EVALUATION OF CADASTRAL INFRMATION SYSTEM WITH THE STANDARD FRAMEWORK: A CASE OF ADAMA CITY, OROMIA, ETHIOPIA

Bayisa Bekele

A Thesis Submitted to

The Department of Architectural Engineering School of

Civil Engineering and Architecture

Presented in Partial Fulfillment of the Requirement for the

Degree of Masters of Science in Geo-informatics Engineering

Office of Graduate Studies

Adama Science and Technology University

Adama, Ethiopia

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Declaration

I declare hereby this research thesis entitled "Evaluation of cadastral information system with the standard framework: A case of Adama city, Oromia, Ethiopia**"** is my original work. That is, it has not been submitted for the award ofany academic degree, diploma or certificate in any other university. All sources of materials that are used for this proposal have been duly acknowledged through citation.

Bayisa Bekele ______________________________

Recommendation

I/we, the advisor(s) of this thesis, hereby certify that I/we have read the revised version of the thesis entitled "Evaluation of cadastral information system with the standard framework: A case of Adama city, Oromia, Ethiopia" by Bayisa Bekele submitted in partial fulfillment of the requirements for the degree of Mater's of Science in Geo-informatics Engineering Therefore, I/we recommend the submission of revised version of the thesis to the department following the applicable procedures.

Major Advisor/supervisor ______________________	______________ Signature	___________________ Date

APPROVAL FORM

We, the advisors of the thesis entitled "Evaluation of cadastral information system with the standard framework: A case of Adama city, Oromia, Ethiopia" and developed by Bayisa Bekele hereby certify that the recommendation and suggestions made by the board of examiners are appropriately incorporated into the final version of the thesis.

Major Advisor/supervisor	Signature	Date

We, the undersigned, members of the Board of Examiners of the thesis by Bayisa Bekele have read and evaluated the thesis entitled "Evaluation of cadastral information system with the standard framework: A case of Adama city, Oromia, Ethiopia" and examined the candidate during opdefense. This is, therefore, to certify that the thesis is accepted for partial fulfillment of the requirement of the degree of Master of Science in Geoinformatics Engineering.

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Lists of Acronyms

GPS	Global positioning system
GCP	Ground Control Points
GIS	Geographic Information System
EFQM	European Foundation for Quality Management SDG
	Sustainable Development Goals

Abstract

This study developed a methodology to measure and evaluate the performance of Adama city cadastral system based on International Scientific journals/desk study/ and case study in the city and the paper contributes and develops an evaluation framework for urban cadastral system. The cadastral system has been subject to a standardized approach for a number of years conducted by both the scientific community and professional organizations. This research study approaches desk study and case study techniques to analyze the assumption set in the objective. This research carried out by evaluating the existing cadaster of Adama city with international standards from the desk study with total Standardized Evaluation Indicators=50. As per the analysis output; 16 % of the system was Strongly weak and 48 % of the system categorizes as moderate strength, 36% of it strong. As resulted from desk study and case study the current major Weakness of Adama city cadaster are lacks a better system of land registration, the spatial accuracy of many control points is poor skill gap of experts, weak system for parcel identification, slow adaptation of modern technology, lack of harmonized proceed, too much paper work , poor standardization of data , use of network technology to exchange data is not available, cadastral system in Adama city takes too long to update, and lack of legal cadaster applications. While there are some strong side of the current system: Starting of developing modern cadaster, 53% users certified, land related problems such as overlapping, land taxation, was minimized. Cadastral system, and the system developed shows that moderately transparent, secured, and accessible.

Key words: *Cadaster, evaluation, desk study, survey study*

CHAPTER ONE: INTRODUCTION

1.3. Background of the Study

In an urban area land is one of the natural resources that provide the physical location for shelter, farming, commerce, industry and other public services for humankind in urban areas. Thus, wise utilization of this vital resource is very important through some systematic handling and managing techniques. In terms of the economic aspect, it serves as a basis for livelihood; in terms of the social aspect, land is a space for interaction; in terms of politics, land is a source of power; in terms of culture, land is a symbol of collective identity (Dale andMcLaren, 2005). Hence, significant efforts have been invested all over the world for the correct Land management, including the development of reliable cadastral systems towards a secure land recordation (Krigsholm, et al 2017). The fuel driving the engine of growth and sustainable development of any nation can be measured with the access of reliable and sufficient land information (Babalola and Kardam, 2011). The Cadastral system provides security and clarity with respect to the status of land parcel and it plays an important role in order to develop and supply new services such as spatial-based parcel information systems (Cete and Yomralioglu, 2004). Prevailing high rate of urbanization, which is mostly manifested in higher growth of urban population and its expected continuation, are to aggravate the problem of urban land use from time to time. The pattern of growth of Ethiopian towns is irregular, uncontrolled and often leads to the emergence of slums. As a result of the absence of proper registration, taxes related to property could not be collected efficiently in most of the towns. Moreover, without having sufficient knowledge and information about the base, the land itself, urban planning in these towns is unthinkable. Because of the above fairly obvious reasons, the need for land information system has become an urgent necessity. A land information system is a tool for legal, administrative and economic decision making and could also be used as an aid for planning and development activities. Therefore, many cities are currently considering surveying, mapping, databasesystem developments are as a vital tool in their strategy to improve the quality and control of urban planning and management. Land registers; tax registers, building registers, population data, physical planning and development control need current information about geographic location.

The United Nations and organizations such as the International Federation of Surveyors (FIG) have for many years undertaken studies to understand and describe land administration systems and particularly the cadastral system component (Ting, L.; Williamson,2001). For this paper, the term cadastral system is defined as a formal sub-system of land administration that includes the organizational system (a set of professional actors with accountable responsibilities to carry out cadastral activities and maintain cadastral information systems), procedures, and regulations, which altogether ensure that the cadastral system is kept up-to- date. In short, a cadastral system is an organizational system usually referring to the operations that a cadastral organization is conducting (DeVries, W.,2017). Urban cadastral system in this context refers to a cadastral system in an area where there is human settlement with high population density and infrastructure of built environment. Urban cadastral systems are highly valuable for generating and distributing comprehensive data during land administration and management processes, and this can be regarded as a cornerstone for efficient operations of any state (. Dawidowicz, et al ,2018).

Both developed and developing countries accept the need to evaluate cadastral systems to help identify areas of improvement and whether their systems are capable of addressing futureneeds. The UN (UN. Sustainable Development Goals. 2015) has envisioned 17 goals for 2030in the form of Sustainable Development Goals (SDG). The SDGs are the blueprint to achievea better and more sustainable future for all. They address the global challenges we face, including those related to poverty, environmental degradation, prosperity, and peace andjustice. According to Rajabifard (2019), countries require access to an effective, efficient, and modern land administration system (LAS) based on a cadastre engine that contains spatially accurate land parcels and corresponding rights, restrictions, and responsibilities.

Performance assessment systems are not new to this domain. There is already a variety of frameworks and methodologies that can evaluate, characterize, and assess cadastral systems (Tony, et al, 2019). In order to determine the fulfillment of SDG objectives, cadastral systems need to be effective and sustainable in their implementation. For this reason, performance evaluation mechanisms are needed (UN: Agenda 21, 1992).

Standardized methods or a quality framework to measure and evaluate urban cadastral systemm around the world are still lacking (Zahir, et al, 2018). This is maybe largely due to the fact that the natures of cadastral systems are dependent on the cultural and social values ofthe societies of the prevailing country in which they operate (Shibeshi, et al, 2015). To date, research has primarily focused on the usage, principles, advantages, and disadvantages of the existing implementations of the urban cadastral system, yet the design of systematic evaluations of the systems is still insufficiently researched (Fawad, et al, 2005). The absence of a proper land registration system, aggravated by problems such as incomplete land registration, the proliferation of illegal settlements, poor urban management, outdated and rigid developmental plans saw the Ethiopian land authorities introducing a number of pilot projects in a number of cities, aimed at improving the cadaster system through GIS applications (Gondo and Zimbabwe, 2010).

The cadastral system in most African countries is in the inception stage. Most of the countries are used cadastral system based on traditional methods. While the sophisticated economies of the 21st century need the services of a modern cadastre to effectively deliver the objectives of sustainable development. In 1972, the Unite Nations (UN) called group of experts to evaluate of the cadastral system in developing countries and to consider setting up a permanent committee to constantly review the developments in this area (Williamson, 1996). Ethiopia, as one of the fastest developing countries in Africa, is in the process of implementing a modern urban cadastral system at the country level. In response to this, new legal and institutional frameworks have been introduced.

1.2. Statement of the Problem

In 2007, a contemporary cadastre evaluation initiative was carried out in four designated pilot project zones across major Ethiopian cities, namely Dessie and Bahir Dar in the Amhara Regions, Adama in the Oromia Regions, and Mekele in the Tigray Region. Unfortunately, all these pilot areas encountered challenges that led to their lack of success. The primary reasons behind the failure of the initial urban cadastre practice in these selected pilot areas included: absence of a legal framework, insufficient resources and technical support from the federal government, limited awareness among the community and higher officials, a shortage of baseline maps and ground-based control points (GCP), and a high turnover of skilled surveyors and GIS experts (Tipple and Alemayehu, 2014; Fisseha, 2023).

The Bogor-Declaration (Williamson, 1996), recommended that in order to improve a cadastral system, it is necessary first to identify its problems. Once these weaknesses have been fully documented and evaluated, it is then possible to re-engineer the system for efficient delivery of cadastral services to the users. Although several authors have addressed evaluation frameworks for different aspects of land administration and management (Shibeshi, et al, 2014), a specific method evaluating urban cadastral systems seems to be missing. According to Gebrewold (Gebrewold, 2016), the key difficulty for the success of cadastral systems is the absence of standardized frameworks, which enable evaluation of the performance of undertaking institutions. In this respect, for Ethiopia, including Adama city, there is no accepted methodology that can measure and evaluate the performance of the urban cadastral system. Thus, this research develops standard frame work for evaluating Adama city cadastral system.

1.3. Objectives of the Study

1.3.1. General objective

The general objective of this study is to evaluate the current status of Adama city cadastral system in order to propose the solutions for the gaps.

1.3.2. Specific objectives

More specifically, the specific objectives of the study are:

- To identify the key factors to evaluate the existing cadaster
- To evaluate the existing Cadastral system with the Desk study approach
- To evaluate the existing Cadastral system with the case study approach
- To propose scientific solutions for the identified weakness of the system

1.4. Research Questions

- What are the factors used to evaluate cadaster?
- What are the strengths and weakness of the cadaster assessed from Desk study?
- What are the strengths and weakness of the cadastre assessed from case study?
- What are the solutions for the identified gaps in cadastral system?

1.5. Significance of the Study

By assessing the cadastral management system, the study seeks to evaluate the efficiency of land administration in Adama City. The study provides a valuable opportunity to discern both the strengths and weaknesses inherent in the current cadastral data management system.

This understanding is pivotal for evaluating areas of success and potential improvement, thereby guiding future enhancements to the system. The comprehensive evaluation facilitates the optimization of resources, ensuring that investments in geospatial technology align precisely with the specific needs and challenges of Adama City. This, in turn, can result in more effective resource allocation, promoting sustainable practices in land management. Through the evaluation process, there is an opportunity to pinpoint areas requiring knowledge transfer and capacity building. This identification can pave the way for targeted training programs andcollaborative efforts aimed at enhancing the skills and capabilities of professionals engaged incadastral evaluation. In conclusion, the study's evaluation of the cadastral system in Adama City, utilizing standard framework, holds significance by addressing practical challenges, informing decision-making processes, and contributing to broader objectives related to efficient land administration and sustainable urban development.

1.6. Scope of the Study

This study's emphasis is Adama City, which is located in Ethiopia's Oromia region. This urban region is the special focus of the inquiry, which aims to evaluate the efficacy of its cadastral management system. The study looks closely at Adama City's current system and evaluate the system in terms of technical, technological and legal ways in which boundaries, land ownership, and land-use planning. The main objective is to offer insightful evaluation, suggestions, and contributions that will improve land administration effectiveness and promote urban growths.

CHAPTER TWO: LITERATURE REVIEW

2.1. Concepts of Cadastre

Understanding the evolution of modern cadastres hinges on recognizing their significance in the human-land relationship. In the digital era, cadastral research has advanced, incorporating innovations in land management and ownership based on both 2D land parcels and 3D floor plans (Billen and Zlatanova, 2003; Stoter and Salzmann, 2003; Stoter and Van Oosterom, 2005; Aien et al., 2013; Shojaei et al., 2013). Information and communication technology (ICT) advancements have propelled collaborative efforts with other fields, demonstrating a strong correlation between cadastral research development and ICT progress, especially in developing countries (Van Oosterom et al., 2002; Selleri and Fabrizi, 2003). The scope of cadastral research has expanded to include geographical-spatial information, transforming the traditional government-centric role into a more user-friendly one.

To confront the changes in cadastral research and facilitate future studies, it is imperative to organize and analyze research across various fields. This research aims to analyze the evolution of cadastral research from international papers, utilizing semantic analyses (macro- and microscopic perspectives) to deduce the research flow (Silva and Stubkjær, 2002).

A cadastre, essentially a register of boundary information, includes graphical presentations of real property units with boundaries determined to establish ownership. The digital cadastral map registers these boundaries, containing a time series with diverse attributes and overlays, carrying legal implications for land use and ownership. Cadastral research has evolved to enable more sophisticated analyses using diverse data sources, addressing land use and landscape changes (Bender et al., 2005; Skånes and Bunce, 1997). The scope of research has extended to enhance efficiency through social scientific approaches and support land ownership within existing legal frameworks (Navratil and Frank, 2004; Van Oosterom et al., 2006).

While studies on applying new technologies in cadastral research persist (Olfat et al., 2018), Silva and Stubkjær (2002) underscore the significant role of societal, political, and economic factors in advancing cadastral research. Notably, a substantial portion (18.2%) of papers published in the field from 1995 to 2020 were categorized as "social science," indicating the interplay of societal factors. With ongoing technological advancements and changes in the data environment, further evolution in cadastral research is anticipated.

