REVOLUTIONIZING LAND GOVERNANCE: RE-ENGINEERING THE CADASTRAL SURVEY EXAMINATION SYSTEM THROUGH DIGITALIZATION - THE CASE OF ZIMBABWE

CHARLENE R ZENGENI, SYDNEY TOGAREPI, TARIRAI MASARIRA, ZIMBABWE

Key words: Digital Cadastral System, Land Governance, Land Management Transparency, Accountability, Sustainable Development Goals, GIS Integration, Institutional Innovation, Sustainable Urban Development

SUMMARY

Efficient examination of cadastral survey records is fundamental to effective land administration, yet in Zimbabwe the process remains largely manual and paper-based, resulting in inefficiencies, delays, and limited integration with modern digital technologies. This paper presents a digital re-engineering framework for the cadastral survey examination system through the development of a web-based prototype, CadastraExamWeb (CEW). The approach integrates user needs assessment, situational analysis, and legislative review to inform system design, ensuring alignment with operational requirements and regulatory constraints. Data collected from Land Surveyors and Department of the Surveyor General (DSG) personnel provided critical insights into existing workflow limitations, user expectations, and opportunities for automation and digital integration.

The proposed system applies an evolutionary prototyping model to support iterative development and refinement, incorporating features such as digital lodgement, workflow automation, real-time tracking, and secure data handling. Validation was conducted through user acceptance testing, peer review, and performance evaluation, ensuring the system's reliability and usability within the cadastral examination context. The results demonstrate that the current system is constrained by bureaucratic processes, high document volumes, and slow approval cycles, while the digital prototype significantly improves efficiency, accuracy, and transparency.

The study concludes that the adoption of a web-based digital examination system can substantially enhance cadastral processes by reducing turnaround times, minimizing errors, and enabling integrated data management. This provides a practical and scalable pathway toward modernizing land administration systems in Zimbabwe and similar developing contexts.

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1. INTRODUCTION

Zimbabwe is currently undergoing a transformation in government service delivery through the adoption of e-governance, which leverages information and communication technologies (ICTs) to improve efficiency, transparency, and public access to services. Cadastral surveying, which underpins land administration, remains largely untouched by digitalization despite its critical role in defining property boundaries, documenting land ownership, and facilitating urban planning and development. Currently, the examination and approval of cadastral survey records relies heavily on paper-based procedures, which are slow, error-prone, and constrained by bureaucratic delays (Kurwakumire & Kuzhazha, 2015).

Land, being one of Zimbabwe's most vital resources, requires a cadastral system that guarantees accuracy, reliability, and efficiency. The Department of Surveyor General (DSG) examines submitted cadastral survey records before their registration in the Deeds Office, ensuring that they meet the statutory requirements outlined in the Land Survey Act [Chapter 20:12] and its regulations. However, poor-quality submissions often trigger delays as records are returned for corrections, creating downstream congestion and administrative inefficiencies (Chimhamhiwa, Mutanga, & van der Molen, 2011).

Manual processing imposes further constraints. Survey record verification is time-consuming, repetitive, and susceptible to human error. The lack of digital integration prevents the use of modern technologies such as Geographic Information Systems (GIS) and automated data analytics, which could otherwise enhance accuracy, reduce processing time, and improve collaboration among stakeholders (Ajayi, 2023). The pressing need to modernize this system aligns with Zimbabwe's broader goal of implementing e-governance initiatives that enhance service delivery across public institutions.

Digitalization offers an opportunity to transform cadastral survey examinations by introducing automation, data validation, real-time tracking, and improved collaboration. This research, therefore, focuses on developing a web-based system to support the lodgement, examination, and approval of survey records. By addressing inefficiencies, inaccuracies, and workflow bottlenecks, the study aims to enhance the overall quality and reliability of Zimbabwe's cadastral system.

1.1 Background of the Study

Cadastral surveying specializes in determining land ownership, delineating property boundaries, and recording legal rights, restrictions, and interests associated with parcels of land. Licensed Land Surveyors, regulated under the Land Surveyors Act [Chapter 20:12], are responsible for preparing accurate survey records that meet statutory requirements. These records facilitate land subdivision, consolidation, and transfer, providing authoritative documentation for land registration and title establishment (Commons et al., 2004).

