Revolutionizing Land Governance: Re-engineering the cadastral survey examination system by harnessing digitalization: Case of Zimbabwe

AUTHOR:
Charlene R. Zengeni

Email: *charlenezengeni1@gmail.com*

Co-authors:

Mr S.Togarepi

Mr T.P Masarira

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ACRONYMS

CSG	Chief Surveyor- General
SR	Surveyor General
DCDB	Digital Cadastre Database
DSG	Department of Surveyor General
CEW	Cadastral Exam Web
Dxf	Drawing Exchange Format
LS	Land Surveyor (s)
LSA	Land Survey Act
PDF	Portable Document Format
RTS	Return to Surveyor
SA	South Africa
SG	Surveyor General
SQL	Structured Query Language
SURPAC	Survey Package

ABSTRACT

This project aimed to re-engineer the Cadastral Survey Examination System through the strategic use of digitalization. The main objective of the research was to develop a Prototype web-based Cadastral Survey Examination System to address the current paper-based process challenges which include inefficiency, inaccuracy, and lack of integration with advancements like data analytics and automation. The resulting slow and outdated evaluation of cadastral survey records is further compounded by institutional bureaucracy and rigid legal frameworks. These systematic limitations undermine the system's performance, causing delays, errors, and subpar outcomes. Addressing these deep-rooted problems through digitalization and process re-engineering has emerged as a critical imperative.

The project was initiated with a comprehensive user needs assessment, surveying Land Surveyors and the Department of the Surveyor General (DSG) personnel. This provided insights into user requirements and insights for developing the prototype. A situational analysis evaluated the current system's strengths and weaknesses, and a legislation and regulatory review identified potential changes needed to accommodate the new digital examination system.

The findings were compiled and presented using graphs and tables. This comprehensive data analysis provided valuable insights into the experiences and perspectives of Land Surveyors and the DSG personnel regarding the examination of cadastral survey records in Zimbabwe.

The CadastraExamWeb (CEW) prototype was built using the evolutionary prototyping model, enabling continuous development and refinement. The prototype underwent validation using user acceptance, peer review, and performance testing methods. Feedback from the targeted audience identified issues and validated decisions, improving the system's reliability and performance. The multi-faceted validation approach ensured the software reliably met user requirements.

Overall, this project demonstrated the transformative potential of digitalization for the Cadastral Survey Examination System.

CHAPTER 1: INTRODUCTION

1.0 Introduction

Zimbabwe is undergoing a transition in the standards of providing governmental services to its citizens as it ramps up its efforts to implement e-governance services (Tsvuura, Mutsau and Mbawuya, 2021a). In an era where digital transformation is reshaping industries and revolutionizing traditional practices, it is high time for cadastral surveying to join the ranks (Kurwakumire and Kuzhazha, 2015). Land is indisputably one of the most precious resources that any nation possesses (Kurwakumire and Kuzhazha, 2015) and the examination process that underpins cadastral surveys, the vital foundation of land ownership and property boundaries, is ripe for re-engineering through the power of digitalization. It is through embracing cutting-edge technologies and harnessing the potential of digital tools, there is an unprecedented opportunity to overcome the limitations of archaic methods and propel cadastral surveying into a new era of efficiency and accuracy.

In most Southern African developing countries, when land parcels are surveyed for registration purposes, cadastral survey records and diagrams undergo examination and approval by the Surveyor General's Office before they can be officially registered in the Deeds Registries (Chimhamhiwa, Mutanga and van der Molen, 2011). For these records to receive approval, they must meet the quality standards outlined in relevant acts and regulations, failure to meet prescribed regulatory requirements results in the records being rejected and returned to the Surveyor for corrections and resubmission. It is essential to highlight that from an inter-organizational perspective, the submission of poor-quality documents upstream triggers congestion in the examination processes downstream as the records are rejected and sent back due to quality concerns (Chimhamhiwa, Mutanga and van der Molen, 2011). According to (Ajayi, 2023), a manual approach to cadastral survey data processing is rigid, time-intensive, and susceptible to computational errors. It is for this reason that there is a pressing need to adopt automation of the system which would facilitate quicker, easier and error-free data processing. In today's rapidly evolving, technology-driven world, the need for efficient and accurate land surveying practices has become increasingly vital.

By harnessing the power of emerging technologies, such as Geographic Information Systems(GIS) and data analytics, there is a great potential to revolutionize how cadastral surveys are conducted, evaluated, and managed (Ting and Williamson, 1998). Moreover, by integrating digital tools into cadastral surveying, one can enhance collaboration, data sharing, and decision-making among stakeholders, ultimately leading to more robust land administration systems. It is through targeting land surveyors, land administration authorities, policymakers, and researchers, that we aim to provide practical insights and evidence-based recommendations that will drive the adoption of digitalization in cadastral surveying.

1.2 Background of the Study

Cadastral surveying is a specialized field of land surveying that primarily deals with the legal aspects of land ownership and property boundary delineation. It involves the accurate determination of boundaries, interpretation of ownership rights, and recording of associated rights, restrictions, and interests of land (Chimhamhiwa, Mutanga, & van der Molen, 2011; Commons et al., 2004). Land surveyors play a key role in subdividing or consolidating land parcels, reconstructing previously established boundaries, and facilitating the transfer of property titles. The profession requires the physical measurement of property boundaries, determination of areas and dimensions, and proper documentation for use in plans, maps, and diagrams, ensuring clarity and legal validity of ownership (Commons et al., 2004).

In Zimbabwe, cadastral surveying is conducted by licensed land surveyors or under their supervision, regulated by the Council of Land Surveyors of Zimbabwe under the Land Surveyors Act [Chapter 20:12]. The country's cadastral system has its roots in Roman-Dutch law, introduced at the Cape of Good Hope and incorporated into the Constitution of Zimbabwe, providing the legal foundation for land ownership and surveying practices (Dube, 2014). The core function of surveyors is to update the national cadastre held at the Surveyor General Department (SGD), ensuring land records are accurate, consistent, and legally recognized (Commons et al., 2004). Zimbabwe's cadastral system is comparable to those in countries such as Botswana, Zambia, South Africa, New Zealand, and Canada, although differences exist in technological advancement and reform implementation. While South Africa and Zimbabwe share Roman-Dutch law as a legal framework, Zimbabwe still lags in digital storage, submission, and examination of survey records (Kurwakumire & Kuzhazha, 2015).

The examination of lodged survey records at DSG is critical to maintaining cadastral accuracy and conformity with statutory requirements (Statutory Instrument 727 of 1979 [CAP 20:12]). E-governance, or the use of ICTs to improve governance and service delivery, is gradually being implemented in Zimbabwe, yet the DSG remains largely manual and paper-based in its operations (Tsvuura, Mutsau & Mbawuya, 2021b; Rajah, 2015). Within DSG, tasks such as searches, lodgement, examination, and approval of survey records are manually conducted. These processes are essential to promoting proper land administration, ensuring accurate property registration, and facilitating the secure transfer of land rights.

1.3 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).

1.4 Research Aim

The aim of this research is:

To Re-engineer the Cadastral Survey Examination System by developing a Web-based Lodgement and Examination Prototype.

1.5 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

1.6 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?

1.7 Motivation and Justification of Study

In an era of rapid technological advancements, the potential of digitalization to transform various sectors of the economy is undeniable. This research aims to explore how digitalization can be harnessed to re-engineer the Cadastral Survey examination system in Zimbabwe, addressing the drawbacks of the existing paper-based approach and paving the way for a more efficient and accurate system.

Due to its heavy reliance on manual procedures and paper-based documentation (Chimhamhiwa, Mutanga and van der Molen, 2011), the existing Cadastral Survey examination system is inefficient and prone to errors as well as delays. This research seeks to address these challenges by proposing innovative digital solutions that can optimize workflows, automate operations, and enhance data accuracy.

The findings of this research could have significant implications for policy and practice, contributing to more efficient Land Administration in Zimbabwe ensuring the accuracy and integrity of land records. By re-engineering the system, this research aims to contribute to a more efficient and reliable Land Administration system in Zimbabwe, supporting economic development, social equity, and environmental sustainability.

Overall, the motivation for re-engineering the Cadastral Survey examination system lies in the potential to harness digital technologies to overcome the limitations of the current paper-based approach and create a more efficient, accurate, accessible, and transparent system that supports informed decision-making and contributes to effective land administration in Zimbabwe.

1.8 Scope and Delimitation of the Study

This research focuses on the lodgement and examination of survey records within the Cadastral Survey Examination System in Zimbabwe.

1.9 Expected Outcome

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

CHAPTER 2: LITERATURE REVIEW

2.1 Review of the current Cadastral System in Zimbabwe

Cadastral systems, which document land ownership, boundaries, and rights, form the backbone of effective land administration globally (Kurwakumire, 2007). Zimbabwe's cadastral system, established in 1897 with the introduction of triangulation (Wayumba, 2013), has remained largely paper-based and manual despite its centrality to the economy. Surveys are prepared by Registered Land Surveyors and submitted to the Department of the Surveyor General (DSG) for examination and approval. While the manual system has functioned for decades, it is inherently slow, labour-intensive, and prone to inefficiencies (Chimhamhiwa, Mutanga & van der Molen, 2011). Long processing times hinder land transactions, reduce economic productivity, and create bottlenecks in the conveyancing process, which averages forty days (Kurwakumire, 2014).

International frameworks, such as Cadastre 2014, emphasize that modern cadastral systems require digitized records, comprehensive databases, and integration with geospatial tools to enhance transparency, efficiency, and decision-making (Williamson, 1997; Foncier, 2014). Zimbabwe has made limited progress toward these goals (Mapamula, Paradzayi & Kurwakumire, 2016). Digital cadastral systems promise improved data accessibility, enhanced accuracy of survey records, real-time updates, and better planning support, representing a pivotal step for modernizing land administration in Zimbabwe. The transition to digital systems aligns with global best practices and can address persistent challenges, including record mismanagement, delays, and lack of integration across land management institutions.

2.2 Review of the Current Survey Examination Process

The DSG, as the principal custodian of cadastral information, coordinates survey examination, approvals, and record maintenance (Commons et al., 2004). Land Surveyors conduct surveys and prepare diagrams, which are then examined for quality, completeness, and compliance with statutory regulations. However, Zimbabwe's Survey Act (1979) and the Land Survey (General) Regulations 1979 were developed for manual systems and have not kept pace with technological advancements (Mapamula, Paradzayi & Kurwakumire, 2016). Consequently, survey records remain paper-based, stored in filing cabinets across the DSG, municipalities, and the Deeds Office, creating inefficiencies in retrieval, storage, and backup (Kurwakumire, 2014).

Operational data highlights these challenges: the DSG processes an average of 50 survey records per day, of which approximately 44% are returned to surveyors for revisions. Of the remaining records, only 32% are approved on the first submission, with subsequent approvals requiring multiple resubmissions (Mashonga, 2002). Average processing times for examination and approval are 47 and 40 hours, respectively, illustrating the system's inefficiency. These delays translate into high transactional costs, reduced productivity, and limited capacity for sustainable land management. Additionally, the reliance on manual processes restricts transparency and hampers timely decision-making, further compounding systemic inefficiencies.

2.3 Legislative Impacts on Digital Examination

Legal frameworks exert significant influence on the digitization of cadastral processes. The Land Survey (General) Regulations 1979 were drafted for manual processes and do not provide explicit guidance for digital submissions, electronic signatures, or digital storage of records. Sections governing fieldwork, diagrams, general plans, and survey records mandate paper-based entries, often requiring specific ink or pencil notations, line corrections, and color washes for diagrams (Land Survey (General) Regulations, 1979). While provisions exist for the Surveyor General to allow electronic field books, other elements such as digital signatures and electronic submissions remain undefined.

In contrast, other jurisdictions have adapted legislation to facilitate digital cadastral examination. New Zealand, for instance, employs Landonline, which allows survey data to be submitted digitally, validated against regulatory requirements, and approved within a secure digital system (Atazadeh, Rajabifard & Olfat, 2023). Similarly, South Africa's Project Vulindlela enables e-lodgement, digital signatures, and online access to approved survey records, while maintaining compliance with statutory requirements (Hull & Whittal, 2013). Legal reform in Zimbabwe would therefore be essential to accommodate digital examination, streamline workflows, and ensure regulatory compliance.

2.4 The Vision for Cadastre 2014 and 2022

Cadastre 2014 envisions a comprehensive land information system integrating digital technologies to enhance access, transparency, and transaction efficiency (Kaufmann & Steudler, 1998). The initiative advocates replacing paper-based systems with electronic databases, digital maps, and geospatial tools capable of managing spatial and legal information effectively. Modernization addresses challenges such as data security, interoperability, and the need for digital examination of cadastral survey records (Foncier, 2014).

Building on this, Cadastre 2022 aims to provide real-time land information services, including property searches, survey lodgements, digital examinations, and fee payments online. Integration with other government departments, such as the Deeds Registry and Mining Cadastre, is a critical objective, unlocking revenue and increasing efficiency throughout the land administration value chain (The Chronicle, 2023; Kalantari et al., 2015). Both initiatives underscore the necessity of technological adoption to improve transparency, reduce errors, and promote equitable access to land information.

2.5 Digital Examination in Other Countries

Digital cadastral examination has been successfully implemented in multiple jurisdictions, providing benchmarks for Zimbabwe.

Victoria, Australia requires surveys to undergo detailed administrative and mathematical checks to ensure compliance with land titles, easements, and boundary regulations. Automated quality control mechanisms and integration with the Digital Cadastral Database streamline the approval process (Falzon, 1998; Warnest, 2005).

New South Wales (NSW) uses e-plan submissions consisting of TIFF images, ASCII geometry files, and administrative data, which are validated against over 100 regulatory rules through automated software. This reduces manual checks, increases compliance, and expedites approvals (Masri & Paudyal, 2021).

New Zealand's Landonline system captures digital survey datasets, applies regulatory validation tests, generates diagrams, and integrates approved data into the authoritative cadastre. The system allows secure, efficient, and standardized examination, minimizing human error (Atazadeh, Rajabifard & Olfat, 2023).

South Africa's Project Vulindlela enables surveyors to submit electronic documents to the Chief Surveyor General, who reviews, approves, and archives the records digitally. Digital signatures and online notifications allow efficient interaction between surveyors and authorities while maintaining legal compliance (Hull & Whittal, 2013).

These international examples demonstrate that digital cadastral examination can improve accuracy, transparency, and efficiency while reducing processing time, transactional costs, and human error. Lessons from these jurisdictions can inform the implementation of Zimbabwe's Digital Cadastral Examination System.

