

The Role of Geographic Information System Technologies in Mapping Land Use Planning And Management in Rwanda, Case of Ntarama Sector in Bugesera District

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Abstract:- This research focused on the Role of GIS Technologies in Mapping Land Use Planning and Management in Ntarama Sector, presents the applications of Geo-informatics System in three different land-use planning (LUP) approaches. The main objective of this research was assessing the role GIS technologies can play in mapping land use planning and management in Ntarama sector of Bugesera District. The methods used here was reposed to the analysis of previous researchers, reports provided by different stakeholders; my own field observation and conducted interviews. Besides, GIS technologies have been used for geo processing and spatial analysis. All have been aiming to collect two types of data; qualitative and quantitative such as primary and secondary data, with the purpose of gathering all information concerning the research topic. Stratified sampling technique has been used by conducting interviews to good information providers. Around 68% of the whole respondent appreciates GIS technologies as the best tool in land management. The participatory land use planning (PLUP), which strongly considers local people perceptions for land utilizations, the guidelines for LUP enhanced with multi-criteria evaluation and land-use planning and analysis system (LUPAS) using interactive multiple-goal linear programming. In this research, there are three main objectives: First, to provide an introduction to geographical information technology along with an historical perspective on the evolving role of GIS in planning, secondary is to overview relevant methods and techniques for GIS-based land-use suitability mapping and modeling, and last one is to identify the trends, challenges and prospects of GIS-based land-use suitability analysis. Briefly, we strongly confirm that GIS plays an important role in the successful of these LUP approaches. Land use suitability assessment using GIS technologies should be a key determinant in any urban and suburban planning and decision-making process.

Keywords:- *Geographic Information System, Mapping, Land Use Planning and Land Management, Rwanda.*

I. INTRODUCTION

This paper explains in deep provides a brief overview on key concepts of the research topic including the role of Geographic Information System technologies in mapping land use planning and management in Rwanda. It clarifies also, the problem statement, the research objectives, the hypotheses and research questions, significance of the study and also the scope of the study. It presents the overview of the whole work.

According to, Malczewski (2004), for a sustainable land use plan, nowadays, land use planning (LUP) approach requires more and more data integration, multi-disciplinary and complex analysis, and need faster or more precise information for the participants in the LUP approaches. Surely, Geographic Information System (GIS), which is strong capacity in data integration and analysis and visualization, become the main tool to support LUP approaches. Between the end of this century and the middle of the next, the human population will double to 12 billion. This means that we will increasingly have to squeeze our little planet for more food, water and fuel. As a result, managing earth's limited natural resources has emerged as perhaps the most crucial problem now faced by humanity. Fortunately, technologies are now becoming widely available that may allow us to feed and power the growing population without destroying the very environment that sustains us in the process. With this technology we are starting to measure virtually everything on earth and how these things move and change over time. Fed into spatial databases called Geographical Information Systems (GIS), these measurements help us understand what's happening all around us and how to improve it (Lang L. 1998).

All over the world, many land related problems have been occurring many years ago, but GIS is helping for the management of the land resources in many countries. In Africa, many disputes and conflicts arise over land because it is the source and basis for the livelihood of the population on the continent. The problems of the resource related to its mismanagement include infertility, erosion, soil quality loss and other many environmental related problems. Other problems related to the ownership of the land include social

conflicts, boundary disputes and another crucial problem arising through the increase of the population which is land scarcity, same case for Rwanda (ESRI, 2004).

According to Willem et al 2009, Land is of enormous value in Rwanda, and will only become more valuable when population increases. It is therefore important to develop a land-use master plan, and think of new ways to earn money (Willem Tims, June, 2009) GIS is an efficient and cost-effective tool for sustainable land management which is the fundamental basis for sustainable development of all sectors in the country. In Rwanda, one of the most densely populated countries in Africa, the majority of households depend on land and agriculture for their livelihoods. Low agricultural productivity has long been a challenge in Rwanda due to land scarcity and agricultural intensification strategies that exhausted the country's natural resources. Following the Rwandan Genocide and the cessation of conflict, the Government of Rwanda established a vision for the country's development based, in part, on the registration of land rights and the transformation of agricultural practices through the Crop Intensification Program (CIP), Land Use Consolidation (LUC), and restrictions on land subdivision through Article 30 of the 2013 Land Law by applying GIS technologies in practices (Michael B. and Ailey K.H, 2017).