Cadastral research involves setting or readjusting boundaries for real estate areas, producing legal effects for properties. Given its connection to people and institutions, this study proposes semantic analyses as a tool for advancing cadastral research. Additionally, global research trends and specific topics have been analyzed using bibliometric methods (Aleixandre-Bena vent et al., 2018; Bielecka and Burek, 2019). Various studies employ co-author or co-word analyses, and there is a growing interest in monitoring development processes and evolutionary trends in the cadastral field, although methods for evaluation, such as quantitative analysis or semantic network analysis of major keywords, remain areas forfurther exploration (Hood and Wilson, 2001; Zevenbergen, 2004; Nepal, 2009; Liu et al., 2016; Zhang et al., 2017; Polat, 2019)

The cadastral plan, representing the land parcel unit, has gained acceptance as the legal unit for purposes such as land registration, taxation, and the overall development of cadastres. Combining these land parcel maps with spatial analysis allows for applications like land use zoning and the delineation of various land administrative boundaries (Yìldiz et al., 2018). However, as noted by Eagleson (2002), a majority of these spatial boundaries have been created in an uncoordinated manner, leading to fragmented boundary units.

The cadastre functions as an information system with two components: a series of maps or plans illustrating the size and location of all land parcels, along with text records describing the land's attributes. While a cadastre serves the purpose of land registration, exclusively dealing with ownership, it also acts as the fundamental building block in a land administrationsystem. The storage of cadastral plans plays a crucial role in land administration and management, emphasizing the importance of developing and maintaining cadastral records and management information infrastructure. The Spatial Data Infrastructure (SDI) initiative aims to facilitate easy and secure access to complete and consistent datasets (Rajabifard et al., 2000).

A key challenge impeding the goals of SDI is the fragmentation of data between non-coterminous boundary systems and across various agencies/departments. This research focuses on investigating a method for organizing spatial and attribute land data by applyingthe principles of hierarchical increments of data as the framework for an overall land information system. Information related to approved cadastral plans, including ownership, purpose, locality, district, area, shape, and geographic extent, is collected, stored, maintained, and analyzed to enhance efficient and effective land administration. The research addresses issues such as boundary overlaps during data integration, composing data into town sheets and layouts, and fitting data into district boundary maps, utilizing current districtadministrative boundaries and associated data (Appiah, 2013).

2.2. Cadastral Management

Cadastral management stands as a crucial element within land administration systems, ensuring the precise and efficient recording of land-related information. The emergence of geospatial technology has brought about a significant transformation in the collection, processing, and management of cadastral data (Krigsholm et al., 2018).

Traditionally, land administration organizations were established to record details concerning property ownership, rights, boundaries, and other attributes of real properties. Various sectors, such as land and property markets, agriculture, forestry, urban planning, and infrastructure management, rely on this information. The certainty of identifying property owners is vital for land and property markets, while other sectors necessitate knowledge of land ownership for their activities (Van der Molen, 2002). Although the development of Land Administration Systems (LAS) has predominantly been driven by providers, there is a growing recognition of the importance of consulting stakeholder views to understand the role land administration can play in supporting sustainable development. Given recent developments like the rise of platform economies and shared processes within ecosystems, discussions on how user groups perceive their future needs for cadastral information have become more critical than ever (Ting, 2002). Land administration revolves around cadastres and land registers, collectively referred to as cadastral systems. It is more meaningful to discuss cadastral systems than cadastres, as these systems depict the interaction between land parcel identification, land rights registration, land valuation and taxation, and the current and potential future land uses (Enemark et al., 2005;

Bogaerts and Zevenbergen, 2001). Within the LAS context, the land management paradigm, a relatively recent concept, emphasizes the role of land policies, land information, and LAS in achieving sustainable development goals (Van der Molen, 2002). Simply put, this paradigm underscores the need to manage land and land resources coherently. Modern land administration theory recognizes that each country employs various techniques and tools to manage land and resources in line with its land policy goals (Williamson et al., 2017). Land administration, therefore, is the utilization of these management techniques and tools within a specific jurisdiction. It is crucial to note that land administration is viewed as "not an end, but a means to an end." In other words, the implementation of land policy through land management tools should always be oriented towards benefiting society (Molen, 2003).

2.3. Cadastral evaluation framework

Both the development of spatial information technologies and the drivers of sustainability have fostered the creation of new visions and models for cadastral systems. The 2030 Agenda for Sustainable Development is a global plan of action for people, planet, prosperity, peace, and partnership. Land 2020, 9, 60 4 of 15 Considering that an estimated 70% of people do notenjoy secure land and property rights, there is a need to accelerate efforts to document, record,and recognize people-to-land relationships in all forms. The 2030 agenda includes 17 goals and 169 targets/indicators adopted on 25 September 2015 by heads of state and government ata special UN summit (Sustainable Development Goals. 2015). Gradually, the cadastral systems have been conceptualized by multipurpose cadastres (Williamson, I.P.1985). Cadastre 2014 (Steudler and Kaufman, 2014), the Bogor Declaration on Cadastres (UN-FIG, 1996), The Bathurst Declaration (UN-FIG, 1999), and the development of sustainable land administration systems. How cadastral systems can support sustainable development is articulated in the Bogor Declaration and The Bathurst Declaration. The Bogor Declaration additionally formulated a way for cadastral systems to combat poverty and environmental decline. The Bathurst Declaration has also articulated the link between good land administration and cadastral systems; the cadastre enables good land administration by providing reliable and usable land information. Enemark et al. [8] formulated the so-called “Land Management Paradigm”, portraying the link between a country’s land policies, land administration functions (tenure, use, value, and development), information infrastructures, and the achievement of sustainable development. A cadastral system can be seen as part of the operational level of land administration. It includes the information systems and processes to facilitate the application of land-related rules and regulations. It also supports the cadastral institutions in their mandate to maintain transparency, accountability, and responsiveness for the management of social, economic, and environmental issues (FIG. Marrakech Declaration,2004). Cadastral information systems are reliable and accurate datasets, which contain evidence for land-related transactions. The reliability and effectiveness of this evidence can be enhanced if there is a framework for performance evaluation of cadastral systems (Greenway,2002). An evaluation framework is a systematic approach, which provides an assessment of the quality of current activities and of the system as a whole. This systematic approach identifies good practices and their indicators in order to assess thestrengths and weaknesses of operational performance of an organizational system (Zahir, 2010). According to international standards, a framework provides an evaluation technique that enables the identification of indicators for cadastral systems subject to improvement (Yilmaz,2015; EFQM, 2012; Rajabifard,2003). An indicator is a specific, observable, and measurable characteristic, which shows changes or the degree of progress of a system in achieving a specific outcome [20]. By understanding how urban cadastral systems function in countries where cadastral systems are effective, it is possible to derive a set of good practices and possible success factors (Zahir, 2010). Such an approach may be relevant for developing countries, which are struggling with finding solutions for institutional problems with cadastral information. By studying, comparing, and analyzing how other countries reach stability and sustainable outcomes in their cadastral systems, it is possible to identify the most relevant elements and aspects (United Nations,1996). International literature shows that there are a number of evaluation frameworks that can measure and evaluate organizational performance. As stated by Gebrewold (2016), good practices and indicators are reference points for evaluations, and they constitute a critical component of an evaluation framework. In Ethiopia, many cadastral projects have been implemented, yet with varying degree of success. Each of these (pilot) projects contained trials for implementing cadastral systems, yet often these were not complementary to existence of earlier projects. This has resulted in overlaps, redundancies, and ill-functioning and inconsistent cadastral systems throughout the country. One of the most notable characteristics of these projects was the consistent absence of a progress performance evaluation of the project in each project phase. In other words, there is no systematic assessment and evaluation of the strengths and weaknesses of earlier projects, and there are no systematic set of guidelines used at the start of projects. On the other hand, there are standards and indicators developed by international organizations that can perform these tasks, yet these standards are not adopted. For instance, the FIG has proposed a set of criteria for the development and evaluation of cadastral systems. Land 2020, 9, 60 5 of 15. In 2004, Steudler developed an evaluation framework for land administration consisting ofpolicy, organizational management, operational, partnerships, and review processes. Furthermore, Shibeshi et al. adapted Steudler's framework to evaluate the status of land administration systems in Ethiopia. Rajabifard developed the so-called cadastral template, which was originally a way to compare cadastral systems globally, but gradually developed into a standardized system, which describes and evaluates the key elements of any cadastral system and has as such become a standard of designing and evaluating cadastral systems. Outside of the cadastral domain, there are evaluation frameworks to evaluate performances of organizational systems, such as the European Foundation for Quality Management (EFQM). This framework evaluates the effectiveness of an organization based on nine indicators. These indicators represent both the input and output of an organizational system. The input indicators are referred to as enablers (leadership, strategy, people, partnership, and process), whereas the output indicators are referred to as results (people, customer, society, and business). The model posits that the achievement of sustained success relies on strong leadership and a clear strategic direction. Further enablers are the need to develop andimprove their people, partnerships, and (internal) processes. Only once these elements are in place is it possible to deliver value-adding services to customers. Another example of an evaluation framework is the "Land Governance Assessment Framework" (LGOV). It is an investigative instrument to assess the status of land governance in a particular country. With aset of strictly defined indicators this LGOV helps to compare a country's land governance to other countries. This can stimulate a particular country to adapt its land governance. Development practitioners of all persuasions recognize that a well- functioning land sector can boost a country's economic growth, foster social development, shield the rights of vulnerable groups, and help with environmental protection. The aforementioned frameworks are aimed at measuring and evaluating the performance of urban cadastral systems policy. Finally, an analytical framework has been developed to guide and facilitate understanding of cadastral systems. In this article, we analyze peer-reviewed literature on the future visions and available models on cadastral system, with the purpose of establishing a framework and a methodology that will help measure and evaluate the performance of national urban cadastral systems.

2.4. Benchmarks for urban cadastral system

cadaster evaluation indicators discussed below

- European Foundation for Quality Management (EFQM) Excellence Model: Enablers: Leadership, strategy, people, process, partnership; results: People, customer, society satisfaction and business results. Excellent organizations have leaders (who shape the future and make it happen) and people (who strive for achievement of organization's goal) and develop a stakeholder-focused strategy (EFQM,2012) .

- Land Governance Assessment Framework

1. Legal and institutional framework.
2. Land use planning, management, and taxation.
3. Management of public land.
4. Public provision of land information.
5. Dispute resolution and conflict management.

Regulations and management of land involve institutions with clear mandates as well as policy processes that are transparent and equitable. Processes for land use planning are efficient, and taxation on land is transparently and efficiently collected. Policy makers assess the extent to which public land holdings are justified and transparently inventoried and managed. Land information systems provide sufficient, relevant, and up-to-date data, at a cost affordable to the general public. Affordable, clearly defined, transparent, and unbiased mechanisms exist for the resolution of land disputes, and these mechanisms function effectively in practice(Gebrewold,2016)

- Land Administration Evaluation Framework Policy, legal, historical, financial, social, political, environmental, cost recovery. There are policy documents, which consider integrated and multi-disciplinary aspects(Steudler, et al 2004)

- Cadastre 2014

1. Complete legal situation of land (public, private).
2. No separation between maps and registers.
3. Cadastral mapping will be replaced by modelling.
4. Manual cadaster will not be longer.
5. Private–public partnership is strengthened.
6. Cost recovery.

The good practice is when cadastral systems are subjected to be evaluated in light of these six elements. Private–public partnership should be strengthened so that technical aspects of cadastre will be performed in supervision with the public(Steudler and Kaufman,2014).

i. The 2030 Agenda for SDG [11] Indicator: 1.4.2. Proportion of total adult population with secure tenure rights to land, with legally recognized documentation and who perceive their rights to land as secure, by sex and by type of tenure. Cadastral system policies support and contribute to the goals of Agenda 2030(UN. Sustainable Development Goals. 2015).

ii. Cadastral Template (six quantitative and two qualitative indicators) [29] Registration systems, population vs. parcel, strata units, percentage of parcels registered, surveyors and lawyers, surveyors vs. lawyers, educational bodies, educational reform issues. There are objective indicators to compare and assess cadastral systems (Rajabifard, et al, 2016).

2.5. Desk study and case study of cadastre Desk study aspect

When conducting a desk study related to cadastre, researchers typically analyze existing information and data without collecting new data themselves. Here are some key points about desk research in the context of cadastre:

1. Purpose: Desk research aims to gather insights, understand existing systems, and inform decision-making related to land management and property rights.

2. Approaches:

- Quantitative Analysis: If existing data is available in a structured format (such as databases or records), quantitative analysis can be performed. Researchers use statistical methods to explore patterns, trends, and relationships.
- Qualitative Analysis: Qualitative approaches involve examining textual information, reports, and documents. Researchers interpret and analyze qualitative data to gain a deeper understanding of the subject.

3. Data Sources:

- Existing Records: Researchers review existing cadastral records, land surveys, property deeds, and legal documents.
- Archives: Historical records, maps, and archives provide valuable insights into land ownership and boundaries.
- Literature: Relevant academic papers, reports, and studies contribute to the desk study.

4. Challenges and Considerations:

- Data Quality: Researchers must assess the reliability and accuracy of existing data.
- Legislation and Policies: Understanding legal frameworks related to land ownership and property rights is crucial.
- TechnologicalAdvances: Desk studies benefit from advancements in geographic information systems (GIS) and spatial data technologies.

5. Evaluating the performance of cadastral systems is essential to ensure their effectiveness and efficiency.

A recent study aimed to develop an evaluation framework for assessing the performance of urban cadastral systems in Ethiopia1.

The research strategy involved a desk review of existing literature, focusing on indicators and good practices.

The study proposed both qualitative and quantitative indicators to evaluate the state of urban cadastral systems in Ethiopia.

By establishing such an evaluation framework, policymakers and practitioners can make informed decisions to enhance cadastral system performance.

