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DEPARTMENT OF CIVIL ENGINEERING

OPTION: LAND SURVEY

FINAL YEAR PROJECT

ASSESSMENT OF URBANIZATION TREND IN RWANDA
CASE STUDY: RWAMAGANA DISTRICT/MUYUMBU SECTOR

Submitted in partial fulfillment of the requirement of the award of Advanced Diploma in Land survey Engineering

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Kigali, **October**, 2024

DECLARATION OF ORIGINALITY

I, **RUGAMBA Alin Innocent** hereby declare that the work presented in this dissertation is my 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 fulfillment of the award of A1 with honors in Land Survey at ULK POLYTECHNIC INSTITUTE.

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Date of submission: ………...……………………….………….…............

APPROVAL

This is to certify that this dissertation work entitled “Evaluating the Urbanization Trend in Muyumbu Sector by Using GIS and Remote Sensing from 2010-2020” is an original study conducted by **RUGAMBA Alin Innocent** under my supervision and guidance**.**

Supervisor’s name**: Eng. MUNYANEZA jean Pierre**

Signature of supervisor**: …………………………………**

Submission date**: ………..……………………..………….**

DEDICATION

This project is dedicated to Almighty God for guidance and inspiration. We extend our heartfelt gratitude to our parents for their unwavering support. Our classmates have been invaluable collaborators in our learning journey. Our supervisor **MUNYANEZA Jean Pierre** for his advice and guidance. Friends have encouraged and motivated us throughout. We acknowledge the Civil Engineering department lecturers and assistants for their knowledge and mentorship. Our brothers and sisters have been unwavering pillars of strength. We also appreciate the ULK POLYTECHNIC INSTITUTE Administration for their support.

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ABSTRACT

Urbanization also refers to the process by which an increasing proportion of a population lives in urban areas or cities, often accompanied by the physical growth of urban areas into surrounding rural areas. Rwanda faces rapid urbanization challenges, including land scarcity and environmental degradation, primarily due to unplanned settlements. One of the most significant consequences of urbanization is the strain it places on infrastructure and public services. As cities grow, there is an increasing demand for housing, transportation, water supply, and waste management systems. High-resolution satellite images from sources USGS earth explore such as Landsat 2020 OLI and Landsat ETM+ 2020 were utilized to capture spatial changes in the Muyumbu Sector over the study period from 2010 to 2010. GIS software, such as ArcGIS and ERIDAS 2015, facilitates the processing, analysis, and visualization of spatial data, enabling the classification of land use categories and the detection of changes over time. The study was conducted to provide the assessment of the urbanization trend in the Muyumbu sector in 10 years, this sector is located in the eastern province of Rwanda in the Rwamagana district. The results of this study show that agricultural land is the one decreased highly by about 12.708% this is a reduction of 639.89ha which converted into other land uses while the area covered by buildings increased by 19.6814% and is about 991.05ha of increase. GIS and Remote Sensing technologies into routine urban planning processes. Local authorities should regularly update and analyze land use and land cover data to monitor urban expansion and assess its environmental and social impacts. The sector should also establish guidelines for sustainable urbanization, focusing on preserving green spaces and optimizing land use for infrastructure and housing.

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LIST OF ACRONYMS AND ABBREVIATIONS

ERIDAS : Earth Resources Data Analysis System

ETM+ : Enhanced Thematic Mapper Plus

EAC : East African Community

OLI : Operational Land Imager

GIS : Geographic Information System

GCP : Ground Control Points

INES : Institut d'Enseignement Superieur

RS : Remote Sensing

LULC : Land Use Land Cover

USGS : United States Geological Survey

UTM : Universal Transversal Mercator

UPI : Ulk polytechnic Institute

CHAPTER ONE: GENERAL INTRODUCTION

1.1 Background of the study

Urbanization also refers to the process by which an increasing proportion of a population lives in urban areas or cities, often accompanied by the physical growth of urban areas into surrounding rural areas (Seto et al.,2013). It involves the movement of people from rural to urban areas, leading to changes in land use, infrastructure development, and the affected regions' social, economic, and environmental dynamics (Surya et al., 2020). Urbanization is a significant global trend driven by factors such as industrialization, economic opportunities in cities, and population growth (Annez & Buckley, 2009).

The urbanization trend refers to the increasing proportion of a country's population living in urban areas compared to rural areas (Rwigema, 2022). Urban growth is defined as the rate at which the population of an urban area increases. This affects the change in land use and land cover in some areas including developing countries. This increase in population growth and unplanned development activities may slow down the country's development and lead to the inappropriate use of land (Gollin et al., 2016).

In Rwanda, this classification is not coherent in the country’s legislation framework. The national land use master plan states that there are at least three approaches to defining urban area which are namely: The first is built-up provided: The agglomeration with an area of more than 20 km^2 and a population of more than 10,000 permanent residents, which results in a population density higher than 500 p/km2. The second is density: Population density or built-up area third is the functional area: Comprise all areas in which public services and facilities are provided (Hudani, 2020).

In Rwanda, are also rapid urbanization and its associated problems such as scarcity of land and environmental degradation (due to the proliferation of unplanned settlements) are among the issues that preoccupy the minds of policymakers and technocrats at the Rwanda Housing Authority (Nduwayezu et al., 2021). Urbanization in the East African Community (EAC) is characterized by rapid population growth and significant migration from rural to urban areas, resulting in a current urbanization rate of approximately 23.5%, making it the least urbanized region in Africa. This trend is driven by various factors, including economic opportunities, industrialization, and the need for improved infrastructure and services (Ogola et al., 2015).

However, the EAC faces numerous challenges related to urbanization, such as underdeveloped transportation networks, inadequate basic services, and high costs of living, which hinder economic development (Masters et al.,2013). Urban areas expand, and the region must address issues like housing shortages, environmental degradation, and the management of informal settlements to ensure sustainable urban growth and enhance the quality of life for its residents. Overall, urbanization presents both opportunities for socio-economic development and challenges that require coordinated planning and effective governance across the member states (Andrew Kitole et al., 2024).

Urbanization is the process through which populations shift from rural to urban areas, resulting in the growth of cities and a corresponding decrease in the rural population. This phenomenon is driven by various factors, including industrialization, economic opportunities, and improved living standards in urban centers (Munir & Ameer, 2022). As cities expand, they often face challenges such as overcrowding, infrastructure strain, and environmental degradation. Urbanization can lead to the emergence of megacities, which are urban areas with populations exceeding 10 million, and it is projected that by 2050, a significant portion of the global population will reside in urban settings, particularly in developing regions like Africa and Asia (Yamashita, 2017).

Global urbanization represents a profound shift in human settlement patterns, characterized by the migration of populations from rural to urban areas, which has accelerated dramatically over the past century (Seto et al.,2013). In 1900, only about 10% of the world's population lived in cities, but this figure surpassed 50% by 2010 and is projected to reach approximately 75% by 2050, adding around 2.5 billion people to urban populations, primarily in Asia and Africa (McDonald et al.,2014). This transformation is driven by various factors, including economic opportunities, industrialization, and improved living standards in urban centers. However, rapid urbanization brings significant challenges, such as overcrowding, inadequate infrastructure, environmental degradation, and social inequality (Reba et al., 2016). Urban areas, while occupying less than 5% of the Earth's land, account for about 70% of global energy consumption and greenhouse gas emissions, highlighting the urgent need for sustainable urban planning and development.

The phenomenon also leads to the emergence of megacities, with cities like Tokyo and Delhi projected to house tens of millions of residents, further complicating governance and resource management. As urbanization continues to evolve, policymakers must implement strategies that promote urban resilience and sustainability to mitigate the adverse effects on ecosystems and enhance the quality of life for urban dwellers (Coaffee et al.,2018).

1.2. Problem Statement

Rwanda faces rapid urbanization challenges, including land scarcity and environmental degradation, primarily due to unplanned settlements (Bimenyimana et al.,2022). These issues are critical for policymakers and technocrats at the Rwanda Housing Authority, who are tasked with addressing the implications of urban growth and ensuring sustainable development practices. Urbanization, the process by which rural areas transform into urban centers, has been a driving force behind societal change across the globe (Baffoe et al.,2020).

This trend, accelerated by economic development, population growth, and technological advancements, has significant implications for social, economic, and environmental aspects of life. Evaluating the urbanization trend is crucial to understanding its impact on various sectors, including housing, infrastructure, public services, and the environment (Nduwayezu et al.,2021). Today, the primary drivers of urbanization include globalization, technological advancements, and economic policies that favor urban development. However, this rapid urbanization has also led to challenges such as overcrowding, inadequate infrastructure, and environmental degradation (Rwanyiziri et al.,2020).

One of the most significant consequences of urbanization is the strain it places on infrastructure and public services. As cities grow, there is an increasing demand for housing, transportation, water supply, and waste management systems. In many cases, especially in developing countries, the rapid pace of urbanization has outstripped the capacity of existing infrastructure, leading to problems such as traffic congestion, inadequate housing, and poor sanitation. Evaluating urbanization trends allows policymakers to anticipate these challenges and develop strategies to address them effectively (Güneralp et al.,2017).

Urbanization also has profound environmental implications. The expansion of urban areas often leads to the destruction of natural habitats, increased pollution, and higher energy consumption (Qu & Long, 2018). The concentration of people and industries in cities contributes to air and water pollution, while the construction of new infrastructure can lead to the loss of green spaces and biodiversity. Evaluating the environmental impact of urbanization is essential for promoting sustainable development and mitigating the negative effects on ecosystems (Ohwo & Abotutu, 2015).