Most of environmental and natural resource management problems including disasters are mostly due to the lack of appropriate information on land. This research will assess the impacts of GIS in the management of land in Ntarama sector, Bugesera district, Eastern province of Rwanda, where the problems such as desertification, famine, soil erosion, loss of soil fertility and problems of watershed management were found. But the crucial problem in the area arising is of lacking correct and appropriate information over land parcels which arise many boundary disputes and parcel based conflicts(MININFRA/Rwanda, 2004).

So, there is a need for using GIS in decision making for sustainable land management. There is a fundamental strategy that underlies all analysis of geo-referenced data. An understanding of this strategy will not only lead to better use of the available methods, but it also needs to understand how different levels of data abstraction are related (Daugherty K., 2006). The main objective of this research was to assess the role that GIS technologies can play in mapping the land use planning and management in Ntarama sector. The paper was guided the following specific objectives:

- To demonstrate with GIS the current land use situation in Ntarama sector of Rwanda
- To determine mechanisms adopted (suitability analysis)for land use changein Ntarama sector of Rwanda
- To propose alternative solutions to the challenges face in land management focusing on the intervention of GIS for effective and sustainable land management

II. LITERATURE REVIEW

This paper is a comprehensive summary of previous research on a topic, and it includes the current knowledge including substantive findings, as well as theoretical and methodological contributions to the particular topic. It provides a brief overview on key concepts of the research topic including not limited to GIS and Land management with their relatives. This part reveals the concepts of GIS as an efficient and cost-effective tool for handling land related problems and planning programs for sustainable development, and land resource in the context of Rwanda. It emphasizes on: GIS technologies and applications, land management with its relatives, in order to achieve sustainable land management through application of GIS.

2.1 Theoretical and empirical literature review

Land as an indispensable basis of livelihood, implies how big it can be the main source of various disputes and conflicts which embarrass sustainable development achievement. On other hand, GIS as a result of scientific research has been an effective tool for handling different crucial problems in planning for development. So if used in land management and planning, it will produce an effective planning and then sustainable land management. So, sustainable development will no longer be a dream as land resource is the pillar of all development initiatives (Osundwa, October 2011).

According to Willem Tims (2009), Rwanda is a small land-locked country, it is the country with the highest population density in Africa. Around 80% of the people earn their livelihood with agriculture or other land related activities. Land is therefore of enormous value. During a devastating genocide, that tookplace in 1994, approximately one million people lost their lives. Apart from the human tragedy, great damage was also caused to both physical and social infrastructure of the country (Viking, 2007).

The government of Rwanda has set some goals within their Rwanda Vision 2020(MFEP, 2000) to improve the country's current situation. According to the Rwanda Vision 2020, the Rwandan government wants to transform the country into a middle income country by the year of 2020. An important step to accomplish this is the development of the Rwanda Land Use and Development Master Plan. The master plan aims at developing sustainable land management, which should lead to a decrease of poverty. The Food and Agricultural Organization(FAO, 2003)underlines that sustainable land management is of key importance to develop a country.

They indicate that “an integrated physical and land-use planning and management is an eminently practical way to move towards more effective and efficient use of the land and its natural resources. That integration should take place at two levels, considering on the one hand all environmental, social and economic factors and on the other all environmental and resources components together (MINAGRI, December 2008)”.

