IMPROVING THE CADASTRAL SYSTEM USING GEOSPATIAL OPEN-SOURCE TOOLS: A CASE OF ADAMA CITY, ETHIOPIA

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Thesis Submitted to the department of Geomatics Engineering

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DECLARATION

I hereby declare that this research thesis entitled "IMPROVING THE CADASTRAL SYSTEM USING GEOSPATIAL OPEN-SOURCE TOOLS: A CASE OF ADAMA CITY, ETHIOPIA" is my original work. That is, it has not been submitted for the award of any academic degree, diploma or certificate in any other university. All sources of materials that are used for this thesis have been duly acknowledged through citation.

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I, the advisor of this thesis, hereby certify that I have read the revised version of the thesis entitled "IMPROVING THE CADASTRAL SYSTEM USING GEOSPATIAL OPEN-SOURCE TOOLS: A CASE OF ADAMA CITY, ETHIOPIA " prepared under my guidance by Million Huluf Nega submitted in partial fulfillment of the requirements for the degree of Master 's in **Geoinformatics Engineering**. Therefore, I recommend the submission of revised version of the thesis to the department following the applicable procedures.

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I, the advisor of the thesis entitled "IMPROVING THE CADASTRAL SYSTEM USING GEOSPATIAL OPEN-SOURCE TOOLS: A CASE OF ADAMA CITY, ETHIOPIA" and developed by Million Huluf Nega hereby certify that the recommendation and suggestions made by the board of examiners are appropriately incorporated into the final version of the thesis.

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We, the undersigned, members of the Board of Examiners of the thesis by Million Huluf Nega have read and evaluated the thesis entitled "IMPROVING THE CADASTRAL SYSTEM USING GEOSPATIAL OPEN-SOURCE TOOLS: A CASE OF ADAMA CITY, ETHIOPIA" and examined the candidate during open defense. 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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LIST OF ACRONYMS

CIS	Cadastre Information System
DBMS	Database Management Software
ESRI	Environmental System ResearchInstitute
GIS	Geographic Information System
GPS	Global Positioning System
LIS	Land Information System
E_Cadastre	Electronic Cadastre

ABSTRACT

A cadastre serves as a comprehensive repository of land-related information, encompassing ownership, use, value, and associated rights, restrictions, and responsibilities. It establishes a legal framework governing land ownership, use, and transfer. Assessing cadastral information systems is crucial for accurate and up-to-date land records, reducing land disputes, and improving land-related transactions. However, outdated systems, inadequate database models, and non-standardized data models create challenges in data storage, processing, and sharing. This leads to time-consuming property transactions, difficulties in property tax collection, and limitations in spatial measurements and analysis. This research aims to assess and enhance the cadastre system in Adama city using geospatial open-source tools. The methods include literature review, data collection, evaluation criteria selection, system evaluation, gap analysis, requirement analysis, SWOT analysis, and cadastre system design. The SWOT analysis reveals strengths, weaknesses, opportunities, and threats. Strengths include physical security and mortgage facilitation, while weaknesses include lack of backup systems, bureaucratic land registration processes, and inefficient access to land information. Opportunities include modern ICT adoption, sustainable development principles, transparent land registers, and e-government practices. Threats include funding limitations, political instability, lack of expertise, and system disruption due to natural disasters. The research concludes that the Adama city cadastre system exhibits deficiencies in database security, technology utilization, accessibility, adherence to land tenure principles, and data integration. Specifically, it highlights shortcomings in ensuring data confidentiality, integrity, and availability, posing risks of data breaches and unauthorized access.

Key Words: Geographic Information System (GIS), Cadastral Information System (CIS).

CHAPTER ONE

INTRODUCTION

1.1 Background of the Study

A cadastre serves as a comprehensive repository of land-related information encompassing ownership, use, value, and associated rights, restrictions, and responsibilities (Riedemann et al., 2016). This system of land registration and management establishes a legal framework governing land ownership, use, and transfer. Typically, a cadastre incorporates a map or plan of the land alongside a register of ownership and other pertinent land details. The wealth of information recorded within a cadastre finds application in diverse fields such as land administration, urban planning, natural resource management, and taxation. A cadastral system plays a pivotal role in facilitating efficient and effective land management by providing a dependable and precise database of land information that supports decision-making processes and encourages sustainable development (Enemark et al., 2014).

According to Rajabifard and Williamson (2011), cadastre systems are crucial for land administration and management as they help in recording and managing information about land ownership, use, and rights. These systems provide a framework for the registration and management of land-related information such as property boundaries, land titles, land use restrictions, and land taxation, which is essential for ensuring legal certainty and promoting sustainable development.

Assessments of cadastral information systems are important for evaluating their effectiveness and identifying areas for improvement. Such assessments can be conducted on different aspects of the system, including the accuracy and completeness of cadastral data, the efficiency and effectiveness of the registration process, and the accessibility and usability of the system for different stakeholders. As noted by Enemark et al. (2014), such assessments are critical in ensuring that land records are accurate and up-to-date, which can reduce the risk of land disputes and improve the efficiency of land-related transactions.

In addition to the importance of cadastre systems for land administration and management, several studies have emphasized the need for effective assessment of these systems. For instance, Rajabifard and Williamson (2011) noted that cadastral information systems are

critical for ensuring legal certainty, promoting sustainable development, and managing land-related information. They emphasized that assessments of cadastral information systems are important for evaluating the effectiveness of these systems and identifying areas for improvement.

Similarly, Enemark et al. (2014) highlighted those assessments of cadastral information systems are critical in ensuring that land records are accurate and up-to-date, which can reduce the risk of land disputes and improve the efficiency of land-related transactions. They noted that such assessments can be conducted on different aspects of the system, including data accuracy and completeness, the efficiency and effectiveness of the registration process, and the accessibility and usability of the system for different stakeholders.

Furthermore, McLaughlin et al. (2021) emphasized the importance of ensuring that cadastre systems meet the needs of their users. They noted that assessments of cadastral information systems can help to identify gaps in the system and ensure that the system is user-friendly and accessible to all stakeholders.

Overall, the importance of cadastre systems and their assessment cannot be overstated. Effective assessment of these systems is crucial in ensuring that they meet the needs of their users, promote sustainable development, and facilitate efficient land-related transactions.

Cadastre systems are essential for land administration and management as they provide an official register of land ownership and property boundaries within a specific jurisdiction, recording and managing information related to land ownership, use, and rights. This includes property boundaries, land titles, land use restrictions, and land taxation, which are fundamental for ensuring legal certainty and promoting sustainable development (Rajabifard and Williamson, 2011).

Effective assessment of cadastral information systems is necessary to ensure the accuracy, completeness, and accessibility of the information stored in these systems. Assessments of cadastral information systems can be conducted on various aspects of the system, such as the efficiency and effectiveness of the registration process, the accuracy and completeness of cadastral data, and the accessibility and usability of the system for different stakeholders.

Assessments of cadastral information systems are critical in ensuring that land records are accurate and up-to-date, which can reduce the risk of land disputes and improve the

efficiency of land-related transactions (Enemark et al., 2014). Such assessments can also identify areas for improvement and ensure that the system is user-friendly and accessible to all stakeholders.

The development of new technologies such as geographic information systems (GIS), remote sensing, and global positioning systems (GPS) has enhanced the accuracy and completeness of cadastral data. These technologies have made it possible to collect, store, and analyze spatial data more efficiently, improving the effectiveness of cadastral information systems (Rajabifard and Williamson, 2011).

In conclusion, accurate and up-to-date cadastral information systems are crucial for effective land administration and management. Effective assessment of these systems is necessary to ensure that they meet the needs of their users, promote sustainable development, and facilitate efficient land-related transactions.

Justification:

The research title aims to improve the existing cadastral system in Adama City, Ethiopia, by leveraging geospatial open-source tools. By incorporating these tools, the research intends to enhance the efficiency, accuracy, and functionality of the system. The use of geospatial open-source tools implies the utilization of freely available software or tools for geospatial data analysis, mapping, and related tasks, offering cost-effectiveness, collaboration opportunities, and customization potential.

The selection of Adama City as the case study area signifies a focus on a real-world implementation or analysis of the cadastral system in this specific location. The findings and recommendations derived from the research are likely to have applicability and relevance to similar contexts or cities facing comparable challenges.

The emphasis on integrating geospatial tools with the cadastral system demonstrates an acknowledgment of the value of geospatial data and analysis in enhancing the system's capabilities, encompassing spatial data management, mapping, spatial analysis, and visualization.

The decision to choose Adama City as the study area for improving the cadastral system using geospatial open-source tools, instead of other cities like Bishoftu, Dukem, Burayu, or others, can be attributed to several reasons:

Researcher's Expertise: The researcher possesses expertise or familiarity with Adama City, including its cadastral system and related challenges. This familiarity facilitates data collection, stakeholder engagement, and understanding of the local context.

Availability of Data: Adama City may have readily available cadastral data or other relevant datasets suitable for analysis and improvement purposes. Accessible data enhances the feasibility and efficiency of the research or project.

Specific Challenges or Issues: Adama City might be experiencing specific challenges or issues concerning its cadastral system, making it an interesting and pertinent case study. These challenges could include data accuracy problems, system efficiency concerns, land tenure conflicts, urban expansion issues, or other factors requiring attention and improvement.

Regional Significance: Adama City may hold regional significance as a rapidly growing urban area or as a representative case for the broader region or country. By researching and improving the cadastral system in Adama, the implications and lessons learned can be applied to other similar urban areas in Ethiopia or even beyond.

Available Resources and Support: The selection of Adama City as the study area may be influenced by the availability of resources, support, or partnerships in the region. Collaborating with local government agencies, academic institutions, or other stakeholders can enhance the outcomes of the research or project.

It is important to note that the choice of a study area is determined by researchers or project teams based on various factors, including research objectives, resources, feasibility, and relevance to the research topic. The specific reasons for selecting Adama City over other cities would ultimately depend on the context and goals of the particular research or project.

1.2 Statement of the Problem

The problem at hand in Adama City is the absence of modern cadastre and land registration systems, as well as suitable database models and standard data models (Adane et al., 2020). This lack has resulted in various issues related to storing, processing, and sharing land-related information. Consequently, property transactions have become time-consuming, property tax collection has become difficult, and spatial measurements and analysis have become limited. Furthermore, the absence of a standardized and centralized system for data collection, storage, and sharing has led to discrepancies, redundancy, and inefficiencies in land administration and management processes (Williamson et al., 2011).

To address these challenges and enhance land administration and management in Adama City, it is crucial to implement a modern cadastre and land registration system, along with suitable database models and standard data models. This implementation would establish a centralized and standardized database for land-related information, facilitating efficient data collection, storage, and sharing among government agencies and the public. By utilizing appropriate database models and standard data models, data accuracy, completeness, consistency, and interoperability can be ensured, leading to improved planning and decision-making (Enemark et al., 2014).

In summary, the absence of modern cadastre and land registration systems, suitable database models, and standard data models in Adama City has resulted in significant challenges in land administration and management. However, by implementing these systems and models, the efficiency, transparency, and accountability of land administration and management processes can be enhanced (Enemark et al., 2014).

Currently, there is a lack of research that evaluates the effectiveness and performance of the existing cadastral system in Adama City. This absence of assessment prevents a comprehensive understanding of the system's strengths and weaknesses, as well as the identification of any gaps that may exist. Without such information, it becomes challenging to plan for future improvements and enhancements to the cadastral system.

Conducting a thorough assessment of the current cadastral system in Adama City is crucial to address any shortcomings and make informed decisions regarding its future development. This assessment would involve analyzing various aspects of the system, including its

functionality, accuracy, efficiency, and usability. By conducting this evaluation, it becomes possible to identify any gaps or deficiencies that may hinder the system's performance and hinder effective land administration and management.

Furthermore, assessing the current cadastral system can provide valuable insights into the specific areas that require improvement. It can help identify technological advancements, such as modern database models and standard data models that can enhance data storage, processing, and sharing capabilities. Additionally, the assessment can highlight the need for a centralized and standardized database for land-related information, which would facilitate efficient data collection and sharing between relevant stakeholders.

Ultimately, conducting a comprehensive assessment of the current cadastral system in Adama City is essential for understanding its limitations and identifying areas for improvement. This evaluation will guide future enhancements, ensuring that the cadastral system is efficient, accurate, and capable of effectively supporting land administration and management processes in the city.

1.3 Objectives of the Study

1.3.1 General Objective

The Main Objective of this research is to assess the cadastre system in Adama city and develop a strategy to enhance it utilizing Geospatial Open-source Tools.

1.3.2 Specific Objective.

The specific objectives of this study are as follows:

- To evaluate the existing cadastral information system of the City Based on Acceptable Standards
- To identify the major existing gaps related to Cadastral information system of the City
- To develop Cadastral Web Map using Open-source Tools

1.4 Research Questions

The research questions for this Research are as follows:

- How does the existing cadastral information system in the city align with acceptable standards and best practices?
- What are the major challenges and gaps in the existing cadastral information system that hinder efficient land administration and management?
- What are the technical requirements and considerations for implementing a Cadastral Web Map using open-source tools in the city?

1.5 Significance of the Study

According to Adane (2020), the significance of the study is multi-faceted. Firstly, it provides a base for the development and implementation of a modern cadastre and land registration system in Adama City, which will lead to improved land administration and management. This will benefit not only the government and land administration experts, but also the landowners and the city's residents as a whole. Secondly, the study proposes an improved model that can be used with existing software, such as ArcGIS, for better and efficient management of land-related information.

The implementation of a modern cadastre and land registration system will also assist land managers and experts in efficiently recording and obtaining information, conducting analysis, and reducing the length of the decision-making process. This will facilitate the registration of land ownership, reduce labor and cost, and generate huge capital for not only the landowners but also the society to improve economic development, as noted by Enemark et al. (2014). Furthermore, the database model developed for the cadastre and land registration system will have an important influence on the efficient planning of public services such as health, education, and the management of urban development and environmental protection.

In conclusion, the implementation of a modern cadastre and land registration system in Adama City will have far-reaching benefits, including improved land administration and management, increased efficiency in decision-making, and improved economic

development and environmental protection, as highlighted by Rajabifard and Williamson (2011).

1.6 Scope of the study

The scope of the study is limited to Adama city of the Oromia Regional State in Ethiopia. The study focuses on the design and creation of a digital cadastre and land registration system for the city using GIS and open-source tools. The system integrates land ownership database records and maps, status, processing, queries/analysis and retrieval of information from the cadastre and land registration system developed. The study does not cover the physical survey of land parcels or the legal aspects of land registration and administration. However, the model/system developed can be used as a template for other cities in Ethiopia that may wish to implement a modern cadastre and land registration system.

CHAPTER TWO

LITRATURE REVIEW

2.1 Theoretical Review

In this chapter, various concepts and theories related to the creation of digital cadastre are discussed. The literature covers topics such as the role of cadastre in sustainable development and the application of geographic information systems (GIS) in digital cadastre creation.

