REPUBLIC OF RWANDA

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ACADEMIC YEAR 2023/2024

DEPARTMENT OF CIVIL ENGINEERING

OPTION OF LAND SURVEYING

FINAL YEAR PROJECT REPORT.

TOPIC: IMPACT OF GEOGRAPHICAL INFORMATION SYSTEM (GIS) ON LAND MANAGEMENT IN RWANDA.

CASE STUDY: RUBAVU DISTRICT (2015 -2024)

A dissertation submitted in partial fulfilment of the requirements for the Award of advanced diploma

In land surveying.

Presented by:

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Under the guidance of:

Eng. MUNYANEZA jean pierre

Kigali, October 2024

DECLARATION OF ORIGINALITY

I, **RUDASINGWA Theogene** do hereby declare that the work presented in this dissertation is my own contribution to the best of my knowledge. The same work has never been submitted to any other University or Institution. I, therefore declare that this work is my own for the partial fulfilment of the award ofthe advanced diploma in civil engineering department, land surveying option at ULK Polytechnic Institute.

The candidate's names: **RUDASINGWA Theogene**

Signature of the candidate: …….

Date of submission: ……..…….……...

APPROVAL

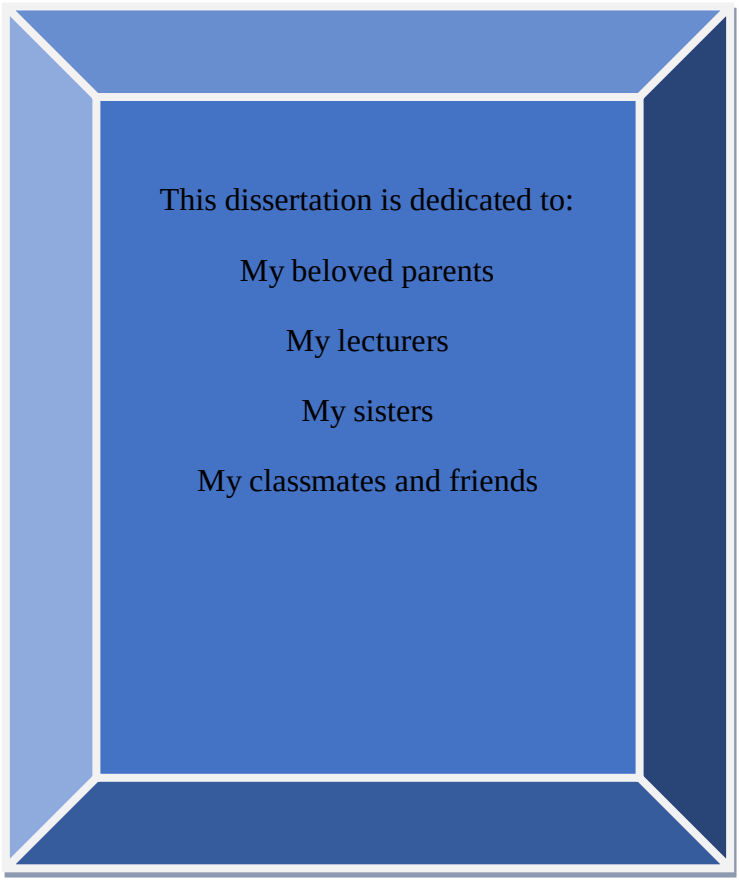
This is to certify that this dissertation work entitled "**Impact Geographical Information System (Gis) In Land Management In Rwanda. Case Study: Rubavu District (2015 -2024)"** is an original study conducted by **RUDASINGWA Theogene** under my supervision and guidance.

The supervisor's names: **Eng. CIMANUKA DAVID BONGWA**

Signature of the supervisor: …….

Submission date: …….…….…….

DEDICATION


This dissertation is dedicated to:
My beloved parents
My lecturers
My sisters
My classmates and friends

ACKNOWLEDGEMENTS

This Thesis has benefited greatly from substantial inputs, guidance and comments from many people and institutions.

First of all, I would like to thank to the Almighty God for giving the wisdom and granting me resources whether financial and non-financial that has made a great contribution to this research project and my education in general.

My gratitude and appreciation to the founder of **ULK**, **Prof. Dr. RWIGAMBA BALINDA**, for the idea and effort of his inspirational education standards.

Our deep sense of gratitude and appreciation also goes to our supervisor, **Eng. CIMANUKA DAVID BONGWA** for his encouragement and support throughout this research. Your professional experience and your practical comments from reviews and critics have made our research fruitful.

We wish to express our sincere thanks to the authorities of ULK Polytechnic Institute, in particular the Department of Civil engineering, land surveying option, for their support in terms of knowledge that leads us to the success of the university struggle.

Thanks also to our all classmates and friends for their moral support and invaluable prayers.

May God bless you all!!!

RUDASINGWA Theogene

ABSTRACT

The general objective of this study is to assess the impact geographical information system (GIS) in land management in Rwanda. Case study: Rubavu district (2015 -2024). The specific objectives were to identify the major factors driving land management, to show how GIS Techniques can be applied on land use management and to examine the overall impacts of GIS on land management. The results show that the level of land management in Rubavu district is characterized by clear land records, land use monitoring, effective and efficient land transfers, proper lad taxation and land disputes resolution. GIS plays a crucial role in land management of Rubavu district. Starting from the first phase of land use planning where by it simplifies the territorial planning, operating, analyzing important data concerning their spatial relationship that allows carrying complex assessment of the situation and creates basis for more exact reasonable decisions regarding land use in this district. To ensure a good land administration a number of data and procedures are required for demarcation and recording. It may entails details such as ownership, land use, land value, land use plan, site development plan, utility plan, survey information, other attributes such as name of owner, plot number, size, use, location, transaction records such as deed of assignment, sublease, mortgage, devolution, release etc. GIS has the capabilities to handle such huge data not only effective but also efficient, secured, faster, and transparent. From these, we can be able to summarize the following advantages of GIS in land administration: It will facilitate land registration processes, data processing, storage and retrieval as well as reduce time, cost and space required for land record and management. It will enhance academic research as access to information will be easy. Guarantee tenure security and transparency among land owners. This will enhance sustainable development. The GIS technology will reduce dispute among land owners thus, mitigate court cases. It would sanitized the system of land transactions in general. Provide security for credit from banks and thus, enhance efficient land market, housing, construction and financial institutions. GIS data base system for land management guarantee data backup in the event of system breakdown. GIS database can provide previous and up to date Maps, layout, plans with details if require at fingertips. GIS database can accept updates easily. Since the GIS database is embedded with information, every potential buyer will want to authenticate (attest) whether the land is genuine and free from stains. GIS allow information sharing by different users at different time.

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LIST OF ABBREVIATIONS

DDP: District development plan

DGPS: Digital Global Positioning System

GIS: Geographic information system

GNSS: Global Navigation Satellite System

GoR: Government of Rwanda

GPS: Global Position System

CHAPTER 1: GENERAL INTRODUCTION

1.0. Introduction to the study

This chapter provides the background of the study, statement of the problem, purpose of the study, objective of the study, research questions, research hypotheses, scope of the study, significance of the study and lastly the structure of the study.

1.1. Background of the study

Numerous European towns of varying sizes and significance adopted the use of Geographic Information Systems (GIS), which became essential to the intricate development of urban and territorial phenomena. GIS applications are regarded by all industries involved in land analysis and management as helpful tools for integrating and analyzing data from various formats, scales, and coordinate systems in accordance with certain cognitive objectives. Land survey and its precise and accurate graphic and cartographic depiction serve as the foundation for each of these components, with surveyors serving as the primary technical figure in Italy. More sophisticated public administrations use these systems for processing data, both spatial and non-spatial, to turn data into information, to integrate various data types, to analyze and model terrestrial phenomena, and to provide expert technical support for better land management in political, administrative, and strategic decision-making.

Environmental protection, environmental impact studies, area placement, use classification definition, green area management, risk area definition, collection, control, and analysis of environmental pollution data, waste management, and cultural heritage are some of the application fields in which Italian surveyors are also active in an effort to encourage administrations to adopt GIS platforms. A continuing source of interest for public administrations due to the many benefits these technologies provide is GIS and Web-GIS; nevertheless, their restricted budgets frequently prevent them from using these technologies.

A land information system is created using a geographic information system (GIS). Usually employed by local governments, a land information system (LIS) is a geographic information

system for cadastral and land-use mapping. A land information system (LIS) is a crucial foundation that can be integrated into other geographic systems or used independently to enable data stewards to retrieve, create, update, store, view, analyze, and publish land information. It is composed of an accurate, current, and reliable land record cadastre and the associated attribute and spatial data that represent the legal boundaries of land tenure. Shakir & Ali, 2012).