2.6.0 Prototyping Model

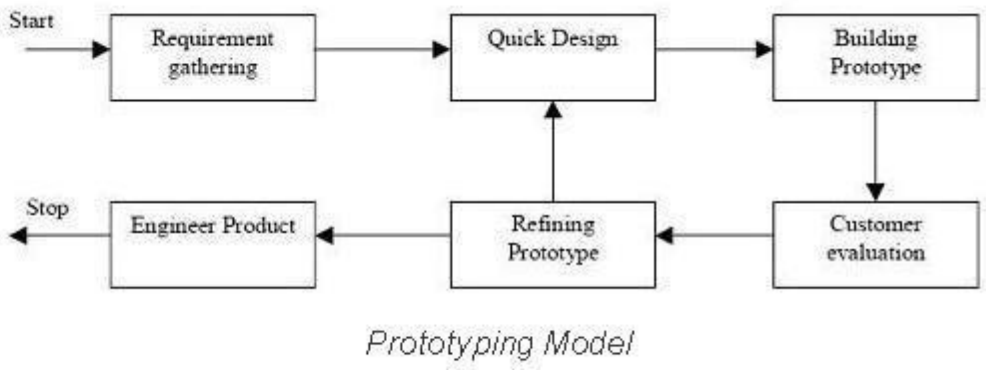


Figure 1: Prototyping Model

The prototype model represents an iterative software development methodology that emphasizes rapid prototyping and early user engagement (Brhel et al., 2015a). This approach involves the elicitation of initial requirements, development of a functional prototype, and iterative refinement based on user feedback until the system meets defined specifications. The key advantage of this model lies in its ability to provide a tangible representation of the software, facilitating early identification of potential issues and enabling users to contribute to the design process (Maryani et al., 2022; MoldStud, 2024). Its iterative nature ensures adaptability to evolving requirements, reduces the likelihood of costly rework, and enhances decision-making throughout development. The prototype model is particularly suitable for systems that require frequent interaction with end-users or involve complex human-computer interfaces, such as web-based applications (GeeksforGeeks, 2023).

2.7 Digital Signatures

Digital signatures serve as a mechanism to ensure the authenticity, integrity, and non-repudiation of data within digital examination systems. They enable secure signing of examination documents, authenticate user identities, and establish a verifiable link between actions and individuals. Integration of digital signatures can be achieved using the PyPDF2 library in Python, which allows for the addition, verification, and management of signatures within PDF documents, commonly used in cadastral record submission.

2.7.1 Web Mapping

The integration of web mapping enhances the functionality of digital examination systems by providing location-based services. The Google Maps API, accessible via the Google API Client Library for Python, allows developers to incorporate features such as area verification, scale and encroachment detection, property surrounding checks, and navigation assistance. Implementation requires adherence to secure authentication and authorization protocols, including API keys and OAuth 2.0, to maintain data privacy and prevent unauthorized access (Bildirici & Ulugtekin, 2010).

2.7.2 SQL Database

Structured Query Language (SQL) databases are fundamental for storing and managing spatial and non-spatial cadastral data. SQLite, an embedded database, offers advantages including simplified deployment, reduced administrative overhead, robust transaction support, and data integrity (Odero, 2008; GDAL Documentation, n.d.). Integration with GIS tools and web frameworks facilitates efficient storage, retrieval, and visualization of cadastral datasets, enabling authorities to maintain accurate, up-to-date records and support decision-making in land administration.

2.8 Summary

Zimbabwe is currently facing challenges with its outdated and mostly manual cadastral system, which is critical for effective land management and economic development. The existing system is inefficient and slows land transactions, resulting in suboptimal use of land resources utilization and impeding overall economic growth. One of the major challenges is the time-consuming nature of the cadastral survey process. From survey submission to review, the process can take a significant amount of time. The examination phase alone can last up to 39 hours, with an additional 29 hours for approval and updating (Mishanga, 2002). This time-consuming process significantly reduces the efficiency of land administration.

The manual system is also prone to manipulation, corruption, and bureaucratic delays. These issues not only hinder sustainable land use but also impact investment attractiveness. To address these challenges, Zimbabwe must embrace digitalization and automation in its land administration system, with a special emphasis on the cadastre component. First, the development of a web-based cadastral survey examination system can help to streamline the processes. Automation of these processes will save time, improve accuracy, and increase access to cadastral information. Zimbabwe can also benefit from technological advances made by other successful cadastral systems around the world. By implementing global best practices, the country can modernize its approach to land administration and increase efficiency. Incorporating digitalization and automation into the cadastre system can improve land management, boost economic growth, and create a more transparent and investor-friendly environment. Zimbabwe must embrace progress and maximize the potential of its land resources.

CHAPTER 3: METHODOLOGY

3.1 Research Approach

The research adopts a qualitative research paradigm to gain an in-depth understanding of the perspectives, opinions, and needs of individuals engaged in cadastral surveying. This approach allows for the collection of rich, descriptive data through qualitative research methodologies (Hull and Whittal, 2023). The insights gathered from these methodologies will inform the development of a practical prototype for survey examinations.

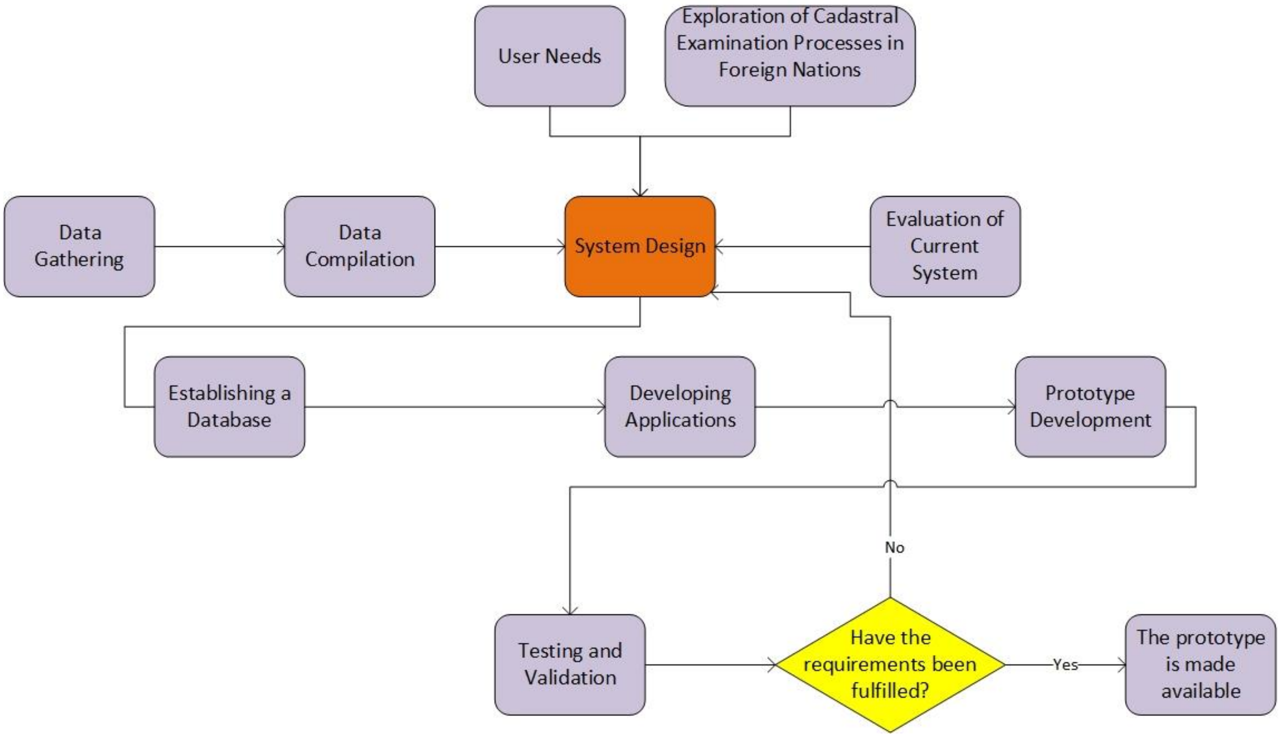


Figure 2: Research Approach Methodology

3.2 Research Design

A case study methodology was used in this investigation. The goal of this strategy is to fully comprehend a complicated problem in the context of real-world situations (Tsang, 2013). Often referred to as a "naturalistic" approach, it explores an event or phenomenon in its natural setting (Crowell and Husserl, 2013). According to Rashid et al. (2019) citing Yin (1994) a case study is an empirical investigation that uses a variety of empirical sources to look at a particular current event or action inside a specified environment. Doing an in-depth study on a specific case—be it an individual, organisation, institution, or community—is the main goal.

According to Biba Rebolj (2013) case studies are especially helpful in qualitative research, which is a methodical and subjective approach meant to clarify and analyse ordinary life events. Zimbabwe's Department of the Surveyor General will be the subject of this research's case study.

3.3 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 (Rashid *et al.*, 2019). 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 (Yin, 1994). Additionally, the study drew insights from existing studies and literature on testing and validation processes.

3.4 Study Population

The study population consisted of 49 registered land surveyors who had significant job experience in both survey examination and cadastral surveying, out of whom 35 responded. In addition, 18 DSG personnel who are involved across the stages of the examination process were also included. These experts were picked because of their specific training and real-world industry experience, making them excellent resources for information about the complexities of cadastral surveying procedures and examination methods. The research sought to obtain thorough insights and viewpoints by concentrating on this particular group, which are necessary for effectively answering the research questions and objectives. The respondents included both male and female land surveyors.

3.5 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.

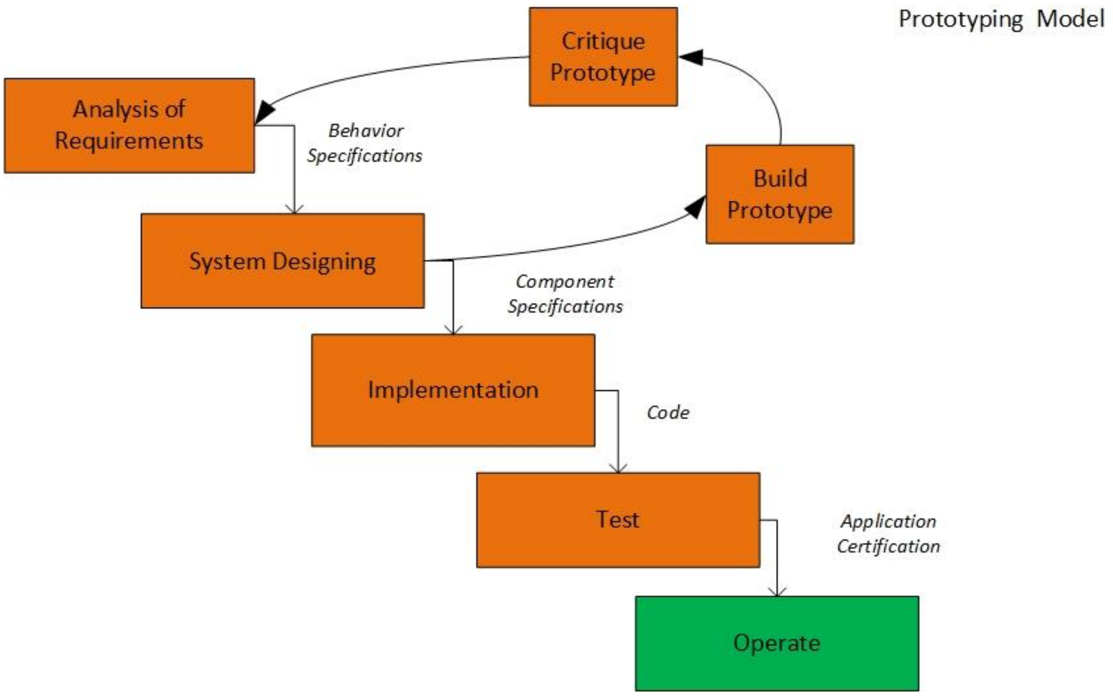


Figure 3: Prototyping Model

3.6 Situational Analysis

The aim of scrutinizing the then-current system was to pinpoint its strengths and challenges. This scrutiny offered crucial insights into the entire examination procedure, facilitating the recognition of areas that needed enhancement through the examination prototype, and underscoring any existing deficiencies. To carry out the evaluation of the then-present examination system, particular questions were incorporated into the questionnaires. These inquiries assisted in collecting data about the operation of the then-current system. By examining the answers to these inquiries, a comprehensive understanding of the existing system was achieved. Two distinct questionnaires were formulated: one for Land Surveyors and another for DSG personnel. Each questionnaire encompassed pertinent questions designed for a specific group of respondents.

The workflows below depict the existing Cadastre Survey Examination process in the Department of the Surveyor General. Based on the workflows, the Cadastral Survey Examination System was re-engineered.