Zimbabwe's cadastral system has its legal roots in Roman-Dutch Law, a framework it shares with South Africa. Despite similarities in legal frameworks, Zimbabwe's cadastral system has lagged technologically, relying primarily on manual, paper-based processes for storing, submitting, and examining survey records (Kurwakumire, 2014). Conversely, countries such as South Africa, Canada, and New Zealand have implemented electronic cadastral systems, integrating GIS, automated verification, and online lodgement, resulting in higher efficiency and accuracy.

The DSG's examination process involves multiple stages, including initial lodgement, technical checks, quality assessment, and final approval. These steps ensure that cadastral records meet legal and technical standards before registration. Currently, all processes are manual, contributing to inefficiencies, delays, and occasional loss of records (Mapamula, Paradzayi & Kurwakumire, 2016).

E-governance, the use of ICTs to improve government service delivery, offers a pathway to address these inefficiencies. By digitizing the cadastral survey examination system, Zimbabwe can improve operational efficiency, enhance data integrity, and enable real-time monitoring of survey records.

1.2 Problem Statement

The current cadastral survey examination system faces multiple challenges and inefficiencies due to its reliance on paper-based processes (Mapamula, Paradzayi and Kurwakumire, 2016). This hampers efficiency, accuracy, and overall effectiveness. The absence of digital integration prevents the system from utilizing advancements like data analytics and automation. These issues lead to a slow and outdated evaluation of survey records, compounded by institutional bureaucracy and rigid legal frameworks (Jacobs and Chavunduka, 2003).

1.3 Research Aim

This research aims to re-engineer Zimbabwe's cadastral survey examination system by developing a web-based lodgement and examination prototype that enhances efficiency, accuracy, and transparency in the administration of land records.

1.4 Research Objectives

Specifically, this study intends:

1. To conduct a User Needs Assessment to gather relevant information on the design of the system.
2. To identify possible legislative and regulatory changes
3. To develop a prototype web-based Cadastral Survey Examination System
4. To validate the prototype web-based Cadastral Survey Examination System

1.5 Research Questions

In order to achieve the set objectives of this research the following research questions have to be addressed:

1. What is the current state of the Cadastral Survey Examination System?
2. What are the specific data requirements and formats that need to be supported by the digital survey examination system?
3. What legislative and regulatory changes may be necessary to support the implementation of Digital Examination?
4. What are the international best practices that can be considered for improving the efficiency and effectiveness of the examination process?
5. What are the desired features and functionalities that would enhance the efficiency, accuracy, and user experience of the new digital examination system?
6. What are the security measures and protocols that need to be implemented to protect sensitive data and ensure the integrity of the system?
7. What specific strategies and solutions can be implemented to improve the efficiency and effectiveness of the Cadastral Survey Examination Process?
8. What are the recommendations proposed for the developed prototype?

1.6 Motivation and Justification

In an era of rapid technological advancements, digitalization has the potential to transform various sectors of the economy. This research explores how digital technologies can be applied to re-engineer Zimbabwe's Cadastral Survey examination system, addressing the inefficiencies of the current paper-based approach and creating a more accurate and streamlined process.

The existing system relies heavily on manual procedures and paper documentation (Chimhamhiwa, Mutanga, & van der Molen, 2011), which makes it prone to errors and delays. This study proposes innovative digital solutions to optimize workflows, automate operations, and improve data accuracy, aiming to overcome the limitations of the traditional system.

The findings could have significant implications for policy and practice, supporting more efficient land administration in Zimbabwe. By adopting a digital approach, the research seeks to enhance transparency, accessibility, and reliability in land records, ultimately contributing to economic development, social equity, and sustainable land management.

1.7 Expected Outcomes

The expected output of this research is a prototype web-based cadastral survey examination system that:

1. A system that facilitates cadastral survey lodgement and examination processes digitally (DSG Office)
2. A facility for surveyors to track and monitor the status of cadastral surveys online

2. LITERATURE REVIEW

2.1 Review of the Current Cadastral System In Zimbabwe

Cadastral systems, responsible for recording land ownership and boundaries, have played a pivotal role in land management throughout history. While manual systems have served developing countries like Zimbabwe for centuries, the emergence of digital technologies has revolutionized Land Administration in industrialized nations (Kurwakumire, 2007).

Zimbabwe's Cadastral System, established in 1897 with the introduction of triangulation (Wayumba, 2013) has witnessed limited evolution despite its crucial role in the country's economy. The system's reliance on manual processes, including the submission of completed surveys for examination and approval has contributed to lengthy land transaction procedures, hindering economic growth and development (Chimhamhiwa, Mutanga and van der Molen, 2011).

