the contract in accordance with standards found on building regulations which provides details regarding to size of rooms, height of buildings, openings for light , and type of materials used, as well as other aspects of construction (FDRE, 2011).

3.2.3.3 Period of Payment (Time of the Final Lease Payment)

A person permitted urban land lease holding will be given a period of lease payment taking into account the payback period of the investment. But before starting this annual payment, the tenant will be allowed grace period depending on the type of the intended development or service. In the FDRE urban land lease holding proclamation grace period refers to the time frame that a lessee is relieved from payment after effecting the advance lease payment and before the commencement of the annual lease payment. This grace period have to commence from the date of the conclusion of the lease contract and it should not last beyond the date of completion of construction. The amount of down payment, as determined by the region or the city administration, shall not be less than 10% of the total lease amount. The remaining balance will be paid on the basis of equal annual installments during the payment term. So regarding to the payment period, there are two basic parts to be determined by experts which is the amount of the annual lease payment and the time of the final lease payment to be effected. However; failure to pay the annual payment in time as originally scheduled will result in penalty fee equivalent to the rate of penalty fee imposed by the Commercial Bank of Ethiopia on defaulting debtors. Furthermore, where a lessee has failed to make payments within the specified time limit and accumulated arrears for three years, the appropriate body shall have the power to seize and sale the property of the lessee to collect the arrears (FDRE, 2011).

3.2.3.4 Damage Deposit

Based on the level of a project as well as location of the construction site such as central, transitional or expansion zones, a damage deposit is required at the time of building permit process. Once the project receives final occupancy, any unused portion of the damage deposit will be refunded to the party who tendered the damage deposit with the City. This deposit is to ensure repair of any damage to City properties. Such repairs might include clean up the road, sewer and sidewalk, remove all trash from the boulevards, water service, sanitary and others. If no deficiencies are outstanding and no damage to city property has been incurred, the deposit will be returned (FDRE, 2011).

3.2.4 Learning from Successes and Failures

Learning in CBR systems is driven by both successes and failures. After a solution has been generated, the final step is to apply the solution, to repair it if necessary, and to learn from the experience.

Success-driven learning: When the landholder's case status is successful; the solution is stored for future reuse, avoiding the need to re-derive it from scratch. Stored cases provide the information that a particular solution did or did not work in a specific real situation. In this way, case acquisition refines initial domain knowledge and allows the system to favor solutions that are more likely to be successful, based on its experience (Leake, 1996). Successful landholder's case indicates that beyond speculation the decision is already proved on the real environment, so that with no doubt it's possible to directly apply its solution to the new query or new case.

Failure-driven learning: CBR is committed to the value of learning from failures as well as successes. First, failures reveal that learning is needed. Second, failures help focus decisions about what to learn: the needed learning must help avoid future failures (Leake, 1996). CBR systems learn from task failures, in which their solutions are unsuccessful (Schank, 1982). Tenants who have failed to complete the newly developed construction project within the specified period are stored in the database as unsuccessful case with its decision on the four critical determinants. So next time this mistake will not be repeated again by the land development experts which is termed us failure driven learning.

In CBR systems, failures can trigger multiple types of learning. When a failed solution is repaired, the new solution is stored; this is simply learning from a new successful solution. In addition, information about the failure itself can be stored as database for future analysis when new information becomes available (Riesbeck & Schank, 1989) or to provide a warning about possible future failures that should be avoided. Within a city planning context, if the purpose is to learn from previous cases bad practices are certainly very important.

3.3 Knowledge Representation

Knowledge representation is one of the basic steps in the process of case based reasoning system development. Knowledge representation is the process of interpreting domain knowledge into computer understandable form using knowledge representation methods. Knowledge representation techniques include semantic network, logics, rules, case base and frames (Chakraborty, 2010). Among these, the researcher use case based representation method for this research.

Cases are the fundamental units of CBR. They are the essence of CBR and their structure in effect determines how CBR operates. A case is a contextualized piece of knowledge, representing an experience that teaches a lesson fundamental to achieving the goals of a reasoner (Kolodner, 1993). Main steps for building a case library includes: defining what a case is (contents/general information), deciding which features should be used to describe the case, and input the feature values for each case. Case representation is the hearth of the CBR system, so case library should correctly represent the experience and knowledge (about the domain) that obtained before. There must be a good number of projects in the ideal case library. To acquire a data is not enough for developing a case library; this data should be identified, classified, indexed and reformatted if required.

The acquired data or cases are represented using one of the different case base representation methods that are appropriate for the researcher. Case base representation methods include feature-value case representation, relational database case representation; predicate based case representation and soft computing case representation methods (Kaster, et al., 2005). For this research feature-value case base representation method is used. The reason for representing cases using feature-value case based representation is that this approach uses old experiences to understand and solve new problems. It also reuses its solutions and lessons learned for future use. And also it represents cases in a simple and more understandable way by using attribute and value pair representation (Bergmann et al., 2005).

For retrieval, the system should know how to match each feature of a new land development application with those of a previous case and how to evaluate the similarity between two cases. The similarity assessment methods for evaluating each feature and the entire case should be defined and the value of each parameter of the algorithm must be set (Shi & Yeh, 1999). The nearest neighbor algorithm (NN or KNN) is used by the system (for retrieval) to find the similarity between a new problem and a previous one. The KNN algorithm is:

$$s = \frac{\sum_{i=1}^{n} w_i \times sim(f_i^I, f_i^R)}{\sum_{i=1}^{n} w_i}$$

where s (Similarity Score) is the sum of weighted similarities of each feature and only those cases whose s is larger than a predefined threshold will be retrieved as the similar cases; w; is the importance of feature i, sim is the similarity assessing function for comparing feature fi, and fiI and fiR are the values for feature fi in the input new case and the retrieved old case respectively (Kolodner, 1993). When retrieving cases, the system calculates the similarities of the old cases in the library. For instance, in the study of Shi & Yeh (1999), only those cases whose similarity values are higher than (or equal) a threshold (in general, this is not compulsory) set by the user will be retrieved.

3.4 Urban Land Development Control Case Structure

Urban land development control case structure has two parts. The first one is the problem (land owner cases) descriptions and the second one is the solution.

Query Description: It is the part of the case structure that consist list of attributes which describes about landholders.

Solution: This part of the case structure provides the suggested construction startup and completion period, payment period and damage deposit required for a particular construction project carried out on a parcel of urban land. Therefore, for this research the researcher identify different description and solution attributes with the help of urban land development experts and from recorded data set of previous tenants' cases. There were different challenges during identification and representation of case structure. There was too many attributes that was found on tenants record during the pre-selection stage of attributes. So that, identifying the most significant attribute was one of the challenges that took long time to come up with the final list of important attributes. The second challenge was some of previous tenants information was missing or filled incorrectly or there was mismatch between attributes and values. So due to this the researcher selected 65 correctly filled successful and unsuccessful previous tenants cases from 17653 previous landholders cases and select 9 description attributes from total of 17 attribute to develop the prototype system.

The most important attributes that affects urban land allocation decision are listed below in table 3.1.

Attribute name	Parameter
initial lease price	Description
highest bid price	Description
advance payment	Description
total lease amount	Description
Basemap number	Description
plot size (land holding size)	Description
building height	Description

land grade	Description
Land use types	Description
construction commencement period	Solution
construction completion period	Solution
period of payment	Solution
damage deposit	Solution
Status	Solution

Table 3.1: The Case Structure for urban land development control

CHAPTER FOUR

DESIGN AND IMPLEMENTATION

The design and implementation part of this research involves the actual development of a prototype CBR system for urban land development control. Therefore, having all the necessary previous landholder's cases from JCLDAA and the knowledge from the domain expert and different relevant documents, the next task is coding the knowledge into computer using appropriate and efficient knowledge representation methods. After knowledge representation the next task is to develop the prototype case based system for urban land development control. For this research, jCOLIBR 1.1 CBR frame work is used to develop the prototype case based system. The retrieval algorithm used in this research is nearest neighbor retrieval algorithm. This is because jCOLIBRI uses nearest neighbor retrieval as a default algorithm for retrieval task. Nearest neighbor retrieval algorithm is also suitable when there are attributes which have numeric (continuous) value (Fag et al., 2007).

4.1 Architecture of CBR for urban land development control (CBRSULDC)

The architecture of the CBRSULDC system shown in figure 4.1 depicts how the prototype works during the decision making process of urban land allocation. As the new query (problem) is entered, the prototype of the system matches the new case to the solved case in the case base of the system by using similarity measurement. If relevant cases are found within the case base, then the prototype system ranks the relevant retrieved cases based on their local similarity. Next, the prototype proposes a solution.

Building of case based reasoning system was started by collecting the previously solved cases (i.e. previous landholder's cases) from JCLDAA consisting of landholders who are successfully acquired urban land by completing the construction project within the specified period in the lease contract as well as tenants whose leasehold of urban land is terminated because he/she failed to do so. Since previously solved cases having missing values and unnecessary information for this research, it need further processing in order to avoid missing values and remove unnecessary attributes. After processing of cases and selecting the most important attributes, assigning weight and important parameters for each attribute was the next performed step. For the selection of important attributes that influence urban land allocation decision, the researcher carried out in-depth consultation with the domain experts.

Once the case based system is developed, users/land development experts can use the system easily to decide on the period and cost of the four critical determinants based on the suggestion given by the system .When the land development expert enter their query/case description through the user interface window, the system searches the best matching cases from the case base and retains the possible solution. If there is exact matching between the query and previous cases in the case base, the system recommends the most matched period and cost of the four critical determinates with the status of the previous decision for a particular urban land. If the similarity between query and existing case is approximate, the proposed solution needs modification (adoption of solution) to fit the new case (query). At the end, the best modified solution will be stored into the case base for future use. The case base system updates its case library incrementally when the system learns from new case.

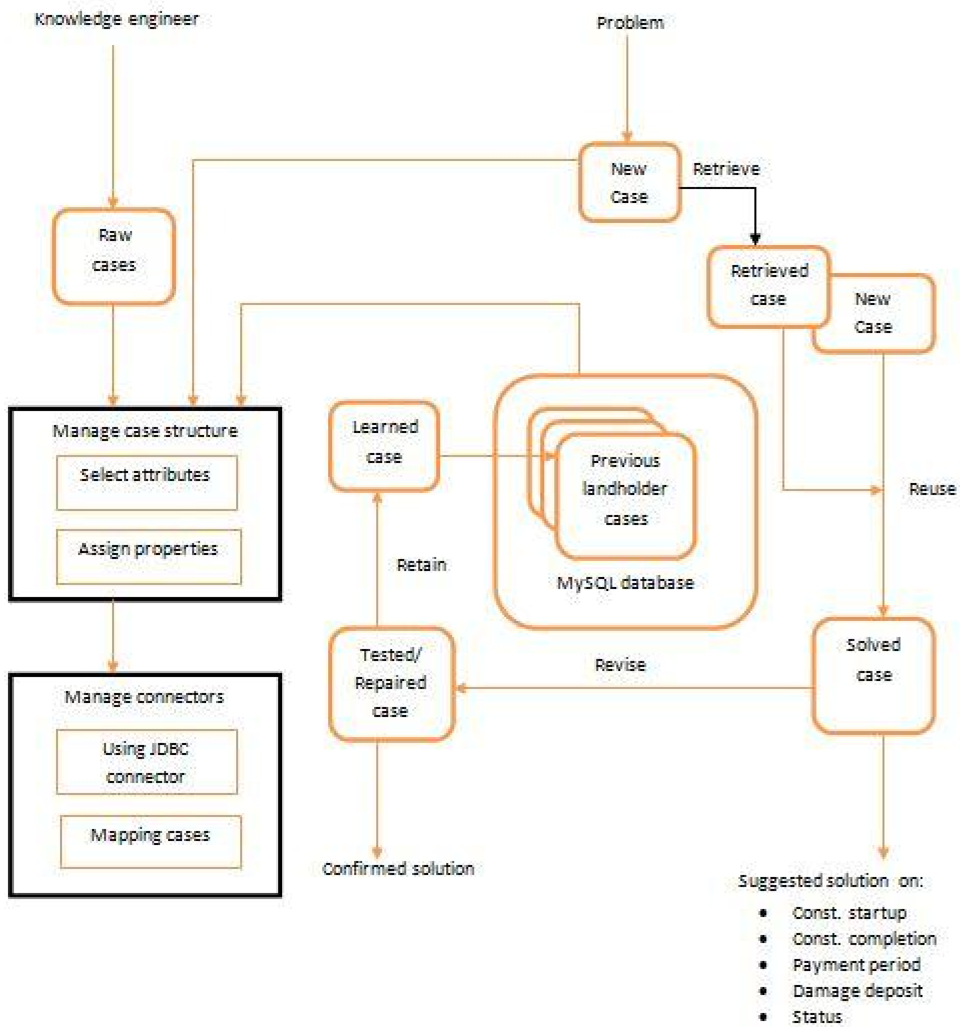

Figure 4.1: Architecture for CBRSULDC

The proposed solution can be derived directly from a retrieved case that matches exactly or partially to the problem of the new case. Partial match of retrieved cases means some attribute values of the existing case and new cases (query) are the same and some attribute values are different. Using the proposed solutions directly may have a risk because some attribute values need of editing (changing) based on different conditions. As a result the user of the system should have made an adaptation on the proposed solution having differences between the proposed case and the new case. In addition to adaptation, case contradictions are revised if there are situations where previous landholder's cases attribute values are not similar with the new case (query) attribute values. There is no similarity between the existing case and new case means there are no previous stored cases having similarity with the new case (query) in all attribute values. Therefore if there is no similarity between the existing and new case, the proposed solution cannot give recommendation to new cases. So during this time, this new case or problem of new landholders can be revised and stored in the case base. Finally, the revised solution is retained in the case base for problem solving for future use.