Case study related to cadaster

The case study focuses to provide an in-depth study on a single phenomenon within its real-life context. Characteristics

- The research strategy especially copes with situations where the boundaries between phenomenon and context are unclear
- It relies on multiple sources of evidence
- The evidence may be either qualitative or quantitative

- The investigator may not control the environment but the results derived depend heavily on the investigative power of the investigator

- Benefits from prior development of theoretical propositions to guide data collection and analysis
- The focus is on a contemporary event (Gerring, 2004)

In this context, a case study provides valuable insights into the practical implementation and challenges faced within a specific land administration system. Here are a couple of relevant case studies:

- A case study examines the evolution of cadastral systems over time. These systems have adapted based on changes in human-land relationships and technological advancements.
- Historically, land was considered a symbol of wealth during the agricultural revolution and feudal era. The cadastre recorded land ownership during this period.
- As the Industrial Revolution unfolded, the cadastre became a tool supporting land transfer and markets, emphasizing physical ties to the land.
- Post-World War II, with population growth, awareness grew that land was a scarce resource. Countries focused on better planning, and the cadastre played a role in supporting this process.

2.6. Empirical Literature Review

The evaluation of Cadastral Data Management Systems (CDMS) encompasses various studies that investigate into the effectiveness, challenges, and advancements in managing cadastral data. Evaluating the Cadastral Data Management System is an important task, as it helps to identify areas where improvements can be made to support better land management and sustainable development. This review highlights key findings from relevant studies, providing insights into the current state of cadastral system evaluation. Here is a literature review on the assessment of cadastral systems:

“Formative and summative validation of building information model-based cadastral data” by Asghari et al. (2021).

This study assessed the impact of technological advancements, such as Geographic Information System (GIS) integration, in improving CDMS capabilities. The findings highlighted that the integration of GIS technologies significantly enhanced spatial data visualization and analysis within cadastral systems.

"Evaluation of the Cadastral System in the United States: An Analysis of Challenges and Opportunities" by Abdalla and Enemark (2011)

This study evaluates the cadastral system in the United States, focusing on the challenges and opportunities for improving the system. The authors identify several areas where improvements can be made, including the need for better coordination between stakeholders, the development of standardized procedures and guidelines, and the introduction of modern ICT.

"Assessment of the Cadastral System in the Netherlands" by Van Oosterom and van der Molen (2018)

This study assesses the effectiveness of the cadastral system in the Netherlands, using a range of indicators including accuracy, completeness, and consistency. The authors identify several areas where improvements can be made, including the need for better coordination between stakeholders, the development of standardized procedures and guidelines, and the introduction of modern ICT.

"Assessing the Performance of Cadastral Systems: A Review of the Literature" by Williamson et al. (2017)

This review provides an overview of the key performance indicators that are used to assess the effectiveness of cadastral systems, including accuracy, completeness, timeliness, accessibility, and cost-effectiveness. The authors highlight the importance of stakeholder involvement in the assessment process, and provide guidance on how to develop a comprehensive assessment framework.

"Assessing the Quality and Performance of Cadastral Systems: A Case Study of Indonesia" by Budiani and Purwanto (2019).

This study assesses the quality and performance of the cadastral system in Indonesia, using a range of indicators including accuracy, completeness, and consistency. The authors identify several areas where improvements can be made, including the need for better coordination between stakeholders, the development of standardized procedures and guidelines, and the introduction of modern ICT.

"Assessment of Cadastral Systems in Developing Countries: A Case Study of Ghana" by Anokye and Owusu-Bennoah (2019).

This study assesses the effectiveness of the cadastral system in Ghana, using a range of indicators including accuracy, completeness, timeliness, and accessibility. The authors identify several areas where improvements can be made, including the need for better coordination between stakeholders, the development of standardized procedures andguidelines, and the introduction of modern ICT.

"Assessment of the Malaysian Cadastral System" by Shojaei et al. (2013)
This study assesses the effectiveness of the cadastral system in Malaysia, using a range of indicators including accuracy, completeness, timeliness, and accessibility. The authors identify several areas where improvements can be made, including the need for better coordination between stakeholders, the development of standardized procedures andguidelines, and the introduction of modern ICT.

Overall, these studies highlight the importance of assessing the effectiveness of cadastral systems, and provide guidance on how to develop a comprehensive assessment framework. They also identify several areas where improvements can be made, including the need for better coordination between stakeholders, the development of standardized procedures and guidelines, and the introduction of modern ICT.

"Assessing the Quality of Cadastral Systems: A Case Study of Uganda" by Lwanga and Abdul-Rahman (2019.)

This study assesses the quality of the cadastral system in Uganda, using a range of indicators including accuracy, completeness, and consistency. The authors identify several areas where improvements can be made, including the need for better coordination between stakeholders, the development of standardized procedures and guidelines, and the introduction of modern ICT.

"Cadastral System Evaluation: A Case Study of Nigeria" by Adesanya et al. (2016)
This study assesses the effectiveness of the cadastral system in Nigeria, using a range of indicators including accuracy, completeness, timeliness, and accessibility. The authors identify several areas where improvements can be made, including the need for better

coordination between stakeholders, the development of standardized procedures andguidelines, and the introduction of modern ICT.

"Measuring the Quality of Cadastral Systems: A Case Study of Pakistan" by Memon and Abdul-Rahman (2018)

This study assesses the quality of the cadastral system in Pakistan, using a range of indicators including accuracy, completeness, and consistency. The authors identify several areas where improvements can be made, including the need for better coordination between stakeholders, the development of standardized procedures and guidelines, and the introduction of modern ICT.

These studies provide valuable insights into the assessment of cadastral systems, and highlight the need for ongoing evaluation and improvement to support better land management and sustainable development.

"Assessing the Effectiveness of the Cadastral System in Australia" by Rajabifard et al. (2013)
This study assesses the effectiveness of the cadastral system in Australia, using a range of indicators including accuracy, completeness, timeliness, and accessibility. The authors identify several areas where improvements can be made, including the need for better coordination between stakeholders, the development of standardized procedures and guidelines, and the introduction of modern ICT.

"Assessment of the Cadastral System in Canada" by Hossain and Abdul-Rahman (2019)
This study assesses the effectiveness of the cadastral system in Canada, using a range of indicators including accuracy, completeness, and consistency. The authors identify several areas where improvements can be made, including the need for better coordination between stakeholders, the development of standardized procedures and guidelines, and the introduction of modern ICT.

In conclusion, the empirical literature on the evaluation of Cadastral Data ManagementSystems reflects a growing interest in understanding the impact, challenges, and advancements in the field. Studies have focused on effectiveness, challenges, technological integration, user satisfaction, and the adoption of evaluation frameworks, providing valuable insights for practitioners and policymakers involved in cadastral data management.

CHAPTER THREE: RESEARCH METHODOLOGY

3.1. Description of Study Area

Adama city founds at 8° 30′ 52.1172″N latitude and 39° 16′ 9.3252″ E longitude at some 80 Kilometers away from Addis Ababa City. The maximum elevation of the city is 1712 meters above mean sea level. Owing to its geographical proximity to international port of Djibouti within the distance of about 777 Kilometers, the city is one of the preferred destinations for trade and industry (Gebreselassie, 2021).

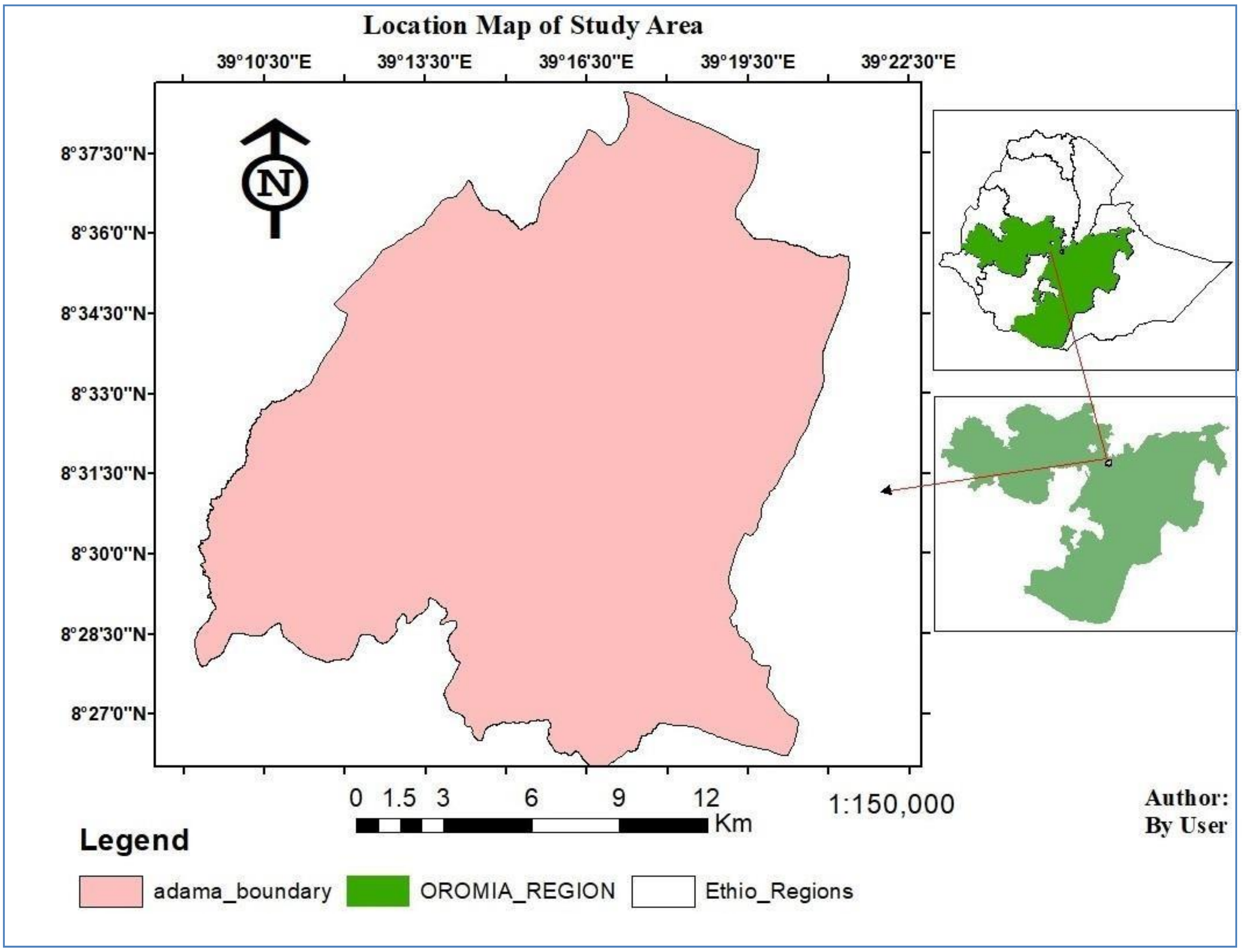

Figure 3. 1: Location of study Area

3.2. Method of Data Collection

The data that were collected for the project were categorized into two: primary and secondary data.

3.1.1. Primary Data Collection

The primary data were gathered through unstructured interviews (or oral interviews) with a variety of people and observation and questionaries. In addition, a reconnaissance survey was undertaken with the use of GPS, which was the primary tool for the study, to collect the current infrastructure components in the area.

3.1.2. Secondary Data Collection

Most of the data were collected from secondary sources (cadastral map, base map, topographic map, satellite map, and attribute information) from the land administration of the study area and Ethiopian Space Science and Geospatial Agency.

3.2. Data Source and Software Used

This part included gathering both spatial and non-spatial data from primary and secondary sources. The table below showed types of data used in the study, their sources, and data specifications.

Table 3. 1: Data and their sources

No	Data	Source	Purpose
1	Orthophoto	SSGII	To digitize parcels and conceptual model
2	Cadastral related Operational Documents	Adama Land administration office	For evaluation
3	Current cadastre status of data	Adama Land administration office	For evaluation
4	Cadastral Socioeconomic	By researcher	For attribute

Software served as the program used for collecting, organizing, analyzing, interpreting, and presenting data. To fulfill the objectives of this study, I utilized the software listed in the table below.

Table 3. 2: Software used and their purpose

S.NO	Name of software	Purpose
1	ArcGIS 10.8 and QGIS 3.28	Data processing and thematic map preparation
3	Google Earth Pro	Use as a base map in visual image interpretation.

3.3. Method of Data Analysis

A scientific methodology is a system of explicit rules and procedures upon which research is based and against which claims to knowledge are evaluated (Frankfort and Nachmias, 1997). As known, research methodology encompasses the ways, means, techniques, approaches, and procedures used to accomplish the research work. This comprehensive data analysis methodology ensures a robust and nuanced evaluation of the cadastral data management system, leveraging both quantitative and qualitative approaches to generate actionable insights and recommendations.

Here is an outline of the data analysis methodology:
First, it was considered prudent to evaluate the organizational structure and the processes of the cadastral system to assess the existing status of Adama city's cadastral data management system. This formed the basis for designing modernization strategies. Secondly, based on the guidelines, this study selected a few performance indicators to guide the evaluation process. These included the organizational structure, technical aspects, legal and financial aspects, security, simplicity, timeliness, accessibility, cost, and sustainability. Apart from the above performance indicators, statements listed in the rule of Cadastre Model were also adopted in the evaluation process. These statements had a strong impact on the development and performance of cadastral database systems and were important in designing the evaluation of any cadastral database.