For a sustainable land use plan, nowadays, land use planning (LUP) approach requires more and more data integration, multi-disciplinary and complex analysis, and need faster or more precise information for the participants in the LUP approaches. Certainly, Geographic Information System (GIS), which is strong capacity in data integration and analysis and visualization, become the main tool to support LUP approaches (Kalf, 2006:Ed).

It is a complex decision making process to prepare a perfect land-use planning, however, the invention of modern GIS technologies has eased such complex jobs in different ways. One, GIS allows to work with large number of datasets, for another way, a number of methods, techniques or models could be embedded with GIS for land-use suitability analysis. A wide number of social, economic, physical and environmental indicators are considered for better urban landuse planning. Geographical data in a GIS environment supports to use those indicators in more sophisticated way in the decision making process of urban land-use planning (Kazi Ullah, 2014).

Land Suitability Analysis (LSA) is a GIS-based process applied to determine the suitability of a specific area for considered use; it reveals the suitability of an area regarding its intrinsic characteristics (suitable or unsuitable). Site selection or suitability analysis is a type of analysis used in GIS to determine the best place or site for something (Heywood, I., Cornelius, S., and Cotrell, E., 2011).

2.2. Conceptual literature review

According to Esri (2012), a geographic information system (GIS) is defined as a system designed to capture, store, manipulate, analyze, manage, and present all types of geographical data. It can be used as tool in both problem solving and decision making processes, as well as for visualization of data in a spatial environment.

Basing to the definition of ESRI (2012), GIS is computer software that link geographic information with descriptive information. It is a system of computer hardware, software, and procedures designed to support the capture, management, manipulation, analysis, modeling, and display of spatially referenced data for solving complex planning and management problems. It is a computer-based tool for mapping and analyzing things that exist and events that happen on Earth. According to ESRI (2004), A working GIS integrates five key components including hardware, software, data, people, and methods. **Hardware:** is the computer on which a GIS operates. Today, GIS software runs on a wide range of hardware types, from centralized computer servers to desktop computers used in stand-alone or networked configurations. It is a Computer system (hardware + operating system). **Software:** GIS software provides the functions and tools needed to store, analyze, and display geographic information.



Figure 1:- Tools and materials in land surveying

III. RESEARCH METHODOLOGY

3.1 Research Design and Population

Previous researches conducted about GIS and land management, and research findings generated during field activities including interviews and field observation, this research has been developed. There is also some research from geoprocessing activities from GIS technologies.

Geographically, the case study of this research is Ntarama sector, one of the sectors of Bugesera district located Eastern province of Rwanda. This country, officially named the Republic of Rwanda is a country in Central/Eastern Africa, and is bordered by the Democratic Republic of the Congo to the west, Uganda to the north, Tanzania to the east, and Burundi to the south. It lies a few degrees south of the equator and is landlocked (GoR, 2015)

