

**DEVELOPMENT OF AN INTEGRATED SYTEM TO ENHANCE
SPATIAL DATA PROCESSING & MANAGEMENT FOR PLANNING
AUTHORITIES**

BY

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I, Clayton Lumwaya do hereby declare that this dissertation is my own original work and has not been submitted to any other college, institution, or university other than the University of Zambia.

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APPROVAL

This dissertation, by Clayton Lumwaya has been approved as partial fulfilment of the requirements for the award of Master of Geoinformation Science and Earth Observation by the University of Zambia.

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DEDICATION

This dissertation is dedicated to my beloved wife, Francin. I extend my heartfelt gratitude for her unwavering love, sacrifice, and patience during the demanding periods of my schoolwork. Her support has been a source of strength and inspiration throughout this journey.

ABSTRACT

In a world where there is constant data generation and processing, the need for an integrated system cannot be overemphasized. The systems that enable the storage of large amounts of spatial data and available to multiple users in real time. However, studies have shown that standalone desktop spatial systems are often rigid and inflexible to support multiple data processing or demands from multiple users, highlighting the inability of traditional systems to effectively manage the ever-growing volume and complexity of spatial data.

Recognizing this challenge calls for a paradigm shift toward integrated spatial management systems. These systems are designed not only to store spatial data efficiently but also to provide a dynamic and flexible framework that can adapt to the evolving demands of data processing requirements. By seamlessly integrating various tools and platforms, integrated spatial management systems offer enhanced accessibility, visualization, and processing of spatial information. The Integrated Spatial Management System, born out of these considerations, stands as a testament in overcoming the limitations of traditional desktop spatial systems. Its core objective is to unlock the full potential of spatial data utilization, promoting accessibility, visualization, and efficient processing. The research employed a quantitative approach. This approach played a pivotal role in gathering field data, contributing to the design and development of the prototype.

Recent research aimed to assess the state of integrated spatial data systems among targeted institutions, revealing that 71.4% of these entities did not have integrated spatial data systems, while 28.6% had partial integration. In response to this gap, the study focused on developing an integrated spatial system architecture that would allow for seamless querying of both spatial and non-spatial data. A significant milestone was the distribution of the database across various platforms, promoting adaptability and flexibility in data management.

The integration process combined existing data management tools used by local authorities, like desktop GIS, with innovative interfaces such as WEB-GIS and Mobile GIS. This approach facilitated real-time web access and data collection, significantly enhancing the capabilities for data manipulation, analysis, and visualization. A key achievement during the project was the implementation of streamlined automated map production, which offered users efficient tools for generating maps for a range of applications.

The integrated system did more than just advance technology; it transformed the approach to data management in planning authorities. The ability to exchange, share, and process data through multiple access points yielded substantial efficiency gains. This allowed users to conduct deeper spatial analyses, identify patterns, and derive valuable insights from the integrated datasets. The automated map production further optimized the system's capabilities, making map generation more efficient and versatile.

Keywords: Geographical Information Systems, Planning Authorities, Integrated Spatial Management System

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LIST OF ABBREVIATIONS

- 1) AWS - Amazon Web Services
- 2) C# - C Sharp (Programming Language)
- 3) CAD - Computer-Aided Design
- 4) DEM - Digital Elevation Model
- 5) GHZ - Gigahertz
- 6) GIS - Geographic Information System
- 7) ICT - Information and Communication Technology
- 8) ISDS - Integrated Spatial Data Systems
- 9) JSON - JavaScript Object Notation
- 10) RAM - Random Access Memory
- 11) SQL - Structured Query Language
- 12) SPSS - Statistical Package for the Social Sciences

1 INTRODUCTION AND BACKGROUND

Introduction

The concept of Integrated Spatial Systems can be defined as an automated process used to combine multiple spatial tools and data types to augment data storage, retrieval, and visualization in real-time (Gill, 2008; Goodchild et al., 2005). This integrated system architecture encompasses various spatial data characteristics, software features, hardware capabilities, and automated processes (Goodchild et al., 2005). Integrated GIS (Geographical Information System) spatial data systems offer a highly flexible platform for collecting data from multiple sources in various formats, including the capability to convert analog data into digital (DiSera & Johnson, 2012). Moreover, according to Esri (2014), integrated Geospatial tools enhance data processing and visualization by enabling access to data in diverse formats (Gill, 2008). Furthermore, these systems facilitate data visualization in multiple formats such as graphs, tables, and texts, recognized as the most efficient approach to presenting geographical information (Killpark, 2005).

The system integration requires a combination of diverse computational tools and processes into purpose-specific inputs and outputs which also enable the synchronization of data in real time. The workflows of the integrated system architecture integration are implemented in conventional scripting and with a dedicated scientific workflow management system, which typically require integrated input and output data types and format. The concept of Data Management relates various activities relating to the planning, development, implementation, and administration of systems for the acquisition, storage, security, retrieval, dissemination, archiving, and disposal of data (Hendriks, 2005). The management of geographic data is in many ways no different from the management of other types of data. However, it is important to recognize that there may be geography-specific issues that need careful thought as part of Data Management activities; for example, ensuring that different users, even those with limited GIS knowledge can easily utilize the spatial data (Gediminas, 2019).

Modern technologies in spatial planning include the employment of Web GIS as part of an internet-based system for service delivery. Web GIS is basically GIS embedded into the authorities' web page which facilitates the delivery of 'e' services to citizens so that they have instant access to services provided by the authority (Diaz, 2021). A Web GIS system incorporates the use of the powerful tools of a desktop GIS such as capturing, viewing, storing, analysis, managing and manipulation of data into an organization's website platform. Its main advantages among others include its simplicity and availability, as it allows for easy

access to geo-referenced information and multiplicity of users at a go using a simple web browser. An internet-based system incorporating Web GIS can, therefore, be a very useful complementary tool in processing of service delivery as it can provide for online submission of plans by clients, while restricting access to submitted plans for scrutiny to relevant officers, as well as enhance horizontal coordination among departments involved in the issuance process. In today's fast-moving and highly technological landscape, the use of GIS in Urban development and management is not only important, but it is a necessity (Farkade & Kaware, 2015).

With the relentless advancement of technology, the significance of digital spatial data has experienced exponential growth. Positioned as a pivotal tool for decision-making, entities spanning the public sector, private businesses, and the public are actively engaged in the collection and generation of spatial data (Diaz, 2021). The applications of spatial data are diverse, ranging from strategic planning and risk assessment to route determination and site selection. However, the production and collection of spatial data are intricate and resource-intensive processes, demanding considerable time and financial investment (Gupta, 2019). The conversion of spatial raw data into usable spatial data adds another layer of complexity, requiring the expertise of specialists, professionals, and individuals with advanced knowledge in the field (Gupta, 2019).

Spatial data collection faces numerous challenges, further complicating spatial data management process. Among the prominent hurdles are the lack of coordination and collaboration, leading to duplicate or parallel activities in the spatial data collection process across different organizations (Farkade & Kaware, 2015). This redundancy not only consumes material resources but also places a strain on human resources, making the overall process more cumbersome. The lack of a unified data collection standard can lead to inconsistencies in data quality and interoperability issues across systems (Choi et al., 2016). Additionally, ensuring data privacy and security in a geospatial context presents unique challenges, especially with the increasing volume and sensitivity of location-based data. Integrating data from various sources while maintaining accuracy and relevance is another key challenge faced by spatial data collection efforts, requiring sophisticated tools and methodologies to address these complexities effectively (Hostadvice, 2019).

The implementation of Integrated Spatial Infrastructure (ISI) is an essential component in the field of spatial data management because it is necessary to take a strategic approach to address the challenges in spatial data management (Gurau & Duquesnois, 2011). The ISI acts

as a foundational framework, facilitating collaboration for the purpose of methodical data management, secure storage, and seamless transmission (Diaz, 2021). The Spatial Data Infrastructure (SDI) offers a comprehensive solution that goes beyond the technical aspects and encompasses the social, institutional, political, and financial dimensions (Gurau & Duquesnois, 2011).

It is important to note that spatial data infrastructures, also known as SDIs, are comprehensive solutions that depict collaborative environments that are specifically designed for spatial data management (Diaz, 2021). Due to the fact that SDIs incorporate financial, social, institutional, and political dimensions, their significance extends beyond the technical considerations that are taken into account (Hendriks, 2005). In its most basic form, spatial data infrastructures (SDIs) serve as an umbrella term that encompasses the entire spectrum of challenges that are associated with the field of spatial data management.

Fundamentally, SDI operates as an all-encompassing framework that goes beyond the limitations that are typically associated with technology. Although it simplifies complex organizational processes related to spatial data in a methodical manner, the true value of this tool lies in the fact that it incorporates elements from a wider range of fields, including the political, social, institutional, and financial spheres (Heywood, 1997). Through the application of this nuanced perspective, SDI is established as a powerful instrument for analyzing the complex dynamics that exist between spatial data and the larger socio-economic and political context.

The integration of Integrated Spatial Infrastructure (ISI) and Spatial Data Infrastructure (SDI) emerges as a crucial strategy in the process of navigating the complexities of spatial data management (Bossler et al., 2016), (Luzet, 2004). These frameworks not only facilitate efficient data handling but also foster collaboration across social, institutional, political, and financial spheres (Kriel, 1994). (Luzet, 2004). They do this by transcending technical limitations and encompassing diverse dimensions. Other benefits include the fact that they facilitate efficient data handling. The implementation of a unified and all-encompassing strategy becomes an absolute necessity when one considers the ever-increasing difficulties that are present in our data-fueled environment. Ensure that spatial data continues to be an asset for informed decision-making in our rapidly evolving industries by playing a central role in coordinating stakeholders and instilling a cooperative ethos in data governance. This is accomplished through the International Space Institute (ISI) (Kubbara,1997). The adoption of

this holistic perspective is essential to fully exploit the potential of spatial data in the context of our ever-increasingly complex technological landscape.

Background

Digital geographical data is becoming more and more significant as technology advances. The usage of spatial data systems for handling big and heterogeneous geographical databases for spatial planning has recently attracted increased interest because of the significant effect of information technologies (IT). Spatial data systems operations have been effective in storage, collection of significant volumes of data as well as a selection of appropriate integrated tools to support decision making (Gediminas, 2019). Both the public and various institutions are actively engaged in gathering and generating geographical data, positioning it as a critical decision-making tool. However, the development and collection of spatial data demand significant effort and resources. This process necessitates the involvement of specialists, experts, and advanced skills for creating spatial data from raw data. The challenges in spatial data collection are compounded by various significant issues, including the absence of standardized tools and systems to meet contemporary geospatial demands. Such redundancy in work not only consumes human and financial resources but also underscores the pressing need for streamlined and efficient approaches (Kilpack et al., 2005).

Institutions worldwide have developed robust Spatial Data Infrastructure (SDI) plans, recognizing their significance in various sectors. However, the pivotal determinant for the successful execution of these plans lies in political support. This necessitates a deep comprehension of SDI and Geographic Information Systems (GIS) by policymakers and politicians at the national level. Without such understanding, securing the essential endorsement and resources for effective SDI implementation becomes arduous. This underscores the global imperative for policymakers to grasp the pivotal role of SDI and GIS technologies in driving societal progress and facilitating informed decision-making across diverse domains (Gediminas, 2019).

Spatial planning institutions, such as Planning Authorities, grapple with the challenge of integrating diverse data from a multitude of sources, including private sector, traditional government agencies, and non-governmental organizations. This integration is vital for ensuring effective service delivery and facilitating informed decision-making processes (Jao & Fronseca, 1996). Historically, the integration of large volumes of heterogeneous data was deemed complex. However, with the advent of technologies such as big data analytics, cloud computing, and geospatial technology, this landscape has undergone a significant

transformation. These advancements enable real-time assessment of disparate datasets, thereby facilitating the utilization of urban data for purposes such as knowledge discovery, public engagement, and advancements in Urban Informatics (Esri, 2014).

The rapid growth of Zambia's population poses significant challenges for planning authorities, making it intricate to plan and provide quality services for the population. Managing, processing, and storing larger volumes of applications for various services become urgent concerns, impacting the quality of services provided to residents and the living environment (Gediminas, 2019). Despite the gravity of these challenges, the emergence of these issues sparks innovation and the generation of new ideas on how to adeptly handle population growth and its associated complexities. This shift in perspective fosters a proactive approach to problem-solving and the exploration of innovative solutions in response to the evolving landscape of spatial planning.

In a developing nation like Zambia, there are several obstacles that make it difficult to access spatial data, which in turn creates barriers to the capacity for efficient planning and decision-making processes. An important obstacle is the limited technological infrastructure, which makes it difficult to access spatial data in a seamless manner. Inadequate internet connectivity and digital resources are particularly problematic in this regard. Another significant challenge lies in the scarcity of skilled professionals with expertise in geospatial technologies. Developing countries often grapple with a shortage of professionals trained in Geographic Information Systems (GIS) and related fields (Gediminas, 2019). The lack of skilled personnel capable of harnessing the potential of spatial data compromises the effective utilization of available resources. Bridging this skills gap is crucial for enhancing accessibility and ensuring that the benefits of spatial data can be fully realized in planning and decision-making processes (Esri, 2014).

Moreover, financial constraints pose a formidable challenge in developing countries, limiting the investment in advanced geospatial technologies and infrastructure. The costs associated with acquiring, implementing, and maintaining such systems can be prohibitive, impeding the ability of planning authorities to establish robust spatial data systems (Kriel, 1994). The limited financial resources also affect the capacity to conduct comprehensive data collection and update existing datasets regularly. This financial constraint contributes to an information gap, hindering the development and implementation of data-driven policies that could significantly improve the quality of services and infrastructure in the country (Kubbara, 1997).

Addressing these challenges requires a concerted effort from stakeholders, including government bodies, international organizations, and the private sector. Investment in technological infrastructure, educational programs to build a skilled workforce, and strategic financial planning are essential steps toward overcoming these hurdles. By systematically addressing accessibility challenges, Zambia can unlock the full potential of spatial data, fostering sustainable development and effective urban and rural planning initiatives (Gill, 2008).

The Zambia National Information and Communications policy (2006), also recognizes the need for new technology as it identifies electronic interactions and transactions as primary in delivering public services due to advantages such as up-to-date information; convenience and ease of use; strong local support and participation; decentralized platforms; “anytime, anywhere” availability etc. (Scouter, 2010). However, according to research by (Scouter, 2010), adoption of ICTs in providing public services both at national and local government level in Zambia is mostly limited to providing basic information online. He further states that ICT platforms available in government agencies do not provide for two-way interactive applications that provide citizens with opportunities for online transactions as well as systems that facilitate better coherence, integration and coordination of processes and systems within and across government agencies (Scouter, 2010). The impact of Information and Communication Technologies (ICTs) is undeniable, as they significantly influence the execution of service delivery with remarkable efficiency and effectiveness. The significant influence of information and communications technology is especially expected in the domain of planning authorities. As the need for improved efficiency in delivering services continues to rise, the integration of Information and Communication Technologies (ICTs) becomes more and more essential. The primary objective is to optimise processes, thus diminishing the time typically required for these activities (Scouter, 2010). Although ICTs have significant potential to improve service delivery, the unfortunate truth is that various technological barriers impede their smooth integration into existing industrial practices (Gurau & Duquesnois, 2011). This poses a considerable obstacle to fully harnessing the transformative capabilities of these technologies (Scouter, 2010).

The obstacles encountered in the implementation of these technologies highlight the necessity for comprehensive strategies to tackle and surmount these difficulties. This may entail allocating resources to build resilient infrastructure, promoting proficiency in digital skills, and creating flexible frameworks that cater to the unique requirements and intricacies of

various sectors (Scouter, 2010). To fully harness the numerous advantages that ICTs can offer to industrial practices, it is crucial to surmount these technological obstacles (Scouter, 2010) (Jao & Fronseca, 1996). Essentially, the revolutionary potential of information and communication technologies lies in their ability to transform service delivery and improve operational efficiency (Scouter, 2010), (Gediminas, 2019). Recognising and resolving the current technological obstacles is an essential measure to fully utilise the capabilities of ICTs and ensure their smooth integration into modern industrial practices.

Information is a valuable resource capable of driving significant transformations in social and economic progress (Gurau & Duquesnois, 2011). ICTs play a crucial role in addressing the planetary disparity within the context of globalization (DiSera & Johnson, 2012). The disparity restricts individuals from accessing and utilizing best practices in their respective contexts due to the presence of barriers (Killpark et al., 2005). Zambia, along with other developing countries, has the capacity to bring about significant change by embracing and utilizing ICT as a strategic instrument (Gill, 2008). Through the utilization of ICT, Zambia can reduce the inequalities in development, thus increasing the chances of a better quality of life for its population (Scouter, 2010) (Budic, 1994).

Furthermore, the strategic integration of ICT not only addresses immediate challenges related to information access but also fosters a more inclusive and participatory society (Scouter, 2010). By leveraging technology as a catalyst for socio-economic advancement, Zambia can empower its citizens with knowledge, enhance educational opportunities, and facilitate the efficient delivery of essential services (Scouter, 2010). Additionally, the adoption of ICT can spur innovation, opening new avenues for entrepreneurship and economic growth. As Zambia navigates the dynamic landscape of the digital age, embracing ICT represents a transformative journey towards a more interconnected, informed, and resilient nation, capable of meeting the evolving needs of its diverse population (Scouter, 2010). ICT enables the creation, access, utilisation, and dissemination of information and knowledge, leading to the establishment of an information-centric society (Farkade & Kaware, 2015). The ability to transform contributes to enhanced productivity, heightened competitiveness, and sustainable economic growth, which are essential requirements for reducing poverty (Gupta, 2019). Hence, the deliberate incorporation of ICT into the developmental agenda has the potential to not only reduce the global development disparity but also promote a fairer and more prosperous future for Zambia and its inhabitants.

Statement of the Problem

Planning authorities in many developing nations like Zambia, face substantial obstacles when it comes to the widespread implementation and efficient utilization of Geographic Information Systems (GIS) (Scouter, 2010), (Hostadvice, 2019). One of the main obstacles is the inadequate technological infrastructure, which hinders the smooth implementation of GIS solutions through restricted access to contemporary computing facilities, limited internet connectivity, and obsolete hardware (Diaz, 2021). The insufficiency of technology hinders planning authorities from effectively utilizing GIS to analyse spatial data and make well-informed decisions. In developing countries, investments in GIS technologies are impeded by financial constraints, which include costs associated with software licensing, hardware upgrades, and critical training programs. The fiscal burden poses a challenge for planning agencies in commencing and maintaining GIS initiatives, thereby constraining their ability to fully exploit the advantages offered by geospatial technologies (De Vries, 2006).

A significant obstacle arises due to the scarcity of proficient individuals who are extensively familiar with GIS applications (Bossler et al., 2016). Developing nations frequently face challenges in assembling a proficient labour force specializing in GIS application development, data analysis, and geospatial technologies. The limited availability of proficient personnel presents a significant barrier to the successful integration and continuous administration of GIS tools in governmental planning organizations (Mzyece, 2012), (Farkade & Kaware, 2015).

The accessibility and dependability of geospatial data represent an additional urgent obstacle (Gurau & Duquesnois, 2011). Numerous developing nations encounter challenges pertaining to spatial data that is inadequate, antiquated, or erroneous, thereby undermining the credibility and effectiveness of GIS applications utilized in planning endeavours (Scouter, 2010). The establishment of comprehensive databases and the assurance of data quality are significant challenges that have a direct bearing on the effective integration of GIS authority (Diaz, 2021). Additionally, the mere lack of knowledge among planning authorities regarding the potential advantages and implementations of GIS introduces an additional stratum of intricacy (Kriel, 1994). The insufficiency of training opportunities for government officials and planners serves as an additional barrier to the efficient implementation of GIS tools, thereby impeding the complete realization of their capacity to improve planning processes (Scouter, 2010) (Choi et al., 2016). Institutional obstacles, including bureaucratic impediments and resistance to change, are substantial factors that hinder the smooth

integration of GIS into established planning procedures (Gupta, 2019). Underutilization and sluggish adoption of geospatial technologies within planning authorities result from the absence of clear policies and strategies for GIS implementation (Gediminas, 2019).

The current landscape of geospatial technologies is undergoing a transformative shift from traditional desktop GIS solutions to integrated systems with diverse access modes (Gupta, 2019). While these advancements offer new possibilities for spatial data utilization, they also promise improved accessibility, visualization, and processing of spatial information. However, the prevalent use of standalone desktop GIS applications presents challenges, as they often operate locally, hindering cross-collaboration among users within organizations or departments (Gediminas, 2019). This isolation can negatively impact data processing quality, work transparency, and collaborative efforts (Scouter, 2010).

Standalone desktop spatial databases, due to their rigidity, struggle to support the dynamic data processing demands from multiple users, necessitating significant additional custom development at an associated cost (Mzyece, 2012). Therefore, there is a pressing need for a system capable of seamlessly transferring and processing data from diverse sources, encompassing both spatial and nonspatial data (Fourie, 2008). This approach fosters information and knowledge sharing, enabling the effective utilization of up-to-date spatial information and facilitating collaboration among various data providers on open platforms (Gurau & Duquesnois, 2011).

Furthermore, the existing database management system employed in handling planning applications relies on a manual filing system (Gupta, 2019). This not only complicates the retrieval of plans but also proves time-consuming and demands substantial floor space for storage. The physical movement of building plans in paper form across different offices further exacerbates the inefficiencies, making it challenging to track progress. These limitations underscore the urgency to explore the integration of an Internet-based system as a complementary tool (Mzyece, 2012), offering a more efficient and streamlined approach to address these challenges in spatial data processing and management for planning authorities (Scouter, 2010).

Aim of the Study

To develop an integrated system that enhances spatial data management and processing.

Research Objectives

- i To establish common spatial data management systems in use by Planning authorities.
- ii To develop a data integrated management system based on gaps on (1).
- iii To develop a data collection application-based model on (2).

Research Questions

- i What common spatial data management systems are in use by Planning authorities?
- ii To what extent can an integrated system enhance spatial data management and processing?
- iii How can a mobile application prototype model enhance spatial data management and processing?

Significance of the Study

The significance of the study extends to both the global context and the institutional level within planning authorities. At the global level, the integration of geospatial data management tools and web technologies represents a crucial step towards enhancing accessibility and efficiency in spatial data utilization. In an era where the demand for spatial data transcends geographical boundaries, the development of systems that streamline data accessibility becomes imperative for organizations worldwide.