3.4. General work flow

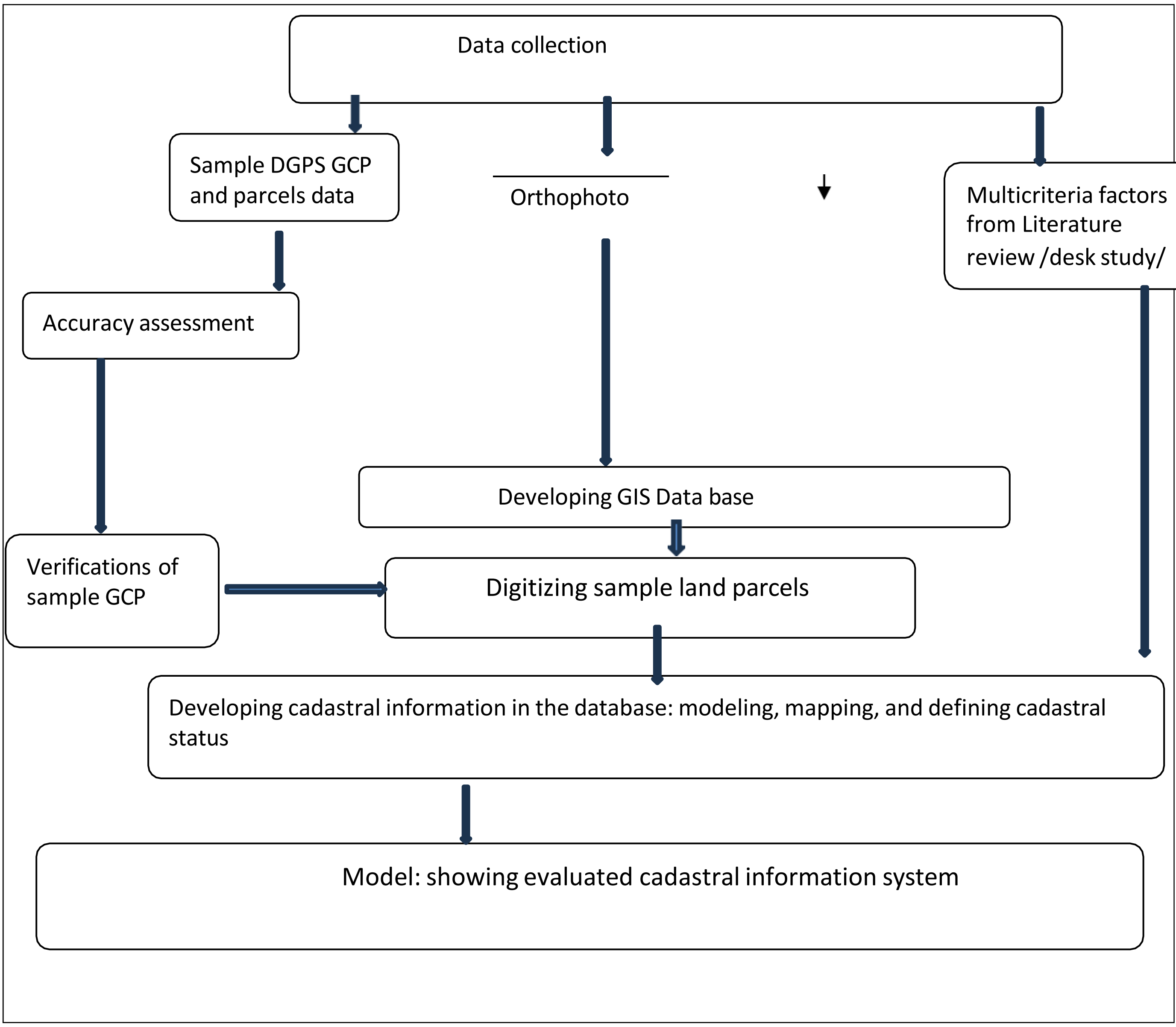

Figure 3. 2: Research Work Flow

CHAPTER FOUR: RESULTS AND DISCUSSIONS

4.1. OVERALL EVALUATION OF CADASTER WITH DESK STUDY

4.1.1. Desk study Indicators for Evaluation of cadaster

The cadastral system has been subject to a standardized approach for a number of years conducted by both the scientific community and professional organizations.

2003–2008 Core Cadastral Domain Model: Advanced information technology. without the availability of full information systems will be difficult to ensure accurate mapping towards fulfillment changing requirements of users.

Data Center and Cloud:

- Internet of Things: solutions enable smart connectivity
- Lacks data exchange.
- Enterprise Network
- Network infrastructures.
- Cybersecurity: Protecting against cyber threats.
- ICT based Managed Services: services for clients
- Covering common aspects of cadastral registrations globally.
- Aligning with the conceptual framework of Cadastre 2014.
- International ISO standards.

2008 Euro-Geographic's: Information technology to provide cutting-edge services for handling the land market. The data on cadastral and property rights should be part of a national spatial data infrastructure should be fully harmonized for data, metadata and services exchange (Dawidoizk and Zróbek, 2014).

- historically-low mortgage rates,
- robust home sales,
- net absorption of multifamily and
- the resilience of the retail property market

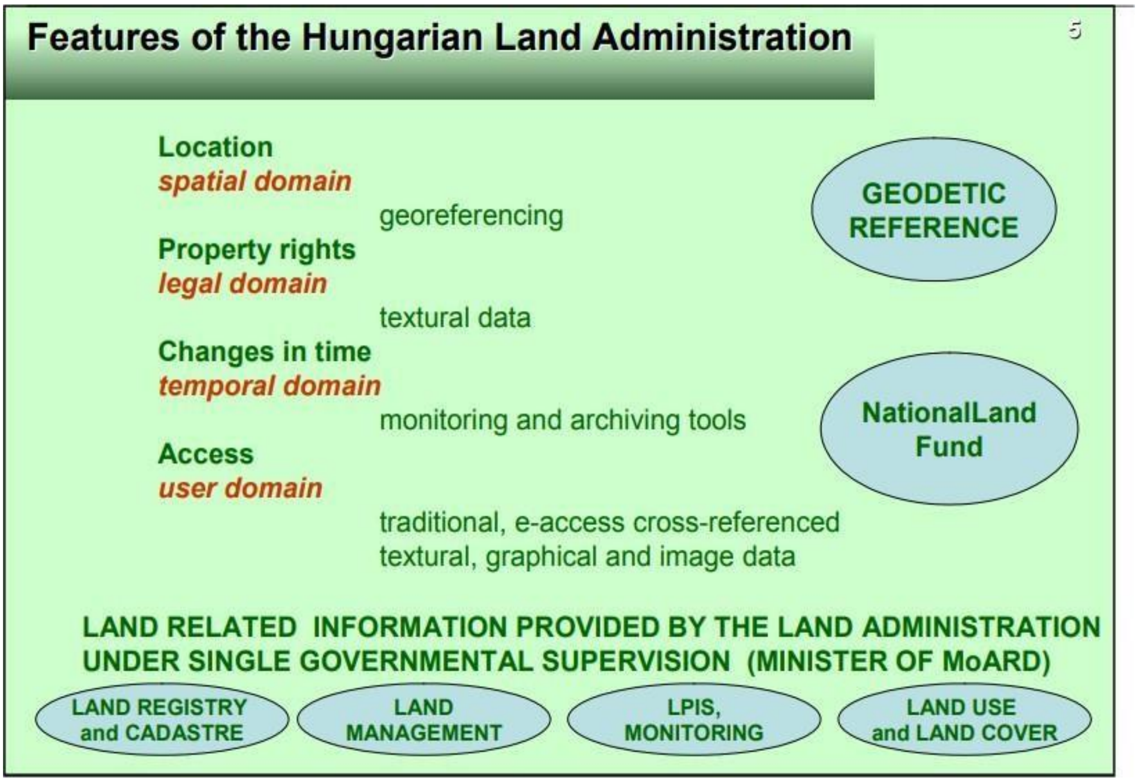

Figure 4. 1: Hungarian land Administration

2011 Cadastre 2.0:

1) High accuracy and timeliness of data visualized in 3D
2) Cadaster should be the foundation of Spatial Data Infrastructures
3) Standard data writing in the object form that allows any mobile spatial analysis
4) Modeling generated via the Internet and mobile devices.
5) Cadastre in Cloud Computing (Dawidowicz and Zróbek, 2014). Archiving: Storing 3D digital cadastral information.

- Interpretation: Understanding 3D boundaries registered in analogue cadastral dossiers.
- Registration: Capturing and managing 3D cadastral information.
- Visualization: Representing 3D boundaries in buildings and other constructions.

- Standardization: Establishing consistent 3D property terminology and concepts.
- Cooperation: Facilitating collaboration between 3D property unit owners.
- Sustainable Land Use: contributes to sustainable urban development and mixed cities
- Modeling generated via the Internet

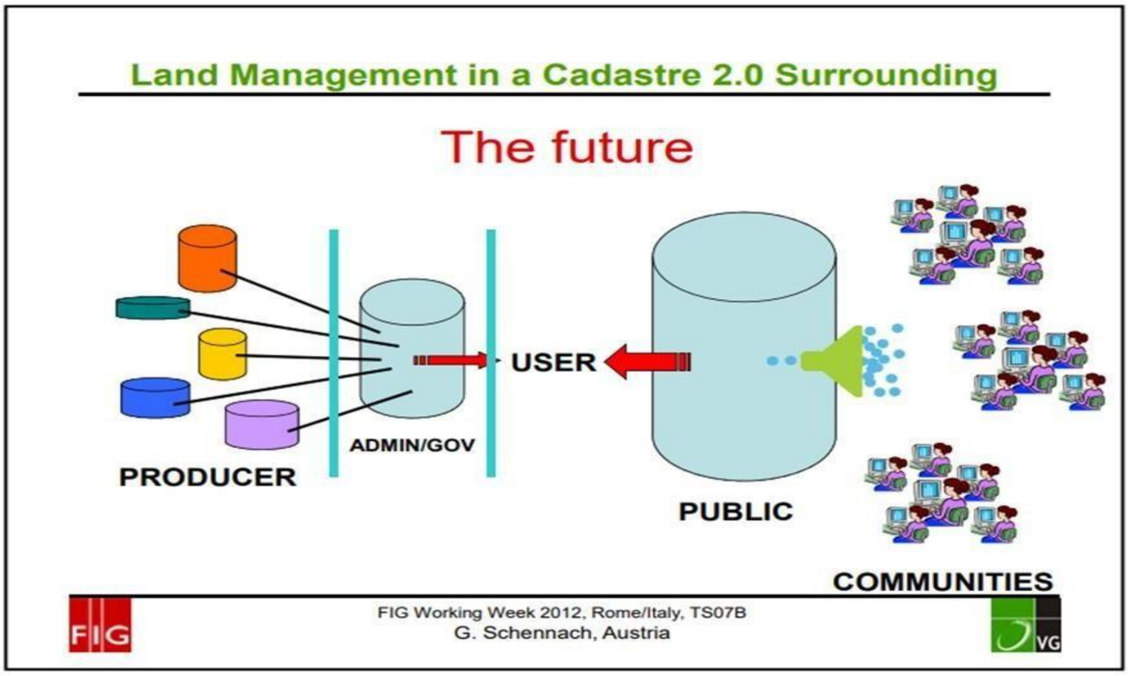

Figure 4. 2:Cadaster 2.0 surrounding

2014 Cadaster:

- Geospatial technology application for cadaster
- Supporting the cadaster with computer programs
- Geographic information is transmitted through “data highway”.
- The Internet and global data networks play a role in the exchange of cadastral data.
- Complete legal situation of land (public, private).
- Cadastral mapping will be replaced by modelling.
- Manual cadaster will not be longer.
- Private–public partnership is strengthened. (Kaufmann and Steudler, 1998).

European Foundation for Quality Management (EFQM) Excellence Model (European Foundation Quality Management (EFQM) Excellence Model. 2012) Enablers:

Leadership, strategy, people, process: People, customer, society satisfaction and business results. Excellent organizations have leaders (who shape the future and make it happen) and people (who strive for achievement of organization's goal) and develop a stakeholder- focused strategy.

- Facilitate coordination among stakeholders.
- Promote international standards and frameworks.
- Activate partnerships to deliver sustainable social, economic, and environmental development.

- Strategy and process,
- Accept Compliance: Ensure products and services comply with specifications.
- Delivery Schedule: Adhere to promised delivery timelines.
- Problem Resolution: Rapidly address issues.
- Complaint Settlement: Handle complaints acceptably.
- Customer Support: Provide assistance in using received information.
- Secure property rights are a cornerstone of wealth in developed nations.
- Achieve positive results by implementing land information and titling systems.
- Providing a reliable basis for land assessment, taxation, and property transactions.

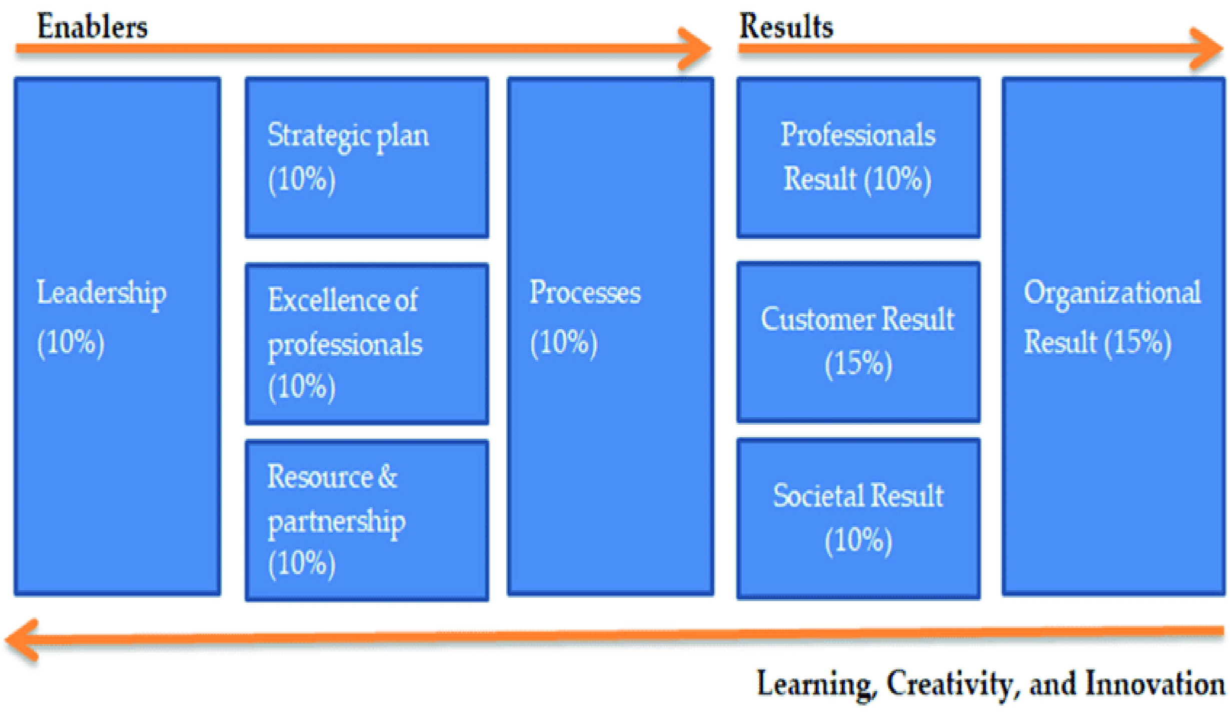

Figure 4. 3: Sample EFQM

The 2030 Agenda for SDG (UN. Sustainable Development Goals. 2015.) Indicators: Proportion of total adult population with secure tenure rights to land, with legally recognized documentation and who perceive their rights to land as secure, by sex and by type of tenure. Cadastral system policies support and contribute to the goals of Agenda 2030.