The issue of urban sprawl is a matter of concern in many countries across the world, especially in developing countries, if it is left unchecked, the phenomenon of uncontrolled urban sprawl will ultimately result in damaging impacts on urban sustainability, to evaluate and monitor the changes in urban settings, continuous spatial and temporal monitoring of our urban environment is a must, urban growth is limited by the quality of data derived from remote sensing images, it a reason why we need the accurate data to be used in this study (Kharel, 2010).

1.3. Purpose of the study

The purpose of this study is to evaluate the urbanization trend by using GIS and Remote sensing (2010-2020): Case study, of Rwamagana District, Muyumbu Sector from 2010 to 2020.

1.4 Research objectives

The specific objectives are:

a. To map land use of the land cover of the Muyumbu Sector from 2010 to 2020.
b. To analyze the impact of urbanization by detecting changes in land use and land cover.
c. To assess the environmental impacts of urbanization in the Muyumbu sector.

1.5. Research questions

The following are the research questions:

a. How can land use of the land cover of the Muyumbu Sector be mapped from 2010 to 2020?
b. What is the impact of urbanization by detecting changes in land use and land cover in the Muyumbu sector?
c. How can the environmental impacts of urbanization be assessed in the Muyumbu sector?

1.6. Research hypothesis

The land use and land cover changes in the Muyumbu Sector from 2010 to 2020 can be effectively analyzed and quantified using GIS and remote sensing technologies, revealing significant transformations in agricultural, residential, and commercial areas due to urbanization and population growth. Urbanization in the Muyumbu Sector from 2010 to 2020 has significantly altered land use and land cover patterns, leading to a reduction in agricultural land

and green spaces while increasing built-up areas, which in turn affects local biodiversity and ecosystem services.

1.7. Scope

This study aims to leverage high-resolution satellite imagery and GIS tools to systematically map and quantify changes in land use categories, such as residential, agricultural, and commerce while assessing the impacts of urbanization on local ecosystems and community structures. By employing methodologies like change detection algorithms and spatial analysis, the research will explore the correlation between urban expansion and socio-economic factors, providing insights into the sustainability of urban development in the region. Ultimately, the findings will contribute to informed urban planning and policy-making, addressing challenges such as land scarcity, infrastructure development, and environmental degradation associated with rapid urbanization.

1.8. Significant of the study

The research can accurately detect and analyze spatial patterns of urban growth, enabling stakeholders to understand the implications of rapid urbanization on local ecosystems, infrastructure, and community well-being. This study not only contributes to the academic discourse on urbanization but also serves as a practical tool for policymakers and urban planners to address challenges such as land scarcity, environmental degradation, and inadequate service provision. Ultimately, the findings can guide the formulation of effective land management strategies and urban policies that promote sustainable urban development while mitigating the adverse effects associated with uncontrolled urban expansion.

1.9. Organization of the study

This research comprises five chapters: the first chapter is the introduction which is the background, statement of the problem, objectives of the study, research hypotheses and significance of the study, and scope of the research. The second chapter (Literature Review) was related to the literature review summarizing theories developed in terms of spatial analysis of land cover and its contribution to dynamics of urbanization from global to local scale. The third chapter (Research Methodology) describes the research design, study area, data collection, and analysis. The fourth chapter (Results and Discussion) presents and analyzes the findings of the study. The last chapter (Conclusion and Recommendations) summarizes the results of the study and formulates its conclusion and further recommendations as well.

CHAPTER TWO: LITERATURE REVIEW

2.1 Introduction

This chapter describes the literature review on assessing the urbanization trends of the study area, this review includes some notes and books referred to in research. This chapter is represented in five sections. Section one defines and discusses key terms and concepts included in this research, section two describes the land use land cover and their similarities, and section three describes the land use/cover change detection. Section four describes the urbanization process and section five describes software applications in land use/cover assessment.

2.2 Definition of Key Concepts

2.2.1 Land

Land or ground, also known as dry land, is Earth's terrestrial surface that is not permanently submerged in water. It makes up 29% of Earth's surface and includes the continents and a variety of small islands. The zone where land meets sea or lakes is known as the coast. Tectonic plate movement under the Earth can create landforms by pushing up mountains and hills. Erosion by water and wind can wear downland and create landforms like valleys and canyons. Both processes happen over a long period, sometimes millions of years (Antrop & Van Eetvelde, 2017)

The land matter was the principal process of every land development that required being resolved before the development could take place on the ground. Land matters refer to the legal ownership of each property (landed or high-rise property) and restrictions on the land title itself. A flourishing life on land is the foundation for our life on this planet. We are all part of the planet's ecosystem and we have caused severe damage to it through deforestation, loss of natural habitats, and land degradation. Promoting sustainable use of our ecosystems and preserving biodiversity is not a cause (Bender, 2006).

2.2.2 Land use

Land use is the term used to describe the human use of land. It represents the economic and cultural activities (e.g., agricultural, residential, industrial, mining, and recreational uses) that are practiced at a given place. Public and private lands frequently represent very different uses (Cecchini & Salvati, 2019).

Table 1: Land Use Cover Types (Visser et al., 2019)

Land use Land cover (LULC) Categories	Land cover description
Forests	An area of land with at least 0.5 ha, with a minimum tree crown over 10%, or with tree species planted or natural having the potential or having reached a minimum height of 3m at maturity in situ. It includes montane, lowland, mangrove, and plantation forests, woodlands, and thickets.
Bushland	Bushland is fundamentally defined as being predominantly comprised of plants that are multi-stemmed from a single root base. It includes the dense and open bushland.
Grassland	For the most part, grassland occurs in combination with either a limited wooded or bushed component or with scattered subsistence cultivation.
Agriculture	The land is actively used to grow crops including agroforestry systems, wooded crops, herbaceous crops, and grain crops.
Urban area	Land that includes settlement or built-up area
Bare land	Land covered by bare soil, rock outcrop, and coastal sand
Water	Includes inland water-and-water-logged areas such as marshland, perennially flooded plains, and swampy areas.

2.2.3 Land cover

Land cover refers to the physical material present on the Earth's surface, encompassing various elements such as vegetation, built structures, bare soil, and water bodies. It is distinct from land use, which describes how humans utilize the land for activities like agriculture and urban development (Verburg *et al*.,2009). The classification of land cover types can vary significantly, leading to inconsistencies in definitions across different surveys and organizations. Data on land cover is primarily gathered through field surveys and remote sensing technologies, enabling the monitoring of changes over time. This information is crucial for applications in environmental management, urban planning, and assessing the impacts of climate change on ecosystems and biodiversity (Wulder *et al*.,2018).

2.2.4 Land use and land cover

Land use and land cover are two distinct but interrelated concepts that describe different aspects of the Earth's surface. Land cover refers to the physical material present on the land, including natural elements like vegetation (forests, grasslands) and human-made structures (buildings, roads), as well as bare soil and water bodies. It provides a snapshot of what is physically present at a given location and is typically assessed through remote sensing techniques or aerial imagery. In contrast, land use describes how humans utilize the land, encompassing activities such as agriculture, recreation, urban development, and conservation (Mohan *et al*.,2011).

This concept reflects the socio-economic activities that take place on the land, which may not always align with the land cover type; for example, a forested area may be used for timber production, wildlife habitat, or recreational purposes. Understanding both land use and land cover is essential for effective resource management, urban planning, and environmental conservation, as they provide critical insights into how landscapes change over time and how best to balance development with ecological sustainability (Zhai *et al*.,2021).

2.2.5 Land use/cover change detection

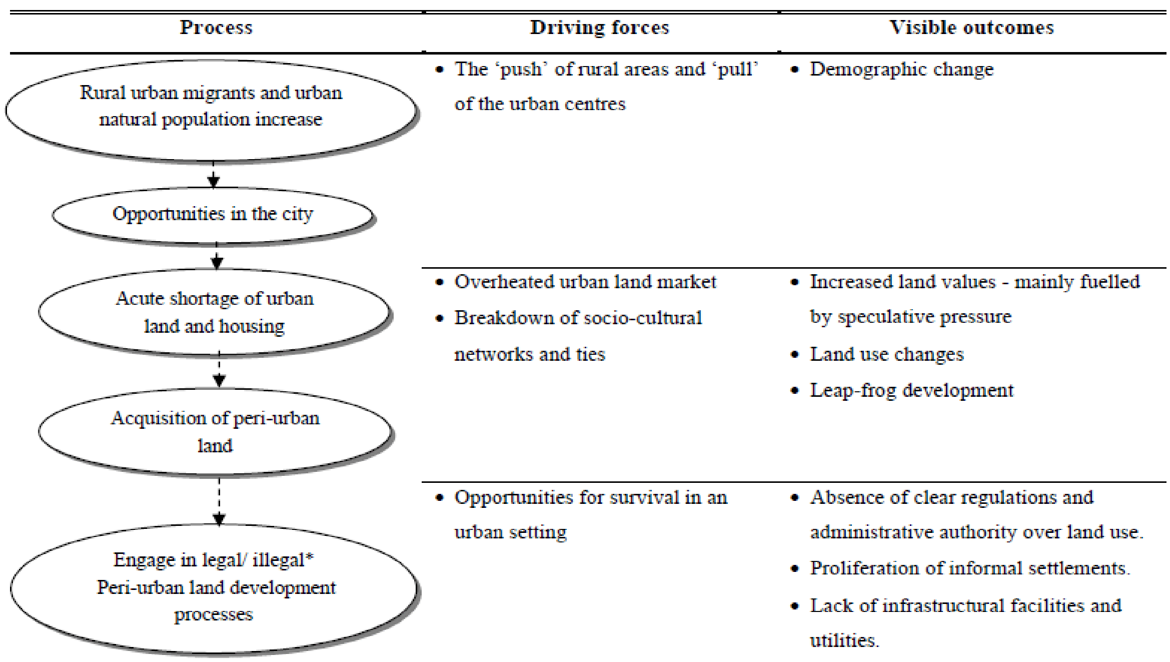
Land use and land cover (LULC) change detection is a critical process for monitoring and managing natural resources, urban development, and environmental changes. It involves identifying differences in the state of an object or phenomenon by observing it at different times using remote sensing data (Chughtai *et al*.,2021). Land use/cover change detection refers to the process of identifying and quantifying the alterations in the landscape over a specific period. This involves the transformation of land from one type to another, such as forest to agricultural land, urban expansion into rural areas, or shifts in natural ecosystems due to human activity or environmental factors (Halmy *et al*.,2015).