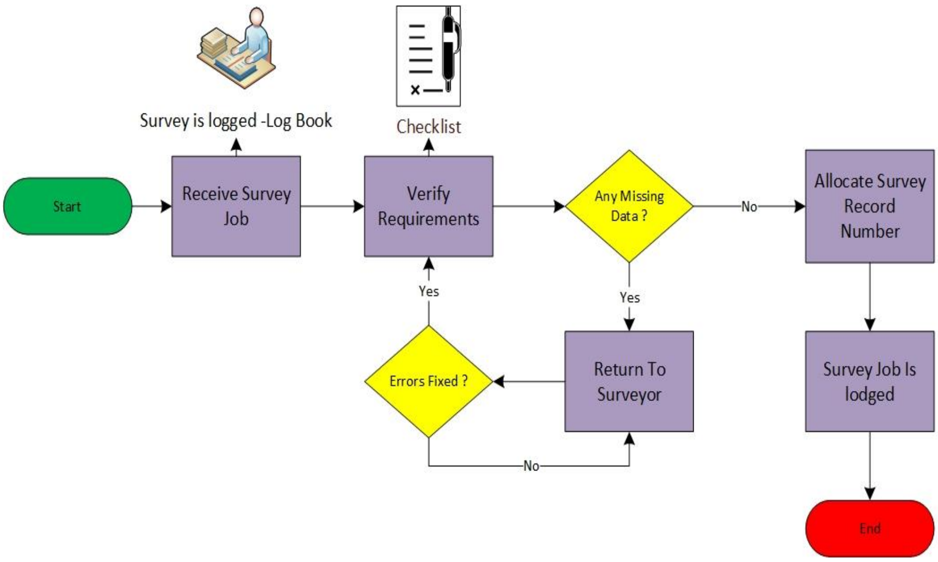


Figure 4: The Preliminary Survey Examination Process of a Land Survey in the DSG

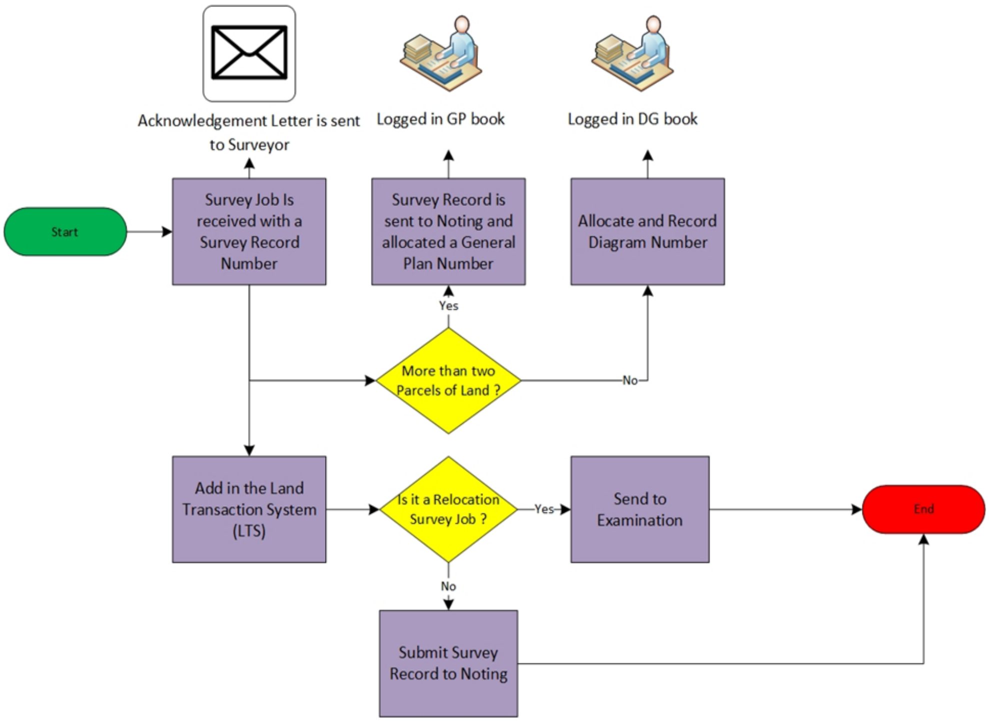


Figure 5: Survey Lodgement Process in the DSG

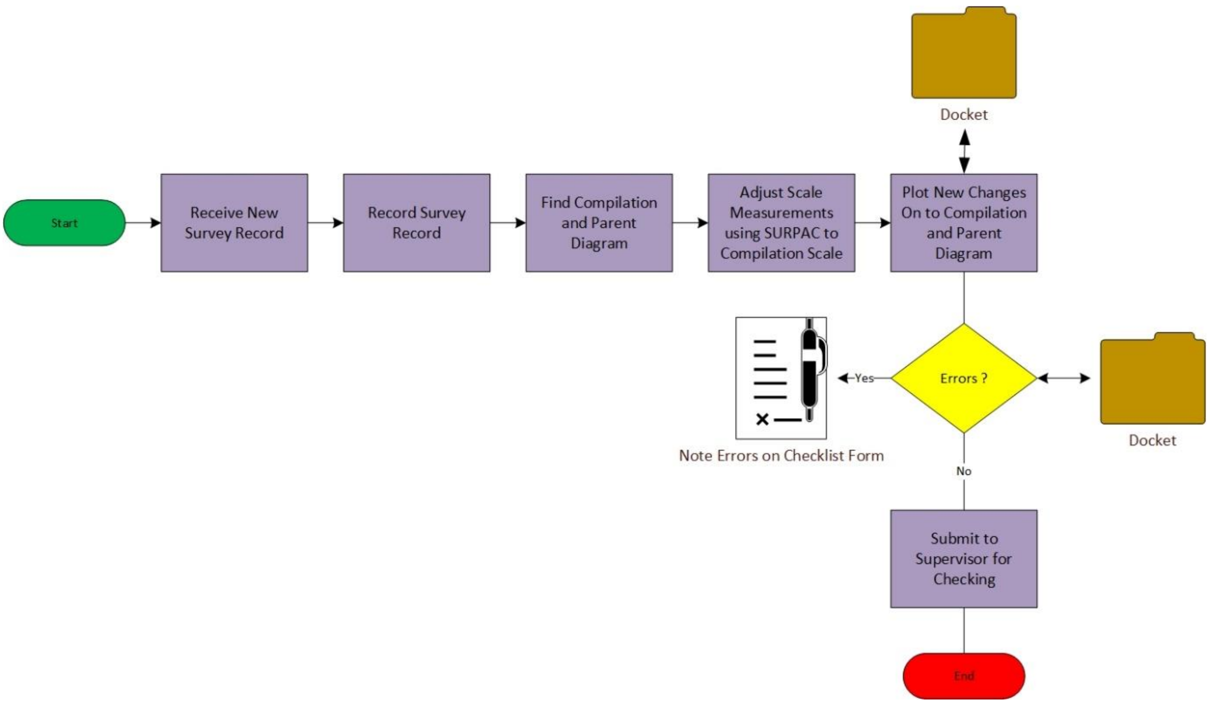


Figure 6: Drawing Office Process Workflow

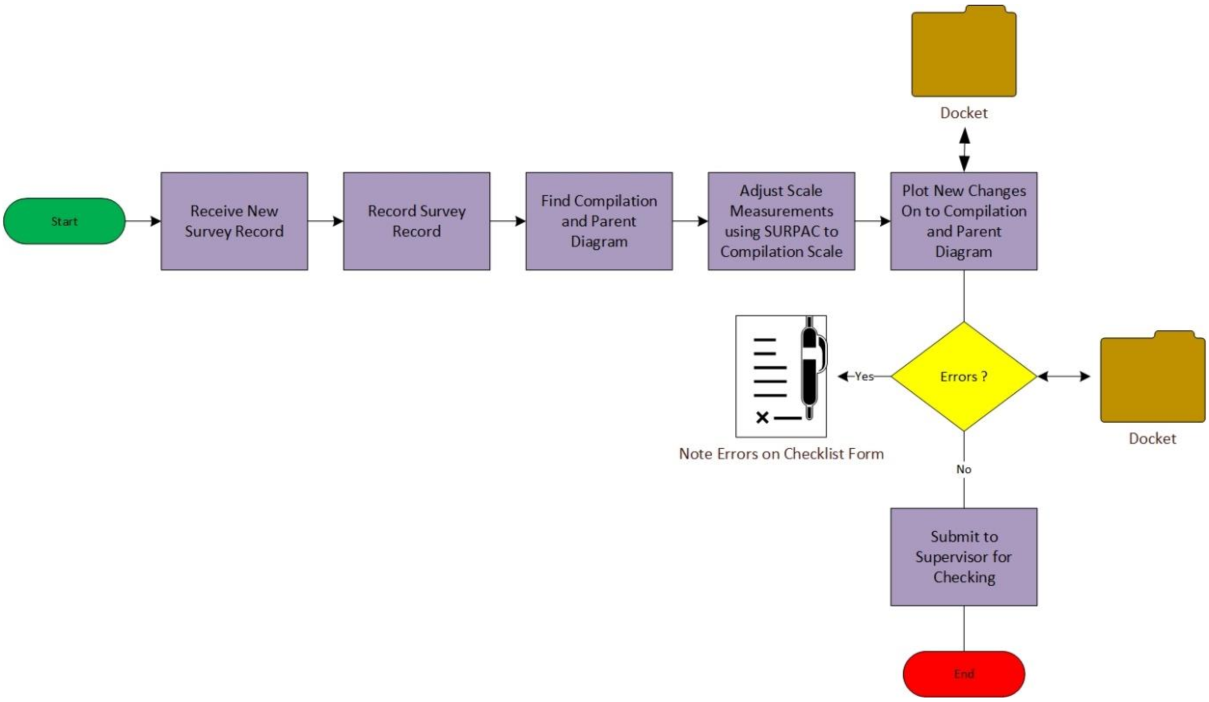


Figure 7: Technical Examination Process Work Flow

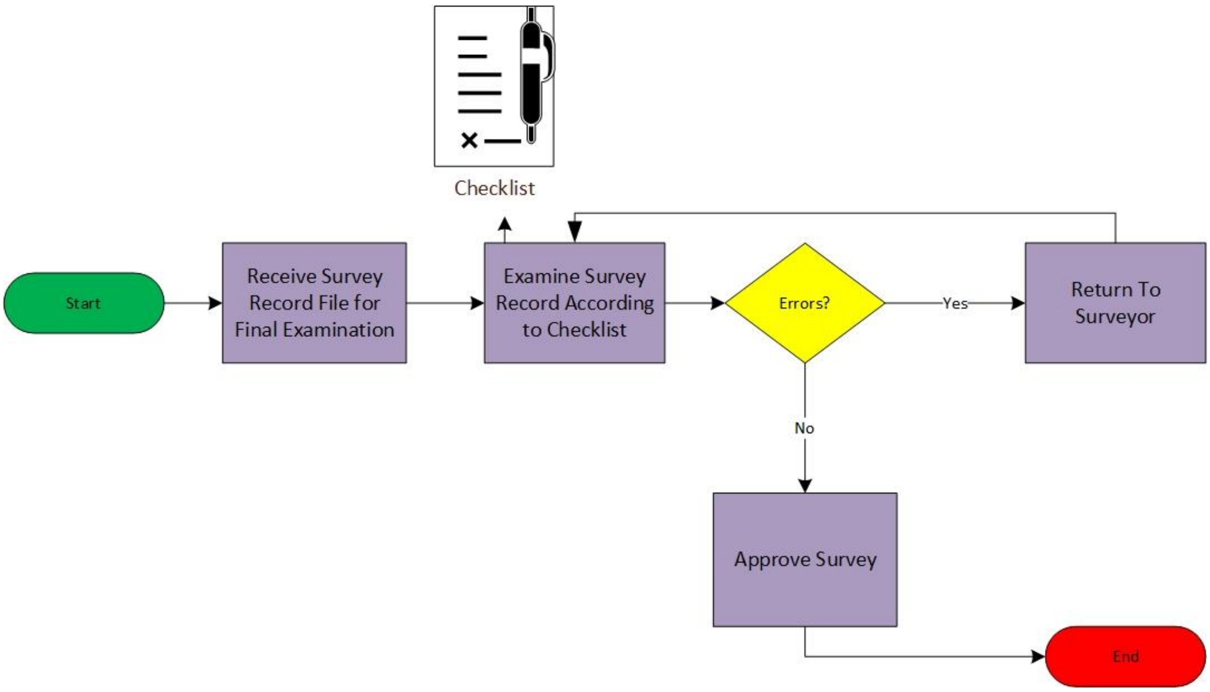


Figure 8: Final Examination Process

3.7 Feasibility Study

The feasibility of implementing digital examination in Zimbabwe was evaluated through a desk study of prior research and user surveys. Previous studies on digital examination methods were reviewed, and questionnaires collected information from users regarding existing software for processing survey records and the availability of equipment capable of capturing, storing, and outputting digital data. The analysis of these responses was pivotal in assessing the Department's IT capabilities and readiness to adopt a digital cadastral survey examination system.

3.8 Prototype Validation

Prototype validation followed the prototyping software development model. A feature prototype was developed, and feedback was collected from 10 Land Surveyors and 10 DSG personnel to assess its strengths, weaknesses, and areas for improvement. Users were first asked about their expectations, then provided feedback during preliminary testing. This iterative process allowed the prototype to be refined based on user input, helping to detect issues early, identify opportunities, and ensure the system met user needs. Validation played a critical role in improving software reliability, performance, and usability, ensuring the final system aligned with operational requirements and expectations.

3.9 Summary

The system was architected to leverage a cloud-hosted online sever infrastructure. This server environment was compatible with any web browser capable of interpreting Python Django, enabling broad accessibility. The online server handled the dual responsibilities of web hosting and data management, facilitating efficient operations and data retrieval.

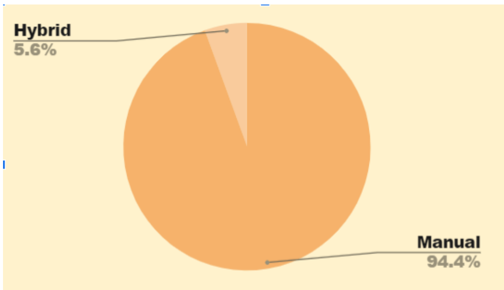
Leveraging a remote server environment provided several key advantages. The scalable and redundant infrastructure ensured robust data security, as information was stored and processed remotely. Additionally, the web-based architecture allowed users to access the system from anywhere with an internet connection, further enhancing flexibility and ease of use.

Overall, this remotely hosted server design offered a comprehensive and adaptable solution that catered to the system's operational requirements. The combination of online accessibility, efficient data handling and robust security delivered a powerful and versatile platform.

CHAPTER 4: DATA PRESENTATION, INTERPRETATION AND ANALYSIS

4.0 Introduction

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. The questionnaires are attached to the appendix of the report. Results from the evaluation sheets are also presented in this section.



The chart shows that the current examination system is highly manual as indicated by 94.4 % of DSG Personnel. This drives us to digitalize the system with technological advancements.