- Technological: plays a pivotal role in modernizing land registration and cadastral systems, enhancing accuracy, efficiency, and adaptability
- Policy: well-crafted cadastral policies are essential for effective land management, property rights, and sustainable development. Cadastral policy provides the framework for governing cadastral operations, procedures, and regulations.
- Legal: refers to the formal sub-system of land administration that includes organizational systems, procedures, and regulations. It ensures that cadastral systems are kept up-to-date and accurately represent the relationships between people and land, including ownership or use rights.
- Institutional: Legal frameworks, professional actors, and accountable responsibilities are integral components of cadastre
- Social: Social aspects in cadastre involve ensuring equitable access to land, gender equality, and community participation
- Economic growth: play a crucial role in economic development. These are public records of land and property ownership that serve several purposes:
- Reducing Transaction Costs: By providing information on land ownership, cadasters make it easier for private agents to engage in land transactions. This reduction in transaction costs facilitates efficient land markets.
- Strengthening Taxation Capacity: Cadasters enable states to tax property effectively. When property rights are well-defined and visible, it becomes feasible for governments to collect taxes based on land ownership.
- Security of Tenure: Cadasters contribute to secure land tenure. Whenpeople have clear ownership rights, they are more likely to invest in their land, leading to economic growth.

- Facilitating Credit Markets: Visible property ownership allows for the functioning of credit markets at a national scale. Lenders can assess collateral and provide loans based on land assets.

- Technical in cadastre:
  - Spatial Accuracy: Ensuring precise parcel boundaries through advanced surveying techniques (e.g., GPS).
  - Data Integration: Integrating data from various sources (maps, survey legal documents) into a unified system.
  - Database Management: Efficiently storing and managing large volumes of spatial and attribute data.
  - Interoperability: Ensuring compatibility with other systems (e.g., Geographic Information Systems
  - Political support: the support less and the intervention high
  - Environmental case in cadastre:
  - Natural Resource Management: Cadastres help manage natural resources such as forests, wetlands, and water bodies.
  - Protected Areas: Cadastres identify and delineate protected areas

Cadaster 2034:

These features, which are reflected within the Cadaster 2034 strategy are:

- Object oriented; defines the blueprint for creating objects. Think of objects as self-contained entities that encapsulate both state (data) and behavior (code).
  - Attributes and Properties: Attributes represent the data associated with an object.
  - Methods: Methods are functions associated to define the behavior of the object.
  - Interaction: Objects interact with each other by invoking methods.
  - Inheritance: Allows you to create a new class based on an existing one
  - Encapsulation: Hides the details of an object and exposes only what’s necessary.
  - Abstraction
- 3D/4D/5D modeling;
  - 3D Modeling represents X Y Z
  - 4D modeling extends 3D modeling by incorporating the time dimension. It adds a temporal aspect to the model
  - 5D modeling goes beyond 4D by integrating cost data into the model.
- Global to align with international standards as mentioned above

- Organic to model rights, restrictions and responsibilities
  - Rights permissions granted to individuals or groups
  - Restrictions are limitations or conditions placed on certain actions or behaviors.
  - Responsibilities refer to social, ethical commitments or attitudes. They involve obligations to act in a certain way.

4.1.2. Evaluating Adama city cadaster with Desk study

This research carried out by evaluating the existing cadaster of Adama city with international standards mentioned above.

Table 4. 1: Evaluating Adama city cadaster with Internationally accepted Standards

Standardized Evaluation check lists of Cadaster	Described as the International Standards	Cadaster Status in Adama city		
		Strong Weakness	Moderate Weakness	Strong strength
2003–2008 Core Cadastral Domain Model (6 indicators)	Data Center			✓
	Internet of Things			✓
	Data exchange		✓	
	Cybersecurity	✓		
	Services for clients			✓
	Fulfil international ISO standards	✓		
2008 Euro-Geographic's (3 indicators)	Resilience of the property market			✓
	Mortgage rates		✓	
	Robust home sales		✓	
	Establishing consistent		✓	

2011 Cadaster 2.0 (5 indicators)	Storing digital cadastral information			✓
	Interpretation of cadastral data		✓	
	Registration: Capturing and managing.			✓
	Visualization: boundaries in buildings and others.			✓
European Foundation for Quality Management (EFQM) Excellence Model (11 indicators)	Secure property rights are a cornerstone of wealth in developed nations.		✓	
	Reliable basis for land assessment, taxation, and property transactions.		✓	
	Facilitate coordination among stakeholders.		✓	
	Promote international standards	✓		
	Activate partnerships to deliver sustainable social, economic, and environmental development.			✓
	Strategy and process			✓
	Accept Compliance: Ensure products and services comply with specifications.			✓
	Delivery Schedule: Adhere to promised delivery timelines.			✓
	Problem Resolution: Rapidly address issues.		✓	
	Complaint Settlement: Handle		✓	

	complaints acceptably.			
	Customer Support: Provide assistance in using received information.	✓		
	Supporting the cadaster with computer programs	✓		
	GIS, GPS applications			✓
2014 Cadaster	The Internet and global data		✓	
(10 indicators)	networks			
	Complete legal situation of land		✓	
	Accessible databases		✓	
	Cadastral mapping will be replaced by modelling.	✓		
	Manual cadaster will not be longer		✓	
	Government–public partnership		✓	
	Decentralized services			✓
	Staff training			✓
	Technological approach		✓	
	Policy implementation			✓
	Legal			✓
	Institutional		✓	
2030 Agenda for SDG (10 indicators)	Social service			✓
	Economic growth		✓	

	Technical in cadaster		✓	
	Political intervention		✓	
	Environmental case in cadastre		✓	
	Customer satisfaction		✓	
Cadaster 2034 (5 indicators)	Organic to model rights, restrictions and responsibilities			✓
	Object oriented	✓		
	3D/4D/5D modeling	✓		
	Global to align with international standards as mentioned above		✓	

Total Standardized Evaluation Indicators = 50 Cadaster Status in Adama city

Strongly weak = 8 ; In percentage = 8/50*100 = 16% Moderate strength = 24; In percentage = 24/50*100 = 48%

Strong strength Strength = 18; In percentage = 18/50*100 = 36%

4.2. OVEALL EVALUATION OF CADASTER WITH CASE STUDY

4.2.1. Case study Indicators for Evaluation of cadaster

There are some technical approaches internationally accepted for evaluation of cadaster status.

Security: The system should be secured internally and operate with, authorized persons only. It should be secure with the technological arrangements in place for duplicate storage of records in case of controls to ensure that unauthorized persons cannot damage or change information. Cadastral systems provide security of property rights by recording and recognizing land ownership. This is crucial for a free-market economy and contributes to improved living standards

Simplicity: Effective technological development makes the cadastral system clear and simple. Complex forms, procedures, and regulations will slow the system down and may discourage use of the system. Simplicity is also important in ensuring that access is fair and the system is maintained.

Timelines: The technological development, such as GPS and remote sensing provides up- to-date information in a timely fashion.

Sustainability: There must be mechanisms in place to ensure that the system is maintained all the times.

Accessibility: Within the constraints of technology, the cadastral system should be capable of providing efficient and effective access to all users. To enable effectivecommunication among involved parties, standardized cadastral systems are essential. These standards prevent redundant development and facilitate communication within and across countries
Cost wise: Modern technology based cadastral system should be operated at fairly low cost.

Let’s explore the cost aspects of cadastre in terms of money, time, and manpower:

− Cadastral processes involve various costs, including:

Fees: These cover services related to property registration, boundary establishment, and documentation. Professional services: Engaging surveyors, lawyers, or notaries incurs costs.

Digital services: Some cadastral offices offer online services with associated subscription fees or transaction charges. Property registration costs, transfer taxes, and stamp duties also contribute to the financial aspect of cadastral transactions.

− Cadastral processes can be time-consuming due to:
Document verification: Ensuring accuracy and legal compliance. Surveying: Accurately establishing property boundaries.

Administrative procedures: Registering property and updating records.
Digital services adoption: Transitioning to digital platforms may require time for training and implementation.

− Manpower: Surveyors: Skilled professionals who physically delineate property boundaries. Legal experts: Lawyers and notaries handle document preparation, verification, and registration. Administrative staff: Responsible for managing cadastral records and responding to inquiries. Digital specialists: Required for maintaining and improving digital cadastral systems.

Reliability: Technological advancement can improve accuracy of the cadastral information system. An inaccurate cadastral information system would have an even worse effect than just useless and users would lose all trust and confidence in the system. **Transparency:** Friedly used approach.

It encodes underlying data while reducing occlusion.
Transparency can be applied to distinguish between physical and legal objects. By varying transparency levels, users can differentiate between different types of boundaries
Information Communication Technology (ICT) aspects: The organization and operation of a cadastral system now-a-days depend on the introduction of modern information and communication technology (ICT). IT and web enabled solutions play an increasing role in modern societies and therefore would need to be taken into account.

Data Integration: The linkage of data is an important factor for the integration of spatial information from different sources. Successful data integration is based on technological support such as GIS data assimilation from different sources.

Legal aspect: The main function of a cadastral system is to protect rights that people have in land and property and the structure of cadastral Law is therefore important (Wayumba, 2013) (Source: Bogor Declaration (Williamson, 1996); Bathurst Declaration

(UN-FIG, 1999); Kauffman and Steudler (1998); Dale and McLaughlin (1998); Enemark (2001); Steudler (2004) and Adama city land administration office)

4.2.2. Technical evaluation of Adama city cadaster with Case study Indicators

Table 4. 2: Technical evaluation of Adama city cadaster

Evaluation elements of Cadaster	Described as the International Standards	Status of Adama city Cadaster. Source: Observations and interviews
Information Technology aspects	The organization and functions of cadaster nowadays depend on the modern information and communication technology	ICT Technologies are applied to make the system digital.
Completeness	All parcels, registered with its complete information, including RRR.	Information of parcels isn't complete.
Reliability	The Cadastral system needs to provide accurate information about land registration. Inaccurate information about parcels would have a worse effect on cadastral system.	Less accuracy.
Up-to-date	The Cadastral system should provide up-to-date or update information in a timely manner.	The cadastral system in Adama city takes too long to update.
Cost wise	The system should be processed with low cost or operated in such a way that costs can be recovered fairly without wastage.	High cost: Finance, man power, Time
Legal Aspects	The main function of a cadastral system is to protect rights, restriction and responsibilities	The cadastral system in Adama city has less organized of legal documentation.
Suitability	Enough and appropriate Offices, materials, finance and expertise.	Less suitable. There is a shortage of offices, materials, and qualified expertise.
	The system should be able to provide	

Accessibility	efficient and effective access to all users of land information. T	The precise cadaster is not easily accessible to all.
Clarity and Transparency	The system should be clear and simple to understand and to use. Complex forms, procedures, and regulations slow the system down and may discourage use of the system.	The system is complicated by various bureaucratic system in land transactions and registration systems. The effect of the system is not transparent, and clear.
Security	The system should be secured in database internally.	The Database is not fully developed. So Adama city cadaster is not secured.
Data Integration	The ability to integrate data from different sources is a crucial aspect of cadastral systems.	Adama city cadaster is less integrated..

To summarize Strength and Weakness of Adama city cadastral System are as follows:

A. Strength:

- Database Established
- ICT applied
- Cadastral system; moderately transparent, secured, accessible, up to date and integrated

B. Weakness:

- Lacks a better system of land registration.
- The Spatial accuracy of many control points is poor.
- Skill gap of experts
- Weak system for parcel identification
- Slow adaptation of modern technology
- Lack of harmonized proceed
- Too much paperwork
- Poor standardization of data
- Use of network technology to exchange data is not available.
- Cadastral system in Adama city takes too long to update.

- Lack of legal Cadaster applications.
- There is a shortage of offices, materials, finances and qualified expertise (Source: Adama city municipality, 2024)

Strength the current ongoing cadastral development of Adama city

- Roughly 93% digital cadaster; only 53% users certified
- Starting of developing modern cadaster
- Minimizing land related problems such as overlapping, land taxation, ….
- Increase title security
- In percentage….