Monitoring these changes is essential for sustainable development, environmental management, and policy-making. Techniques used in land use/cover change detection often rely on remote sensing and geographic information systems (GIS), which allow for the collection of spatial data over large areas and extended periods. Satellite imagery is commonly used to capture different wavelengths of light, highlighting changes in vegetation, water bodies, or built-up areas. These changes are then analyzed using image classification techniques, where land cover is categorized into various types, such as forests, agricultural lands, urban areas, and water bodies (Xing *et al*.,2018).

2.3 Urbanization process

Urbanization refers to how people shift from rural areas to cities. During the last century, global populations have urbanized rapidly: 13% of people lived in urban environments in the year 1900. 29% of people lived in urban environments in the year 1950. Urbanization is also the process by which large numbers of people become permanently concentrated in relatively small areas, forming cities (Gu, 2019).

figure 2. 1: The urbanization process (BAYSAL et al., 2022)



2.3.1 Urbanization growth and its consequences

Urbanization is a trend unique to the past few centuries. By 2050 it's projected that more than two-thirds of the world population will live in urban areas. It's projected that close to 7 billion people will live in urban areas in 2050. (Costa) People tend to migrate from rural to urban areas as they become richer. Urbanization occurs mainly because people move from rural areas to urban areas and it results in growth in the size of the urban population and the extent of urban areas. These population changes lead to other changes in land use, economic activity, and culture (Nandy, 2015).

The consequences of urban growth are that wealth is generated in cities, making urbanization a key to economic development. However, urbanization has caused air and water pollution, land degradation, and loss of biodiversity. It has forced millions of people to live in slums without clean water, sanitation, and electricity. However, positively the higher standard of living associated with urbanization provides people with better food, education, housing, and health care. Urban growth generates revenues that fund infrastructure projects, reducing congestion and improving public health (Yang *et al*.,2014).

2.4 Application of Remote sensing and GIS in LULC assessment

Remote Sensing, as a direct adjunct to professional fields, has recently played an important role in the study and assessment of natural resources in any part of the world. Anthropogenic changes in land use and land cover and land use are often assumed to be identical, they are rather quite different. Land cover may be defined as the biophysical earth's surface, while land use is often shaped by human, socioeconomic, and political influences on the land. Remote Sensing (RS), integrated with Geographic Information System (GIS), provides an effective tool for analysis of land use and land cover changes (Chowdhury *et al*.,2020).

Digital change detection is the process that helps in determining the changes associated with land use and land cover properties concerning geo-registered multi-temporal remote sensing data. Remote sensing also is one of the tools that is very important for the production of Land use and land cover maps through a process called image classification (Habte *et al*.,2021). For the image classification process to be successful, several factors should be considered including the availability of quality Landsat imagery and secondary data, a precise classification process, and the user’s experiences and expertise in the procedures. The objective of this research was to classify and map land-use/land cover of the study area using remote sensing and Geospatial Information System (GIS) techniques (Gadrani *et al*.,2018).

2.4.1 Accuracy assessment

Accuracy assessment is an important part of any classification project. It compares the classified image to another data source that is considered to be accurate or ground truth data. Ground truth can be collected in the field; however, this is time-consuming and expensive. It is performed by comparing a map produced from remotely sensed data with another map obtained from some other source (Mohammed, 2013). Landscape often changes rapidly.

Therefore, it is best to collect the ground reference as close to the date of remote sensing data acquisition as possible (Pande *et al*.,2021). The accuracy of any map may be tested by comparing the positions of points whose locations or elevations are shown upon it with corresponding positions as determined by surveys of higher accuracy. Accuracy assessment is important because remotely sensed data are often used for mapping and developing environmental models that are used for management and decision-making purposes (Barakat *et al*.,2019).

2.4.2 Image Enhancement

Image enhancement is a subfield of digital image processing. The purpose of image enhancement is to improve the contrast and sharpen the image to enable further processing or analysis. It is the purpose to adjust digital images so that the results are more suitable for display or further image analysis (Ortiz *et al*.,2012). Image enhancement techniques can be divided into two categories: frequency domain methods and spatial domain methods. The color enhancement process consists of a collection of techniques that seek to improve the visual appearance of an image or to convert the image to a form better suited for analysis by a human or machine (Qi *et al*.,2021).

2.4.3 Image Classification

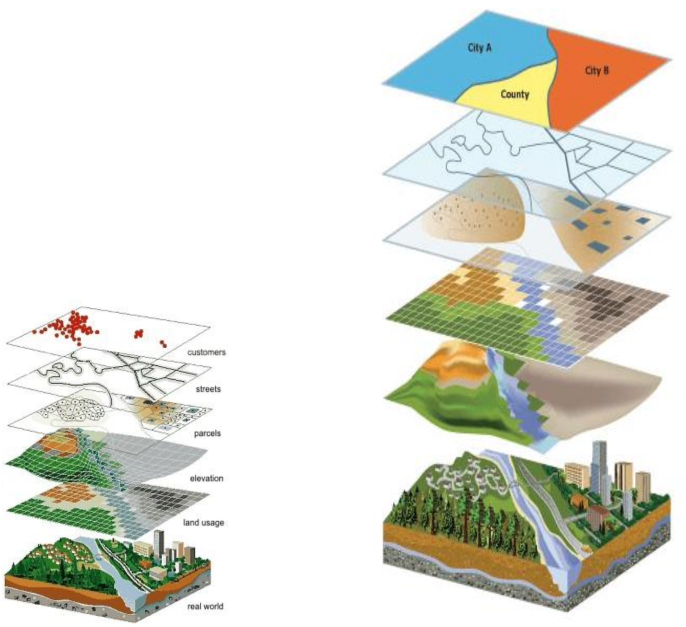
Image classification is the process of categorizing and labeling groups of pixels or vectors within an image based on specific rules. The categorization law can be devised using one or more spectral or textural characteristics. Two general methods of classification are 'supervised' and 'unsupervised'. Image classification is an important field in digital image analysis. It creates a base from which images are analyzed.

Remotely sensed images come in different colors and pixels. These diverse colors are used to analyze the study area and draw conclusions (Rawat & Wang, 2017). Digital image classification uses the spectral information represented by the digital numbers in one or more spectral bands, and attempts to classify each pixel based on this spectral information. This type of classification is termed spectral pattern recognition. The objective of image classification is to identify and portray, as a unique gray level (or color), the features occurring in an image in terms of the object or type of land cover these features represent on the ground (Sharma *et al*.,2018).

2.4.4 Image analysis

Image analysis involves processing an image into fundamental components to extract meaningful information. Image analysis can include tasks such as finding shapes, detecting edges, removing noise, counting objects, and calculating statistics for texture analysis or image quality. It is important to analyze and evaluate images you use for research, study, and presentations. Images should be analyzed and evaluated like any other source, such as journal articles or books, to determine their quality, reliability, and appropriateness. Images should be analyzed and evaluated on several levels (Abràmoff *et al*.,2010).

figure 2. 2: Spatial analysis process (Wubie & Alemie, 2020)



2.5 Factors that influence urban growth

Urban growth is influenced by a range of economic, social, and environmental factors. Economic opportunities, particularly the availability of jobs and the potential for higher income play a key role in attracting people to cities. As industries and businesses expand, cities become hubs for employment, drawing rural populations and even international migrants seeking better livelihoods. The growth of infrastructure, including transportation systems, healthcare, and education, further enhances the appeal of urban areas, creating a cycle where more people move to cities to access these amenities, contributing to urban expansion (Linard *et al*.,2013).