Within planning authorities, the adoption of emerging technologies like Web GIS holds immense significance. These technologies not only facilitate the processing and visualization of GIS data but also enable the delivery of electronic services ('e-services') to citizens. By embedding GIS functionalities into web platforms, planning authorities can offer instant access to services, fostering greater transparency and efficiency in governance (Diaz, 2021). Moreover, the integration of spatial systems into organizational websites enables seamless collaboration and coordination among departments involved in various processes, such as building permit issuance.

In a rapidly evolving and technologically driven landscape, the utilization of integrated spatial data processing systems is no longer merely advantageous but has become a necessity. Planning authorities globally recognize the importance of leveraging such systems to optimize their operations, enhance decision-making processes, and ultimately, better serve their constituents. Therefore, the significance of this study lies in its contribution towards advancing spatial data management practices, not only at the institutional level but also within the broader global context of urban and regional planning.

Scope of the study

Study aims is to develop an integrated system to enhance spatial processing and management in local and planning authorities. This will create an integrated platform where data can be processed and visualised using different platforms and tools. This research study was carried out in Lusaka district of Lusaka province of Zambia. The system prototype was tested using the Lusaka Provincial Planning Authority.

Organization of the Dissertation

The dissertation is divided into five chapters. Chapter One covers the introduction to the dissertation and information on the background of the study. The statement of the problem is given, followed by the aim and objectives. The research questions, scope and significance of the study are also covered in this chapter. Chapter Two outlines the various literature done by different scholars on the subject matter, identifying findings and gaps. Chapter Three highlights the methodology that was employed to carry out the study, discussing the design, population, data collection methods, techniques, and analysis. The proposed research method, hypothesis and ethical considerations are also covered. Chapter Four presents the analysis of the collected data. The chapter also tests and presents the results of the hypothesis stated in Chapter three. It will interpret, discuss, and conclude the results the research results. Chapter Five answers the study questions discussed in the first chapter. Conclusions and recommendations are given based on the findings of the study.

Chapter Summary

Chapter one serves as an introduction to the research project and starts with the research introduction to the concept of spatial data management. In this chapter, it was highlighted that application of integrated geographic information systems and web technologies offered more advantages over traditional planning methods (Budic, 1993) In addition, (Arrowsmith et al, 2007) claims that Web-GIS serves as a viable tool for data management, processing, and visualisation and these are key components of a spatial data-based system. Therefore, having noted the problem, the objectives of the study were set, and associated research questions asked as a way of guiding the research process.

2 LITERATURE REVIEW

Introduction

This chapter defines the important terminologies applied in this scientific research. In addition, the chapter further reviews relevant literature related to environmental impact assessment and its supplementing application which is Web GIS. This chapter further draws lessons from those cases to establish a practical understanding of the topic.

Background to the Study

2.1.1 Geographic Information System (GIS) Concept

The Geographic Information System (GIS) is a collection of computerised tools, both hardware and software, that are used to collect, store, retrieve, transform, process, and display mapping information. In addition, GIS is a computer system that is able to manipulate, and display information that is tied to specific locations in relation to geography. In its most basic form, geographic information systems serve as a connection between computerised mapping and database systems (Gill, 2008) (Choi et al., 2016). GIS databases contain a wide range of information, including demographic, social, political, and environmental data (Goodchild et al., 2005). Layers are used in geographic information systems to display various types of information. Each layer represents a category of information regarding environmental parameters, such as roads, vegetation, settlements, forest cover, and different types of information. In addition, Geographic Information Systems permits the extraction of distinct data sets from a variety of sources, including raster and vector data. Furthermore, data can be saved on a computer, where it can be analysed, modelled, and the relationship between features can be calculated accordingly (Gill, 2008), (Choi et al., 2016).

The Geographic Information System is an essential component in the efficient operation of local governments because it provides a robust set of tools for the management and analysis of spatial data. The capability of Geographic Information Systems in local authorities to integrate various sets of information that are associated with geographical locations is one of the most significant advantages of using geographic information systems (Goodchild et al., 2005). A comprehensive understanding of the local environment is made possible by this integration, which takes into account data pertaining to the environment, as well as social, political, and demographic information. GIS provide decision-makers with valuable insights into complex spatial relationships, the ability to overlay and analyse these layers of information is essential. This enables decision-makers to engage in more informed and strategic planning.

Through the facilitation of a visual representation of data, Geographic Information Systems (GIS) improves decision-making processes within the context of local governance. Not only does this help in recognising patterns and trends, but it also helps in determining areas that might be in need of targeted interventions or improvements (Gill, 2008), (Choi et al., 2016).. The use of geographic information systems (GIS) allows local authorities, for instance, to map out infrastructure, such as roads and utilities, and evaluate the current state or plan for future developments. In addition, geographic information systems (GIS) play a significant role in emergency management. They assist local authorities in responding quickly and effectively to crises by mapping affected areas, coordinating resources, and communicating vital information to the general public. The application of geographic information system (GIS) technology in local governments highlights the significance of this technology in promoting effective governance through the utilisation of data-driven decision-making and spatial analysis (Diaz, 2021) (Farkade & Kaware, 2015).

Planning Authority

In the field of urban development and construction, the local and planning authorities bear the responsibility of issuing planning permits (Gill, 2008), (Budic, 1993). In addition to assessing the suitability of a specific location, these authorities are responsible for establishing the regulatory framework that governs construction and planning activities (Weber, 2017) (Budic, 1993). By granting a planning permit that confirms the legal suitability of a site for construction, Planning Authorities have established the necessary foundation for any potential future development in the area. This declaration serves as the cornerstone for ensuring compliance with the legal and planning requirements (Gill, 2008).

The creation of layout plans marks the initial stage of the obligations that local and planning authorities have to fulfil. They have a crucial role in facilitating communication between ownership departments to ensure a seamless transition from site evaluation to the start of construction. This aids in facilitating effective communication and ensuring a seamless transition (Budic, 1993). One of their most crucial tasks is to compile comprehensive permit files, which consist of architectural drawings, paperwork, and other essential documentation. These documents undergo rigorous evaluations and categorization, and a unique identification number is assigned to each file for the purpose of referencing and monitoring (Gill, 2008) (Weber,2017). As they explore the intricacies of their job, these authorities analyse architectural plans to verify their compliance with the guidelines specified in the site's validity declaration (Budic, 1993). To maintain the established standards set by

regulatory frameworks and ensure the integrity of the construction process, it is crucial to carry out a thorough examination (Gill, 2008) (Weber, 2017). The Local Authority carefully evaluates each stage of the procedure prior to making decisions regarding permit requests. The purpose of this action is to guarantee the implementation of all essential measures and safeguards in order to safeguard the community's interests and maintain compliance with the established guidelines (Gill, 2008).

Both planning and development are mutually advantageous, yet they are also exceedingly challenging endeavours. Due to the limited availability and high worth of land, numerous urban issues are linked to land-related activities. The conventional techniques of surveying and land documentation are inadequate for effectively managing the current urban landscape (Weber, 2017). This is because both individuals and technology are continuously progressing at an accelerated pace, surpassing the norm. The necessary tool in the present situation must possess the ability to capture, store, analyse, and ultimately provide a viable solution (Gill, 2008).

The Geographic Information System (GIS) is a highly effective and potent analytical tool for urban planning and management. The recent progress in the information technology field, such as the Internet, mobile computing, internet banking, remote sensing, and virtual reality, has resulted in substantial transformations in various aspects of our social lives. This phenomenon is evident even in the domain of urban planning (Budic, 1993). It is necessary to study the conventional attributes of geographic information systems (GIS), such as the rate of change, the increase in impermeable areas, and the growth pattern, along with the applications of GIS in relation to urban safety, because this is currently a pressing requirement. Urban planners face the difficult task of effectively managing cities while prioritising safety. Urban planners must incorporate various technological advancements into urban planning (Weber, 2017).

2.1.2 Common GIS Tools in Planning Authority

The field of Geographic Information Systems (GIS) has revolutionised the methods of obtaining, transmitting, publishing, sharing, and visualising geospatial information (Gaudet, 2003). The significance of this functionality in planning is paramount, as decision-making processes heavily depend on information gathered from multiple departments and organisations (Budic, 1993). In addition, the use of GIS enables citizens to interact with the Planning authority via the internet, thereby enhancing service delivery by allowing citizens to actively participate in shaping their surroundings (Diaz, 2021).

GIS encompasses both the technology and the scientific methods used to analyse spatial data and make informed decisions based on location. The integration of Web GIS and desktop GIS is becoming more prevalent. Web GIS depends on desktop GIS for creating resources. Desktop GIS has enhanced its functionality to utilise web resources. Web GIS, the integration of the Web and geographic information system(s) or science (GIS), has become a powerful Internet application that has motivated numerous individuals to utilise the Web (Esri,2014) (Budic, 1993) (Weber, 2017) (Jadallah et al., 2016). Moreover, GIS has significantly profited from the Internet paradigm of extensive connectivity and the impetus generated by the Web. The advent of the Web has enabled the utilisation of Geographic Information Systems (GIS) in various settings, ranging from office environments to scientific laboratories. GIS has been widely accessible to millions of households and utilised by billions of individuals across various industries, including government, business, education, and research (Weber, 2017).

WebGIS is notable for its merits, as it provides a wide range of applications that meet the diverse needs of users. Web maps can be accessed remotely from any internet-connected device, offering convenience, flexibility, and accessibility (Jadallah et al., 2016). The system's implementation cost is comparatively inexpensive, making it a cost-effective option for the Planning Authority. The design of the system is user-friendly, allowing for seamless interaction with many users (Jadallah et al., 2016). The versatility of WebGIS is a prominent benefit, as it can be reconfigured and redesigned to accommodate changing needs. Nevertheless, there are obstacles, such as reliance on internet accessibility for optimal performance. Some features may have restrictions, and creating a prototype is necessary before implementation (Budic, 1993) (Weber, 2017). Desktop GIS has both advantages and disadvantages. Positively, it offers a wide array of functionalities, equipping users with robust tools for sophisticated geospatial analysis. The software is pre-developed, which simplifies the implementation process. Nevertheless, there are limitations such as a limited user base and reliance on internet access for certain features (Weber, 2017) (Jadallah et al., 2016).

The cost of implementing Desktop GIS is typically high, which can be a hindrance for organisations with limited budgets. Moreover, it lacks the versatility of remote accessibility from any device. To summarise, the decision between WebGIS and Desktop GIS depends on specific requirements, the scale of the Planning Authority, and the resources that are accessible. Every system possesses its own advantages and disadvantages, which highlights the importance of thoroughly evaluating requirements in order to make well-informed decisions in geospatial data management (Weber, 2017), (Budic, 1993).

2.1.3 Challenges in GIS application in planning authorities.

Planning authorities in developing countries face specific challenges when implementing Geographic Information Systems (GIS), which can be attributed to various factors (Vretanos, 2005). To attain the desired level of quality and standardisation in geospatial data, a substantial obstacle must be overcome. The data landscape in many developing countries is characterised by various factors, such as limited resources, outdated data, and diverse collection methodologies (Vretanos, 2005) (Jadallah et al., 2016). Ensuring the accuracy, consistency, and compatibility of geospatial information is a challenging and time-consuming endeavour. To resolve this problem, it is imperative to proactively enhance the techniques used to gather data, implement rigorous quality control measures, and foster a culture of standardising data among the planning authorities. Capacity building initiatives should prioritise training programmes that empower professionals to efficiently navigate and enhance the fragmented data landscape. This aspect of the initiative is highly significant.

The lack of sufficient technological infrastructure poses a major barrier to the adoption of geographic information systems (GIS) in developing nations. Several factors hinder the attainment of optimal effectiveness when utilising geographic information system (GIS) tools (Vretanos, 2005). The factors encompass obsolete hardware, sluggish internet connectivity, and inadequate software resources. Another contributing factor to the worsening of the situation is the limited availability of proficient experts with experience in geographic information system (GIS) technologies. To tackle these problems, it is crucial to allocate resources strategically towards enhancing technical infrastructure, implementing comprehensive training programmes to improve GIS proficiency among employees, and fostering partnerships with educational institutions to ensure a consistent supply of qualified GIS experts (Budic, 1993).

Developing nations are facing increasing challenges in achieving interdepartmental collaboration and data sharing, which are crucial for the successful implementation of GIS applications. There is a likelihood that bureaucratic structures will have restricted integration, leading to the presence of isolated data within the different departments comprising the planning authority (Vretanos, 2005). To overcome these challenges, it is necessary to implement standardised protocols for data sharing, promote open data initiatives, and foster a culture of collaboration among different departments. To enhance the development of skills and capabilities, it is crucial to incorporate not only technical training but also initiatives that

promote efficient communication and cooperative methods. This is due to the necessity of integrating both forms of training (Weber, 2017).

In developing countries, where limited resources are often a challenge, the issue of insufficient financial resources is a persistent barrier that they must consistently surmount. The initial costs of implementing a geographic information system (GIS) may pose a foreseeable obstacle to progress. The expenses encompass the procurement of software licences, the enhancement of hardware, and the execution of comprehensive capacity-building initiatives. To alleviate these financial constraints, it is necessary to implement innovative funding models, establish international collaborations, and acquire targeted assistance from donors. Planning authorities can utilise these platforms to greatly facilitate the implementation of GIS technologies, leading to enhanced efficiency and sustainability in development practices (Vretanos, 2005).

In order to effectively address these challenges, developing countries can utilise geographic information systems (GIS) as a powerful tool for strategic planning, decision-making, and sustainable development (Jadallah et al., 2016). To effectively utilise geographic information systems (GIS) and make a beneficial impact on the socio-economic conditions of these countries, it is crucial to overcome these obstacles through a comprehensive and contextually sensitive approach (Budic, 1993) (Vretanos, 2005).

Framework integrating geospatial information systems.

The demand for a new geospatial framework has greatly increased due to the need to overcome the limitations of traditional desktop GIS systems (Luzet, 2004). These limitations stand out from others due to their exorbitant costs and limited storage capacity. This cutting-edge framework seamlessly integrates the capabilities of hybrid cloud computing with the advanced features of geographic information systems (GIS). The symbiotic relationship between these two domains aims to harness a range of advantages, such as enhanced flexibility and heightened security, to effectively handle the diverse array of data types available. This is done to cater to the diverse range of data types available in the market (Jadallah et al., 2016). The core principles of geospatial information systems are closely integrated with the dynamic landscape of cloud computing through the framework. To achieve this objective, it is necessary to conduct a thorough investigation into the intricacies involved. This document thoroughly addresses significant issues, such as cost analysis, data migration strategy development, and security protocol enhancement. Furthermore, the framework broadens its range of analysis to encompass the assessment of the effectiveness of

architectures across a diverse range of cloud computing services (Luzet, 2004). This is an extra advantage of the framework. The primary objective is to attain harmonious integration across all aspects of data processes, encompassing storage, transmission, management, processing, analysis, and quality assurance. The stated objective must be achieved. The exhaustive efforts made in this direction are extensively documented in reference (Horita et al, 2007). The detailed documentation can be found at references (Jadallah et al., 2016).

This versatile framework can be applied to various industries to address the persistent challenges caused by inefficient resource allocation. This aids in mitigating the longstanding challenges. This framework possesses not only the technical intricacies but also the flexibility to be implemented across diverse industries. The liberation of decision-making from geographical constraints and temporal limitations is a contributing factor to the development of a more precise and agile decision-making process.

When considering the future, it is crucial to remember that future efforts should be concentrated on improving the integration of the spatial framework (Jadallah et al., 2016). This is something that should always be given careful consideration. To accomplish this objective, it is imperative to conduct a thorough evaluation. During this type of evaluation, it is imperative to consider various aspects, including the cost implications, the flexibility of data migration, and the steadfast dedication to security (Tao, 2006). The process of integration should include a thorough assessment of the architecture's performance across different levels of cloud computing services, including Software as a Service (SaaS), Platform as a Service (PaaS), and Infrastructure as a Service (IaaS). When considering the prerequisites of geospatial analysis, this assessment should be in total alignment. For a comprehensive analysis, please refer to citation (Horita et al, 2007).

Another crucial aspect to consider is that the focus on integration should not solely revolve around the amalgamation of tools. For geospatial integrated systems to achieve success, it is imperative that they prioritise all aspects of data, such as storage, transmission, management, processing, integration, analysis, and accuracy (Luzet, 2004). This task must be completed to ensure that the systems yield the intended results. In order to achieve a comprehensive and effective solution for geographic information systems (GIS), it is imperative to implement a strategy that encompasses all aspects and is highly efficient. This approach will pave the way for a new era of efficiency and adaptability in GIS. Only by employing this approach can we generate a solution of this nature (Luzet, 2004).

2.1.4 Integrated Urban Management for Decision Support: A Holistic Approach to City Governance

Urban landscape conditions often contain intricate ecosystems that exhibit dynamic interactions among social, economic, and environmental components. To effectively navigate these intricacies, it is imperative to move away from individual strategies and towards a holistic and integrated organisational framework for urban management. This strategy is based on the use of data-driven decision-making, which involves utilising real-time information and predictive analytics to guide decisions regarding infrastructure development, resource allocation, and policy implementation (Budic, 1993). The paramount element of integrated urban management is the facilitation of cooperation among diverse sectors, alongside the eradication of conventional barriers that separate transportation, water, energy, waste, and public safety (Tao, 2006). Utilising digital technologies is a crucial element in implementing integrated urban management systems. The data that these systems gather and analyse is sourced from a diverse range of channels, such as sensors, cameras, and platforms for citizen feedback. This extensive dataset can provide valuable insights into traffic patterns, energy consumption, environmental quality, and social dynamics (Tao, 2006). Predictive models facilitate the ability to forecast upcoming trends, simulate different scenarios, and identify potential obstacles. This empowers city officials to take proactive measures in addressing issues, optimising the allocation of resources, and making well-informed decisions that have a positive impact on all residents (Budic, 1993).

An integrated approach to urban management provides advantages that extend beyond mere cost reduction and efficiency enhancement. This approach promotes the development of cities that are environmentally friendly and able to withstand and adjust to the constantly evolving challenges they encounter (Lemmens 2006). Integrated urban management establishes the foundation for a future urban environment that is healthier, more equitable, and more accessible to people by promoting efficient resource management, reducing pollution, and addressing the impacts of climate change. Adopting integrated urban management as a method of decision support is not only a technological advancement, but also a transformative approach to city governance. This approach establishes the foundation for a future in cities that is both environmentally sustainable and economically prosperous (Tao, 2006).

The significance of Integrated Spatial Data Systems (ISDS) lies in their ability to effectively address the challenges associated with urban data management, particularly the fragmentation

caused by numerous operational databases. ISDS offers a solution for integrating and sharing diverse datasets among urban agencies, facilitating decentralized communication and decision-making across the entire network. However, it is important to acknowledge that the survey has limitations. There is a lack of emphasis on the technical challenges and difficulties involved in implementing ISDS. For instance, specialized skills and expertise are required to coordinate the administration and sharing of various datasets, representing one such limitation. These technical complexities highlight the need for comprehensive planning and capacity-building efforts to ensure the successful implementation and utilization of ISDS within urban environments. There is also a lack of discussion on the potential security risks and privacy concerns that are associated with integrating and sharing large amounts of sensitive urban data. This is another limitation. In addition, the survey provides information regarding the importance of performance in operational systems as well as the potential influence that ISDS may have on the performance of these systems (Budic, 1993).

It is necessary for analysis systems to be flexible and possess a wide range of capabilities in order to accommodate the development of integrated spatial data systems. Utilising integrated spatial data systems is an ideal method for creating an integrated spatial data system that allows decision-makers to investigate, organise, and address complex urban challenges. This provides decision-makers with the ability to address these challenges (Tao, 2006).

As the urban data management environment continues to develop, there will be a much greater emphasis placed on informal integrated spatial data systems for the purpose of decision implementation. The integration of planning, modelling, simulation, and spatial representation is made possible by Integrated Spatial Data Systems (ISDS) (Tao, 2006). In addition to this, it enables decentralised communication and decision-making activities across the entire network. Not only can it be utilised by technical individuals, but it can also be utilised by users who are not technically oriented. The rapid expansion of the Internet is a clear demonstration of the potential for ecosystems of this kind due to its widespread use. It will be recognised that the technology that is utilised in spatial data warehousing is of utmost importance to this change. The disparate data problem has been acknowledged to have been further exacerbated by the creation of numerous different operational databases (Budic, 1993). Figure 1 below shows Integrated Urban Management system design.

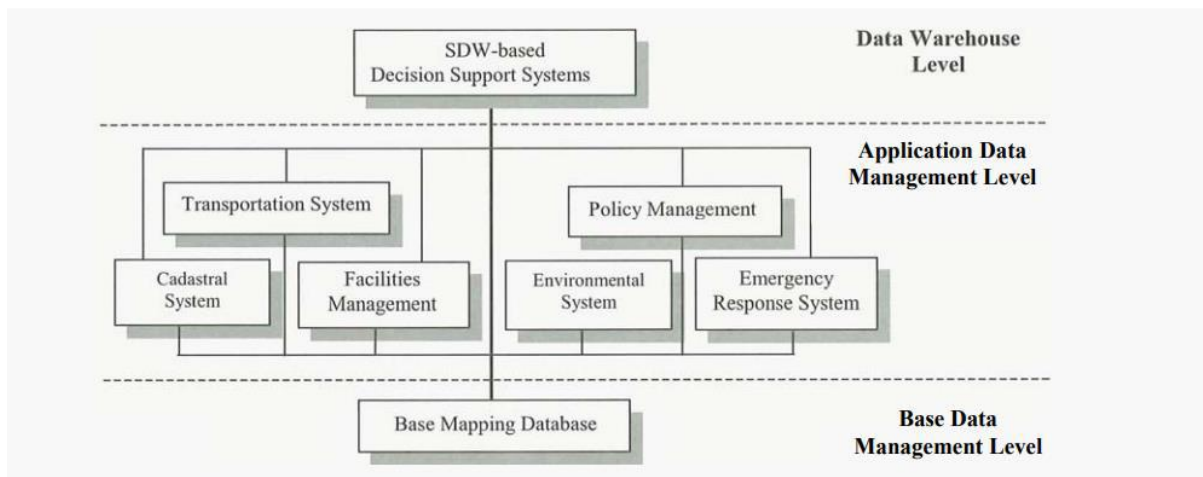


Figure 1: Integrated Urban Management: Source (Tao,2010).