The practice of controlling how land resources are used and developed—in both urban and rural contexts, albeit primarily in urban areas—is known as land management. Land resources are used for many different things, such as ecotourism initiatives, forestry, organic farming, and water resource management. Terrestrial ecosystems are subject to the beneficial and negative effects of managing land. Overuse or abuse of land can cause degradation, lower output, and upset natural equilibriums (Booth, 2009). According to Deng et al. (2016), land use management is the process of using land to suit shifting human requirements (such as forestry, agriculture, and conservation) while maintaining the land's long-term socioeconomic and ecological functions.

Since "land administration" in Australia is the province of the States, the majority of Land Information System-related operations have historically been started and carried out by the corresponding state governments (Dalrymple et al., 2003). More than thirty local government agencies in Australia have made LIS a priority. These groups typically oversee 500,000 people living in up to 500,000 parcels. The systems' levels of design complexity differ significantly. While some place a lot of focus on CAD and graphics, others prioritize corporate planning, land administration, financial management, and land information management. While some systems just use graphics or text, others use both. (Enemark, 2012).

With assistance from the World Bank and the Ugandan government, the Ministry of Lands, Housing, and Urban Development (MLHUD) of the Government of the Republic of Uganda has so far implemented the National Land Information System (NLIS) with impressive success. Regarding the modernization of land governance, Uganda is acknowledged as a leader. The National Land Information System (NLIS) has significantly shortened the time needed for land transactions, which has already improved service delivery throughout the land sector (Burke, 2020).

Since this vision was established in 1999, the Rwandan government has enacted laws, regulations, and other directives with the goal of strengthening the nation's property system. As a result, land use management got its start in 1999, when land was declared to be the most important foundation for the country's sustainable development. Before adopting the GIS-based technology, which made it simple and efficient, it was done in the early years in an analog fashion and was updated periodically (Patra et al., 2018). There are several reasons Rwanda chose to implement land use management, but the primary one is that land is a necessity. Land is rare in Rwanda, one of the most populous countries in Africa. Both the population and the economy of the nation are expanding steadily at the moment. Natural resources of the nation, especially arable land, are not growing. As a result, there is more rivalry and land-use conflict, which is made worse by potential climate change effects and can only be settled through sustainable planning.

As a result, there are rising demands for better land use planning, better living conditions, and the management of natural resources. Additionally, infrastructure construction is utilizing quickly evolving technologies. Creating an efficient management system is essential if we are to properly manage, safeguard, and utilize our land (as well as water). This will set the stage for Rwandans' lives to be better off in the present, and our children to have the same prospects for prosperity and health, as well as a beautiful and secure environment as our own (Metternicht, 2017). Because of this, the government launched a planning process through the Rwanda Land Management and Use Authority, with the National Land Use Management Plan serving as the initial phase. Typically, this plan is created using GIS features, which streamline territorial planning operations and analyze pertinent data regarding their spatial relationship to enable complex situation assessments and provide a foundation for the adoption of more precise and rational decisions regarding land use (Patra et al., 2018).

Since GIS plays a significant role in land use management, an optimization model can be connected to one for data input and results display. Through scenario analysis, land use planners can investigate several land use scenarios with varying goals and limitations, encompassing biophysical and socio-economic aspects (Farooqi & Gazali, 2014). In order to accomplish a desired and harmonious development of the built environment, land use management refers to the set of legal rules and regulations that apply to land. To regulate

development, each city propert has its own set of rules. The zoning of the property determines these rules. These regulations are set forth in the property's zoning. The practice of controlling how land resources are used and developed, both in urban and rural areas, is known as land use management. Land resources are employed for many different things, such as ecotourism initiatives, reforestation, organic farming, and the management of water resources (Use et al., 2000).

Spatial and geographic data can be captured and analyzed using the theorized framework known as Geographic Information System (GIS).The user can create interactive queries, save and change both spatial and non-spatial data, analyze the output of spatial information, and graphically display the results of these operations by presenting them as maps with the help of GIS applications, which are computer-based tools. Since GIS enables spatial and attribute queries in addition to spatial searches through an incredibly effective and efficient data base management system integrated into the GIS infrastructure, GIS actually helps with land use management. It will ease property searches and facilitate land transactions. GIS considerably simplifies territorial planning operating analyzing necessary data concerning their spatial relationship that allows carrying out complex assessment of the situation and creates a basis for adoption of more exact and scientifically reasonable decisions in the course of land use (Farooqi & Gazali, 2014).

1.2.Problem statement

In Rwanda, land is scarce and we should be cautious about the way we use our land. As a consequence, the Government has through Rwanda Land Management and Use Authority initiated a planning procedure with the first step resulting in a National Land Use and Development Master Plan. The citizens are supposed to follow for the better land use though in order to ensure that it's followed there is land use management which ensures that the provided land use is followed. Though many people tend to use the land the things which are not intended for makes it hard for the government to its goal of having proper use of land for economic development. In addition, before the application of GIS, the Government of Rwanda especially the body in charge of land management in Rubavu district struggled to find information on land intended to be used for proper land use activities. It was also very hard enough to obtain information on who owns a land such

as landowner, location, area, use etc. so that they can be advised on the intended use in Rubavu district.

Even if the government of Rwanda applied GIS for ensuring the efficient and effective land management. A little is known whether the intended goal was achieved. It is in this regard this study intends to assess the impact geographical information system (GIS) in land management in Rwanda. Case study: Rubavu district (2015 -2024). The results that will be obtained will give the clear picture regarding to the impact geographical information system (GIS) in land management specifically Rubavu district.

1.3.Purpose of the study

The purpose of this study is to conduct a research on assessing the impact geographical information system (GIS) in land management in Rwanda. Case study: Rubavu district (2015 -2024). In addition, this study is carried out in partial fulfilment of the requirements for the award of advanced diploma in land surveying.

1.4. Objective of the Study

1.4.1. Main objective

The general objective of this study is to assess the impact geographical information system (GIS) in land management in Rwanda. Case study: Rubavu district (2015 -2024).

1.4.2. Specific objectives

This project's specific objectives were as follows:

a) To evaluate the level of land management in Rubavu district.
b) To examine the overall impacts of GIS on land management.

1.5.Research questions

Based on the project's serviceability and functionality, answers to the following research questions will be offered in order to fulfil the above particular objectives.

a) What is the level of land management in Rubavu district?
b) How GIS Techniques can be applied in land management?

c) What are the overall impacts of GIS in land management?

1.6. Scope of study

This study will be delimited in terms of space, time and domain. In terms of space, this research will be conducted in the Rubavu District. Secondary, the study will be limited in time as it has completely done in short time of the period from 2015 to 2024. Finally, this study will be limited in terms of domain of Land Surveying.

1.7. Significance of the study

This research will help the researcher to get some information about the impacts of land use and land cover change on agriculture production from 2015 to 2024 in Rubavu district. This research will help the researcher to increase skills in using engineering software like GIS software, ERDAS software and Google earth image processing. It will help future researchers to find the findings and recommendations generate the needed information that would be used by various stakeholders of agriculture production. For future, this research study is intended to be a reference study for other research. This research will help students to have more knowledge about land use and cover change and its impacts. This assessment will create a good picture of ULK to the quality of education. This study also will remain as ULK's property and future students can use it as reference for their final year projects. This study will be important to the community because it will give information about the impact geographical information system (GIS) in land management in Rwanda.

1.8. Structure of the research

This thesis is made up of seven chapters that focus on achieving the purpose of this research and answering research questions. A summary of the chapters is provided below. Chapter one introduces the background of the problem, study area, problem statement, purpose of the study, research objectives, scope of the study, the significance of the research, and structure of the study. Chapter two will form the theory base of this research and provides a literature review on the level of land management in Rubavu district, how GIS Techniques can be applied on land use management and on the overall impacts of GIS on land use management. Chapter three will describe the methods which will be used in achieving research objectives and provides an outline

of data gathering and analysis processes. Chapter four will discuss the results about the level of land management in Rubavu district, how GIS Techniques can be applied on land use management and on the overall impacts of GIS on land use management from interviews, questionnaires, and reports analysis. It also underlines the main discussion points for the findings. Finally, chapter five will provide the study conclusions, recommendations, and possible future work.

CHAPTER 2: LITERATURE REVIEW

2.0.Introduction

This section of the study explains the definitions of the key terms and included the theoretical frameworks related to this research. Under this chapter, the researcher reveals the work done by the previous researchers, scholars and authors basing on the specific subject under study. These may be found in textbooks, journal on Internet literatures and other published documents relevant to the variables under study.

2.1. Definition of key concepts

The definition of the key concepts of this research projects included: geographical information system and land management. The usefulness of defining those key concepts was enables the users to understand clearly the content of this research projects.