As stated in the FIG Statement on the Cadastre (1995), a successful cadastre should provide security of tenure, be simple and clear, be easily accessible, and provide current and reliable information at a low cost. The concept of the cadastre involves two basic sets of information: registers that record rights in land through textual and alphanumeric data, and maps that define the boundaries and extent of land parcels over which these rights apply. The cadastral system is designed with both registers and maps having equal importance and should not be separated, as noted by Steudler et al (1997).

In the analogue cadastral system, textual information is recorded in the Land Register Book, while spatial data is recorded in a map drawn to scale that shows land parcels in a particular area. These two descriptions of property are linked by a unique parcel number shown on both, as highlighted by the cadastral concept.

According to Dashe (1987), cadastral surveying answers questions such as where the land is located and what the extent or size of its boundaries is. It also indicates the land parcel's separate identity both geographically on a map or record and physically on the ground by means of survey beacons. On the other hand, cadastre answers questions concerning ownership of the land and the conditions under which it is held.

2.2 Cadastral surveying

The concept of a cadastre is widely recognized as a system that provides security of tenure, simplicity, clarity, accessibility, and reliable information at a low cost (FIG Statement on the Cadastre, 1995). The cadastral system comprises two basic sets of information: registers based on textual and alphanumeric data that record rights in land and maps that define the boundaries and extent of land parcels over which these rights apply. Williamson (1997)

describes the registers and the map as "two sides of a coin" and emphasizes that they should not be separated.

Cadastral surveying is the branch of surveying used to establish property lines and property corner markers. According to Ghilani and Wolf (2008), the three major categories of cadastral surveys are original surveys to establish new section corners in unsurveyed areas, retracement surveys to recover previously established boundary lines, and subdivision surveys to establish monuments and delineate new parcels of ownership. Cadastral surveying is usually undertaken using ground survey methods, such as plane tables or tapes and optical squares, electronic distance measuring equipment, or satellite positioning fixing using GPS. Computerized mapping systems and geographic information systems reduce the importance of the physical map in favor of graphical databases.

Cadastral surveying answers questions about the land's location and the extent of its boundaries, while cadastre answers questions concerning ownership of the land and the conditions under which it is held (Dashe, 1987). The cadastral map provides a standardized inventory of all who have the right to land within a geographical setting and forms the basis of the digital cadastre in this study.

2.3 Digital Cadastre

A digital cadastre focuses on the land parcel as the primary unit of information and is designed to maintain, analyze, and disseminate information about land ownership, value, records and registration, land assessment, and allocation. The major data fields of a digital cadastre include the coordinates of beacons, lengths and bearings of boundary lines, area of plots, perimeter, parcel owner, ground rent, land market value, land use, adjoining plots, reference controls, among others. It is mainly applicable in built-up or urban areas on a large scale. Land information includes every record about land use (agricultural, residential, commercial, etc.) and their market/economic values. Therefore, a digital cadastre is an aspect of LIS, just as LIS is an aspect of GIS, as noted by Rajabifard and Williamson (2011).

As stated by Cichocinski (1999), a modern or digital cadastre should answer two basic questions: 1) what is at a particular location? A location can be described in many ways using, for example, a place name, an address, or a geodesic reference such as coordinates. 2) Where are certain conditions to be found? The second question is the converse of the first

and requires spatial analysis to be answered. Instead of identifying what exists at a given location, someone may want to find a location where certain conditions are satisfied (e.g., all parcels owned by a particular person).

To sum up, a digital cadastre is an essential tool for efficient land administration and management, providing accurate and reliable information about land parcels, ownership, and value. It is an aspect of LIS and uses GIS technology to analyze and disseminate spatial data, as highlighted by Enemark et al. (2014).

2.4 Types of cadastre

In this literature review, we delve into the various types of cadastre, ranging from basic to advanced, including legal, fiscal, multipurpose, economic, smart, and web cadastre. We explore each type extensively, examining their characteristics and applications.

Legal cadastral systems refer to the legal frameworks and regulations that govern the establishment, maintenance, and administration of cadastral systems. These systems provide the legal basis for land registration, land tenure, property rights, and the recording and management of cadastral data. Here are key aspects of legal cadastral systems:

Legislation and Regulations: Legal cadastral systems are underpinned by legislation and regulations that define the legal framework for land administration and cadastral activities. These laws establish the rules and procedures for cadastral surveys, land registration, land transfers, property rights, and dispute resolution.

Property Rights and Land Tenure: Legal cadastral systems play a crucial role in establishing and protecting property rights and land tenure. They define the rights, restrictions, and responsibilities associated with land ownership and use. These systems ensure that landowners have legal recognition and security over their land, facilitating investment, economic activities, and land market transactions.

Cadastral Surveys and Boundaries: Legal cadastral systems specify the requirements and standards for cadastral surveys and the establishment of parcel boundaries. They outline the technical procedures for surveying and mapping land parcels, ensuring accuracy and consistency in defining property boundaries Dale et al. (2005).

Land Registration: Legal cadastral systems typically include provisions for land registration. This involves recording cadastral information, including property ownership, boundaries, encumbrances, and other relevant details, in a formal land register or cadastre. Land

registration provides a public record of land rights, enabling transparency, facilitating land transactions, and protecting against fraudulent claims.

Data Management and Access: Legal cadastral systems establish rules for the management, storage, and access to cadastral data. They define who can access the data, how it can be used, and the procedures for data updates, maintenance, and preservation. These systems often specify data privacy and confidentiality measures to protect sensitive information.

Dispute Resolution Mechanisms: Legal cadastral systems include mechanisms for resolving disputes related to land ownership, boundaries, or other cadastral matters. They provide procedures for mediation, arbitration, or court adjudication to resolve conflicts and maintain the integrity of property rights.

Compliance and Enforcement: Legal cadastral systems outline mechanisms for compliance and enforcement of cadastral regulations. They specify the roles and responsibilities of government agencies, surveyors, land administrators, and other stakeholders involved in the cadastral process. Compliance ensures adherence to legal requirements, quality standards, and ethical practices within the cadastral system.

Legal cadastral systems provide the legal framework necessary for effective land administration, property rights protection, and efficient management of cadastral data. They contribute to good governance, land tenure security, and the development of sustainable land markets. The specific elements and requirements of legal cadastral systems may vary between countries or jurisdictions, reflecting local legal traditions, institutional arrangements, and societal needs Dale et al. (2005).

Physical cadastre primarily focuses on the accurate representation and documentation of land boundaries and related physical features on the ground.

It involves surveys, measurements, and mapping of land parcels, including their geometric dimensions, coordinates, and spatial relationships.

The physical cadastre is concerned with establishing cadastral infrastructure such as reference points, control networks, and survey markers to enable precise positioning and referencing of land parcels.It typically involves field surveys and the use of surveying instruments to collect data on land boundaries, topography, and other physical attributes.

The information captured in a physical cadastre serves as the foundation for legal and administrative purposes, such as property registration, land titling, and land valuation.

The accuracy and reliability of the physical cadastre are crucial for ensuring the security of land tenure, facilitating land transactions, and resolving boundary disputes Krigsholm et al. (2005).

"Economic cadastre" refers to a specialized component of a cadastral system that focuses on capturing and managing information related to economic activities and land use. It is an extension of traditional cadastral systems that primarily deal with land ownership and property rights Plimmer et al. (2005).

The economic cadastre plays a crucial role in supporting economic development, land management, and policy-making by providing detailed information about land use, land values, and economic activities associated with land. Here are some key aspects of economic cadastre described by Krigsholm et al. (2005).

Land Use Classification: Economic cadastres often include a classification system that categorizes land according to its use or economic activities. This classification helps identify different types of land, such as agricultural land, residential land, commercial land, industrial land, or recreational land. It enables policymakers and planners to understand the distribution and dynamics of economic activities across the territory.

Valuation and Assessment: Economic cadastre incorporates mechanisms for property valuation and assessment. It involves determining the market or assessed value of land and properties based on factors such as location, size, land use, infrastructure, and development potential. Valuation information is useful for taxation purposes, land valuation for transactions, and assessing the economic viability of land use options.

Land Market Information: Economic cadastres provide data on land transactions, including sales, leases, and transfers. This information helps track changes in property ownership, monitor land market trends, and support informed decision-making by stakeholders involved in real estate development, investment, or policy formulation.

Zoning and Planning Support: Economic cadastres can support land use planning and zoning activities. By integrating zoning regulations and land use restrictions into the cadastre system, it becomes possible to ensure compliance with planning policies, manage development permits, and enforce land use regulations.

Economic Impact Analysis: Economic cadastres can be used to assess the economic impact of land use changes or development projects. By analyzing data on land values,

employment, tax revenues, and other economic indicators, policymakers and planners can evaluate the potential benefits and costs associated with different land use scenarios.

Spatial Analysis and Decision Support: Economic cadastre systems often incorporate geospatial analysis capabilities to visualize and analyze economic data in conjunction with geographic information. This spatial analysis can provide insights into the spatial distribution of economic activities, identify patterns, and support evidence-based decision-making in economic planning, infrastructure development, and spatially targeted policies.

Land Management and Monitoring: Economic cadastres contribute to effective land management by providing a comprehensive overview of land use, economic activities, and associated value. They support monitoring and evaluation of land policies, land use changes, and the impacts of economic development on land resources.

Economic cadastres are essential tools for governments, urban planners, policymakers, and researchers to understand and manage the economic aspects of land use. They facilitate informed decision-making, promote efficient land markets, and contribute to sustainable economic development.

Economic cadastre, also known as fiscal cadastre or cadastral valuation, refers to the component of a cadastral system that focuses on the assessment, valuation, and taxation of land and properties for economic purposes. It involves the identification, classification, and valuation of land parcels and real estate assets to determine their economic value and the associated taxes or fees to be levied. Here are key aspects of economic cadastre:

Property Valuation: Economic cadastre involves the valuation of land and properties for various purposes, such as property taxation, land market transactions, financial reporting, and investment analysis. Valuation methods may include market-based approaches, income approaches, or cost approaches, depending on the specific context and purpose.

Assessment of Taxes and Fees: Economic cadastre plays a vital role in the assessment and collection of taxes and fees related to land and property. It determines the taxable value of properties based on their assessed market value or other valuation criteria. This information is used to calculate property taxes, land use fees, development charges, or other fiscal obligations imposed by the government.

Land Market Analysis: Economic cadastre provides valuable information for analyzing land markets, property trends, and real estate investments. It enables the identification of market

values, price fluctuations, and spatial patterns of property transactions, which can inform decision-making by investors, developers, and policymakers.

Land Use Planning and Development: Economic cadastre supports land use planning and development by considering the economic value of land parcels. It helps identify areas with high-value or underutilized land, guiding decisions on zoning, development incentives, and infrastructure investments to optimize land utilization and economic growth.

Property Rights and Land Market Efficiency: An effective economic cadastre contributes to the establishment of secure property rights and efficient land markets. Accurate and transparent property valuations ensure fair transactions, reduce information asymmetry, and encourage investment in land and real estate. This, in turn, promotes economic development and stimulates market activity.

Financial Management and Revenue Generation: Economic cadastre assists in financial management by providing reliable data for revenue forecasting, budgeting, and financial planning. It helps governments generate revenue from property taxes and fees, which can be allocated to public infrastructure, services, or other development initiatives.

Policy Formulation and Decision-making: Economic cadastre provides policymakers, government agencies, and other stakeholders with essential information for formulating land-related policies and making informed decisions. It supports evidence-based policy development, monitoring of economic indicators, and evaluation of the effectiveness of fiscal measures related to land and property.

Economic cadastre is a critical component of cadastral systems, facilitating efficient land administration, revenue generation, and economic planning. It aims to ensure fair and equitable taxation, promote land market efficiency, and support sustainable economic development. The specific approaches and practices in economic cadastre may vary across countries and jurisdictions based on local legal frameworks, valuation methods, and fiscal policies.

A multipurpose cadastral system is a computer-based system designed to record, store, and provide not only land-tenure and land-valuation information, but also a wide variety of information that can be functionally related to and referenced by property parcel, as noted by Abdul et al. (1999). According to Enemark (2010), modern land administration theory acknowledges the history of the cadastre as a central tool of government infrastructure and

highlights its central role in implementing the land management paradigm. However, since there is no definition that suits every version, it is sensible to talk about cadastral systems rather than just cadastres. These systems incorporate both the identification of land parcels and the registration of land rights. They support the valuation and taxation of land and property, as well as the administration of present and possible future uses of land. Multipurpose cadastral systems support the four functions of land tenure, value, use, and development to deliver sustainable development.

As highlighted by Steudler et al (1997), multipurpose cadastres are increasingly seen as fundamental to economic development, environmental management, and social stability in both the developed and developing worlds. The cadastral infrastructure includes a unique identification of the land parcels derived from cadastral surveys. This cadastral identification is then seen as the core component of any land information system.

2.5 The Role of the Cadastre in Sustainable Development

In addition to its role in establishing fiscal and legal purposes and as a tool for the management of land and land-use planning, the cadastre plays a major role in sustainable development and environmental improvement. The cadastral infrastructure includes a unique identification of land parcels derived from cadastral surveys, seen as the core component of any land information system. Such land information systems, within the next ten years, will form an integral part of a model of our man-made and natural environment (Enemark, 1999), which will build on the core cadastral and topographic data sets that will be complete on a countrywide basis and kept up-to-date.

While classical hardcopy-based approaches are still being used for land registration, technology is playing a central role in many areas of human life. Internet-based methods and open-source software tools provide excellent facilities for overcoming the drawbacks of handwritten-based style and communication among different government sectors. Several scholars have reviewed the basic concept of data modeling, database design, and GIS-based cadastre and land registration systems, including Larsson (2002), who extensively reviewed cadastral and land registration systems in developing countries, and Tuladhar (2003), who introduced the uses of UML for describing cadastral information systems in terms of static and dynamic models. Ahmed (2016) conducted research on 3D

modeling for urban cadastral registration and management for the case of Bahirdar Town, but the model could not handle information on restrictions, responsibilities, land development, valuation, and taxation information.

While various researchers have contributed scholarly articles aimed at solving different aspects of Land Administration Systems, such as registering and recording land information, little research has been conducted on disseminating reliable land information via web-based GIS. However, Sunday & Igbinom (2010) developed a web-based land information system tool for online land administration using Postgresql as a database and QGIS as a desktop GIS for data processing and visualization, while QGIS cloud as geospatial web services. According to Atilola (2010), the success of any land administration depends on the flow of information relating to land and property between different government agencies and between these agencies and the public. Therefore, any nation serious about land reform should adopt new methods of land administration, such as web-based GIS (Didigwu & Olakanmi, 2016; Enemark et al., 2005).

Sustainable land management and administration systems refer to approaches, practices, and systems that aim to ensure the responsible and efficient use of land resources while considering social, economic, and environmental sustainability. These systems integrate principles of sustainable development into land management and administration processes to achieve long-term benefits for current and future generations. Here are some key aspects of sustainable land management and administration systems explained by(Plimmer et al., 2005).