2.1.5 Cloud Based Integrated GIS Systems.

The GIS Cloud architecture brings together Web Geographic Information System (GIS) features and services. A good example of this is Google Map, which is an application programming interface (API) that combines maps, satellite images, and other geospatial data. It can provide advanced geospatial data collection, processing, analysis, and dissemination capabilities (Mason, 2007). It is also important to note that the majority of advanced geographic information system (GIS) cloud applications are not always free and can be expensive for a particular region. Because of this, a customer who is concerned about the cost of services can create a web-based or cloud-based geographic information system (GIS) by utilising open-source software (Gediminas, 2019).

The process of migrating databases, which is an essential component of the evolution of an organisation, requires careful planning regardless of the scale of the project. When contemplating a migration to Oracle, it is especially important to conduct an evaluation of the existing application portfolio in order to gain an understanding of the difficulties, complexities, and effort that are necessary for a smooth transition. A multitude of tools are available to facilitate the migration of databases and applications, and each of these tools varies in terms of the degree of automation and accuracy of SQL statement migration (Budic, 1993). Considering this variability, it is recommended that proofs of concept be carried out using these tools. This is especially true when it comes to larger migration projects. Database migrations have an effect that is not limited to the databases themselves; rather, they have a direct influence on applications that are dependent on the databases. The challenges that are

associated with design within organisations are complex and will vary depending on the features and functionalities that need to be utilised. Certain organisations have adopted policies with the intention of promoting database-agnostic applications, with the intention of strategically avoiding the implementation of software features that are proprietary. By taking this preventative approach, the effects of database changes on applications are reduced to a minimum (Gediminas, 2019) (Budic, 1993).

The process of migration begins with the collection of data, and a wide variety of data types are gathered in relation to the case study. The information consists of tabular data, whether it is digital or not, as well as spatial data (Kubbara, 1997). For the purpose of converting the tabular data that was not digital, the digitation or rectification procedure was utilised. Create a connection between the tabular data and the spatial data format after the conversion has been completed. Any and all of the information is stored in a single folder. There is now the capability to convert any and all data into standardised spatial data (Gill, 2008). For the purpose of gathering information for a particular case study, the data analysis was carried out. The development of a spatial database system, as well as the selection and implementation of cloud computing and spatial database technology, are all accomplished through the process of data analysis. When selecting database solutions, open-source software that does not require ownership of a licence is given priority (Gediminas, 2019). The process of enterprise architecture planning is utilised in the framework design process to generate a structured diagram that assists in the organisation of data and problem concepts in a more effective process. When it comes to system design, the various phases of database and application architecture are the primary focal points. The application design is focused on the stage that will be used to create the cloud-based Web GIS and geodatabase application. The creation of GIS Web applications and a geodatabase was followed by an evaluation to determine whether the expectations had been satisfied. In addition to this, it is feasible even during times of resource scarcity (Budic, 1993).

Data Collection Mobile Application Architecture

Mobile devices, including mobile phones, and tablet computers, have made significant progress in terms of technological innovation. For instance, modern devices are now equipped with high-resolution, full-colour screens, as well as features like Bluetooth, and a range of additional accessories such as GPS, digital cameras, and infrared scanners (Farkade & Kaware, 2015) . Furthermore, the integration of voice and data networks, along with the emergence of next generation networks such as 3G, will result in a significant enhancement

of data transfer speed, network capacity, and geographical reach of mobile networks. Although a substantial portion of the underlying technology is already available in handheld and mobile computing, there are still obstacles to be addressed in terms of the usability of mobile applications. Compared to its desktop equivalent, the usability of a mobile computer is generally regarded as relatively subpar (Farkade & Kaware, 2015).

A notable example of this is the underwhelming adoption rate of new WAP-enabled mobile phones among consumers in several countries (Budic, 1994). An often-encountered reason for failure is when web designers merely endeavour to transfer their websites to mobile Internet (Arrowsmith et al, 2007). This is the primary cause of failure (Farkade & Kaware, 2015). To create mobile applications that are highly user-friendly, software designers must possess a comprehensive understanding of the distinct attributes of mobile computing and effectively leverage those attributes. The key attributes encompass the technological aspects, the demographic of users, the patterns of usage, and notably, the context and surroundings in which mobile devices are employed. Although extensive research has been conducted on desktop computing, mobile computing is a comparatively recent paradigm that is fundamentally different from desktop computing (Killpark et al., 2005). Mobile computing is defined by numerous distinct features and inherent qualities.

Mobile devices have a lower capacity for resource utilisation compared to desktop computers. They are subject to limitations regarding storage capacity, memory, processing power, battery duration, screen dimensions, and other factors (Tao, 2006). In addition, they depend on mobile networks, which exhibit significant variability in terms of both their performance and reliability. However, the distinctions are not limited solely to the technology itself. They also encompass the usage patterns, context, and environment in which mobile computers are employed. The mobile environment is distinguished by its diversity, where users are frequently faced with a range of ever-changing situations (Nourjou & Thomas, 2016).

2.1.6 Mobile Applications for Field Data Collection

An effective management system is essential for planning authorities to attain operational efficiency and efficiency in data collection. This system must encompass infrastructure, workforce, and resources. The mobile application empowers Planning Authority to make well-informed decisions and operate with maximum efficiency by relying on accurate information (Farkade & Kaware, 2015) (Lemmens 2006). Municipal authorities, particularly those in the utility industry encompassing water, electricity, and telecommunications, have a

critical requirement to record and uphold up-to-date information regarding their networks. This information offers comprehensive details concerning the geographical position, technical attributes, and logical arrangements. This information is crucial for the effective implementation of service and maintenance operations. South Africa, like other emerging countries, has recognised the deficiency of comprehensive network information in its public utilities. Presently, these utilities are encountering challenges in integrating field data with the preexisting network information during the data collection and verification procedures (Arrowsmith et al, 2007) (Nourjou & Thomas, 2016).

The deployment of mobile data collection teams for conducting comprehensive field audits is a cost-efficient and effective solution, despite its dependence on manual labour. The Geographic Information System (GIS) database systems are used to implement the Land use Layer (Nourjou & Thomas, 2016). The individuals responsible for mobile data collection frequently rely on tangible maps and documents that encompass comprehensive information regarding the sources of the data. Consequently, these circumstances result in lengthy procedures, vulnerable workflows, and difficulties in establishing a platform that enables the exchange of varied information. Mobile solution enables the efficient transfer of information between the field and the corporate database (Diaz, 2021). The updated data is obtained instantly and sent to a mobile device in the field through wireless networks. Later, the staff will verify the changes and then integrate them back into the database. This will streamline the entire process of data collection for the benefit of the local authorities.

Related Works and Gaps in the Literature

2.1.7 Related Requirements for establishing information system to manage building permits in Planning Authorities.

The study was conducted provided valuable insights into the implementation of an information system for the management of building permits. The study articulated a compelling case for the adoption of advanced technology, underscoring the imperative for innovative solutions within the realm of urban planning and development (Mahrous & Wahed, 2017). A primary objective of the study was the formulation of a conceptual framework for an information system tailored to the intricacies of building permit management. This underscored the necessity for a meticulously defined plan and structure preceding the implementation of technology-driven solutions. An in-depth exploration of this framework provided a nuanced understanding of the guiding principles shaping its development and its adaptability to the dynamic challenges inherent in urban development.

The researchers placed significant emphasis on the identification of organizations involved in the permit issuance process, alongside a comprehensive understanding of their respective responsibilities and requirements. This accentuated the need for a discerning comprehension of organizational roles and the diverse needs of stakeholders. Negotiating these intricacies was imperative for the meticulous design of an information system attuned to the specific requirements of each organization (Mahrous & Wahed, 2017).

At the heart of the proposed solution lay the integration of Geographic Information System (GIS) technology, recognized as a pivotal tool for managing the permit issuance process. A detailed exploration of specific GIS functionalities and their practical applications in permit management was warranted. Additionally, a thorough examination of any challenges or benefits associated with GIS integration contributed to a comprehensive grasp of the proposed technological solution. The literature underscored the importance of secure GIS databases with restricted access for individual organizations, safeguarding the integrity of information. A more detailed examination of the specific security measures proposed, including data encryption, user authentication, and access control, enhanced our understanding of how information integrity was upheld (Mahrous & Wahed, 2017). Figure 2 below shows the Requirements for establishing an information system

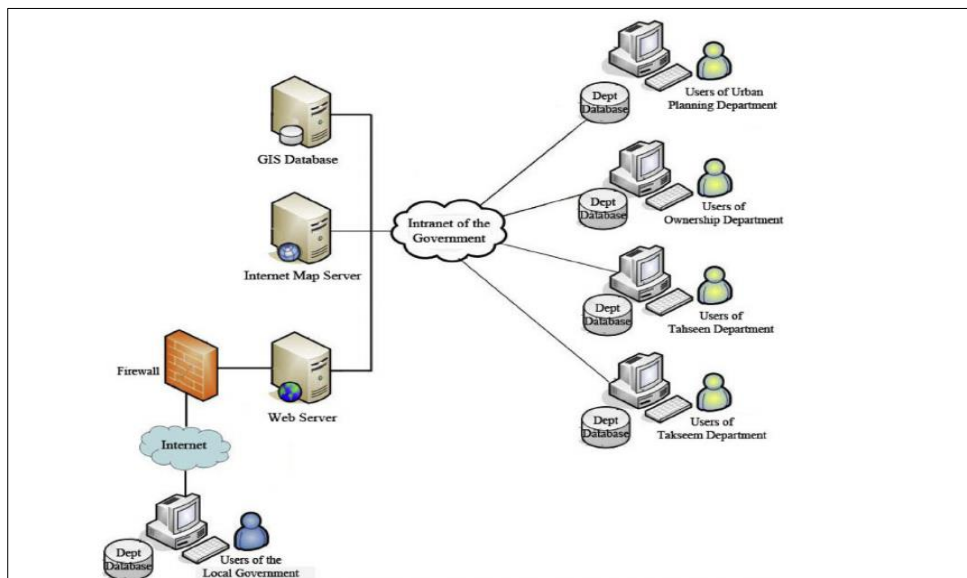


Figure 2: Requirements for establishing an information system (Wahed,2017).

One of the key lessons learned is the need to have adequate information pertaining to the needs and roles of each organisation and department, to ensure efficient coordination and flow of information. Secondly, a lesson has been learned pertaining to the need to have a

dedicated GIS database for each organisation and a central database where information is shared between all involved departments and organisations (Mahrous & Wahed, 2017).

In conclusion, the literature not only underscores the significance of an information system in building permit management but also beckons further exploration of technological solutions, organizational dynamics, and the practical implications of GIS integration within the specific context of Planning Authorities in Egypt. (Mahrous & Wahed, 2017).

2.1.8 Web-GIS Based Utility Management System: A Case Study of Deep Housing, Pokhara, Nepal

The study aimed at designing the system to support the utility spatial data management. The key components of the system included a mechanism that allowed system administrators to dynamically add or remove utilities at specific locations, providing flexibility for adapting to changing requirements. Moreover, the project incorporated a customer care system designed to facilitate issue submission by users and streamline issue tracking for utility maintenance by administrators. The system's foundation relied on base layers from OpenStreetMap (OSM), Mapbox, and Dark Map, offering a comprehensive view of utility networks. Various utility layers, ranging from road networks and transmission lines to water supply networks, sewer lines, drainage networks, and amenities like telephone and television networks, streetlights, buildings, plots, housing boundaries, temples, parks, and swimming pools, were seamlessly integrated into the system (Mahrous & Wahed, 2017). Figure 3 below shows the Utility management system

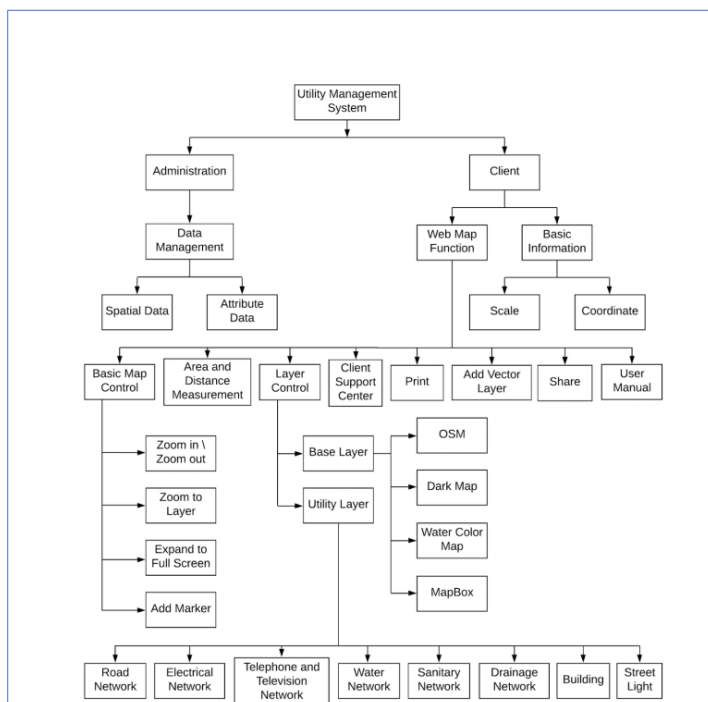


Figure 3:Utility management system (kshetri,2020)

The representation of each layer, coupled with its attribute data, allowed for effective overlay analysis, and enabled the simultaneous study of multiple layers. This approach enhanced the system's analytical capabilities, providing users with a holistic understanding of the spatial relationships between different utility components (Mahrous & Wahed, 2017). The system encompassed a wide range of basic map features, including zooming in/out, layering, extending to full screen, adding markers, incorporating vector layers, measuring distance and area, printing, sharing, and generating reports. These features contributed to the overall functionality and user experience of the system, making it a comprehensive and versatile tool for utility management in the context of Deep Housing, Pokhara, Nepal (Mahrous & Wahed, 2017).

The integration of diverse utility layers showcases the importance of a comprehensive approach, accommodating various infrastructure elements (Mahrous & Wahed, 2017). The system's dynamic management mechanism, allowing administrators to add or remove utilities, emphasizes the need for adaptability in evolving scenarios. The inclusion of a customer care system highlights the significance of user engagement and streamlined issue resolution (Mahrous & Wahed, 2017). Additionally, the use of base layers from OpenStreetMap, Mapbox, and Dark Map underscores the importance of diverse data sources for accurate utility representation, while the overlay analysis capability demonstrates the value of spatial understanding in managing interconnected utility components. The user-friendly interface and functionality further emphasize the importance of intuitive features for enhanced user experience and system adoption (Mahrous & Wahed, 2017).

2.1.9 Web- GIS Approach for Serving Land Price Information: China

This study aimed to develop a web-based GIS system to provide a practical solution for land price information and models for analysis.

This study aimed to develop a web-based GIS system to offer a practical solution for accessing land price information and conducting analytical models. The research findings underscored the significant enhancement in understanding land price patterns and distributions achieved through the incorporation of GIS-based web integration and web GIS technology. This improvement in accessibility proved beneficial for a broader audience, including investors and administrators with limited domain knowledge (Chung, 2016). Additionally, the study showcased the versatile application of web GIS in various informative

web models tailored to the specific needs of the land market, following a comprehensive review of background information and land price analysis models (Chung, 2016). However, critical limitations were identified within the Web GIS system. One notable constraint was the absence of real-time data updates, potentially impeding users' ability to make informed decisions as the data on the Web GIS might not accurately reflect current land prices (Chung, 2016). Another limitation concerned the system's restricted spatial analysis capabilities, which may not meet the requirements of advanced users seeking more sophisticated analytical tools (Chung, 2016). Additionally, concerns arose regarding the system's storage capacity, potentially limiting the volume of data that could be stored and processed. The security of the Web GIS system also emerged as a concern, given its susceptibility to cyber threats such as hacking and data theft (Chung, 2016). Figure 4 below shows Land Price Information.

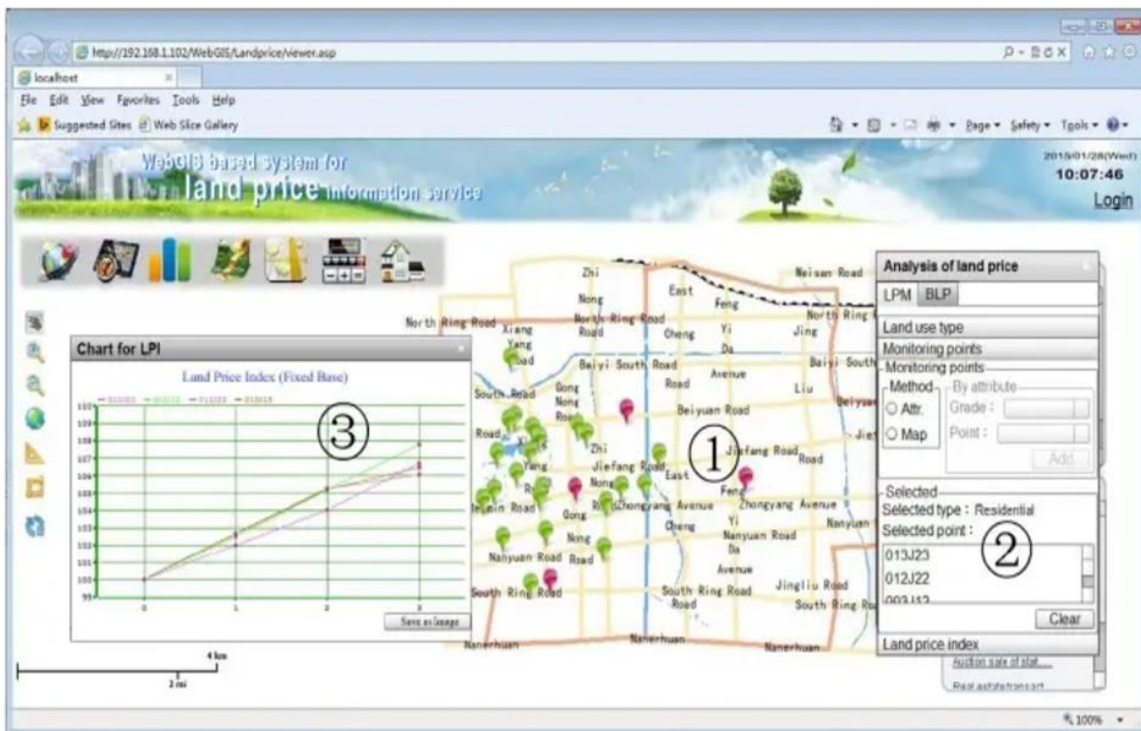


Figure 4: Land Price Information: (Yang Y, 2015)

Key lessons from this study include recognizing the significance of continuous efforts to improve data timeliness for informed decision-making. The findings underscore the importance of addressing spatial analysis limitations to cater to the needs of advanced users, and they highlight the necessity for expanding storage capacities to accommodate growing datasets (Chung, 2016). Furthermore, the study emphasizes the imperative of enhancing the

security infrastructure of web GIS systems to mitigate potential cyber threats, ensuring the integrity and confidentiality of land price information. These lessons contribute to the ongoing refinement of web GIS systems, informing future developments and enhancing their effectiveness in providing accurate, timely, and secure land price information (Chung, 2016).

2.1.10 Web-based GIS Land Records System: Ghana

The object was to provide a quick, secure, and easy way of registering land parcels via the Internet and other communication devices and decentralise the lands registration process and lessen the burden and workload on the land registration offices. The study aimed to streamline the land registration process, providing a quick, secure, and convenient platform for registering land parcels via the Internet and other communication devices (Tagoe, 2011).

The primary objective was to decentralize the lands registration process, alleviating the burden on land registration offices. This system enabled any device with Internet access to communicate with the central land registration database, facilitating the retrieval of information related to land parcels of interest (Tagoe, 2011).

The research findings emphasized the critical role of qualified land registration staff and planners with programming knowledge in maintaining the system effectively. The success of the land registration system was contingent on the availability of competent personnel. Additionally, the study highlighted the importance of an existing core of qualified professionals to initiate the process and provide essential training (Tagoe, 2011). The conclusion drawn from the research emphasized the limited analytical methods and information sources for land pricing within the developed system (Tagoe, 2011). To address this limitation, it was recommended that the promotion of the system should include the introduction of more analysis models, such as sales comparison approaches for parcel appraisal. Web GIS technology played a pivotal role in the implementation, incorporating a login system and enabling remote land parcel document verification and validation via the Internet. The utilization of Web GIS not only facilitated the decentralization of the land registration process but also enhanced accessibility and efficiency in managing land records. The findings and conclusions from this study contribute valuable insights to the ongoing development and enhancement of land registration systems, emphasizing the importance of qualified personnel and the continual expansion of analytical methods to further refine and optimize such systems (Tagoe, 2011).

2.1.11 WebGIS for Water Utility Management at Copperbelt University

The primary objective of the study was to design a web-based access to geographic data and basic query tools, thereby augmenting data accuracy, integrity, and preventing duplication (Okello et al, 2019). This was imperative to facilitate data interchange formats with other software, notably Computer-Aided Design (CAD). The study detailed the shortcomings of traditional paper-based utility maps and proposed a more effective system grounded in the organization, manipulation, and presentation of spatial data (Okello et al, 2019). The conclusive findings underscored the substantial reduction in maintenance costs and the provision of a centralized, web-based system containing accurate and current information for end users. The incorporation of PostGIS, QGIS, and GeoServer demonstrated the judicious selection of tools for the development of an efficient web GIS water management utility system (Okello et al, 2019). Furthermore, the study highlighted the significant cost reduction and increased efficiency achievable through GIS implementation. The successful integration of specific GIS tools serves as a crucial lesson, emphasizing the necessity of selecting appropriate technologies for system development (Okello et al, 2019). Figure 5 below shows Water Utility Management.