The Cadastre 2014 initiative, a global standard for Land Administration, highlights the importance of a functional cadastral system and a robust cadastral information system for effective land management. However, a comparative study revealed that Zimbabwe has yet to make significant progress toward implementing these best practices (Mapamula, Paradzayi and Kurwakumire, 2016). In an era of rapid technological advancements, the need for digital transformation in Zimbabwe's cadastral system is becoming increasingly apparent. Embracing digital technologies can offer numerous benefits, including enhanced efficiency, increased accuracy, improved accessibility, enhanced decision-making, and economic growth (Williamson, 1997).

The transition to a digital Cadastral System represents a pivotal step towards modernizing the Land Administration in Zimbabwe, aligning global best practices and paving the way for a more efficient, transparent, and sustainable land management system.

3. METHODOLOGY

This study employed a mixed-methods research approach. Surveys and interviews were conducted with thirty-five Land Surveyors and eighteen DSG personnel to assess current challenges and gather user requirements.

The CadastraExamWeb (CEW) prototype was developed using the evolutionary prototyping model. This approach allowed iterative development, incorporating user feedback at multiple stages to refine functionality, interface design, and workflow automation. Prototype validation involved ten Land Surveyors and ten DSG personnel, ensuring balanced feedback representative of end-users. The validation process utilized structured evaluation questionnaires to assess usability, performance, and functionality.

Data analysis included quantitative survey evaluation using descriptive statistics and qualitative feedback analysis to identify patterns, needs, and challenges. These findings informed system design decisions and the development of core CEW functionalities, including digital lodgement, automated verification, real-time status tracking, and secure data management.