4.2 Case-based Reasoning System for urban land development control

The development of CBR application involves a number of steps, such as collecting cases and background knowledge, modeling a suitable case representation, defining an accurate similarity measure, implementing retrieval functionality, and implementing user interfaces (Stahl et al., 2008). In this study, the researcher uses the main or core feature of jCOLIBRI to deliver the actual prototype. As García et al (2008) presented jCOLIBRI has been constructed as a core module to offer the basic functionality for developing CBR application. Implementing a CBR application from scratch remains a time consuming software engineering process and requires a lot of specific experience beyond pure programming skills (Stahl et al., 2008).

jCOLIBRI can be started by clicking on exe file jCOLIBRIGUI.bat and then the GUI of jCOLIBRI will appear and it becomes ready for usage as shown in figure 4.2. GUI of jCOLIBRI helps one to create new CBR application with predefined task and methods. These predefined tasks and methods are represented in XML files that describe the tasks supported by the framework (tasks.xml) along with the methods for solving these tasks (methods.xml). The predefined tasks and methods stored in the framework of jCOLIBRI GUI for the purpose of configure the new system using (reusing) the tasks and methods that are predefined in the framework tasks.xml and methods.xml. Building a CBR system is a configuration process where the system developer selects the tasks the system must fulfill and for every task assigns the method that will do the task (García et al., 2008).

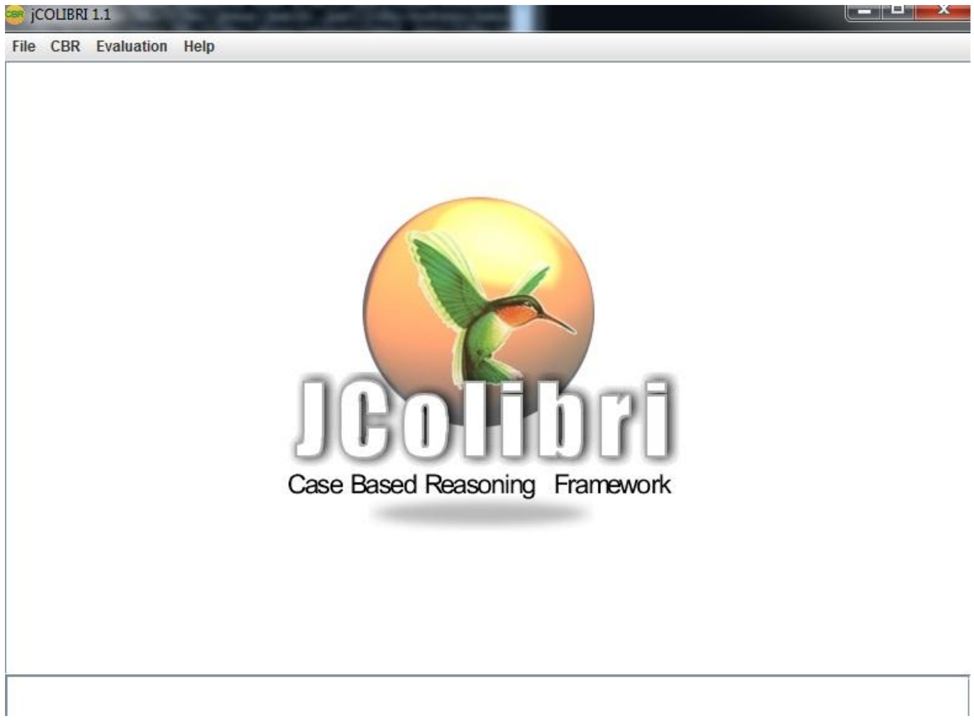

Figure 4.2: The Main Window of jCOLIBRI

After running jCOLIBRI GUI as shown in figure 4.2, the next task was creating new CBR applications. Figure 4.2, Shows the main window of jCOLIBRI with upper toolbar consisting of 4 menu lists, namely, file, CBR, Evaluation and Help. New CBR application can be developed step by step through this GUI. To develop new CBR application the next step is select "new CBR system" on the CBR toolbar. After that the box for entering new application name are displayed as shown figure 4.3.

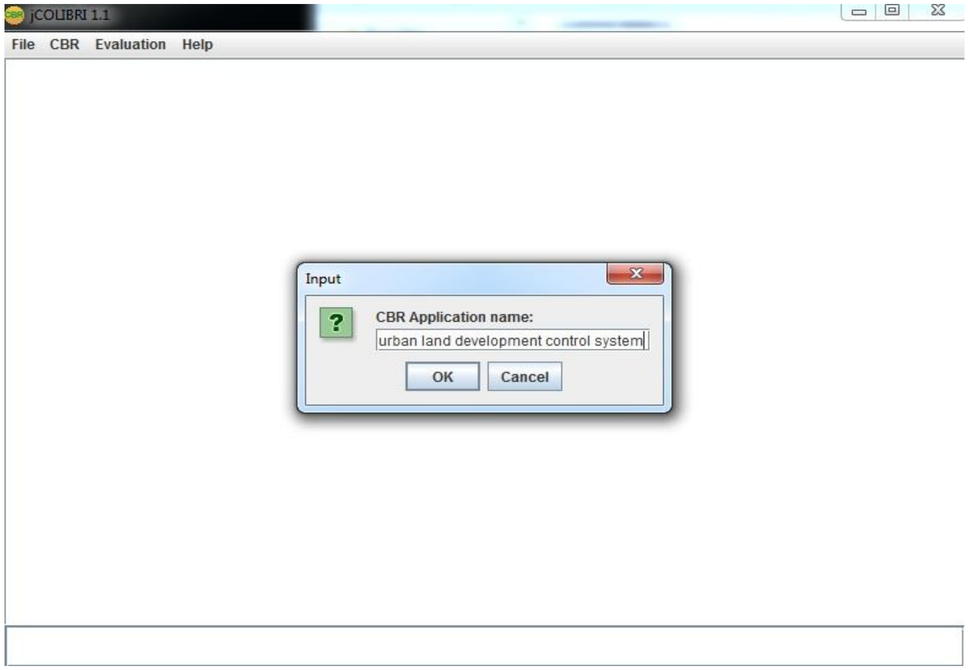

Figure 4.3: Creating new CBR Application

Then, a new window will appear to select one extension out of five as shown in figure 4.4. The five extensions are (García et al., 2008); Core extension, Case Retrieval Nets Extension, Description Logic Extension, Textual Extension and User Components Extension. Core extension contains basic components of jCOLIBRI. Case retrieval nets extension support case retrieval nets. In description logic extension, description logic of jCOLIBRI is supported. Textual base CBR components are supported in textual extension. If user wants to define his/her own components he/she can use user components extension. For the development of the system the researcher used all the five extension. Core extension contains all basic components of jCOLIBRI that are needed to make case based recommender system. User components extension allows programmers to define their own data types. Hence, the researcher defined three data types which is unique and could only be utilized by the developed system CBRSULDC this includes: BuildingHeightsEnum, LandGradesEnum and LandUseTypesEnum. Each of this data types is packed with possible values which is shown in the dropdown menu. For instance for the data type BuildingHeightsEnum the possible values provided by the researcher are "G+0, G+1, G+2, G+3, and G+4"; for LandGradesEnum the possible values provided by the researcher are "first, second, and third"; and finally for LandUseTypesEnum data type the possible values provided are "residential, commercial, industrial and mixed".

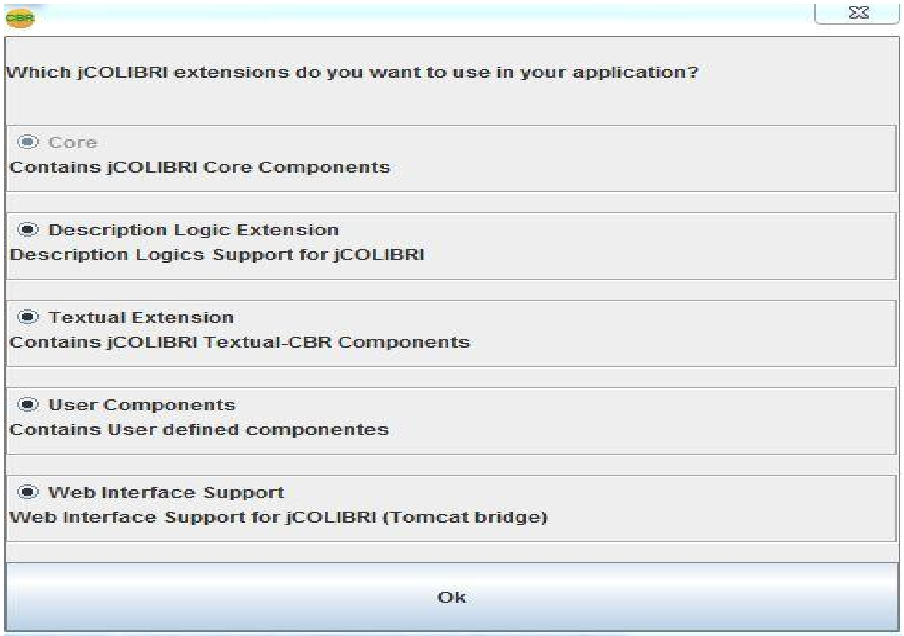

Figure 4.4: Types of jCOLIBRI extensions

After selecting the core extension as shown in figure 4.4, the main CBR application window that contains preCycle, CBRcycle and post Cycle applications are displayed as shown figure 4.5.

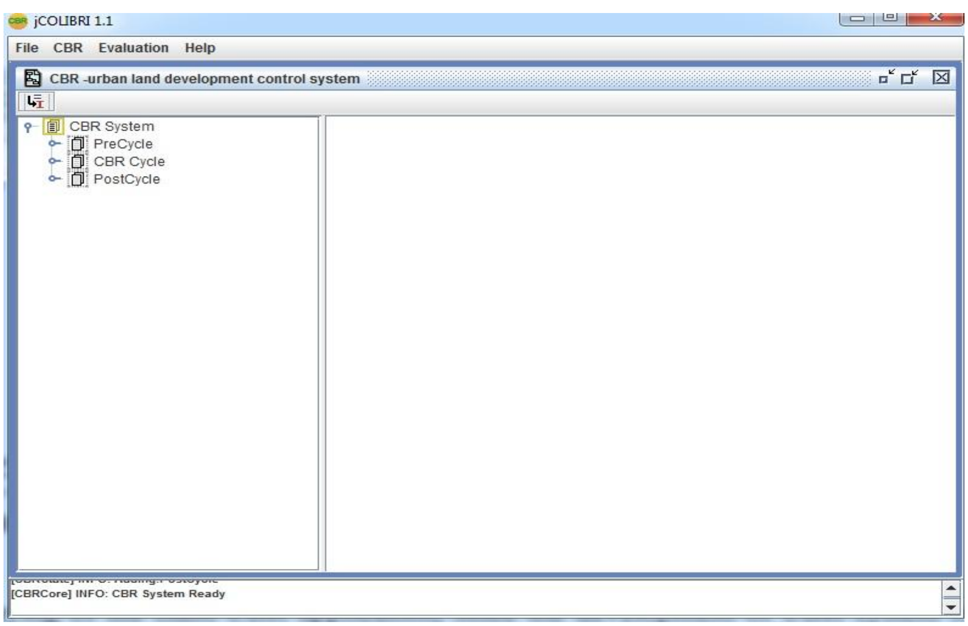

Figure 4.5: CBR applications

After displaying of the main CBR application, since the development of CBR system is very complex, the development of the CBR system for urban land development control in this research is divided into the following subsections which enable to achieve the objectives of this research.