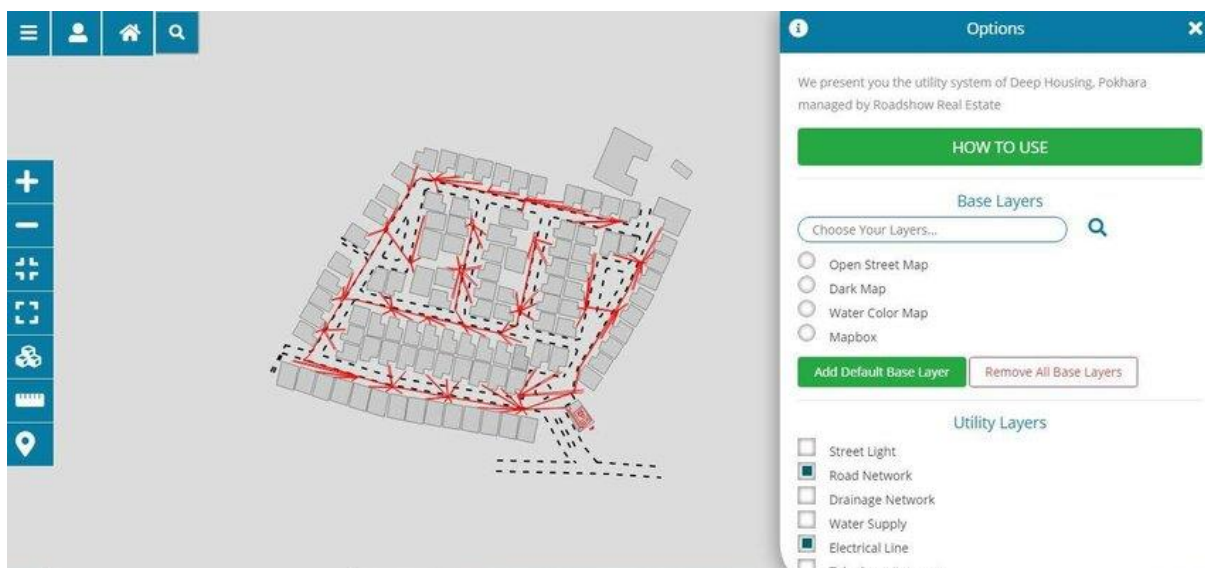


Figure 5: Water Utility Management: Okello et al (2015)

Above all, the study underscored the pivotal role of web GIS in providing enhanced access to high-quality geospatial information, thereby contributing to optimized planning, implementation, monitoring, and information delivery processes in utility management. These lessons offer valuable guidance for organizations seeking to refine their utility

management practices through the strategic deployment of geospatial information tools and techniques (Okello et al, 2019).

2.1.12 Using spatial analysis and GIS to improve planning and resource allocation in a rural district of Bangladesh.

The primary objective of the study was to assess the utilization of Geographic Information Systems (GIS) for planning, monitoring, and decision-making in the context of local government health administration (Robin et al, 2019). The evaluation focused on the efficacy of incorporating maps with spatial data into the planning processes of local government health administrators. The integration of these maps, supported by a strengthening project in 2016, aimed to enhance planning, resource allocation, and program monitoring. Notably, the allocation of funding was strategically prioritized based on GIS maps, with a focus on clusters of disadvantaged communities and underserved unions, the lowest administrative units (Robin et al, 2019). The figure 6, below shows, web-based GIS enhanced functionality.

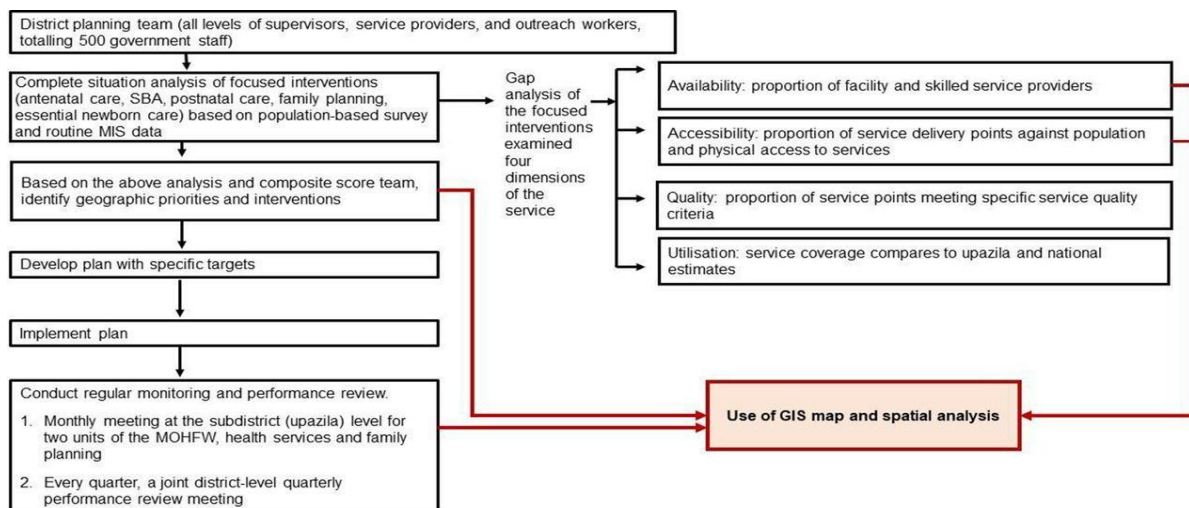


Figure 6: web-based GIS enhanced functionality Kabir N, et al (2014)

A mixed-methods approach was employed to analyse the outcomes of the planning process. Data from various sources, including services data, district planning reports, population-based surveys, local government annual expenditure reports, and financial information, were examined (Robin et al, 2019). The project identified that the lowest-performing unions received additional funding from local government budgets to improve health facility service readiness and oversight.

Despite challenges in processing maps quickly during planning discussions, both managers and participants expressed satisfaction with the use of spatial analysis. However, a recognized need emerged for the implementation of more web-based GIS tools, particularly to enhance

community-level service delivery and analyze performance during monthly meetings (Robin et al, 2019). Despite certain limitations, the study highlighted the effectiveness of GIS maps in enabling local health administrators to identify gaps in health services, prioritize underserved unions, and track outcomes (Robin et al, 2019). The findings underscored the potential of GIS in supporting evidence-based decision-making in the realm of public health administration, while also identifying areas for improvement, such as the incorporation of web-based GIS tools for enhanced functionality (Robin et al, 2019).

2.1.13 Guidance on spatial related data, GIS, and foresight in Arctic

The study on local land use planning in the Arctic provides key lessons in the effective utilization of Geographic Information Systems (GIS) and spatial data integration (Weber, 2017). The primary objective is the comprehensive use of GIS tools, combining spatial data from diverse sources for individual land use planning projects. The versatility of these tools, including design and illustration programs, GIS mapping software, and data management programs, underscores the importance of an integrated approach. Additionally, the study emphasizes the frequent association of GIS tools with sophisticated scientific models, highlighting their adaptability in advanced analytical contexts (Weber, 2017). The research also points out the evolving landscape of GIS platforms, with local authorities incorporating specialized digital platforms and more contemporary tools like QGIS. The shift towards participatory platforms facilitates stakeholder engagement, allowing participants to contribute data on local resource utilization and express opinions on proposed land use development plans. This reflects a crucial lesson in the importance of user-friendly and participatory technologies to enhance community involvement in decision-making processes (Weber, 2017). Moreover, the study noted the changing dynamics in GIS platform preferences, with a trend towards more advanced international tools challenging the traditional national platforms. This lesson underscores the need for continuous adaptation to technological advancements, ensuring that land use planning methodologies remain effective and relevant over time. Overall, the study offers valuable insights into the evolving landscape of GIS applications in local land use planning, emphasizing the importance of integration, adaptability, and community engagement for effective decision-making processes (Weber, 2017). The figure 7 below, shows City Planner framework.

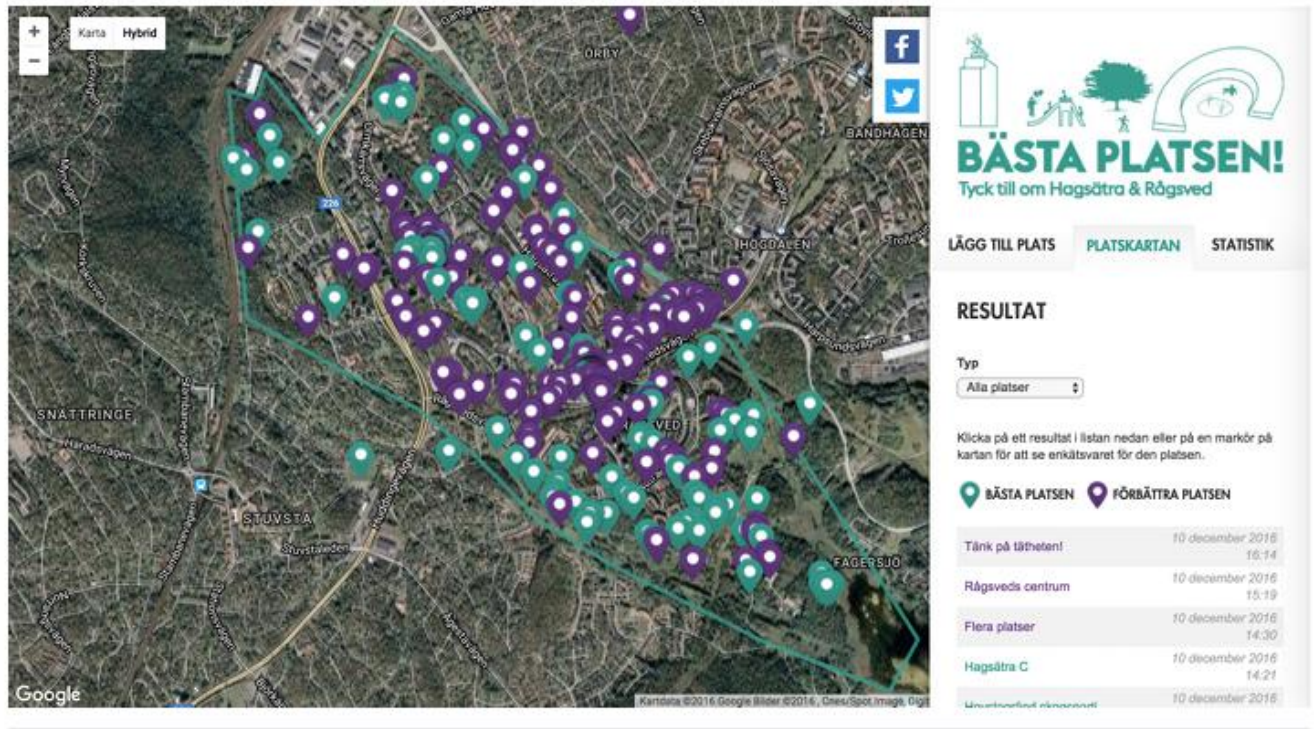


Figure 7: City Planner framework (cityplanneronline.com)

One significant takeaway was the comprehensive use of GIS tools, which integrated spatial data from various sources for individual land use planning projects. The versatility of these tools, encompassing design and illustration programs, GIS mapping software, and data management programs, underscored the importance of an integrated approach. Additionally, the study highlighted the frequent association of GIS tools with sophisticated scientific models, showcasing their adaptability in advanced analytical contexts (Weber, 2017).

The research also pointed out the evolving landscape of GIS platforms, with local authorities incorporating specialized digital platforms and more contemporary tools like QGIS. The shift towards participatory platforms facilitated stakeholder engagement, enabling participants to contribute data on local resource utilization and express opinions on proposed land use development plans.

2.1.14 System architecture of cloud-based web GIS for real-time macroeconomic loss estimation

The paper presents a detailed system architecture for a web GIS, specifically tailored for the creation of a real-time decision support tool that analyses macroeconomic impacts. The primary objective is to integrate web GIS on the cloud with an autonomous software system, focusing on real-time situational awareness for outage status and economic losses within power and electric utilities (Nourjou & Thomas, 2016). The web GIS is represented as a

complex system composed of multiple systems. It utilises various advanced technologies including ESRI's ArcGIS platform, Amazon Web Services (AWS), an enterprise spatial database, C#, RESTful API, and JSON format. The complex structure highlights the authors' dedication to a technologically varied and strong solution (Nourjou & Thomas, 2016).

The inclusion of cloud integration is becoming increasingly important in the design of the system, as it improves both accessibility and scalability. The utilisation of AWS is specifically emphasised for its ability to guarantee the system's promptness and flexibility in accommodating different workloads, emphasising the significance of effective cloud computing in the execution. The GIS server is a core element that includes a collection of REST APIs for GIS web services, such as map services and geodata services. This modular approach enables effortless utilisation by various applications, such as web mapping applications, mobile geographic information system (GIS) applications, and desktop software. The cloud-based embedded geodatabase enables seamless sharing, visualisation, analysis, and updating of data (Nourjou & Thomas, 2016).

In order to verify the effectiveness method, the study created a web map application and an operations dashboard. These applications efficiently utilise GIS web services and APIs, demonstrating the practicality and functionality of web GIS in real-world situations. The paper highlights the web GIS system's adaptability, emphasising its relevance in various fields such as the Internet of Things, public safety, cloud communication, crisis response, web map applications, location-based services, and real-time GIS. This broad scope underscores the potential for widespread adoption in various fields (Nourjou & Thomas, 2016).

Nevertheless, specific deficiencies and potential opportunities for enhancement are recognised. The paper could benefit from a more detailed discussion on scalability considerations, security measures, user experience design, integration challenges, and data governance practices. Examining these facets would yield a more thorough comprehension of the system's execution and uncover possible avenues for improvement (Nourjou & Thomas, 2016).

2.1.15 The Android -A Widely Growing Mobile Operating System With its Mobile based Applications.

The research investigated the Android operating system, revealing several key findings. Firstly, the study substantiated the prevalence of Android as one of the most widely used mobile operating systems (Farkade & Kaware, 2015). Beyond its extensive usage, Android

was recognized for its potential to significantly contribute to the improvement of diverse areas in contemporary life. The technical underpinnings of Android, rooted in the Linux kernel, were crucial aspects of the findings (Farkade & Kaware, 2015). The paper delved into the four main layers constituting the architecture of the Android Operating System, providing insights into its structural intricacies. Moreover, the study identified Android as a disruptive technology with broader potential applications beyond its initial introduction on mobile handsets (Farkade & Kaware, 2015).

Despite the valuable insights obtained, the research identified certain gaps and potential areas for expansion. Specifically, the study highlighted the need for concrete examples or case studies to illustrate the practical benefits of Android applications (Farkade & Kaware, 2015). A more detailed exploration of the four main layers in the Android Operating System's architecture would have enhanced the technical understanding of its structure.

The research also emphasized the importance of addressing challenges or limitations associated with the implementation of Android applications to provide a more nuanced perspective. Furthermore, an expansion on user experience considerations, including insights into how these applications met user needs and potential challenges in usability, was deemed essential for a comprehensive analysis. Lastly, exploring the future implications of Android applications in the context of emerging technologies or trends was identified as a potential avenue for enriching the research's overall depth and relevance (Farkade & Kaware, 2015).

Table 1 below shows the summary of the literature reviewed

A Summary of the Related Works

Author	Topic	Findings	Gaps
DiBiase et al. (2010)	The new geospatial technology competency model	The research identified the key and essential geospatial technology needed to create the integrated GIS systems. The research further provided a model for geospatial technology.	The study did not explore specific strategies and tools needed to develop the competencies outlined in the model.

DiSera and Johnson (2012)	Opportunities to Utilize the DOL Geospatial Competency Model	The study highlighted the potential of leveraging the DOL Geospatial Competency Model to address diverse governmental needs at different administrative levels. - Identifying and addressing the key competencies required in the geospatial technology field.	The study did not provide technical solutions to challenges relating to data integration. Further, the system was limited to Geospatial.
Diaz (2001)	Web-GIS Based System for the Management of Objections	The study highlighted the Implementation of a Web-GIS system proved effective in managing objections to comprehensive municipal land use, streamlining the objection-handling process. - Comprehensive Municipal land use management.	The study narrowly focused on Web-GIS and overlooked the integration of mobile GIS, which could enhance accessibility and responsiveness.
Frumusanu. (2014)	A Closer Look at Android RunTime (ART) in Android L	The research provided Detailed examination and architecture for a functional Android Runtime (ART) in Android L.	The study did not explore practical applications and advantages of using Android Runtime (ART) in different contexts.
Gault and Peutherer (1988)	The potential for GIS in a large urban authority	The study showcased the framework for an integrate spatial data management system for urban planning.	the study needed for further exploration and development in the practical implementation of this system within the context of a large urban authority. This could involve addressing

			challenges such as data interoperability, scalability, user adoption, or integration with existing urban planning processes
James et al. (2012)	Geomorphic change detection using historic maps and DEM differencing	The study showcased the Application of geospatial technology for detecting and analysing geomorphic changes using historic maps and DEM differencing. - Temporal dimension of geospatial analysis.	The study did not evaluate the accuracy and reliability of the method in detecting long-term geomorphic changes.
Jadallah et al. (2017)	Integrating geospatial technologies urban Planning	The study showcased the Integration of geospatial technologies in urban Planning. - Positive impact observed on spatial ability and map-analysis skills of Planners.	The study did not Explore long-term effects and sustained benefits of integrating geospatial technologies in urban Planning.
Mahrous, and Wahed (2017)	Requirements to develop information system	The study articulated a compelling case for the adoption of advanced technology, underscoring the imperative for innovative solutions within the realm of urban planning and development	The study narrowly focused on the exploration of technological solutions, organizational dynamics, and the practical implications of GIS integration within the specific context of Planning Authorities in Egypt
Goodchild et al. (2005)	Towards a general theory of geographic representation in	The study provided the theoretical framework general of geographic representation in GIS.	The study did not explore specific tools needed to develop such integrated

	GIS		geospatial system.
Souter. (2010)	A Critical Analysis of e-Government in Zambia	Research provided an Examination of challenges and opportunities in the e-Government sector such as capacity and financial resources	The research did provide alternative solutions to identified problems, such as the adoption of open-source tools
Tagoe & Mantey (2011)	Web-based Land Records System	The success of the land registration system was contingent on the availability of competent personnel. Additionally, the study highlighted the importance of an existing core of qualified professionals to initiate the process and provide essential training	The study did not evaluate the accuracy and reliability of the of the records being generated by the system
Adaktylou et al. (2018)	Using Geospatial Technology to Enhance Science education	Successful case study demonstrating the use of geospatial technology in science teaching. - Positive impact on students' learning experiences.	The study did not explore potential challenges and barriers to the widespread adoption of geospatial technology in science education.
Kabir, et al (2014)	web-based GIS enhanced functionality	The study highlighted the effectiveness of GIS maps in enabling local health administrators to identify gaps in health services, prioritize underserved unions, and track outcomes	The study narrowly focused on the application of the webGIS in health sector and did not outline how the system would integrate other geospatial tools
Nourjou &	System architecture	The study show cased the	The study did not examine

Thomas. (2016)	of cloud-based web GIS for real-time macroeconomic loss estimation	Development of a system architecture for cloud-based web GIS to enable real-time macroeconomic loss estimation.	of practical challenges and limitations in implementing the proposed system architecture.
Okello, et al. (2017)	Web-GIS for Water Management	Above all, the study underscored the pivotal role of web GIS in providing enhanced access to high-quality geospatial information, thereby contributing to optimized planning, implementation, monitoring, and information delivery processes in utility management.	The study narrowly focused on Web-GIS and overlooked the integration of mobile GIS, which could enhance accessibility and responsiveness.
Janssen (2009)	Understanding coordinate systems, datums and transformations	The study provided a theoretical framework for coordinate systems, datums, and transformations.	Exploration of challenges or limitations in the practical application of coordinate systems and transformations in real-world scenarios

Table 1: Literature Review and Gaps

Chapter Summary

The literature review delves into the diverse applications of Geographic Information Systems (GIS) across various fields. Throughout the studies, a consistent theme emerges, emphasizing the crucial role that GIS plays in enhancing management processes. The research consistently highlights GIS's potential to enhance decision-making efficiency and quality, be it in building permit issuance, land price information management, or water utility administration. GIS is portrayed as a valuable tool for streamlining operations, reducing costs, and enabling well-informed decision-making.

A notable trend evident in the literature is the integration of GIS with web-based platforms. Multiple studies showcased the benefits derived from merging GIS with the internet, enhancing communication, data submission, and information sharing. This integration not

only improves accessibility but also fosters collaboration in planning and administration. Additionally, the literature emphasizes the vital role of data integration from diverse sources, with GIS tools consistently employed to integrate spatial data from different origins, providing a comprehensive understanding of geographical contexts across various applications. However, challenges and limitations are recurrent themes in the literature. Concerns regarding real-time data updates, spatial analysis capabilities, and system security are highlighted in several studies.

Despite GIS's effectiveness, the literature stresses the need for continuous improvement, adaptation to evolving technologies, and addressing specific drawbacks such as real-time data updates. These challenges underscore the dynamic nature of GIS applications, necessitating ongoing refinement to meet the evolving needs of planning, administration, and decision support. In summary, the literature collectively emphasizes GIS's versatility in improving processes, optimizing resource allocation, and fostering collaboration across diverse domains. It offers a nuanced understanding of the benefits and challenges associated with GIS applications, highlighting the imperative for continual refinement and adaptation in the field.

3 RESEARCH METHODOLOGY

Introduction

This chapter discusses the research methodologies that were employed in the study. The chapter includes the research design, study population, sampling design, data collection techniques and the data analysis techniques.

Research Design

The research was thoughtfully designed, employing a quantitative method to capture rich insights into the development of integrated system aimed at enhancing spatial data processing and management. Through quantitative data collection, a descriptive study design was employed, emphasizing comprehensiveness to allow for a nuanced exploration of the multifaceted aspects inherent in such development. To systematically gather quantitative insights, a meticulously crafted questionnaire was employed. This questionnaire was designed and administered strategically to elicit specific and measurable responses from the participants, thus streamlining the process of extracting meaningful conclusions. By leveraging the responses obtained through the questionnaire, the research was adeptly positioned to derive statistically significant findings. This approach contributed to a robust understanding of the challenges and opportunities associated with spatial data processing and management for planning authorities.

3.1.1 Conceptual Model:

The conceptual model was developed based on Technology Acceptance Model (TAM) which integrates various components and external variables to provide a comprehensive understanding of the factors shaping the adoption and utilization of the integrated spatial data processing and management system by planning authorities. The Technology Acceptance Model (TAM) outlines that the perceived ease of use (PEOU) and perceived usefulness (PU) of a technology significantly influence users' behavioural intentions and actual usage. In the context of this study, TAM serves as the foundation for examining the adoption and usage behaviours of planning authorities towards the integrated spatial data processing and management system. Figure 8 below shows the TAM Model.