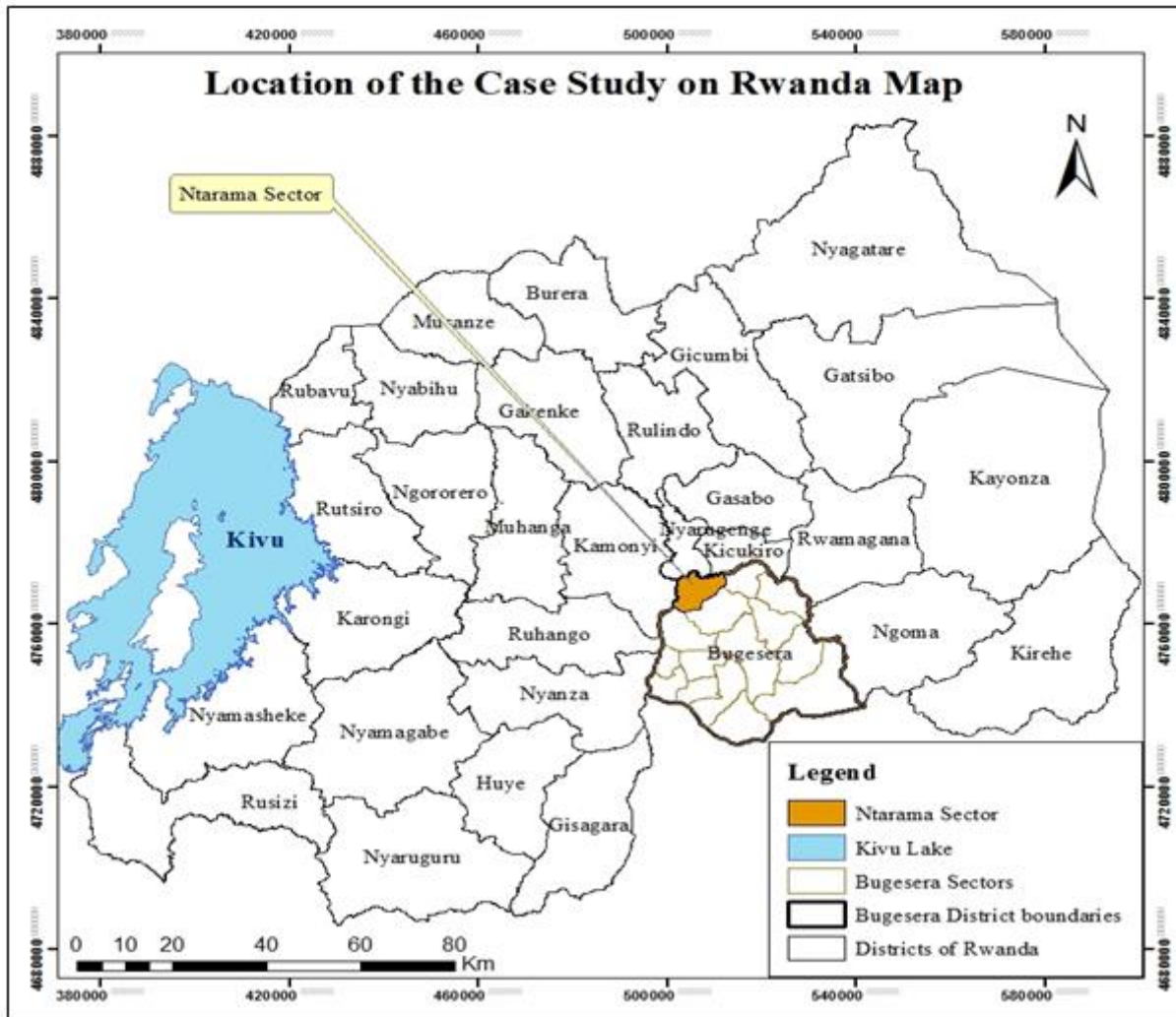


Figure 2:- Location of the Study Area at the country level

3.2 Sample Design

Sample is defined as a set of individuals selected from a population, usually intended to represent the population in a research study (Gravetter and Wallnau, 2017). Ntarama sector is located in Bugesera District; one of the Districts composing Eastern province. The sector borders with Nyarugenge and Kicukiro Districts, two districts of Kigali city, in the North, Musenyi and Nyamata sectors of Bugesera district in the South, Mwogo sector in the East and Kamonyi district of Southern province in the West of Ntarama sector. Ntarama sector currently lies in three cells namely Kibungo, Kanzenze and Cyugaro. A population is the complete set of individuals, objects, or measurements having some common observable characteristics (Mbaaga, 1990). The populations that were intended to be questioned are from various areas; there are those from the local

authorities in charge of the environment, local population, health and educational centers. Ntarama sector has 20,928 populations living in 3 cells (District, 2018).