Land Use Planning: Sustainable land management and administration systems emphasize the importance of land use planning. This involves assessing and determining the most appropriate uses of land based on its ecological, social, and economic characteristics. Land use planning considers factors such as soil quality, water availability, biodiversity, infrastructure, and community needs to promote sustainable land utilization and minimize conflicts.

Land Tenure Security: Ensuring secure and equitable land tenure is a fundamental aspect of sustainable land management and administration. Clear and enforceable land tenure rights provide individuals and communities with the incentive to invest in land resources, conserve

ecosystems, and adopt sustainable land management practices. It helps prevent land-related disputes, promotes responsible land use, and supports long-term land stewardship.

Participatory Decision-making: Sustainable land management and administration systems often involve engaging stakeholders, including local communities, indigenous groups, landowners, and relevant institutions, in decision-making processes. Participatory approaches foster inclusive governance, allow for diverse perspectives, and promote sustainable practices that consider local knowledge and values.

Ecosystem Conservation and Restoration: These systems prioritize the conservation and restoration of ecosystems within land management practices. Protecting biodiversity, maintaining ecological balance, and enhancing ecosystem services (such as water filtration, carbon sequestration, and soil fertility) are key objectives. Sustainable land management practices, such as agroforestry, conservation agriculture, and sustainable forestry, are employed to minimize environmental degradation and promote ecosystem resilience.

Integrated Land Information Systems: Sustainable land management and administration systems often incorporate integrated land information systems. These systems enable the efficient management, analysis, and dissemination of land-related data, including cadastral information, land use data, environmental data, and socioeconomic data. Integrated systems support evidence-based decision-making, facilitate monitoring and evaluation of land management practices, and enhance transparency and accountability.

Capacity Building and Knowledge Sharing: Sustainable land management and administration systems place importance on capacity building and knowledge sharing. This involves providing training, technical assistance, and information to stakeholders involved in land management. It promotes the adoption of sustainable practices, disseminates best practices, and enhances the understanding of the interconnections between land, environment, and social well-being.

By implementing sustainable land management and administration systems, societies can optimize land use, protect natural resources, support livelihoods, and contribute to sustainable development goals. These systems are critical for achieving long-term land stewardship, resilience, and equitable land governance (Plimmer et al., 2005).

2.6 Database Design for Cadastre Information System

The design and creation of a well-structured database is a fundamental process in every GIS work executed, as it is the process by which real-world entities and their relationships are analyzed and modeled to solve specific problems and find solutions to questions of interest (Kufoniyi, 1998). The heart of a GIS is a well-structured spatial database, and the process of designing a database is called data modeling. The database design phase comprises three basic processes: conceptual, logical, and physical design (Kufoniyi, 1998).

The conceptual design phase involves presenting human conceptualization of reality in a simplified manner to meet the information requirements of the application (Kufoniyi, 1998). The objective is to determine the basic entities, the spatial relationships among the entities, and the attributes of each entity that support the process and application for which the database is designed. In this phase, an entity-relationship (ER) model is often used to illustrate the relationships between entities in the database (Chapple, 2012).

The logical design phase deals with the transition of the conceptual data model into the data structure of a particular database management software (DBMS) (Ndukwe et al., 2001). In this phase, entities, their attributes, and their relationships are represented in a single uniform manner in the form of a relation. The logical database design is employed to generate a geo-relation database structure that translates the conceptual model into a logical structure.

The physical design phase involves translating real-world entities into computer-compatible forms of the chosen structuring model, such as relational, geo-relational, network, and hierarchical. In this study, the relational (table) structuring method was used due to its easy implementation and management. All geospatial and non-spatial (attribute) data were structured and actualized to form a database in a format acceptable by the implementing software and hardware. The database was designed such that stored information can be accessed and retrieved at a later date, updates can be done from time to time, and analytical functions can be performed to answer generic questions for the study.

Database design is a crucial process in GIS work, as it involves analyzing and modeling real-world entities and their relationships to solve specific problems (Kufoniyi, 1998). The design phase typically consists of three levels: conceptual, logical, and physical design. Conceptual design is the modeling of the projected system independent of the data method that is to be used, while logical design involves transitioning the conceptual data model into

the data structure of a particular DBMS. Finally, physical design involves translating real-world entities into computer-compatible forms of the chosen structuring model.

In the design of a cadastre system, an entity-relationship (ER) model was used to illustrate the relationships between entities in the database (Chapple, 2012). The logical database design was then employed to generate a geo-relation database structure, which involved representing the entities, their attributes, and their relationships in a uniform manner in the form of a relation. This was done to ensure that there was no information loss or unnecessary duplication of data.

The physical design involved structuring all geospatial and non-spatial data in a format acceptable by the implementing software and hardware. For this project, relational (table) structuring method was used due to its easy implementation and management. Point, line, and polygon layers were created for spatial objects on the digital cadastral map, and attribute data needs of the database were also structured in tables to enable information storage, retrieval, and updates, as well as analytical functions to be performed (Ndukwe et al., 2001).

2.7 GIS and Cadastral System

A Geographic Information System (GIS) is a computer system that includes hardware, software, and procedures designed to support the capture, management, manipulation, analysis, and display of spatially-referenced data for solving complex planning and management problems (ESRI, 2007). Kufoniyi (1998) describes GIS as an integrated computerized system for the storage, retrieval, manipulation, analysis, and display of geographically referenced data. GIS integrates spatial and other kinds of data or information within a single system and offers a consistent framework for analyzing geographic data by putting maps and other spatial data and information into digital forms.

The power of a GIS lies in its ability to relate different types of information in a spatial context and reach a conclusion about their relationship. A GIS can contain information relating to cadastral maps, corresponding parcel titles, ownership, and locational reference. Locational reference is a critical capability of GIS software, such as ArcGIS, which was used in the processing and digitization of data for this project. Most information about our world contains a locational reference, placing that information at a specific point on the

globe. Therefore, when collecting parcel or land information, it is essential to know the location of the plot and its topology (ESRI, 2007).

2.8 LIS, CIS, E-Cadastre ,Smart Cadastre and Web cadastre

As previously mentioned, a Land Information System (LIS) is a component of Geographic Information System (GIS), and its main component is the digital cadastral map (Cichocinski, 1999). However, land information is crucial to government, non-profit, and private sector activities, and adopting GIS/LIS techniques can advance broader social purposes by making more effective public decisions and using natural resources more optimally (Aruna, 2009). GIS supports spatial analysis and modeling procedures for solving complex planning and management problems, and by taking advantage of GIS technology, a Land Record Information Management System for cadastral mapping can be developed by integrating a digital cadastral map and a land record database.

Dale and McLaughlin (1998) define LIS as a combination of human and technical resources, along with a set of organizing procedures that result in the systematic collection, storage, retrieval, dissemination, and use of land information. According to the International Federation of Surveyors (FIG), LIS is a tool for legal, administrative, and economic decision-making and an aid for planning and development that consists of a database containing spatially referenced land-related data for a defined area, as well as procedures and techniques for the systematic collection, updating, processing, and distribution of data.

Atilola (2011) identified several important facts associated with the increasingly popular land information systems, including the necessity of modern computerized land records information services to enable timely and accurate answers to fundamental questions about public and private rights and responsibilities to land. It is also important to know the spatial reliability of all data sets at all times to ensure that land and land ownership rights and responsibilities are not incorrectly determined because of imprecise information.

The components for LIS implementation include geospatial data, software and programs, hardware systems, operators (surveyors, land officers, etc.), and integrated approaches and methods (Aruna, 2009).A Land Information System (LIS) is a comprehensive system that manages various types of information related to land and land-related activities. It includes

data such as land ownership, land use, land parcel boundaries, land valuation, land administration, land development, and land records. LIS aims to provide a centralized platform for storing, organizing, analyzing, and presenting land-related data to support decision-making processes related to land management, urban planning, land development, and environmental management(Aruna, 2009)..

A Cadastral Information System (CIS) is a subset or component of a Land Information System specifically focused on the management of cadastral data. Cadastral data refers to information about land parcels, their boundaries, ownership, rights, and interests associated with those parcels. The primary purpose of a CIS is to accurately capture, store, update, and manage cadastral data, such as cadastral maps, survey records, land registration information, and legal documents related to land ownership and transactions. CIS is used to support land administration, land registration, and land tenure systems, ensuring the accuracy of cadastral information and facilitating land-related transactions and decision-making processes (Smith etal. 2023).

In summary, while both LIS and CIS deal with land-related information, a LIS is a broader system that encompasses various aspects of land information management, including land use, valuation, and administration. On the other hand, a CIS specifically focuses on cadastral data and is primarily concerned with accurately recording and managing information related to land parcels, boundaries, and ownership.

E-Cadastre refers to the digitalization and computerization of cadastral systems and processes. It involves the use of electronic tools, technologies, and databases to capture, store, manage, and disseminate cadastral data. E-Cadastre systems replace traditional paper-based approaches with digital platforms that enable more efficient data management, improved accessibility, and faster processing of land-related information. With E-Cadastre, land parcels, boundaries, ownership details, and other cadastral information can be easily accessed, updated, and shared electronically(Doe etal.,2023).

Smart Cadastre goes beyond the digitalization of cadastral systems and incorporates advanced technologies such as Geographic Information Systems (GIS), remote sensing, global positioning systems (GPS), and data analytics to enhance the capabilities and functionalities of the cadastral system. Smart Cadastre leverages these technologies to improve the accuracy, efficiency, and effectiveness of land administration processes. It enables automated data capture, real-time data integration, spatial analysis, visualization of

land information, and the integration of cadastral systems with other systems, such as planning, taxation, and land management systems. Smart Cadastre aims to provide intelligent and interconnected solutions that support better decision-making, streamline processes, and improve overall land governance.

In summary, E-Cadastre focuses on the electronic management of cadastral data, while Smart Cadastre incorporates advanced technologies to create a more sophisticated and integrated cadastral system capable of providing intelligent and efficient land administration solutions.

A web-based cadastral system refers to a cadastral system that is accessible and operates through the internet or a web browser. It leverages web-based technologies to provide users with online access to cadastral data, tools, and functionalities. Here are some key features and benefits of web-based cadastral systems descriped by (Doe etal. 2023):

Accessibility: Web-based cadastral systems offer the advantage of accessibility from anywhere with an internet connection. Users can access the system using various devices, such as computers, laptops, tablets, or smartphones, without the need for specialized software installations.

Data Sharing and Collaboration: Web-based systems facilitate easy sharing and collaboration of cadastral data among different stakeholders, such as government agencies, surveyors, land administrators, and the public. Authorized users can access and share data in real-time, improving coordination and communication among stakeholders.

Interactive Mapping and Visualization: Web-based cadastral systems often include interactive mapping capabilities, allowing users to visualize cadastral data on maps. Users can view parcel boundaries, ownership information, land attributes, and other relevant spatial data. These maps can be customized, layered with additional information, and analyzed using various geospatial tools.

Data Integration and Interoperability: Web-based systems can integrate with other information systems, such as land administration databases, land registries, valuation systems, or planning systems. This integration enables seamless data exchange, avoids data duplication, and facilitates better decision-making by providing a comprehensive view of land-related information.

Online Services and Transactions: Web-based cadastral systems can provide online services and facilitate land-related transactions, such as online land registration, online payment of fees, submission of applications, and issuance of certificates. This improves efficiency, reduces paperwork, and enhances user convenience.

Data Security and Backup: Web-based systems can implement robust security measures to protect cadastral data from unauthorized access or data breaches. Regular data backups and disaster recovery mechanisms can be implemented to ensure data integrity and availability.

Scalability and Flexibility: Web-based systems can be easily scaled up or down based on user demands and system requirements. They offer flexibility in terms of system updates, enhancements, and integration with new technologies or standards.

Web-based cadastral systems play a crucial role in modernizing land administration processes, improving data accessibility, efficiency, and transparency. They offer a user-friendly platform for managing cadastral data, supporting decision-making, and providing effective land governance services.

2.9 Cadastral Information System for Decision Making

A cadastral system is a reliable and accurate database of land information that supports decision-making in land management (Kufoniyi, 1998). There are several ways in which a cadastral system supports decision-making, such as land use planning, land administration, natural resource management, taxation, and infrastructure development.

With information on land ownership, land use, and land values, a cadastral system can support land use planning by identifying suitable areas for different types of land use and developing land use policies that promote sustainable development. It can also support land administration by helping administrators manage land transactions and maintain accurate records of land ownership and use.

A cadastral system can also support natural resource management by providing information on land ownership and use, which can help managers identify areas of high ecological value and develop policies and programs for the sustainable use and conservation of natural resources. Additionally, information on land values can support property taxation by helping tax authorities assess property values accurately and collect taxes efficiently, generating revenue for local governments.

Lastly, a cadastral system can support infrastructure development by providing information on land ownership and use, which can help planners identify suitable areas for the construction of roads, buildings, and other infrastructure, and develop plans for the efficient and effective use of land.

In summary, a cadastral system provides a foundation for decision-making in land management, supporting the development of policies and programs that promote sustainable development, efficient land transactions, effective land administration, and the responsible use and conservation of natural resources (Kufoniyi, 1998).

2.10 Cadastral Systems in Developed Countries

Cadastral systems exhibit higher levels of accuracy, completeness, and accessibility in developed countries as compared to developing countries, due to factors such as greater investment in technology, robust legal frameworks, and effective coordination among stakeholders (Enemark, 2014). However, there are also similarities and challenges shared across both developed and developing countries.

Differences between cadastral systems in developed and developing countries include the greater access to advanced surveying and mapping technologies, such as GPS and LIDAR, in developed countries, which enables more accurate and efficient mapping of land parcels. Developed countries also tend to have more robust legal frameworks for land registration and transaction, which help to ensure the accuracy and reliability of cadastral information. Additionally, developed countries have more effective coordination among stakeholders, including government agencies, surveyors, and landowners, which helps to ensure the accuracy and completeness of cadastral information.

However, both developed and developing countries face challenges related to informal land ownership and use, which can make it difficult to establish accurate and complete cadastral information. Both also require standardized procedures and guidelines for surveying and mapping to ensure consistent and accurate cadastral information. Furthermore, transparency and accountability in the land registration and transaction process are essential for preventing corruption and promoting good governance in both developed and developing countries.

In conclusion, while there are differences between cadastral systems in developed and developing countries, there are also common challenges and opportunities for improvement. Effective coordination among stakeholders, investment in appropriate technology, and robust legal frameworks and standardized procedures are necessary to ensure the accuracy and completeness of cadastral information (Enemark, 2014).

2.11 Challenges that Developing Countries face when Implementing Cadastral System Improvements

Developing countries encounter several challenges when implementing cadastral system improvements (UN-Habitat, 2016). The following are some of the key challenges:

Limited Financial Resources: Developing countries often have limited financial resources to invest in cadastral system improvements. This can make it difficult to fund the development and implementation of new technologies, establish new legal frameworks, or invest in capacity building and training programs.

Lack of Infrastructure: Developing countries may lack the necessary infrastructure, such as roads and communication networks, to support the implementation of cadastral system improvements. This can make it difficult to collect and maintain accurate and up-to-date cadastral information or to provide access to land information for stakeholders.