4.2.1 Building the Case Base

One of the objectives on building the case base is collecting previous landholder cases in order to build a case base and represent the cases using the appropriate case representation method. So, the researcher collected previous landholder's cases from JCLDAA. The acquired cases are used to build urban land development control CBR system that can offer decision support to urban development control departments and lease office experts. All the acquired cases are stored in MySql server 5.7 database in a feature-value representation format. Feature value representation means each attribute has its own value in a column and row format. The case base is represented as sql database files feature value representation comprising of n columns representing case attributes (A1, A2, A3... An) and each m rows representing individual cases C ({C1, C2, C3, ...,Cm}). Each attribute has a sequence of possible k values associated to each column attribute A={V1, V2, V3, ..., Vk}. The reason for representing cases using feature-value representation is that this approach supports nearest neighbor retrieval algorithm and it represents cases in a simplest way (Salem et al., 2005).

```
MySQL 5.7 Command Line Client
3 rows in set (0.00 sec)

mysql> describe landholder;
+------------------------------------+-------------+------+-----+---------+-------+
| Field                              | Type        | Null | Key | Default | Extra |
+------------------------------------+-------------+------+-----+---------+-------+
| CaseId                             | varchar(10) | YES  |     | NULL    |       |
| InitialLeasePrice                  | int(11)     | YES  |     | NULL    |       |
| HighestBidPrice                    | int(11)     | YES  |     | NULL    |       |
| AdvancePayment                     | int(11)     | YES  |     | NULL    |       |
| TotalLeaseAmount                   | int(11)     | YES  |     | NULL    |       |
| BasemapNumber                      | int(11)     | YES  |     | NULL    |       |
| PlotSize                           | int(11)     | YES  |     | NULL    |       |
| BuildingHeight                     | varchar(30) | YES  |     | NULL    |       |
| LandGrade                          | varchar(30) | YES  |     | NULL    |       |
| LandUseTypes                       | varchar(30) | YES  |     | NULL    |       |
| ConstructionCommencementPeriod     | varchar(50) | YES  |     | NULL    |       |
| ConstructionCompletionPeriod       | varchar(50) | YES  |     | NULL    |       |
| PaymentPeriod                      | varchar(50) | YES  |     | NULL    |       |
| DamageDeposit                      | int(11)     | YES  |     | NULL    |       |
| Status                             | varchar(30) | YES  |     | NULL    |       |
+------------------------------------+-------------+------+-----+---------+-------+
15 rows in set (0.00 sec)

mysql>
```

Table 4.6: Screenshot from internal structure of the utilized SQL file

```
MySQL 5.7 Command Line Client
| case1  |          3 |         10 |  third     40000 |        2000
00 |          23 |     200 | G+0         | third     | residential  | six
months                | two years          | five years        |
       15000 | unsuccessful |
| case2  |          7 |         20 |            70000 |        6000
00 |          34 |     300 | G+0         | first     | residential  | seve
n months              | three years        | nine years        |
       17000 | successful   |
| case3  |          6 |         29 |            80000 |        5800
00 |           9 |     400 | G+1         | third     | commercial   | thre
e months              | two years          | eleven years      |
       48000 | successful   |
| case4  |          6 |         27 |            72000 |        5400
00 |           2 |     250 | G+1         | first     | commercial   | one
months                | one and half years | nine years        |
       12000 | unsuccessful |
| case5  |          5 |         13 |            50000 |        4000
00 |          54 |     250 | G+0         | second    | residential  | five
 months               | one and half years | four years        |
       11000 | successful   |
| case6  |          6 |         14 |            50000 |        3500
```

Table 4.7: list of cases from case library of the SQL file

So in this step, JCOLIBRI software demands SQL database (see Figure 4.6). In this respect, SQL file (see Table 4.7) is imported to system by MySQL server 5.7.

4.2.2 Case Representation

Case representation in case-based reasoning (CBR) makes use of familiar knowledge representation formalisms from AI to represent the experience contained in the cases for reasoning purposes. A large variety of representation formalisms have been proposed. However, three major types of case representation have arisen: feature value (or propositional) cases, structured (or relational) cases, and textual (or semi-structured) cases. For this research the researcher uses feature-value case representation because feature value case representation represent a case as attribute-value pairs, similar to the propositional representations used in Machine Learning (ML), that support k-nearest neighbor matching and instance-based learning (Yemisrach, 2009).

Case representation is one of the main components in case based system, because case representation is the process of represent the case in the way the programming language (jCOLIBRI) easily understands or interpret. Designing a case structure helps to define easily the features available in the case and to measure the similarity between existing case and new cases (query). Hence, the overall application of this research is to retrieve similar cases from the case base that can show future reasoning, problem solving, transforming a solution retrieved into a solution appropriate to the current problems (i.e. to retrieve similar cases to the query from the case base that guide urban land developers), and supporting officials decision making during urban land allocation process. The collections of cases are represented in the feature-value representation to make efficient retrieval process. This is done through case indexing process in the jCOLIBRI programming tool. Indexing refers to assigning index to cases for retrieval by comparing the existing case and the query given by the user (Lenz et al., 1998).

4.2.3 Description of CBRSULDC Case Attributes

A case is composed of three components: description (describes the problem), solution (represents a possible solution approach) and result (reveals if the proposed solution is able to solve the problem). Description and solution are collections of simple or compound attributes, permitting us to build a hierarchical case structure.

Defining case structure in jCOLIBRI are done by using simple manage case structure window. Description of attribute is the way of describe attributes or manage the case structure that used for the recommendation of the four critical determinants in urban land allocation decision. Description of attributes are done by add simple or compound description attributes in description case structure and set properties of attributes or metadata of attributes for each description attributes. Metadata of attributes are including weight of attribute, data type of attribute and similarity function.

Before creating CBR application we need to configure the case structure. Then use the toolbar menu button CBR and select option mange case structures. After that the new windows will appear for configuration of case structure as shown in the figure 4.6. In the figure, the left side's options are case structure description, solution and result. If we want to add Description cases in application, we can add by using "add simple" button. Add simple button is used to add simple attributes only. "Remove button" can be used to remove the description attribute if it's not necessary .When select one of description attributes, for instance select on initial lease price, then its properties will appear on the right side. Name, type, weight and similarity of case are properties of description attribute. "Apply changes" button was used to change the properties of description attribute Local similarity is used for computing the similarity of each attributes. After defining the structure of cases, case structure is saved in xml file format. During configuration of case structures, jCOLIBRI creates codes automatically and saves in xml file format.

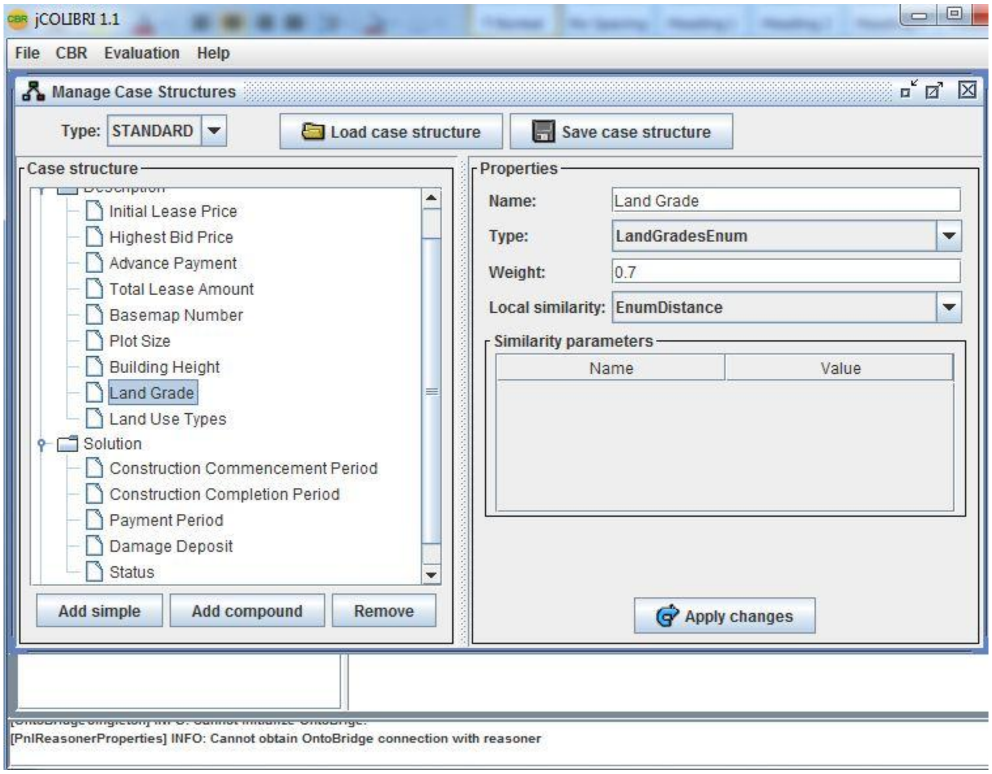

Figure 4.8: Defining Case Structures and similarity

As shown in figure 4.8 the case structure in this research consists of nine description attributes that served to contain descriptions of the problem needed to make decision by the system and five solutions attributes. Since the goal of this research is to support urban land development experts during decision making process regarding to the four critical determinants, the developed CBRULDC system gives recommendation or solution. Solution attribute is assigned to the new case after experts provide the value of all description attributes and measuring the similarity between the existing cases attribute value and new cases attribute value. For this research the solution attributes include suggested construction commencement period, construction completion period, payment period and damage deposit with status of the previous landholders which indicates whether previous decision made on the four critical determinants was correct or incorrect.

Table 4.1 shows the description of case attributes and solution attributes regarding name, data type, weights, local and global similarity.

Significant attributes			
Attribute Name	**Data Type**	**Weight**	**Local Similarity**
Initial lease price	Integer	0.6	Threshold
Highest bid price	Integer	0.8	Threshold
Advance payment	Integer	0.7	Threshold
Total lease amount	Integer	1.0	Threshold
Basemap	Integer	1.0	Threshold
Plot size (land holding size)	Integer	0.8	Threshold
Building height	String	0.7	Equal
Land grade	String	0.7	Max String
Land use types	String	1.0	Equal
Solution			
Construction completion period	String	1.0	Equal
Period of payment	String	1.0	Equal
Startup date	String	1.0	Equal
Damage deposit	Integer	1.0	Equal
Status	String	1.0	Equal

Table 4.1: Descriptions and Weight of the Selected Attributes

Table 4.1 shows the general description of attributes consisting of attribute name, data type, weight and local similarity. The most significant attributes to the problem domain are having the highest weights value of 1.0 as shown in table 4.1. These attributes are the most relevant one that helps to determine the four critical determinants in urban land allocation decision. Moreover, attributes like initial lease price, highest bid price, advance payment, plot size, building height and land grade has a weight value of 0.6, 0.8, 0.7, 0.8, 0.7 and 0.7 respectively. The assignment of weights to each attribute indicates the importance of the attributes on land allocation decision such that attributes having high weight is the most relevant one and vice versa. The weight value of each attribute has been assigned by undertaking a deep consultation with the domain expert. The local similarity of most description attributes is threshold. This is due to the similarity between query and cases can be calculated with a threshold value. If there is no exact match, relevant cases were retrieved within some threshold value and the best similar case from retrieved cases were taken as a solution for adaptation in reuse and revise stage. Few attributes such as building height and land use types has equal similarity weight since local similarity needs exact match of existing cases and new case (query). Finally land grade has maximum string similarity weight since the similarity between query and cases can be calculated with maximum string length.

After identifying relevant attributes of the case, the next task is definition of appropriate similarity measure in JCOLIBRI. JCOLIBRI follows both local and global similarity measures.

I. Local similarity: Local similarity measure divides the similarity definition into a set of local similarity of each attribute. There are three types of local similarity measurement:

A. Equal: If we select equal local similarity for each attribute, then our input and value of case base must be exact match. If the value between attribute are exactly match, the system gives (assign) a solution or period and cost of the four critical determinants with its status to new cases. Otherwise matches are a failure and have no any solution to the new query.

B. Interval: When we select similarity interval and adjust interval value, then, jCOLIBRI matches value keeping in mind that interval. Exact value match is not compulsory in interval local similarity.

C. Max string: if we select the max string local similarity, the system matches by using the maximum string length.

II. Global Similarity is linked with compound attributes and used to get similarity of collected attributes in unique similarity value. Global similarity calculates the final similarity measure. Global similarity has a single data type which is average similarity.

- Average: It is a type of global similarity that considers the average of all attribute of local similarity values. The local similarity of all case attributes which have string data type have either equal and Max String similarity value .The Global similarity of all case attributes which have any data type have average similarity value.

4.2.4 Managing Connectors

Once case structures are configured in jCOLIBRI, CBR systems must access the stored cases in an efficient way from the case base. So, managing connector performs the task of configuring the connector that is going to load the case base. JCOLIBRI supports both SQL database and plain text file to store its cases base. jCOLIBRI splits the problem of case base management in two separate although related concerns: persistency mechanisms through connectors and in-memory organization.

Cases are often derived from legacy databases, thereby converting existing organizational resources into exploitable knowledge. To take advantage of these previously existing resources, facilitate intelligent access to existing information, and incorporate it as seed knowledge in the CBR system (the case base), jCOLIBRI offers a set of connectors to manage persistence of cases.