4.1 Challenges being faced as a result of using the existing Cadastral Survey Examination System

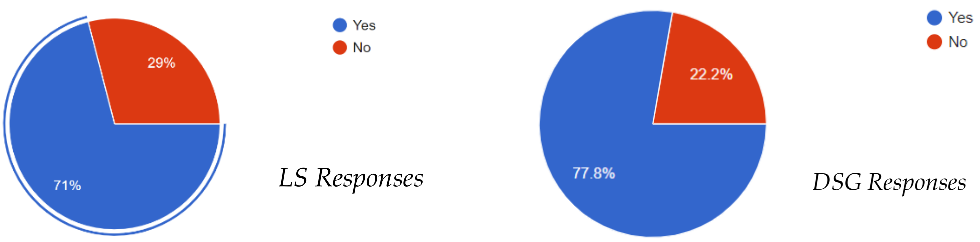
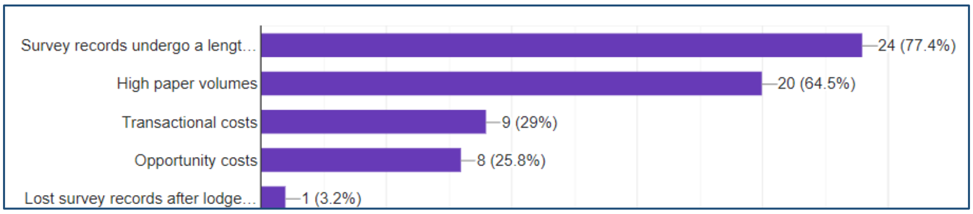
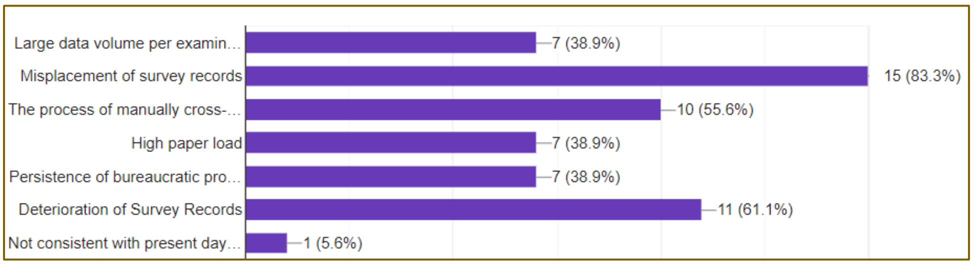


Figure 9: Responses show that Land surveyors and the DSG personnel experience challenges in the current survey examination process



LS Responses



DSG Responses

Figure 10 shows the respondents' challenges faced in the current cadastral survey examination system

Land surveyors and the DSG personnel face challenges in the current cadastral survey examination system as indicated in figure 10. The developed digital examination Prototype, CEW effectively solves the key challenges identified through the DSG and LS respondents (Figure 11). To address record misplacement (83.3%) in digital examinations, the prototype incorporates efficient data tracking. It streamlines bureaucratic processes (81.1%) through electronic approvals and automation.

This also solves the challenge of a lengthy approval process (77.4%) as indicated by the LS n figure 11. The prototype's scalable data management capabilities handle large data volumes (38.9%), thus also reducing high paper volumes (64,5%) indicated by LS. Additionally, the prototype's intelligent processing tools automate manual cross-checking (38.9%) which was previously a pain point, addressing concerns over transactional costs (29%) and opportunity costs (25.8%).

4.1.1 Lengthy Approval Process for Survey Records

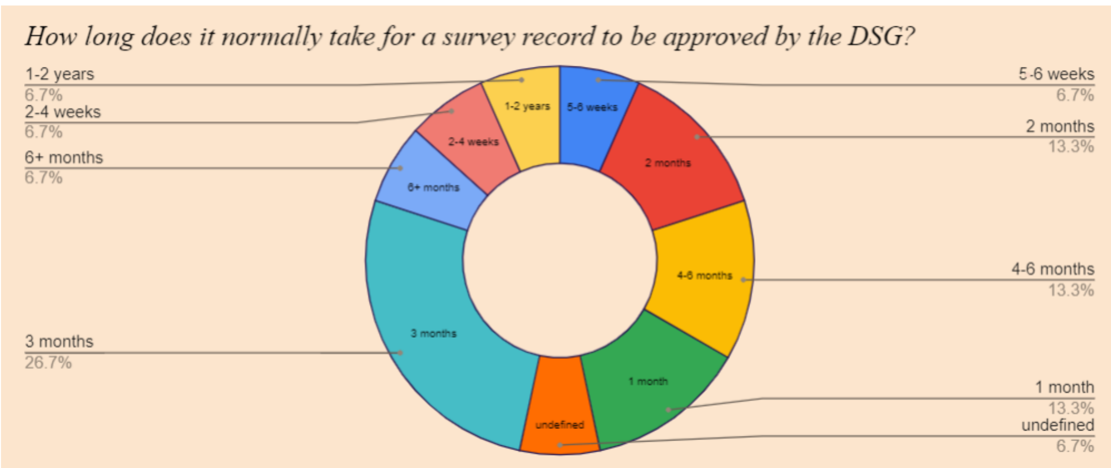


Figure 11 shows the time it takes for cadastral survey records to be approved as per the LS responses

4.1.1 Lengthy Approval Times

The chart shows that 73.4% of Land Surveyors have their cadastral survey records approved within one month to two years due to the current manual system. Approval times vary depending on survey size, type, and quality, with small surveys taking as little as two weeks. Respondents highlighted delays caused by multiple examiners, consultations, and workload. The CEW prototype addresses these delays by digitalizing the process, automating workflows, and ensuring transparency, significantly reducing approval times and improving efficiency for both Land Surveyors and the DSG.

4.1.2 Bureaucratic Processes

The manual system involves multiple layers of review, verification, and authorization, causing inefficiencies and delays. DSG examiners noted that reliance on paper-based procedures and lengthy approval processes hampers effectiveness. The CEW prototype streamlines these processes through electronic approvals and automated progression through examination stages.

4.1.3 High Paper Volumes

High paper volumes create logistical challenges, increase errors, and slow data retrieval. Both Land Surveyors and DSG examiners face misplacement, deterioration, and cumbersome management of physical survey records. Digitalization reduces reliance on paper, improving record-keeping and efficiency.

4.1.4 Opportunity and Transactional Costs

The current system incurs direct transactional costs and indirect opportunity costs, including time, resources, and productivity lost in managing paper records and lengthy approvals. Digitalization through CEW minimizes these costs, enabling more efficient use of resources and faster decision-making.

4.2 Understanding User Requirements for the Cadastral Survey Examination System

4.2.1 Perspective on the data formats required for submitting survey record property layout

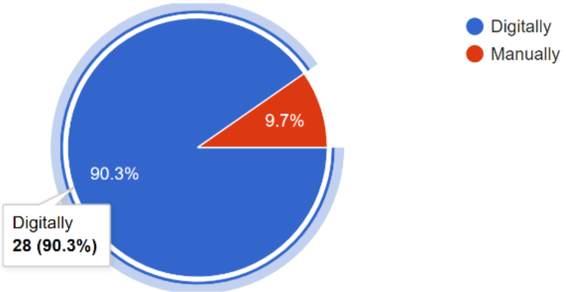


Figure 12: Pie chart showing how land surveyors prepare their cadastral survey records

The chart above shows that 90.3% of the Land Surveyors prepare their survey records digitally and therefore this allows submission of documents in the digital form such as .docx, .csv, pdf, geoJSON, Dxf and jpeg amongst other image formats as illustrated in the developed CEW Prototype.

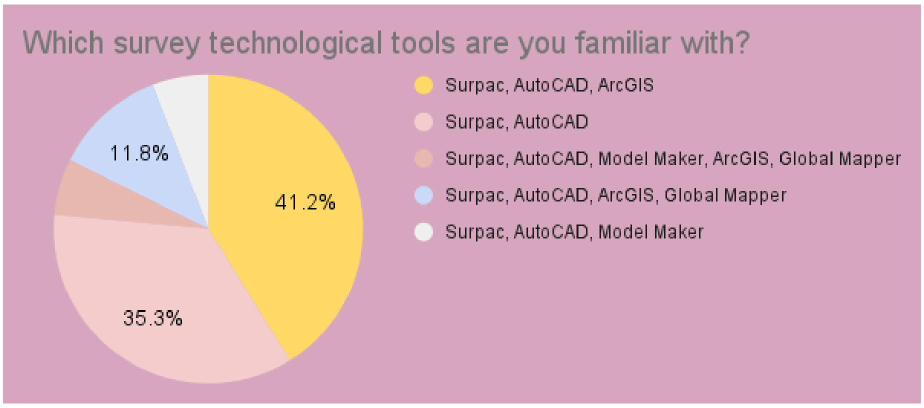


Figure 13

According to the DSG responses in figure 14, the majority (41.2%) of the DSG Personnel are familiar with Surpac, AutoCAD, and ArcGIS. A significant portion (35.3%) are familiar with an even broader set of tools including Global Mapper and Model Maker. The digital examination prototype therefore prioritizes support for common file formats associated with these tools, such as Dxf, geoJSON and .shp. The Prototype allows the submission of the drawings as GeoJSON format and Pdf which is then digitally signed as the final document.

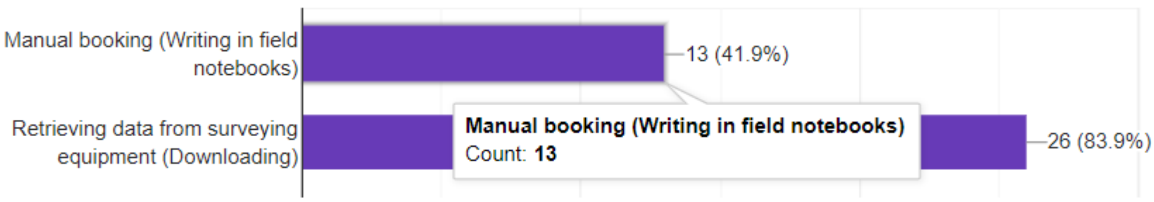


Figure 14

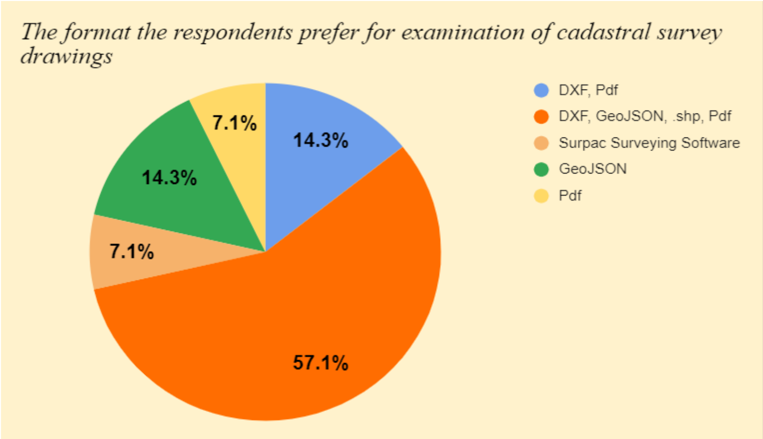


Figure 15: Format respondents prefer for examination of cadastral survey drawings

4.2.2 Notifications and Updates

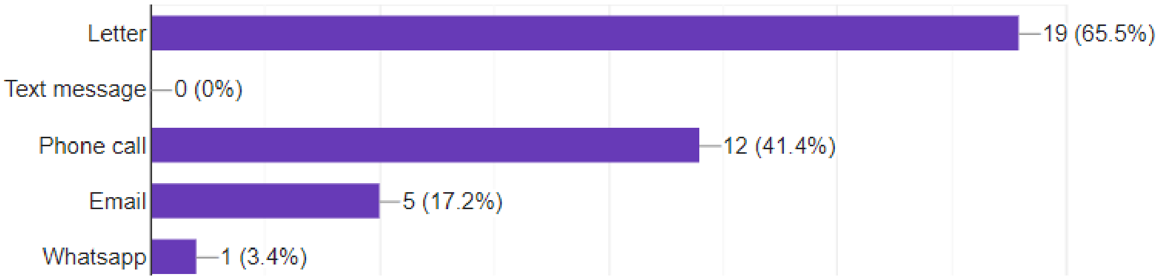


Figure 16

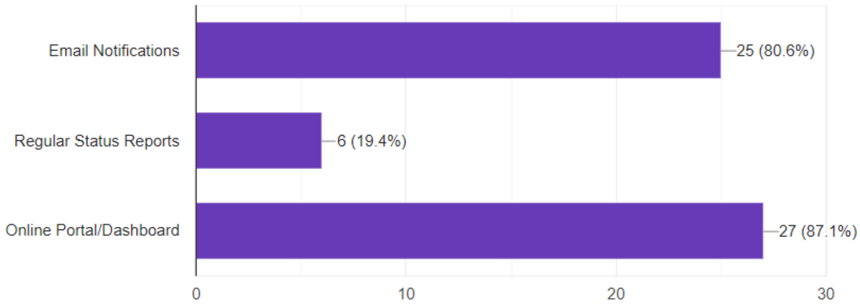
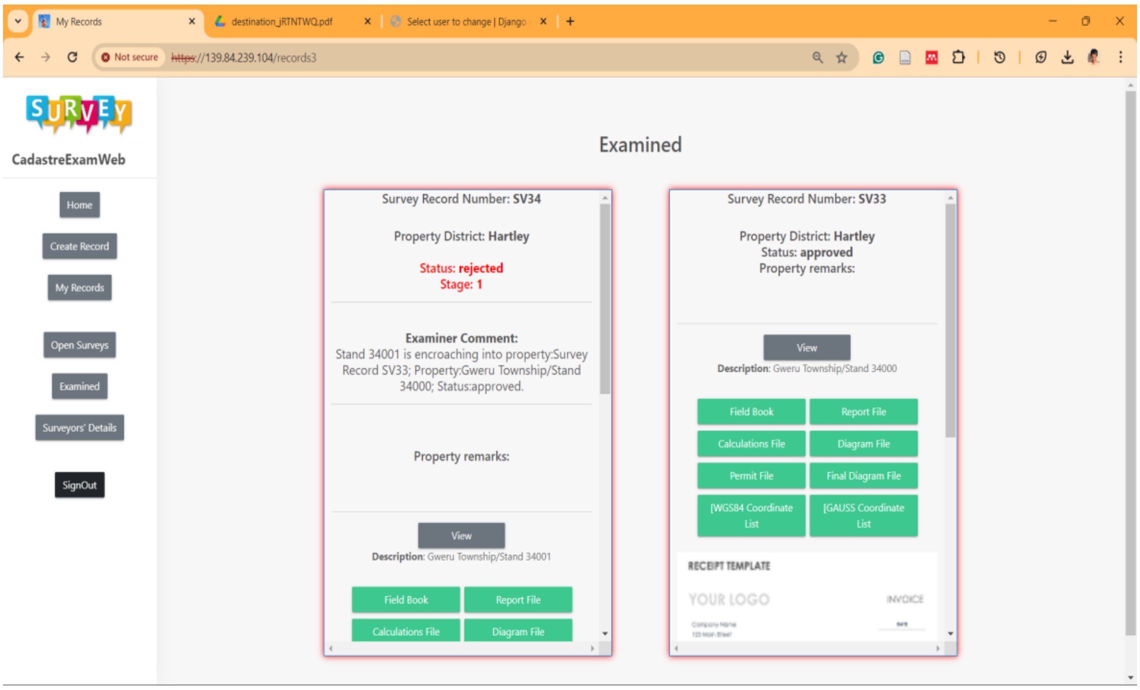