Limited Human Resources: Developing countries may also have limited human resources, such as trained surveyors, land administrators, and other cadastral system professionals. This can make it difficult to establish and maintain accurate and complete cadastral information or to implement new cadastral system improvements.

Informal Land Ownership: Developing countries often face challenges related to informal land ownership, such as customary or communal land tenure systems, which can make it difficult to establish accurate and complete cadastral information. This can lead to land disputes and conflicts, which can undermine the effectiveness of cadastral system improvements.

Political Instability: Developing countries may also face political instability, which can make it difficult to establish and maintain a stable legal and regulatory framework for the

cadastral system. This can undermine the effectiveness of cadastral system improvements and make it difficult to attract investment in land and property markets.

In general, these challenges can make it difficult for developing countries to implement cadastral system improvements and undermine their effectiveness. However, by focusing on capacity building, public-private partnerships, and community-based approaches, developing countries can overcome these challenges and promote more effective and sustainable land management practices (UN-Habitat, 2016).

2.12 Challenges in Managing and Sharing Cadastral Data

Managing and sharing cadastral data presents several common challenges that can be complex and difficult to address (van Oosterom et al., 2017). Some of these challenges include:

Data quality and accuracy: The accuracy and reliability of cadastral data is critical for its usefulness. However, data quality issues can arise due to various factors such as errors during data collection, inconsistent data formats, and incomplete data.

Data security: Cadastre data contains sensitive information, and data security is a critical challenge in managing and sharing it. It is important to ensure that the data is protected from unauthorized access, modification, and disclosure.

Data standardization: Cadastre data is often collected and managed by different organizations and individuals using different methods and standards, which can result in inconsistencies. Therefore, data standardization is a challenge in managing and sharing cadastre data, as it is important to ensure that the data is standardized to enable interoperability and effective sharing among various stakeholders.

Data integration: Cadastre data often needs to be integrated with other datasets such as land use, zoning, and environmental data. Therefore, data integration is a challenge in managing and sharing cadastre data, as it is important to ensure that the data can be effectively integrated to provide a comprehensive view of land information.

Data accessibility: Cadastre data is often managed by government agencies and may not be easily accessible to the public. Therefore, data accessibility is a challenge in managing and

sharing cadastre data. It is important to ensure that the data is accessible to all stakeholders who need it, while also protecting sensitive information.

Data sharing agreements: Cadastre data is often subject to legal and policy requirements, and data sharing agreements must be established to ensure compliance. Therefore, data sharing agreements are a challenge in managing and sharing cadastre data. It is important to ensure that the data sharing agreements are established with all stakeholders, and that they are effectively enforced.

Overall, managing and sharing cadastral data requires addressing the challenges of data quality and accuracy, data security, data standardization, data integration, data accessibility, and data sharing agreements to ensure that the data is accurate, secure, standardized, integrated, accessible, and subject to appropriate data sharing agreements (van Oosterom et al., 2017)

2.13 Methods of Assessing Cadastral Systems

Assessing cadastral systems is essential to identify areas for improvement and ensure that cadastral information is accurate, complete, and accessible (FAO, 2014). The following are some of the key methods used to assess cadastral systems:

Quality Control and Quality Assurance (QC/QA): QC/QA involves the establishment of standardized procedures and guidelines for surveying and mapping, as well as the implementation of quality control and quality assurance measures to ensure the accuracy and completeness of cadastral information. This can include field checks, data validation, and error correction procedures.

Performance Indicators: Performance indicators are quantitative measures used to assess the effectiveness of cadastral systems. Some common performance indicators include the number of registered land parcels, the percentage of land parcels with accurate and up-to-date information, and the time required to process land transactions.

Stakeholder Surveys: Stakeholder surveys can be used to assess the level of satisfaction among stakeholders, such as landowners, surveyors, and land administrators, with the cadastral system. Surveys can also be used to identify areas for improvement and inform the development of new cadastral system policies and procedures.

Peer Review: Peer review involves the evaluation of cadastral systems by independent experts, such as academics or professionals from other countries. Peer review can provide valuable feedback and recommendations for improving the accuracy and completeness of cadastral information.

User Testing: User testing involves the evaluation of cadastral system interfaces and services by end-users, such as landowners and real estate professionals. User testing can help to identify usability issues and inform the development of more user-friendly interfaces and services.

Overall, these methods can help to ensure that cadastral information is accurate, complete, and accessible, and can identify areas for improvement in cadastral systems. By employing these methods, governments and other stakeholders can promote more effective and sustainable land management practices, and support equitable and prosperous societies (FAO, 2014).

2.14 Empirical literature review

Assessing the effectiveness of cadastral systems is an important task, as it helps to identify areas where improvements can be made to support better land management and sustainable development. Here is a literature review on the assessment of cadastral systems:

"Assessing the Performance of Cadastral Systems: A Review of the Literature" by T. Williamson, K. S. Abdalla, and S. Enemark (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 S. Budiani and A. 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 A. K. Anokye and E. 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 and guidelines, and the introduction of modern ICT.

"Assessment of the Malaysian Cadastral System" by R. Abdul-Rahman and C. A. Rajabifard (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 and guidelines, 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.

"Evaluation of Cadastral Systems in Developing Countries: An Analytical Framework for Assessing Performance" by S. Enemark, K. S. Abdalla, and P. McLaren (2013)

This study presents an analytical framework for assessing the performance of cadastral systems in developing countries, based on the principles of good governance, efficient administration, and sustainable development. The authors apply the framework to case studies in Africa and Asia, and identify several areas where improvements can be made to support better land management and sustainable development.

"Assessing the Quality of Cadastral Systems: A Case Study of Uganda" by M. S. Lwanga and R. 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 M. O. Adesanya, O. O. Fagbenle, and O. A. Akinwumi (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 and guidelines, and the introduction of modern ICT.

"Measuring the Quality of Cadastral Systems: A Case Study of Pakistan" by S. A. Memon and R. 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 R. Rajabifard, J. Wallace, and I. Williamson (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 M. M. Hossain and R. 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.

"Evaluation of the Cadastral System in the United States: An Analysis of Challenges and Opportunities" by K. S. Abdalla and S. 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 T. A. van der Molen and P. A. M. van Oosterom (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.

These studies show that Cadastral systems are important for managing land ownership and land use. Assessing cadastral systems is important to ensure their accuracy, completeness, and efficiency. By assessing cadastral systems, we can identify areas for improvement and implement changes to make the system more effective.

Assessment of cadastral systems can include various aspects such as legal and institutional frameworks, operational procedures, technical infrastructure, and human resource capacity.

For example, assessing the legal and institutional frameworks involves reviewing the laws and regulations that govern the cadastral system and identifying any gaps or inconsistencies that may hinder its effectiveness. Assessing the technical infrastructure involves evaluating the hardware and software used in the cadastral system and determining if they are up-to-date and adequate for the system's needs.

The benefits of assessing cadastral systems are numerous. For example, it can lead to greater efficiency in land administration processes, reduce errors and disputes, increase transparency and accountability, and improve access to land information. By making improvements to cadastral systems, we can also support economic development, land management, and social welfare.

In summary, the assessment of cadastral systems is crucial for identifying areas for improvement and implementing changes to make them more effective. By doing so, we can ensure that land ownership and land use are managed in a transparent, fair, and efficient manner.

Assessing the effectiveness of cadastral systems is a crucial undertaking, as it aids in identifying areas that require improvement to enhance land management and promote sustainable development. A literature review on the assessment of cadastral systems reveals valuable insights:

Williamson, Abdalla, and Enemark (2017) provide an overview of key performance indicators used to assess cadastral system effectiveness, including accuracy, completeness, timeliness, accessibility, and cost-effectiveness. They emphasize the significance of stakeholder involvement in the assessment process and offer guidance on developing a comprehensive assessment framework.

Budiani and Purwanto (2019) evaluate the quality and performance of Indonesia's cadastral system using indicators such as accuracy, completeness, and consistency. The study identifies the need for improved stakeholder coordination, standardized procedures and guidelines, and the integration of modern information and communication technology (ICT).

Anokye and Owusu-Bennoah (2019) assess the effectiveness of Ghana's cadastral system, employing indicators such as accuracy, completeness, timeliness, and accessibility. The

authors highlight the importance of enhanced stakeholder coordination, standardized procedures and guidelines, and the integration of modern ICT.

Abdul-Rahman and Rajabifard (2013) evaluate the effectiveness of Malaysia's cadastral system, focusing on indicators such as accuracy, completeness, timeliness, and accessibility. The study identifies the need for improved stakeholder coordination, standardized procedures and guidelines, and the integration of modern ICT.

These studies emphasize the importance of assessing cadastral system effectiveness and offer guidance on developing comprehensive assessment frameworks. They identify common areas for improvement, including enhanced stakeholder coordination, standardized procedures and guidelines, and the integration of modern ICT. Ongoing evaluation and improvement are crucial to support better land management and sustainable development (Enemark et al., 2013; Lwanga and Abdul-Rahman, 2019; Adesanya et al., 2016; Memon and Abdul-Rahman, 2018).

2.15 Key Insights from the Literature Review

Through an extensive review of the literature, several valuable lessons have emerged regarding the modernization of cadastral systems to smart cadastre and electronic cadastre. These insights provide important guidance for practitioners, policymakers, and researchers in the field.

Evaluation of Existing Systems: The first step towards modernization is a comprehensive evaluation of the current cadastral system against internationally accepted standards. This evaluation helps identify gaps, strengths, weaknesses, and opportunities for improvement.

Importance of International Standards: Benchmarking against international standards and best practices is critical for ensuring the effectiveness and compatibility of modernized cadastral systems. Adherence to these standards promotes interoperability, data accuracy, and transparency.

Building on Existing Strengths: Recognizing the strengths of the current cadastral system, such as legal frameworks and institutional structures, provides a solid foundation for integrating new technologies and methodologies. Building upon these strengths can streamline the modernization process.

Addressing Weaknesses: Identifying and addressing weaknesses within the existing system is crucial for successful modernization. Outdated technologies, inefficient processes, and inadequate data management practices must be remedied to enhance efficiency and accuracy.

Exploring Innovative Technologies: The literature review highlights the potential of advanced technologies, such as smart cadastre and electronic cadastre. Integrating these technologies can significantly improve data accessibility, decision support, and overall efficiency of land administration processes.

Stakeholder Engagement and Collaboration: Involving relevant stakeholders, including land administrators, policymakers, and citizens, is vital for successful modernization. Collaboration and engagement foster a shared understanding of goals, promote buy-in, and ensure the development of inclusive and user-friendly systems.

Continuous Training and Capacity Building: Adequate training and capacity building initiatives are essential for smooth adoption and utilization of modernized cadastral systems. Ensuring that personnel have the necessary skills and knowledge helps maximize the benefits of the new technologies.

The literature review provides valuable lessons for modernizing cadastral systems into smart cadastre and electronic cadastre. By evaluating existing systems, adhering to international standards, building on strengths, addressing weaknesses, exploring innovative technologies, fostering stakeholder engagement, and investing in training, the process of modernization can be effectively navigated, leading to improved land administration and management practices.

Based on the literature review, it is evident that in order to transition from traditional cadastral systems to smart cadastre and electronic cadastre, it is crucial to evaluate the existing systems against internationally accepted standards. This evaluation enables the identification of gaps, strengths, weaknesses, and opportunities within the current system, thus paving the way for finding appropriate solutions and effectively modernizing the cadastral system.

To elaborate on this identified gap, it is essential to conduct a comprehensive assessment of the city's existing cadastral system. This evaluation should consider factors such as data

accuracy, accessibility, interoperability, efficiency, and transparency. By benchmarking against international standards and best practices, the gaps and shortcomings within the system can be identified.

The strengths of the existing cadastral system, such as established legal frameworks, institutional structures, and available data resources, should also be recognized during the evaluation. These strengths can serve as a foundation for building upon and integrating new technologies and methodologies.

Simultaneously, weaknesses and challenges within the current system need to be identified. These may include outdated technologies, inadequate data management practices, limited stakeholder engagement, or inefficient processes. Understanding these weaknesses is crucial for developing targeted improvement strategies.

Furthermore, evaluating the existing cadastral system against international standards provides an opportunity to identify areas for enhancement and innovation. It helps in recognizing potential areas where new technologies, such as smart cadastre and electronic cadastre, can be integrated to improve efficiency, accuracy, and accessibility.

Finding solutions and modernizing the cadastral system involves implementing appropriate strategies to address the identified gaps and weaknesses. This may include adopting advanced technologies, updating legal and policy frameworks, improving data management practices, enhancing stakeholder collaboration, and providing training and capacity building for relevant personnel.

In summary, the literature review emphasizes the importance of evaluating the existing cadastral system against international standards as a prerequisite for modernizing it into a smart cadastre and electronic cadastre. This evaluation helps in identifying gaps, strengths, weaknesses, and opportunities, leading to effective solutions and a successful transition to a more advanced and efficient cadastral system.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Description of the Study Area

Adama City is extending between geographic coordinates of 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.

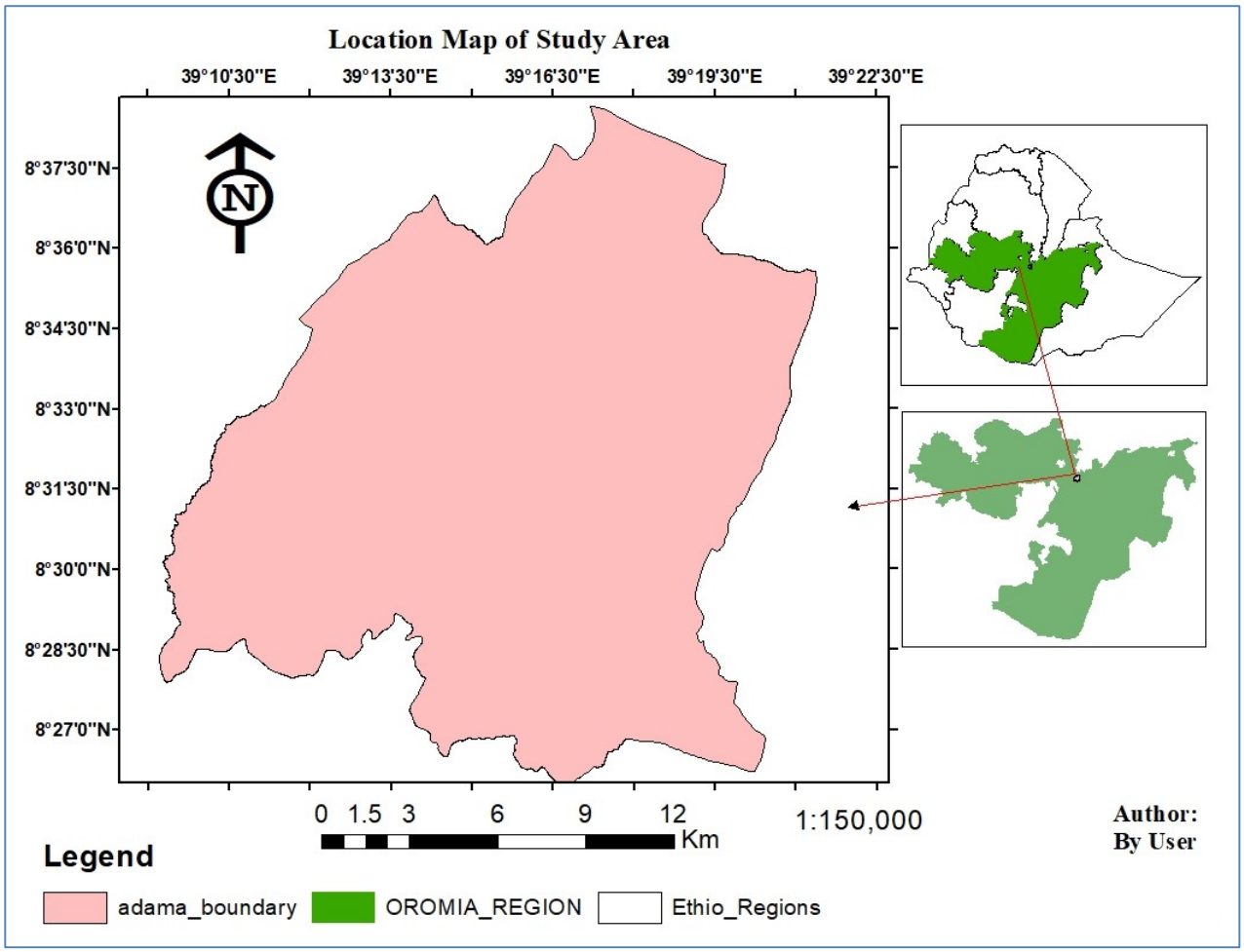

Figure 3.1. Location map Adama city

3.2 Data Source

The studies will mainly be supported by geospatial datasets gathered from different sources.