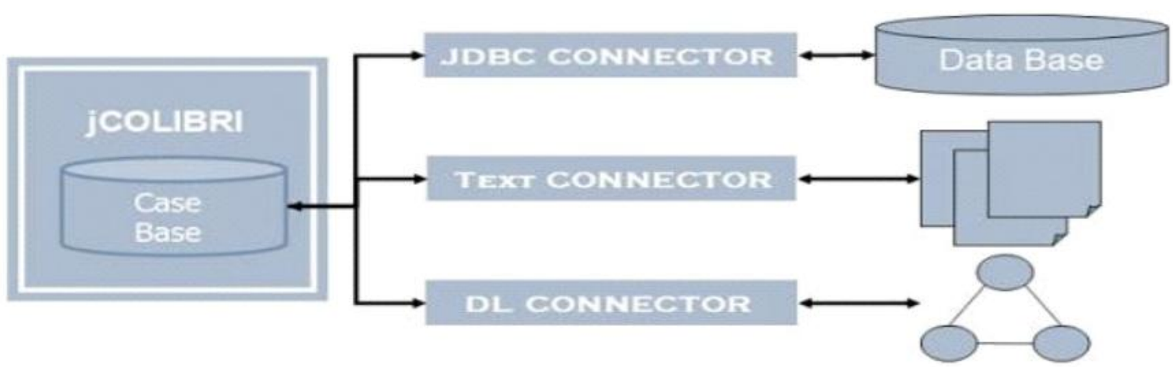

Figure 4.9: jCOLIBRI Connector Schema

Connectors are objects that know how to access and retrieve cases from the storage media and return those cases to the CBR system in a uniform way. Therefore connectors provide an abstraction mechanism that allows users to load cases from different storage sources in a transparent way. As shown in figure 4.9, jCOLIBRI includes connectors that work with plain text files, relational databases and Description Logics systems.

For the implementation of CBRSULDC prototype, the researcher used SQL database connector because landholder's cases are stored in MySql server as SQL file format as shown figure 4.10.

SQL file case base connector is used for persistence of cases. In this connector, the researcher has to specify the path of case structure, driver, sub protocol, host name, port number, database name, table name, user and password. All the attributes of a case should be mapped. The case structure path is used to access and match attributes from case structure and all the other properties are used to connect the jCOLIBRI with the database. In calibration steps, jCOLIBRI uses the JDBC10/SQL connector to communicate with SQL database and also user creates the case structure with enumerated data types. It is connector's responsibility to retrieve data from case base and return it back to GUI. Like that of case structure, connector is also saved in xml format.

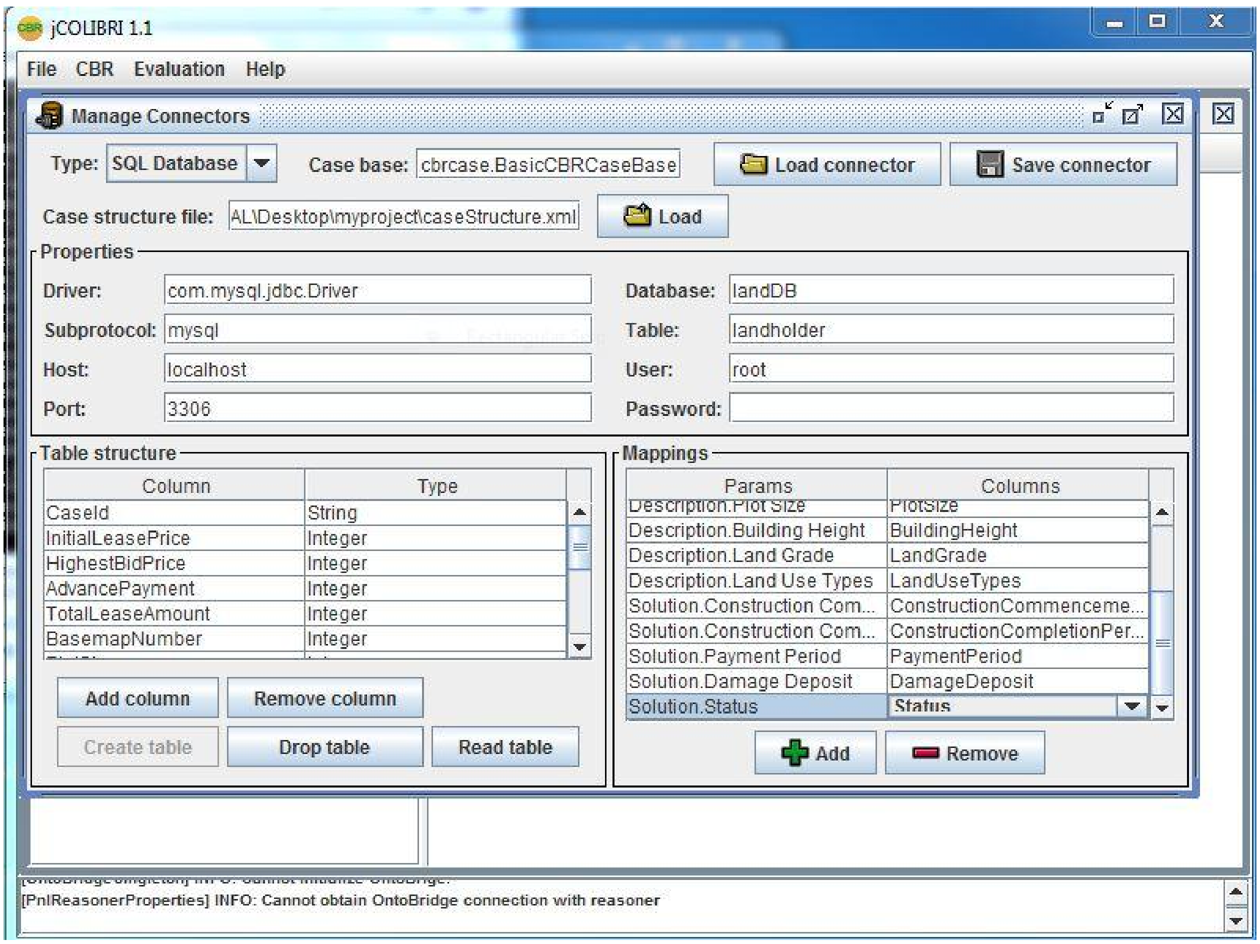

Figure 4.10: Managing Connector Configuration

4.2.5 Managing Tasks and Methods

JCOLIBRI is organized into packages. These packages can perform and execute tasks and methods of decomposition process. For the development of prototype case based system, the researcher used core package task. The detail of each tasks and methods can be discussed separately as follows.

4.2.5.1 Managing Tasks / CBR application

After configuring the connector and case structure, the next task is selecting tasks and methods of application. jCOLIBRI has two types of task packages, namely, Core packages and User defined package tasks. For the development of CBRSULDC prototype, the researcher used core package tasks. A core package contains all classes that represent core functionality of a CBR application such as the domain model, case bases, similarity functions and retrieval algorithms. Core packages also have predefined tasks and methods that used to configure new system by reusing the tasks rather than using tasks or methods defined by the system developer itself like user defined packages, because defined tasks and methods by user itself for every system is time taking and complex. Different core packages are available in JCOLIBRI. The main components of Core packages which are used in CBRSULDC prototype development are PreCycle, main CBR cycle and PostCycle. The component of core packages is the final and important step for creating a new application where the CBR application is configured. The left side of Figure 4.11 shows PreCycle, CBR Cycle and PostCycle.

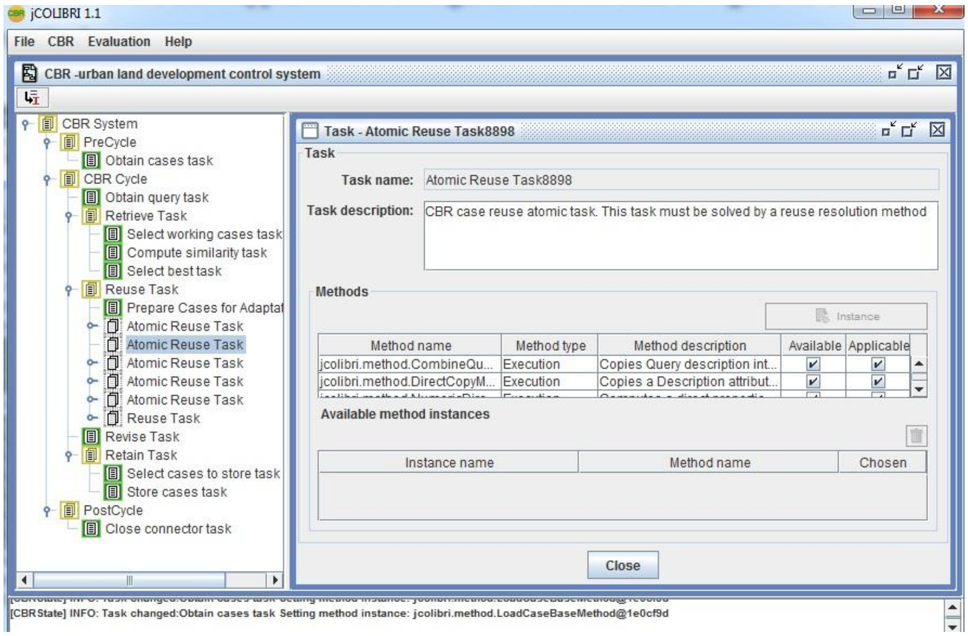

Figure 4.11: Configure the CBR Application

From the above figure, the main tasks and activates on each CBR systems or components of core packages can be describe as follows:

- **PreCycle task:** from the component of the core packages the researcher start with "PreCycle" in order to loads the cases from data sources (case base). In preCycle tasks are solved once before the main cycle, like computing the index structure or processing texts in textual CBR. Therefore to load the cases from the case base it is necessary to define the path of the connector on subtask of Precycle called "obtain cases task" and make "instance" to instantiate the tasks and methods. In Precycle task there is only one subtask called "obtaining case task". Obtain case task is used to retrieve (load) cases from landholder's case base before the execution of the main CBR cycle.
- **Main CBR cycle:** is the main task of CBR cycle and it also has sub tasks. The developer has to give path of case structure that is saved in xml format in Main CBR cycle sub task called "obtain query task". "Obtain query task" is used to knows the number of landholder's case attributes that are available after he path is assigned. In addition to obtaining query task, there are other significant tasks under the main CBR cycle. These are retrieve tasks, reuse tasks, revise task and retain tasks.

- **Retrieve tasks**: is used to retrieve case(s) from the stored case base. Retrieve tasks is also decomposed in to different subtasks. These subtasks include select working cases task, compute similarity task and select the best case. "Select working case task" selects cases from case base and stores them into current context. "Compute similarity task" compute similarity of the stored cases with the new query case entered by the user using the query window. "Select best case" shows the best matched case(s) after computing the similarity of stored cases against the new case. It means that the number of best matched case(s) is shown to the user depending on the method used and the threshold.
- **Reuse/Adaptation tasks**: enable to reuse previously stored cases. It has three subtasks. These subtasks are: prepare cases for adaptation task, atomic reuse task and reuse task. "Prepare cases for adaptation task" selects cases from case base and stores them into context. Here also specifying the path of case structure in this method is needed to "instantiate" the tasks and methods. "Atomic reuse task" should be resolved by reuse resolution method. After the process of the two subtasks "Reuse task" generates the proposed solution for the problem based on similarity. But there are situations where previous landholder's cases are not similar with the new case or the new landholders who is waiting for the decisions on the four critical determinants, so during this time, this new case can be stored in the case base and will be reused by other similar new landholder cases for the next time. The system can learn at every entry of new case and new land development experts adopt this knowledge for urban land allocation decision.
- **Revise task**: is the evaluation and correction stage about the suggested solution in reuse phase. As shown in figure 4.12 after selecting the most similar cases from the retrieved results, the solution for the problem should be confirmed and validated before the solution is stored for future use.
- **Retain tasks**: is the stage of case retention on a persistence layer. It has also its own subtasks like "select cases to store task" and "store cases task". "Store case" was used to type a new case name as shown in figure 4.13. Select cases to store task give authentication to the user for storing case. The store cases task enables to store case(s) into the case base. Retain task is performed after having

confirmation in revision phase. So after the evaluation and correction of retrieved cases in revise task the problem together with its solution will be stored in case base.

- **PostCycle:** is the last task in managing tasks in jCOLIBRI. PostCycle task have only one sub task called "close connectors task" which is usually executed after the main CBR cycle. Its main task is to close a connection between case base and GUI.