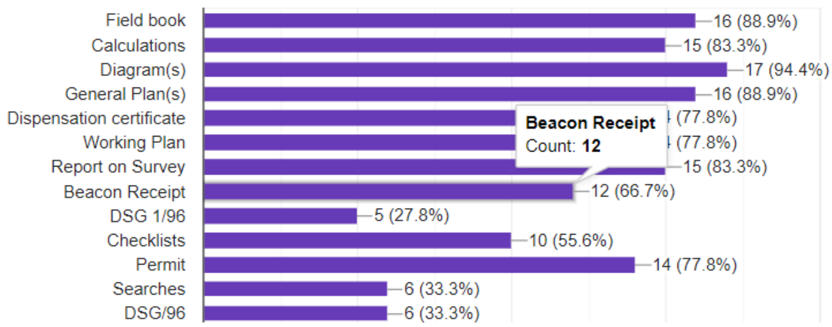
Figure 17 : Preferred Methods for Receiving Updates and Notifications



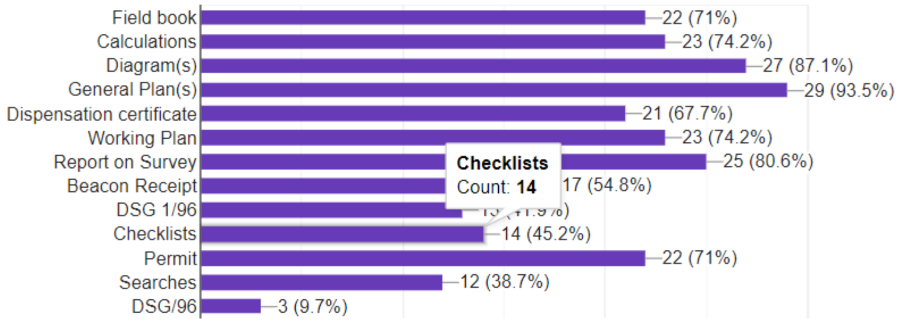
An online dashboard demonstrated in the CEW Prototype showing communication between the Land Surveyor and the Examiner.

4.2.3 Perspectives on the Minimum Required Documents for Digital Examination at the Department of the Surveyor General (DSG)

The nature of the existing system in terms of lodgement of surveys by surveyors consists of a number of documents. Respondents had different perspectives when questioned on what they thought on the submission of *only* the diagram, report, general plan, permit, calculations coordinate list and field book as the requirements for digital examination at the DSG.



DSG Responses



LS Responses

Figure 18

Chief to note in the findings is that while respondents were comfortable with reducing the quantity of documents required at the point of submitting a survey at the DSG, the LS and DSG respondents indicated documents that needed to be added. The core technical documents that considered essential by the respondents are the field book (88.9% and 71%), Calculations (83.3% and 74.2%), Diagrams (94.4% and 87.1%), General Plans (88.95 and 93.5%), Permit (77.8% and 71%), Survey Report (83.3% and 80.6%), Dispensation Certificate (77.8% and 67.7%). 71% of the 53 Respondents agree that the final documents should include the Field book, Calculations, Diagram(s), General Plan(s), Working Plan, Report on Survey and Coordinate List.

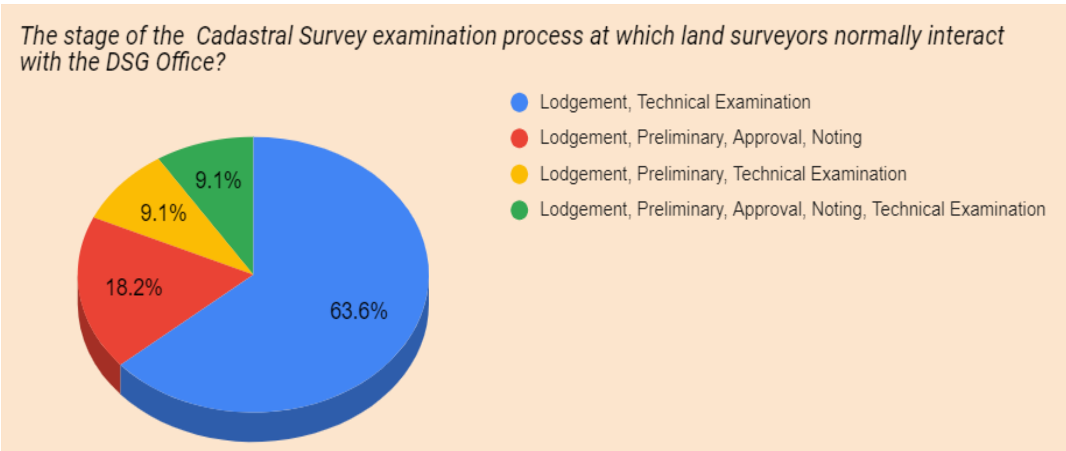


Figure 19: Shows the stages Land Surveyors mostly interact with the DSG Office

63.6% of the Land Surveyors interact with the DSG Office during the Lodgement and Technical Examination Stages of the Cadastral Survey Examination System. The

CadastraExamWeb prototype allows LS to remotely submit their documents for accuracy and integrity checks at the DSG, streamlining the whole process.

Additionally, during the examination, CEW enables real-time tracking of survey records by Land Surveyors, as comments and feedback no longer need to be sent via physical letters. This real-time communication facilitates improved collaboration and transparency between the LS and the DSG Office.

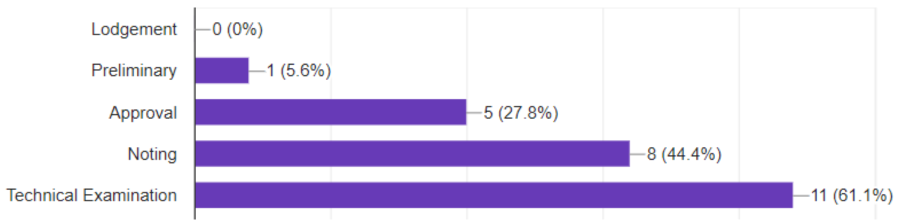
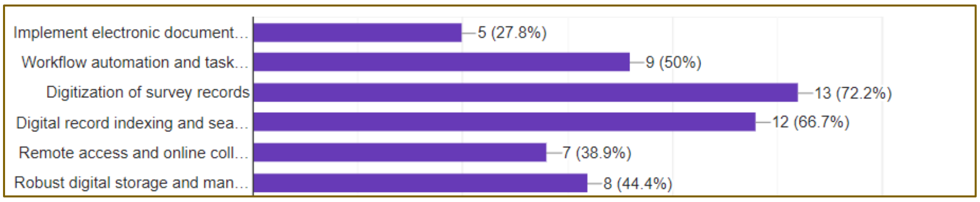


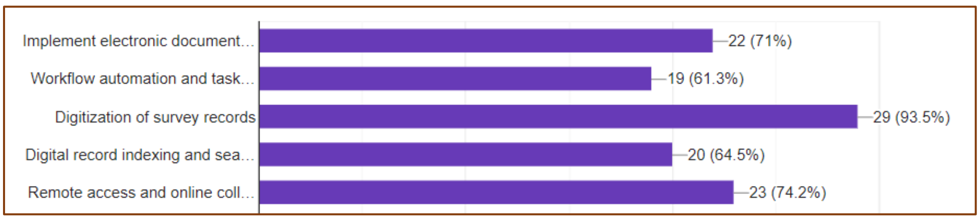
Figure 20 shows the examination stages which take most time as per DSG responses

The survey data as indicated in figure 20 reveals that Technical examination is the most-time consuming part of the examination process according to the DSG (61.1%) which is also the stage LS interact mostly with the DSG. To address this, the developed prototype digitalizes checks and implements the use of digitalized checklists, streamlining and accelerating this critical step. Additionally, the Noting stage, indicated by 44.4% of the responses, has been enhanced through automatic encroachment detection in CEW, making this stage more efficient and reducing the overall time required. These improvements to the most-time intensive stages, informed by the DSG feedback, demonstrate the system's commitments to optimizing the examination workflow and addressing the key bottlenecks identified.

4.3 International Best Practices to Enhance Survey Examination Efficiency and Effectiveness



DSG Responses



LS Responses

Figure 21: Perspectives on improving the existing cadastral Survey Examination System

Another interesting result of the research as shown on Figure 21 is that the system should have the following capabilities; *electronic document management systems (EDMS), workflow automation and task management, digitization of survey records, digital record indexing and search capabilities, as well as remote access and online collaboration.*

4.3.1 Workflow automation and task management

Over 50% of respondents (Figure 21) underscore that it is imperative to have *an automated system that facilitates seamless online functionality across all stages of the examination process, transcending the traditional limitations associated with manual procedures*. Such automation not only expedites the workflow but also enhances accessibility and collaboration among examiners operating at various stages. Crucially, the developed prototype possesses the capability to delegate tasks within the examination chain, thereby optimizing efficiency and resource allocation. This delegation mechanism ensures that responsibilities are allocated judiciously, mitigating bottlenecks and streamlining the overall examination process. By integrating these features, the electronic survey examination system can realize its full potential as a dynamic and responsive platform, empowering examiners to perform their duties with greater agility and effectiveness.

4.3.2 Digital record indexing and search capabilities.

The concept of digital record indexing and search capabilities refers to the ability of the electronic survey examination system to organize and categorize digital records in a structured manner, enabling efficient retrieval and navigation..

This emphasis on digital record indexing and search capabilities underscores the significance of technological features that optimize the accessibility and usability of digital resources within the survey examination framework. *One respondent pointed out that as part of international best practices, the system should be able to index and search records within the system so that there is easy retrieval of records, accuracy, and efficiency in how business is done on a day-to-day basis.*

4.3.3 Electronic Document Management Systems

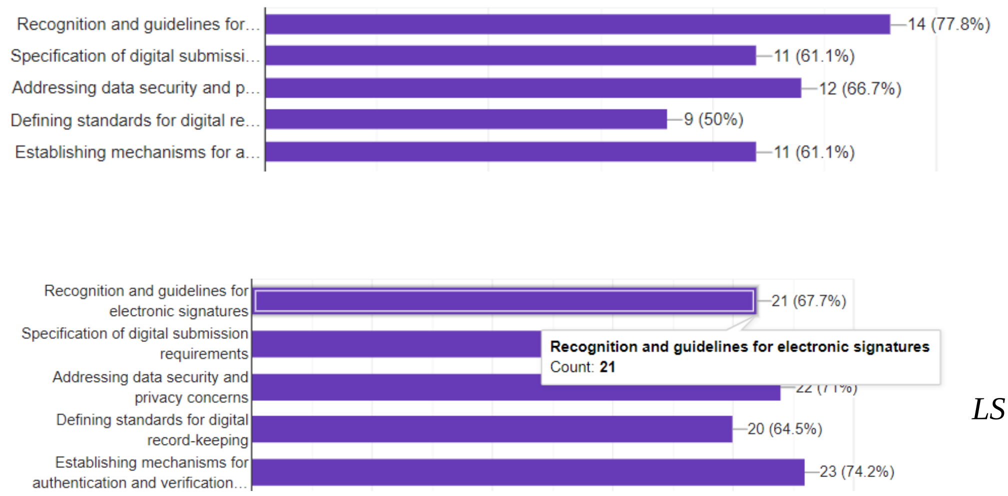
According to over 50% of respondents (Figure 21), one of the ways to enhance survey examination efficiency and effectiveness, especially within the use of an electronic survey examination system is to implement *an Electronic Document Management System (EDMS)*. In New Zealand, the introduction of an EDMS in electronic survey examinations has streamlined the entire process. By doing so, they have minimized the need for physical paperwork and manual handling, thus saving time and resources. This approach has not only improved the efficiency of conducting electronic survey examinations but also ensured the security and integrity of Survey Records.

Furthermore, in nations such as South Africa, the Cadastral Information System (CIS) functions as a digital infrastructure for the organization of land data and cadastral documentation. Analogously, it incorporates an Electronic Document Management System (EDMS), akin to Australia's Landgate electronic cadastre, which has significantly optimized procedures pertaining to land governance and oversight. Hence, by emulating such globally recognized benchmarks, it is assured that the electronic survey system could be fortified through the incorporation of an electronic document management framework, facilitating the storage and seamless retrieval of survey records during the examination process.

4.3.4 Digitization of survey records

For a digital survey examination system to be effective, digitizing survey records is a critical feature. The study's conclusions show that 82.85% of participants (Figure 21) emphasized the significance of digitizing survey data. By converting all physical survey documents and records into a digital format, the system eliminates the need for bulky paper-based storage and enables efficient data management. The system can increase search ability and retrieval, remove the requirement for physical storage, enable remote access and examiner cooperation, and convert paper survey materials and data into a digital version. Due to the ability to backup, safeguard, and prevent illegal access to digital documents, digitization also improves data security and integrity. The digital survey examination system may take full advantage of digital technology by integrating thorough digitization procedures, which improves survey data management, accessibility, and dependability across the examination workflow.

4.4 Exploring Legislative Constraints or Challenges in the Contemporary Cadastral Survey Examination System



DSG responses

LS Responses

Figure 22

4.4.1 Electronic Signatures

In the study conducted, it was clear that respondents were aware of the fact that the new electronic Survey Examinations System would face challenges in terms of legal frameworks governing the practice and examination of cadastral datasets. Chief among these challenges was the *lack of recognition and guidelines for electronic signatures*, as highlighted by 73% of respondents. The existing legal frameworks do not take into account the use of electronic signatures which is crucial in the digital examination process where documents such as survey reports require signatures from the examiner endorsing that the survey record has been checked for completeness and accuracy. The absence of a defined legal and regulatory environment for electronic signatures constitutes a significant constraint in transitioning the contemporary cadastral survey examination system to a digital platform.

4.4.2 Specification of digital submission requirements

Another outcome of the research conducted was there is no mention or specification of the requirements in terms requirements needed in the submission of land survey documents on an electronic system. 71% land surveyor by profession respondents indicated that the *lack of specifications of requirements needed upon submission of land survey documentation means that the new system will be contrary to the existing legislature governing the practice and* *procedures relating to land surveying*. Given the view, it becomes critical that there is a revision of the existing legislature governing land surveying in Zimbabwe in order for the electronic Examination System to be useful in the examination and administration of land in Zimbabwe.