2.1.1. Land

Land is a delineable area of the earth's terrestrial surface, surrounding all attributes of the biosphere above and below this surface including near-surface climate the soil and terrain forms, the surface including shallow lakes, rivers, marshes, and swamps, the near-surface sedimentary layers and associated groundwater reserve (Briassoulis, 2009).

Law N° 27/2021 of 10/06/2021, governing land in Rwanda, article 2 (24º) defines land as a field, a plot or a farm located in a known geographical area and with boundaries, including its airspace, the objects underground, the surrounding biodiversity, structures and developments on that surface (GoR, 2015).

Land is the solid surface of the Earth that is not permanently covered by water, or land can be defined as the surface of the earth identify by specific boundaries, including the airspace above that portion of surface, the minerals beneath it, and the surrounding biodiversity, erections and developments on that surface. In legal terms, it is immovable and permanent asset inclusive of rights associated with the earth from the center to the infinity sky.

2.1.2. GIS

GIS is a Geographic Information System that served as a tool for managing and analysing any geographic feature. GIS is a peculiar technology with the essential features of spatial references and data analysis (Akeh & Mshelia, 2016). GIS has Spatial and Attribute data. The Spatial data describes the location with respect to earth surface while attribute data defines the characteristic or quality of the spatial feature. The application of GIS technology has aroused interest and concern of government and professionals in policy and decision making and using natural resource in a more optimal way. Thus, many organizations are moving LIS into GIS. In many developing countries such as India, have pioneered the use of this technology in land Information system. The analogue system has gradually been phase out. The GIS is multifunctional in nature, time saving and high precision. Geographic Information System (GIS) is a robust, reliable and versatile technology that can be used in managing land records (Akeh & Mshelia, 2016)

2.1.3. Land management

The process of effectively using a land's resources is known as land management. According to Keesstra et al. (2018), land management includes all actions related to the preservation of land and natural resources that are necessary for sustainable development. All actions related to the management of land and natural resources that are necessary to accomplish sustainable development are included in the field of land management (Enemark, 2006). Land management organizational structures vary greatly throughout nations and regions globally, reflecting local legal and cultural contexts. The spectrum of land administration functions that guarantee appropriate management of rights, limitations, obligations, and hazards in respect to property, land, and natural resources is the operational component of the land management paradigm (Williamson et al., 2010).

According to Coyle et al. (2016), these functions include land tenure, which involves securing and transferring rights to land and natural resources; land value, which involves valuing and taxing land and properties; land use, which involves planning and controlling the use of land and natural resources; and land development, which involves putting utilities, infrastructure, and construction plans into place. The operational process of putting land policies into practice in a thorough and sustainable manner is then known as land management. The practice of controlling how land resources are used and developed—in both urban and rural contexts, albeit primarily in urban areas—is known as land management (Hurni, 2008).

Land resources are employed for many different things, such as ecotourism initiatives, forestry, organic farming, and water resource management (YALCIN, 2017). The methods by which a land use outcome is attained are outlined in land management practices. Since land management methods invariably influence improved land use outcomes (economic, social, and/or environmental), ACLUMP has been focusing more and more on land management practices (Needham, 2016). The organization within the Nation that is in charge of keeping up the Oneida Nation Register of Deeds, executing and managing commercial and agricultural leases on the Nation's behalf, handling trust and land acquisition transactions, and performing other duties as specified by this legislation is known as Land Management (Shoemaker, 2016).

2.1.4. Sustainable land management

In order to meet the growing demand for food and fiber while preserving ecosystem services and livelihoods, Amenu (2019) defines sustainable land management (SLM) as a knowledge-based process that helps integrate land, water, biodiversity, and environmental management (including input and output externalities). SLM is necessary to meet the demands of a growing population. Inadequate land management may lead to land degradation and a significant reduction in the productive and service functions (Arfasa & Amenu, 2018).

Sustainable land management (SLM) is a knowledge based procedure that helps integrate land, water, biodiversity and environmental management to meet rising food and fiber demands while sustaining ecosystem services and livelihoods (Motavalli et al., 2013). In layman’s terms, Sustainable Land Management involves the Preserving and enhancing the productive capabilities of land in cropped and grazed areas that is, upland areas, downslope areas, and flat and bottom lands; sustaining productive forest areas and potentially commercial and non-commercial forest

reserves; and maintaining the integrity of watershed for water supply and hydropower generation needs and water conservation zones and the capability of aquifers to serve the needs of farm and other productive activities (Dutta, 2018).

2.2.Concepts of GIS

2.2.1. History of GIS

A Geographical Information System (GIS) is an automated information system that is able to compile, store, retrieve, analyze and display mapped data – cf Huxhold (1991: 27-8) and ESRI (1990: 1-2) for various definitions of a GIS. A decade ago, this technology was limited to only a relatively small number of universities and state agencies. The two general types of user are systems users, who have hands-on use of the technology, and end users, who are users of the information generated by a GIS. Today, however, GISs are used by government officials, natural resource analysts and many others. Their applications include environmental research and model building, urban demographic studies and transportation analysis, to mention but a few. While the use of GISs is expanding almost daily, their most important applications include those that support decision making - cf Maguire et al (1992: 26^0) and Peuguet & Marble (1990: 18-29) for overviews of the evolution of GIS methodology and applications.

Map data used by a GIS are collected from existing maps, aerial photographs, satellites and other sources. A digitizer or similar device is used to convert compiled map data to a digital form to make it compatible with a computer. This transformation allows a computer to perform the storage, retrieval and analysis of the mapped data. Maps produced by a GIS are typically displayed on computer monitors or printed on paper. Unlike many other forms of computer graphics, such as computer-aided design (CAD) systems, a GIS displays actual geographic or mapped objects. It is, however, more than a mapping system. What distinguishes a GIS from even the most sophisticated mapping system is its ability to analyse data and to present the results of the analysis as useful information to assist decision makers (cf Huxhold, 1991: 25-29). In order for a GIS to accurately represent occurrences on the earth's surface, data must be reliable, accurate and pertinent. Because the success of the GIS and of all decisions that are subsequently based on it ultimately rests on the integrity of the data, the system must be capable of compiling, updating and maintaining the data.

No matter how sophisticated the analytical tools, if data are misused or questionable, it will raise doubts about the final output. The adage 'garbage in, garbage out' certainly holds true in the world of GISs (cf-Aronoff, 1989: 35-6).

The requirement to provide answers to geographical or spatial problems motivates the usage of GIS, and the resulting data collection, database analysis, and output are meant to address such questions. Data collection for a GIS serves two purposes: either to test theories and create models, or to inventory a geographically specified area (e.g., to locate all mature timber stands in a specific area). While the data are initially gathered for one of these purposes, in reality, information gathered to address one set of questions is often utilized in later studies to address other issues that were not originally considered. To address queries on fertilization schedules, for instance, comprehensive information on soils that was first gathered to identify the kinds of trees or crops that can be cultivated in a particular area may be used. The geographic object locations are shown on maps, and each object's physical attributes are described in attribute data found in the GIS database.

A GIS that is used to study forestry problems may incorporate attribute data that is either nonphysical (like anticipated market value and management codes) or physical (like timber species and tree diameter). For every mapped wood stand, situation (attribute) data and site (map) data are linked during a GIS analysis. The analytical strength of GISs comes from this link, which is created automatically by the GIS program (see Burrough, 1986: 1–12). The distinct spatial phenomena or map themes are called "map layers" in GIS jargon. Different layers may correspond to different property ownership, soils, and roadways. All the relevant attribute and map data are included in each layer. This article will use the layered map model to provide examples of GIS analysis and application, even though there are alternative, non-layered approaches to GIS as well.

2.2.2. Capabilities of a GIS

2.2.2.1. Spatial questions that drive analysis

GIS applications are the result of spatial questions. The following questions are commonly involved:

• What exists at a particular location on the face of the earth? (Vocational analysis)

• When is a specific spatial condition satisfied?

• What has spatially changed over time?

• What kind of pattern will emerge from geographical data?

• What will happen if certain phenomena are entered into predetermined scenarios?

2.2.2.2. Locational analysis

Mapped data can only show an object's location; it cannot provide an explanation for its location. For instance, an aerial photo may demonstrate the robust growth of eucalypti in some portions of a plantation, but it is unable to explain why the species is not doing well in other regions. On the other hand, by concurrently analyzing computerized maps of trees, soil, and soil moisture, GIS analysis may reveal a relationship between tree growth, soil type, and accessible water. In mapped data, spatial analysts are always looking for patterns. A geographical pattern is created when a tree species' distribution is defined. Examining the commercial viability of a potential plantation species may require analyzing the linkages between markets, transportation, and production. The necessary data to investigate these complex relationships can be swiftly and simply stored in the GIS.