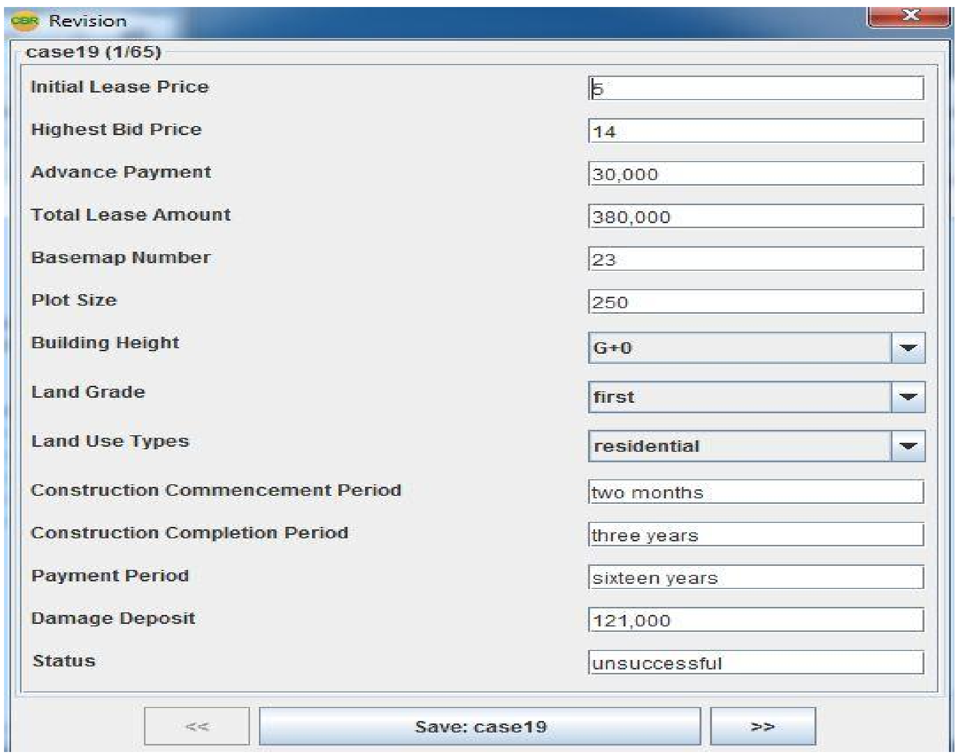

Figure 4.12: Revision task

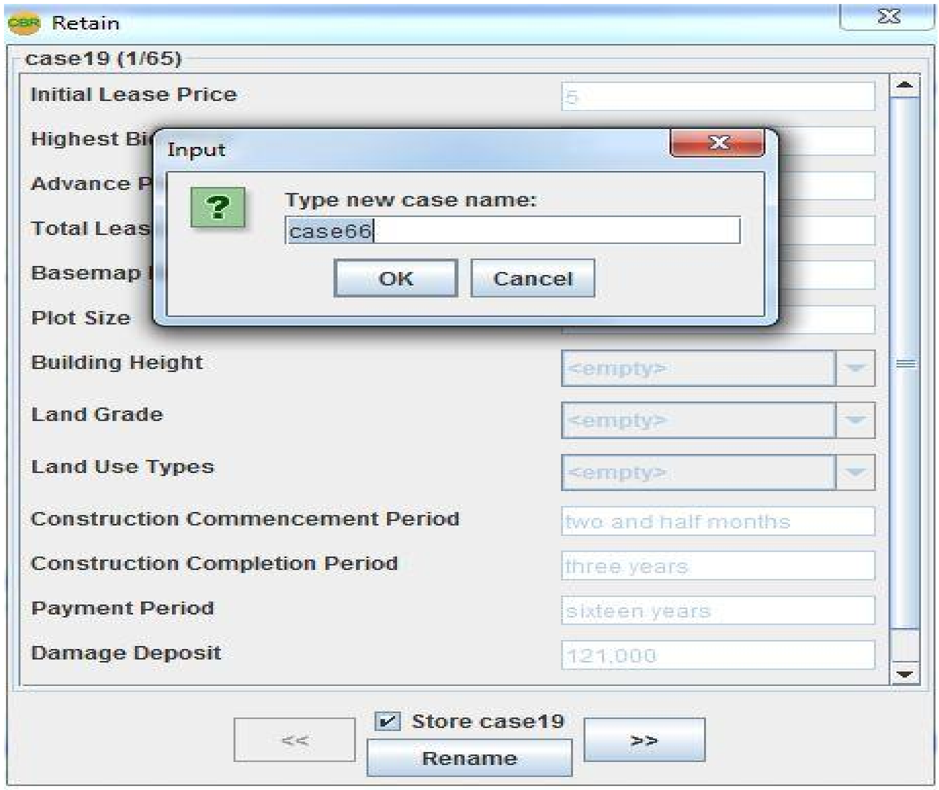

Figure 4.13: Retain task

4.2.5.2 Case Similarity, Matching and Ranking

One of the primary goals of CBR system is to retrieve best similar cases by using some similarity assessment of heuristic functions. The similarity function involves computing the similarity between the stored cases in the case base and the new cases (query), and selects nearest similar cases to the query. Therefore, jCOLIBRI uses the nearest neighbor algorithm as a case retrieval technique. Nearest neighbor algorithm is used to measure the similarity between the stored (existing) cases and the new cases (queries), and return the search results within their ranked order. Accordingly Figure 4.14 shows the displayed similarity score of each previously solved cases in the case base to the new query which is computed using nearest neighbor algorithm. For each attribute in the query and case, local similarity function measures the similarity between each and every simple attribute values in the case base with new case queries. Based on the matching weighted sum features from those simple attributes, the similarity score between the queries and stored cases for each simple attribute is assigned.

Finally, the average score (global similarity) of the whole attribute between the existing case and the query are computed and the result is assigned to the object (the similarity between the stored case and the query). And then the maximum degree of similarity among the retrieved cases is displayed according to their ranked order.

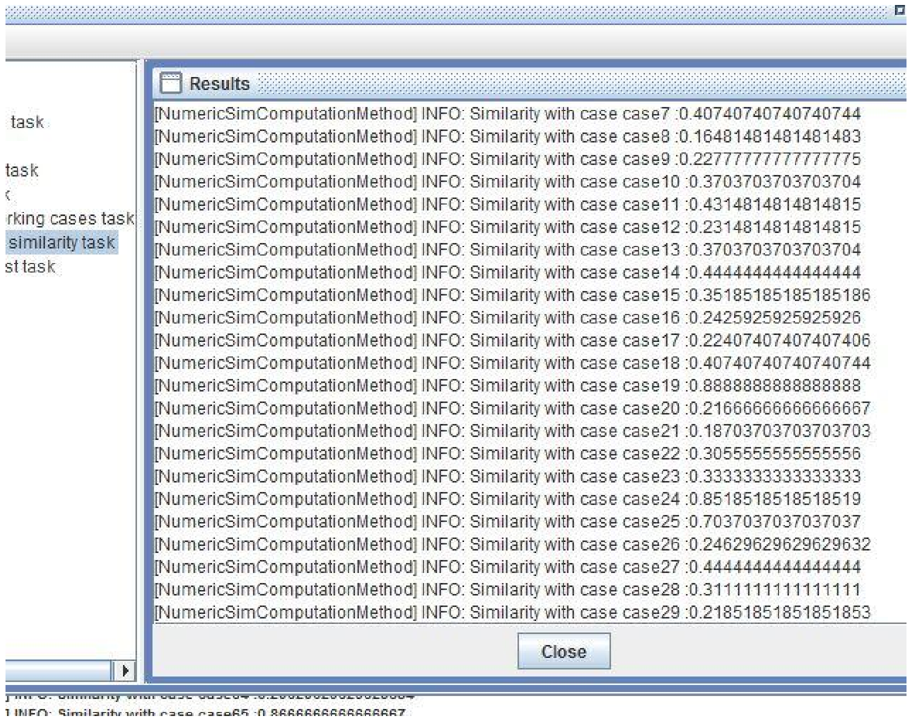

Figure 4.14: case similarity, matching and raking

4.2.5.3. Managing Methods

The managing method library stores classes that actually resolve the task. These classes can resolve the CBR cycle using in programming or using GUI. All tasks that are mentioned in 4.3.5.1 should have their own methods to be assigned in order to achieve the tasks goal. The following is a list of methods which are used to solve tasks for the CBRSULDC prototype system.

LoadCaseBaseMethod: This method returns the whole available cases from the case base to designer. This method uses connector to retrieve case base.

ConfigurQueryMethod: This method resolves obtain query task. By receiving case structure as input parameters, it displays a GUI window so that user can enter query to retrieve cases from the case base.

SelectAllMethod: This method allows displaying all the available cases from the case base to the result window.

SelectSomeMethod: This method resolves to select best task by choosing the "n" number of nearest exact similar cases from the returned cases. The "n" indicates since there is more than one similar (relevant) case to the new case (query), the system retrieve "n" number of similar cases in ranking order of from highest similarity to lowest similarity. These method requests the users enter the value of each query as input. Then the system measures the similarity between the new queries input value and the existing case value. Finally the system suggests period and cost of the four critical determinants for a new landholder's case that best match with the requested input.

NumericSimilarityComputationalMethod: this is used to calculate similarity between the query and cases that are stored in the case base.

NumericProportionMethod: it is the sub method of reuse task which involves in computing numeric proportion between the description attributes and solution attributes.

ManualRevisonMethod: Manual revision method permits users to modify cases in the query window as they need.

RetainChooserMethod: This method allows the user to choose the method. Chosen method will store case base. User can choose if he/she want this method to store in case base.

In general, these are some of the methods discussed and used in this research. But, there are many other methods available in jCOLIBRI method library. It is the task of the knowledge engineer to choose the most appropriate methods during designing CBR application. Figure 4.15 shows the configuration of tasks and methods. The left side shows the tasks and subtask and the right side shows the methods.

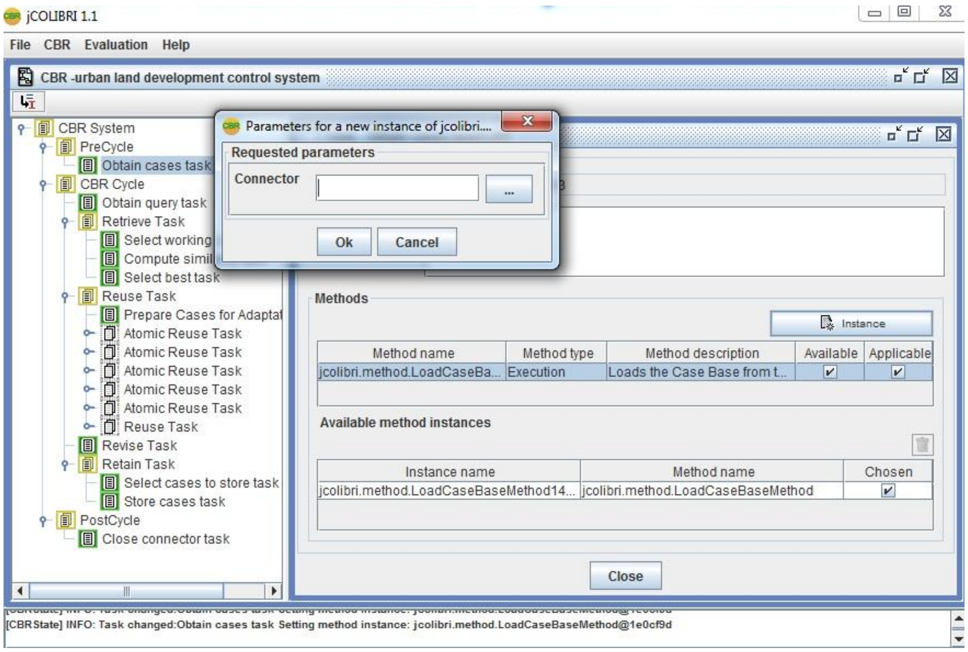

Figure 4.15: Tasks and Methods Configuration

Therefore; once every task is configured by a method that solves it then it is possible to run the CBR deployed system where the tasks are solved using the given sequence. Also it is feasible to use the (solve to) button in the GUI to execute a selected set of tasks. The result for the query is shown in the right area of the graphical interface as show in figure 4.16.

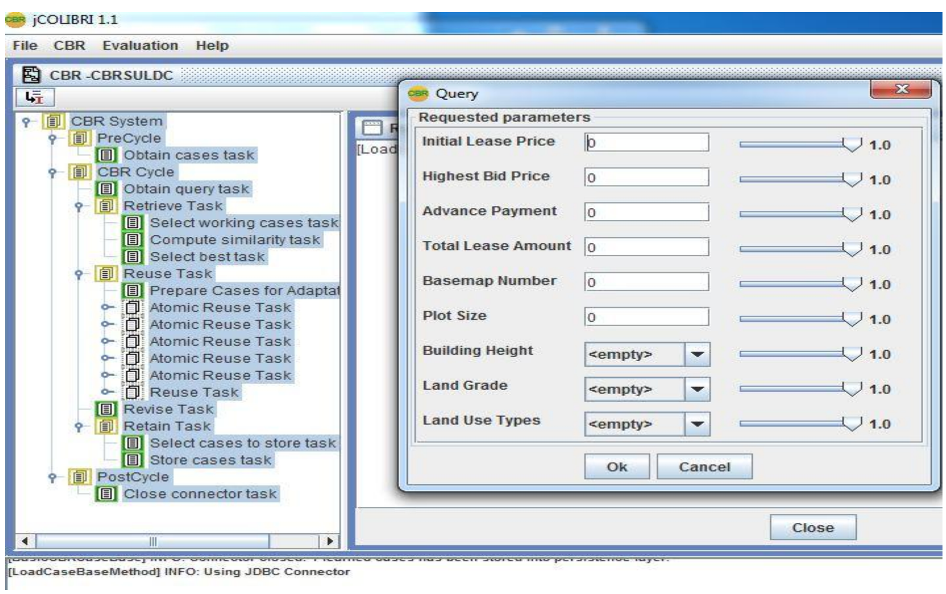

Figure 4.16: Testing the CBR system

4.2.5.4. Deploy the case based reasoning system

After defining and configuring all the necessary steps required in designing case based reasoning system in JCOLIBRI, new case (query) entry application for new landholder case is the next step as shown in figure 4.17.