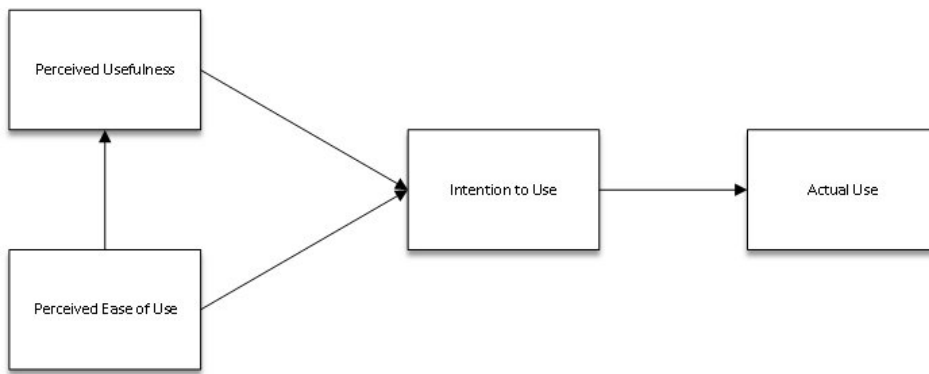


Figure 8: TAM Model

3.1.1.1 Ease of Use (PEOU):

Perceived ease of use refers to the extent to which planning authorities perceive the integrated system as straightforward and user-friendly in handling spatial data processing tasks. Key considerations include the intuitiveness of the user interface, the simplicity of data input and retrieval processes, and the clarity of system functionalities.

3.1.1.2 Perceived Usefulness (PU):

Perceived usefulness pertains to the degree to which planning authorities believe that the integrated system enhances their effectiveness in spatial data processing and management tasks. This encompasses the system's capability to improve data accuracy, facilitate data analysis and visualization, and support informed decision-making in urban planning processes.

3.1.1.3 Actual System Usage:

Actual system usage measures the extent to which planning authorities actively engage with and utilize the integrated system in their daily work routines. Metrics such as the frequency and duration of system usage, as well as the specific functionalities utilized, provide insights into the level of system adoption and integration into planning workflows.

3.1.1.4 Behavioural Intention to Use:

behavioural intention to use reflects planning authorities' willingness and readiness to continue using the integrated system over time. Factors influencing this intention include satisfaction with the system's performance, perceived benefits accrued from its usage, and alignment with existing planning practices and objectives.

Baseline Study

3.1.2 Population of the Study

The study focused on a diverse population consisting of urban planners, system analysts, and GIS specialists from Planning (Physical) and local Authorities, thereby encompassing a broad spectrum of expertise within the field. Purposive sampling was selected as the preferred sampling technique due to its deliberate selection of individuals perceived to possess relevant insights into spatial data processing and management for planning authorities. According to Zambia Institute of Planners (2023), there were 1100 planners actively working in Local and Planning Authorities included in this study. This sizable and varied population served as the foundation for the research, highlighting the extensive expertise present in the field of planning. It also provided a valuable dataset for examining the dynamics of spatial data processing and management. Purposive sampling played a crucial role in this study by meticulously selecting participants with specialized knowledge and experience relevant to the research objectives. By deliberately focusing on professionals proficient in urban planning, systems analysis, and GIS, the study ensured that the sampled population could offer substantive perspectives on the complexities of spatial data processing and management within planning authorities.

3.1.3 Sample Size and Sampling Technique

The sample size of 285 was computed from a pool of 1100 professionals registered and working in spatial data management department within Local Authorities. With a 95% confidence level and a margin of error of 5%, this sample size of 285 was deemed necessary to gain a comprehensive understanding of the research.

where

z is the z score

ϵ is the margin of error

N is the population size

\hat{p} is the population proportion

$$n = \frac{z^2 \times \hat{p}(1-\hat{p})}{\epsilon^2}$$

3.1.4 Data Collection Methods

This study utilized data gathered from both primary and secondary sources to ensure a comprehensive analysis. Primary data were obtained through surveys conducted specifically for this research, allowing for direct insights into the research objectives. Secondary sources included local datasets, academic publications, reports, and other pertinent existing information within the field. By combining information from these sources, the study was

able to triangulate data and provide a robust foundation for analysis and interpretation. This dual approach ensured the inclusion of diverse perspectives and enabled a thorough exploration of the research topic.

3.1.5 Instruments for Data Collection

The questionnaire was pre-tested and adjusted depending on the feedback from the pre-test. Quantitative data was collected through a questionnaire. Further, a quantitative questionnaire was uploaded in KOBO Collect (a digital survey tool) software on the tablet for quick administration and completeness. Furthermore, secondary quantitative data was collected using a quantitative data extraction tool.

3.1.6 Data Analysis

Quantitative data was analysed using SPSS version 20. The justification for selection of SPSS data analysis tool is that the software can manipulate complex data, analyse it with simple instructions and generate well-organized reports. The research used descriptive statistic approach in data analysis and interpretation.

3.1.7 Ethical considerations

Ethical considerations in research, as highlighted by Creswell (2014), demand meticulous attention throughout the entire research process. Anticipating and addressing ethical issues is imperative from the onset of the study through data collection, analysis, and reporting phases. In this study, ethical protocols were diligently observed.

Prior to data collection, all participants were provided with detailed information about the study's purpose and procedures through an introductory letter accompanying the questionnaire link. Assurance of anonymity was guaranteed, as the questionnaire did not request the respondent's name, thereby encouraging voluntary participation. The questionnaire was administered via a secure online platform, ensuring convenience and accessibility for respondents. Responses were collected electronically through the same platform, maintaining consistency in data collection procedures, and protecting participant privacy. These ethical measures were implemented to uphold the rights and confidentiality of participants, foster transparency in the research process, and ensure the integrity of the study.

3.1.8 Limitations

The study was limited in scope to planning institutions, which may restrict the generalizability of the findings to other sectors or disciplines. Furthermore, the research focused solely on certain aspects or functionalities of geospatial data management, mobile

GIS and web technologies, potentially overlooking other relevant factors or technologies that could impact spatial data processing and management. Additionally, the study may have been constrained by factors such as time, budget, and access to data or resources, which could have influenced the comprehensiveness of the research findings. Despite these constraints, efforts were made to mitigate limitations where possible. Rigorous methodological approaches were employed to ensure the validity and reliability of the research within its defined parameters. Additionally, transparency in reporting was prioritized to provide readers with a clear understanding of the study's limitations and implications for interpretation.

System Design and Implementation

The design phase focused on optimising database performance, creating intuitive user interfaces, implementing sophisticated spatial algorithms, and ensuring compatibility with pre-existing systems. The subsequent implementation involved meticulous coding, rigorous testing, and strategic integration into planning workflows. The section highlights the importance of training sessions for staff members of the planning authority and emphasises the need for continuous evaluation mechanisms to monitor the effectiveness of the system and provide information for possible improvements. In summary, this offers a thorough explanation of the meticulous strategy employed to guarantee the successful development and incorporation of the system into the planning ecosystem. Figure 9 below shows the Current Model.

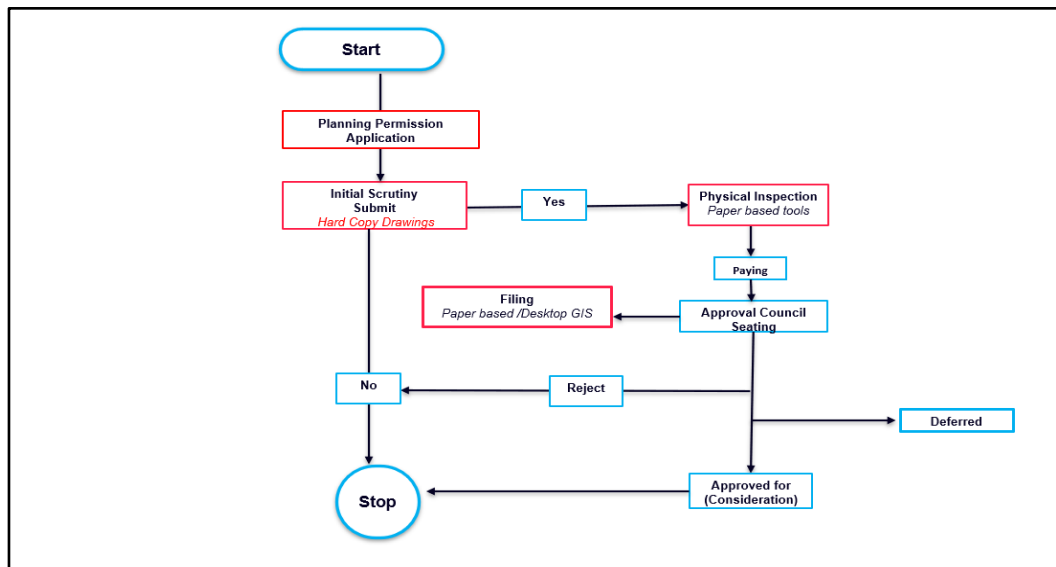


Figure 9: Current Model

The absence of interoperability poses significant challenges for the planning authority, particularly in terms of seamless geodata coordination across departments. A

noteworthy gap identified in the current model is the non-adherence to data standards during collection, processing, and maintenance, resulting in difficulties maintaining data integrity and enabling effective data integration. Furthermore, the absence of integrated systems connecting planning permissions applications with physical inspections is evident. The current approach relies on standalone processes, often paper-based, hindering efficient reporting. While strides have been made in linking computers through Desktop GIS, there is a pressing need to enhance security in data-sharing environment. The spatial databases in use are currently standalone systems, contributing to isolated data systems with limited real-time sharing and management capabilities.

3.1.9 Proposed Business Process

The proposed model aims to address the shortcomings of the existing system by introducing automation to the processes of planning permission services. It achieves this by implementing an integrated database accessible through Desktop GIS, Mobile GIS, and WebGIS platforms, thereby improving security and control within the data-sharing environment. Unlike the current isolated spatial databases, the proposed model facilitates real-time data sharing and management. Its core functionality revolves around spatial data management and processing, utilizing a variety of spatial data sources and tools to enhance decision-making and streamline operational workflows. By leveraging this integrated approach, the model seeks to enhance efficiency, accuracy, and collaboration in spatial data management processes. Figure 10 below shows the Proposed Model.

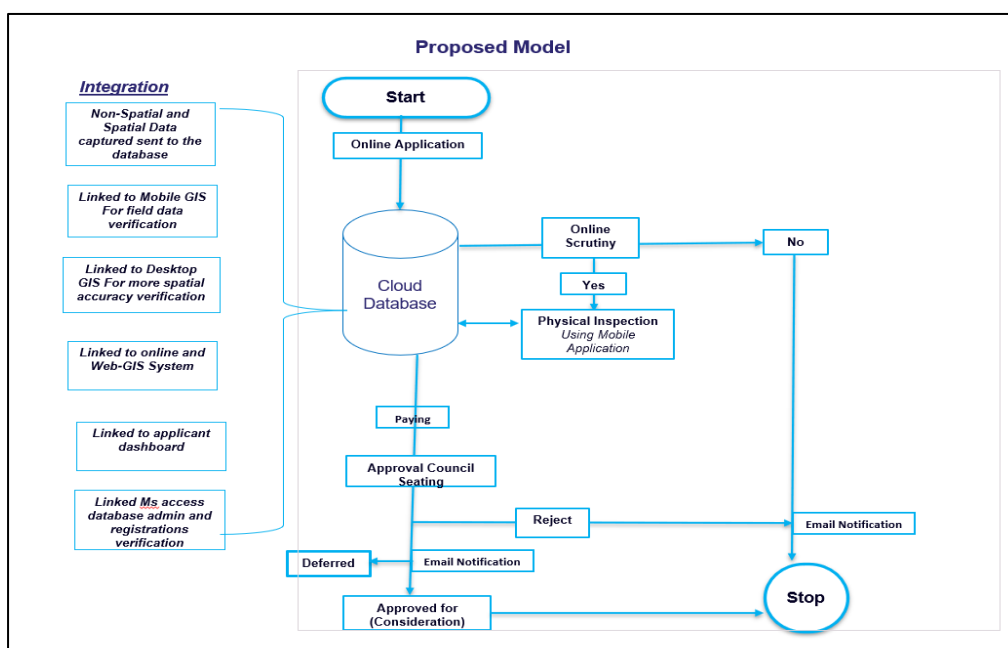


Figure 10: Proposed Model

The system seamlessly integrates data from various sources, facilitating timely analysis, and provides clients with tailored access through secure login sessions. Noteworthy is the collaborative approach involving both technical and non-technical users, such as GIS experts and administration officers, to ensure effective data integration. Recognizing the importance of interoperability, the model aligns with established principles for overcoming information integration challenges and emphasizes the technical abilities required for effective data manipulation and analysis. The proposed model represents a shift from the semi-paper-based current system to a fully integrated data management system, introducing online planning permission applications and integrated databases accessible through Mobile GIS, WebGIS, and Desktop GIS.

3.1.10 Requirements Specification

This outlines the functional, non-functional, hardware, and software requirements essential for the development and implementation of the spatial data processing and management system within the planning authority.

3.1.10.1 Functional Requirements

This section defines the expected inputs and outputs of the system. Inputs include clients applying for parcel registration or new land parcels advertised by the planning authority. The anticipated outputs encompass Geo maps, Land Use Maps, and various reports, including field inspection reports.

3.1.10.2 Hardware Requirements

Outlined are the hardware specifications necessary for optimal system performance. This includes a processor with a minimum speed of 2.1 GHz (Pentium 3 or higher), a minimum of 2GB RAM, at least 60 MB of free disk space, and an internet connection.

3.1.10.3 Software Requirements

The spatial data processing and management system necessitates compatibility with diverse operating systems, notably Windows for widespread desktop use and Android for mobile accessibility. Additionally, the system is designed to be accessible through major web browsers, including Google Chrome, Mozilla Firefox, Safari, and Microsoft Edge, ensuring a user-friendly experience across different platforms. For efficient storage and retrieval of spatial data, the inclusion of database management software such as MySQL or PostgreSQL is imperative. Geographic Information System (GIS) software plays a pivotal role,

encompassing desktop GIS (e.g., ArcGIS), mobile GIS, and web-based GIS applications like Leaflet and Google Maps API, enhancing the system's spatial data processing and mapping capabilities. Furthermore, internet connectivity tools and protocols are integrated to facilitate seamless communication with online services and data sources. This comprehensive suite of software requirements forms the foundation for the development of an integrated system that caters to various user needs and ensures robust spatial data processing and management functionalities.

3.1.11 Design Specification

3.1.11.1 System High Level Overview Design

The model was developed with a view to enhance spatial data management and processing. The model involves procedures such as preparation of data, updating, data processing to the server (Postgis). The data from the server will be accessed from different points and tools. The Desktop GIS will be linked to the system to enable data manipulation, analysis, and visualisation (automated map production). The web GIS interface will allow users to access information through the web, the System database which is the engine room, responsible for processing tasks and requests made by the users. The proposed system facilitates the easy and efficient exchange and sharing of information on and data processing of non-spatial data from different access points. The design model of the integrated data management system consists of Mobile GIS, WebGIS and Desktop GIS. clients can apply for services by login to the web Gis. field inspection data captured using the mobile device and is accessible via a web browser of the device. The application on the mobile device, which can either be a smartphone or a mobile computer sends the captured data onto the database in the cloud. The web application on the user's computer embedded with a GIS application is used to display geo locations of properties on a map together with summary reports which can be used for strategic decision making by the admin.

The proposed system is a Web GIS based system to facilitate the easy and efficient exchange and sharing of information and files. This system requires numerous inputs for it to function properly and these include Software, People, Data, Hardware, and Communication Channels. This system also allows the use of ArcGis and Qgis software to organise, store, manipulate and process data. The process requires input data such as population, land use and other relevant geospatial data sets which is later processed using modelling and analysis techniques to produce maps, charts and tables related to the project. Furthermore, the data is then

processed into web map format in order to be processed by the web server. Figure 11 below shows the system Integrated Spatial Framework.

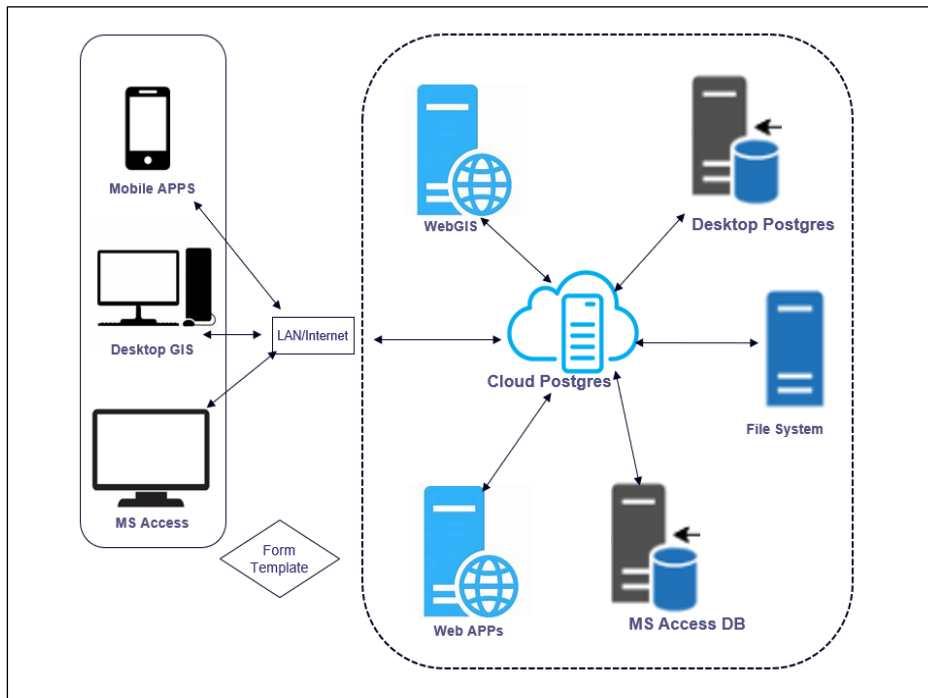


Figure 11: Integrated Spatial Framework

The system is also composed of the backend users They are also involved in Compilation, analysis and processing of applications sent to the site by the clients. In addition, they have full access and control of Web Server Database and the general information displayed on the website. Through the system interface, a client can access the planning authority’s website through the internet, using a web browser where a client can view and interact with all information related to property and register applications. Figure 11 above shows the system Integrated Spatial Framework.

3.1.11.2 Logical Design

The system's operational dynamics are visually represented, illustrating the interactions among three key actors. These actors include the field inspector utilizing the application, the client engaging with planning services from the planning authority, and the admin manager functioning as the system administrator. Figures 12,13 and 14 below shows the system Admin, client and Mobile Application Model respectively.

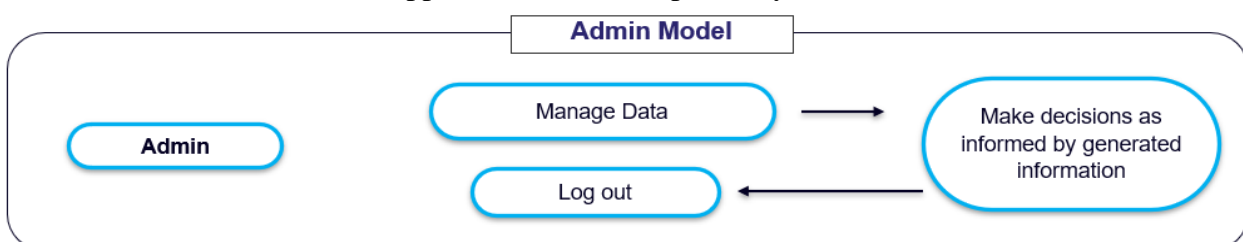


Figure 12: Admin Model

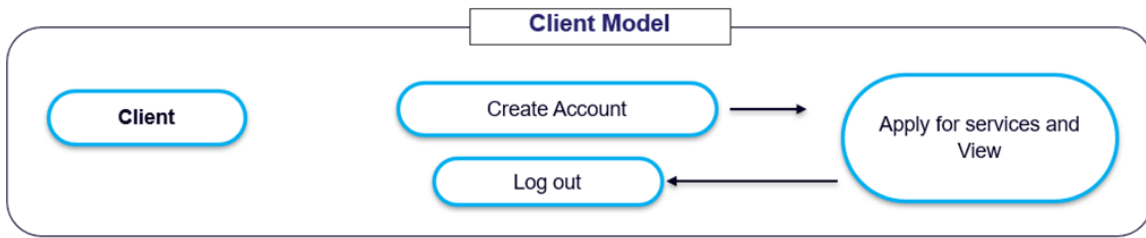


Figure 13: Client Model

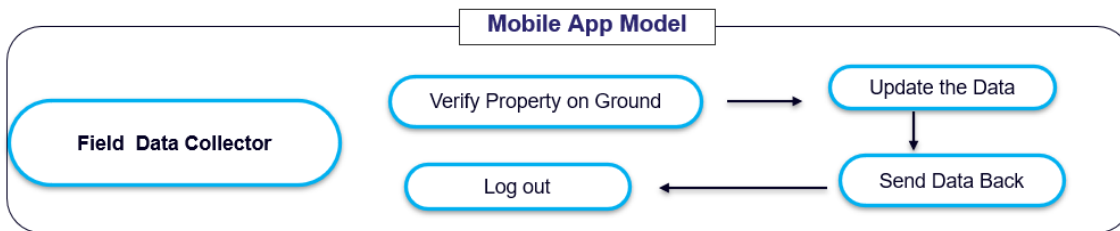


Figure 14: Mobile Application Model

3.1.11.3 Use Case Diagrams

The integrated spatial data management system provided a user-friendly interface, allowing regular users to perform map operations, query land use data, and contribute by uploading geospatial information through a mobile app. Admin functionality encompassed database maintenance, information publication, and advanced geospatial analysis tools for planning authorities. Figure 15 below shows the system Use Case Diagrams.

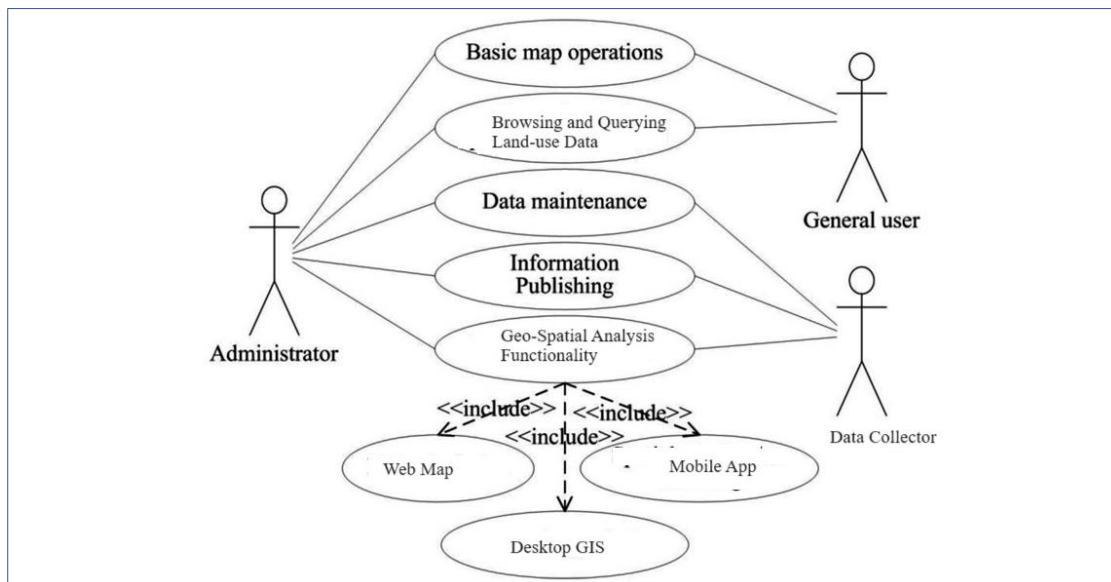


Figure 15: Use Case Diagrams

Security measures ensured data integrity and confidentiality, and both users and administrators benefited from audit trails capturing their activities. The system's scalability, adherence to data standardization, and seamless mobile app integration contributed to its effectiveness in enhancing spatial data processing and management for planning authorities, offering a robust solution for data collection, analysis, and decision-making.