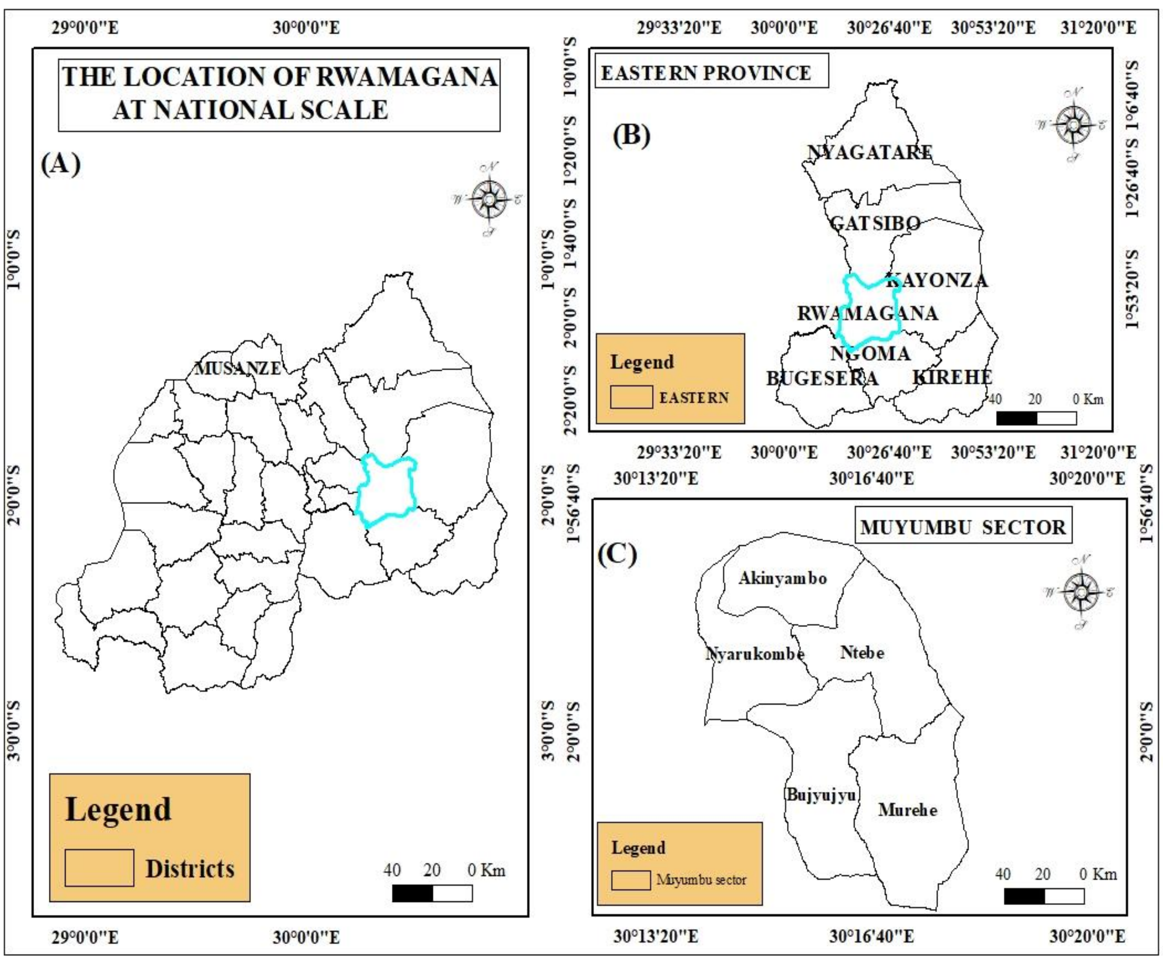
Social factors such as improved living standards, access to services, and better quality of life also drive urban growth. The concentration of educational institutions, healthcare facilities, and entertainment options in cities makes them attractive, especially for younger populations. Additionally, political and environmental factors, such as government policies promoting urban development and the effects of climate change forcing populations to relocate from rural areas, further accelerate the growth of urban spaces. The result is a continual expansion of cities, often leading to the development of megacities and suburban areas (Shafizadeh-Moghadam *et al*.,2015).

CHAPTER THREE: RESEARCH METHODOLOGY

3.0 Introduction

Muyumbu Sector is located in the Rwamagana District of Rwanda's Eastern Province, characterized by its vibrant agricultural landscape and growing population. As of the 2022 census, Muyumbu had a population of approximately 56,881, reflecting significant growth from 24,242 in 2012. The sector is composed of several localities, including the notable town of Gasima, which serves as a central hub for commerce and services in the area. Situated at an elevation of about 1,548 meters, Muyumbu benefits from a tropical savanna climate, conducive to agriculture, which remains a primary economic activity for its residents. The sector's strategic location, approximately 50 km from Kigali, enhances its connectivity and potential for development, making it an essential area for urban planning and resource management within the region.

figure 3. 1: Geographical location of the Muyumbu sector



3.1. Research Design

The research design for evaluating urbanization trends using GIS and remote sensing from 2010 to 2020 will involve a multi-phase methodology that integrates satellite imagery analysis, spatial data processing, and statistical evaluation. Initially, high-resolution satellite images from sources such as Landsat will be acquired for the specified years 2010 and 2020 to capture land use and land cover changes in the Muyumbu Sector. These images will undergo preprocessing steps, including atmospheric correction and geometric rectification, using software like Eridas2015 and ArcGIS.

Subsequently, land cover classification will be performed using supervised and unsupervised classification techniques to identify different land use categories such as Built-up, Forest, Vegetation, and bare soil. Change detection analysis will be conducted to quantify the extent and nature of urbanization over the decade, employing metrics like Shannon's entropy to assess urban sprawl patterns. The results will be analyzed to understand the socio-economic and environmental impacts of urbanization, providing valuable insights for urban planning and policy-making in the region. This comprehensive approach will ensure a robust evaluation of urbanization trends, facilitating informed decision-making for sustainable development.

3.2. Research Instrument

High-resolution satellite images from sources USGS earth explore such as Landsat 2020 OLI and Landsat ETM+ 2020 were utilized to capture spatial changes in the Muyumbu Sector over the study period from 2010 to 2010. GIS software, such as ArcGIS and ERIDAS 2015, facilitates the processing, analysis, and visualization of spatial data, enabling the classification of land use categories and the detection of changes over time. Remote sensing techniques, including supervised and unsupervised classification methods, will be employed to derive land cover information and quantify urban growth patterns. Statistical tools and landscape metrics were also integrated to assess the environmental impacts of urbanization, providing a comprehensive framework for understanding the socio-economic and ecological implications of land use changes in the region.

3.2.1. Choice of the research instrument

Satellite imagery coupled with spatial analysis tools. Satellite imagery provides high-resolution, time-series data essential for tracking land-use changes over time, offering a detailed view of urban sprawl and density. GIS software is then employed to analyze this data, allowing for the integration of various spatial datasets, such as population distribution, infrastructure development, and environmental impact. This combination enables a comprehensive evaluation of urbanization patterns facilitating the identification of trends, hotspots, and potential areas for sustainable urban planning.

3.2.2. Validity and Reliability of the Instrument

The satellite imagery from USGS Earth Explorer provides high-resolution spatial data that can be effectively processed and analyzed using GIS software like ArcGIS and Erdas 2105. The preprocessing steps, including atmospheric correction and geometric rectification, enhance the quality and usability of the images. The supervised and unsupervised classification techniques employed for land cover mapping have been widely used and validated in numerous studies, demonstrating their reliability in deriving accurate land use information.

Change detection analysis using metrics like Shannon's entropy has been proven effective in quantifying urban sprawl patterns and assessing the impacts of urbanization. The integration of statistical tools and landscape metrics further strengthens the validity of the research by providing a comprehensive framework for evaluating the environmental and socio-economic implications of land use changes. Overall, the choice of research instruments and analytical methods is grounded in established practices and scientific literature, ensuring the validity and reliability of the study's findings.

3.3. Data Gathering Procedures

Data will involve the acquisition of high-resolution satellite imagery from 2010 and 2020, primarily from USGS earth explorer sources, covering the Muyumbu Sector. These images will undergo preprocessing steps, including atmospheric correction and geometric rectification, using software like Erdas and ArcGIS. Ground-truthing data, such as land use maps and field surveys, are collected to validate the satellite imagery and support the classification process. Ancillary data, including census records, socio-economic indicators, and infrastructure maps, was gathered to contextualize the urbanization trends and analyze their impacts. The collected data was integrated into a GIS database, enabling spatial analysis, change detection, and the generation of urbanization metrics like Shannon's entropy. This comprehensive approach ensures that the research is grounded in reliable and multifaceted data, providing a robust foundation for evaluating the spatial and temporal dynamics of urbanization in the Muyumbu Sector.

Table 2: Data and Sources

Data	Data	Source of data	Use
(Landsat (8 OLI) ETM7+ (2010 and 2020)	Raster	Downloaded from USGS (https://www.usgs.gov)	land use land cover of study area
Administrative boundary	Vector	Downloaded from Rwanda Geo-portal(http://geoportal.rlma.rw)	describing the area of study

Table 3: The Information on Bands of Landsat used in the study

Landsat 7 ETM+ Bands				Landsat 8 OLI/TIRS Bands			
Band	Resolution (m)	Color	Wave-length (μm)	Band	Resolution (m)	Color	Wave-length (μm)
				1	30	Coastal/ Aerosol	0.435-0.451
1	30	Blue	0.441-0.514	2	30	Blue	0.452-0.512
2	30	Green	0.519-0.601	3	30	Green	0.533-0.590
3	30	Red	0.631-0.692	4	30	Red	0.636-0.673
4	30	NIR	1.547-1.749	5	30	NIR	1.566-1.651
5	30	SWIR-1	1.547-1.749	6	30	SWIR-1	1.566-1.651
6	60	TIR	10.31-12.36	10	100	TIR-1	10.60-11.19
				11	100	TIR-2	11.50-12.51
7	30	SWIR-2	2.064-2.345	7	30	SWIR-2	2.107-2.294
8	15	Pan	0.515-0.896	8	15	Pan	0.503-0.676
				9	30	Cirrus	1.363-1.384

3.3.1. Data pre-processing

- ✓ **Geometric correction/registration**

In image geometric correction, the Landsat8 image will be transformed into one coordinate system with the same study area Shapefile to reduce the size of the image file to include only the area of interest. The Geometric image registration was performed to minimize all geometric distortion inherent to the image. The Landsat 8 OLI image was registered to a common universal Transversal Mercator (UTM) WSG84 Datum, the administrative boundaries area of the study has projected 36S Zone coordinates as a system. By reducing large amounts of geometric errors, a pear in raw data.