The topography of Bugesera where Ntarama sector is located is characterized with a mixture of plateau with an altitude varying between 1,100m and 1,780m and undulating hills dominated by varying heights. The region is predominantly vegetated by dry savannas which are characterized by short grasses, shrubs and short trees, a characteristic of arid and semi-arid areas. Ntarama sector is one of 15 sectors of Bugesera District. Bugesera District has 1,288 km² of area and the total population of 361,914 with estimated Density of 280/km², whereas Ntarama sector has 63 square kilometers and 6,872 Population (MINITERE/CERECE 2003)

Basing to limited time and resources, the study does not cover the entire population equals to 15000 populations; the sampling technique must be used. So, the model of Alain Bouchard (2002) will be used. On the basis of the formula stipulating that when the universe of the population is lower than 100,000 individuals, we came up with a sample of 68 individuals as a constant number of Alain Bouchard, and our case coincides with the following formula:

$$nc = \frac{N \times n}{N + n}$$

N: Size of the statistical universe
 n: Sample size for the statistical universe
 nc: Corrected sample size

Thus, we will have,
 N = size of the statistical universe which corresponds to the total population located in Ntarama sector
 n = sample size for the infinite statistical universe 68 as given by Alain Bouchard (2002)
 nc = sample size corrected for an infinite statistical universe

At this time, $nc = \frac{N \times n}{N + n}$

$$nc = \frac{20,928 \times 68}{20,928 + 68} = 67.7 = 68 \text{ Populations}$$

By applying the formula to our population of 20,928 populations living in Ntarama sector as found in the report of Bugesera district, we obtain a sample of 68 populations to be questioned. With this, each interviewee will be selected randomly in all cells of Ntarama sector.

3.3 Data Collection and Analysis

After setting the sample to be surveyed as referred by Miaouis and Michener (1976), it is important to choose technique to be used during data collection. The most effective for this research is “stratified sampling technique” which will be applied by using interview.

(FGDs) is a qualitative data collection method that engages 6 to 12 people with shared characteristics pertinent to the specific discussion topic and is led by a trained facilitator. They are normally based around a short list of guiding questions, designed to probe for in-depth information. Discussions typically last between one and two hours.

Global Positioning System (GPS) is part of satellites orbiting round the universe. It sends the details of their position in space back to earth. It has many applications in diverse areas. It is available to any user with a GPS receiver (Francis Olawale Abulude, Abulude, 2015). It is a satellite-based radio navigation system developed and operated by the U.S. Department of Defense. It can be used free of charge by anyone and it provides accurate position, velocity, and time (PVT) information to an unlimited number of suitably equipped space users (TomTom, Abulude, 2015).

For the usage of GPS, the first step will be to set it, so that the data to be captured will fall in their exact places/locations on the ortho photo. The following are considered as example of unit settings of GPS:

Projected Coordinate System: Universal Transverse Mercator (UTM)
 False_Easting : 500000
 False_Northing : 5000000
 Central_Meridian : 30
 Scale_Factor : 0.9999
 Latitude_Of_Origin : 0.0
 Linear Unit : Meter
 By default, the datum is WGS_1984

Normally, dissertation writing involves the handling of statistical data. Procedure of data collection is the technique used to obtain the information used in a dissertation to substantiate the claims made by a writer. Here we have, the use of surveys which is mainly effective for those who need qualitative data like this dissertation. Open-ended questions are used in this research in order to get the perception people on land use, attitudes towards government policy about land management, the knowledge people have about GIS application to land management, and those information have been analyzed to obtain the conclusions needed.

IV. FINDINGS AND DISCUSSION

The aim was to explore visible (physical) and abstract (social and cultural) factors playing role in land management in the sector; assess the role of GIS in the management of land management in Ntarama sector and illustrating the land patterns. In order to analyze whether GIS is known and applied in the management of land. If not, discuss according to considered factors, how GIS can be applied to improve land management and hence sustainable development.