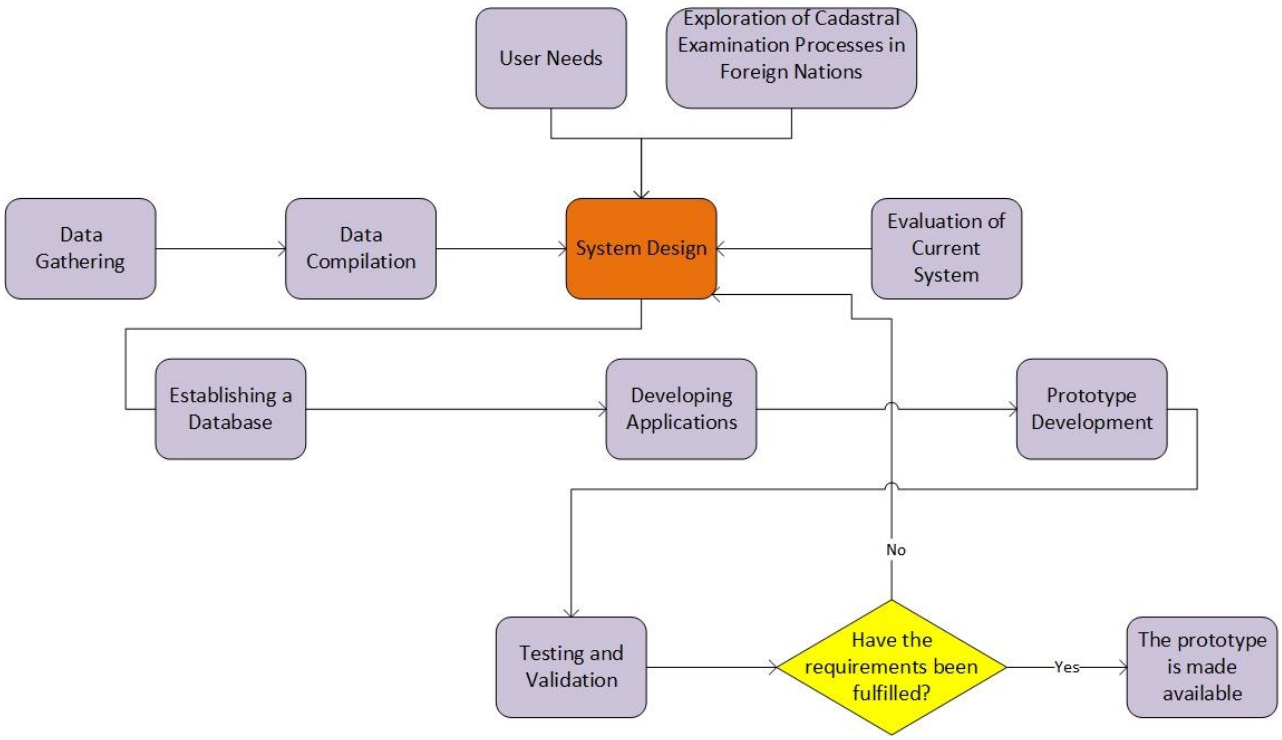


Figure 1: Research Approach Methodology

3.1 Data Collection

The study focused on the DSG personnel and the Professional Land Surveyors throughout Zimbabwe. Primary data was collected from various sources, including legal documents governing cadastral surveying in Zimbabwe and other African countries. Questionnaires were distributed to Land Surveyors across multiple platforms such as the Dare platform, Zimbabwe Institute of Geomatics (ZIG), Survey Institute of Zimbabwe (SIZ), and OpenStreetMap Zimbabwe. These land surveyors possessed expertise in surveying and survey examination processes and were familiar with legal frameworks for Cadastral Surveying in Zimbabwe and other countries. The research utilized online questionnaires for data collection. The questionnaire with both open-ended and close-ended questions

Secondary data was gathered from online articles and reviews exploring the advancement of an electronic cadastre in Zimbabwe. Additionally, the study drew insights from existing studies and literature on testing and validation processes.

3.2 Software Development Model

CadastraExamWeb (CEW) was developed utilizing the evolutionary prototyping model. This approach allowed CEW to serve as a foundation for the continuous development and refinement of improved prototypes. The selection of this model was due to its non-linear nature, contrasting with models like the waterfall model. This characteristic was beneficial to the research as it facilitated the seamless incorporation of requirements, enabling modifications at any stage of application development, and ensuring the delivery of a high-quality product. The prototyping model provided the flexibility to accommodate changes in the design phase, even when the system was operational.

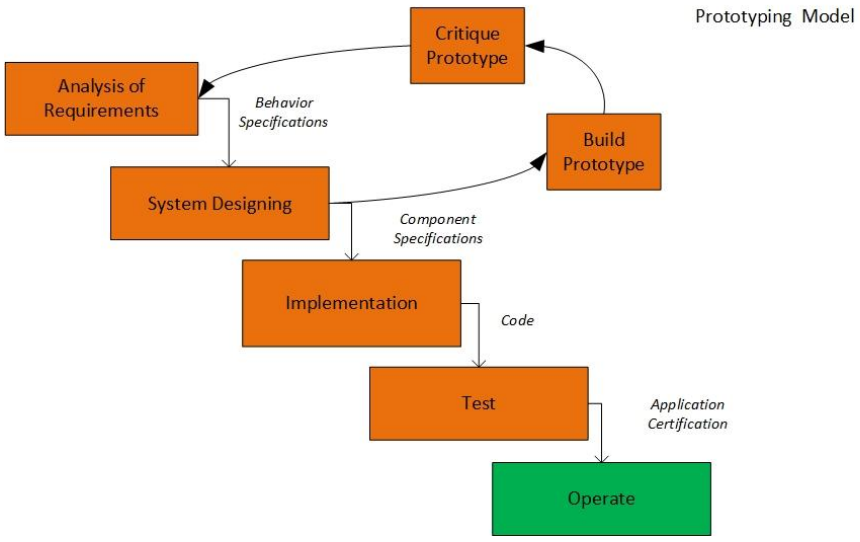
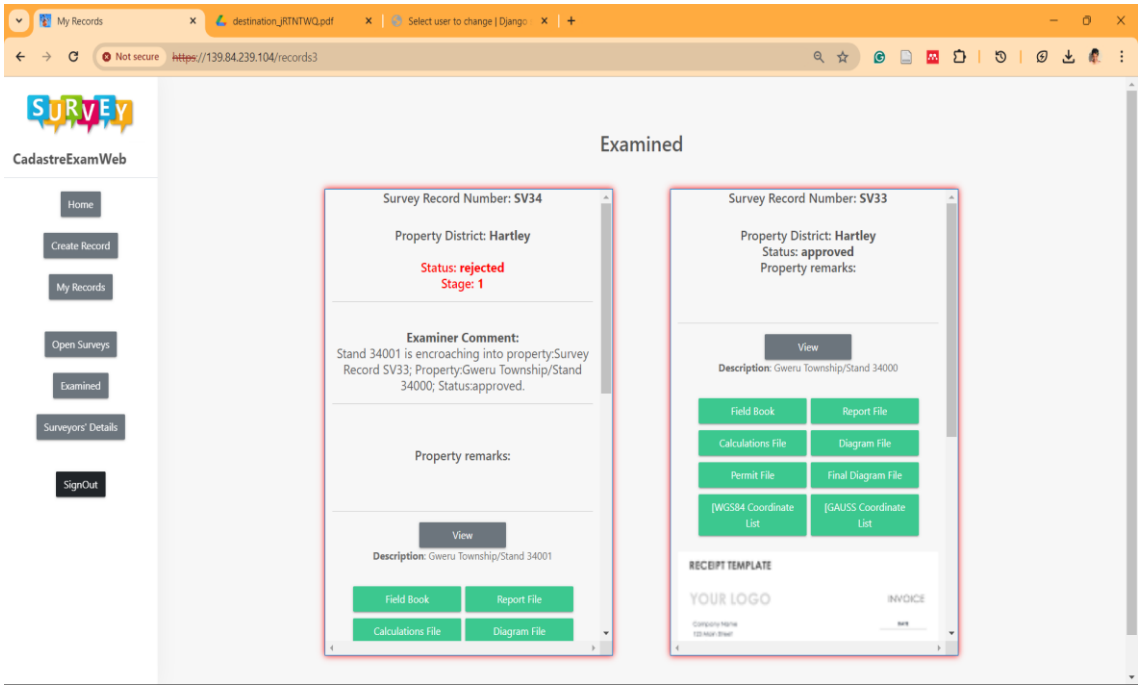