- ✓ **Layer stack**

This step was used to combine separated bands into one multispectral image. The combination bands of Landsat 8 OLI are bands 2, 3, 4, 5, 6, and 7. This band enables the researcher to extract the needed information relating to their desire.

- ✓ **Pan sharpening**

This step is to combine the multispectral bands with the panchromatic band to get an image of 15-meter resolution. Landsat 8 OLI data are acquired at two different resolutions which are the multispectral bands (band 1 to 7) collected at 30 m resolution and the panchromatic band (band 8) collected at 15 m resolution, Multispectral image is produced by sensors that measure reflected energy within several specific bands of the electromagnetic spectrum and it indicates that the sensor can accept signal in various narrower bands separately while a panchromatic band is essentially a black and white band and it has very high signal compared to multispectral bands whose capability that enable to see a smaller portion and still get a strong signal. Hence panchromatic often resembles one wide band with lower spatial resolution (often 50% less than multispectral band) which helps us to see finer details (Riggan, 2004).

- ✓ **Image sub-setting**

The area of interest (AOI) was prepared for the Muyumbu sector to extract the required study area from the Landsat image. The Landsat tile is much larger than a project study area. In this case, it was beneficial to reduce the size of the image file to include only the area of interest, the study area shapefile was projected to be given the same projection as the one of the satellite images. Then it was used to subset that satellite image using ERDAS Imagine 2015.

3.3.2. Data processing

- ✓ **Visual image interpretation**

Image enhancement techniques were used to improve the quality of an image as perceived by a human. These techniques are most useful because many satellite images when examined on color, it gives inadequate information for image interpretation. False Color Composite (FCC) of band combination of (band 5, 3, and 2 for Landsat 8 OLI) and true color composite was used to visualize the image for urban Areas.

- ✓ **Image classification**

This study investigated using the maximum likelihood supervised classification to create thematic maps from a multiband raster image. Satellite images have been converted to classified images by grouping the pixels of an image into specific training areas for categorizing all pixels in an image to obtain a given set of labels.

- ✓ **Land use/land cover**

Land Use/Land Cover refers to data that is a result of classifying raw satellite data into land use and land cover (LULC) categories based on the return value of the satellite image. Land use defined in this way establishes a direct link between land cover and the actions of people in their environment

- ✓ **Recording**

After the classification process, all signature sample point was grouped as a class by record function according to the determined land cover classification type in study area. Recording involved the assignment of new values to one or more classes and was used to reduce the number of classes and combine classes.

- ✓ **Accuracy assessment report**

In this research, each Land use Land cover map was compared to the reference data to assess the accuracy of the classification. The Reference Data was prepared by considering the ground control point, the field knowledge, and the Google Earth image. During this classification in accuracy assessment, the Ground Control Points (GCPs) were used to identify the exact position of the place under consideration with latitude and longitude with its type by visual observation.

3.4. Data Analysis and interpretation

The research will involve a systematic approach to processing and analyzing the collected satellite imagery and ancillary data from the Muyumbu Sector. Initially, the high-resolution satellite images will be classified into distinct land use categories such as Buildup, Vegetation, Forest, and Forest using supervised classification techniques like the maximum likelihood algorithm. Change detection analysis will be conducted to quantify the extent of urbanization over the decade, employing metrics such as Shannon's entropy to assess urban sprawl patterns. The results will be visualized through GIS mapping to illustrate spatial changes and trends, allowing for a comprehensive interpretation of how urbanization has impacted land use and the environment. Statistical analyses will also be performed to correlate urban growth with socioeconomic factors, providing insights into the implications of these changes for local communities and ecosystems. This multi-faceted analytical framework will ensure that the findings are robust, reliable, and informative for urban planning and policy-making.

3.5. Ethical considerations

Research is paramount to ensure responsible research practices and the protection of individual rights and community interests. Key ethical issues include the potential misuse of geospatial data, which can lead to privacy violations if sensitive information about individuals or communities is inadvertently revealed. Researchers must follow to principles of transparency and accountability, ensuring that data collection and analysis methods are clearly communicated and that the data is used solely for intended purposes. Obtaining informed consent from local communities and stakeholders is essential, particularly when ground-truthing data is involved.

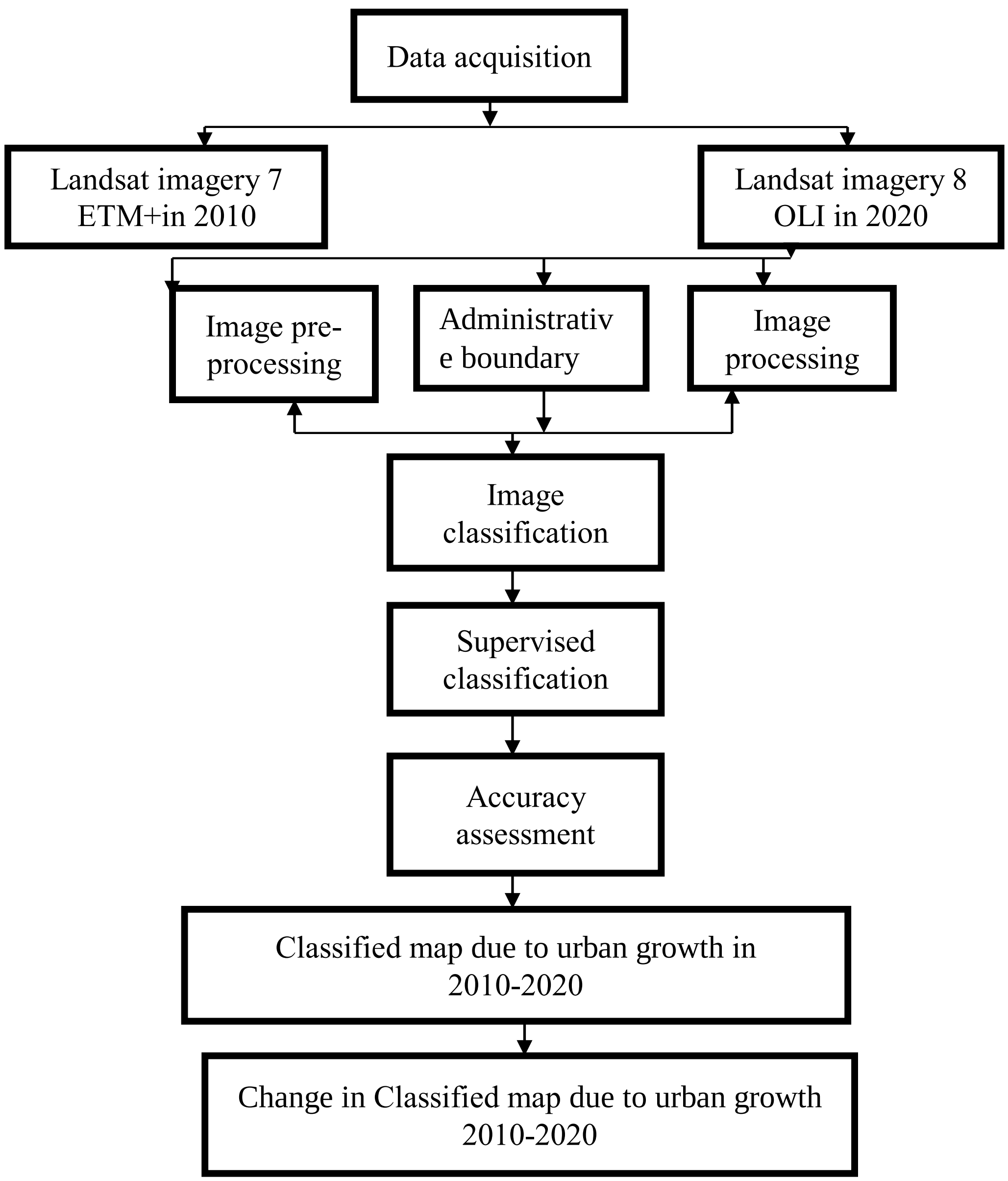
The study should also consider the implications of urbanization on vulnerable populations, ensuring that findings contribute positively to urban planning and policy-making without exacerbating existing inequalities. Furthermore, the research must comply with international guidelines and legal frameworks governing remote sensing and data sharing, promoting cooperation and respect for the rights of all affected parties. By addressing these ethical considerations, the research will not only enhance its credibility but also foster trust and collaboration among stakeholders involved in urban development.

3.6. Limitations of the study

This study included several challenges related to data availability, resolution, and methodological constraints. One important limitation is the reliance on satellite imagery, which may not capture all nuances of land use changes, particularly in areas with rapid or informal development, leading to potential inaccuracies in classification. Variations in spatial and temporal resolutions of different satellite data can affect the consistency and comparability of results over the study period from 2010 to 2020.