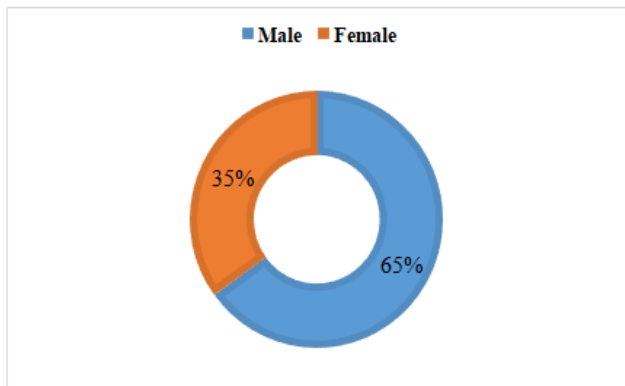
Forwarding analysis of the result acquired from both local community and local authorities on current land management in Ntarama sector. Then, it emphasizes on the interpretation, analysis and discussion of the reliable results to strengthen the research conducted.

4.1. Interpretation and discussion of the results

The research was conducted in Ntarama, one of 15 sectors composing Bugesera district, located in Eastern Province, including Nyamata, Musenyi, Ntarama, Mwogo, Mayange, Juru, Rilima, Gashora, Ruhuha, Mareba, Ngeruka, Kamabuye, Nyarugenge, Rweru and Shyara. The process of land registration which is crucial in land management was already completed but the activities of giving final official documents for land ownership was still going ahead. The following sections interpret the results from the field survey according to the question asked in the questionnaire reports from the archive.

My research findings and participation in several activities are not dominated by one sex. During my research, 65% were male, while 35% were female.

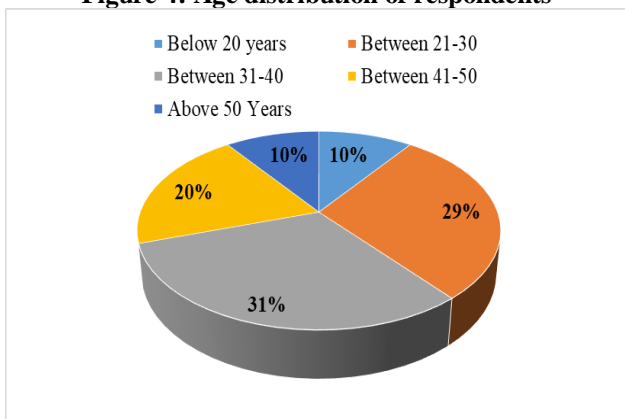
Figure 3: Gender distribution of respondents



Source: Field survey (2019)

During the field data collection, each category of people has been represented. This classification of age helped me to find how local people involvement are behaving about activities of land use management, both youth and elders people were represented and they are classified them in the following categories: below twenty years (13%), between 21-30(22%), between 31-40(27%), between 41-50(28%) and the rest 13% is the group of people above 50 years old.

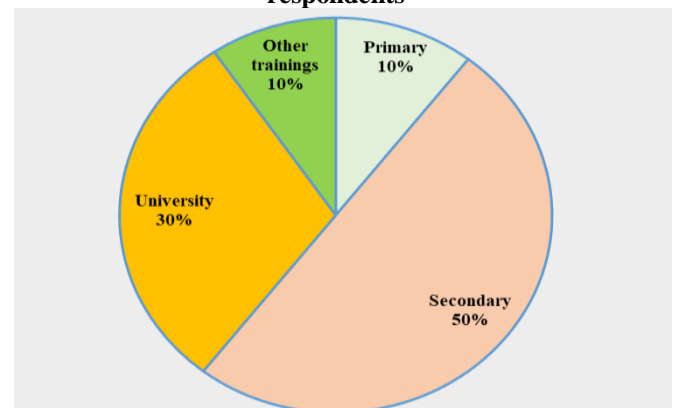
Figure 4: Age distribution of respondents



Source: Field survey (2019)

The activities of land use management are more interesting for people of different levels of education. According to my research, 10.5% have primary level, 50% of my respondents have secondary level, 30% have university level and 9.5% have other trainings .This variation of all level of education is more helpful in the understanding of activities, policy and target of Ministry of Agriculture and Animal resources through its Rwanda Agriculture Board in charge.