3.1.11.4 Activity Diagrams

The process started with the initiation of online applications, where applicants submitted their requests. The applications underwent an approval and scrutiny process to determine their validity. If approved, a schedule for field inspection was established. Using the application, inspectors conducted on-site assessments and collected relevant data. The feedback obtained during the inspection was seamlessly integrated into the system. Subsequently, comprehensive reports were generated and communicated to the applicants via email. This streamlined process, from online application to field inspection and email feedback, enhanced efficiency, and communication within the building control system. Figure 16 below shows the system Activity Diagrams.

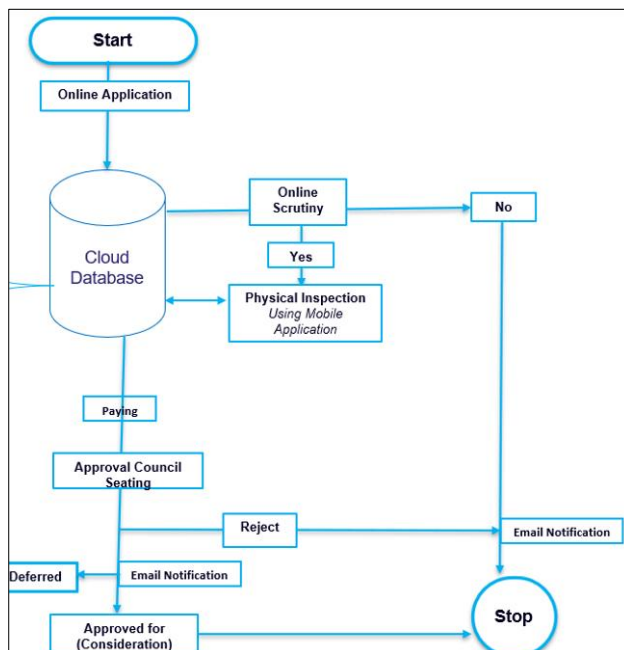


Figure 16 Activity Diagrams

3.1.11.5 Sequence Diagrams

The system administrator (admin) initiates the process by approving registration applications and creating accounts for field inspectors. After successful registration, clients gain the ability to apply for various planning services, such as requesting a new plot or applying for a change in land use and conversion. Subsequently, the field inspectors employ a mobile application to conduct on-site inspections, assessing the real-world conditions and generating

recommendations based on their observations. The field inspection data is then transmitted back to the system. Figure 17 below shows the system Sequence Diagrams.

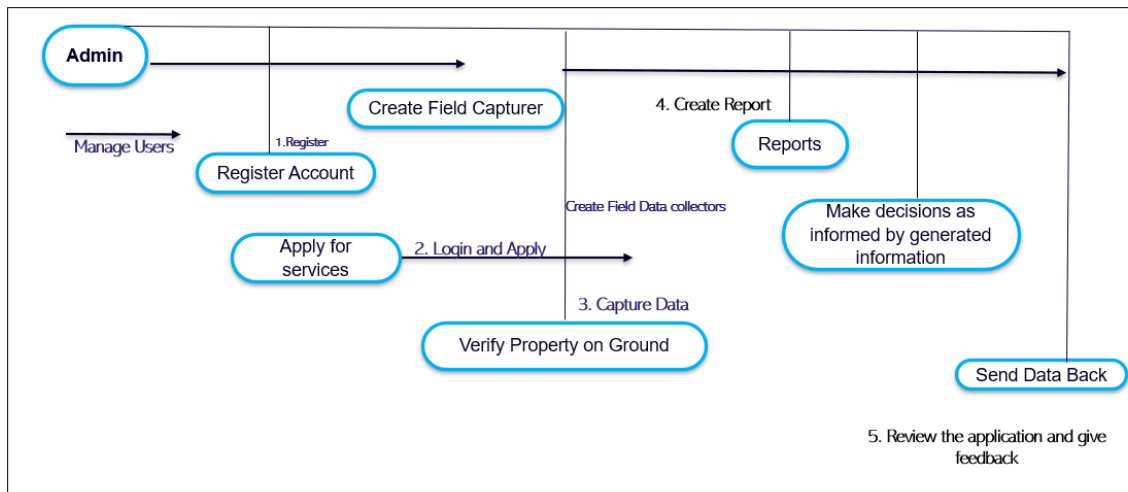


Figure 17: Sequence Diagrams

The system admin, equipped with the collected information from both clients and field reports, reviews the applications. Drawing on this comprehensive dataset, the admin makes informed decisions regarding the planning services requested. This sequence of actions ensures a structured and efficient workflow, integrating the roles of clients, field inspectors, and the system administrator for a streamlined planning service process.

3.1.11.6 Database Design

The chosen database solution for implementing the integrated data management system is identified as the PostgreSQL Relational Database Management System (RDBMS). PostgreSQL serves as the foundational platform for storing, processing, and retrieving data within the system. Leveraging the robust capabilities of PostgreSQL aligns with best practices in relational database management, ensuring efficient and organized handling of data to meet the requirements of the integrated data management system. This deliberate choice reflects a commitment to a reliable and scalable database solution for the seamless functioning of the overall system. Figure 18 below shows the system Database relations design.

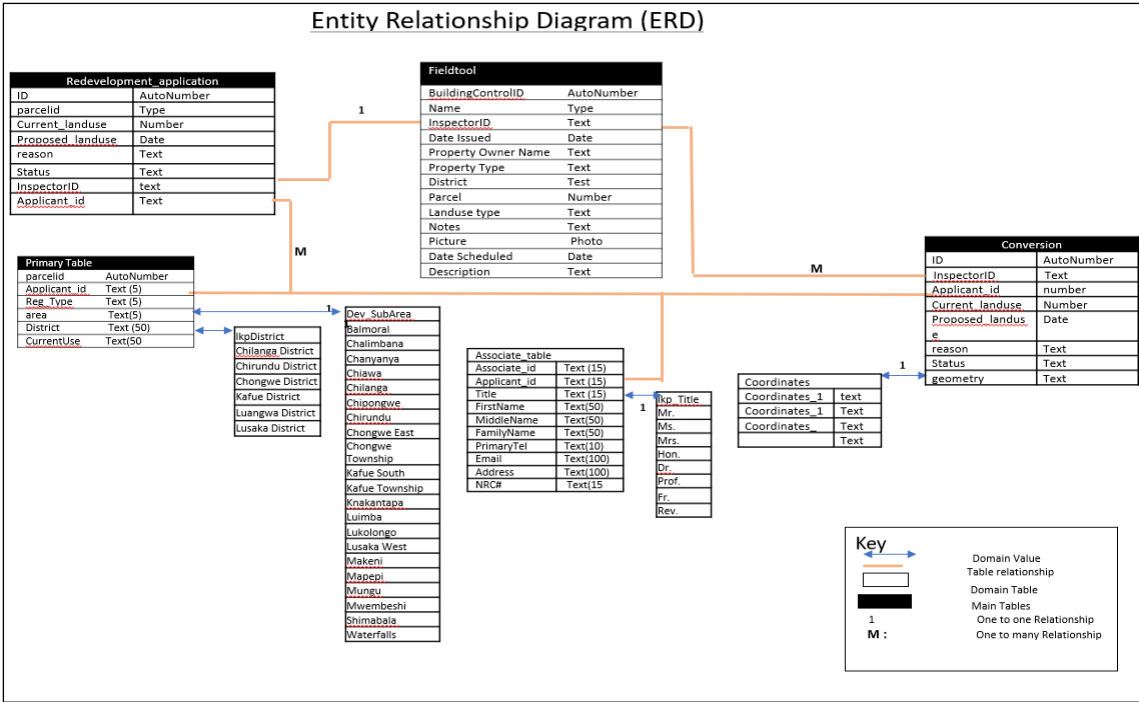


Figure 18: Database Design

The Building Control Database is designed as a mobile application with synchronization capabilities to a web map, facilitating efficient management of building-related data. The key entities include Buildings, Permits, Inspections, and Users. Buildings can have multiple Permits, each associated with a specific Building. Permits, in turn, can undergo multiple Inspections. Users, identified by UserID, play roles in managing and accessing building-related information. The figure 19 below shows the system Mobile Application Database relations.

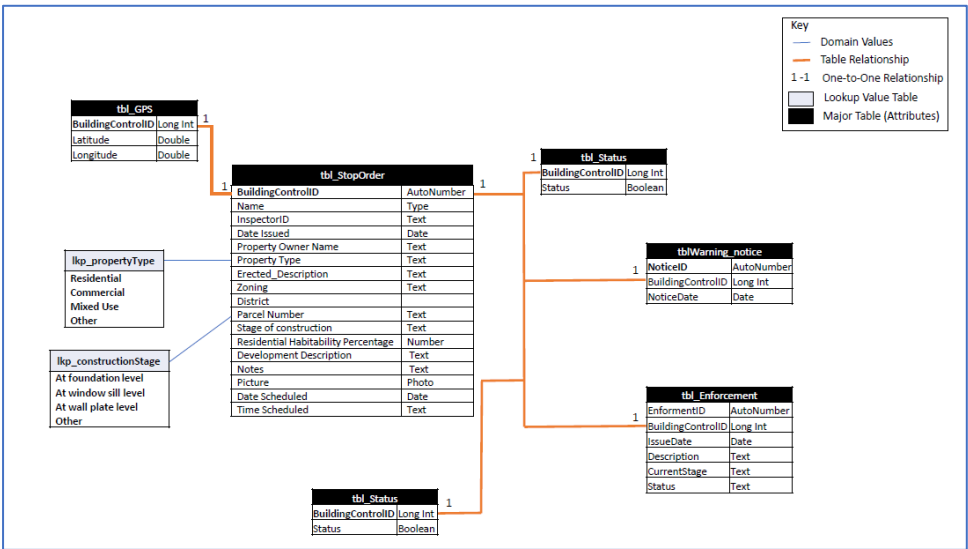


Figure 19: Mobile Application Database relations.

The synchronization feature ensures real-time updates between the mobile application and the web map, allowing for geotagging of building data for spatial representation. This comprehensive Entity Relationship Diagram (ERD) establishes the foundation for a robust system, enhancing building control authorities' ability to track and manage permits and inspections seamlessly across mobile and web platforms.

3.1.11.7 Security Design

The security design for the integrated system prioritized several key aspects to ensure the confidentiality, integrity, and accessibility of sensitive spatial data. Security requirements encompassed robust measures to safeguard user accounts, prevent unauthorized access, and protect against potential threats. Legislative compliance was a crucial consideration, adhering to relevant data protection regulations and standards applicable to spatial data management. The figure 20 below shows the system security design.

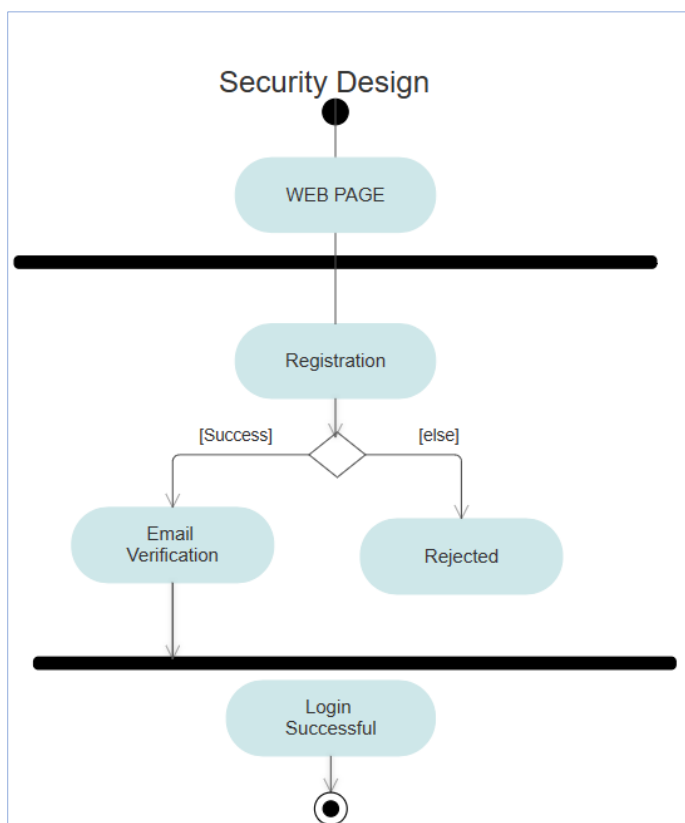


Figure 20: Security Design

The system incorporated stringent login procedures, including email verification, to authenticate users and verify their identities. This process involved sending a verification email upon user registration, ensuring that only authorized individuals gained access to the

system. Secure login mechanisms, such as multi-factor authentication, bolstered the overall system security by adding an additional layer of user verification. By addressing these security considerations, the system aimed to provide a secure environment for planning authorities, maintaining the confidentiality of spatial data, and complying with legal requirements.

System Implementation

During this crucial phase, the conceptual framework was transformed into a concrete system through careful planning and meticulous execution. The development process progressed from the initial conceptualization stage to the operationalization stage as the spatial data management system began to take form. The activities involved in this project include coding, creating a database, and integrating different functionalities smoothly. Stringent testing protocols were established to guarantee the system's compliance with predetermined benchmarks. This phase represents the connection between generating ideas and achieving practical functionality.

3.1.12 System Development

System Development reveals the complex procedure of successfully creating the integrated spatial data management system. The essential elements for spatial data processing and management were built using strategic programming, coding, and database creation. Stringent testing protocols were implemented to detect and correct any irregularities, guaranteeing that the ultimate system seamlessly conforms to predetermined specifications. The System Development phase demonstrates a commitment to designing a system that not only meets but surpasses performance benchmarks, offering a dependable and effective tool for planners, field inspectors, and administrators.

3.1.13 System Deployment

The spatial data management system was successfully transitioned from the development environment to active deployment. This entailed deploying the system on servers or cloud platforms, carefully configuring the infrastructure, and setting up accessibility for end-users, specifically personnel from the planning authority. Stakeholders were provided with the essential skills to effectively utilise the system through user training sessions. Efficient data migration strategies were utilised to guarantee a seamless transition. The emphasis on continuous support during this phase guarantees the long-term and effective functioning of the implemented system, enabling planning authorities to efficiently manage spatial data.

Chapter Summary

Chapter Three plays a crucial role in this research project, as it concentrates on two essential elements: research methodology and system prototype design. This chapter provides a thorough analysis of the research design, highlighting its crucial role in addressing the current research questions. Concurrently, the chapter explores the complexities of designing the model, which is a vital step in preparing for the development of the system prototype.

This chapter primarily focuses on conducting a thorough assessment of the current database model. The objective is to examine the current methods employed to promote collaboration across various domains. Through the implementation of this assessment, the research establishes a robust basis on which the proposed model is carefully constructed. This strategic approach guarantees that the suggested model not only tackles the identified research questions but is also guided by a sophisticated comprehension of the present state of database methodologies. The section explores the modelling of the prototype system. This involves a comprehensive examination of the application's design structure, integrating principles derived from Geographic Information System (GIS) and Web-GIS concepts. These elements are essential in determining the structure of the application database. The deliberate incorporation of GIS and Web-GIS concepts demonstrates a dedication to utilising advanced technologies, guaranteeing that the prototype system seamlessly conforms to current practices in both GIS and web-based geographical information systems.

4 RESULTS

Introduction

Having designed the research and the model solution to the problem, the research was conducted, firstly by carrying out a survey with a sample to establish the common spatial data management systems in Zambia and processing whose data provided depth in the development of the prototype. This chapter focuses on the results as the output of the research activity. Overall, this chapter serves as a comprehensive summary of the research outcomes.

Baseline Study Results

4.1.1 Descriptive Statistics

The primary aim of the analysis is to address research inquiries regarding the current state of integrated data management systems in local authorities.

4.1.1.1 Demographic Data

This study presents the educational composition of the participants. As shown in the table 2 below, 12% of the participants possess master's degrees, which signifies their high level of academic qualifications. 45% of individuals possess a bachelor's degree, constituting 57% when combined with those holding a master's degree. 25% of the population holds a diploma, while 82% holds either a master's or a bachelor's degree.

Education	Count	Percentage	Cumulative
Masters	34	12	12
Degree	129	45	57
Diploma	71	25	82
Other	34	18	100
Total	285	100	

Table 2: Demographic Data

4.1.2 Duration in the use Spatial Data Management

The study sought to establish how long the participants have been engaged in spatial data management. As shown in the table 3 below, most participants constituting 42.9% submitted that they have been working with spatial data for approximately 4-7 years. Meanwhile, 28.6

% of the sampled participants shared that they have been using spatial data for approximately 3 years and below. participants that have been using spatial data for approximately 8-10 years represented a sample of 14%, a statistic like participants that have used spatial data for over 10 years.

	Percent		Cumulative
0-3 years	82	28.6	28.6
b) 4- 7 years	41	14.3	42.9
c) 8 - 10 years	41	14.3	57.1
d) 10+ years	122	42.9	100
Total	285	100	

Table 3: Duration in the use Spatial Data Management

4.1.3 Level of Expertise

To ascertain the technical know-how, regarding spatial data management present within the sampled institutions, it was thought to inquire on the level of expertise in the following categories: a) Beginner b) Intermediate c) Expert c) Developer. As highlighted in the table 4 below, 57.1% of respondents submitted that they are experts in spatial data management. In the same vein, 28.6% submitted that their level of expertise in spatial data management is intermediate while 14.3% presented themselves as Developers.

	Count	Percent	Cumulative Percent
b) Intermediate	82	28.6	28.6
Beginner	41	14.3	42.9
c) Expert	162	57.1	100
Total	285	100	

Table 4:4.2.3 Level of Expertise

4.1.4 Current GIS systems in use in Planning Authority

Regarding the utilisation of GIS systems among the surveyed institutions, the data shows that there is a unanimous preference for Desktop GIS. All respondents (100%) reported using this system. Moreover, the survey reveals a dual trend in the implementation of mobile and web-

based GIS systems. As shown in the figure 21 below, more precisely, 42% of the institutions employ Mobile GIS, indicating a notable yet not widespread implementation. Similarly, an additional 42% of the institutions utilise Web GIS, indicating an equal level of significance in this category. The detailed distribution of GIS technology in the surveyed institutions reveals a diverse landscape, demonstrating a thorough integration of both conventional and new GIS platforms.

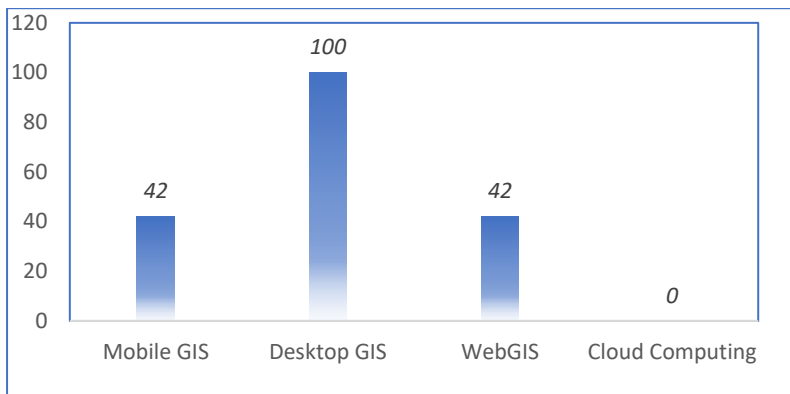


Figure 21:GIS Systems currently in use.

4.1.5 Spatial Data Management Specialisation

The study aimed to establish specialization concerning spatial data management among the surveyed institutions, as depicted in figure 22 below. Analysis revealed that all institutions specialize in data management, with 85% demonstrating specialization in data collection. Moreover, findings indicated that 57% of institutions possess expertise in data analysis, while 42% are specialized in integrated data management. These insights shed light on the diverse areas of specialization within the sampled institutions, providing valuable context for understanding their capabilities and priorities in spatial data management.

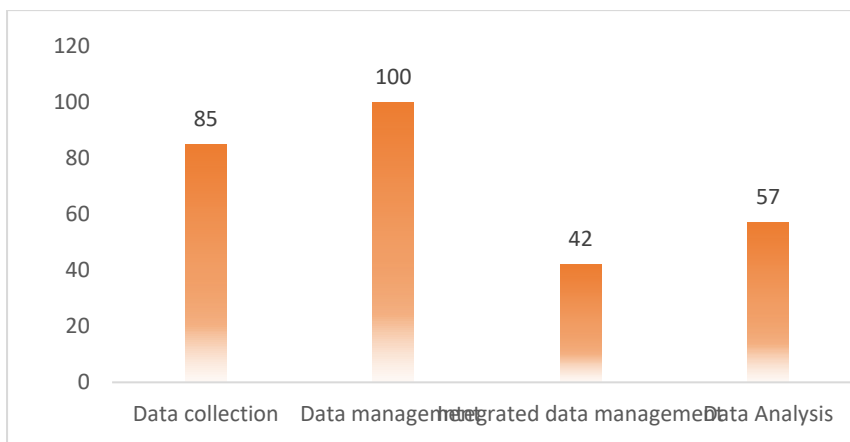


Figure 22:Spatial Data management specialisations.

4.1.6 System Integration

The research sought to establish if the systems currently being used in Planning Authorities are auto integrated with other systems. According to the findings illustrated in table 5 below, a significant majority, comprising 71.4%, had not implemented auto-integration for their data storage systems. In contrast, 28.6% of the institutions had successfully auto integrated their data storage systems, showcasing a smaller yet notable percentage embracing streamlined integration practices.