Weakness the current ongoing cadastral development of Adama city

- Less quality
- Low
- Political intervention
- Less customer satisfaction

Table 4. 3:Geospatial Technological development of Adama city cadaster

Technological development Statements	Technological development of cadaster- Description as the International Standards	Gap of Technological development In Adama city.
Development of GIS	The GIS data model is fundamentally different in its simplicity & approach; Common to the GIS is the use of database; GIS is powerful to analyze spatial data	Applied
Development of Remote sensing in cadaster	3-D perspective; Historical record; Updating information; Comparability of data; Rapid data collection; Quantitative analysis (eg.change detection)	Orthophoto applied
Development of GPS in cadaster	Geodetic control point, establishing; Cadastral surveys;	Applied

4.2.3. Case study on GPS function in cadastral spatial referencing system

Cadastral spatial referencing system Late investigation Project was funded by the United States and the geodetic work was performed by the U.S. Coast & Geodetic Survey. The origin of the geodetic work was in southern Egypt near Abu Simbel, south of Lake Nasser, at station Adindan where Easting = 22°10′07.1098″N North of the equator, Easting = 31°29′21.6079″ East of Greenwich. The ellipsoid of reference was the Clarke 1880 (modified). In Ethiopia the sets of parameters used for transforming from the Blue Nile Datum of 1958 to the WGS84 Datum are based on eight-station solutions parameters where $\Delta X = -165m \pm 3m$, $\Delta Y = -11m \pm 3m$, and $\Delta Z = +206m \pm 3m$

Summary of organized spatial referencing parameters of Adama city, Ethiopian:

- Prime Meridian: Greenwich (0.0) - Latitude origin: Equator (0.0)
- Local Spheroid/ Reference Ellipsoid: Clarke_1880 modified
- GPS Global ellipsoidal Datum: WGS84
- Local ellipsoidal Datum: Adindan (Figure 4.1)
- Semi major Axis: 6378249.145 for datum Clarke_1880
- Semi minor Axis: 6356514.869549776 for datum Clarke_1880
- Inverse Flattening: 293.465 (no unit) for datum Clarke_1880
- False Easting = 450 km, and False Northing = 5,000 km.
- Projection system: Universal Transverse Mercator with cylindrical-conformal
- Name of Projected Coordinate System:
- Coordinate system: UTM

The ability of GPS to determine the precise location of user anywhere, under any weather conditions, attracted millions of users worldwide from various fields and backgrounds. However, one common problem that many newcomers to GPS face is the issue of datum and coordinate systems. Traditional way of spatial referencing system isn't effective in point positioning system. But, a GPS technology determines the precise positioning of ground points (Janssen, 2009).

In spatial reference system, GPS can be used to establish the position of cadastral points in terms of coordinates. A spatial reference system of Adama city can be updated, stored and visualized in a better way if it connects to GPS system.

Positioning of Adama city cadastre directly depends on coordinate system and reference datum of Ethiopia. UTM coordinate system of Ethiopia is projected from world geodetic coordinate system through the UTM projection system. These coordinate system and projection system of Ethiopia is developed on the ellipsoidal reference datum.

The current spatial referencing system of Adama city is not supported with GPS. Hence, these studies highlight on the role of GPS in measuring, updating and geo-referencing the spatial referencing system of Adama city. Refers to the ground truth coordinates derived through DGPS survey can update and geo-reference the current cadastral coordinates.

The coordinate data in the spatial reference system should be updated at any time using DGPS collected data. Here GPS techniques can reduce the problem of obtaining geo- referencing and updating the information of the spatial reference system. If the accuracy of coordinates of Adama city has been improved through GPS technology, directly the accuracy of positioning of the spatial reference system the city to be improved. The application of GPS on Adama city coordinate system will be indirectly improved the data system of Ethiopia. This indicates GPS technology has the capability of improving the accuracy of the spatial reference system

Optical surveying equipment's such as total stations are often used for digital cadastral surveys. One of the major problems in using the total station instrument for cadastral surveying in the field is the requirement of the huge number of traverse stations to cover the mapping area. These stations must have indivisibility. In addition, destruction of established control points of the people, farming tools and other development activities is numerous. All these problems can be readily overcome in cadastral survey by using GPS technology. This technology supports modern cadastral surveying techniques inimproving the determination of the precise position of land parcels such as establishing control points for cadastral surveys and demarcation of parcel boundaries. Post Processing of GPS data GPS1 point number is the base station for the others and then it is the reference point or control point for the other points. The source of this base station for the reference control point is Adama city municipality and cross checked from the Adama master plan (Figure 4.7).

Northing of GPS1=949,195.329 Easting of GPS1=533,775.368

After processing, Spectrum Survey displays a Process Summary report. Check these reports to make sure that vector are fixed, and that has a high percentage of observations used. Lower percentages indicate that spectrum survey may have rejected many observations for various reasons such as multipath, cycle slips, etc.

Adjustment of GPS control points

In the process of adjusting GPS control points, the collected control points must adjust to the known control base station. In this study, the source of the control base station is an Adama city municipality. The other GPS values are collected from the field using GPS radian IS instrumental. These control points were adjusted to the reference of a base station control point using spectrum survey GPS software (Table 4.2 and Figure 4.9).

Table 4. 4: Adjusted GPS coordinates

Point name	Easting	Northing
GPS1	533,775.368	949,195.329
GPS2	528,662.285	949,321.014
GPS3	530,249.788	947,316.784
GPS4	526,234.682	945,656.520
GPS5	525,401.289	942,329.378
GPS6	525,579.883	939,749.686
GPS7	528,543.223	942,369.066
GPS8	529,284.087	937,685.928
GPS9	531,189.061	941,092.449
GPS10	532,849.325	945,226.572

Accuracy measurement of GPS data

As in all types of surveying observations, GPS observations contain errors. The principal sources of these errors are (1) orbital errors in the satellite, (2) signal transmission timing errors due to atmospheric conditions, (3) receiver errors, (4) multipath errors (signals being reflected so that they travel, indirect routes from satellite to receiver), and (5) mis-centering errors of the receiver antenna over the ground station and receiver height- measuring errors. To account for these and other errors, and to increase the precisions of point position, GPS observations are very carefully made according to strict measurements.

The fact that errors are present in the observations makes it necessary to analyze the measurements for acceptance or rejection (Ghilani and Wolf, 2006). By using two GPS receivers tracking the same satellites simultaneously, it is possible to remove many systematic errors and determine their relative difference in position to better accuracies (millimeter level). Control station established by GPS in this study shall comply with the horizontal accuracy standard of <3cm (EMA, 2015).

GPS accuracy measurement parameters applied is: ➢ Root Mean Square Error detection

➢ Closure error computation

Root Mean Square Error detection

RMSE general formula for the computation of GPS data errors:

$$RMSEx = \sqrt{\frac{\sum_{i=1}^{n}(X_{obs,i} - X_{model,i})^2}{n}}$$

$$RMSEy = \sqrt{\frac{\sum_{i=1}^{n}(Y_{obs,i} - Y_{model,i})^2}{n}}$$

RMXEx is total Root Mean Square Errors in the Easting measurement RMXEy is total Root Mean Square Errors in the Northing measurement

Xobs or Yobsare observed values and Xmodel or Ymodel are modeled or existing values.

N is the number of observations.

Xobs – Xmodel or Yobs – Ymodel are the residuals errors computed in Table 4.4. RMSEx =square root [($-0.032^2-0.037^2-0.011^2+0.046^2 0.03^2+0.039^2-0.024^2+0.049^2+0.044^2-0.029^2$)/10] = square root of 0.001024+ 0.001369 + 0.000121+0.002116+ 0.0009+ 0.001521+ 0.000576+0.002401+ 0.001936+ 0.000841/10 = square root of 0.012805/10 = square root of 0.0012805 meter = 0.035784075

RMSEy = square root [($0.012^2-0.007^2+0.037^2-0.037^2+0.011^2-0.004^2-0.038^2+0.043^2+0.01^2-0.006^2$)/10]= square root of 0.000144+0.000049+0.001369+0.001369 +0.000121 +0.000016 +0.001849+ 0.001089+0.0001 +0.000036/10 = square root of 0.006497/10 = square root of 0.0006497meter =0.025489213

Table 4. 5: Root Mean Square Errors computation

Point Name	ΔE Easting / Residuals/	ΔN Northing /Residuals/	RMXE of Easting	RMXE of Northing
GPS1	-0.032	0.012	-0.032^2	0.012^2
GPS2	-0.037	-0.007	-0.037^2	-0.007^2
GPS3	-0.011	0.037	-0.011^2	0.037^2
GPS4	0.046	-0.037	0.046^2	-0.037^2
GPS5	-0.030	0.011	-0.030^2	0.011^2
GPS6	0.039	-0.004	0.039^2	-0.004^2
GPS7	-0.024	-0.038	-0.024^2	-0.038^2
GPS8	0.049	0.033	0.049^2	0.043^2
GPS9	0.044	0.010	0.044^2	0.010^2
GPS10	-0.029	-0.006	-0.029^2	-0.006^2
	summation		0.012805	0.006497
	Summation/10		0.0012805	0.0006497
RMSE	Square root		0.035784075	0.025489213

Closure error computation

The GPS coordinates, networks will typically consist of interconnected closed loops. For each closed loop, the algebraic sum of the easting coordinates should equal to zero. The same condition should exist for the northing components. An unusually large closure error within any loop will indicate that either a blunder or a large random error exists in one of the coordinates of the loop. To compute loop closure error, the difference in coordinate components is simply added algebraically to the loop chosen. If the algebraic sum of the coordinates should be out of zero, the loop closure error exists with that amount. For precision evaluation purposes, loop closure errors are expressed in terms of the ratios of resultant closure errors to the total loop lengths. For any loop, the resultant closure error is the square root of the sum of the squares of the values of easting closure error and northing closure errors. Precision evaluation using loop closure error computation applies in this research to compare the accuracy of existing control points with the same points currently measured from the field. The procedures follow in this research are derived from Ghilani and Wolf approaches of adjustment computations of spatial data. In this study the application of computation of closure errors in comparing the precision of existing control points with the points currently measured from the same position of Adama city follows the procedures below.

1. Organize the existing control points, currently measured points, coordinate network loop and perimeter of the loop, which are important components to compare the precision of position of GPS points (Figure 4.10).

2. The loop closure error computation starts with the calculating the difference in coordinate components of easting and northing.

3. As shown in Table 4.8 if GPS2-1 is the Difference between the coordinates of GPS2 and GPS1; Then continues with this computation procedures and repeat for all data (Table 4.5)

4. Next the differences in coordinate components are simply sum up algebraically for the loop as a loop closure error result at northing & easting;

Table 4. 6: Closure errors and relative precision computation

Point Name	Existing Easting in m	Existing Northing in m	Current Observed Eastingin	Current Observed Northing in
GPS1	533,775.336	949,195.341	533,775.368	949,195.329
GPS2	528,662.248	949,321.007	528,662.285	949,321.014
GPS3	530,249.777	947,316.821	530,249.788	947,316.784
GPS4	526,234.728	945,656.483	526,234.682	945,656.520
GPS5	525,401.259	942,329.389	525,401.289	942,329.378
GPS6	525,579.922	939,749.682	525,579.883	939,749.686

GPS7	528,543.199	942,369.028	528,543.223	942,369.066
GPS8	529,284.136	937,685.971	529,284.087	937,685.928
GPS9	531,189.105	941,092.459	531,189.061	941,092.449
GPS10	532,849.269	945,226.566	532,849.325	945,226.572
	Difference of coordinates at each control point stations			
GPS2-1	-5,113.0880	125.6660	-5,113.0830	125.6850
GPS3-2	1,587.5290	-2,004.1860	1,587.5030	-2,004.2300
GPS4-3	-4,015.0490	-1,660.3380	-4,015.1060	-1,660.2640
GPS5-4	-833.4690	-3,327.0940	-833.3930	-3,327.1420
GPS6-5	178.6630	-2,579.7070	178.5940	-2,579.6920
GPS7-6	2,963.2770	2,619.3460	2,963.3400	2,619.3800
GPS8-7	740.9370	-4,683.0570	740.8640	-4,683.1380
GPS9-8	1,904.9990	3,406.5280	1,905.0040	3,406.5510
GPS10-9	1,660.1640	4,134.1070	1,660.26	4,134.1230
GPS1-10	926.0670	3,968.7750	926.0430	3,968.7570
Closure errors	0.03 m	0.04 m	0.03 m	0.03 m
Total Resultant	0.05 m		0.03 m	
Perimeter	39473.53		39473.11	
Relative precisions	1/789470.6		1/1315770.3	

1. Computation of resultant or total misclosure errors in Northing (N) and Easting (E) of the coordinate network loop;

$\text{Total misclosure errors} = \sqrt{E^2 + N^2}$ Where E^2 represents summation of Easting loop closure errors and N^2 is summation of Northing loop closure errors.

$$\text{Existing data total misclosure errors} = \sqrt{E^2 + N^2} = \sqrt{(-0.04)^2 + (0.03^2)}$$
$$= 0.05$$

$$\text{New collected total misclosure errors} = \sqrt{E^2 + N^2} = \sqrt{(-0.03)^2 + (0.03)^2}$$
$$= 0.03$$

To determine the boundary of parcels from the survey work of GPS, it would be necessary to measure corner of parcels and other monuments or control points. In this research coordinates obtained from the GPS survey were then compared with coordinates obtained from the municipality by Adama city. Comparing the computed the coordinates for the same parcels.

Values of corner coordinates show some varied results. The comparison of the measured GPS data and existing value of the parcels and the output can be summarized by the following steps.

1. Organize new collected Parcels corner coordinate values from GPS and existing parcel corner coordinate values from the master plan on the table (Table 4.6)
2. Compute the residual errors of Easting and Northing for each corner of the parcel. The difference in Northing /dN/ for corner ID 1 = 945793.623 - 945793.611 = 0.012.
3. The difference in Northing /dE/ for corner ID 1 = 531321.466 - 531321.478 = -0.012. With the same procedures the residual errors in all corners are computed (Table 4.6) Difference in easting and northing is the residual errors resulted from the difference of existing current measurements of GPS data.
4. Calculate position shift. Based on the results of residual errors the difference inposition between GPS coordinates and existing coordinates of parcel is computed using Pythagoras formula as follows.

The linear distance between the current measurements of GPS points and the existing points is

= the $\text{square root of [change in Easting2} + \text{change in Northing2]}$ GPS GCP1 = $\text{square root}[0.012^2 + (-0.012^2)] = 0.012$

GPS GCP2 = $\text{square root}[-0.015^2 + 0.06^2] = 0.061$
GPS GCP3 = $\text{square root}[0.04^2 + (-0.08^2)] = 0.028$
GPS GCP3 = $\text{square root}[0.033^2 + 0.025^2)] = 0.042$

This difference in position shows that the errors occurred more in the existing corner values of the parcel when compared with the new collected GPS data with the more accurate GPS instrument and software. This implies that there is shift of position of parcels in Adama city. In Figure 4.10 due the small scale of the map the existing position and new GPS position points seems to overlap and the shift of the position of parcel has not observed on the map.