2.2.2.3. Satisfying a spatial condition

Often, a GIS user wants to know if the mapped data will satisfy specific requirements. Let's say someone wants to determine the best location for new groundwater wells. The wells must be situated beside or next to access roads that serve a specific logging camp, and they must be found within 10 kilometers of that camp. A wide region where the wells could be located would be defined by the overall spatial circumstances. Each new well's precise position would subsequently be determined, in part, by vocational evaluations carried out using well-siting criteria.

2.2.2.4. Temporal analysis

One's view of the world and the world itself are dynamic and ever-changing. The last ten years have seen a significant shift in the consequences of tropical land use and the expansion of agricultural towns. Answers to some problems might not be meaningfully provided by knowledge

that is limited to a specific moment in time. For several years, an analyst might examine the connection between shifting land-use practices and modifications to settlement laws. Maps of different dates can be stored and compared using a GIS to carry out these temporal analysis.

2.2.2.5. Emerging patterns

Users of GIS look for spatial patterns, or if two or more objects vary in the same way throughout space. They might wish to know, for instance, whether there are comparatively more accidents on roads with clay surfaces than on roads with gravel surfaces. If so, other inquiries on which road segments are the riskiest might come after this one.

2.2.2.6. Evaluating different scenarios

Asking yourself "What would happen if..." leads to the creation of scenarios. What would happen to coastal areas, for instance, if sea levels rose, the ice caps melted partially, and global temperatures increased? In this case, the user makes use of a model intended to predict and chart the possible effects of climate change on sea level in coastal regions. By using this kind of model, one can create a fictitious scenario and predict how it will turn out. Occasionally a shift in assumptions leads to a forecast that deviates significantly from what was anticipated. Sensitivity analysis is a crucial tool for testing a model's assumptions because of this. The degree to which the result is dependent upon or sensitive to the model's assumptions can be ascertained through sensitivity analysis.

2.2.3. Basic database requirements

A GIS must allow the operator to:

• Ingest data from outside sources

• Update and alter data easily

• Ask data-related questions of the database.

These features are provided by the database management system (DBMS) software that is a component of most GISs. The same functions outside of the GIS can likewise be programmed into commercial database management software packages.

2.2.3.1. Importing and exchanging the database

Standard ASCII (American Standard Code for Information Interchange) files are a common format for data input into a GIS. It's possible for a GIS to import data files in several formats. Manual data entry is another way to grow the database. Any database management system (DBMS) can create new records or geographical items of interest. This method is sometimes employed to populate the database with a comparatively small number of new objects (a few printed pages). Error checking is another feature of the DBMS that is available when new records are generated or changed. It is important to use caution when gathering, automating, and updating the database because not all problems can be fixed in this manner.

For land management purposes, a GIS must also be able to generate data files that can be exported to different system ideas. Data files are written in a common format (such as ASCII) during the exporting process to a file that may subsequently be imported by other systems.

2.2.3.2. Updating attributes

Another common task is updating or editing the database. Since no user can foresee all future data needs and applications, a GIS must provide easy ways to modify, refine or correct the database. Attribute data are seldom static. Maintaining the currency of the data therefore depends on updating capability.

2.2.3.3. Querying the database

'Database analysis' is the process of manipulating the database to provide precise answers to data-related issues. Tabular output is the outcome of a database analysis query. The resulting products can be imported into spreadsheet applications for additional analysis or included in a summary report. Logical expressions that place restrictions or limitations on the database search are defined in order to query the database. These logical expressions define the geographical objects to be

investigated and/or the methodology for analyzing the data. Next, a subset of the database is created. Certain logical statements are straightforward and only call for one condition, while others are quite intricate and call for several.

For instance, the user could ask, "Where is the crop grown in province X?" to access a database that has information on the location, ownership, and size of a crop. The DBMS generates a data subset in search of the solution and presents it in tabular form with rows and columns of data. The subset generated to address this query satisfies the requirements that the data pertain to a specific crop in province X and that the crop is owned by a certain corporation. On the other hand, there are several requirements for the question "Where are crop plantings that are larger than 15 hectares?" Consequently, the database generates a subset of the data that satisfies each of these requirements. There is another kind of question that can be asked with logical expressions that calls for mathematical examination. In response to these queries, the database management system (DBMS) computes standing volume, produces descriptive statistical summaries, and converts between measurement systems (e.g., converts an area described in hectares into acres). When a statistical examination of the database's numerical data is necessary, these kinds of operations are frequently used.

2.3.Concepts of land management

2.3.1. Benefits of sustainable land management.

Sustainable Land Management (SLM) is the group of technologies and skills that can be applied for sustainable land use (Bloomfield et al., 2018). Sustainable land management was defined by the UN 1992 Rio Earth Summit as “the use of land resources, including soils, water, animals and plants, for the production of goods to meet changing human needs, while simultaneously ensuring the long-term productive potential of these resources and the maintenance of their environmental functions.” (Hurni, 2008). Sustainable land management facilitates land to meet the rising food and fiber demands while sustaining livelihoods and the environment (Motavalli et al., 2013). Sustainable land management minimize the land degradation, rehabilitating degraded areas and ensuring the optimal use of land resources and decide the sustainability/resilience or degradation/vulnerability of land resources (Henry et al., 2018).

SLM is essential for minimizing land degradation, rehabilitating degraded land, ensuring the sustainable use of land resources (i.e. soils, water and biodiversity) and maximizing resilience (Doran, 2000). Sustainable land management combines technologies, policies, and activities aimed at integrating socioeconomic principles with environmental concerns, so as to simultaneously: maintain and enhance production (productivity) (Chigbu, 2021), reduce the level of production risk, and enhance soil capacity to buffer against degradation processes (stability/resilience), protect the potential of natural resources and prevent degradation of soil and water quality (protection), be economically viable (viability), be socially acceptable, and assure access to the benefits from improved land management (acceptability/equity) (Huggins, 2018).

SLM protects and enhances the multiple services and functions provided by land, which fall into four distinct categories (Bovet, 2018). The first category is provisioning services such as provision of food, fodder, fibre, fuel and freshwater (Hurni, 2008). SLM helps to increase food security, especially for smallholder farmers, provide energy, provide local fresh and clean water and Support livelihoods. The second category is Regulating services such as regulation of climate, water quality and quantity, pollination, and diseases control. SLM helps to improve water availability and quality, Store and sequester carbon, mitigate damages caused by extreme weather events or natural hazards, Regulate pests and diseases (Arfasa & Amenu, 2018).

The third category is supporting services such as support nutrient and water cycling, support Soil and vegetation cover for water, carbon and biodiversity (Baskent, 2021). SLM helps to mitigate soil degradation and enhance soil quality, structure, and functioning, enable nutrient and water cycling, enhance primary production and nutrient cycling, provide habitats for species, which increases biodiversity, cultural services. SLM helps to keep cultural and natural landscapes alive and protect cultural heritage, valorize indigenous knowledge and production methods, enhance the aesthetic experience and provide a space for recreation (Birungi & Hassan , 2010).

The objective of sustainable land management (SLM) is to harmonize the complimentary goals of providing environmental, economic, and social opportunities for the benefit of present and future generations, while maintaining and enhancing the quality of the land (soil, water and air) resource (Roy, 2009). Sustainable land management is a necessary building block for sustainable land resources, and it is a key element in AGENDA 21's goal of sustainable development (Chapter 10)

(Barker, 2006). Sustainable agricultural development, conservation of natural resources, and promoting sustainable land management are key objectives of the new World Bank rural investment program, From Vision to Action and increasingly these objectives are being included in all agricultural development and natural resources management projects (Barton, 2009).

Sustainable land management combines technologies, policies, and activities aimed at integrating socioeconomic principles with environmental concerns, so as to simultaneously: maintain and enhance production (productivity), reduce the level of production risk, and enhance soil capacity to buffer against degradation processes (stability/resilience), protect the potential of natural resources and prevent degradation of soil and water quality (protection), be economically viable (viability), be socially acceptable, and assure access to the benefits from improved land management (acceptability/equity) (Dumanski, 2010).

The definition and these criteria, called pillars of SLM, are the basic principles and the foundation on which sustainable land management is being developed. Any evaluation of the sustainability has to be based on these objectives: productivity, stability/resilience, protection, viability, and acceptability/equity .The definition and pillars have been field tested in several countries, and they were judged to provide useful guidance to assess sustainability (Amenu, 2019).

2.3.2. Principles of sustainable land management

The benefits of sustainable land management are based on four principles. The first concept revolves around institutional support from government entities (Benedict & McMahon, 2002). Small business owners and larger corporations are more inclined to find less toxic means of production if given incentives that work to increase their income (Hurni, 2008). Thus, it is up to government officials to make land management more attractive. The second principle emphasizes the importance of participation. It is not enough for the government to offer incentives that reward sustainability practices. Farmers and companies must also actively cooperate with the goals that such incentives support (Wang et al., 2012).