4.4.3 Data Security and Privacy

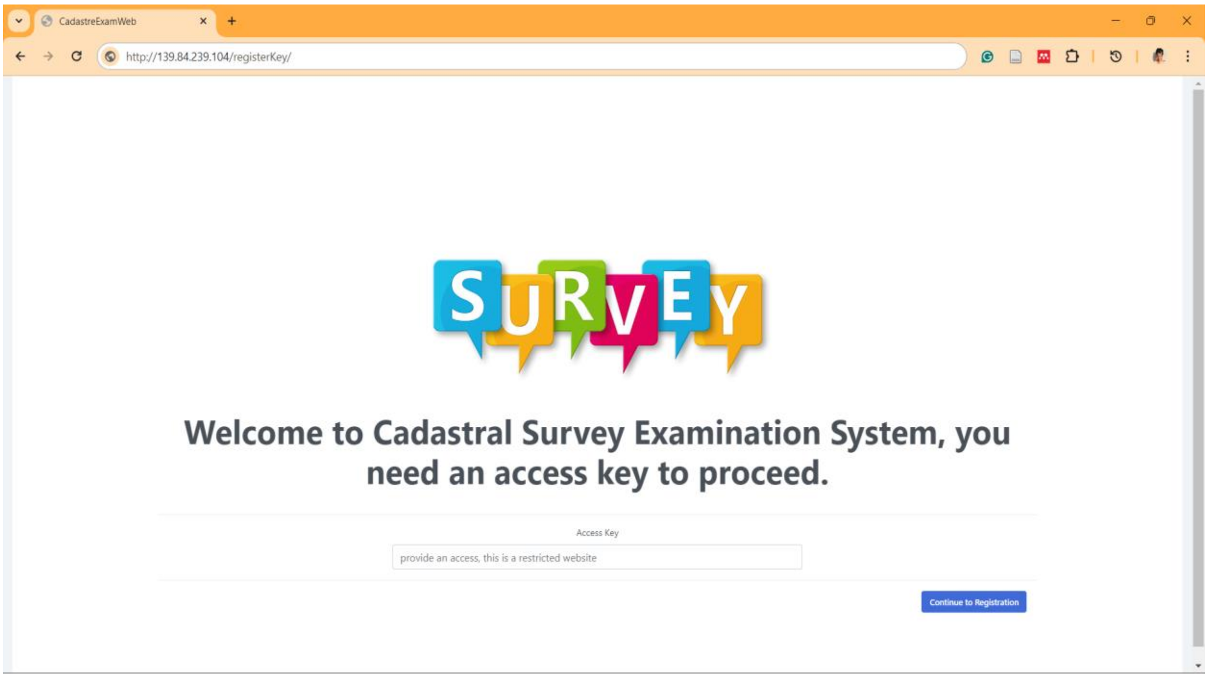
Apart from the legal challenges around electronic signatures, over 70% of respondents raised concerns regarding privacy and security especially in the use of a new electronic system in the lodgement and examination of land surveys. The Cyber Data Protection Act (2021) is in effect in Zimbabwe, but its rules on data security and privacy have several noticeable loopholes.

When it comes to specifying the necessary precautions to shield data from unauthorized use or access, the Act is very ambiguous. The controller, his or her representative, if any, or the processor "shall take the appropriate technical and organizational measures that are necessary to protect data from negligent or unauthorized destruction, negligent loss, unauthorized alteration or modification," according to Section 18, which deals with data security.

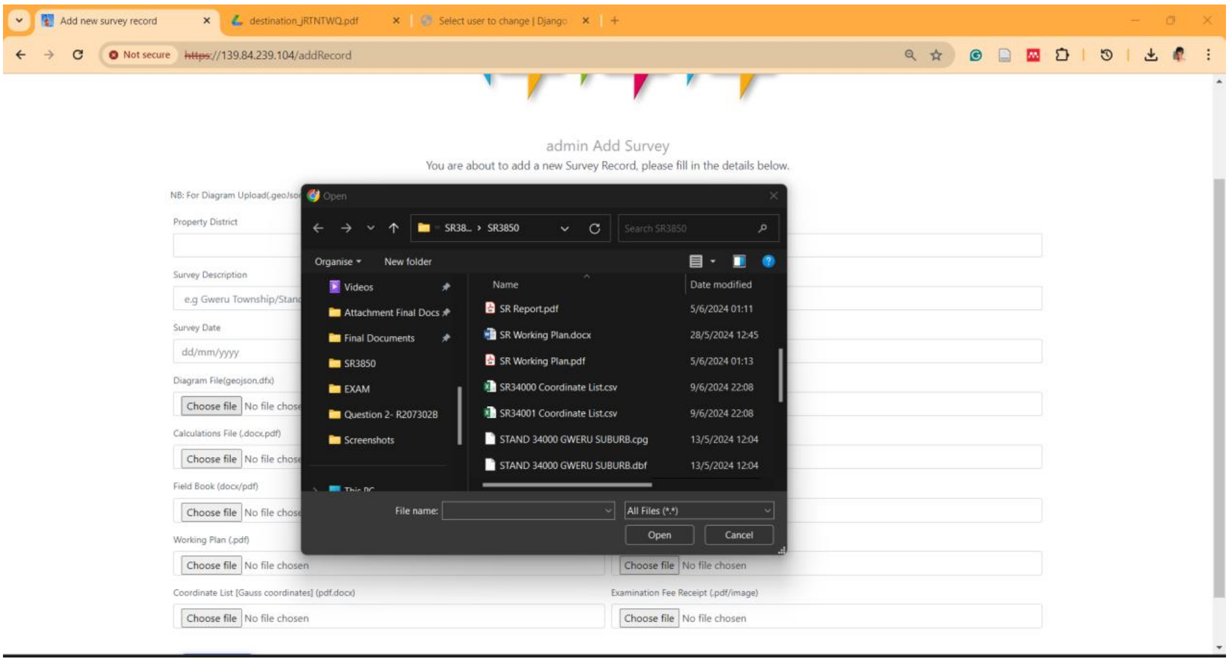
It further stipulates that the selection of these measures must take into account "the nature of the data to be protected and the potential risks to the data subject on the one hand, and the state of technological development and the cost of implementing the measures on the other." Respondents perceived this as a barrier to guaranteeing the proper security and privacy precautions for an electronic survey evaluation system since it leaves space for interpretation and ambiguity.

4.4.4 Standards for digital record-keeping

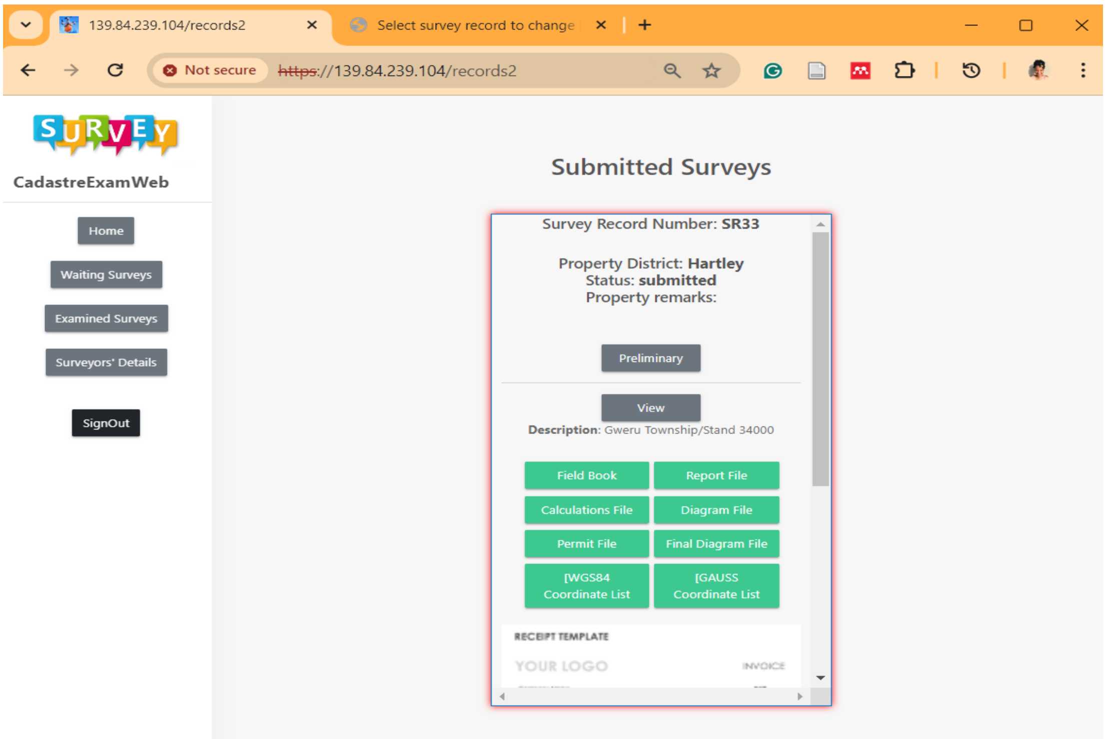
The absence of standards for digital record keeping is yet another challenge of constraint facing the contemporary electronic survey examination system. According to the results gathered from respondents, 58% pointed out that "*the absence of standards for digital record keeping*" in the present legislature means that the contemporary electronic survey examination system will constrained significantly as there is a need to define the standards by which all survey data sets being lodged and examined are recorded and kept digitally.



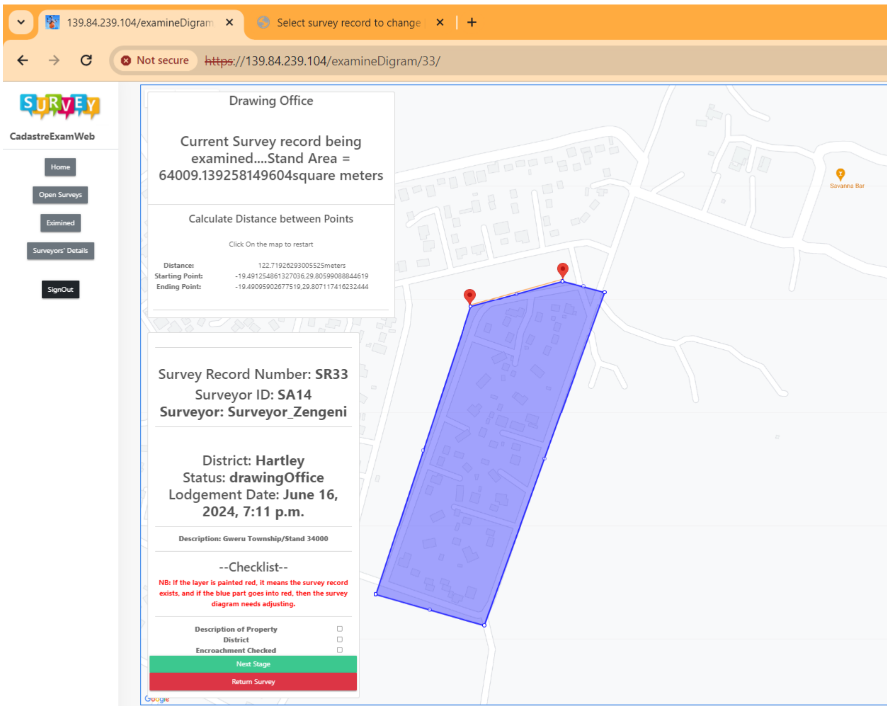
The restricted access to the system



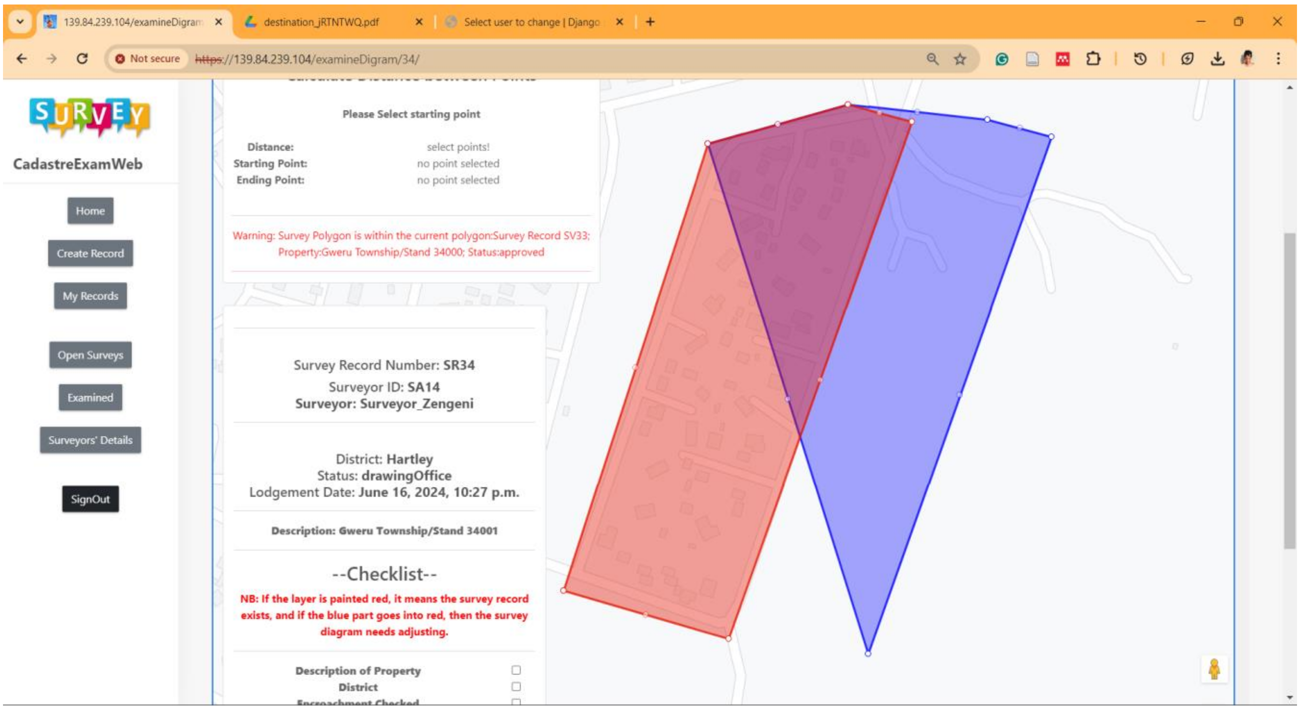
Lodgement of Survey Records by the Land Surveyors: A