Figure 2: Prototyping Model

4. DATA PRESENTATION, INTERPRETATION AND ANALYSIS

This chapter delves into the analysis and presentation of research findings through textual exposition and tabular representation. It elucidates the findings in alignment with the research questions that underpin the study. Of particular focus is exploring how leveraging digitalization in Zimbabwe can optimize the cadastral survey examination system, thereby augmenting its efficiency and effectiveness. 35 Land Surveyors out of 45 distributed questionnaires and 18/20 DSG personnel responded to the questionnaires and the results are based on these respective samples. The responses, 77.85 for LS and 90% for the DSG personnel are effectively representative for conducting the research. Rea and Parker (2014) suggest that response rates above 70% are considered efficient for surveys, indicating success in engaging the targeted population. Some of the results from the evaluation sheets are also presented in this section.



An online dashboard demonstrated in the CEW Prototype showing communication between the Land Surveyor and the Examiner.

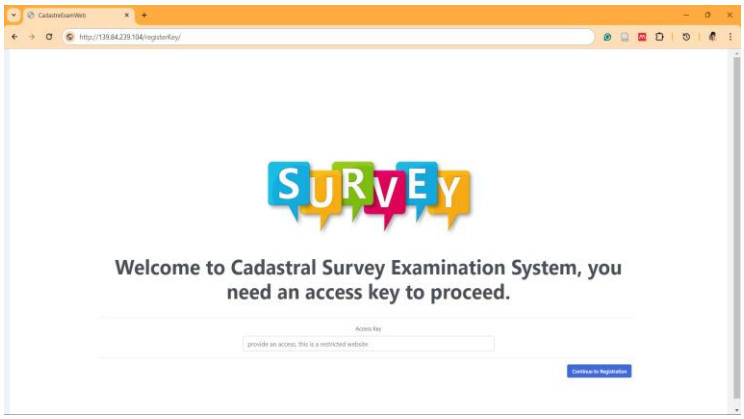
4.1 Key Functions of the Prototype Web-based System for the Examination of Cadastral Survey Records

Table 1 shows the functions of the developed CadastraExamWeb (CEW) Prototype as per the user requirements