The significance of utilizing the ecosystem to integrate the use of natural resources in society is emphasized by another sustainable land management principle (Tompkins, 2004). According to Doran (2000), this principle calls for governments and communities to fully support farmers by implementing social and economic policies that eliminate the need for farms to employ harmful chemicals to preserve their harvests. Stakeholders active in all tiers of land sustainability have priority under the ultimate SLM principle. This management concept lays the onus of finding answers and better practices on legislators as well as business and technology specialists (Arfasa & Amenu, 2018).

2.3.3. Major factors driving land management

Those practices are framed by several factors (economic, social and cultural) and by the policies applied (agriculture, spatial planning, environment, economic, land tenure, etc.).

The majority of prior empirical investigations identified the determinants of land management practice adoption (Birungi & Hassan, 2010). Land size, access to information (extension services), livestock ownership, land tenure system, social capital, family labor availability, failure to link conservation to livelihoods, weak organizational and institutional arrangements, profitability of land management practices, plot distance from home, slope and fertility of farm plots and age of household heads are all factors that influence the adoption rate of land management practices (Teshome et al., 2016).

With the climate crisis growing, it is more important now than ever to address and lean into the benefits of sustainable land management (Amenu, 2019). Individuals and communities can positively contribute to the practice by conserving water, rehabilitating and re-purposing land, and cultivating natural resources in a way that leads to more growth (Barton, 2009). Companies also have a responsibility in SLM to adopt production practices that do not harm the environment in the long run. Sustainable land management is much like a puzzle that, when having all the pieces in order, delivers positive and long-lasting results to humans, animals, and the environment as a whole. Sustainable living is essentially impossible without proper land management. Such is the

reason why governments and private corporations must work together to find solutions to the problems that prevent environmental growth (Briassoulis, 2009).

2.4.Overall impacts of GIS on land management.

To ensure a good land administration a number of data and procedures are required for demarcation and recording. It may entails details such as ownership, land use, land value, land use plan, site development plan, utility plan, survey information, other attributes such as name of owner, plot number, size, use, location, transaction records such as deed of assignment, sublease, mortgage, devolution, release etc. All these and many others may accumulate into a large stream of information. Managing such huge information manually will be difficult. According to (Akeh & Mshelia, 2016) GIS, being a computerized system, has the capabilities to handle such huge data not only effective but also efficient, secured, faster, and transparent.

From these, we can be able to summarize the following advantages of GIS in land administration: It will facilitate land registration processes, data processing, storage and retrieval as well as reduce time, cost and space required for land record and management. It will enhance academic research as access to information will be easy. Guarantee tenure security and transparency among land owners. This will enhance sustainable development. Revenue proliferation to government via consent fee, title ascertainment fee, re-validation of titles, deed of assignments, Mortgage, Lease, update fees, Map copies (for site plans, building plan,),power of attorney, etc. Since the GIS technology has the capability of allocating a distinct geographical coordinates to piece of land, thus, issues regarding multiple transactions and double allocations, illegal transactions will be phased out.

The GIS technology will reduce dispute among land owners thus, mitigate court cases. It would sanitized the system of land transactions in general. Provide security for credit from banks and thus, enhance efficient land market, housing, construction and financial institutions. GIS data base system for land management guarantee data backup in the event of system breakdown. GIS database can provide previous and up to date Maps, layout, plans with details if require at fingertips. GIS database can accept updates easily. Since the GIS database is embedded with information, every potential buyer will want to authenticate (attest) whether the land is genuine and free from stains. GIS allow information sharing by different users at different time.

CHAPTER 3: MATERIALS AND METHODS

3.0. Introduction

This chapter presents the methodology that was used in the study. It indicates the research design, the target population, data collection methods and the procedures of data collection, the sample size, data collection instruments, and data processing and data analysis.

3.1. Presentation of the study area

This study was carried at Rubavu district. Rubavu district is one of the seven districts of the country district in Western Province, Rwanda. Its capital is Gisenyi, a large beach resort and border city. Rubavu district is bordered in the east by Nyabihu District, west and north by the Democratic Republic of Congo and south by Rutsiro district. The district of Rubavu is composed of 12 administrative sectors including Bugeshi, Busasamana, Cyanzarwe, Gisenyi, Kanama, Kanzenze, Mudende, Nyakiliba, Nyamyumba, Nyundo, Rubavu and Rugerero. The geographical coordinates of Rubavu district are 01° 40′ 52.53″ S and 29° 19′ 45.55″ E. This district According to NISR (2022), this district has 388.4 km² Area, 546,683 populations and 1,408 /km² Population Density (NISR, 2022).

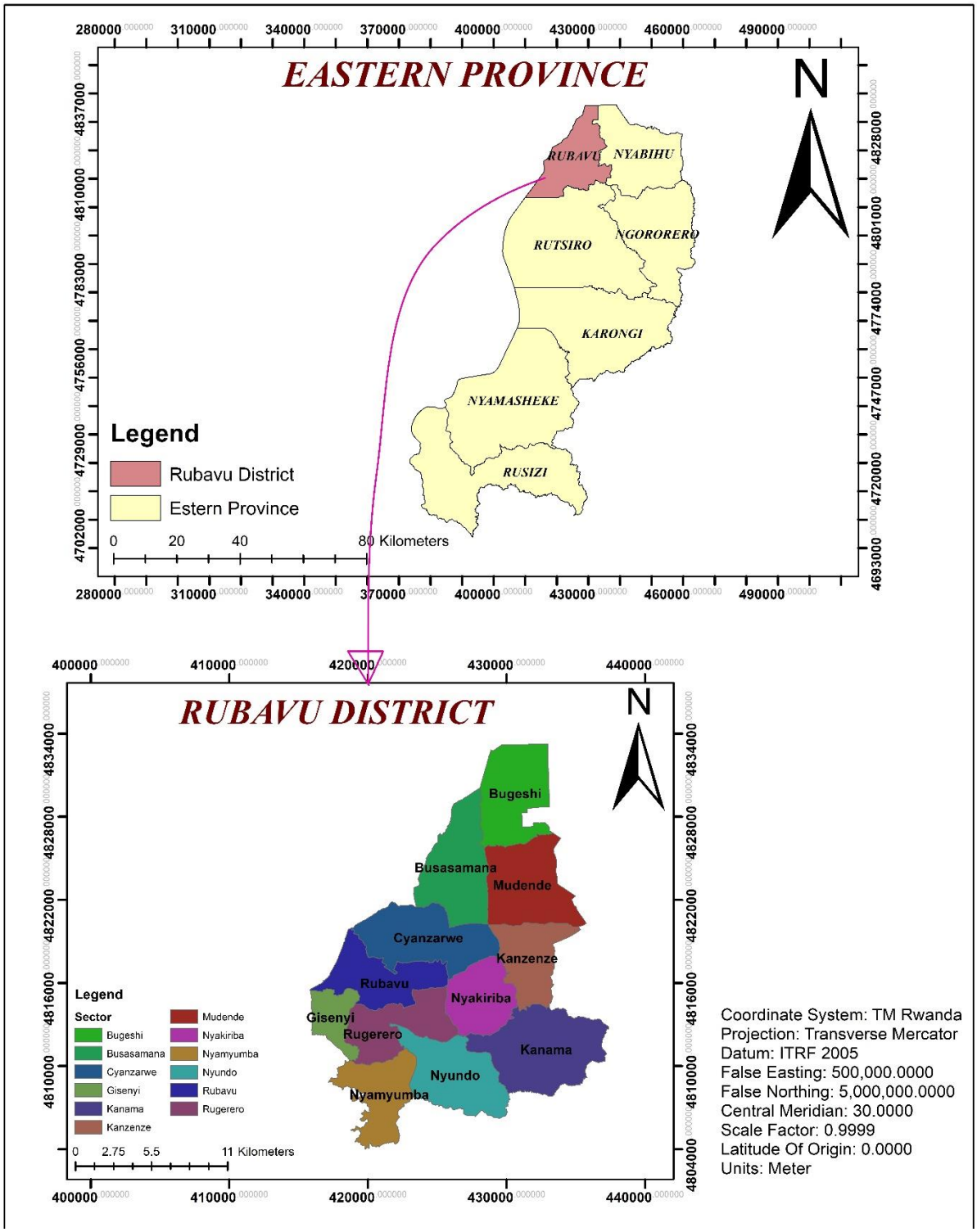


Figure 3.1**: Administrative map of Rubavu district**

3.2. Research design

This study used both a qualitative and quantitative research design. Qualitative, as well as quantitative approaches will be employed to collect data. It used both qualitative and quantitative approaches during sampling, data collection, and analysis. At data collection stage, Qualitative approach was used to collect ideas and opinions from farmers in an open-ended interview to the respondents where people provided their experiences in agriculture, while quantitative approach was used to collect responses from government institutions and nongovernment organizations in a closed-ended interview. A questionnaire was used to collect numerical data and also observation method was onsite to evaluate what was being done.