Ground-truthing efforts may also be constrained by logistical issues, such as accessibility to certain areas and the availability of up-to-date local land use data, which are essential for validating remote sensing classifications. The complexity of urban systems and the influence of socio-economic factors on land use changes may not be fully captured through remote sensing alone, necessitating a multi-disciplinary approach that integrates qualitative data. These limitations highlight the need for careful interpretation of the findings and consideration of supplementary data sources to enhance the robustness of the study.

figure 3. 2: flow chart methodology

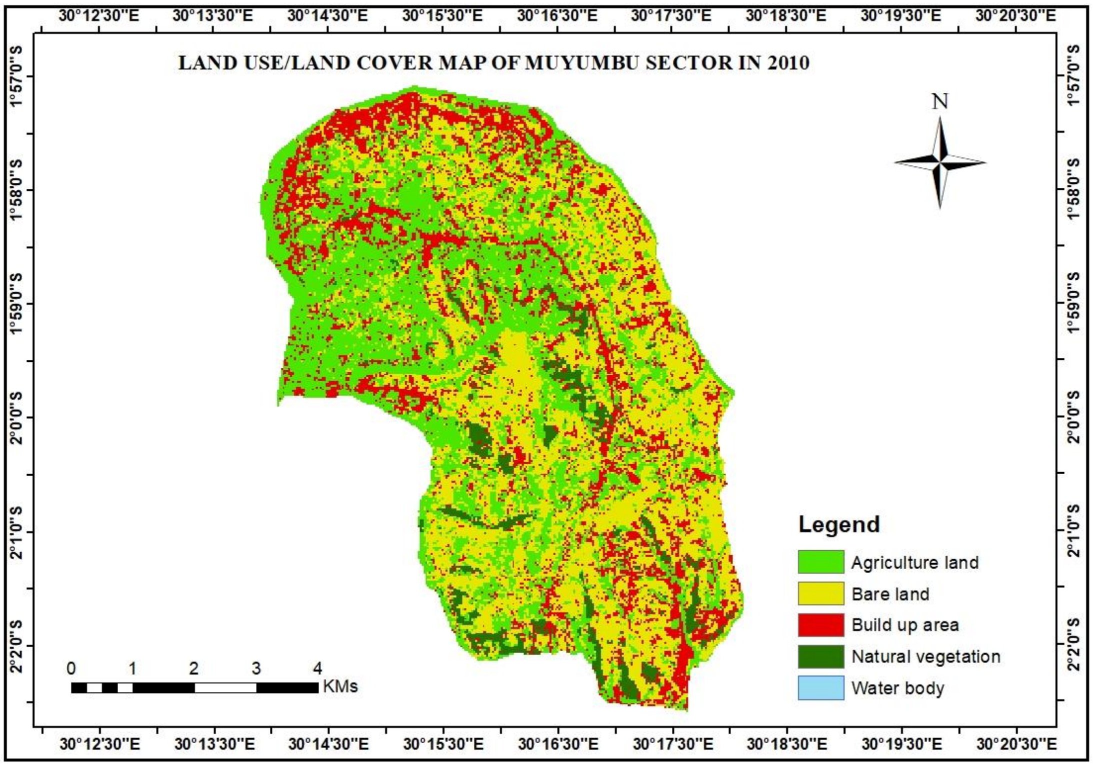


CHAPTER FOUR : RESULTS AND DISCUSSIONS

4.1 Introduction

This chapter presents the results and their discussions after processing and analyzing the data collected. It describes in detail maps and tables the land use/cover of the study area and their corresponding accuracy assessment.

figure 4. 1: Land use land cover 2010



As results in Figure 4 showing the land use/cover map of the Muyumbu sector in 2010, it's clear that a large area of the Muyumbu sector was covered by barren land and agricultural area and the building was not at a high level of land occupation.

4.2.1 Accuracy Assessment of LULC 2010

After producing the map showing different classes of Muyumbu sector the accuracy assessment was conducted because the accuracy is considered as the degree of closeness of results to the true values. It determines the quality of the information derived from remotely sensed data. Accuracy assessment was done based on the visual interpretation of images supported by ground truth data obtained on Google Earth Pro by producing randomly points of the produced map and converting them into KML to make them visible on Google Earth Pro.

Table 4: Accuracy assessment table of LULC 2010

Class name	Agriculture	Bare Soil	Buildings	Natural Vegetation	Water Body	Total (User)
Agriculture	8	1	0	1	0	10
Bare Soil	1	8	0	2	0	11
Buildings	0	1	5	0	0	6
Natural Vegetation	0	0	0	2	0	2
Water Body	0	0	0	0	1	1
Total (Producer)	9	10	5	5	1	30

Table 4 represents the points used in the accuracy assessment and their appropriate location, and the total points used were 30, and 24 of them were in the appropriate location according to the land use/cover of where they were placed on the map. After obtaining the table of accuracy assessment, different formulas were applied to obtain overall accuracy, user accuracy, producer accuracy, and the kappa coefficient (T).

Overall Accuracy = $\frac{\text{(Total number of correctly classified pixel) (Diagonal)}}{\text{(Total number of reference pixels)}}$ *100

Overall Accuracy = (24/30) *100

=0.8=80%

Users Accuracy = $\frac{\text{(Number of correctly classified pixel in each category)}}{\text{Total number of classified pixels in that category (the row total)}} * 100$

Agriculture= 8/10 *100= 80%

*****100 Bare Soil= 8/11 *100= 72.72%

Buildings= 5/6 *100= 83.34%

Natural Vegetation= 2/2 *100= 100%

Water Body= 1/1 *100= 100%

Producer Accuracy = $\frac{\text{(Number of correctly classified pixel in each category)}}{\text{Total number of classified pixels in that category (the column total)}} * 100$

Agriculture= 8/9 *100= 88.89%

Bare Soil= 8/10 *100= 80%

Buildings= 5/5 *100= 100%

Natural Vegetation= 2/5 *100= 40%

Water Body= 1/1 *100= 100%

Kappa Coefficient (T)= $\frac{(\mathrm{TS} * \mathrm{TCS})-\sum(\text{Column total} * \text{Row total})}{\mathrm{TS}^2-\sum(\text{Column total} * \text{Row total})} * 100$

Where: TS is the Total Sample and

TCS is the Total Collected Sample

Therefore, **Kappa Coefficient (T=**$\frac{(30*24)-((9*10)+(10*11)+(5*6)+(5*2)+(1*1)}{900-((9*10)+(10*11)+(5*6)+(5*2)+(1*1))}$

$$= \frac{720-241}{900-241} * 100$$

=0.7268=72.68%

Table 5: Land use distribution in 2010

Class name	Area(ha)	Percentage (%)
Agriculture land	1879.14	37.31818785
Bare land	1966.54	39.05391812
Build up area	970.194	19.26726159
Natural vegetation	219.336	4.355834079
Waterbody	0.241619	0.004798356
Total	5035.45351	100

Table 5 represents the distribution of the land of the Muyumbu sector in 2010 and their corresponding percentages the barren land occupied a large area with 39.05% of the whole industry, agriculture land occupied 37.32% of the entire sector, buildings occupied 19.267% of the whole industry, natural vegetation occupied 4.35% of the whole area and the area covered by water was the smallest with 0.00475% of the whole sector.

4.2.2 Overall Accuracy

Overall accuracy refers to the degree to which a measurement, calculation, or prediction aligns with the true value or standard. It is a critical metric in various fields, including statistics, science, and data analysis, as it reflects the reliability and validity of results (Brovelli *et* *al*.,2015). High overall accuracy indicates that the methods used are effective and that the conclusions drawn are trustworthy. Conversely, low accuracy can lead to erroneous interpretations and decisions. Therefore, ensuring high overall accuracy involves rigorous testing, validation, and adherence to best practices in data collection and analysis (Shao *et al*.,2019).

4.2.3 User accuracy

User accuracy refers to the extent to which a user or system correctly identifies or categorizes information, often in the context of machine learning, data analysis, or user interfaces. It is a crucial metric for evaluating the performance of algorithms, particularly in classification tasks, where it measures the proportion of true positive predictions made by the model relative to the total number of instances classified. High user accuracy indicates that users can effectively utilize the system or that the system performs well in understanding user inputs, leading to improved user satisfaction and trust (Taddei *et al*.,2006).

4.2.4 Produce accuracy

Accuracy is defined as the degree to which a measured value aligns with the true or accepted standard value. It encompasses two main types: absolute accuracy, which measures how close a value is to an exact true value, and relative accuracy, which assesses closeness to a standard value independent of scale. In practical terms, achieving high accuracy often involves minimizing errors through careful measurement techniques and calibration of instruments. For example, in scientific experiments, accuracy can be quantified using percent error, which indicates the deviation of a measured value from the true value (Hyndman, 2014).

4.2.5 Kappa Coefficient

The Kappa coefficient, specifically Cohen's Kappa (κ), is a vital statistical measure used in accuracy assessment to evaluate the agreement between two raters or classification systems when categorizing items into discrete categories. It quantifies the level of agreement beyond what would be expected by chance, making it particularly useful in fields like remote sensing, healthcare, and social sciences where subjective judgments are common (van Vliet *et al*.,2011). The Kappa coefficient is calculated using the formula:

$$\boldsymbol{k = \frac{po - pe}{p1 - pe}}$$

Where po is the observed agreement and pe*pe* is the expected agreement by chance. Values of κ range from -1 to 1, with 1 indicating perfect agreement, 0 indicating no agreement beyond chance, and negative values suggesting worse than chance agreement. Interpretation of Kappa values follows established guidelines: values above 0.8 indicate almost perfect agreement, 0.6 to 0.8 suggest substantial agreement, 0.4 to 0.6 indicate moderate agreement, and below 0.2 reflect slight or poor agreement. In practical applications, such as land use classification studies, Kappa coefficients provide a more comprehensive understanding of model performance compared to simple accuracy metrics, helping researchers assess the reliability of their classifications effectively.