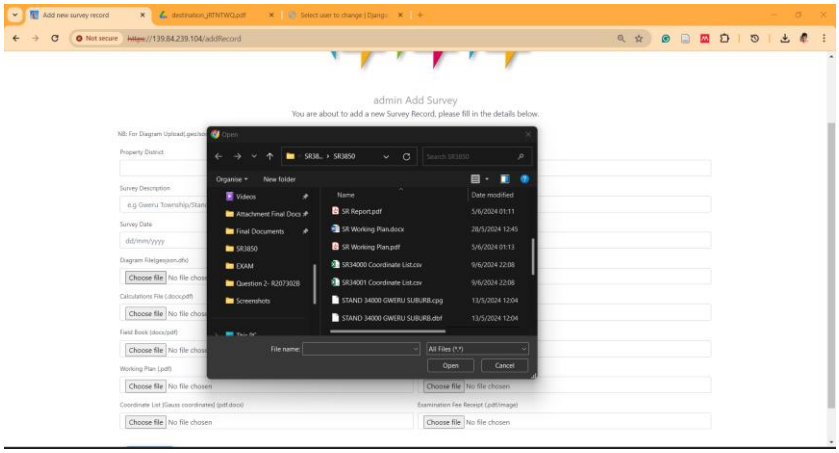
Module	Prototype Features	Details Shown
User Access and Administration	• User Registration; Access key required • User Login • User authentication; email verification code • Definition of user roles (Examiner and Land Surveyor)	• Name • Surname • Registration No. • Company Name • Company Address • Email • Telephone Number • Cell phone Number • Password settings
Reporting and Correspondence	• Dashboard • File Upload and Download capability • Document Preview during lodgement and examination	• Spatial Map • Surveyor Name • Surveyor/ Examiner unique ID • Survey Description • Lodgement Date • Survey District • Survey Status • SR Remarks • Lodged Records • RTS Option
Survey Lodgement	• The system supports different formats such as docx, pdf, geoJSON, csv, jpeg, png • Document format verification • Indexing: Automatic assignment of Survey Record Number and Property Diagram S.G No. • Real-time lodgement date recorded and displayed	
System Examination	**Preliminary Examination** • Online Checklist (Includes Survey Acceptance or Rejection Options) **Drawing Office** • Area check • Distance Calculation • Existing property referenced (SR Number and property details such as area displayed on click)	• Spatial Map • Examiner Name • Examiner unique ID • Survey Description • Lodgement Date • Survey District • Survey Status • SR Remarks • Waiting Records

	• Encroachment Check • Online Checklist (Include Survey Acceptance or Rejection Options) **Technical Examination** • Examining Diagram, working Plan, Coordinate List [Gauss & WGS84], Report, Field book, Calculations, Exam fee receipt • Technical map (Spatial Map) • Coordinates verification (Coordinate list (.csv) file and spatial map beacons) • Validation criteria (such self-property geometry • Online Checklist (Include Survey Acceptance or Rejection Options) **Final Examination** • Digital Signature assigned upon approval • Online Checklist (Include Survey Acceptance or Rejection Options)	• Examined Records • Surveyor Contact Details • RTS Option; Send SR Remarks • Digital Signature assigned • Document Approval
Non Functional Requirements		
Interface	• The Interface is user friendly and easy to use • All text and colours are uniform within the system	

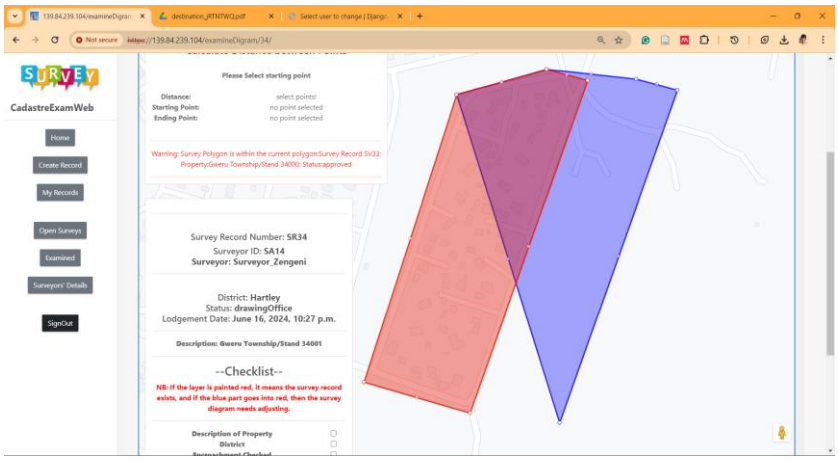
The collected findings underscore the necessity for distinct functionalities, as informed by the aggregated responses and incorporating fundamental security protocols requisite for system integrity. Furthermore, guided by the discovered insights, the system has been compartmentalized into five modular components: (i) User Access and Administration, (ii) Survey Lodgement, (iii) Survey Examination and (iv) Reporting and Correspondence. Both functional and non-functional requirements, with a focus on user interaction, have been delineated from the gathered requisites. The system was being hosted on a live server.