3.3. Population of the study

The study population is a set of people, services, elements and events, group of things or households that are being investigated or that a research is concerned (Morrison, 2010). The population of this study was 1 director of one stop Centre, GIS officer and land surveyor, Land administer, and 12 sector land managers in Rubavu district

3.4. Sampling technique

Due to the limitations of resources, time and logistics in contacting people within the project of assessing the impact geographical information system (GIS) in land management in Rwanda, case study of Rubavu district, purposive sampling technique was adopted because it was enable the researcher to reach the targeted respondents quickly.

3.5. Source of data

In this research, researcher used both primary and secondary of data. In this research, Primary and secondary source of data were used for collecting data on the level of land management in Rubavu district, how GIS Techniques can be applied on land use management and the overall impacts of GIS on land management.

3.5.1. Primary source of data

The primary data are those data which were collected afresh and for the first time and thus happen to be original in character (Sapsford & Jupp, 1996). The primary data of this research are data which are related to the level of land management in Rubavu district, the application of GIS Techniques on land use management and the overall impacts of GIS on land management. These data were obtained through the survey by observation on the field, direct communication with the respondents through personal interview, questionnaires and by using DGPS in order to assess the impact geographical information system (GIS) in land management in Rwanda. Case study: Rubavu district (2015 -2024).

3.5.2. Secondary source of data

Secondary data were obtained from various sources like documents available in ULK main library, on the internet, Rubavu district reports; written or recorded documents, thesis and dissertations in relation to the needs were consulted for assessing the impact geographical information system (GIS) in land management in Rwanda.

3.6. Data collection techniques

In collecting data of this study, questionnaire, interview, and documentation technique were used in order to get information for assessing the impact geographical information system (GIS) in land management in Rwanda

3.6.1. Questionnaire technique

Questionnaire is a written or print form use in gathering information consisting of a list of question to be submitted to one or more persons or respondents (Kothari, 2004). The formulation or questionnaire items based on the nature of the problem to be solved and respondents briefed on the objectives of the study (Gagnon, 2010). In this research project, questionnaires were formulated in English and care took to ensure that questions are not subjective and it was used to gather information from private surveyors and government surveyors from one stop centre of Rubavu district as the respondents of this research project.

3.6.2. Interview technique

An interview is defined as a more personal form of survey research in which questions are posed in face or telephone exchange between the interviewer and respondent (De Leeuw, 1992). The study used face to face interview method to gather data related to the impact of urban expansion on agriculture activities and these data were collected through person's interaction where structured and semi-structured interviews were used to the private land surveyors and government land surveyors from one stop centre of Rubavu district to collect qualitative data in order to address all the questions of this research.

3.6.3. Documentation

Secondary data were obtained from various sources like documents available in ULK main library, on the internet, Rubavu district reports; written or recorded documents, thesis and dissertations in relation to the needs were consulted for evaluating the level of land management in Rubavu district, application of GIS Techniques on land use management, examining the overall impacts of GIS on land management.

3.7. Instruments and materials used at field and their functions

The equipment or instruments used at the field are different and each have its function, then all of those are in the table below.

Table 3. 1: Material, Tools, Equipment and Function

Equipment, tools and material	**Function**
1. Spectra precision GNNS ROVER	For establishment of bench mark and detail data collection, verification and implantation
2. DGPS	For navigation and localization of the field
3. Note book	For recording description and remark
4. Smart phone	Used for communication and taking a picture of report during field data collection

3.8. Software to be used in the project

The software types were used for different types of activities in the process of analysing the impact of urban expansion on agriculture activities in Rwanda specifically in Rubavu district (2014 -2024) include ArcGIS10.8.1. ArcGIS 10.8.1 software was utilized to analyse a spatial location and decision making and to prepare the administrative map of the study area and the map of the output of the research; Microsoft Word and Excel 2016 was used to write the report.

3.9. Data processing and analysis

The data were collected, sorted, edited, coded and tabulated for analysis. During this process, the collected data were transformed into meaningful information for easy interpretation and understanding. The data were analyzed by arranging and organizing them properly to be easily interpreted. The following steps were followed in data processing:

3.9.1. Data processing

Data processing is generally the collection and manipulation of items of data in order to produce meaningful information (Klomp, 2016). This research was needed to process data through the editing, coding and tabulation data as shown below.

3.9.1.1. Editing

Editing is the process by which errors in completed questionnaires and recorded interviews are identified whenever possible (Bourque & Clark, 2005). The major aim of editing in this research project was to discover mistakes made during the field study, to monitor accuracy and find out whether there are some unfiled spaces in questionnaire guide. Sometimes the respondent made some spelling and grammatical mistakes the editor needs to correct them. The researcher edited the responses of the respondents in order to hold clear results from the respondent's answers.

3.9.1.2. Coding

Coding is used to summarize data by classifying different responses that made into categories for easy interpretation and analysis (Clark, 2005). The purpose of coding in surveys was to classify

questions into meaningful categories to bring out their essential patterns (Bourque & Clark, 2005). In coding, the questions used numbers, it uses in this study in order to summarize data by classifying the different respondents into categories for easy dealing and understandable.

3.9.1.3. Tabulation

Tabulation is a simple process of counting the number of observation that is classified into certain categories (Kothari C. , 2004). Tabulation consisted of putting the data into some kind of statistical tables such as percentages occurrence of the responses for a particular question and them calculate percentages were done in order to present finds understandably and clearly, for everyone who initiated to read this research document.

3.9.2. Data analysis

Data analysis is defined as a process of cleaning, transforming, and modeling data to discover useful information for business decision-making (Benson, 2012). The purpose of data analysis is to extract useful information from data and taking the decision based upon the data analysis (Schulte, 2016). The data were processed, analyzed and interpreted by using relevant statistical tools through descriptive statistics; in another word in order to interpret and analyze the study needed, the Microsoft Excel version 2016 was employed after being coded and SPSS software version 22 was used to analyze the data in order to complete this research. In this study, the results will be presented in forms of graphs, tables and figures which showing the percentages and frequencies for easy data interpretation and understandable by the future researchers (NISR, 2012).

CHAPTER 4 RESULTS AND DISCUSSIONS

4.0. Introduction

This chapter presents the results from analyzed and processed data and discussions with respect the specific objectives and the main objective of this research, which is to assess the impact geographical information system (GIS) in land management in Rwanda. Case study: Rubavu district (2015 -2024). This chapter is composed into two main parts that are the identification of respondents and the presentation of findings. The information presented in this chapter are discussed and presented by using chart and Tables.

4.1. Characteristics of surveyed respondents

The respondents of this study were classified according to their gender, marital status, education level, by their age.

4.1.1. Gender

In this study respondents were surveyed in terms of gender so as to know their gender status. Below is the table which shows the distribution of respondents by gender.

Table 2: **The distribution of respondents by gender**

Gender	**Frequency**	**Percentages**
Male	11	52.38%
Female	10	47.62%
Total	21	100%

Table 2 illustrates that 52.38% of respondents were male and 47.62% of respondents were female. This indicates that male was more interested than the female but since the questions were not gender sensitive, the higher number of males have no significant reason.

4.1.2 Marital status

In this study respondents were surveyed in terms of marital status so as to know their marital status. Below is the table which shows the distribution of respondents by marital status.

Table 3: **The distribution of respondents by marital status**

Marital status	**Frequency**	**Percentages**
Single	4	19.05%
Married	14	66.67%
Divorced	3	14.29%
Total	21	100%

Table 3 illustrates that 19.5% of respondents were single while 66.67% of respondents were married and 14.29% of respondents were divorced. The obtained results indicate that the majority of respondents were married. This has no significance to the validity of their responses.

4.1.3 Age

In this study respondents were surveyed in terms of age so as to know their age category. Below is the table which shows the distribution of respondents by age.

Table 4: **The distribution of respondents by age**

Age categories	**Frequency**	**Percentage (%)**
Between 18-30 years	5	20%
Between 31-40 years	6	32.00%
Between 41-50 years	6	32.00%
Between 51 and above	4	16 %
Total	**21**	**100**

Table 4 illustrates that 20 % of respondents were in the age category between 18-30 years, 32% of respondents were in the age category between 31-40 years; 32% of respondents were in the age

category between 41-50 years and 16% of respondents were in the age category between 51 and above years. This implies that majority of respondents are mature with their age between 41-50 years. This implies that a significant proportion of respondents are in their maturity ages and have fresh mind, hence they are able to easily cooperate and provide adequate and accurate information about the variables under study.