Table3.1: Data and their sources

No	Data	source	purpose
1	Orthophoto	Adama Land administration office	To digitize the parcel
2	Policy and Operational Douments	Adama Land administration office	For evaluation
3	Parcel Data	Adama Land administration office	To prepare cadastre information in geodata base.

3.3 Required Software

In this research different software are used for storing, preparing, mapping and visualizing cadastre information's.

Table 3.2 Required software

No.	software	Purpose
1	ArcGIS 10.8	For Preparing cadastral map
2	Google Earth pro	For verification of GCP and cadastral plot, using as a Base Map
3	QGIS Plugins	-For mapping and visualizing cadastre information -To prepare web mapping application
4	Post gresql/Microsoft Access	To store the parcel information

3.4 Description of Methodology

It can be described that; research methodology is how research works are to be done systematically. It gives the research work plan how the identified research problems are to be carried out and solved scientifically and practically.

The research methodology employed in this study involved a combination of methods and methodological procedures to fulfill its objectives. One of the primary methods utilized was a comprehensive literature review. This involved an extensive examination of existing scholarly articles, books, reports, and relevant literature sources. The literature review was conducted to gather a deep understanding of the current best practices, techniques, and methodologies employed in cadastral assessment and the preparation of cadastral systems.

The purpose of the literature review was to establish a solid foundation for the development of the research framework and methodology. By reviewing and synthesizing existing knowledge and research findings, the study aimed to identify the most effective and widely accepted approaches in the field of cadastral information systems. This enabled the researcher to gain insights into the essential components, functionalities, and standards that should be considered in evaluating the existing cadastral information system and identifying gaps.

The literature review also served as a means to identify any existing research gaps or areas that have not been adequately addressed in previous studies. By identifying these gaps, the study aimed to contribute to the existing body of knowledge by filling in these research and providing valuable insights into the cadastral information system of the city. Additionally, the literature review assisted in identifying the appropriate research frameworks, methodologies, and data collection techniques that would be employed in the study. It provided a theoretical and conceptual framework that guided the research design and ensured that the study was aligned with established principles and accepted standards in the field.

Overall, the literature review was a crucial initial step in the research methodology, as it provided a comprehensive understanding of the current state of knowledge and informed the subsequent stages of the study, including the development of research questions, data collection methods, and data analysis techniques. It laid the groundwork for the successful execution of the research objectives and ensured the study's validity, reliability, and relevance.

The second step involved data collection, while the third step involved selecting evaluation criteria. The data collection process aimed to gather relevant information about the existing cadastral system in Adama city. Various types of data were collected to gain a comprehensive understanding of the system. These included policy documents and guidelines related to land administration and cadastral systems in the city. These documents provided insights into the legal and regulatory framework governing the cadastral system and the guidelines followed for its implementation. In addition to policy documents, geospatial data sources were also utilized in the data collection process. This included orthophoto, which are high-resolution aerial images that provide detailed information about the land surface.

The third step in the research method involved selecting evaluation criteria. To establish appropriate evaluation criteria, the study relied on a combination of literature review and best practices from other countries. By reviewing existing literature and examining successful cadastral systems implemented in other regions, the study identified key factors and indicators that should be considered when evaluating the existing cadastral system in Adama city.

These evaluation criteria encompassed various aspects, including data accuracy, completeness, consistency, interoperability, and usability. By selecting evaluation criteria based on established literature and best practices, the study aimed to ensure a comprehensive and objective assessment of the cadastral system's performance in Adama city.

The research methodology employed in this study includes a fourth method, which is the evaluation of the existing cadastral system. This method involves a comprehensive assessment of various aspects of the system. The evaluation process aims to identify any gaps or deficiencies in the existing cadastral system. Furthermore, the evaluation considers the infrastructure supporting the cadastral system. This includes the physical infrastructure, such as the availability and condition of surveying markers, boundary monuments, and reference points. It also encompasses the technological infrastructure, such as the availability and adequacy of computer systems, software applications, and data storage facilities.

Another important aspect of the evaluation is an assessment of the human resources involved in the cadastral system. This includes evaluating the qualifications, skills, and training of the personnel responsible for conducting surveys, managing data, and

administering the cadastral system. The evaluation seeks to determine whether the human resources are adequately trained and equipped to perform their duties effectively. In addition, the evaluation examines the data handling methods employed within the cadastral system. This involves assessing the processes and procedures for data collection, data entry, data storage, and data sharing. The evaluation seeks to identify any inefficiencies, discrepancies, or gaps in the data handling methods that may impact the accuracy, completeness, or consistency of the cadastral information. By conducting a comprehensive evaluation of the existing cadastral system, the study aims to identify any shortcomings or areas for improvement. The findings from this evaluation will inform recommendations for enhancing the system's performance, addressing any identified gaps, and improving the efficiency and effectiveness of land administration and management processes.

Overall, the evaluation of the existing cadastral system is a crucial research method that provides valuable insights into the strengths and weaknesses of the system. It helps to identify areas for improvement and informs decision-making processes aimed at enhancing the overall performance and functionality of the cadastral system.

The research methodology employed in this study includes a fifth method, which is the gap analysis and requirement analysis. This method is used to identify the gaps in the existing cadastral system and determine the requirements of experts and decision-makers. The analysis is conducted through a combination of SWOT analysis and collecting input from relevant stakeholders. The gap analysis involves evaluating the existing cadastral system and comparing it against desired or expected standards. This assessment helps to identify any shortcomings, deficiencies, or gaps that exist in the system. Through the SWOT (Strengths, Weaknesses, Opportunities, and Threats) analysis, the study examines the strengths and weaknesses of the current system, as well as the potential opportunities and threats it faces.

By conducting a SWOT analysis, the research aims to gain a comprehensive understanding of the current state of the cadastral system, including its strengths that can be leveraged, weaknesses that need to be addressed, and opportunities for improvement, and potential threats that may hinder its effectiveness.

In addition to the SWOT analysis, the study collects requirements from experts and decision-makers involved in the cadastral system. This involves conducting interviews, surveys, or focus group discussions to gather input and insights from relevant stakeholders.

These requirements represent the needs, expectations, and desired improvements identified by those who have a direct stake in the system's performance and outcomes. By collecting requirements from experts and decision-makers, the study ensures that the design and development of the spatial database and system are aligned with the practical needs and expectations of the stakeholders. This helps to bridge the identified gaps and address the deficiencies identified in the existing system.

The findings from the gap analysis and requirement analysis provide the basis for the subsequent stages of the research, specifically the design and development of the spatial database and system. The identified gaps and requirements guide the decision-making processes and inform the design choices, functionalities, and features of the proposed system.

Overall, the gap analysis and requirement analysis method is essential in identifying the gaps in the existing cadastral system and collecting the necessary input from experts and decision-makers. This ensures that the design and development of the spatial database and system are tailored to address the identified gaps and meet the specific requirements of the stakeholders involved.

The research methodology employed in this study includes a sixth method, which is the design of the cadastre system. This method involves the design and implementation of a spatial database and system using open-source software and plug-ins. The design process includes the development of a conceptual and logical design, identification of entities and attributes, and the definition of tables and fields. The physical design phase involves the development of physical data structures and the implementation of the design using a chosen database management system (DBMS). The design was tested using ArcGIS geodatabase and PostgreSQL/PostGIS open-source spatial database tools, and performance testing was conducted.

The design of the cadastre system begins with the development of a conceptual design, which involves defining the high-level requirements and objectives of the system. This includes identifying the key entities, attributes, and relationships that need to be captured and managed within the spatial database. The conceptual design provides a blueprint for the overall structure and functionality of the system. Next, a logical design is created, which involves translating the conceptual design into a more detailed representation. This includes defining the specific tables and fields that will be used to store the cadastral data. The logical

design ensures that the system is capable of capturing and managing the necessary information effectively.

The physical design phase focuses on implementing the logical design using a chosen DBMS. In this case, open-source software and plug-ins such as ArcGIS geodatabase and PostgreSQL/PostGIS are utilized. The physical design involves developing the necessary data structures, such as tables, indexes, and views, and configuring the DBMS to optimize performance and data integrity.

Once the cadastre system design is implemented, performance testing is conducted to evaluate its efficiency and effectiveness. This involves assessing the system's response time, data processing capabilities, and scalability. The performance testing helps to ensure that the system performs optimally and meets the requirements of the users.

By employing open-source software and plug-ins, the design of the cadastre system leverages cost-effective and widely accessible tools. Open-source solutions offer flexibility, customization options, and a vibrant community of developers and users for support and collaboration.

In summary, the cadastre system design method involves the development of a conceptual, logical, and physical design for the spatial database and system. It utilizes open-source software and plug-ins for implementation and testing. This methodology ensures a robust and efficient design that aligns with the specific requirements of the research and provides a solid foundation for the subsequent stages of the study.

The research methodology employed in this study includes a seventh method, which involves developing a web cadastre using open-source software and conducting testing and validation of the system. This method focuses on assessing the accuracy, consistency, flexibility, and usability of the cadastre database and system, ensuring that it can effectively support various land administration and management processes.

The development of the web cadastre involves utilizing open-source software tools and technologies to create a user-friendly and accessible system that can be accessed through web browsers. Open-source software offers flexibility, customization options, and cost-effectiveness, making it a suitable choice for developing the web-based cadastre.

During the development process, attention is given to ensuring the accuracy of the system. This involves verifying that the cadastral data stored in the database is reliable, up-to-date, and aligned with the real-world land parcels. Measures are taken to ensure that survey

measurements are accurately captured and recorded in the system, and that any discrepancies or errors are identified and resolved.

Consistency is another important aspect of the system that is evaluated during the testing and validation phase. This includes checking for consistency in the data, such as ensuring that boundaries of adjacent land parcels do not overlap or have gaps. The system is also assessed for consistency in terms of data entry, data storage, and data retrieval processes.

Flexibility is another criterion considered in the testing and validation process. The system should be able to accommodate different uses and adapt to evolving requirements. This includes evaluating whether the system can handle updates, modifications, and additions to the cadastral data, as well as supporting various functionalities and user requirements.

Usability is a critical factor in ensuring the effectiveness of the cadastre database and system. The system is assessed to ensure that it is user-friendly, intuitive, and easily navigable. User testing may be conducted to gather feedback and insights from potential users, helping to identify any usability issues and make necessary improvements.

Overall, the testing and validation of the web cadastre system aim to ensure that the database and system function adequately and meet the requirements of land administration and management processes. By assessing accuracy, consistency, flexibility, and usability, the study ensures that the developed system is reliable, efficient, and capable of supporting various uses and requirements.

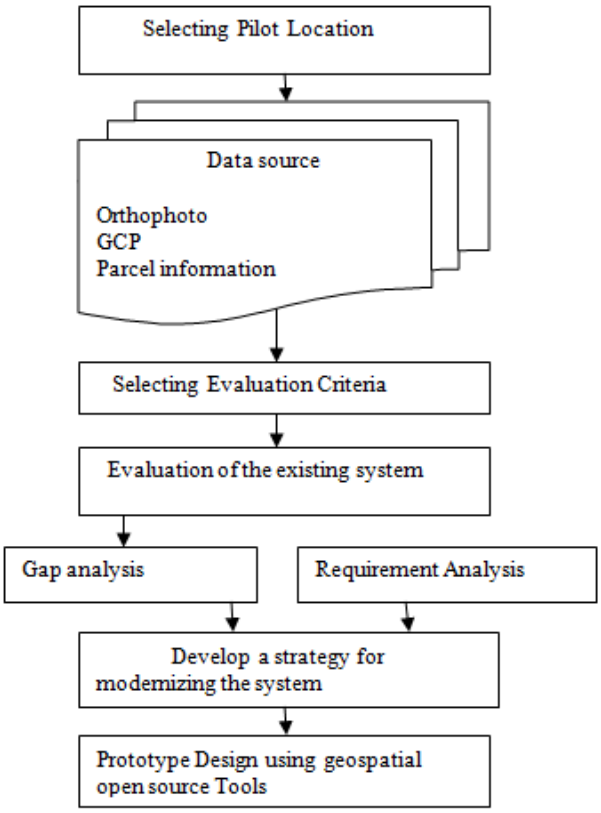

Figure 3.2: Flow Chart of Methodology

CHAPTER FOUR

RESULTS AND DISCUSSIONS

In this chapter, the research evaluation results are presented, which are categorized into three main areas: the evaluation of the cadastral system, testing of geospatial technologies, and design of a new cadastral model. The evaluation is summarized in a table, which includes international indicators, good practices, the situation of the Adama city cadastre, and performance gaps. The data from the table is used to develop a SWOT matrix to evaluate cadastral systems based on internationally recognized benchmarks and good practices. The research aims to evaluate the Adama City cadastral system using methods that have been successful in developed countries. The evaluation is conducted in four stages, with each stage focusing on different aspects of the cadastral system, including management level, operational level, external factors, and review process. The evaluation methodology employs analytical and qualitative methods to assess cadastral principles, user issues, reliability, security, accuracy, efficiency, transparency, and accessibility. The stakeholders' responsibility is to assess the overall performance of the system.

This chapter presents the findings of the research evaluation, which is divided into three main areas: the evaluation of the cadastral system, testing geospatial technologies, and designing a new cadastral model. A table summarizes the results in terms of international indicators, good practices, the Adama city cadastre's situation, and its performance gap compared to internationally accepted practices. The data from the table is used to develop a SWOT matrix that shows the benchmarks for evaluating a cadastral system, including good international practices, the Adama City cadastre's situation, and performance gaps.