Submitted Survey Record with assigned SR Number

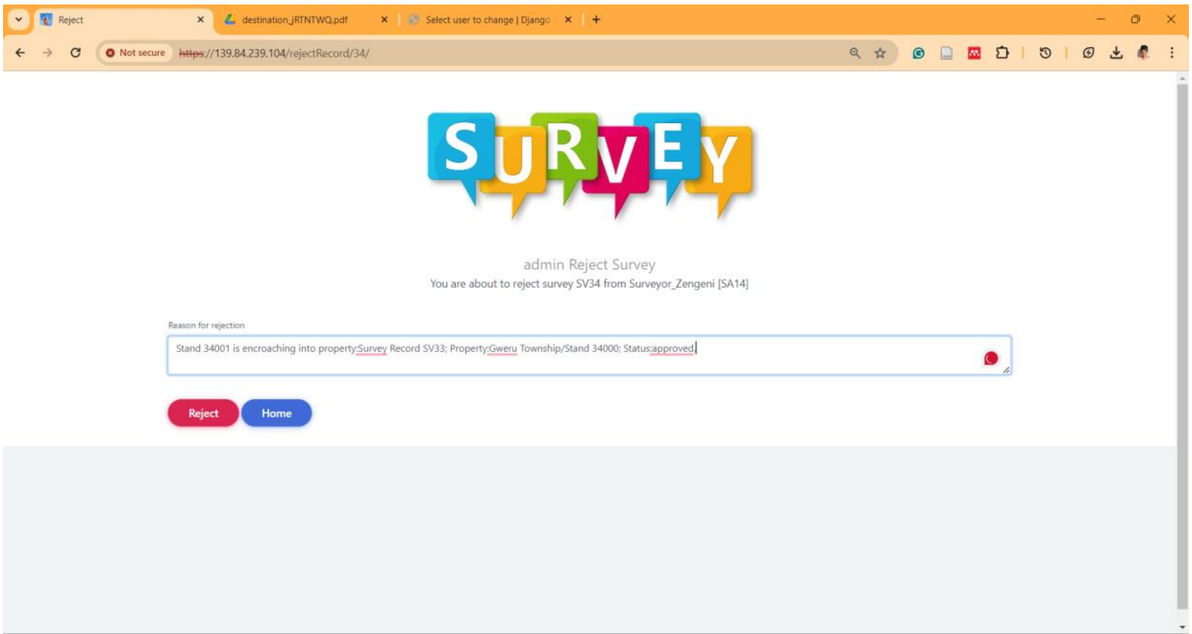


Drawing Office Stage: Area of property shown and distance between points calculated

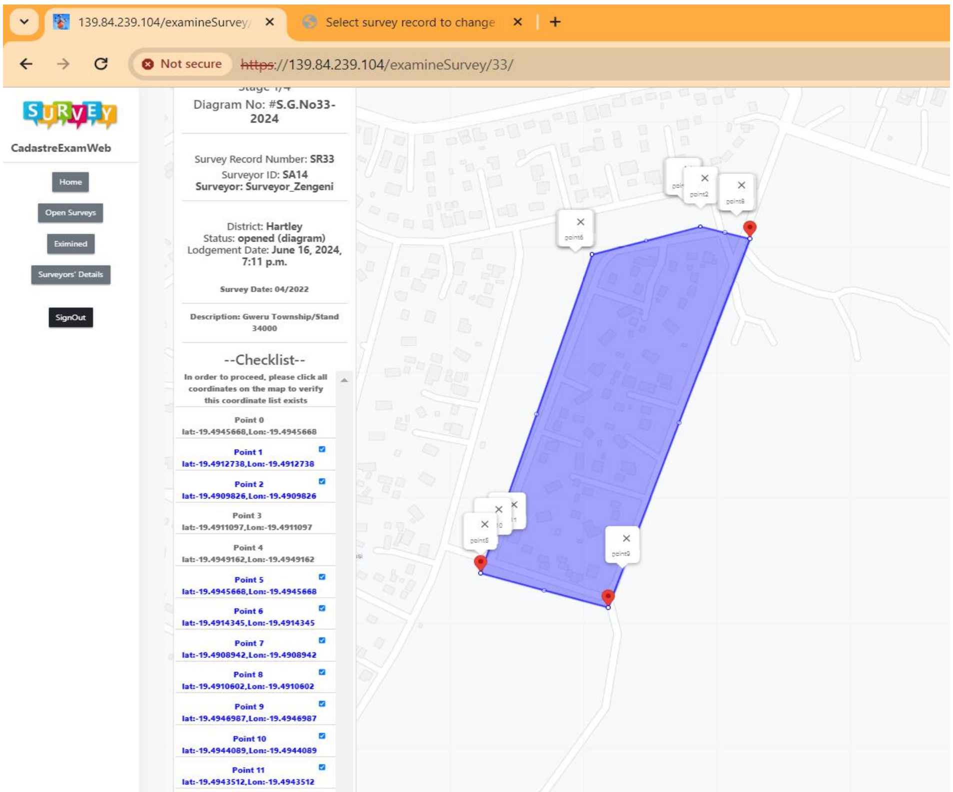


Automatic encroachment detection

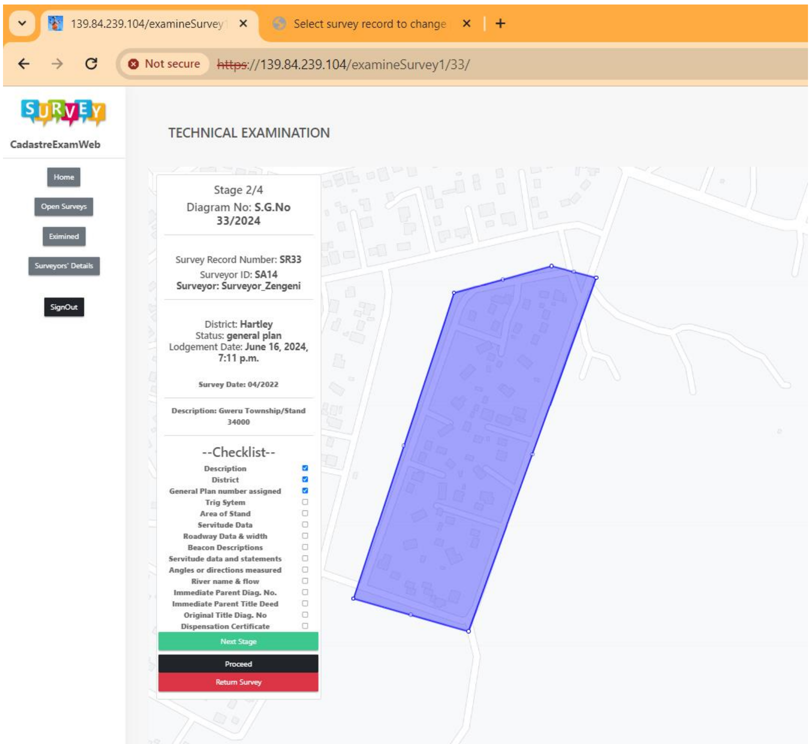
The figure above shows a property being currently being examined (blue) encroaching into another already existing and examined property(red) during the Drawing Office Stage. Information is produced on the survey description and SR Number of the encroached property.



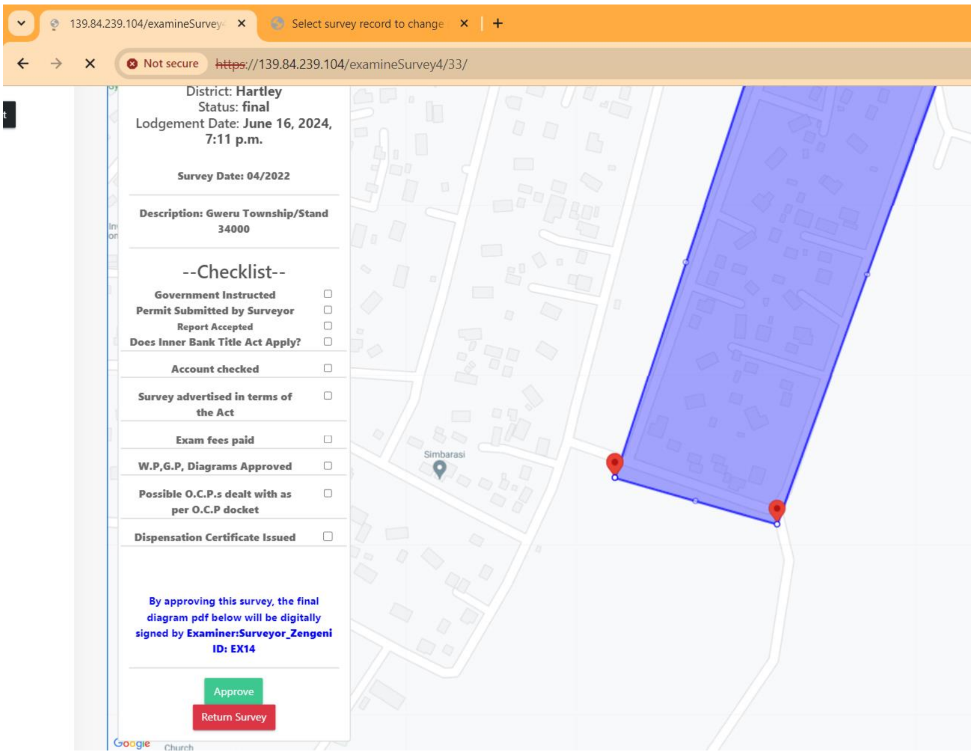
Sending SR Remarks to the LS



Technical Examination Stage: Verification of Coordinate List and Property Beacons as well as Work stations and Trig Stations



General Plan Checklist



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

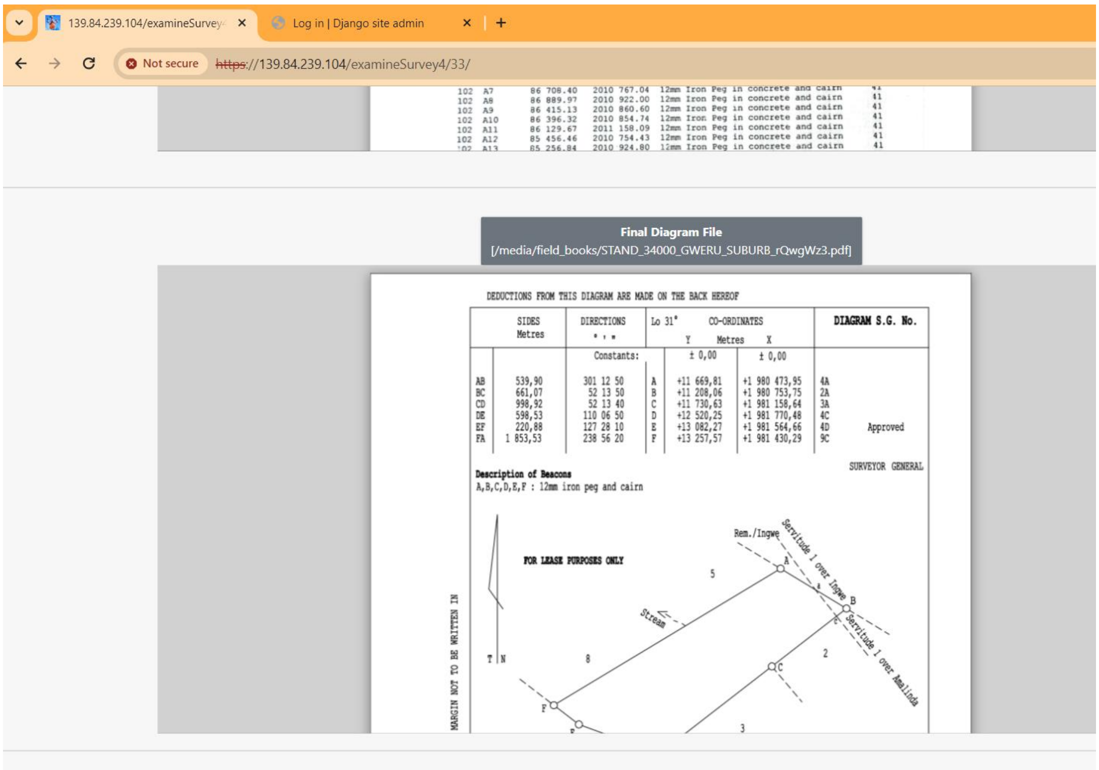
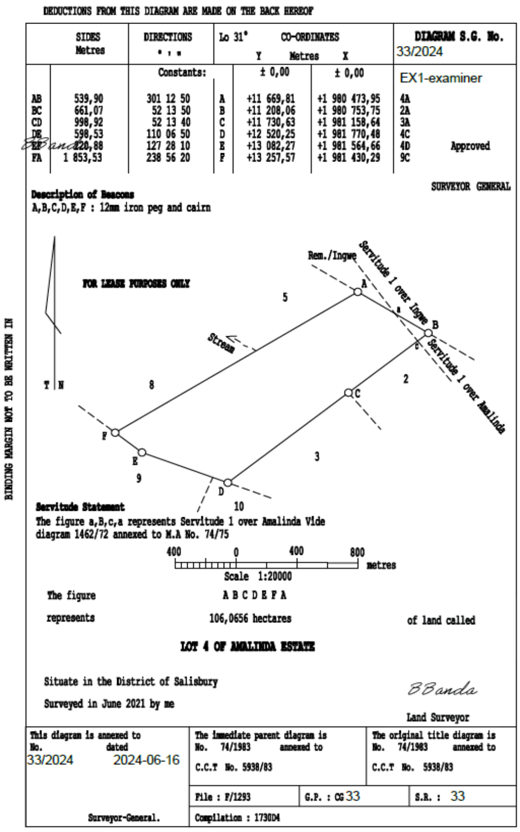
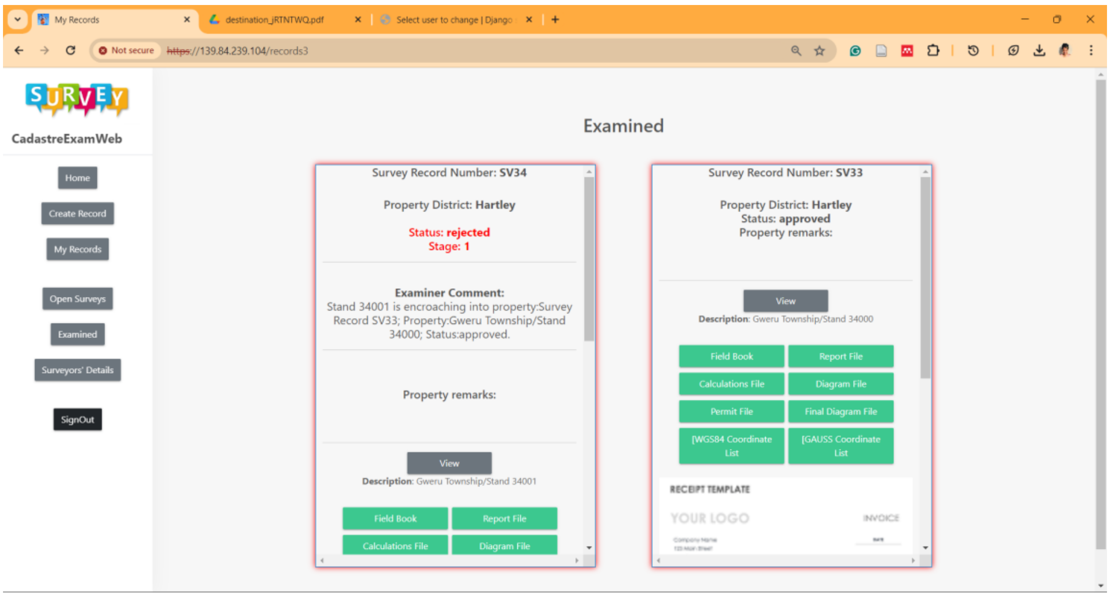