4.2. Presentation of the results and findings

This section consists of presentation and interpretation of the results and findings, which helped to achieve the specific objectives and research questions of this study. It includes the results and findings obtained from the surveyed respondents live in Rubavu district.

4.2.1. Level of land management in Rubavu district

Agriculture - - Percentage of land under consolidation 59.6% (EICV 5) 15.9% Percentage of land protected against soil erosion 88.7% (EICV 5) 68.5% Percentage of land under irrigation 0.3% (EICV 5) 6% Energy - - Percentage of Households using Electricity for lighting 40.8% (EICV 5) 27.1% Water and sanitation - - Percentage of Households using an improved water source 98.6% (EICV 5) 87.1%

4.2.2. Application of GIS in land management

GIS plays a crucial role in land management of Rubavu district. Starting from the first phase of land use planning where by it simplifies the territorial planning, operating, analyzing important data concerning their spatial relationship that allows carrying complex assessment of the situation and creates basis for more exact reasonable decisions regarding land use in this district. Below are some applications of GIS in land use management.

4.2.2.1. Land use decisions making.

GIS allows Rubavu district authorities to analyze trends and visualize the impacts of them while also with GIS, the district be able to identify areas with problems and come up with decisions to

solve them for example, they can identify areas who are prone to risk of disasters and decide to move them to safer place.

4.2.2.2. Land use management of interest places.

GIS allows using of remote sensing data which allows Rubavu district to monitor its city so that they can estimate scales and rates of degradation of green cover, flora and fauna. For example they can monitor this district to estimate the soil erosion in this district every month.

4.2.2.3.Buffering the roads.

Rubavu district can use GIS in buffering roads where they can buffer roads with in ten meters so that anyone knows that they should build on land near the road or use it for other things with in ten meters. This can help a lot in land use management since land wouldn't be misused.

4.2.2.4.Mapping the entire region land use

Land use management wouldn't be possible without land use planning and then land use planning wouldn't be there without GIS. Rubavu district can use GIS technics to make a map of entire district land use. With this map showing each land with is its proper use, it can get easier to monitor and manage the land use of the entire district by making sure everyone is respecting land use plan.

4.3.3.5. Digitizing for better land use

Digitizing is a tool of GIS that can also be of use in land use management for example Rubavu district may have a place where there is no road and during land use plan decide to put a road, an easiest way to do that will be the digitizing of the existing plan of that area to see where it could pass and how it would look.

4.2.2.5.Store and maintain land use data for future use

With GIS special features, Rubavu district can collect, store and maintain land use data and records to facilitate future land use plans. They can decide accordingly and in case of misunderstandings on particular use those data can be of use. For example, if a citizen decides to build a house in a land reserved for agriculture and went to ask for permission to construct the ones in charge can look in the stored land use data and shows her that her land can only be used for agriculture.

4.2.2.6. Zoning of this district

This is another GIS technic which can contribute to good land use management since it offers information about zones allocating industrial zone, residential zone and other zones. With zones land use management became success thanks to GIS. To sum up GIS technics can provide good out come if applied in land use management, it could not only improve development of this district but also can save time for the ones in charge of land use management and proper land use can be achieved.

4.2.3. The Overall impacts of GIS on land use management.

To ensure a good land administration a number of data and procedures are required for demarcation and recording. It may entails details such as ownership, land use, land value, land use plan, site development plan, utility plan, survey information, other attributes such as name of owner, plot number, size, use, location, transaction records such as deed of assignment, sublease, mortgage, devolution, release etc. All these and many others may accumulate into a large stream of information. Managing such huge information manually will be difficult. According to (Akeh & Mshelia, 2016) GIS, being a computerized system, has the capabilities to handle such huge data not only effective but also efficient, secured, faster, and transparent.

From these, we can be able to summarize the following advantages of GIS in land administration: It will facilitate land registration processes, data processing, storage and retrieval as well as reduce time, cost and space required for land record and management. It will enhance academic research as access to information will be easy. Guarantee tenure security and transparency among land owners. This will enhance sustainable development. Revenue proliferation to government via consent fee, title ascertainment fee, re-validation of titles, deed of assignments, Mortgage, Lease, update fees, Map copies (for site plans, building plan,),power of attorney, etc. Since the GIS technology has the capability of allocating a distinct geographical coordinates to piece of land, thus, issues regarding multiple transactions and double allocations, illegal transactions will be phased out.

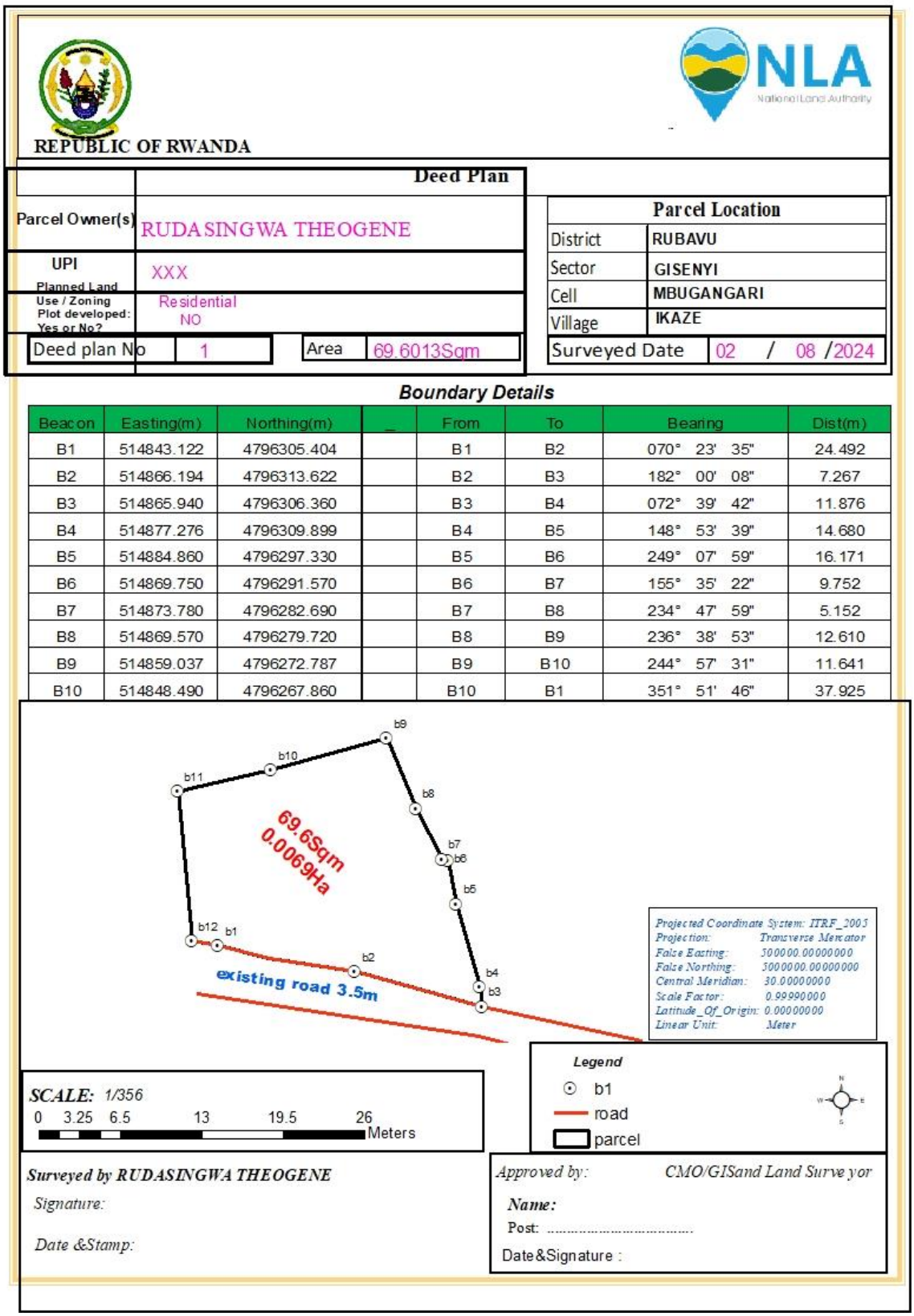
The GIS technology will reduce dispute among land owners thus, mitigate court cases. It would sanitized the system of land transactions in general. Provide security for credit from banks and thus, enhance efficient land market, housing, construction and financial institutions. GIS data base

system for land management guarantee data backup in the event of system breakdown. GIS database can provide previous and up to date Maps, layout, plans with details if require at fingertips. GIS database can accept updates easily. Since the GIS database is embedded with information, every potential buyer will want to authenticate (attest) whether the land is genuine and free from stains. GIS allow information sharing by different users at different time.