4.3 Land Use/cover and land distribution of Muyumbu Sector in 2020

The below map was classified and it provides all information on different land use/land cover that was in the study area in 2020. By observing it's clear that the buildings occupied a large area compared to any other class to means that the built-up area has been increasing compared to buildings in 2010.

figure 4. 2: Land use/cover map of Muyumbu sector in 2020

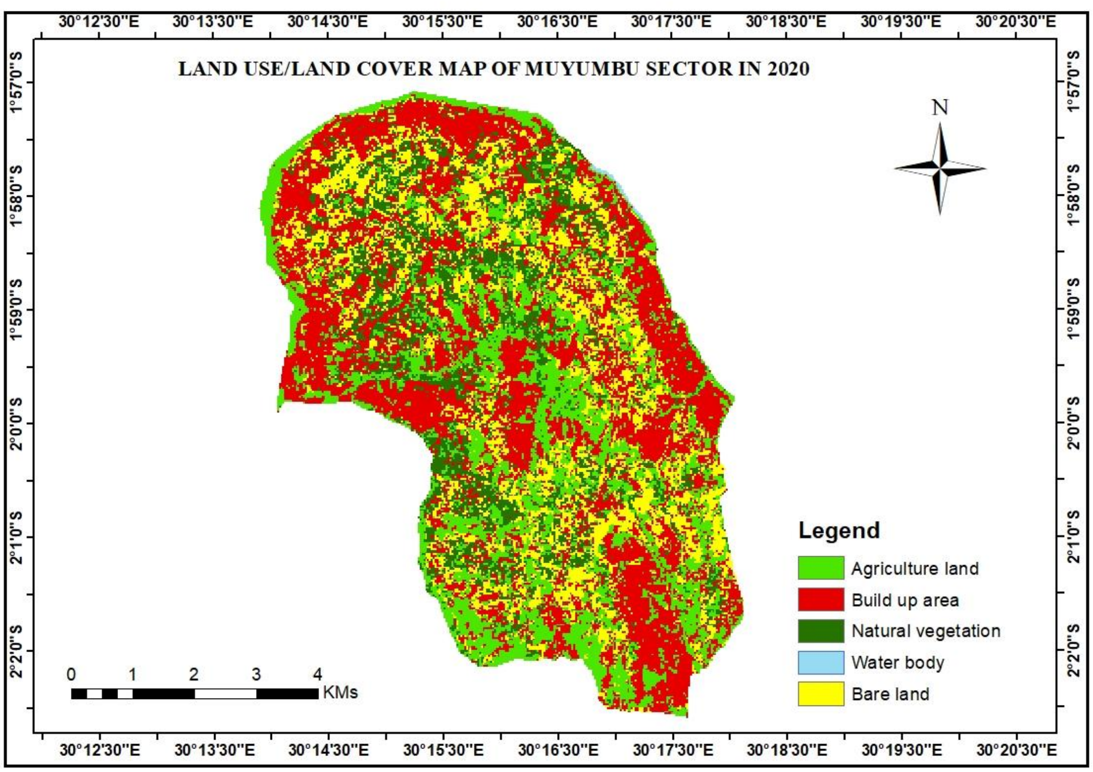


Figure 4.2 shows the land use/cover of the Muyumbu sector in 2020 and by observing the map it's visible that the building area has been increasing while the barren land and the agricultural land have been decreasing. After producing the map also an accuracy assessment was performed to check if the produced results were correct.

4.3.1 Accuracy Assessment of LULC 2020

As observed in the previous content of this study the accuracy assessment is required for the image classification to check the closeness to the true data of the obtained data, also on this land use/cover 2020 the accuracy assessment was done as follows.

Table 6: Accuracy assessment table of LULC 2020

Class name	**Agriculture**	**Bare Soil**	**Buildings**	**Natural Vegetation**	**Water Body**	**Total (User)**
Agriculture	8	1	0	0	0	9
Bare Soil	0	2	1	0	0	3
Buildings	0	2	6	0	0	8
Natural Vegetation	0	1	0	7	0	8
Water Body	0	0	0	0	2	2
Total (Producer)	8	6	7	7	2	30

Table 6 represents the number of total used points as 30 and the total number of correctly classified pixels (indicated in green color) to be 25 points according to the formula used to compute the overall accuracy it doesn't have to be less than 75%, we obtained the overall accuracy as 83.34%, and the kappa coefficient(T) to be 78.38%.

Table 7: Land use distribution in 2020

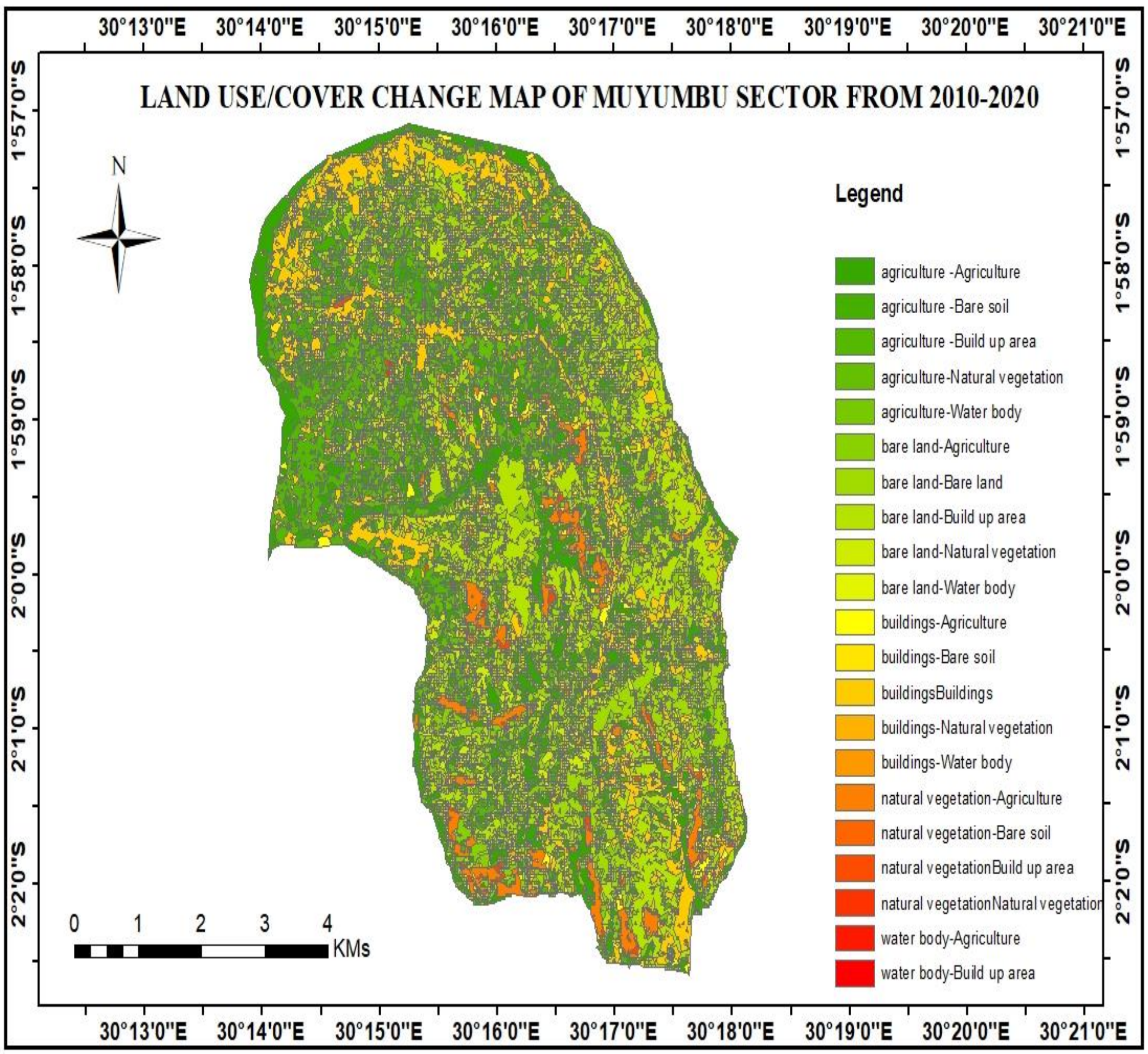
Class name	**Area(ha)**	**Percentage (%)**
Agriculture land	1239.25	24.6104943
Bare soil	1047.49	20.8022971
Build up area	1961.24	38.9486269
Natural vegetation	782.102	15.5319079
Waterbody	5.37151	0.10667381
Total	5035.45351	100

Table 7 indicates the land use occupation in 2020 and it represents that the agricultural land occupied 1239.25ha of the whole sector, the barren land occupied 1047.49ha of the whole sector, the natural vegetation occupied 782.102ha of the whole sector, the buildings occupied 1961.24ha of the whole sector, and the area covered by water was the lowest one with 5.37151ha, and the area occupied by buildings was the highest with 39.95% of the whole sector.