	Count	Percent	Cumulative Percent
a) No	203	71.2	71.4
b) Yes	82	28.8	100
Total	285	100	

Table 5: system integration

4.1.7 Using Mobile Application

Lastly, it was sought to establish whether mobile application is being used by the participants in the target institutions. According to the findings illustrated in table 5 below, a significant majority, comprising 70%, had not implemented the use of mobile application in data collection. In contrast, 30% of the institutions had successfully implemented the use of mobile application in data collection, showcasing a smaller yet notable percentage embracing streamlined integration practices.

	Count	Percent	Cumulative Percent
a) No	200	70	70
b) Yes	85	30	100
Total	285	100	

Table 6: Using Mobile Application

4.1.8 Limitation in adoption of Integrated System

To ascertain the Limitation in adoption of Integrated System working participants working in planning authorities. As highlighted in the figure below, 57.1% of respondents submitted that lack of expertise contributed to limited adoption of integrated System in Planning Authority. In the same vein, 28.6% submitted that that Operationalization Cost contributed to limited adoption of integrated System in Planning Authority while 14.3% attributed to other factors such as pollical will.

	Count	Percent	Cumulative Percent
Expertise	82	28.6	28.6
Other	41	14.3	42.9
Operationalization Cost	163	57.1	100
Total	285	100	

Table 7: Limitation in adoption of Integrated System

System Automation and Implementation Results

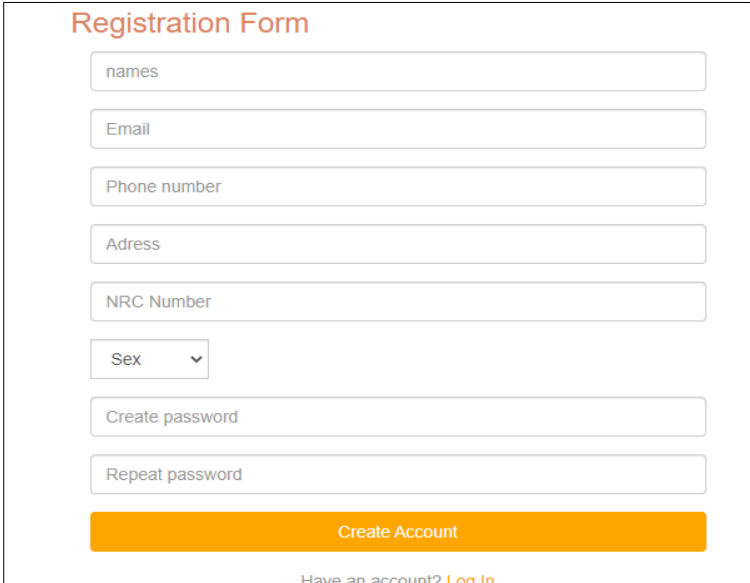
The system integration was successfully accomplished through the linkage of the webGIS with both the desktop GIS application QGIS and the mobile GIS application utilized for field data collection. The WebGIS Integration serves as a central hub, connecting various components of the system. This linkage likely facilitates seamless communication between the web-based geographical information system and other interfaces, ensuring a cohesive and integrated user experience.

The integration with QGIS, a desktop GIS application, indicates a robust connection between the webGIS and a powerful desktop tool. This connection allows for advanced geographic analysis, visualization, and manipulation of spatial data, enhancing the capabilities of the overall system. Moreover, the integration with the Mobile GIS Application plays a crucial role in the efficient collection of data from the field. This connection likely enables field inspectors to utilize the mobile application for on-site data gathering, ensuring real-time updates and accurate information input into the system. In essence, the successful integration of the webGIS with both QGIS and the Mobile GIS Application reflects a comprehensive approach to data management, combining the strengths of web-based, desktop, and mobile platforms for a well-rounded and effective GIS system.

4.1.9 System Implementation Results

4.1.9.1 Client Module

This module showcases how clients, or the users were accessing the system, and it starts with the client accessing the url to the system and filling out the registration form. Client Registration Form was filled out by the clients through providing their personal and contact information, address, and password. The registration is needed for all the clients that need to access the planning services from the planning authority. The registration was done for the clients who already have the properties already registered with the planning authority or want to apply for a new property advertised by the planning authority. The screenshot in figure 23 shows the system prototype registration form.



The screenshot displays a registration form titled "Registration Form" in orange text. The form contains several input fields: "names", "Email", "Phone number", "Adress", "NRC Number", "Sex" (a dropdown menu), "Create password", and "Repeat password". Below these fields is a prominent orange "Create Account" button. At the bottom of the form, there is a link that reads "Have an account? [Log in](#)".

Figure 23: Registration Form

Following a successful registration, users are directed to the login page as the initial point of system access. The login page, illustrated in the accompanying figure, prompts users to enter their username and password. This two-step authentication process enhances security and establishes personalized access to the system. The inclusion of a dedicated login page not only contributes to the system's security measures but also prioritizes user experience by providing an intuitive entry point. The visual representation in the screenshot adds a practical dimension to the description, offering insight into the design and aesthetics of the login interface. Overall, the login page is a critical component, ensuring secure and user-friendly interactions within the system. The screenshot in figure 24 shows the system prototype login form.

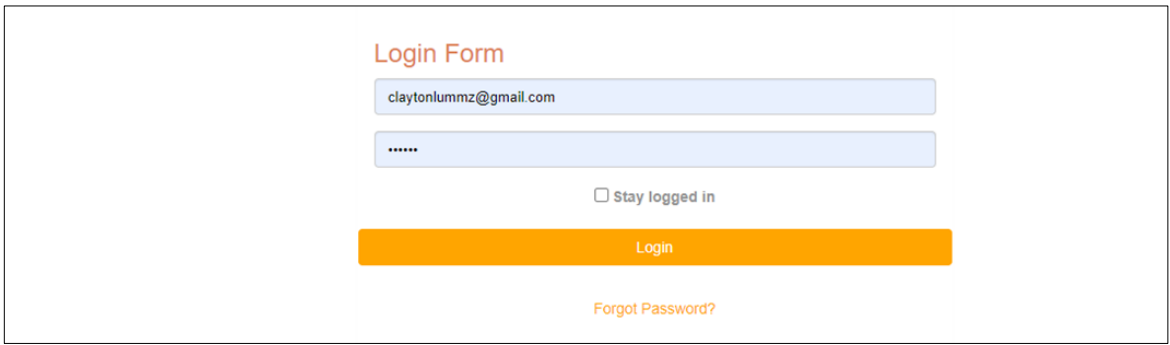


Figure 23: Login Form

4.1.9.2 Application for services

The user has access rights of the dashboard upon successful login, the dashboard provides users with quick access to information and common tasks. The dashboard is being used to track the application process and shows the number of properties the user has in the system. The dashboard embedded with the web map that enabled the clients to see the actual location of the properties. The dashboard also can show the detailed property details such as property ID, the land use, and the status for both the applications in progress and the properties. The screenshot in figure 25 shows the system application form.

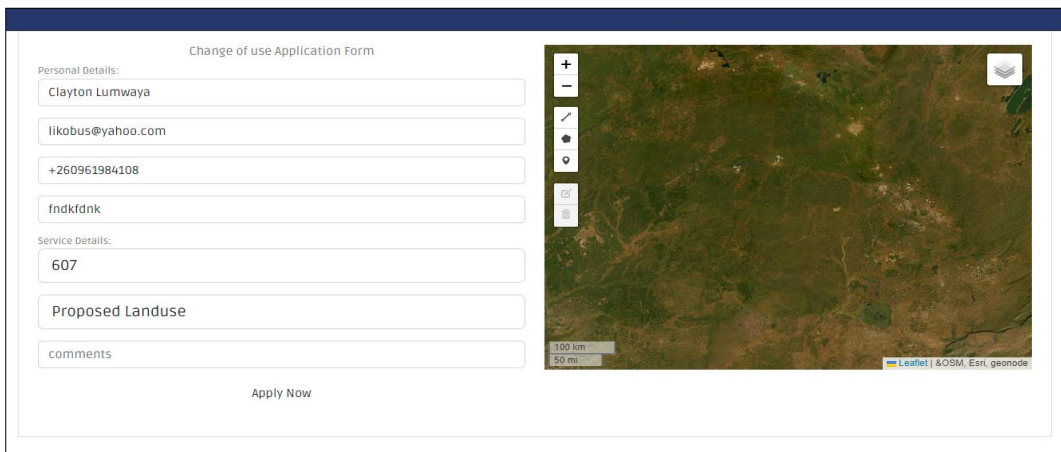


Figure 24: Application Form

The system allowed the user to apply for different services provided by the Planning Authority such as provision of land conversions, application for new land parcels and change of use. The the application form for change of use in which the system automatically was able to pick the type of properties that the client had in the system. In addition, the system also automatically picked the client details such as name, email, phone, number, and address and allowed them to select the specific type of the property they want to change use and the preferred use type. The screenshot in figure 26 shows the Client Application tracking tab.

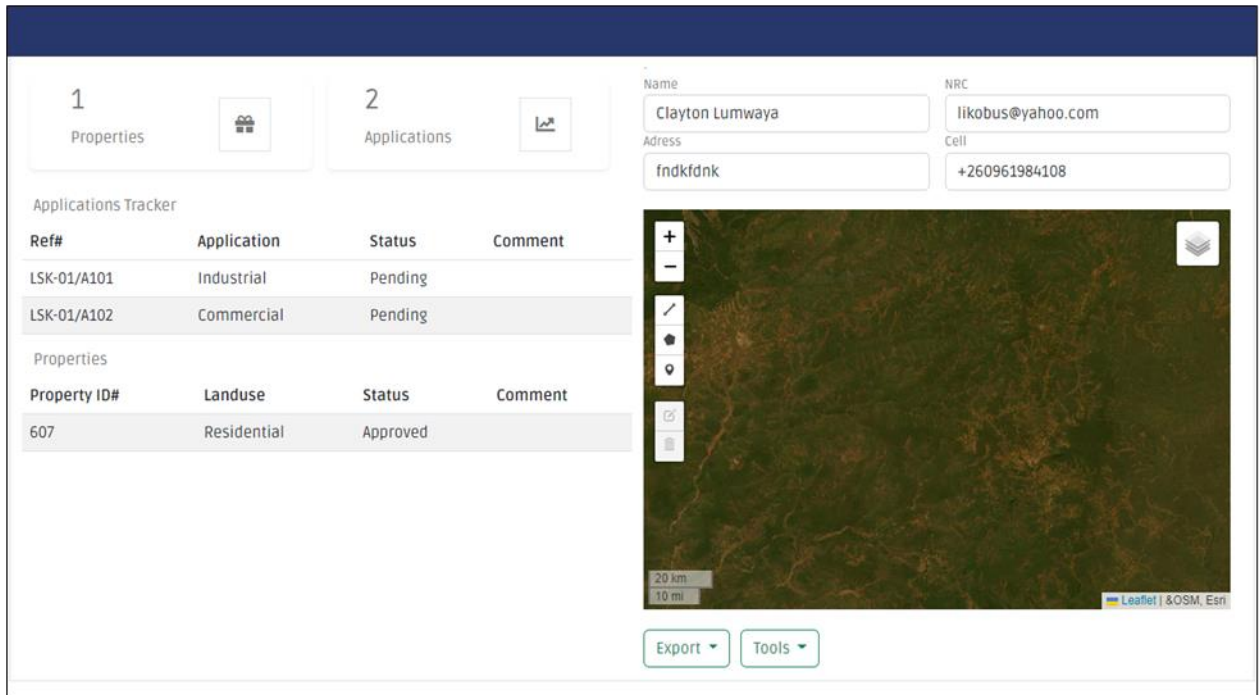


Figure 25: Client Application tracking.

4.1.9.3 Admin Mode

The system was developed to review all the applications form the client as shown in the figure below. The panel also allowed the admin to perform other functionalities such exporting the table to excel sheet and search for the application using the property number. In order to approve a particular parcel, the admin was required to click on the approve button and the approval page was loaded showing the details of the application. The approval page will be loaded showing the details of the application including the admin then assigns the property ID to the applicants applying for new properties. The admin was able to approve or reject the applications by reviewing their application details that the client has sent and comment the recommendations on from the by the field inspector. Upon approval or rejection, the system was able to send the feedback to the client.

In the system's operational context, the system administrator, acting as the admin, had the authority to approve registration applications and create accounts for field inspectors. Following registration approval, clients gained the ability to apply for various planning services, including requests for new plots and changes in land use or conversion. After successful login, the admin accessed a comprehensive dashboard that provided quick access to vital information and common tasks. The screenshot in figure 27 shows the admin approval page.

Export Table

#	Name	NRC	Cell	Current	Status	Action
LSK-01/A101	Clayton Lumwaya	likobus@yahoo.com	+260961984108	Industrial	Pending	Aprove
LSK-01/A102	Clayton Lumwaya	likobus@yahoo.com	+260961984108	Commercial	Pending	Aprove
LSK-01/A104	Clayton Lumwaya	likobus@yahoo.com	+260961984108	Residential	Pending	Aprove
LSK-01/A105	Clayton Lumwaya	likobus@yahoo.com	+260961984108	Commercial	Pending	Aprove
LSK-01/A106	Clayton Lumwaya	likobus@yahoo.com	+260961984108	Industrial	Pending	Aprove
LSK-01/A107	Clayton Lumwaya	likobus@yahoo.com	+260961984108	Commercial	Pending	Aprove
LSK-01/A108	Clayton Lumwaya	likobus@yahoo.com	+260961984108	Residential	Pending	Aprove

1/1 [Next](#)

Figure 26: Approval panel.

4.1.9.4 Dashboard

This dashboard served as a centralized hub, allowing the admin to efficiently track and display the number of properties and their types within the system. It featured an embedded web map, facilitating interactive engagement with the layout plan, and incorporated graphs for a detailed analysis of plots within the layout plan. This holistic dashboard not only streamlined administrative tasks but also enhanced the visual representation and analytical capabilities for effective planning services. The screenshot in figure 28 shows the admin dashboard page.

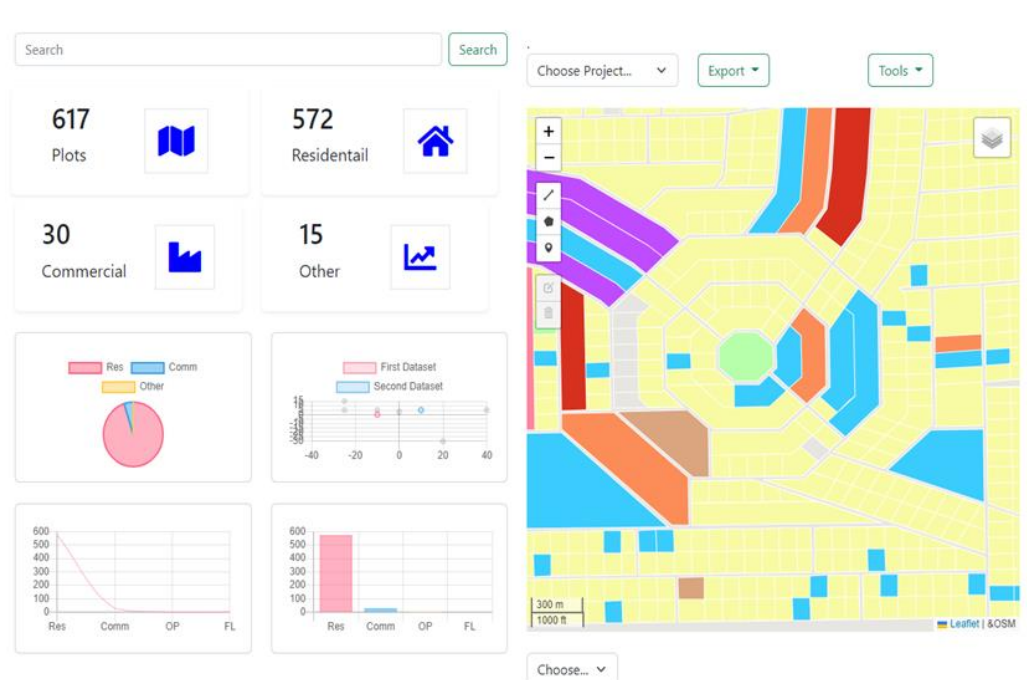


Figure 27: Dashboard.

The system afforded users the capability to not only view but also actively manage and edit applicant details. This encompassed a comprehensive range of information, including the number of properties associated with the user, precise property locations, and a suite of actions empowering users to create, update, and delete data within the system. The screenshot in figure 29 shows the applications page.

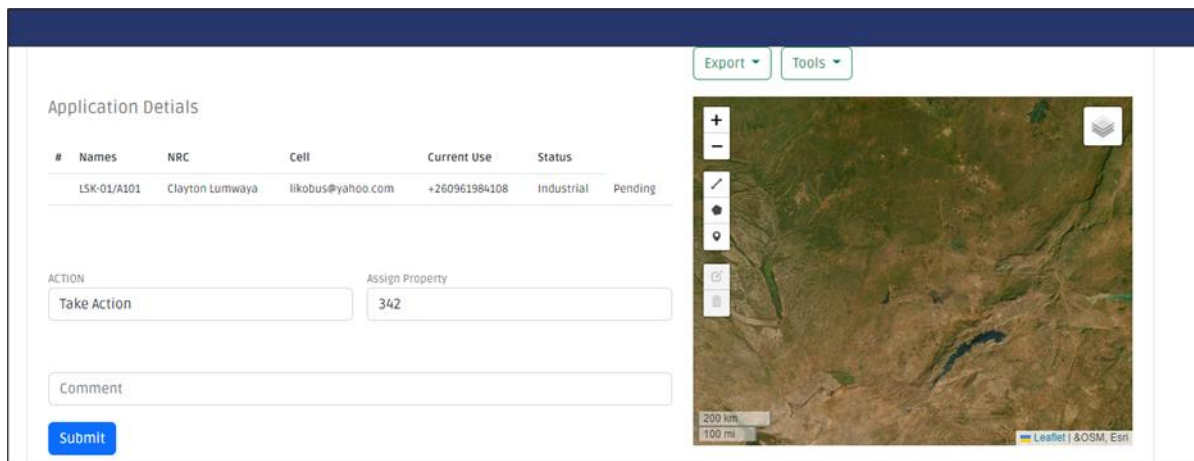


Figure 28; Application Details

The user interface facilitated a seamless experience, enabling efficient navigation through applicant details and providing a dynamic platform for making real-time modifications to property information. This versatility in functionality empowered users to maintain accurate and up-to-date records, ensuring that the system served as a robust tool for property management and data manipulation. The ability to take various actions within the system underscored its user-friendly design, promoting user autonomy and facilitating a streamlined process for handling property-related information.

4.1.9.5 Mobile Application Module

One of the most important developments in the field of development control and field inspection procedures was the configuration of the system to integrate without any difficulty with a mobile application that was specifically designed for that purpose. Field inspectors were given the ability to conduct inspections using the mobile application while they were out in the field as a result of this integration, which provided a multifaceted approach. The inspectors were able to collect data in real time, conduct assessments on the spot, and formulate recommendations based on the actual conditions that were observed on the ground thanks to this innovative approach. The utilisation of the mobile application not only sped up the process of conducting field inspections, but it also ensured that the information that was

gathered was accurate and that it was collected immediately. The screenshot in figure 30 shows the mobile applications page.

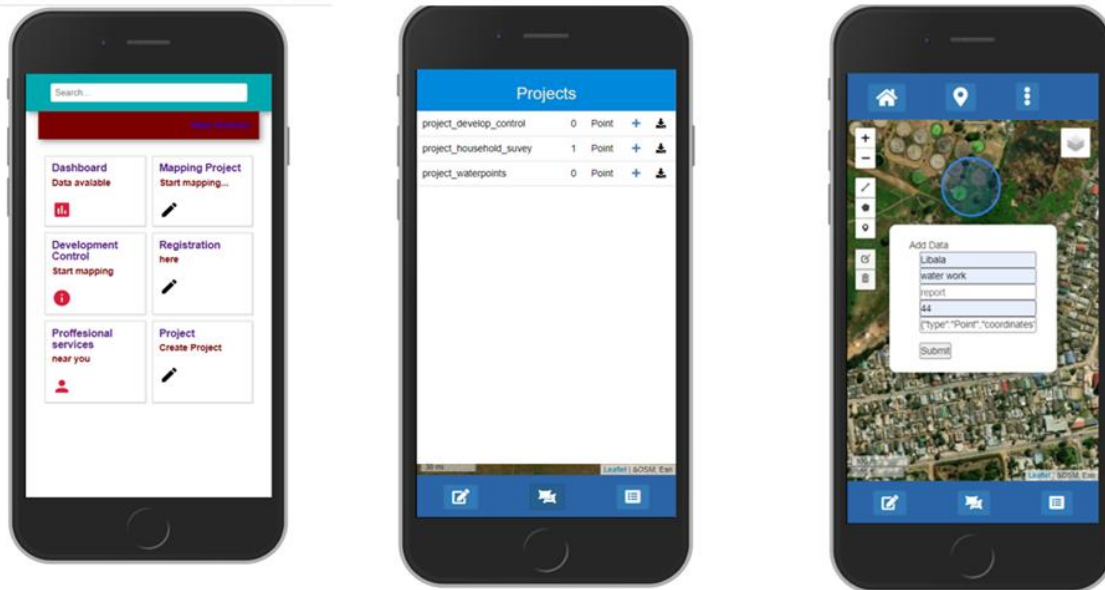


Figure 29: Mobile Application

In this streamlined workflow, the system administrator played a crucial role in the subsequent stages of the process. The responsibility that they were responsible for included conducting a thorough examination of the applications that were submitted by customers, analysing the information that was provided, and comparing it with the comprehensive field reports that were generated by the mobile application software. The system administrator was able to make well-informed decisions regarding development control as a result of this comprehensive review process. The integrated system promoted a collaborative and data-driven decision-making environment, which fostered efficiency and accuracy in the management of development processes. This was accomplished by bridging the gap between on-site observations and client submissions.