Table 4. 7: Checking parcels position

Corner	Existing Parcel corner		New collected Parcels		dN	dE	position
	Easting	Northing	Easting	Northing			
1	531321.478	945793.611	531321.466	945793.623	0.012	-0.012	0.012
2	531329.317	945817.985	531329.377	945817.970	-0.015	0.060	0.061
3	531366.798	945803.223	531366.718	945803.263	0.04	-0.08	0.028
4	531357.633	945779.351	531357.658	945779.384	0.033	0.025	0.042

4.3. PROPOSED SOLUTIONS FOR ADAMA CITY CADASTRAL CHALLENGES

The management and storage of cadastral data pose significant challenges due to the complexity of the data and the need for effective storing, manipulating, retrieving, managing, querying, and analyzing data. Let's delve into some of the challenges and potential solutions: Conceptual to Physical Model Conversion:

The Land Administration Domain Model provides a conceptual model for cadaster but lacks specific guidelines for practical implementation.

Design a well-defined database schema by identifying code lists, defining integrity constraints, and considering normalization.

This step-by-step approach ensures a robust and comprehensive 3D cadastral database1. User-Friendliness and Expertise:

Specialized expertise for comprehensive understanding and implementation. Lack of user-friendliness hinders widespread adoption.

Develop user-friendly guidelines and training materials to bridge the gap between Conceptual model and practical implementation.

Designing a Cadastral Database: Existing literature pays less attention to the principles and fundamentals of designing a cadastral database.

Solution: Investigate design steps for a cadastral databas, considering multivalued attributes, integrity constraints, and data type definitions.

A well-defined database schema is crucial for success.

The development of a robust GIS-based Cadastral Information System (CIS) can significantly enhance land-related services and economic growth. Here are the key aspects:

Cadastral Information System (CIS):

- o The main objective is to create a GIS-based Cadastral Information System that goes beyond basic tasks like providing legal security through titles or deeds.
- o The CIS should efficiently handle various purposes related to land and property, including taxation.
- o Features of the CIS include
- – cadastral data models,
- – cadastral identification numbers,
- – accurate data representation.
- – The cadastral designation and cadastral number uniquely identify each real property object.
- – Implementation Approach:
- – The gap between the existing cadastre system and the desired CIS must be bridged.
- – A phased-out implementation approach is recommended, starting with smaller areas and gradually covering the entire city.
- – SWOT Analysis:
- – Conducting a SWOT analysis helps identify
- – strengths,
- – weaknesses,
- – opportunities,
- – and threats related to the CIS implementation.
- – Understanding these factors is crucial for successful adoption and sustained operation.
- – Address Locator Integration:
- – Another project focuses on integrating a digital cadastral information system with an address locator.
- – This integration enhances spatial referencing and facilitates efficient property management.

The proposed solutions aim to

- – improve land-related services,
- – Legal security, and
- – economic outcomes in Adama City.
- – By leveraging GIS technology and addressing cadastral challenges, the city can pave the way for sustainable development and efficient land administration.

Table 4. 8: Adama city Proposed solutions for the identified gaps

Evaluation Elements of Cadaster	Descriptions for evaluations	Proposed solutions by researchers for the identified gaps
2003–2008 Core Cadastral Domain Model (6 indicators)	– Data Center – Internet of Things – Data exchange – Cybersecurity – Services for clients – Fulfil international ISO standards	Developing new approaches for cadastral improvements: Data Center , Cybersecurity, ISO standards
2008 Euro-Geographic's (3 indicators)	– Resilience of the property market – Mortgage rates – Robust home sales	Improving: Resilience of the property market, Mortgage rates, Robust home sales
2011 Cadaster 2.0 (5 indicators)	– Establishing consistent – Storing digital cadastral information – Interpretation of cadastral data – Registration: Capturing and managing. – Visualization: boundaries in buildings and others.	Improving digital cadastral information, Interpretation of cadastral data, Registration, Visualization

European Foundation for Quality Management (EFQM) Excellence Model (11 indicators)	– Secure property rights – Reliable basis taxation, and property transactions. – Facilitate coordination among stakeholders. – Promote international standards – Activate partnerships to deliver sustainable social, economic, and environmental development. – Strategy and process – Accept Compliance: Ensure products and services comply with specifications. – Delivery Schedule: Adhere to promised delivery timelines. – Problem Resolution: Rapidly address issues. – Complaint Settlement: Handle complaints acceptably. – Customer Support: Provide assistance in using received information.	Establish Reliable basis for property rights, land taxation, deliver sustainable social, economic, and environmental development, Strategy and process , Delivery Schedule, Complaint Settlement

2014 Cadaster (10 indicators)	– Supporting the cadaster with computer programs – GIS, GPS applications – The Internet – Complete legal situation of land – Accessible databases – Cadastral mapping will be replaced by modelling. – Manual cadaster will not be longer – Government–public partnership – Decentralized services – Staff training	Supporting the cadaster with computer programs, GIS, GPS ,the Internet, legal situation of land, databases, modelling., partnership, decentralized services, Staff training
2030 Agenda for SDG (10 indicators)	– Legal – Institutional – Social service – Economic growth – Technical in cadaster – Political intervention – Environmental consideration in cadaster – Customer satisfaction	Implement legal, modify institution, less political intervention, consider environment, and check customer satisfaction
Cadaster 2034 (5 indicators)	– Organic to model rights, restrictions and responsibilities – Object oriented – 3D/4D/5D modeling	Adama city cadaster apply the rights, restrictions and responsibilities, Object oriented And 3D/4D/5D modeling
Cadastral data quality case	GCP and parcel extent accuracy	Fully apply moder technology: GPS, Orthophoto, ICT, database

	– Completeness – Reliability	Adama city cadaster will be completed based on schedule,

Technical evaluators	−Up-to-date −Cost wise −Accessibility −Transparency −Security	Accurate, up to date daily, cost wise(saving time, finance, man power), secured (database), transparent and accessible (intermate based)

Summary of solutions:

- Developing new approaches for cadastral improvements: Data Center , Cybersecurity, ISO standards
- Establish Reliable basis for property rights, land taxation, deliver sustainable social, economic, and environmental development, Strategy and process , Delivery Schedule, Complaint Settlement
- Improving digital cadastral information, Interpretation of cadastral data, Registration, Visualization
- Modifying supporting of the cadaster with

– computer programs,
– The Internet,
– Legal aspect,
– Databases,
– Modelling.,
– Decentralized services,
– Staff training
– Reliability
– Up-to-date
– Cost wise
– Accessibility
– Transparency
– Security

4.4. Proposed model of Adama city cadaster evaluation

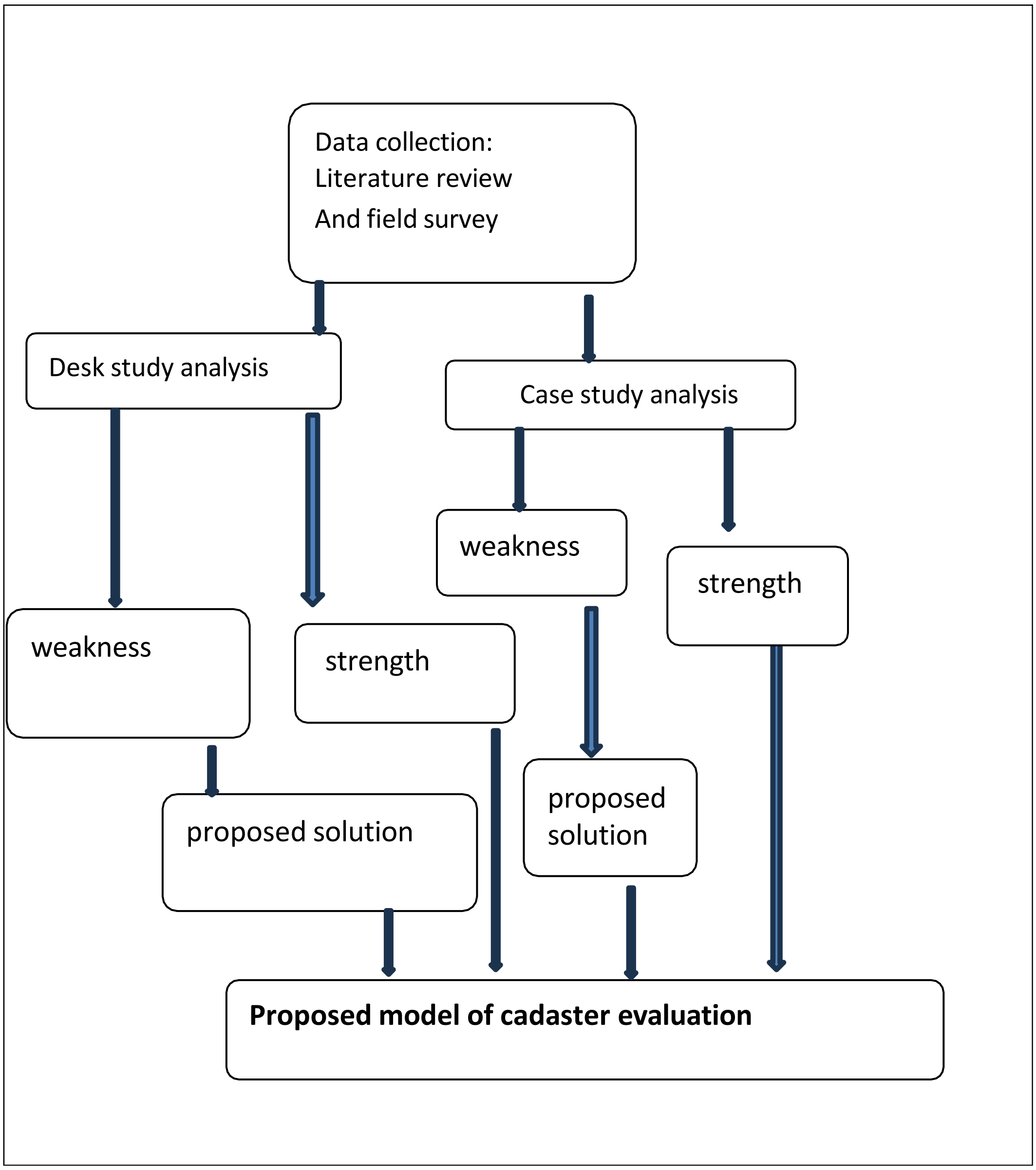

Figure 4. 4: Proposed model

CHAPTER FIVE CONCLUSION AND RECOMMENDATION

5.1. Conclusions

This study was to develop a methodology to measure and evaluate the performance of urban cadastral system based on International Scientific journals/desk study/ and case study in the city and the paper contributes and develops an evaluation framework for urban cadastral system by identifying the key factors to evaluate the existing cadaster.

To evaluate the existing Cadastral system with the Desk study approach; it totally depends on internationally accepted criteria. To evaluate the existing Cadastral system with the case study approach, the research identified control point accuracy and parcel accuracy are not at the level of the require precision.

To propose scientific solutions for the identified weakness of the she framework defines good practices and their indicators of an ideal urban cadastral system application. This contribution could be used for systematic evaluation and comparison of cadastral system practices. This paper proposes that evaluating urban cadastral systems connected to broader economic and societal issues. The framework model provides a basis for evaluating urban cadastral systems in a more standardized and comprehensive approach.

5.2. Recommendations

All in all, the result of this paper will enable policy makers, management officials, and implementers to follow up, monitor, and evaluate the strengths and weaknesses of the cadastral system performance in response to improvements in an organizational capacity, technology, and availability of access to spatial information.

Based on the result obtained, the researchers suggest the following recommendations:
In implementing an urban cadastral system, the issues of political willingness and commitment, legal and institutional issues, socio-economic aspects, environmental influences,and technical standards should be at the heart of the cadastral system

Decision makers, politicians, and professionals should be involved in selecting the best system as their support is essential to the establishment of sound cadastral system.

While the ultimate responsibility for the urban cadastral system lies with the government,the to play in the cadastral system policy implementation, so the cadastral system should be

Any organization carrying out cadastral system implementations should follow theprocedures in measuring and evaluating performance of the operations in a timely manner

Urban cadastral system implementing institutions should use the proposed evaluation framework as a benchmark rather than merely evaluating through annual report.

REFERENCE

Abdalla, K. S., & Enemark, S. (2013). Evaluation of Cadastral Systems in Developing Countries: An Analytical Framework for Assessing Performance.

Adesanya, M. O., Fagbenle, O. O., & Akinwumi, O. A. (2016). Cadastral System Evaluation: A Case Study of Nigeria.

Aien, A., Kalantari, M., Rajabifard, A., Williamson, I., & Wallace, J. (2013). Towards integration of 3D legal and physical objects in cadastral data models. Land use policy, 35, 140-154.

Aleixandre-Benavent, R., Aleixandre-Tudó, J. L., Castelló-Cogollos, L., & Aleixandre, J. L. (2018). Trends in global research in deforestation. A bibliometric analysis. Land use policy, 72, 293-302.

Amanuel, T. (2008). Preparation of coordinate based cadastral map in rural Ethiopia. Degree of Master of science in remote sensing and GIS, Addis Ababa university, Ethiopia case study Biteejersalafoka, Oromia region, Addis Ababa University Earth Science Department, MSc thesis.

Anokye, A. K., & Owusu-Bennoah, E. (2019). Assessment of Cadastral Systems in Developing Countries: A Case Study of Ghana.

Appiah, M. (2013). Building a Cadastral Information Systems for Land Records Management Using Hierarchical Approach and Geographic Information Systems: The Case of Ashanti Region, Ghana (Doctoral dissertation).

Babalola, S. O. and Kardam, M. S. (2011). Developing a cadastral information system forpart of Fadaman-mada area of Bauchi metropolis for sustainable development. ATBU Journal of Environmental Technology, 4(1): 105 – 118.

Bender, O., Boehmer, H. J., Jens, D., & Schumacher, K. P. (2005). Analysis of land-use change in a sector of Upper Franconia (Bavaria, Germany) since 1850 using land register records. Landscape Ecology, 20, 149-163.