4.1 Introduction

In most developing countries, there is a lack of systematic evaluation of cadastral systems' performance, and the Adama City land cadastre system does not have a regular evaluation framework. This research aims to evaluate the Adama cadastral system using methods that have been successful in developed countries.

The evaluation of the Adama cadastral system is based on four areas: management level, operational level, external factors, and review process. Each area has specific evaluation aspects that must be assessed individually. The research highlights good practices and indicators of a well-functioning cadastral system in developed countries, and employs analytical and qualitative methods. The evaluation methodology is conducted in four stages: analyzing assessment criteria, identifying good practices, identifying performance gaps, and establishing a summary profile using SWOT analysis.

The management level focuses on strategies, institutional and organizational settings, human resources issues, and cadastral principles such as comprehensiveness and completeness. The operational level includes user, product, and service issues, reliability, security, accuracy, efficiency, transparency, and accessibility. External factors may include technology, capacity building, human resources, or professional associations. The review process assesses the system's overall performance.

Table 4.1: International Standards for identifying Performance Gaps of Adama cadastre

International Requirements	Good International Practices	Situation of Adama Cadastre	Performance Gap
Security of Cadastral Records	The system should be secure such that a land market operates effectively and efficiently. Financial institutions should be willing to mortgage land quickly. There should be certainty of ownership and parcel identification. The system should be physically secure with arrangements in place for duplicate storage of records in case of disaster.	The Adama city cadastre is physically secure but lacks a back-up system. In Adama Financial institutions are willing to mortgage land quickly There is some controls to ensure that unauthorized persons cannot damage or change information.	Lack of backup system for emergency recovery. Lack of comprehensive computerization as most land records are held in analogue form

	There should be controls to ensure that unauthorized persons cannot damage or change information.		
Clarity and Simplicity	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. Costs in the system should be minimized, access should be fair, and the system should be well maintained	The Adama cadastre system is complicated by various, bureaucratic system in land registration systems. Complex forms, procedures, and regulations slow the system down	Lack of harmonized and decentralized system. And too much paper work.
Timeliness	The system should provide up-to-date information in a timely manner, and all parcels should be included in the system	Currently majority of parcels are recorded but not all are included in the Adama cadastre.	Lack of computerization, lack of efficient data transfer system,
Accessibility	The system should be able to provide efficient and effective access to all users of land information. This should be within the constraints of cultural sensitivity, legal and privacy issues	Now the cadastral system is decentralized to the sub cities however The system could not provide efficient and effective access to all users of land information.	Lack of computerization and infrastructure to share the information

Cost	The system should be low cost or operated in such a way that costs can be recovered fairly without unduly burdening the users	The cost for the service is relatively low	
Sustainability	There must be mechanisms in place to ensure that the system is maintained all the times. This includes procedures for completing the cadastre in a reasonable time frame and keeping information up- to-date	The Adama cadastral tasks are not finished in time and Lack of quick up-date of the cadastre.	Lack of quick up-date of the cadastre.
Technology	The organization and functions of cadastre nowadays depends on the introduction of modern information and communication technology, and how much the customers are taken into consideration in this process	Introduction of modern ICT is slow and inadequate	Slow adaptation of modern ICT technology, no cadastral modeling
Land Policy Principles	Availability of National Land Policy which takes into account: responsibilities of the various land related activities such as land management, land reform, land registration, land administration, recognition of growing complexity rights, restrictions and responsibilities in relation to land, cost recovery of governments services	National Land Policy is available in land registration and management	
Land Tenure Principles	Formal recognition of appropriate land principles, recognition of indigenous and informal tenures,		

	and appropriate response to circumstances of tenure.		
Spatial Data Infrastructure Principles (SDI)	Recognize the role of SDI in supporting land administration, development of infrastructure or business systems and the role of land parcel layer in the SDI.	Currently Adama City does not have Spatial Data Infrastructure.	Lack of SDI and all the related benefits
Human Resource Development	There should be sustainable long-term capacity of educated and trained personnel to operate the system in both the public and private sectors.	There is no enough experts and capacity building trainings	
Sustainable Development	Land issues and land information play crucial role in the concept of sustainable development, which is the basic aim of global action plans such as Agenda 21. Sustainable Development relies on three main pillars of economic, socil and environmental concepts	The Adama city cadastre is traditional legal cadastre has not embraced sustainable development principles.	Lack of observation of sustainable development principles.
Holistic Approach to Land Issue	Land issues are better dealt with when there is a political agreement for a common responsibility to land or an appointed land board or council that has the overall responsibility for the management of land.		
Inclusion of all rights, Restrictions, and Responsibilities	With increasing pressure on land, there is a trend that public authorities impose more and more restrictions and responsibilities on land, which are being integrated into the cadastre. Land owners and	The cadastral system of Adama city not documents all factors affecting land.	

	other participants need to know about all factors affecting land and its market		
Good Governance and Civic Participation	Good Governance principles require that decision making on land issues require transparence and complete information and informed civil society that participates effectively in land matters.	access to information at the land registry is controlled	Lack of transparency in the content of the land register and heavy state control of land. Citizen participation in ensuring accurate content of Register is lacking
E Government	The development of E-Government is about the use of information and communication technology to facilitate the processes of government and public administration, including land information.	There is no E-Government practice to facilitate the process of land administration and management.	So far there has been no land modeling for the development of multiple purpose cadastre and property register.
Data Integration	The ability to integrate data from different sources is a crucial aspect for cadastral systems. Cadastral systems need to be standardized, complete, comprehensive, trustworthy and regularly up-dated.	The Cadastral system of Adama city is not standardized and is not regularly up dated.	Lack of integration, standardization, and regular up-dating. Lack of comprehensive Land Information Management System
Importance of spatial Data Component	Standardization of spatial data require a good geodetic reference and a good cadastral	Adama city cadastre is currently operated on several disjointed geodetic frames	Lack of harmonized geodetic system and establishment

	model. The Government needs to be spatially enabled	and there is no standard cadastral modeling process	of cadastral models for realization of the multi-purpose cadastre.

4.2 Swot Analysis Result of Adama Cadastre

Strengths:

- Physical security of the cadastre
- Financial institutions are willing to mortgage land quickly
- Controls in place to prevent unauthorized access and changes to information
- Majority of parcels are recorded in the cadastre
- Low cost for services

Weaknesses:

- Lack of backup system for the cadastre
- Complicated bureaucratic system in land registration
- Slow procedures and regulations
- Incomplete recording of parcels in the cadastre
- Inefficient and ineffective access to land information
- Lack of quick updates to the cadastre
- Slow introduction of modern ICT
- Traditional legal cadastre not embracing sustainable development principles
- Not documenting all factors affecting land
- Lack of transparency in the content of the land register
- Heavy state control of land
- Lack of citizen participation in ensuring accurate content of register
- No E-Government practice to facilitate land administration and management

- No land modeling for the development of multiple purpose cadastre and property register
- Lack of integration and standardization
- Disjointed geodetic frames and no standard cadastral modeling process

Opportunities:

- Introduction of backup system for the cadastre
- Simplifying bureaucratic procedures and regulations
- Completing recording of all parcels in the cadastre
- Improving access to land information
- Quick updates to the cadastre
- Introduction of modern ICT
- Embracing sustainable development principles
- Documenting all factors affecting land
- Increasing transparency in the content of the land register
- Reducing state control of land
- Encouraging citizen participation in ensuring accurate content of register
- Introduction of E-Government practice to facilitate land administration and management
- Land modeling for the development of multiple purpose cadastre and property register
- Integration and standardization of cadastre system
- Comprehensive Land Information Management System

Threats:

- Lack of funding for implementing necessary changes
- Political instability leading to changes in land policy
- Lack of political will to implement changes
- Lack of expertise and capacity building trainings
- Disruption of cadastre system due to natural disasters or other events

The SWOT analysis of Adama cadastre system reveals a number of strengths, weaknesses, opportunities, and threats. The strengths include the physical security of the cadastre, willingness of financial institutions to mortgage land quickly, and controls in place to prevent unauthorized access and changes to information. However, the weaknesses include lack of backup system, complicated bureaucratic system in land registration, incomplete recording of parcels in the cadastre, and inefficient and ineffective access to land information.

The opportunities identified include introduction of modern ICT, embracing sustainable development principles, increasing transparency in the content of the land register, and introducing E-Government practice to facilitate land administration and management. The threats include lack of funding for implementing necessary changes, political instability, lack of political will, lack of expertise and capacity building trainings, and disruption of cadastre system due to natural disasters or other events.

To address the weaknesses and threats, Adama city needs to prioritize the implementation of modern ICT, simplify bureaucratic procedures and regulations, complete recording of all parcels in the cadastre, improve access to land information, introduce backup system, and introduce E-Government practice to facilitate land administration and management. It is also important to increase transparency in the content of the land register, embrace sustainable development principles, and encourage citizen participation in ensuring accurate content of register. Adequate funding and political will is necessary for the implementation of necessary changes. Capacity building trainings for experts and standardization of cadastre system is also important for the effective and efficient operation of the cadastre system.

Overall, the Adama City Cadastre faces several weaknesses that need to be addressed to improve the efficiency and effectiveness of the system. The implementation of modern ICT, the development of a comprehensive Land Information Management System, and the introduction of E-Government practice can provide opportunities for improvement. However, the implementation process may face several threats, including lack of financial resources, political instability, and limited data availability.

The SWOT analysis provides valuable insights into the strengths, weaknesses, opportunities, and threats associated with the Adama Cadastre. These findings have several implications for the land administration and management processes. Let's examine them in more detail:

Implications of Strengths:

Physical security of the cadastre: This strength ensures the protection and integrity of the cadastral data. It implies that the system can be relied upon for accurate land information, contributing to increased trust and confidence among stakeholders.

Financial institutions willing to mortgage land quickly: This strength facilitates efficient and timely land transactions, promoting economic activities and investment in the region.

Controls to prevent unauthorized access and changes: This strength safeguards the integrity and reliability of the cadastral information, ensuring that unauthorized modifications or tampering are prevented.

Majority of parcels recorded in the cadastre: This strength indicates a substantial coverage of land parcels, enabling better land management, planning, and decision-making processes.

Low cost for services: This strength implies cost-effectiveness, making land-related services more accessible and affordable for various stakeholders.

Implications of Weaknesses:

Lack of backup system for the cadastre: This weakness highlights the vulnerability of the system. Implementing a backup system is crucial to ensure data security and prevent loss in case of technical failures or disasters.

Complicated bureaucratic system in land registration: This weakness suggests the need for streamlining administrative procedures and simplifying the registration process to enhance efficiency and reduce delays.

Incomplete recording of parcels in the cadastre: This weakness hampers the comprehensiveness of the system. Completing the recording of all parcels is necessary to ensure accurate and up-to-date land information.

Inefficient and ineffective access to land information: This weakness implies limitations in accessing and retrieving land information. Improving information accessibility and usability is essential to facilitate land-related decision-making processes.

Lack of quick updates to the cadastre: This weakness indicates the need for timely updates to reflect changes in land ownership and boundaries, ensuring the system remains current and reliable.

Implications of Opportunities:

Introduction of backup system: This opportunity addresses the weakness of lacking a backup system and enhances data security and system resilience.

Simplifying bureaucratic procedures: Streamlining administrative processes can reduce delays, enhance efficiency, and improve the overall land registration experience.

Completing recording of all parcels: Ensuring the comprehensive coverage of land parcels in the cadastre enhances the system's reliability and usefulness for land management and planning.

Improving access to land information: Enhancing accessibility and usability of land information can empower stakeholders to make informed decisions and contribute to effective land administration.

Introduction of modern ICT: Embracing modern technologies can improve the efficiency, accuracy, and accessibility of the cadastre system, enhancing overall land administration and management processes.

Implications of Threats:

Lack of funding for implementing necessary changes: Insufficient funding could hinder the implementation of improvements and modernization initiatives, affecting the quality and effectiveness of the cadastre system.

Political instability leading to changes in land policy: Political instability can disrupt land policies and regulations, impacting the consistency and continuity of land administration processes.

Lack of political will to implement changes: Without strong political support, necessary reforms and changes may face resistance or delays, impeding the progress of the cadastre system.

Lack of expertise and capacity building trainings: Insufficient expertise and capacity can hinder the effective operation and maintenance of the cadastre system. Investing in training and capacity building is essential to address this challenge.

Disruption of cadastre system due to natural disasters or other events: Natural disasters or unforeseen events can disrupt the cadastre system, resulting in data loss or system

downtime. Establishing contingency plans and disaster recovery strategies is crucial to mitigate such risks.

Understanding these implications is crucial for decision-makers and stakeholders involved in land administration and management. They provide a roadmap for addressing weaknesses, capitalizing on strengths, pursuing opportunities, and mitigating threats, ultimately leading to an improved and more effective cadastre system.

In general, to enhance the cadastral information system in Adama city and promote effective land management and sustainable development, several strategies can be implemented. First, it is crucial to develop a comprehensive cadastral database that centralizes all land parcels and their ownership information. This database should be regularly updated and maintained to ensure its accuracy and reliability.

Second, institutional capacities responsible for cadastral administration need to be strengthened. This can be achieved through training and capacity building programs, equipping them with the necessary resources to carry out their duties effectively.

Third, the legal and regulatory framework for cadastral administration should be reviewed and updated to align with international best practices and standards. This ensures that the system operates efficiently and transparently.

Fourth, adopting modern geospatial technologies such as GPS and GIS can significantly improve the accuracy and reliability of cadastral data. These technologies enable precise mapping and documentation of land parcels.

Fifth, increasing public participation in cadastral administration processes is essential. Providing access to cadastral information and involving the public in decision-making processes fosters transparency and accountability.

Sixth, inter-agency collaboration should be strengthened to facilitate effective data sharing and utilization among different agencies involved in cadastral administration.

Lastly, establishing a monitoring and evaluation system is crucial. This system should be designed to monitor the performance of the cadastral information system using international benchmarks and indicators. Regular assessments will help identify areas for improvement and ensure continuous enhancement of the system.

By implementing these strategies, the quality of the cadastral information system in Adama city can be improved, leading to better land management practices and sustainable development

4.3 Cadastral Surveying Techniques

According to Williamson, Enemark, and Wallace (2010), cadastral surveying plays a critical role in establishing a reliable cadastre system by providing accurate spatial information. It is important to ensure that the spatial information is collected with acceptable accuracy, and that the methodology of cadastral boundary collection is appropriate for the local conditions.

In the case of Adama city cadastre, it is crucial to evaluate the accuracy of the data collection methods used, such as total station and digitalization from orthophotos. Both methods have their limitations, and it is important to ensure that each method meets the required geometrical accuracy standards.

Establishing a cadastre system involves a series of steps, and each step must be carried out with acceptable accuracy to ensure the reliability and accuracy of the final product. This includes not only cadastral surveying, but also data management, information sharing, and stakeholder engagement.