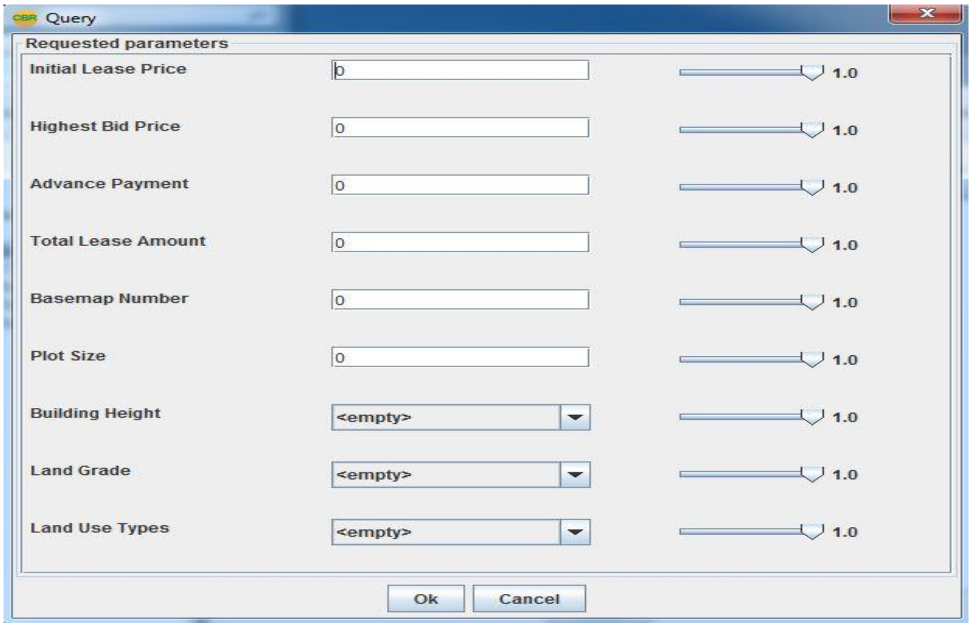

Figure 4.17: Window for Case Entry into the Case Base.

In the above figure the domain experts, in this case urban development control department and lease office team, are required to enter the query to each requested parameters or attributes in the space provided. The parameters which the system automatically fills by the number zero indicate that the filed could only accept no other values but only integers. After entering the query, at the bottom of the screen they will see the results of similar previous landholder's cases and the suggested period and cost of construction commencement, construction completion, payment period, damage deposit and the status which shows whether the previous decisions made by the experts was successful or unsuccessful on the execution log.

For instance, the first box of the query window requests the initial lease price of the land. All urban lands have a benchmark price which is a threshold price determined by taking into account the cost of infrastructural development, demolition cost as well as compensation to be paid to displaced persons in case of built up areas, and other relevant factors. Then followed by highest bid price, which is the highest amount of money given by the bid winner for a particular square meter plot. Also in “advance payment” box the experts are required to enter the down payment provided by the bid winner during auction competition. Next information about the total lease amount, plot size, basemap number, land grade and land use type is required to be filled by the experts and this information could be obtained from the bidding document. Finally the building height is required to be entered, this is height of the planned building construction expected to be constructed by the new landholders. The format of the value for this attribute is “G+0” for ground construction projects; “G+1” for ground plus one construction projects and the same is true for other higher building heights.

CHAPTER FIVE

PERFORMANCE EVALUATION

Testing and evaluation of the prototype case based reasoning system is the final step that helps the knowledge engineer to measure whether the system achieves the proposed objectives or not. This chapter presents testing and performance evaluation description of the prototype system. For the performance evaluation the researcher have conducted case similarity testing, retrieval performance evaluation using recall and precision, assessment of the reuse and retain process, and user acceptance testing of the prototype.

For building the prototype CBR system, one of the main steps was building of previously solved cases for the case base. There were about 65 previously solved successful and unsuccessful landholder's cases which was collected and used from Jimma city land development and administration agency for developing and testing the prototype CBRSULDC. The cases were represented by using feature-value pairs, in which each case represented with different number of attributes. Data cleaning like handling missing values, inconsistent data and redundant data were handled.

5.1 Case Similarity Testing

An experiment is made to understand how a query/new cases are matched with the cases from the case base. For this experiment, the researcher used three experimental groups. These three cases are randomly selected from the case base; one experimental case from residential, commercial and mixed land use types. The first group is made up of cases from the case base. The second group consists of cases which are made by modifying one of the attribute values of the case from the case base, while the third group is made up of cases which have two modified attribute values. Each test case is presented to the system individually to evaluate the performance of the similarity measures. Table 5.1 below shows sample queries that are used in this experiment with their values.

	initial lease	highest bid price	advance payment	total lease amount	basemap	plot size	building height	land grade	Land use types

	price								
Query 1	3	17	40000	260000	23	250	G+0	secon d	residential
Query 2	8	41	91000	900000	81	600	G+3	first	commercial
Query 3	5	27	55000	450000	67	400	G+1	first	mixed

Table 5.1: Sample queries utilized in case similarity experiment with its values

Based on the above attributes listed in table 5.1, the next step is doing the experiments for the three groups residential, commercial and mixed since many number of cases are available in each group in the case library. To test each group three queries are prepared with a total of nine queries. After the query is provided to the system the similarity of the query with respect to the case are generated as shown in table 5.2.

Query	Description of Query	With respect to case	Degree of similarity
Query 1	The same value for all attributes	Case 4	1.0
Query 2	A value of attribute “highest bid price” is changed	Case 4	0.92
Query 3	Values of attribute “highest bid price” and “plot size” is changed	Case 4	0.71
Query 4	The same value for all attributes	Case 37	1.0
Query 5	A value of attribute “total lease amount” is changed.	Case 37	0.82
Query 6	Values of attribute “total lease amount” and “building height” is changed.	Case 37	0.74
Query 7	The same value for all attributes	Case 62	1.0
Query 8	A value of attribute “land use type” is changed.	Case 62	0.82

Query 9	Values of attribute “land use type” and “land grade” is changed.	Case 62	0.76

Table 5.2: Query similarity with their corresponding cases from the case base

The case similarity test result of this experiment shows that when the values of the test case attributes is the same with the case stored in the case base, the degree of similarity(global similarity) becomes 1.0 (i.e. exact match) as in query 1, query 4, and query 7 as shown in table 5.2. On the other hand, the degree of similarity decreases when there is a change in one or more attribute values of the test case as compared to a case from the case base. When values of an attribute with higher weight value changed, the degree of similarity highly decreases. For instance “query 1” result indicates that the degree of similarity yields 1 if there is no attribute value difference between query and the case stored in the case base. Whereas “query 2” prepared by modifying one of the attribute “highest bid price” with a weight value of 0.80 which scored 0.92 degree of similarity. Lastly in “query 5” the same alteration has been made as it is done in “query 2”, the value of one of the attribute “total lease amount” has been modified but with a weight value of 1.0 and the degree of similarity scored in this test in 0.82. This indicates that as it is shown in “query 2” and “query 5” the same alteration was made on both queries by modifying only one of the attributes however; different degree of similarity result has been obtained from the experiment due to the difference on weight of the modified attribute, 0.80 and 1.0 in query 2 and query 5 respectively. Therefore; when attribute values with higher weight value changes the degree of similarity highly decreases. Consequently this declination in degree of similarity due to difference in weight of attributes has significant effect on retrieval result of the prototype system. It highly decreases the relevance of the retrieved cases and this brings difficulty in order to apply or adapt the solution of the retrieved case to the new problem.

5.2 Testing the CBR Cycle

As it is discussed in the previous chapter, the prototype case based reasoning system for urban land development control was developed to help in urban land allocation decision making. So here, the researcher evaluated the performance of the system by taking real test cases. In this research precision and recall which are the main information retrieval and statistical evaluation tools, were used for evaluation of the prototype CBRSULDC.

From the previous related works on the application of case based reasoning system in different areas, the researcher come to understand that Alemu (2010) used 10 test cases; whereas Henok (2011) and Getachew (2012) used seven test cases for each case. Accordingly, for validation of developed systems using precision and recall values the researcher selected 7 test cases with the help and in confirmation of domain expert in that these numbers of cases are representative of the whole collection of landholder's in the case base. For each test case, selection of more relevant cases were identified by the domain experts from previously solved cases and used for evaluation of the prototype system.

5.2.1 Retrieve and Reuse Evaluation

During the experiment, the performance of the system has been compared with suggestion of experts in the domain in terms of accuracy, where the overall goal is to show how close the system worked compared to the domain experts. The domain experts identified relevant cases from the case base for each test case.

In jCOLIBRI the retrieval of similar cases took place by using nearest neighbor similarity algorithm. Assessing similarity between two cases represented with attribute-value pair entails two concepts; similarity between attributes and relative relevance of each attribute. For the first case comparing attribute by attribute took place by assigning similarity value 1 when the values of two compared attributes are the same and similarity value 0 is assigned when the values of the attributes are not the same.

In the second concept similarity assessment is done by assigning weights for each attributes according to their significance in land allocation decision by the domain experts. In practice, each attribute is not equally relevant, and this has to be represented in the similarity assessment for retrieval of accurate similarities. For the problem description the importance of the attributes is denoted by a number between 0 and 1; with that larger numbers represent more important attributes because more important attributes play a larger role and it highly affects urban land allocation decision.

In comparing the problem case (query) with the previously solved case (in case base) in CBRSULDC, global similarity which is the average of the local similarities of the given attributes was used for similarity measures in retrieving relevant cases from the case base. The testing method used for evaluating the performance of the prototype system was made by using the parameters precision, recall and F-measure. These three parameters were used in order to measure the accuracy of the prototype system. Precision and recall are the common statistical performance evaluation methods in information retrieval process. They are useful measures of retrieval performance in CBR (McSherry, 2001). According to McSherry (2001), recall is defined as the ratio of the number of relevant cases returned to the total number of relevant cases for the new case in case base ; whereas precision is the ratio of the number of relevant cases returned to the total number of cases for a given new cases. F measure is a derived effectiveness measurement. The resultant value is interpreted as a weighted average of the precision and recall.

Precision and recall can be calculated with the following formulas:

$$recall = \frac{number\ of\ relevant\ cases\ retrieved}{total\ number\ of\ relevant\ cases}$$

$$precision = \frac{number\ of\ relevant\ cases\ retrieved}{total\ number\ of\ cases\ retrieved}$$

F-measure is the harmonic mean of precision and recall, with a value between 0 and 1. It is calculated as:

$$F - measure = \frac{2\ (recall * precision)}{recall + precision}$$

The researcher determined seven test cases for the system performance evaluation by confirming with the domain experts. Relevant cases for each test case are selected by the domain experts from the case base as it is shown in Table: 5.3. This work was a bit tedious and time taking for the domain experts to identify similar cases that might have same solution attribute with the test case.

Test cases	Relevant cases from the case base by domain experts
Test case1	Case13,case25,,case26,case33,case40,case44,case61,case63

Test case2	Case24,case29,case47,case55
Test case3	Case2,case6,,case7,case11,case34,case40,case47,case49,case52,case55,case57
Test case4	Case1,case5,case14,case33,case41
Test case5	Case17,case26,case33,case34,case56,case58
Test case6	Case3,case9,,case16,case18,case20,case24,case41,case43,case44,case49
Test case7	Case13,case15,case36,case39,case52,case62,case61,case64

Table 5.3: Relevant cases assigned by domain experts for sample test cases

There is no standard threshold value for degree of similarity to test the prototype CBRSULDC in retrieving relevant cases for the test case query. And the researcher used a threshold value of [0.8, 1.0], which is identified after experimenting to have a better precision value. With this threshold, after computing the similarity values a minimum of 4 total cases were retrieved for test case two and a maximum of 11 total cases were retrieved for test case 3. This total cases retrieved include both relevant and not relevant cases retrieved during an experimentation,

Test cases	Relevant cases suggested by domain experts	Relevant cases retrieved by the system	Total cases retrieved by the system	Recall	Precision	F-measure
Test case1	8	6	9	0.75	0.67	0.71
Test case2	4	4	5	1.0	0.80	0.89
Test case3	11	9	12	0.81	0.75	0.78
Test case4	5	4	6	0.80	0.67	0.73

Test case5	6	5	8	0.83	0.63	0.72
Test case6	10	9	12	0.90	0.75	0.82
Test case7	8	6	10	0.75	0.60	0.67
Average				0.83	0.70	0.76

Table 5.4: Performance measurement of CBRSULDC using precision and recall

In the study, for calculating the recall value, comparison of numbers of relevant cases which is retrieved by the system and the relevant cases selected by the domain experts is used. For example for the first test case, from eight relevant cases selected by the domain experts the system retrieved only six cases so that the recall for Test case 1 is 0.75. And the rest recall values can be calculated in the similar manner as it is shown in Table 5.4.