The restricted access to the system

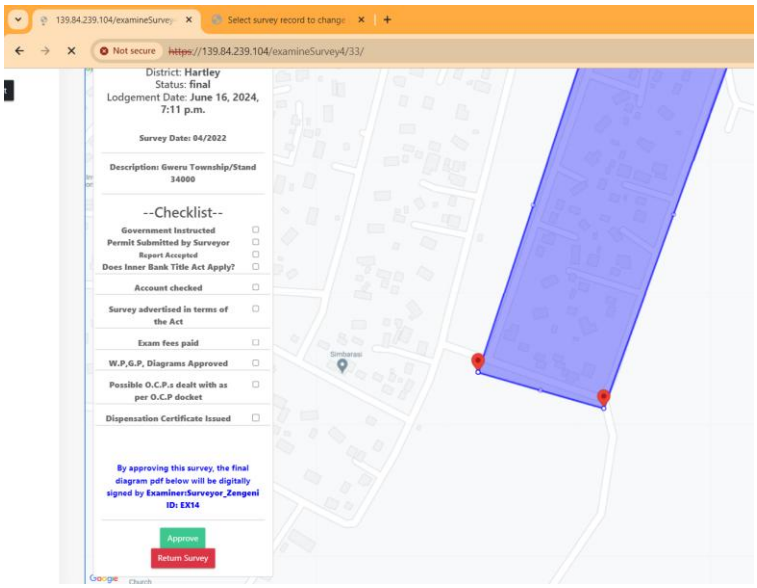


Lodgement of Survey Records by the Land Surveyors

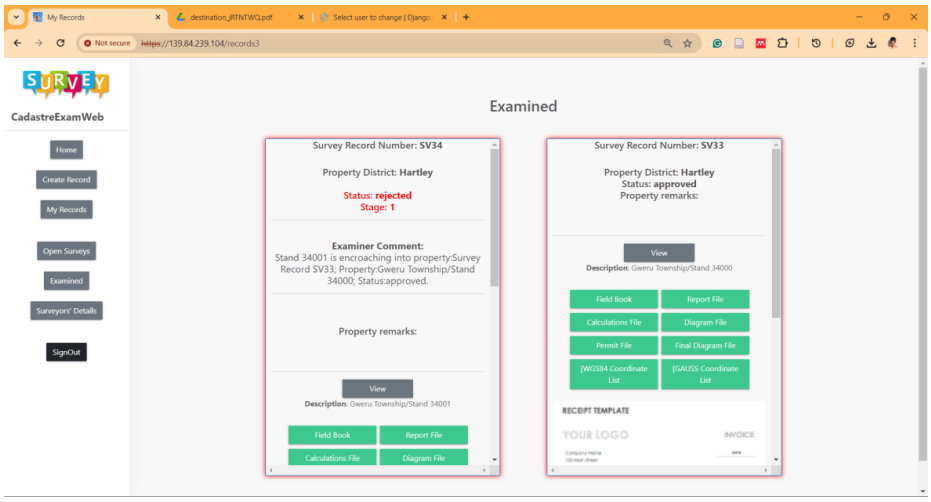


Automatic encroachment detection

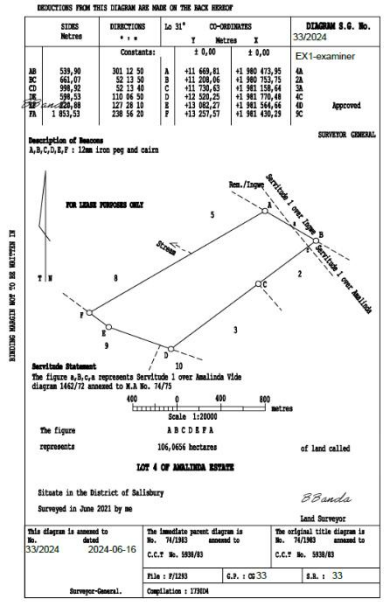
The figure above shows a property being currently being examined (blue) encroaching into another already existing and examined property(red) during the Drawing Office Stage. Information is produced on the survey description and SR Number of the encroached property.



Final Examination Checklist: Examiner digitally signs approved document using a unique automatically generated Digital Signature which is unique to each Examiner



SR Remarks automatically appear at the Land Surveyor Online Dashboard.



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CD 990,92	52 13 48	C +11 730,63	+1 981 158,64	3A
DE 590,53	110 06 50	D +12 520,25	+1 981 770,48	4C
EF 220,88	127 28 10	E +13 062,27	+1 981 564,66	4B
FA 1 853,33	238 56 20	F +13 257,57	+1 981 430,25	3C

Approved

SURVEYOR GENERAL

Description of Beacons
A,B,C,D,E,F : 12mm iron peg and cairn

FOR LEASE PURPOSES ONLY

Ren./Expwy

Servitude 1 over Amalinda Vide B

Servitude 1 over Amalinda

Stream

Servitude Statement
The figure a,B,c,a represents Servitude 1 over Amalinda Vide diagram 1462/72 annexed to M.A No. 74/75