Diagram document before approval and signed



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

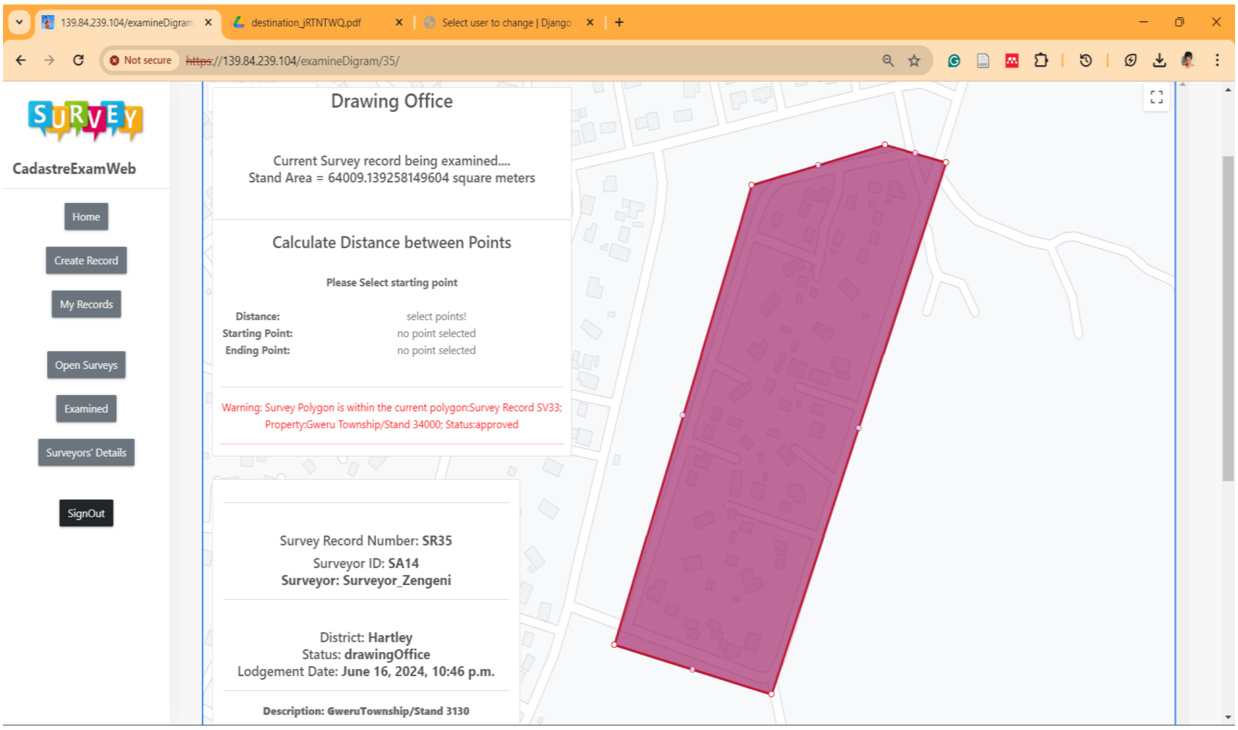


SR Remarks automatically appear at the Land Surveyor Online Dashboard.

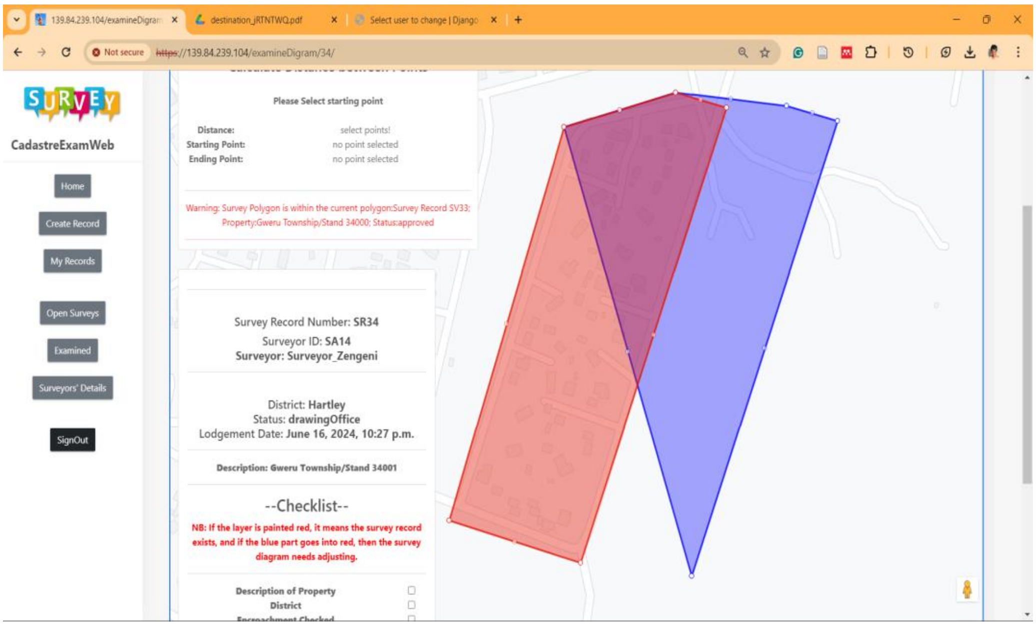
As the Survey Record moves from each stage to the next the status automatically reflects on the side of the Land Surveyor and therefore Land Surveyors can track the progress of their Survey Records in real time.

4.5.1 System Validation

Examiner cannot proceed to next stage without checking the details on the checklist



Self-validation: loading a property against itself.

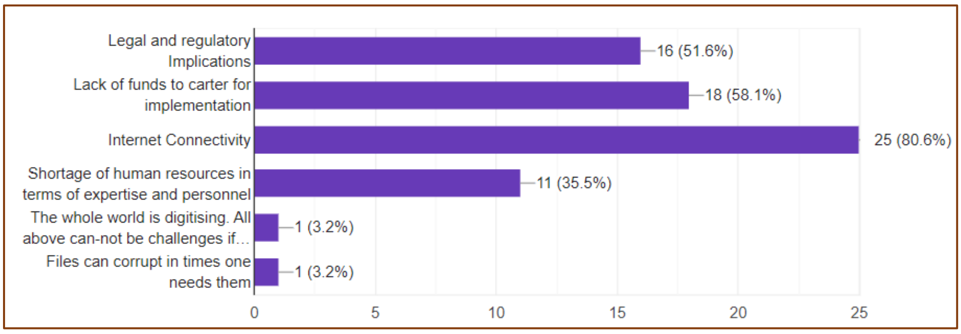


Automatic detection of encroaching property boundaries

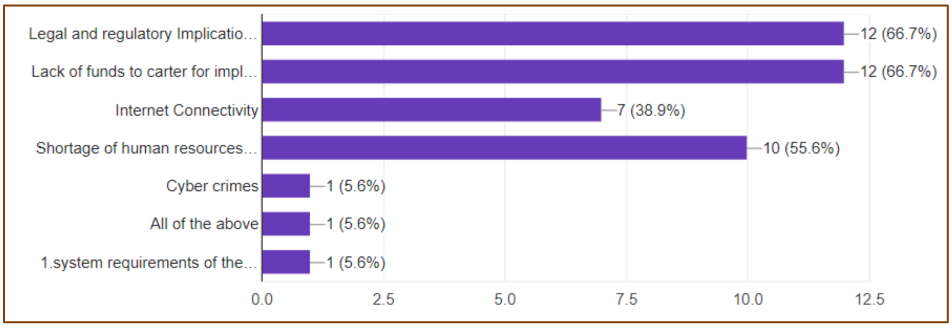
Table 1 shows results of the Prototype evaluation

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*

4.6 Integrating a Prototype Web-Based Survey Examination System: Challenges and Considerations in Alignment with Existing Survey Management Systems or Databases



LS Responses



DSG Responses

Figure 23 shows challenges which can be encountered whilst implementing and integrating the digital examination system in the industry

4.6.1 Internet Connectivity

In the study conducted, over 60% of respondents as indicated in figure 24 also point out another challenge noted as far as introducing a web-based survey examination system and integrating it with the existing survey management system- the issue of internet connectivity. '*One of the foremost challenges is ensuring stable and reliable internet connectivity*'. In many regions or organizations, internet infrastructure may be inadequate or prone to interruptions, hindering the seamless operation of a web-based survey examination system. "*Without consistent connectivity, users may face difficulties in accessing or submitting survey responses, potentially compromising data integrity and timeliness.*"

4.6.2 Shortage of Human Resources

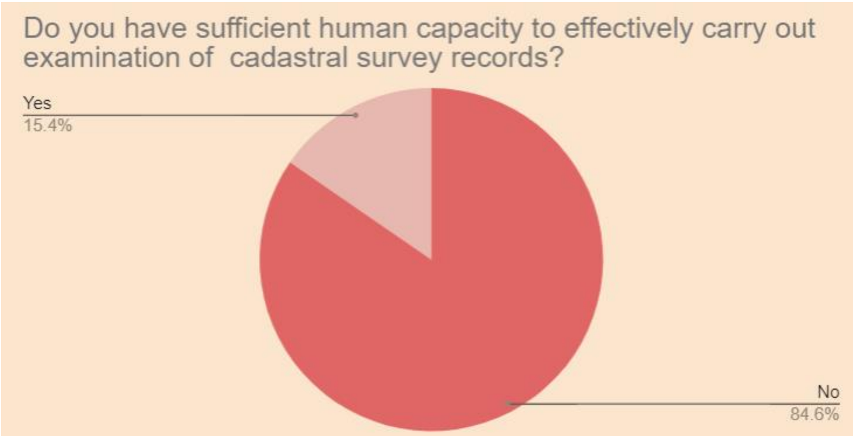


Figure 24 shows the DSG responses indicating that they have a shortage of human resources

4.6.3 Legal and Regulatory Implications

The most significant challenge, which cited by 59% of the respondents agree to is the legal and regulatory implications of transitioning to a digital system. This suggests that existing legal and regulatory frameworks may not adequately address or support the use of digital technologies in the survey examination process. Compliance with legal and regulatory frameworks is crucial when integrating a survey system, especially when handling sensitive data or conducting surveys in regulated industries. *"Ensuring adherence to data protection laws, privacy regulations, and ethical guidelines adds complexity to the integration process. Failure to address these legal and regulatory implications adequately could result in legal challenges or reputational damage for the Department of the Surveyor General. Therefore, there is need to change regulatory frameworks and laws governing land surveying practice in Zimbabwe so that it accommodates electronic survey lodgements and examination",* said one respondent.

4.7 Summary

The chapter centred on presenting the results derived from the applied research methodology that forms the foundation of this study. Within this chapter, the findings presented align with the research questions established in Chapter 1. The explored themes aimed to comprehend the obstacles encountered within the predominantly manual-based survey examination system to inform the development of the electronic survey examination prototype system, alongside outlining the requisites for the electronic survey examination system, among other pertinent considerations.

CHAPTER 5: SUMMARY, RECOMMENDATIONS AND CONCLUSION

5.1 Introduction

This section of the study provides a brief summary of research findings. In the chapter, a summary of the research and recommendations to challenges identified pertaining to the development of an electronic survey examination system in Zimbabwe will be provided. The Chapter will end with a conclusion.

5.2 Recommendations

In the study conducted, challenges with regards to the development and use of a Digital Survey Examination System in Zimbabwe were noted and the following recommendations are offered.

5.2.1 Legislative Constraints, Electronic Signatures and Standards for Record Keeping

On the challenge of legislative constraints or legislation which does not embrace the use of digital systems to not only lodge surveys but to examine surveys using digital technology. It is recommended that the Government of Zimbabwe should take a proactive stance in amending legislature governing land surveying in Zimbabwe and ensure that it allows for the use of ICT to lodge, examine and share survey records.

The amendment of existing legislature will pave way for the use of electronic signatures and approvals online thereby improving efficiency in the way records are approved as well as decisions are made. In addition, it reduces costs as surveyors no longer incur transport costs not only to lodge surveys but also to get approval signatures for their work.

The keeping of records is critical; however, their retrieval is even more essential when they are needed. The paper based or manual system being used at the moment is cumbersome and time consuming especially in retrieving records. It is therefore recommended that standards for record keeping and retrieval within an electronic survey examination system are established in order to ensure a safe, accurate and easy file storage system is in place.

5.2.2 Specification of digital submission requirements

Technology is always changing; the way business Is done within the Department of the Surveyor General has to change also with time. Therefore, it is recommended that the DSG should embrace the lodgement of survey records digitally. However, there is need for the government of Zimbabwe through responsible ministries to establish which documents are crucial for submission and in what form are they supposed to be submitted. In the study conducted, respondents especially land surveyors highlighted that a select document are pertinent for submission and others can be eliminated as they are of low priority. Therefore, with the use of an electronic system there is need to specify which documents can be submitted digitally as some can also be replaced through the use of digital systems.

5.3 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.

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