4.4 Land use/cover change detection of the Muyumbu sector from 2010 up to 2020

The land use land cover change detection consists of the identification of changes that appeared in 10 years from one class of land use to another. Therefore, the map below shows how changes happened in the specified locations and the table shows the rate at which the change.

figure 4. 3: Land use/cover change map of Muyumbu sector from 2010-2020



The figure above indicates the change detection of the Muyumbu sector and many have changed through different human activities like deforestation and any other human activities that affect the urbanization process. The table below shows the appearance change in area (ha) and in percentage.

Table 8: Land use/cover change detection in the Muyumbu sector from 2010-2020

Class names	Area(ha)		Area (%)		change from 2010-2020	
	2010	2020	2010	2020	Area(ha)	Area (%)
Agriculture land	1879.14	1239.25	37.31819	24.6104943	-639.89	-12.708
Bare soil	1966.54	1047.49	39.05392	20.8022971	-919.05	-18.2516
Build up area	970.194	1961.24	19.26726	38.9486269	991.05	+19.6814
Natural vegetation	219.336	782.102	4.355834	15.5319079	562.77	+11.1761
Waterbody	0.241619	5.37151	0.004798	0.10667381	5.13	+0.1019
Total	5035.45351	5035.45351	100	100	0.00	0.0000

As the results of the map showing the change detection the table above represents the change of land use/cover in terms of area(ha) and percentages (%), the agricultural land that used to occupy 1879.14ha in 2010 changed to 1239.25ha in 2020 to mean that it decreased about 12.708%, the barren land used to occupy 1966.54ha in 2010 changed to be 1047.49ha in 2020 to mean that it decreased about 18.2516%, the building area used to occupy 970.194ha in 2010 and changed to be 1961.24ha in 2020 it means that it increased about 19.6814ha, the natural vegetation that occupied 219.336ha changed to 782.102ha that means it increased about 11.1761%, and the area covered by water increased from 0.241619ha up to 5.37151ha that is 0.1019% of the increase.

Table 9: Land use conversion from 2010-2020

2020 / 2010	Agriculture land	Bare soil	Build up area	Natural vegetation	Waterbody
Agriculture land	659.57	278.781	488.65	443.02	4.73889
Bare soil	287.771	573.684	869.297	235.433	0.0961066
Build up area	121.764	180.07	568.806	98.5808	0.337494
Natural vegetation	166.692	14.5367	33.6893	4.20789	0
Waterbody	0.210027	0.00	0.0315921	0.00	0

As indicated in Table 9 the land use/cover has been changing from one class to another annually and the table above shows how the land use has been converted to others in 10 years as it is in the study after all the indicated measures are in terms of area (hectares). Therefore, the agriculture land that converted into bare soil is 278.871ha, agriculture that converted into build up area is 488.65ha, agriculture land that converted into natural vegetation is 443.02ha, agriculture land converted into water body is 4.73ha, bare soil converted into agriculture is 287.77ha, bare soil converted into build up area is 869.3ha, bare soil converted into natural vegetation is 235.433ha, bare soil converted into water body is 0.33ha, natural vegetation converted into agriculture land is 166.7ha, natural vegetation converted into bare soil is 14.53ha, natural vegetation converted into built up area is 33.68ha, water body converted into agriculture is 0.21ha and the water body converted into built up area is 0.03ha, not only the land use that has been converted to other type but also there are amount of area that didn't change to any other land use like the agriculture land of 659.57ha, bare soil of 573.68ha, build up area of 568.806ha, natural vegetation of 4.207ha all those continued having their land use. After this analysis, it's visible that the land use change with the highest value is from bare soil to a build-up area of 869.28ha.

4.5. Assessing the environmental impacts of urbanization

Assessing the environmental impacts of urbanization in the Muyumbu Sector from 2010 to 2020 reveals significant changes driven by rapid development and population growth. Urbanization in this area has led to a transformation of land use patterns, primarily shifting from agricultural to residential and commercial uses. This change has resulted in the loss of arable land, which is critical for local food production and biodiversity. Remote sensing technologies, such as satellite imagery, have been instrumental in monitoring these land use changes, allowing for the analysis of spatial dynamics and the extent of urban sprawl.

The environmental consequences of this urban expansion include alterations in local ecosystems, increased surface runoff due to reduced vegetation cover, and heightened vulnerability to soil erosion. As natural habitats are converted into built environments, a corresponding decline in flora and fauna diversity impacts ecological balance. Urbanization often leads to increased pollution levels in both air and water due to higher vehicle emissions and runoff from impervious surfaces, which can contaminate local water bodies.

Moreover, urban heat island effects become more pronounced as green spaces diminish, leading to higher temperatures in urban areas compared to surrounding rural regions. This phenomenon exacerbates energy demands for cooling and can adversely affect public health, particularly among vulnerable populations. The integration of GIS and remote sensing data not only aids in quantifying these environmental impacts but also supports the development of sustainable urban planning strategies that aim to mitigate negative outcomes while accommodating growth.

CHAPTER FIVE: CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusion

Based on the results of this research, our objectives have been achieved. However, the following conclusion: Through the analysis of satellite imagery, the study observed a marked expansion of built-up areas, alongside a corresponding decline in agricultural and vegetated lands. This urban sprawl is indicative of population growth, infrastructure development, and socioeconomic changes, which align with broader national policies aimed at enhancing urbanization in Rwanda. GIS tools were instrumental in mapping these changes spatially and temporally, while Remote Sensing allowed for a detailed comparison of the land cover between the two time periods. The findings highlight the need for sustainable urban planning to balance development with environmental conservation, ensuring that future urbanization in Muyumbu supports both economic growth and ecological integrity.

The change in land use and land cover due to urban sprawl in the Muyumbu sector between the years 2010 and 2020 have changing where land use changed because of development due to Rwanda Vision 2020-2050. The study was conducted to provide the assessment of the urbanization trend in the Muyumbu sector in 10 years, this sector is located in the eastern province of Rwanda in the Rwamagana district, as it is one of the areas that is being more developed due to the urbanization growth where agriculture areas are decreasing while settlement areas are increasing and this may affect the development of the country because agriculture acts like a great pillar in the country's economy. The results of this study show that agricultural land is the one decreased highly by about 12.708% this is a reduction of 639.89ha which converted into other land uses while the area covered by buildings increased by 19.6814% and is about 991.05ha of increase.

Observing these changes that happened within 10 years it's predictable that if nothing is done to change the urbanization growth rate the whole area will be covered by settlements and this leads to the reduction of agricultural area which contributes to the living of the population of this area and the country in general. In conclusion, urbanization is very necessary for the development and growth of a person though can cause a lot devastation of in the world, it offers a lot of positive effects on the social and financial aspects of a person. It is important the for government to find out ways that can help in solving the negative effects so that it becomes a Win-Win situation for both the country and the people. The assessment of environmental impacts due to urbanization in the Muyumbu Sector highlights the urgent need for balanced development approaches that prioritize ecological integrity alongside economic progress. By leveraging advanced technologies like GIS and remote sensing, stakeholders can better understand these dynamics and implement measures that promote sustainable urbanization practices for the future.

5.2. Recommendations

For this research project, the following recommendations should be taken into consideration to contribute to the sustainable development of the research sector.

- **Muyumbu Sector**

It is essential to integrate GIS and Remote Sensing technologies into routine urban planning processes. Local authorities should regularly update and analyze land use and land cover data to monitor urban expansion and assess its environmental and social impacts. The sector should also establish guidelines for sustainable urbanization, focusing on preserving green spaces and optimizing land use for infrastructure and housing.

- **Rwamagana District**

The district should collaborate with local universities and technical experts to build capacity in the use of GIS and Remote Sensing for urban management. By creating an open-access database of satellite imagery and spatial data, Rwamagana can enhance transparency and community involvement in urban planning, ensuring that future developments align with local needs and environmental conservation goals.

- **Rwanda Housing Authority (RHA)**

The RHA should utilize GIS and Remote Sensing to identify areas suitable for housing development, considering factors such as infrastructure, population density, and environmental sustainability. Leveraging these technologies, the authority can ensure that future housing projects in Muyumbu and other sectors are in line with national housing standards, address housing shortages, and contribute to orderly urbanization while protecting natural resources.

- **Government of Rwanda**

The government should promote the nationwide adoption of GIS and Remote Sensing technologies for urban planning, integrating them into the national land use management system. Policies should focus on enhancing data-sharing platforms between districts to improve decision-making processes and ensure that urbanization is managed efficiently across the country.

5.3 Suggestions for further study

To evaluate the urbanization trend in Rwamagana District's Muyumbu Sector from 2010 to 2020 using GIS and remote sensing, it is crucial to integrate spatial data analysis with satellite imagery to identify land-use changes over time. Start by collecting high-resolution satellite images for the years 2010 and 2020, focusing on key indicators such as the expansion of built-up areas, vegetation cover, and infrastructure development. Utilize GIS tools to overlay these images, enabling you to visualize the transformation in land patterns. Remote sensing techniques, such as the Normalized Difference Vegetation Index (NDVI) or built-up area indices, can provide quantitative assessments of urban sprawl and the conversion of rural or natural landscapes into urban settings. Combine this geospatial analysis with census data, population density, and land policies to understand how demographic growth has influenced urbanization. By integrating spatial statistics and qualitative data, this study will offer a comprehensive evaluation of urbanization trends, helping policymakers make informed decisions about sustainable land use planning and urban management in the region.

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