400 0 400 800 metres
Scale 1:20000

The figure A B C D E F A
represents 106,0656 hectares of land called
LOT 4 OF AMALINDA ESTATE
Situate in the District of Salisbury
Surveyed in June 2021 by me
BBanda
Land Surveyor

This diagram is annexed to No. 33/2024 dated 2024-06-16	The immediate parent diagram is No. 74/1983 annexed to C.C.T No. 1938/83	The original title diagram is No. 74/1983 annexed to C.C.T No. 1938/83
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Surveyor-General.	Compilation : 17JUN	

Approved and signed document: Diagram number added, digital signature as well as SR Number.

Table 2 shows results of the Prototype evaluation.

FEATURE OF SYSTEM RATED	*VERY POOR*	*POOR*	*GOOD*	*VERY GOOD*
User friendliness of the CEW Prototype			*5*	*15*
Display and response time			*4*	*16*
Clarity of system's menus and navigation			*3*	*17*
Sense of direction toward goal			*1*	*19*
Effectiveness of data visualization tools			*3*	*17*
Analytical capabilities of the system			*6*	*14*
Security and Data Privacy features			*5*	*15*
Recovery from errors			*4*	*16*
Rating of ease of use			*3*	*17*

The CEW prototype received highly positive feedback across multiple criteria. In terms of user friendliness, display and response time, clarity of the system's menu's and navigation, and sense of direction towards the goal, 75% of the responses were rated a "Good," with the remaining 25% being "Very Good." The effectiveness of the data visualization told, the analytical capabilities of the system, and the security and data privacy features also scored well, with 755 of the evaluations in the "Good" and 25% in the "Very Good" range. Overall, the consistently high ratings, with 75 or more the evaluations in the 'Good' to 'Very Good' range, indicate efforts to develop a user-friendly, efficient and robust digital solution for the Cadastral survey examination process was successful.

5. SUMMARY, RECOMMENDATIONS AND CONCLUSION

The Digital Examination System Prototype has the potential to be further enhanced through the addition of several features Firstly, the system should be equipped with the ability to allow users to download regular reports on their examination progress and results, with the flexibility to customize report templates and export data in various formats. This will provide users with a more comprehensive overview of their interactions with the system.

Furthermore, before allowing documents to be lodged, the existing system should incorporate a robust identity confirmation process incorporating features like two-factor authentication or integration with national databases to verify the identity of the submitting person, thus enhancing the security and reliability of the system.

The system should also be able to integrate with other relevant systems and databases such as the Deeds Office, to enable seamless data sharing and streamlined processes

5.1 CONCLUSION

The study sought to provide a basis for developing a Cadastral Electronic Survey Examination System capable of transforming business within the Department of Surveyor General. It should be noted that, for a complete transformation of how surveys are lodged and examined, there is need to change the legal framework governing land surveying in Zimbabwe. The research alludes to the merits for harnessing digitalization in cadastral survey examination in Zimbabwe, it contributes and sets a basis for developing an electronic cadastral system capable of improving the efficiency and accuracy of land administration in Zimbabwe through effectively examining surveyed land. While the research was mainly aimed at developing a prototype, it is essential to note that further research based on finding of this study can and will contribute to the development of a first electronic cadastre in Zimbabwe.

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BIOGRAPHICAL NOTES

Charlene Zengeni is a Geomatics Engineer with expertise in engineering and cadastral surveying, GIS, and remote sensing. She is a member of the Zimbabwe Institution of Engineers (ZIE), the Survey Institute of Zimbabwe (SIZ), and the Zimbabwe Institution of Geomatics (ZIG). Her professional interests focus on digital cadastre, land administration systems, and the application of geospatial technologies to enhance land governance and sustainable development. She is also a CAAZ (Civil Aviation Authority of Zimbabwe) Certified UAV Pilot with experience in LiDAR drone mapping, topographic surveys, and GIS-based spatial analysis.

Charlene's research on re-engineering the cadastral survey examination system through digitalization reflects her commitment to innovation in land administration and the advancement of efficient, transparent, and technology-driven solutions.

CONTACTS

Charlene Ruvimbo Zengeni

Department of Geomatics & Surveying, Faculty of Engineering and the Built Environment, University of Zimbabwe, Zimbabwe.

Telephone: +263788786237, +263717166458

E-mail: charlenezengeni1@gmail.com

Web: https://www.linkedin.com/in/charlenezengeni/