Now through GIS it is very easy manage land. Through GIS there has been land registration to record all the land information in the country especially in Rubavu district like one of the districts of Western province. Land registration has been very important in the implementation of land use planning for better land management in Rubavu district and development of land resources and to improve the image of Rubavu district in general. GIS have extremely many positive impacts on land use management since it made land use management easier and quick not to mention the reduction of improper land use. Below are some of those impacts of GIS in Land use management.

4.2.3.1. Making a deed plan

ArcGIS 10.8 facilitate in making deed plan. On the other hand deed plan is a document which contains land information such as land owner, land use, UPI, location et c. Actually deed plan plays a big role in land information recording since it contains all necessary information for land registration. Land registration helps to acquire better land use management because with land registration it gets easier to get all necessary information that can be used in land management.



REPUBLIC OF RWANDA

NLA National Land Authority

Deed Plan

Parcel Owner(s)	RUDASINGWA THEOGENE
UPI	XXX
Planned Land Use / Zoning	Residential
Plot developed: Yes or No?	NO
Deed plan No	1
Area	69.6013Sqm

Parcel Location

District	RUBAVU
Sector	GISENYI
Cell	MBUGANGARI
Village	IKAZE
Surveyed Date	02 / 08 /2024

Boundary Details

Beacon	Easting(m)	Northing(m)	_	From	To	Bearing	Dist(m)
B1	514843.122	4796305.404		B1	B2	070° 23' 35"	24.492
B2	514866.194	4796313.622		B2	B3	182° 00' 08"	7.267
B3	514865.940	4796306.360		B3	B4	072° 39' 42"	11.876
B4	514877.276	4796309.899		B4	B5	148° 53' 39"	14.680
B5	514884.860	4796297.330		B5	B6	249° 07' 59"	16.171
B6	514869.750	4796291.570		B6	B7	155° 35' 22"	9.752
B7	514873.780	4796282.690		B7	B8	234° 47' 59"	5.152
B8	514869.570	4796279.720		B8	B9	236° 38' 53"	12.610
B9	514859.037	4796272.787		B9	B10	244° 57' 31"	11.641
B10	514848.490	4796267.860		B10	B1	351° 51' 46"	37.925

Figure 4.1**: Deed plan.**

4.2.3.2. Determination of previously uses of land to plan its future use

When we were in one stop Centre of Rubavu district, we identified that With GIS, land use management became effective hence it provides land officers with information about the previous uses of land to be able to plan its uses in future this facilitate to know what can suit best the land according to its previously uses.

4.2.3.3.Better land use planning

Rubavu district intends to make better land use planning with GIS since GIS technics can facilitate them in land use management since they will facilitate Getting the big picture of the land to be used and know what it can be suitable for by tapping into GIS data like gentle slopes and closeness of that land to roads this can improve better land use planning.

Below, is the proposed land use planning map of Rubavu district. This map was produced by using ArcGIS 10.8. This map below itself is an impact of GIS in land use management since that map was produced using GIS. It shows how land use plan is supposed to be and with it local authorities will be able to manage well the land use of the entire Rubavu district

4.2.3.4.Boundary knowing of land uses

GIS is currently used by land officers in this district to get to know the real boundary of land parcels to be used for planned use, this contribute to better decision making in regard with land use management.

4.2.3.5.Better decision making

With GIS, Rubavu district is managing to acquire information like slope analysis, soil study on the land intended for certain use to see if it will able to support its proposed use. This facilitates better land use management unlike planning without knowing the characteristic study of the land.

4.2.3.6.Land use management services are available online in digital form

Rubavu district is trying hard in providing land use services online and digital format, As GIS now has features which allow online working with even more than one user at the same time, with this feature land use planner can get to work together afar apart and produce something impressive not to mention how GIS made it easier to get land use services in digital form now you can get the

digital deed plan and upload or download anywhere you are. This is helping residents of Rubavu district to get effective service on time.

4.2.3.7.Easy to edit, modify errors in land use records.

By the use of GIS, people in Rubavu district can find error on their land title and went to land use office to correct it which can take no longer than an hour for example if someone find out that on his or her land title the type of use is commercial while it was supposed to be residential she can get to land use officer and correct it in just a blink of an eye.

CHAPTER 5: COCLUSION AND RECOMMENDATION

This section provides the conclusion and recommendations of this research, which have been formulated referring to the obtained results found in the study area.

5.1. Conclusion

The general objective of this study is to assess the impact geographical information system (GIS) in land management in Rwanda. Case study: Rubavu district (2015 -2024). The specific objectives were to identify the major factors driving land management, to show how GIS Techniques can be applied on land use management and to examine the overall impacts of GIS on land management. The results show that the level of land management in Rubavu district is characterized by clear land records, land use monitoring, effective and efficient land transfers, proper lad taxation and land disputes resolution. GIS plays a crucial role in land management of Rubavu district. Starting from the first phase of land use planning where by it simplifies the territorial planning, operating, analyzing important data concerning their spatial relationship that allows carrying complex assessment of the situation and creates basis for more exact reasonable decisions regarding land use in this district. To ensure a good land administration a number of data and procedures are required for demarcation and recording. It may entails details such as ownership, land use, land value, land use plan, site development plan, utility plan, survey information, other attributes such as name of owner, plot number, size, use, location, transaction records such as deed of assignment, sublease, mortgage, devolution, release etc. All these and many others may accumulate into a large stream of information. Managing such huge information manually will be difficult.

According to (Akeh & Mshelia, 2016) GIS, being a computerized system, has the capabilities to handle such huge data not only effective but also efficient, secured, faster, and transparent. From these, we can be able to summarize the following advantages of GIS in land administration: It will facilitate land registration processes, data processing, storage and retrieval as well as reduce time, cost and space required for land record and management. It will enhance academic research as access to information will be easy. Guarantee tenure security and transparency among land owners. This will enhance sustainable development. Revenue proliferation to government via consent fee, title ascertainment fee, re-validation of titles, deed of assignments, Mortgage, Lease, update fees,

Map copies (for site plans, building plan,),power of attorney, etc. Since the GIS technology has the capability of allocating a distinct geographical coordinates to piece of land, thus, issues regarding multiple transactions and double allocations, illegal transactions will be phased out.

The GIS technology will reduce dispute among land owners thus, mitigate court cases. It would sanitized the system of land transactions in general. Provide security for credit from banks and thus, enhance efficient land market, housing, construction and financial institutions. GIS data base system for land management guarantee data backup in the event of system breakdown. GIS database can provide previous and up to date Maps, layout, plans with details if require at fingertips. GIS database can accept updates easily. Since the GIS database is embedded with information, every potential buyer will want to authenticate (attest) whether the land is genuine and free from stains. GIS allow information sharing by different users at different time.

Now through GIS it is very easy manage land. Through GIS there has been land registration to record all the land information in the country especially in Rubavu district like one of the districts of Western province. Land registration has been very important in the implementation of land use planning for better land management in Rubavu district and development of land resources and to improve the image of Rubavu district in general. GIS have extremely many positive impacts on land use management since it made land use management easier and quick not to mention the reduction of improper land use.

5.2. Recommendation

For effective and efficient land management through the use of GIS, the following recommendations are necessary: -

a) There is need for Rubavu district to established its Geographical Information System that will create a geospatial database for land management
b) Adequate fund should be budgeted for the acquisition of the necessary hardware, software and other peripheral devices required for the successful establishment of the system
c) Capacity training for staff members in the land registries and other professionals such as planners, estate managers, valuers, etc. that are directly and indirectly involved in the implementation of the new system.

d) Capacity training, orientations, workshops, seminars and certifications will also be required from time to time to other personnel who are engaged in land transactions such as property dealers, land owners, village/ward heads, stewards or brokers etc.
e) The property dealers and land brokers should be registered with the relevant authorities. And such persons should pay an annual tax and vat on every transaction.
f) There is the need for an enlightenment campaign to the general public on the relevance of this GIS system and its benefits in reducing land disputes.
g) It is also recommended to issue right of ownership certificate (C of O)to all the developed parcels within the existing area which have been documented in the GIS database; this will authenticate and guarantee tenure security and transparency among land owners as well as sanitized the system of land transactions in the future.
h) It is recommended to rescue the large amount of valuable data such as hard copy maps, plans and other related data that are slowly decaying in offices into the GIS database.
i) To be build much trust and confidence and to avoid forging of illegal document in land transactions, it should be made mandatory to every potential buyer and seller of land to authenticate from the GIS office whether the parcel is genuine and free from stains.
j) All land brokers and anyone who contract in the name of land should pay for authentication of parcel from the GIS office. This will generate revenue to the office.
k) Similarly after every transactions of land, those concern should update such information from the GIS office so as to effect such changes of ownership into the database. And such updates should attract charges for revenue purpose.

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