Bielecka, E., & Burek, E. (2019). Spatial data quality and uncertainty publication patterns and trends by bibliometric analysis. Open Geosciences, 11(1), 219-235.

Billen, R., & Zlatanova, S. (2003). 3D spatial relationships model: a useful concept for 3D cadastre?. Computers, Environment and Urban Systems, 27(4), 411-425.

Bogaerts, T., & Zevenbergen, J. (2001). Cadastral systems—alternatives. Computers, environment and urban systems, 25(4-5), 325-337.

Budiani, S., & Purwanto, A. (2019). Assessing the Quality and Performance of Cadastral Systems: A Case Study of Indonesia.

Burns, T., Grant, C., Nettle, K., Brits, A. M., & Dalrymple, K. (2007). Land administration reform: indicators of success and future challenges. Agriculture and Rural Development Discussion Paper, 37, 1-227.

Cete, M., and Yomralioglu, T. (2004). Cadastre: the key component in urban-based information systems, FIG working week, Athens, Greece, 22 – 27.

Colotelo, A., Paio, A., & Nunes, C. (2016). User-Centered Design for Land Administration Information Systems. Procedia Technology, 22, 1609–1616.

Dale, P.; McLaren, R. GIS in land administration. In Geographical Information Systems: Principles, Techniques, Management and Applications, Abridged Edition; Longey, P., Ed.; John Wiley & Sons, Inc.: New York, NY, USA, 2005; pp. 859–875.

Daniel, T. (2014). Urban cadaster in Ethiopia.The municipal development partnership, Africa local government action forum presentation, 1 –15.

Das, S. N., Sreenivasan, G., Srinivasa Rao, S., Joshi, A. K., Varghese, A. O., Prakasa Rao, D. S., ... & Jha, C. S. (2022). Geospatial Technologies for Development of Cadastral Information System and its Applications for Developmental Planning and e- Governance. In Geospatial Technologies for Resources Planning and Management (pp. 485-538).

Dawidowicz, A.; Zr´ óbek, R. A methodological evaluation of the Polish cadastral system based on the global cadastral model. Land Use Policy 2018, 73, 59–72. [CrossRef]

DeVries, W. Is There Any Difference Between Cadastral Systems and Land Administration?
2017

Eagleson, S. (2002). GIS applied to administrative boundary design. University of Melbourne, Department, 20.

EFQM. European Foundation Quality Management. European Foundation Quality Management (EFQM) Excellence Model. 2012. Available online: https://www.efqm.org/ (accessed on 30 October 2019).

Enemark, S., Williamson, I., & Wallace, J. (2005). Building modern land administration systems in developed economies. Journal of spatial science, 50(2), 51-68.

Fawad, R.; Muhammad, A.; Ahmed, K. Land Records Information Management System. In Proceedings of the 25th Annual ESRI International User Conference, San Diego, CA, USA, 25–29 July 2005.

FIG. Marrakech Declaration. Urban-Rural Interrelationship for Sustainable Development; International Federation of Surveyors (FIG): Frederiksberg, Denmark, 2004; Volume 33.

Fisseha, T. (2023). Opportunities and Challenges for Modern Land Information System Spesifically: Examining the Ongoing Opportunities and Challenges of Cadastral Surveying and Mapping Practice in Bahir Dar City, in Case Study of Fasilo Sub City (No. 9706). EasyChair.

Gebreselassie, T. A. (2021). Network based geospatial distribution and location allocation of public health Centers a case study of Adama city Oromia Ethiopia.

Gebrewold, Z.H. Land Governance Assessment Framework (LGAF) Implementation in Ethiopia. Final Country Report. 2016.

Gerring, J., 2007. Case Study Research: Principles and Practices. Cambridge University Press.
Gondo, T. and Zibabgwe, S. (2010). GIS solutions and land management in urban Ethiopia. perspectives on capacity, utilization and transformative possibilities, Management

research and practice, 2(2) : 200 - 216.

Greenway, I. The Nairobi Statement on Spatial Information Development; FIG Publication; The International Federation of Surveyors (FIG): Copenhagen, Denmark, 2002; Volume 30.

Hood, W. W., & Wilson, C. S. (2001). The literature of bibliometrics, scientometrics, and informetrics. Scientometrics, 52, 291-314.

Hossain, M. M., & Abdul-Rahman, R. (2019). Assessment of the Cadastral System inCanada.

Igbokwe, J. I., Okwuenu, C. M., & Igbokwe, E. C. (2023). Development of a GIS based tourism infrastructure in Awka, Onitsha and Nnewi urban areas of Anambra state Nigeria.

Krigsholm, P., Riekkinen, K., & Ståhle, P. (2018). The changing uses of cadastral information: A user-driven case study. Land, 7(3), 83.

Krigsholm, P.; Zavialova, S.; Riekkinen, K.; Ståhle, P.; Viitanen, K. Understanding the future of the Finnish cadastral system—A Delphi study. Land Use Policy 2017, 68, 133–140. [CrossRef]

Liu, F., Lin, A., Wang, H., Peng, Y., & Hong, S. (2016). Global research trends of geographical information system from 1961 to 2010: a bibliometric analysis. Scientometrics, 106, 751-768.

Lwanga, M. S., & Abdul-Rahman, R. (2019). Assessing the Quality of Cadastral Systems: A Case Study of Uganda.

Memon, S. A., & Abdul-Rahman, R. (2018). Measuring the Quality of Cadastral Systems: A Case Study of Pakistan.

Molen, P. (2003, April). "The Future Cadastres–Cadastres after 2014". In FIG Working Week (pp. 13-17).

Navratil, G., & Frank, A. U. (2004). Processes in a cadastre. Computers, Environment and Urban Systems, 28(5), 471-486.

Nepal, S. K. (2009). Traditions and trends: A review of geographical scholarship in tourism. Tourism Geographies, 11(1), 2-22.

Olfat, H., Shojaei, D., Briffa, M., Maley, S., & Rajabifard, A. (2018). Strategic actions for increasing the submission of digital cadastral data by the surveying industry based on lessons learned from Victoria, Australia. ISPRS International Journal of Geo- Information, 7(2), 47.

Polat, Z. A. (2019). Evolution and future trends in global research on cadastre: a bibliometric analysis. GeoJournal, 84(4), 1121-1134.

Rajabifard, A. (2014). Cadastre 2014 in Relation to Spatial Data Infrastructure (SDI). CADASTRE 2014 and Beyond, 49-53.

Rajabifard, A. Sustainable Development Goals Connectivity Dilemma; CRC Press: Boca Raton, FL, USA, 2019.

Rajabifard, A., Williamson, I. P., & Holland, P. (2005). Spatially Enabling Land Administration: A Proposal. Computers, Environment and Urban Systems, 29(1), 7– 25.

Rajabifard, A., Williamson, I. P., Holland, P., & Johstone, G. (2000). From Local to Global SDI initiatives: a pyramid building block. Proceedings of the 4th GSDI Conference, Cape Town South Africa.

Rajabifard, A.; Daniel, S.; Ian, W. Stig Enemark: Cadastral Templete. 2003. Available online: http: //cadastraltemplate.org/ (accessed on 14 February 2016).

Rajabifard, R., Wallace, J., & Williamson, I. (2013). Assessing the Effectiveness of the Cadastral System in Australia.

Reddy, G. O. (2018). Spatial data management, analysis, and modeling in GIS: principles and applications. Geospatial Technologies in Land Resources Mapping, Monitoring and Management, 127-142.

Selleri, M., & Fabrizi, C. (2003). The role of ICT in the devolution of cadastral service. In Strategies for Renewal of Information Systems and Information Technology for Land Registry and Cadastre, Symposium held by FIG Commission (Vol. 7).

Shibeshi, G.B.; Fuchs, H.; Mansberger, R. Lessons from Systematic Evaluation of Land Administration Systems. The Case of Amhara National Regional State of Ethiopia. World Dev. 2015, 68, 282–295. [CrossRef]

Shibeshi, G.B.; Fuchsb, H.; Mansbergerc, R. Toolbox for the Development of Cadastral and Registration Proclamation for Second Level Certification Program in Ethiopia. Int. J. Sci. Basic Appl. Res. 2014, 13, 244–259.

Shojaei, D., Kalantari, M., Bishop, I. D., Rajabifard, A., & Aien, A. (2013). Visualization requirements for 3D cadastral systems. Computers, Environment and Urban Systems, 41, 39-54.

Silva, M. A., & Stubkjær, E. (2002). A review of methodologies used in research on cadastral development. Computers, environment and urban systems, 26(5), 403-423.

Skånes, H. M., & Bunce, R. G. H. (1997). Directions of landscape change (1741–1993) in Virestad, Sweden—characterised by multivariate analysis. Landscape and urban planning, 38(1-2), 61-75.

Steudler, D., Keßler, C., & Burghardt, D. (2012). Quality Assurance in Cadastral Processes – A Spatial Data Infrastructure Approach. Land Use Policy, 29(2), 402–411.

Steudler, D.; Kaufman, S. (Eds.) Cadastre 2014 and Beyond; FIG Publication; FIG: Copenhagen, Denmark, 2014; Volume 61. Land 2020, 9, 60 15 of 15

Stoter, J. E., & Van Oosterom, P. J. M. (2005). Technological aspects of a full 3D cadastral registration. International Journal of Geographical Information Science, 19(6), 669-696.

Stoter, J., & Salzmann, M. (2003). Towards a 3D cadastre: where do cadastral needs and technical possibilities meet?. Computers, environment and urban systems, 27(4), 395-410.

Ting, L. (2002). Principles for an integrated land administration system to support sustainable development.

Ting, L.; Williamson, I. Land Administration and Cadastral Trends: The Impact of the Changing Humankind-Land Relationship and Major Global Drivers: The NZ Experience. Surv. Rev. 2001, 36, 154–174. [CrossRef]

Tipple, G., & Alemayehu, E. Y. (2014). Stocktaking of the housing sector in sub-Saharan Africa. Part 3: Ethiopia.

Tony, B.; Chris, G.; Kevin, N.; Anne-Marie, B.; Kate, D. Land Administration Reform. Indicators of Success and Future Challenges. 2007. Available online: http://citeseerx.ist.psu.edu/viewdoc/summary?doi=10.1.1. 459.1314 (accessed on 2 December 2019).

UN. Sustainable Development Goals. 2015. Available online: https://www.un.org/sustainabledevelopment/ poverty/ (accessed on 10 October 2019).

UN. Sustainable Development Goals. 2015. Available online: https://www.un.org/sustainabledevelopment/ poverty/ (accessed on 10 October 2019).

UN: Agenda 21. United Nations Conference on Environment & Development Rio de Janerio, Brazil, 3 to 14 June 1992. 1992. Available online: https://sustainabledevelopment.un.org/outcomedocuments/agenda21 (accessed on 3 October 2019).

UN-FIG. The Bathurst Declaration on Land Administration for Sustainable Development; FIG Publication; The International Federation of Surveyors (FIG): Copenhagen, Denmark, 1999; Volume 21. 16, Zahir,2018

UN-FIG. The Bogor Declaration. United Nations Interregional Meeting of Experts on the Cadastre Bogor, Indonesia. 1996.

Van der Molen, P. (2002). The dynamic aspect of land administration: an often-forgotten component in system design. Computers, Environment and Urban Systems, 26(5), 361-381.

Van Oosterom, P. J. M., and van der Molen, P. (2018). Assessment of the Cadastral System in the Netherlands.

van Oosterom, P., Lemmen, C., & Bennett, R. (2009). SDI and Land Administration. Land Use Policy, 26(2), 299–307.

Van Oosterom, P., Lemmen, C., de By, R. A., & Tuladhar, A. M. (2002, May). Geo-ICT technology push vs. Cadastral market pull. In OEEPE workshop.

van Oosterom, P., Lemmen, C., Ingvarsson, T., van der Molen, P., Ploeger, H., Quak, W., ... & Zevenbergen, J. (2006). The core cadastral domain model. Computers, Environment and Urban Systems, 30(5), 627-660.

Williamson, I. (1996). UN-FIG, Bogor declaration on cadastral reform. Report from united Nations interregional meeting of experts on the cadastre, Symposium on Cadastre and Land Management, 64th FIG Permanent Committee Meeting and Symposia,Singapore, Singapore Institute of Surveyors and Values, 64: 1- 5.

Williamson, I., Enemark, S., Wallace, J., & Rajabifard, A. (2017). Land administration for sustainable development (p. 487). Redlands, CA, USA: ESRI Press Academic.

Williamson, I.P. Cadasters and Land Information Systems in Common Law Jursdictions. Surv. Rev. 1985, 28, 114–129.

Yìldiz, O., Coruhlu, Y. E., & Biyik, C. (2018). Registration of agricultural areas towards the development of a future Turkish cadastral system. Land use policy, 78, 207-218.

Yilmaz, A.; Ça ˘gda¸s, V.; Demir, H. An evaluation framework for land readjustment practices. Land Use Policy 2015, 44, 153–168. [CrossRef]

Zahir, A.; Arbind, T.; Jaap, Z. Developing a Framework for Improving the Quality of a Deteriorated Land Administration System Based on an Exploratory Case Study in Pakistan. 2010.

Zevenbergen, J. (2004). A systems approach to land registration and cadastre. Nordic journal of surveying and real estate research, 1(1).

Zhang, H., Huang, M., Qing, X., Li, G., & Tian, C. (2017). Bibliometric analysis of global remote sensing research during 2010–2015. ISPRS International Journal of Geo-Information, 6(11), 332.

Appendix

Structure interviews Questions

1. Explain cadastral evaluation for Adama city in context of Ethiopia
2. What are the main gaps identified in Adama city cadaster?
3. What are the proposed solutions for the identified gaps?
4. Is there a cadastral system follow international standard?
5. Can you categorize the status of Adama city cadaster into strong weakness, moderate weakness and strong strength as per international standards?
6. Is there a cadastral system follow national standard?
7. Does the current cadastral system based on customer satisfaction?
8. What are basic Strategies you are considering in new cadastral development
9. What are basic Procedures following in cadastral processing?
10. What are the general requirements in cadaster?