4.1.9.6 Desktop GIS Integration

Desktop GIS software, such as QGIS, was identified as a common software being used in planning authorities for geospatial data analysis and visualization. Because of this, the system was designed to integrate with existing tools like QGIS to enable seamless data exchange and more advanced geoprocessing. The integration was done through establishing a connection between QGIS and the system, a PostGIS geodatabase was used. PostGIS is an extension for PostgreSQL that provides spatial database functionality. It allows users to store, query, and manage geospatial data directly within

a relational database. By utilizing PostGIS, the system could efficiently handle large amounts of spatial data while maintaining compatibility with QGIS. The integration process began with configuring the connection to Desktop QGIS. This step involved establishing a secure communication channel between QGIS and the PostGIS geodatabase. The administrator's username and password were entered to authenticate the connection. This ensured that only authorized users could access the spatial data. After successful authentication, QGIS was able to access the PostGIS geodatabase and import shapefiles as layers. The shapefiles contained information about land use, which was crucial for the administrator's geospatial analysis. Once the shapefiles were imported into QGIS as layers, the administrator could leverage QGIS's extensive geospatial tools to manipulate, analyse, and visualize the data. This included performing complex geoprocessing tasks, such as spatial joins, buffers, and intersections. QGIS's robust visualization capabilities also allowed the administrator to create detailed maps and reports based on the imported layers. The integration between the system and QGIS through the PostGIS geodatabase enabled a seamless workflow for the administrator. They could access and process spatial data in a familiar desktop GIS environment while benefiting from the additional capabilities provided by the PostGIS geodatabase. This integration made it easier to conduct geospatial analyses and create visual representations of the data for better decision-making. The screenshot in figure 29 shows the system desktop version.

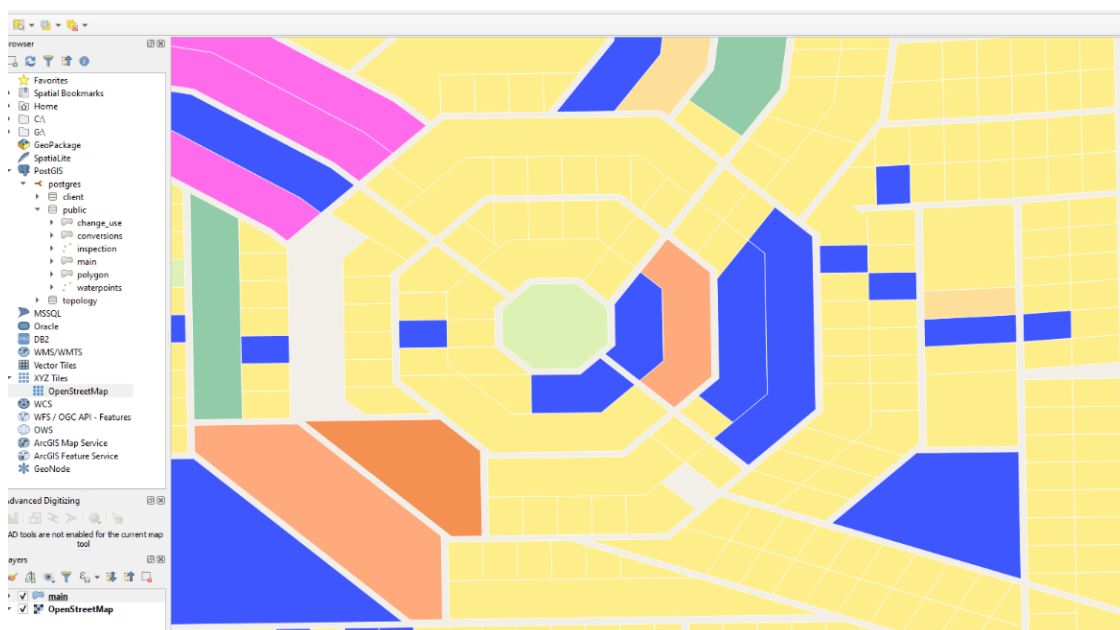


Figure 30: Desktop.

4.1.10 System Validation

System validation played a crucial role in the development lifecycle as the integrated spatial data management system underwent thorough testing and verification to ensure it met the specified requirements and functioned as intended. Throughout this phase, the system underwent various tests, including functional, performance, and security testing, to validate its capabilities. Functional testing assessed whether the system's features aligned with the defined requirements, ensuring seamless functions such as map operations, land use data queries, and data uploads. Performance testing evaluated the system's responsiveness and scalability, especially in handling a growing volume of spatial data. Security testing verified the effectiveness of the implemented security measures, including user authentication and data encryption. The successful completion of system validation instilled confidence in the reliability and effectiveness of the integrated spatial data management system, ensuring its readiness for deployment and use by planning authority.

Chapter Summary

This chapter serves as the culmination of the research endeavours, presenting the outcomes derived from the study. It showcases the implemented prototype, offering a tangible demonstration of the research findings and their practical application. Through detailed discussions, the chapter elucidates key insights, trends, and patterns uncovered during the research process, thereby contributing to addressing the research objectives and filling identified gaps in the literature. Moreover, it provides an in-depth overview of the prototype system, delineating its functionalities, features, and capabilities aimed at enhancing spatial data management practices. Additionally, the chapter outlines the requirements necessary for the prototype system to operate effectively, encompassing technical specifications, data inputs, software dependencies, and essential resources or infrastructure. Overall, this chapter serves as a pivotal component of the research report, encapsulating the results of the research activity and highlighting the potential impact of the developed prototype on spatial data management processes.

5 DISCUSSION AND CONCLUSIONS

Introduction

This is the closing chapter of the dissertation. It provides the summary of the work done, from the research inception to the end of the research process as conclusion of the research project and offers the recommendations on the way forward with regards to the research project and the prototype. Finally, the chapter suggests the future research works in relation to integration of spatial data as well as comments on the enhancements which can be made to the work documented in this dissertation.

Discussion

This section discusses the finding to answer the research questions developed in the first chapter.

5.1.1 Common spatial data management systems in use by planning authorities.

This research project, focused on understanding geospatial data management and web technologies to improve data processing and management. In trying to meet the first research objective, it endeavoured to establish the common spatial data management tools used by local authorities. The finding from the research showed that of all sampled institutions, all the respondents used Desktop GIS. On the other hand, 42.9% use Mobile GIS while the other 42.9% use Web GIS. This finding aligns with (Weber et al, 2017), GIS tools are frequently used in conjunction with sophisticated scientific models and are commonly used by the local authority to enhance data management. The common tools include AutoCAD or the Adobe Creative Suite, GIS mapping programs like ArcGIS, QGIS (an open-source and cooperatively produced suite of GIS tools), and MapInfo, as well as data management programs like Microsoft Excel or PostgreSQL. Furthermore, the Desktop GIS tools including ArcGIS and QGIS were commonly used, it's worth noting that the choice of the tools was based on the cost of acquisition as a result of the institutions opting for open-source tools such as QGIS. Therefore, this contributed to limited use of integrated systems by the institutions as the ready to use integrated come with high cost and on their hand the open source is often stand alone and unintegrated. These findings are consistent with the research conducted by Jadallah et al. (2017), which emphasizes the significant advantages of integrated Geospatial Information Systems (GIS) enhanced by cloud computing. The study underscores that integrating cloud computing with GIS helps address limitations associated with traditional desktop GIS systems. These limitations include high initial costs, storage constraints, and the inability to

offer location-independent accessibility, where GIS functionality can be accessed from any location at any time.

Findings show that a considerable number of institutions have been engaged in spatial data management for a considerable amount of time (over 10 years). The study further established that within the sample, half of the target institutions rated their level of knowledge in data management as 'experts'. The findings align with Adaktylou et al. (2018), who mentioned that a high level of expertise in data management among institutions engaged in spatial data management should ideally enable and foster interoperability for seamless integration within the organisation which was however not the case.

Building upon the understanding that all sampled institutions specialize in spatial data management, the design of the Web Map deliberately incorporates tools aligned with those utilized by local authorities in their day-to-day operations. This integration serves to enhance visualization, analysis, and navigation capabilities, offering a more efficient and comprehensive approach compared to traditional spatial analysis methods. This approach is in line with the observations made by Weber et al. (2017), who noted that local governments typically employ a combination of GIS tools in their operations. These tools are characterized by their ability to utilize spatial data in an integrated manner, often combining data from multiple sources for individual land use planning projects. By incorporating tools reflective of those used by local authorities, the Web Map aims to facilitate a smoother transition to digital spatial data management practices, ultimately enhancing the efficiency and effectiveness of spatial analysis and decision-making processes.

The investigation into the use of mobile applications for data collection revealed that a significant majority, comprising 70% of the participants in the target institutions, had not embraced mobile applications for this purpose. However, there was a positive note as 28.6% had successfully implemented mobile applications, indicating a smaller but notable percentage that recognized the advantages of streamlined integration practices. The findings highlighted a potential area for improvement in adopting modern technology for more efficient data collection processes. Further exploration was needed to understand the reasons behind the hesitancy of the majority. These findings resonate with the observations made by Gault and Peutherer (1988) in their work on technology adoption in similar contexts.

The study identified key limitations in the adoption of integrated systems within planning authorities. A significant challenge lay in the lack of expertise, with 57.1% of respondents

attributing the limited adoption to this factor. This underscored the importance of investing in training and skill development programs. Operationalization cost was identified by 28.6% as a barrier, suggesting a need for strategies to address financial concerns and highlight the long-term benefits of integrated systems. Additionally, 14.3% attributed the limitation to other factors, including political will, necessitating a deeper exploration of organizational and external dynamics influencing decision-making. These findings aligned with the insights provided by DiBiase et al. (2010) in their research on challenges faced in the integration of systems within organizational structures.

The investigation into the auto-integration of data storage systems revealed a substantial gap, with 71.4% of target institutions not implementing auto-integration. This suggested a missed opportunity for optimizing data management processes for efficiency and accuracy. On a positive note, 28.6% had successfully auto integrated their data storage systems, showcasing a smaller yet notable percentage that recognized the value of streamlined integration practices. Souter (2010) also mentioned encouraging wider adoption of auto-integration through successful case studies and providing resources for implementation could enhance overall data management efficiency within the target institutions. These findings resonated with Jadallah et al. (2017) insights into the challenges and benefits associated with data integration in organizational settings.

5.1.2 Development of an integrated data management system based on gaps identified in Planning Authorities

The development of an integrated data management system, as informed by identified gaps within Planning Authorities, draws upon existing literature advocating for the integration of GIS databases with web functionalities. In response, a model tailored to address these gaps was crafted, leveraging insights gleaned from desktop reviews and questionnaire administrations. The findings resonate with previous research, such as that of Yang et al. (2015), which underscores the efficacy of GIS-based web integrated spatial analysis models and web GIS technology. These tools enable a broader audience, including investors and administrators with limited domain knowledge, to gain insights into the spatial distribution and change patterns of land prices through online platforms. This underscores the potential of WEB GIS in diverse informative web models. Notably, many institutions currently face challenges as they have not integrated their data storage tools with their management systems, risking the loss of valuable data accumulated over time.

To address this issue, the developed system leverages PostGIS as a geospatial information storage solution. The integration process begins with incorporating procedures for data preparation, updating, and processing, all accessible through a central server utilizing PostGIS. Furthermore, literature emphasizes the importance of a dedicated central database for a well-integrated data management system, facilitating seamless information sharing among all stakeholders involved. Using PostGIS, QGIS, Arc GIS and Mobile GIS (among other apps and tools), the researcher developed an effective and efficient web GIS data integrated management system that combines various data to produce patterns and links. It was concluded that WebGIS resulted in improved access to quality geo-spatial information in the planning, implementation, monitoring and information delivery process through the deployment and exploitation of geo-spatial information tools and techniques. The findings align with Goodchild et al. (2005) as the detailed description of the mobile GIS application's architecture, including the use of the Leaflet library and PostgreSQL. By linking admin users and data collectors to holistic datasets through organisational web credentials, it was thought to leverage cloud-based data repositories for improved integration of spatial data directly within environmental decision making. The findings align with Okello, et al (2017) whose study highlighted the workflow for the Data management system, an online map is created to curate and compile the heterogeneous data directly collected from the field.

The web GIS interface allowed the clients to access information through the web and track the System database which is the engine room, responsible for processing tasks and requests made by the clients. The proposed system facilitates the easy and efficient exchange and sharing of information on and data processing of both non-spatial and spatial data. The findings resonate with Nourjou, & Thomas (2016) who highlighted the significant advancements in Web GIS technology over the past decade, particularly in revolutionizing data management.

The integration was done by linking the system to multiple tools and access points that include WebGIS, mobile GIS and desktop GIS which provides the use of both spatial and non-spatial data. Furthermore, the system ensured that its functionality efficiently improved the operation of the local government system by introducing an online application platform and mobile application for data collection from the field. The system integration was able to be done by linking the system to various spatial tools such as WebGIS, Mobile GIS and Desktop. Furthermore, the findings showed that the integration enabled local authorities to access the applications and provide services in real time. The findings align with (Yang et al, 2015), where the study showed that the integration was able to enable local authorities to be

able to access the application in real time, compared to the traditional way of receiving the application and physically.

The findings align with Okello, et al (2017) who highlighted that data integration comprised many tasks from data exploration and communication with clients to technical data collation. To effectively manage these tasks, the system takes both technical and non-technical aspects of integration into account. Data standardisation was undertaken to provide the basis for development of a data model, framework, and integration of geo-web service. The data standardisation of the existing data processing and management model was undertaken to introduce a best practice integration data model through suggesting new revisions to existing data models to meet the needs of the broader range of users. The introduction of web services is another concept aimed at improving service delivery and efficiency in data accessibility by multiple users in real time. The findings resonate with Kabir N, et al (2014) as the emphasis on the integration of an easy-to-use form builder in the Web GIS platform aligns with the themes of efficiency and timesaving explored in Kabir's work on GIS technologies in data collection.

5.1.3 Development a data collection application-based model.

Nourjou & Thomas (2016) highlighted that over the past ten years, mobile GIS technology has advanced significantly and is currently revolutionising the data collection sector. There are numerous new mobile software platforms on the market that can assist you in completing your task, whether you're using GIS data to make maps, gather field measurements, or see real-time surveillance data. The findings resonate with Nourjou & Thomas (2016). The significant advancements in mobile GIS technology discussed align with their observations about the progress in this field over the past decade, particularly in revolutionizing data collection. The mobile GIS application's architecture or platform was the Leaflet library, which includes functionality like zooming, panning, gazing, and region and distance estimate capabilities. Additionally, using PostgreSQL to pull and push data, the system was connected to an online Postgres database. Finally, geographic analysis tasks like buffering, counting, counting features, routing, interpolation, and exporting data into different formats were carried out using the Turf JS library. The data layers came from the admin-created projects and allowed for real-time data analysis.

To enhance the data collection processes for institutions, the Web Gis platform integrates an easy-to-use form builder which is efficient and time saving. The system enables the local government to easily deploy questions for data collection and subsequently allows for live data analysis. Data collection stands as a crucial operational aspect for local authorities,

underscoring the significance of robust procedures. The research took measures to integrate a mobile application with web GIS and other systems to streamline data collection and monitoring processes. This integration facilitated the scheduling and execution of field inspections, ensuring that pertinent data was efficiently gathered through the mobile application. The research findings highlighted a notable gap in the absence of a standardized template for development control or ground inspection procedures among local and planning authorities. To address this gap, the research was designed to create and embed a standardized template within the mobile application. This initiative is pivotal in establishing a uniform framework for field inspections and development control, promoting consistency and efficiency in these processes. The findings align with Tagoe & Mantey (2011) as the emphasis on designing a standard template for field inspection resonates with Tagoe and Mantey's contributions to discussions on GIS applications in the context of local authorities.

The findings indicate that field inspection facilitated local authorities in verifying that the information provided in applications aligns with on-site conditions. The seamless integration between the mobile application, web GIS, and the system allowed for standardized tools for verification and updating within the system, facilitating efficient data validation and synchronization with the central server. The admin is therefore able to review the application and make appropriate decisions whether to approve or reject the application. The mobile application was used as a ground truthing tool that was done by the data collectors where go to checked on property underground and attach pictures, take note and make recommendations based on what is carding present the property and the data was sent to the server where the admin and the other stakeholders can review the application.

Conclusions

The main purpose of the study was to devise a model of effective to enhance spatial data management in local authorities by creating an Integrated Spatial Data Management System (Hendriks, 2005). This innovative system, designed as a model, played a pivotal role in promoting collaboration across various domains. The system incorporated fundamental principles such as a user-friendly hierarchical arrangement, strong compatibility with other systems, and efficient procedures for exchanging, finding, retrieving, and utilising geographic information (Killpark et al., 2005).

The research emphasised the importance of a proficient Integrated Spatial Data Management System, in accordance with the principles outlined by (Gediminas, 2019). It played a crucial role in enabling effective spatial analysis by incorporating up-to-date formats and integrating

data attributes that provide additional value. The focus on user-friendly design and improved functionality greatly improved the utilisation of spatial data.

The research project focused on addressing the urgent challenges arising from the rapid population growth in Zambia, specifically the critical requirements of planning authorities. The increase in population necessitated the competent management, processing, and storage of larger quantities of applications for diverse services by these authorities (Kubbara, 1997) (Killpark et al., 2005). The proposed Integrated Spatial Management System utilised advanced tools, including Web GIS, Mobile GIS, and Desktop GIS. These tools enabled the system to effortlessly capture, view, store, analyse, manage, and manipulate data within an organization's website platform (Gediminas, 2019).

One notable benefit emphasised in the research results was the straightforwardness and ease of use of the proposed system. The design of the system allowed for convenient retrieval of geo-referenced data and supported concurrent usage by multiple users through a user-friendly web browser interface. This simplicity not only improved user experience but also tackled the practical challenges arising from the growing demand for services due to population growth (Killpark et al., 2005).

Moreover, the research findings highlighted that the integrated spatial management system efficiently enabled the transfer and dissemination of data, encompassing both spatial and non-spatial data. The incorporation of various access points, such as Web GIS, Mobile GIS, and Desktop GIS, offered a flexible and all-encompassing solution for data processing. This approach not only optimised operations but also enhanced the overall efficiency of managing various types of information (Farkade & Kaware, 2015) (Killpark et al., 2005).

Ultimately, the research project effectively accomplished its goals, furnishing profound responses to the three fundamental research inquiries. The questions focused on implementing standardised spatial data management systems in local government bodies, creating a model to improve spatial data management and processing, and constructing an efficient data management system (Killpark et al., 2005).

Recommendations

The necessity for local authorities to adopt integrated data management systems is emphasised by the possibility of increased efficiency in service delivery and enhanced data quality. In light of this requirement, it is crucial for local authorities to adopt this technological transition, guaranteeing a smooth and efficient handling of data.

The government should give priority to implementing e-government strategies in public institutions, alongside the adoption of integrated data management systems. This strategic focus is essential for improving the provision of public services. An important aspect of this prioritisation involves enhancing the supply of internet service infrastructure to planning authorities, which enables the successful implementation of integrated systems.

In order to guarantee the effective advancement of such systems, it is crucial to involve a proficient Information Technology specialist. The developer should be instructed to design a comprehensive system that includes all essential functions encoded into the website. Concurrently, it is important to make a focused attempt to reduce the dependence on paid additional features and software extensions, with the goal of reducing ongoing expenses for upkeep. Given the financial limitations experienced by most planning authorities in Zambia, this strategic approach becomes especially crucial.

In light of the financial constraints, it is imperative to enhance the funding allocated to planning authorities. Sufficient funding is essential not only for the initial implementation but also for promptly addressing ongoing maintenance expenses. This financial assistance allows planning authorities to obtain the essential infrastructure needed for the smooth functioning of integrated data management systems. In the end, a system that has sufficient funding and is managed effectively plays a crucial role in enhancing public services and ensuring high-quality data.

Future Works

Future research should broaden its scope to encompass a wider range of geographical and administrative contexts. This entails examining the applicability of the Integrated Spatial Data Management System across diverse regions, considering differences in infrastructure, governance structures, and technological landscapes. Additionally, there is a need to explore the integration of emerging technologies like artificial intelligence, machine learning, and blockchain into spatial data management systems. This proactive approach ensures the continued relevance and efficacy of the system amidst evolving technological landscapes.

Developing sustainable and cost-effective models for long-term maintenance is imperative. Subsequent studies should explore innovative funding mechanisms, maintenance strategies, and partnerships to ensure the sustained effectiveness of the Integrated Spatial Data Management System beyond its initial implementation phase. Furthermore, research efforts can focus on providing policy recommendations for governments and planning authorities to

facilitate the widespread adoption of integrated data management systems. This involves addressing regulatory frameworks, data privacy concerns, and policy incentives to encourage the adoption of such transformative technologies.

Achievements:

The research project successfully achieved its primary objectives, providing valuable insights into the development and implementation of an Integrated Spatial Data Management System. The designed prototype demonstrated the feasibility of fostering collaboration, ensuring robust interoperability, and enhancing the overall efficiency of spatial data usage. The findings contribute to the existing body of knowledge in the field of GIS, data science, and spatial data management, offering practical solutions for local authorities facing challenges related to population growth and increased demand for services.

Chapter Summary

This chapter discussed and concluded the study. The chapter showed how the research questions were answered.

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APPENDICES

Appendix 1 - Questionnaire



QUESTIONNAIRE

*Generic

How long has your institution been working with spatial data?

1. How long has your institution been working with spatial data?

- a) 0-3 yrs b) 4- 7 yrs c) 8 - 10 yrs d) 10+ yrs

2. Level of education:

- master's b) degree c) diploma d) other

3. What are your institution's specialisations?

- Data collection b) Data management c) Integrated data management

3. What is your level of expertise in spatial data management?

- a) Beginner b) Intermediate c) Expert d) Developer

*Data Collection

1. What tools do you use for data collection?

- a) Kobo b) ODK c) SW maps d) Arcgis apps d) Other
(Specify)

2. Are the tools selected in (1) open source? a) Yes b) No

3. What type of data do you collect?

- a) Spatial data b) non-spatial data

4. Are the tools automated and integrated in your local data management systems?

- a) Yes b) No

5. If not, what is the challenge?

- a) Limited expertise b) Cost of infrastructure c) other
- b)

***Data Management**

1. What spatial data management tools are you currently using?

- a) ArcMap b) Arc Pro c) Postgres d) Q GIS e) Other

2. What platform do you use to store your data?

- a) Local storage b) Cloud storage c) Other

3. Do you consider the type of storage selected in (2) secure?

- a) Yes b) No

4. Does your data storage allow multiple user access?

- a) Yes b) No

5. Are the data storage systems integrated with other systems?

- a) Yes c) No

6. What main challenges do you encounter in data management?

***Data Processing**

1. What type of GIS tools do you use to process your data?

- a) Mobile GIS b) Desktop GIS c) Web GIS

2. Are your GIS processing systems integrated?

- a) Yes b) No

Appendix 2: Publications

[Development of an Integrated System to Enhance Spatial Data Processing & Management for Planning Authorities \(scirp.org\)](#)