In the case of precision, it is relevant cases retrieved by total number of retrieved cases, which total numbers of retrieved cases contains both relevant and non relevant retrieved cases within the threshold value used; i.e. [0.8, 1]. For example Test case1 contains six relevant cases retrieved and three not relevant cases retrieved from the case base, with a total of nine retrieved cases. And so, the precision value is 0.67; and for the rest test cases, precision values are calculated in the same manner as shown in Table 5.4.

As shown in table 5.4, the calculated recall values for each test case is above 75%, which shows the ability of retrieval of the prototype CBR system to obtain most of the relevant cases from the case base is good. In evaluating the performance of the CBRSULDC prototype system, with recall values, has got an average recall value of 83%, which indicated a higher recall value; hence, it is clear on that the prototype system could obtain most of relevant cases from the case base. Therefore, the prototype system CBRSULDC has a capacity to retrieve relevant cases that allow effective decision towards urban land allocation particularly on the four critical determinants.

On the other hand the prototype system retrieved relevant cases to the system with an average of 70% precision. Although, the average precision value is good, few number of cases used are one of the limitations for the developed system.

Although, it was difficult to attain the ideal 100% precision and recall values in practice. As it is shown in Table 5.4, precision and recall values for the prototype system have been an average value of 70% and 83%, respectively. The value for F-measure which was 0.76 also showed good performance of the prototype system. Generally, precision, recall and F-measure average values shown us the average performance of the system as good and could be used to assist urban land development experts in their day to day decision making activities regarding to new land development process throughout the city.

5.2.2 Revise and Retain Tests

One of the main advantages of CBRSULDC is its ability to update the solution whenever needed. Depending on the location of the new development, such as central, transitional or expansion zone, the period along with cost of the four critical determinate is varied, due to this there will be high level of adaptation from the previous stored cases. In most situations, it is very rare to see a new case is exactly the same as a previous case. Users have to adapt this knowledge according to the context of the new problem. The reuse of the retrieved case solution in the context of the new case focuses on two aspects: a) the differences among the past and the current case and b) what part of a retrieved case can be transferred to the new case. Case revision consist two tasks: a) evaluate the case solution generated by reuse. If it is successful, learn from the success (case retainment), b) otherwise repair the case solution using domain-specific knowledge (repair fault) (Aamodt & Plaza, 1994).

For situations such as when a case exactly matches with the query, the adaptation will be null and the retrieved case is used without adaptation. But if there is no retrieval of exact matched case, the retrieved best similar cases solution can be adapted by the domain experts whenever it is necessary to do so. Since the process of land development control is complex, many factors such as the government policies, the socioeconomic and environmental impacts, the traffic and infrastructural implications, and compatibility of land uses, should be taken into consideration. According to Shi & Yeh, retrieved similar previous cases could be modified to some extent to fit (adapt) new situation. For example, under the new condition, a new opinion may need to be added, a previous opinion may not be needed any more or need to be modified (Shi & Yeh, 1999).

So during the adaptation or modification of the solution, it should be done in a great care by considering all the above factors to bring the desired result which is a successful land development. Once cases have been adapted, the domain expert could adjust the values of the working cases in a manual way, in order to confirm the validity of the solution which is made by the domain experts. The modified case in CBRSULDC which doesn't affect the original case, after it is confirmed by the domain experts, will be retained or stored in the case library for future use.

5.3 Testing Improvements from Learning

In CBR, all cases are independent of each other, and therefore a new case can be learned, or manually added, without it changing the rest of the case base. This is a very interesting approach, because making the system learn, could improve its performance over time. In the process of learning, a CBR try to retain all the cases it encounters and increase its case-base quickly (Kolodner, 1993).

The main aim of testing of the improvement from learning is to test the learning performance of the prototype from previously solved landholder cases in future use. For this experiment a new tenant case is provided to the prototype. The sample of tenant case that is used for the testing purpose is as follows:

Initial lease price	Highest bid price	Advance payment	Total lease amount	Basemap number	Plot size	Building height	Land grade	Land use types
3	9	25,000	150,000	06	250	G+0	second	residential

Table 5.5: sample query of new tenant case

After the problem description of the above new tenant case is fed to the prototype, the prototype computes the degree of similarity between the new and the old cases from the case base. Then the prototype retrieves cases which are considered as relevant case, rank ordered. Then the prototype recommends a solution to the new case from the retrieved relevant cases. The proposed solution for the new tenant case regarding to the four critical determinants including status of the decision is “three months” for construction startup, “two and half years” for construction completion, “six years” for payment period, “18,000 birr” for the damage deposit and the status of previous decision for related case was “successful”. As this solved tenant case is new for the CBRSULDC, the revise phase of the prototype proposes the new solved tenant case to be verified by domain experts. The revise process is depicted in figure 5.1.

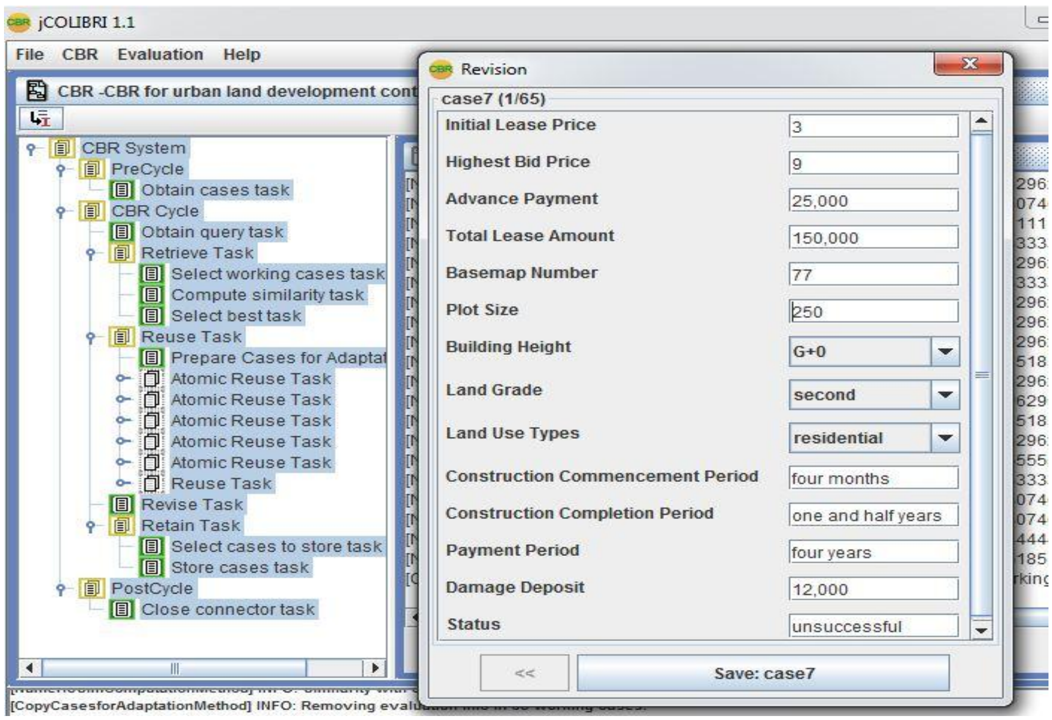

Figure 5.1: Revise process for the newly solved cases

The domain expert knows the validity of the proposed recommended solution. As the domain expert confirms that the new solved tenant case is valid, it retained for future use by the retain process of the prototype. So this new case is stored and added in the existing case base and will be used in future recommendations. This is shown in figure 5.2 below:

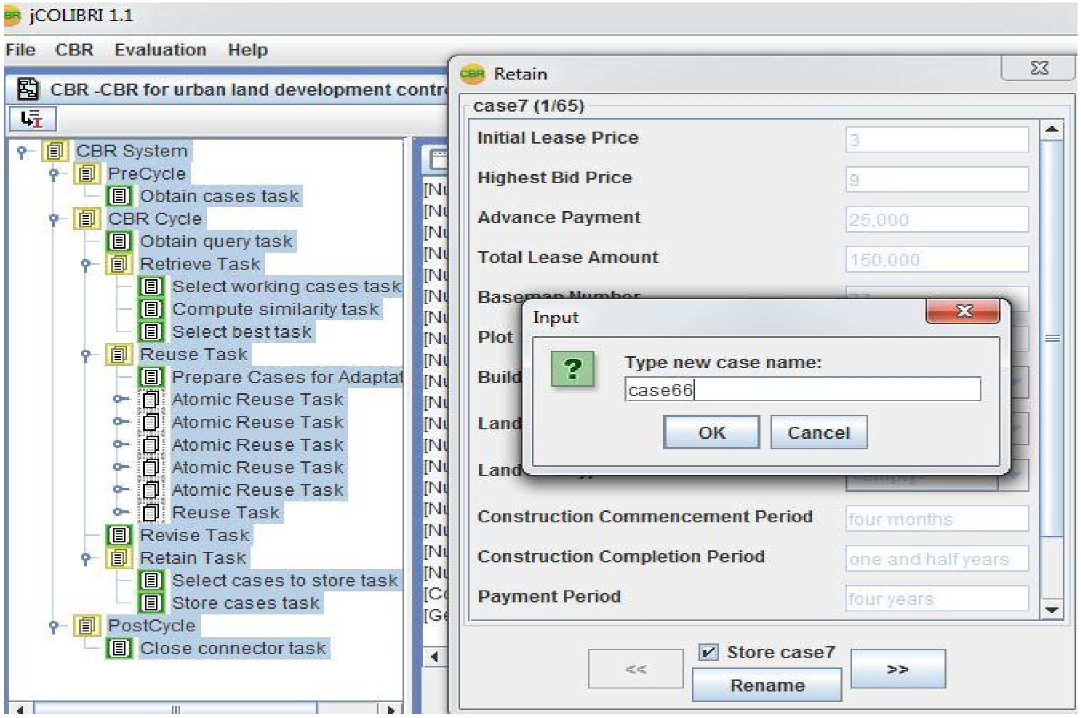

Figure 5.2: Retaining process of the newly solved case for the future use

In order to test the improvement from learning of the prototype, the problem description of the above tenant case is again fed to the prototype. This time the prototype directly proposes a solution for the case, but the revise task phase doesn't propose the solved tenant case to be verified by the domain expert. This shows that the CBRSULDC system has learnt from successfully solved tenant cases and uses it in solving other tenant cases. This type of learning is known as incremental learning because it always adds knowledge that is new and useful in addition to the existing knowledge.

5.4 User Acceptance Testing

According to John (2001) user acceptance testing, as one of evaluation process, is performed to confirm that the developed system achieved its objectives. User acceptance testing consists of a process of verifying that a solution works for the user, i.e. it measures the quality of the application. Any system development is meaningless unless and otherwise the users evaluated and accepted to work with it. So the researcher tests the acceptance of CBRSULDC by domain experts. For the purpose of acceptance testing of CBRSULDC the researcher identified and selected five land development experts (urban development control department and lease office staffs) from Jimma city land development and administration agency.

The evaluation criterion or parameters selected for the user testing process are taken with the consideration of the works of Althoff (1997) on evaluating and validating of CBR systems, which is also used by Getachew (2012) and Biazen (2013).

Description of the parameter values were as follows: Performance Value 1=Poor; 2=Fair; 3=Good; 4=Very good; 5=Excellent

No.	Evaluation Parameters	Performance Value						
		Poor	Fair	Good	Very Good	Excellent	Average	%
1	Ease of use of the CBS			1	3	1	4	80
2	Efficiency of the system in time			1	4		3.8	76
3	Interactivity of the user interface				4	1	4.2	84
4	effectiveness towards provision of adequate lessons from previous both successful and unsuccessful land allocation decisions				2	3	4.6	92
5	Adequacy and clarity of decision support			2	2	1	3.8	76
6	Relevancy of the retrieved cases for decision making			1	3	1	4	80
7	Fitness of the final solution to the new case			1	2	2	4.2	84
8	Relevancy of the attributes in representing landholder's case				2	3	4.6	92
9	Rate the significance of the			1	3	1	4	80

	system in the domain area							
		Total average					4.1	83%

Table 5.6: result of user Acceptance Testing by domain experts

As it is depicted in the above Table 5.6, testing for user acceptance of CBRSULDC is done by participating five domain experts. They all give their selection according to the evaluation parameters and also given some comments for future progress.

For the first parameter “ease of use of the CBRSULDC”, one of the five respondents rated the system as good, three of them rated as very good and one respondent rated as excellent. On average 80% of respondents were accepted the prototype for its “ease of use”. For the case of second parameter which was “efficiency of the system”, one respondent rate the system as good and four respondents rated the system as very good; so the system is accepted by an average of 76% of respondents.

For the third parameter “interactivity of the user interface of CBRSULDC”, four of the five respondents rated the system as very good and one respondent rated as excellent. On average 84% of respondents were accepted the prototype for its “interactivity of the user interface”.