The accuracy and reliability of the spatial information collected during cadastral surveying, and the effective management and sharing of this data throughout the cadastre system, are critical to the success of the system (Williamson, Enemark, & Wallace, 2010).

4.4 Security of Cadastral Records

The security and backup of the Adama city cadastre records are a major concern due to the lack of physical security and backup systems. Although the hardcopy file management system is an improvement from previous methods, it is still susceptible to theft, damage, or loss (Kumar et al., 2019). While storing scanned documents on the system is a good start, it is not sufficient to ensure the long-term security and accessibility of the data.

To address these concerns, it is necessary to implement an efficient spatial database management system that can securely store and efficiently retrieve the data, while also providing a backup mechanism. This system would make it easier to manage and update the data, and to share it with authorized stakeholders (Kumar et al., 2019).

The use of personal laptops for storing and processing cadastre information is also a security concern, as these devices may lack the same security features as a centralized database system. This increases the risk of data loss or theft. Therefore, clear policies and guidelines on the use of electronic devices for storing and processing cadastre information are essential, and all experts and stakeholders should receive training on these policies.

Overall, the lack of physical security and backup systems, as well as the use of personal laptops for storing and processing cadastre information, pose serious challenges to the security of the Adama city cadastre records. Implementing an efficient spatial database management system and establishing clear policies and guidelines on the use of electronic devices can help improve the security and accessibility of the data (Kumar et al., 2019).

4.5 Clarity and Simplicity

The complexity of the Adama City Cadastre system can be a significant barrier to its effectiveness (Alemu & Zeleke, 2021). The bureaucratic processes, lack of harmonization, and excessive paperwork can make it difficult for stakeholders to understand and navigate the system.

To improve the clarity and simplicity of the Adama City Cadastre system, several steps can be taken. First, the system should be simplified by reducing the number of complex forms, procedures, and regulations. This can be done by streamlining the processes and eliminating unnecessary steps. The system should be designed to be user-friendly and easy to understand. Second, the system should be harmonized and decentralized to ensure that stakeholders have access to consistent and accurate information. This can be done by establishing clear guidelines and standards for data collection and management, and by ensuring that all stakeholders have access to the same information.

Third, the system should be digitized to reduce the reliance on paper-based processes. This can be done by implementing a centralized database system and by providing stakeholders with access to the system through a user-friendly interface. This can help to reduce the administrative burden and improve the efficiency of the system.

To ensure adherence to guidelines and standards in the Adama City Cadastre system, several measures can be taken, including establishing clear guidelines and standards, providing training and education, monitoring and audit, enforcement, and continuous improvement (Alemu & Zeleke, 2021).

Overall, improving the clarity and simplicity of the Adama City Cadastre system requires a comprehensive approach that includes simplifying the processes, harmonizing and decentralizing the system, and digitizing the processes. By taking these steps, the system can be made more accessible and user-friendly, which can help to improve its effectiveness and promote transparency and accountability in land management.

4.6 Timeliness and Accessibility

The timeliness and accessibility of the Adama City Cadastre system are critical to its effectiveness (Alemu & Zeleke, 2021). In the past, the centralized system and lack of computerization, trained experts, and efficient data transfer mechanisms have led to delays in including all parcels in the system and providing access to land information.

To improve the timeliness and accessibility of the Adama City Cadastre system, several steps can be taken. First, the system should be decentralized to the sub-cities to facilitate the process and ensure that all parcels are included in the system. This can help to improve the accuracy and completeness of the data and ensure that stakeholders have access to the information they need.

Second, the system should be computerized to reduce the administrative burden and improve the efficiency of the system. This can be done by implementing a centralized database system and providing stakeholders with access to the system through a user-friendly interface. This can help to reduce the time and effort required to access land information, and promotes transparency and accountability in land management.

Third, trained experts should be employed to manage the system and ensure that the data is accurate and up-to-date. This can help to ensure that the system is managed effectively and efficiently, and that stakeholders have confidence in the information provided.

Fourth, an efficient data transfer mechanism should be established to ensure that data is transferred accurately and securely. This can be done by implementing a standardized data transfer protocol and ensuring that the system is compatible with other land management systems.

Overall, improving the timeliness and accessibility of the Adama City Cadastre system requires a comprehensive approach that includes decentralization, computerization, trained experts, and efficient data transfer mechanisms (Alemu & Zeleke, 2021). By taking these

steps, stakeholders can have timely and efficient access to land information, which can help to promote transparency and accountability in land management.

4.7 Technology and Spatial Data Infrastructure

The Adama City Cadastre system is currently lacking in modern information and communication technology, as well as a cadastral modeling and spatial data infrastructure, which can lead to inefficiencies and inaccuracies (Alemu & Zeleke, 2021). The slow adaptation of modern ICT technology and lack of standardization and regular updating can further exacerbate these issues.

To modernize the Adama City Cadastre system and increase its performance, several steps can be taken. First, modern ICT technology, including database management systems, GIS, and web technology, should be incorporated into the system. This can help to improve the accuracy and efficiency of data management and access, and facilitate data sharing among stakeholders.

Second, cadastral data modeling should be done to ensure that all necessary cadastral-related data is stored, managed, and retrieved efficiently in the cadastre system. This can help to improve the completeness and accuracy of the data, and ensure that stakeholders have access to the information they need.

Third, a spatial data infrastructure should be established to provide a framework for the management, sharing, and use of spatial data. This can help to improve the accessibility and interoperability of spatial data, and promote the use of spatial data in decision-making processes.

Fourth, the cadastre system should be standardized and regularly updated to ensure that it is complete, comprehensive, trustworthy, and up-to-date. This can help to improve the accuracy and completeness of the data, and ensure that stakeholders have access to reliable information.

Fifth, a comprehensive Land Information Management System (LIMS) should be established to manage all land-related data and services in an integrated and coordinated manner. This can help to improve the effectiveness and efficiency of land management, and promote transparency and accountability in land governance.

Overall, modernizing the Adama City Cadastre system and establishing a spatial data infrastructure and LIMS requires a comprehensive approach that includes incorporating

modern ICT technology, cadastral data modeling, standardization, regular updating, and establishing a comprehensive land information management system (Alemu & Zeleke, 2021). By taking these steps, the cadastre system can be managed more effectively and efficiently, and stakeholders can have access to reliable land information to support decision-making processes.

4.8 Sustainable Cadastre System and Sustainable Development

The sustainability of the Adama City Cadastre system is crucial for sustainable development in the city (Alemu & Zeleke, 2021). While the progress of the system has improved over the years, there are still challenges related to spatial data collection methods, data management, and land registration processes. Additionally, the traditional legal cadastre in Adama City has not embraced sustainable development principles, which can limit its ability to support sustainable development.

To ensure the sustainability of the Adama City Cadastre system and promote sustainable development, several steps can be taken. First, there is a need to adopt modern spatial data collection methods to ensure that the data collected is accurate, reliable, and up-to-date. This can be done by using advanced surveying technology and aerial imagery to collect spatial data.

Second, data management systems should be modernized to ensure that data is properly stored, managed, and shared among stakeholders. This can be achieved by using modern database management systems, GIS, and web technology to facilitate data sharing and collaboration among stakeholders.

Third, land registration processes should be streamlined to ensure that the cadastre is completed in a reasonable time frame and that information is kept up-to-date. This can be achieved through the use of modern registration processes and the implementation of standard operating procedures.

Fourth, the Adama City Cadastre system should embrace sustainable development principles by integrating land administration and urban planning. This can be done by using the cadastre system as a tool to support sustainable land use planning, environmental protection, and social equity.

Overall, the sustainability of the Adama City Cadastre system is crucial for sustainable development in the city (Alemu & Zeleke, 2021). By adopting modern spatial data

collection methods, modernizing data management systems, streamlining land registration processes, and embracing sustainable development principles, the cadastre system can support sustainable development in Adama City.

4.9 Good Governance, Civic Participation and E-Government

The lack of transparency in the content of the land register and heavy state control of land in Adama City is a cause for concern as it limits citizen participation in land registration processes (Alemu & Zeleke, 2021). Good governance principles require transparency and complete information for effective decision-making on land issues and the participation of an informed civil society in land matters. The development of e-government, through the use of information and communication technology, can facilitate the processes of land administration and promote citizen participation.

To address these challenges, several steps can be taken. First, the Adama City Cadastre system should be modernized to ensure that it is transparent and accessible to the public. This can be achieved by using modern ICT technologies such as GIS and web technology to make the cadastre system available online to the public.

Second, citizen participation in land registration processes should be promoted. This can be done by providing training and capacity building to community members to enable them to participate effectively in land management. Additionally, the government should involve civil society organizations in land management and decision-making processes.

Third, land modeling should be done to enable the development of a multiple-purpose cadastre and property register. This can help to provide comprehensive land information management systems that can be used for land administration and urban planning.

Fourth, the development of e-government should be prioritized to facilitate the processes of land administration. This can be achieved through the use of technology to automate land registration processes and enable citizens to access land information and services online.

Overall, promoting good governance, civic participation, and e-government is crucial for effective land administration and sustainable development in Adama City (Alemu & Zeleke, 2021). By modernizing the Adama City Cadastre system, promoting citizen participation, developing land models, and prioritizing the development of e-government, stakeholders can ensure that land administration processes are transparent, efficient, and effective, and that citizens have equal access to land and resources.

4.10 Prototype of Adama City Cadastral Database Model.

The research presents a prototype of the Adama city cadastral database model, focusing on the conceptual and logical data modeling stages.

Conceptual data modeling involves constructing an information model for an enterprise that is independent of physical considerations. It is based on users' requirements and aims to capture the essential information needed. In this research study, a conceptual design for the cadaster data modeling was developed. The model represents the key information entities and relationships relevant to the cadastral system in Adama city.

Moving to the next stage, logical data modeling involves taking the conceptual design and selecting a specific data model to implement the data structure. It is a higher-level abstraction that is independent of a particular database management system (DBMS) and other physical considerations. The logical design in this research study utilized a specific data model, such as a relational, hierarchical, or network model, to represent the information used in the Adama city cadastral system.

In the logical design of the cadaster modeling, primary keys and foreign keys were identified and utilized. A primary key is a field in a table that uniquely identifies each row or record in a database table. In this model, primary keys such as interest holder's ID, parcel ID, building ID, and legal document ID were used to uniquely identify and distinguish each entity.

Foreign keys, on the other hand, are used to establish relationships between tables. They link two tables together by matching the values of a primary key in one table with a foreign key in another table. This allows for the establishment of meaningful connections and associations between different entities within the database model.

Finally, the physical design of the database specifies the actual configuration and implementation details of the database. It includes aspects such as table structures, file organizations, indexes, security measures, data types, and other relevant parameters. The physical design translates the logical model into a concrete representation that can be implemented using a specific DBMS.

By developing this prototype of the Adama city cadastral database model, the research provides a foundation for further improvements and enhancements in the design, implementation, and utilization of the city's cadastral system.

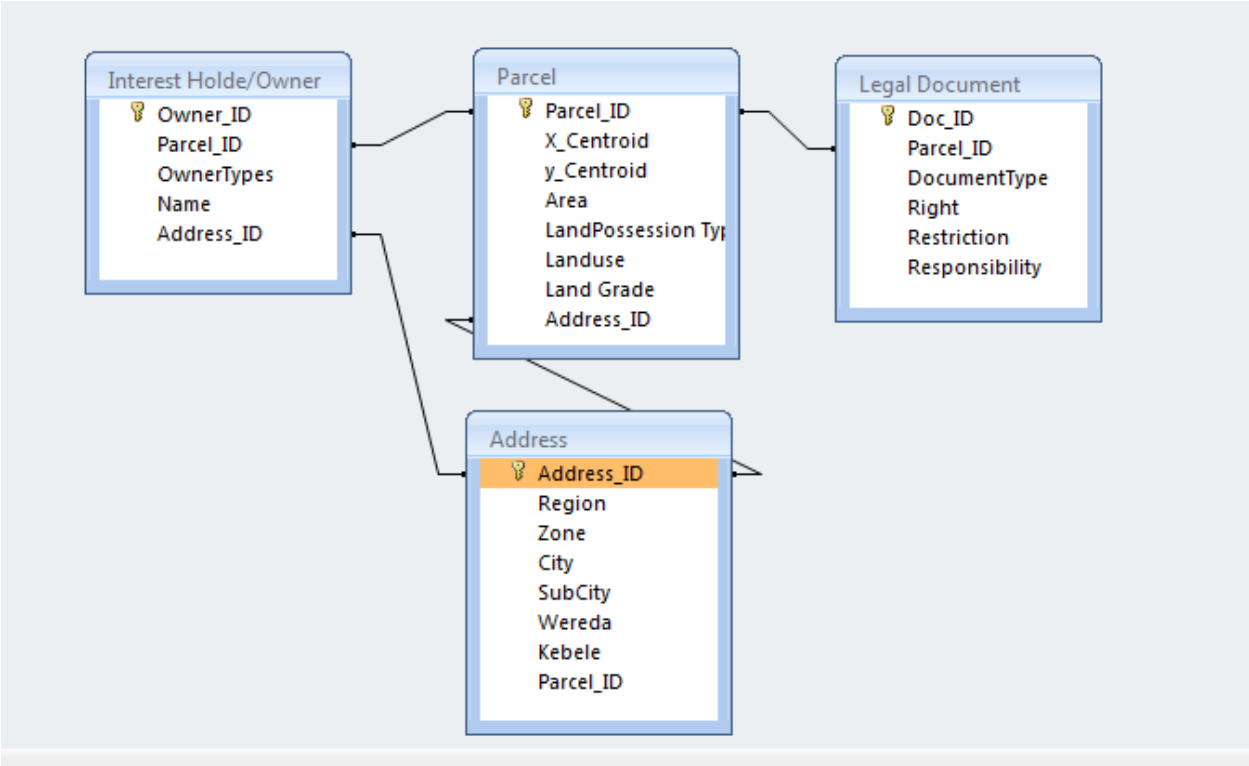

Figure 4.1: Prototype of the Adama city cadastral database model

The provided figure illustrates the logical model of a legal cadastre, showcasing the relationships between the parcel table and other essential components such as the owner, legal document, and address. These relationships are established using primary and foreign key relationships, with the parcel ID serving as the primary key.

The figure highlights the structure of the logical model, which is designed to represent the relationships and associations between different entities within the legal cadastre system. The parcel table, which contains information about individual parcels of land, serves as a central component in this model.

To establish connections with other relevant data, the logical model employs primary and foreign key relationships. The parcel ID, a unique identifier assigned to each parcel, acts as the primary key within the parcel table. This means that it uniquely identifies each entry in the parcel table.

Furthermore, the figure demonstrates how the parcel table is linked to other tables, such as the owner table, legal document table, and address table. These connections are established through foreign keys, which reference the parcel ID in the parcel table. By utilizing foreign keys, the model ensures that the related data in other tables can be associated with the correct parcel.

The logical model of the legal cadastre presented in the figure enables efficient data management and retrieval by establishing clear relationships between different components. It allows for seamless navigation and querying of the database, facilitating tasks such as retrieving ownership information, legal documents, and addresses associated with specific parcels.