For the case of “effectiveness towards provision of adequate lessons from previous unsuccessful land allocation decision”, two respondents rated the system as very good and rest three respondents rated the system as excellent; on average 92% of the respondents accepted the prototype system in its “effectiveness towards provision of adequate lessons from previous unsuccessful land allocation decision”.

Finally for the case of fifth, sixth, seventh, eighth and ninth parameters: “adequacy and clarity of decision support”, “relevancy of the retrieved case in the decision making”, “fitness of the final solution to the new case”, “relevancy of the attributes in representing landholder’s case” and “significance of the system in the domain area”; got an average acceptance of 76%, 80%, 84%, 92% and 80% respectively. This indicates that the prototype system is good enough in all the above parameters.

Generally the user acceptance testing for CBRSULDC achieved a total average acceptance of 83% that showed the importance and applicability of the prototype system in decision making. According to the comments collected from the domain experts during testing, the respondent emphasized on the need for training on the CBRSULDC for better understanding and usability of the prototype system. A CBR system will be able to generate a better suggestion if it has a large case base. CBR is unsuitable when there is little case available. So relating to this they mentioned the need of additional cases to the case base in order to give more options so that it is possible to extract best solutions to the new query. They also mentioned the limitation of the CBRSULDC, as the rationale or the cause of unsuccessful land development that carried out in the city is not presented with detail explanations to achieve higher learning for urban development control department and lease office staffs.

5.5 Comparison of the Performance of CBRSULDC with other CBR Systems

To identify the strong and weak side as well as unique feature of the system, performance comparison is made between CBRSULDC and other previously conducted CBS within and outside the domain. Most of the previous research focus was on retrieval performance of the case based reasoning system but some of them did not conduct user acceptance testing by the domain expert. Thus, the recall and precision value of retrieval performance of the systems developed by earlier researches are compared as shown in table 5.7 below.

Domain area and researcher	**Tools used**	**Retrieval task**		**User Acceptance**
		Recall	Precision	
City Planning Shi & Yeh (2001)	GIS & CBR shell	88%	70%	Not evaluated
Mental health Getachew (2012)	jCOLIBRI	82%	71%	86%
City planning Kaster et al. (2005)	GIS & jCOLIBRI	86%	67%	89%
Town house valuation Pacharavanich et al. (2000)	myCBR	79%	68%	Not evaluated
Construction Project	jCOLIBRI	81%	73%	74%

Valuation Dikmen et al. (2007)				

Table 5.7: a comparison of CBRSULDC system with other CBR systems

As indicated in table 5.7, the result of the recall value of the system is nearly similar with that of (Dikmen et al. 2007, Getachew 2012 & Pacharavanich et al. 2000), while the value of precision shows an improvement from the precision value of (kaster et al. 2005 & Pacharavanich et al. 2000). In Shi & Yeh (2001) work, they tried to show how CBR can be used to handle planning applications in development control. The systems retrieve one best similar case solution to the problem whereas in CBRSULDC multiple cases are retrieved and ranked from highest to lowest based on similarity value and presented to the user for evaluation and selection. An algorithm ranks cases according to the highest match score.

Also Pacharavanich et al. (2000) examined the usefulness of the CBR system for the valuation of townhouses in Bangkok/Thailand. This system supports automatic adaptation whereas in CBRSULDC instead of automatic adaptation, the system left this task for the user. Experts are allowed to select a case for adaptation manually. It doesn't provide automatic adaptation. This allows the expert to choose the best related cases in addition to ranked similarity scores of cases and adapt its solutions to the new problem.

One of the main objectives of this research is to provide support in the decision making process of urban land development control. This is done by undertaking user acceptance test after implementing the system. Based on analysis of user acceptance data more than an average value is registered which is a promising result. User acceptance testing is crucial since this process allows for any issues to be fixed before the systems goes live. It also helps to determine whether the developed system fits with the intended use or not. But this test is not evaluated in (Shi & Yeh 2001 & Pacharavanich et al. 2000) researches.

Furthermore, the developed prototype system in this research has the capability of providing status of previous land development decisions made by the municipal government. Alongside to the four critical determinants, the status parameter has immense benefit by means of showing whether the previous decisions were successful or not which in turn help to avoid repetition of similar mistakes. But in (Dikmen et al. 2007, Getachew 2012, Pacharavanich et al. 2000, Shi & Yeh 2001 & Kaster et al. 2005), the developed prototype system does not provide details about status of the previous decisions.

Generally the main aim of the CBS model is to help urban development control department and lease office experts to prepare and forward reasonable, comprehensive and consistent recommendations regarding to the four critical determinants. This approach calls for a representation of the values, arguments and opinions in the system. Also, descriptions of the cases and outcomes of the retrieval should be understandable to the user.

The study attempt was made to answer the following questions which includes: what are the cases suitable for developing CBS that are related to urban land development?, how the acquired cases will be modeled and represented in developing a CBR system?, to what extent the developed CBS learn from experience?, and finally to what extent the proposed system get acceptance by the City Land Development and Administration Agency staffs?. From the literature review, system testing and user acceptance evaluation, the study finds that this design science research paradigm approach has achieved its main objective because it can retrieve the useful cases to the urban development control department and lease office experts in urban land development control decision making process. Hence the system has the potential to be an aiding and advisory system.

If the purpose is to learn lessons and experiences from previous cases in land development process, both good practices and bad practices are certainly very important for decision maker. Another underlying issue is about the utilized case numbers in CBR model. 65 cases are used in case library for developing the prototype system. By consulting the domain experts it is decided that this case number is sufficient to develop and test the prototype system. Shi & Yeh (1999) used approximately 100 cases and Domeshek & Kolodner (1993) used 20 cases at the beginning of "Arhie" and grew up to 150 cases in 2nd version.

In this study the whole model approach is proposed to reach land development control decision support, so it is decided that the final decision maker should be human land development experts. In this manner auto reuse/adapt cycles of CBR process are not used after retrieval instead the expert manually adapt solutions provided by previous developers. Auto adaptation process has also some operational difficulties in using complex domains. According to Shi & Yeh (1999) the main objective of a CBR model which deployed for city planning domain is to search and represent useful cases for the user; the further inference such as auto adaptation can be optional. The system can be used in order to transfer expertise and render advice or recommendations, much like a human expert. Urban land development often requires the experiences and expertise of experts in its complicated decision-making process. By utilizing CBR technique it is possible to facilitate this process.

CHAPTER SIX
CONCLUSION AND RECOMMENDATIONS

6.1 CONCLUSION

This research attempts to apply Case-Based Reasoning in the domain of land development control. The main aim of the CBS model is to help urban development control department and lease office experts to prepare and forward reasonable, comprehensive and consistent recommendations regarding to the four critical determinants. This approach calls for a representation of the values, arguments and opinions in the system. Also, descriptions of the cases and outcomes of the retrieval should be understandable to the user.

For this research, previously solved cases by experienced land development experts were collected purposely from Jimma city land development and administration agency. The relevant knowledge acquired from domain experts and secondary document is conceptually modeled using hierarchical structure conceptual modeling method that represents concepts and decision making processes in urban land development control. After the acquired knowledge is modeled, case based reasoning technique is used for representing the knowledge. Cases were represented with attribute-value format. The prototype system CBRSULDC is developed by using jCOLIBRI Programming tool.

CBRSULDC prototype system uses the prominent CBR cycles (Retrieval, Reuse, Revise and Retain) to perform different tasks. In CBRSULDC, the first task is retrieval of cases by entering a new problem description (case) by using the query window. Then, similarity computation is performed and retrieves most similar cases. After retrieval of similar cases, reusing the previously solved case solution will be applied to the new case if there is exact match between query and old case from the case library. Otherwise manual revision of cases to fit the problem at hand by the land development experts will be carried out. The last task is storing the revised case in the case base for future use. The retrieval task of the prototype system uses Nearest Neighbor retrieval algorithm. In summary, the developed CBRSULDC provides urban developers to recognize, understand and generate creative solution to a new problem while it provides raw but comprehensive and original information, and tools to facilitate the decision-making process.

The evaluation result shows that CBRSULDC system is encouraging since the retrieval performance of the prototype registers an average value of 83% recall, 70% precision and 76% F-measure. In addition, testing the improvement from learning has been done to examine the learning performance of the prototype from previously solved landholder cases in future use. Based on the result of the test it is confirmed that CBRSULDC system has the capability to learnt from successfully solved tenant cases and uses it in solving other tenant cases. This type of learning is known as incremental learning because it always adds knowledge that is new and useful in addition to the existing knowledge. Therefore, all the aforementioned test result supports the conclusion that CBR is an ideal technique for solving urban land development problems.

The user acceptance evaluators (the domain experts) assign more than average value for all parameters that are used in the user evaluation form for the prototype. So the average user acceptance evaluation achieved was 83% which is a higher acceptability from the end user side and this implies the importance and applicability of the prototype system in decision making. As a result; it can be concluded that, CBRSULDC can be used in supporting decisions in urban land allocation process. Furthermore the developed CBRSULDC prototype system is found to be prominent and capable enough to overcome land development and related problems in a way by supporting land development experts during decision making process in urban land development control.

6.2 RECOMMENDATIONS

Although the results of this study are promising, there are challenges that need further investigation for future work. Therefore, the researcher recommends the following issues as a future research direction based on this study.

- Even if the registered recall and precision performance of the system is prominent, the experiment result indicates that some of relevant cases retrieved by the system and relevant cases selected by the domain experts were somewhat contradictory due to imprecise assignment of weigh to some of the selected attributes. Therefore; for the problem of weighing the attributes according to the level of their importance, efficient machine learning approach that can learn from the data after training the data is recommended.

- The attributes used in this research are collected from previous landholder's cases in JCLDAA. But this attributes found to be insufficient in order to provide full-fledged advanced decision support during urban land allocation which additionally take the pre-selection stage in to consideration. So further research needs to be conducted with the inclusion of other important attributes that have significant impact on urban land development control.
- The status parameter only provides the outcome of the previous decisions made by the land development experts which is whether result of the decision was successful or unsuccessful, but it does not give explanation on the root cause of the problem behind this failures. So further research needs to be done in order to add justification facility that can give explanation on the cause of unsuccessful land development in addition to end result of the development; so that it will be possible to avoid repetition of similar mistakes for the future.
- To enhance the performance of the prototype case based system hybrid strategy approaches should be investigated which combines rule based reasoning and case based reasoning. So it is recommended to explore the integration of CBR with rule-based reasoning. Integrated usage of reasoning models can be complementary to each other. For example rule-based reasoning can be used to contain the rule part which is proclamation of Ethiopian lease land tenure system or when new regulations/circumstances are introduced which make previous cases less relevant.
- Based on the evaluation on the performance measure of the system, it is proven that CBRSULDC system helps land development experts in land allocation decision. But the system is developed in English and hence language barrier is observable on some of the users which affect interactivity of the prototype system. Further investigation should be conducted in order to develop a system in different local languages. This helps the expert to easily interact with the system using their own language.
- It is possible to make the developed CBRSULDC system accessible from different locations by creating and maintaining the case library in web based environment. So it is recommended to investigate further study on the development of a web based case library for the system as a result urban land development control experience of a particular city

could be shared for other cities throughout the country or abroad to achieve better experience sharing between municipal governments of different cities.

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APPENDIXES

Appendix I

Interview questions to Domain Experts

After introducing the objective of the study and confirm the respondents' willingness to participate in the study the interviewer records their answers for the following interview questions.

1. What criteria's are considered in the grant process of a particular urban land to applicants?
2. Is their consistency in urban land allocation final decision made by different land development experts?
3. What attributes are given more consideration in order to identify period and cost of the four critical determinants?
4. Among various land use types which one is categorized under tendering as well as allotment land acquisition mechanism?
5. What are the main determinants factors to identify a bid winner during the pre-selection phase?
6. What are the current problems in the municipal government that affect the decision making process of land development control?
7. What is the critical cause that drives the municipal government to carryout unsuccessful land development in the city?
8. What alternative should be taken in to consideration in order to avoid unsuccessful land development throughout the city?

Appendix II

Prototype Evaluation form for the Domain Expert

This is an evaluation form to be filled by land development experts in order to evaluate the case based reasoning system for urban land development control. Description of the parameter values are as follows.

Performance value	1	2	3	4	5
Description	Poor	Fair	Good	Very good	Excellent

Instruction: please assign (X) on the appropriate value for the corresponding parameter of evaluation questions of the case based reasoning system for urban land development control.

No	Evaluation criteria	Performance value						
1	Ease of use of the CBS	1	2	3	4	5	Average	%
2	Is the system efficiency in time							
3	Is the user interface interactivity?							
4	effectiveness towards provision of adequate lessons from previous both successful and unsuccessful land allocation decisions							
5	Adequacy and clarity of decision support							
6	Relevancy of the retrieved cases for decision making							
7	Fitness of the final solution to the new case							
8	Relevancy of the attributes in representing landholder's case							
9	Rate the significance of the system in the domain area							