In summary, the figure depicts the logical model of a legal cadastre, showcasing how the parcel table is connected to other crucial elements via primary and foreign key relationships. This model provides a structured representation of the relationships between parcels, owners, legal documents, and addresses, enabling effective data management and retrieval within the legal cadastre system.

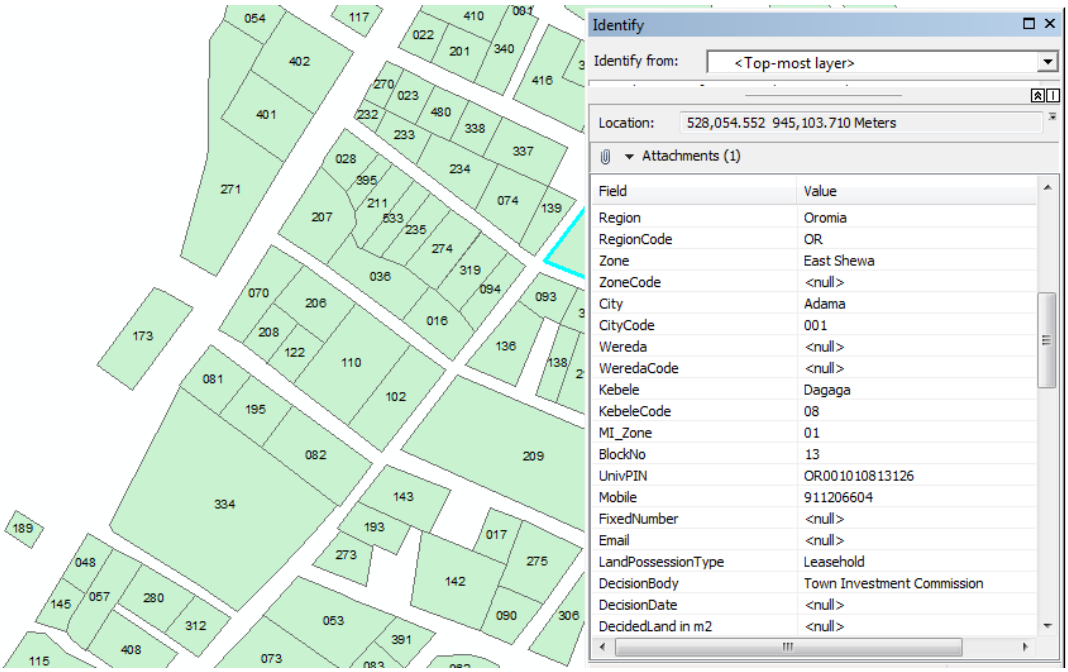

Figure 4.2: Utilization model from ArcGIS software

The depicted figure demonstrates the utilization of the ArcGIS software for implementing the model. By employing the identifier tool, all the recorded information is displayed in the above section.

The figure highlights that the model's implementation was carried out using ArcGIS software, which is a powerful geographic information system (GIS) platform widely used for spatial data analysis and visualization. This indicates that the model's functionality and features were integrated within the ArcGIS environment, allowing users to leverage the software's capabilities for managing and analyzing geographic data.

The identifier tool, a specific functionality provided by ArcGIS, plays a crucial role in the figure. It enables users to interact with the map or dataset and retrieve relevant information about specific features or locations. In this case, the identifier tool was employed to gather and display the recorded information in the section above the figure.

The use of the identifier tool facilitates efficient data exploration and analysis within the ArcGIS software environment. It enables users to easily access and view detailed information associated with specific elements on the map or within the dataset, providing a comprehensive understanding of the recorded data.

4.11 Storing Cadastre Information on Spatial Database Management System.

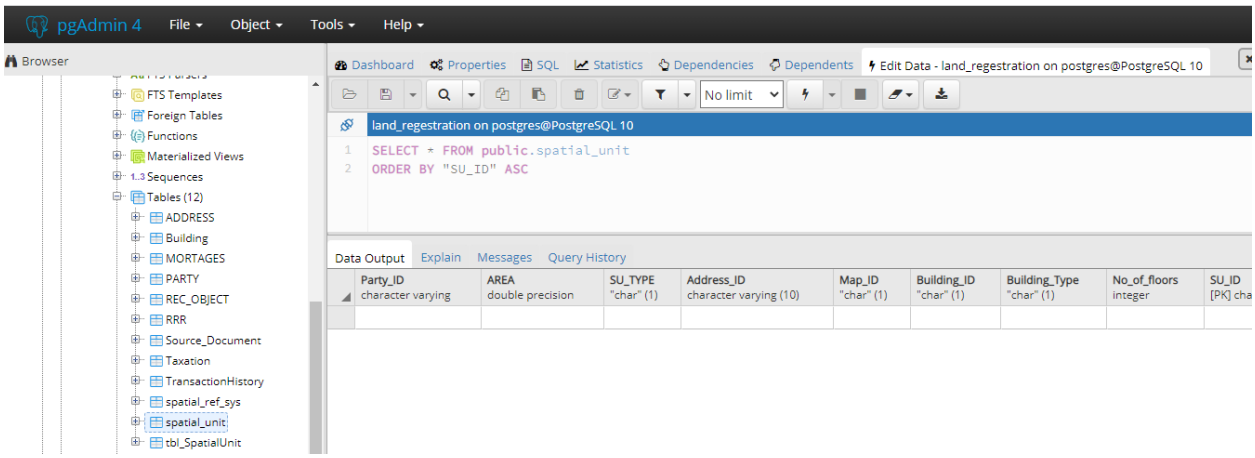

Figure 4.3: The process of uploading cadastral data onto PostgreSQL

The figure above illustrates the process of uploading cadastral data onto PostgreSQL, a robust and widely used relational database management system. In this case, the data is uploaded utilizing the PostGIS extension, which provides enhanced spatial capabilities within the PostgreSQL environment.

The figure emphasizes the significance of utilizing PostgreSQL as the database management system for storing and managing cadastral data. PostgreSQL is known for its reliability, scalability, and strong support for complex data structures. By incorporating the PostGIS extension, which adds spatial functionality to PostgreSQL, the system becomes capable of efficiently handling and analyzing spatial data.

The upload process showcased in the figure involves transferring the cadastral data into a PostgreSQL database with the assistance of the PostGIS extension. This allows for the storage and organization of cadastral information in a structured manner, providing the foundation for subsequent spatial analyses and queries.

By leveraging the capabilities of PostGIS, users can take advantage of advanced spatial features, such as spatial indexing, spatial querying, and geometric operations. This enables them to perform complex spatial analyses on the uploaded cadastral data, such as determining the proximity of parcels, calculating areas, and conducting spatial joins with other datasets.

4.12 Web Cadastre with Opensourse Software

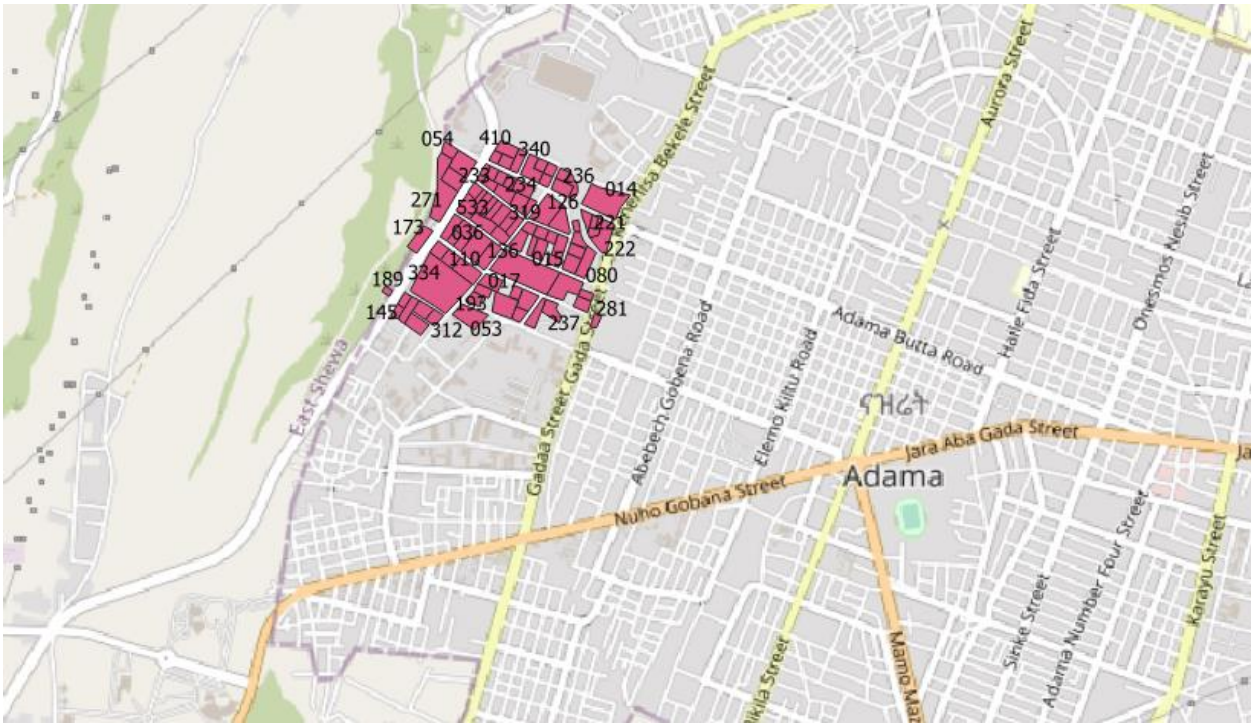

Figure 4.4: Web-based cadastral information system development

The provided illustration depicts the potential and advantages of utilizing open-source software in the development of a web-based cadastral information system. This indicates that there are opportunities for leveraging freely available software solutions to create a comprehensive system for managing land ownership and related data online.

By embracing open-source software, organizations can harness a range of benefits. It enables them to tap into a vast community of developers who contribute to the software's improvement and customization. Moreover, open-source solutions often provide flexibility, allowing users to tailor the system according to their specific requirements and integrate it seamlessly with other technologies.

The figure highlights the relevance of open-source software in the context of web cadastral information systems, which are designed to handle a variety of land-related information such as property boundaries, ownership records, and land-use regulations. By adopting open-source software, developers and organizations can enhance the efficiency, accessibility, and accuracy of these systems, ultimately benefiting both administrators and users.

Overall, the figure emphasizes the potential of open-source software in revolutionizing the preparation and functionality of web-based cadastral information systems, offering a promising avenue for organizations to leverage cost-effective and customizable solutions for managing land-related data.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

This chapter presents the findings and suggestions derived from the research conducted. The conclusions reflect the overall outcomes of the study in relation to its objectives, providing a comprehensive summary of the research findings. On the other hand, the recommendations focus on addressing the identified gaps in the study and offer suggestions for further exploration in the researched areas.

Furthermore, this chapter includes recommendations aimed at enhancing the cadastral systems of Adama city. These suggestions are intended to guide future research endeavors and initiatives that seek to improve the effectiveness and efficiency of the city's cadastral systems.

By presenting these conclusions and recommendations, this chapter provides a valuable synthesis of the research findings, offering insights for both the current study and future research directions in the field of Adama city's cadastral systems.

5.1 Conclusion

The conclusion of this research highlights several key deficiencies within the Adama city cadastre system. Overall, the cadastre system is found to be inefficient in various aspects, including database security, technology utilization, accessibility, adherence to land tenure principles, and integration of data and spatial infrastructure.

Firstly, the research identifies shortcomings in terms of database security. The existing cadastre system lacks robust measures to ensure the confidentiality, integrity, and availability of the data it holds. This poses a significant risk in terms of potential data breaches and unauthorized access, compromising the reliability and trustworthiness of the system.

Secondly, the research reveals technological limitations within the Adama city cadastre system. The system falls short in harnessing the full potential of modern technologies such as Geographic Information Systems (GIS), Global Navigation Satellite Systems (GNSS), and Remote Sensing. This hampers efficient data collection, analysis, and visualization processes, hindering effective decision-making in land administration.

Furthermore, the research uncovers challenges related to accessibility. The cadastre system lacks user-friendly interfaces and mechanisms for stakeholders, including landowners, surveyors, and government officials, to easily access and interact with cadastral information. This hinders the efficient retrieval of data and impedes the smooth functioning of land-related transactions and processes.

Moreover, the research identifies a lack of adherence to essential land tenure principles within the Adama city cadastre system. This includes issues related to clear land ownership documentation, effective dispute resolution mechanisms, and equitable distribution of land rights. The absence of these principles undermines the credibility and effectiveness of the system in ensuring secure and transparent land administration.

Finally, the research highlights the absence of adequate data integration and spatial infrastructure within the cadastre system. The integration of cadastral data with other relevant datasets, such as land use and zoning information, is limited. This hinders comprehensive analysis and planning, hindering the ability to make informed decisions regarding land management and urban development.

In conclusion, the Adama city cadastre system exhibits shortcomings in terms of database security, technology utilization, accessibility, adherence to land tenure principles, and data integration with spatial infrastructure. Addressing these deficiencies is crucial for improving the efficiency and effectiveness of the system, ensuring secure land administration and supporting sustainable urban development in Adama city. To address these challenges, it is recommended that the city adopts open-source technologies such as PostgreSQL and QGIS software as a means to modernize the system.

5.2 Recommendation

Suggested areas for further research in the field of Adama city cadastre include:

3D Cadastre Implementation: Explore the application of 3D cadastre in Adama city, focusing on the integration of vertical dimension in the cadastral system. Investigate the potential benefits, challenges, and technical requirements of implementing 3D cadastre, and propose strategies for its successful adoption.

Evaluation of the Land administration System: Conduct a comprehensive evaluation of the land administrational system in Adama city. Assess its effectiveness, efficiency, accuracy,

and reliability in managing land information and supporting land administration processes. Identify areas for improvement and propose recommendations to enhance the system's performance.

Web-Based Cadastral Information System: Develop a web-based cadastral information system specifically tailored to meet the needs of Adama city. Design and implement a user-friendly interface that allows stakeholders, such as landowners, surveyors, and government officials, to access and interact with cadastral data easily. Evaluate the system's usability, functionality, and security, and gather feedback for continuous improvement.

Integration of Spatial Technologies: Investigate the integration of emerging spatial technologies, such as Geographic Information Systems (GIS), Global Navigation Satellite Systems (GNSS), and Remote Sensing, into the cadastral system of Adama city. Explore how these technologies can improve data collection, analysis, visualization, and decision-making processes in land administration.

Legal and Institutional Framework: Examine the legal and institutional framework supporting the cadastral system in Adama city. Analyze the existing land laws, policies, and regulations, and assess their alignment with international best practices. Identify any gaps or inconsistencies and propose legal and institutional reforms to enhance the effectiveness and efficiency of the cadastral system.

By focusing on these suggested areas for further research, valuable insights can be gained to enhance the cadastral system in Adama city, leading to improved land administration, efficient decision-making, and sustainable urban development.

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