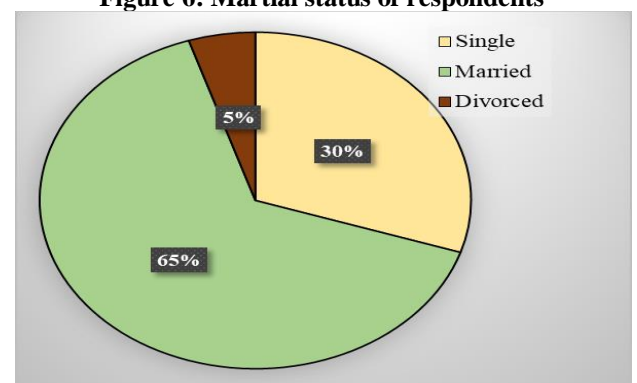
Figure 5: Variation of Levels of Education of the respondents



Source: Field survey (2019)

Marital status is one of the factors highly influencing the change in responsibilities of someone, which also influences the way of perceiving things according to the importance and reason. The following is the figure presenting marital status of the respondents during my research where 65% are married and 30% are single and other 5% are divorced.

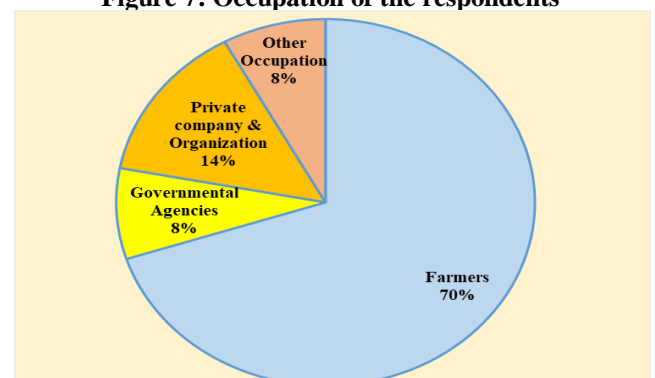
Figure 6: Marital status of respondents



Source: Field survey (2019)

About occupation of the respondents, I found that 70% were farmers, 8% were working in governmental agencies, 14% work in other organization and companies and 8% have other occupation (fig 11).

Figure 7: Occupation of the respondents



In the sector, there are many ways of acquiring land parcels and they are of four types: inheritance, purchasing, gift and lease as illustrated by the figure below. Purchasing is the extended way through which the local community in Ntarama’ cells obtain and own land parcels. The reason is that almost all cells are dwelt by people coming from elsewhere, who are not natives and the demography is very dynamic because the sector is pretending mostly to become an urban area formed by planned settlement.

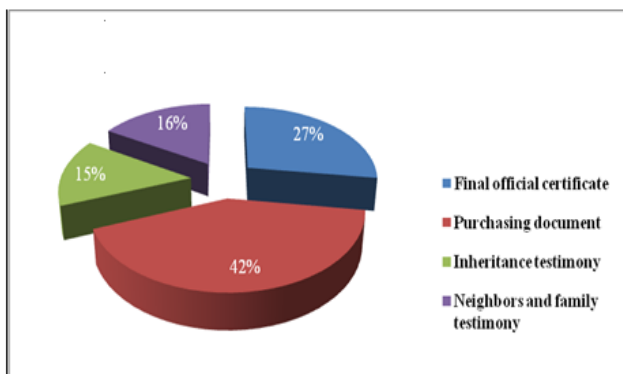
Figure 8: Ways of acquiring land in Ntarama sector by number of respondents



Source: Field survey (2019)

The relationship over land in Ntarama sector has been characterized by a big number of owners with purchasing documents as trustful proofs without official final land ownership certificate, because the activity of providing the final official certificate for land ownership was not yet completed in the sector. It is mentioned in the following figure:

Figure 9: Proof of land ownership



Source: Field survey, November, 2019

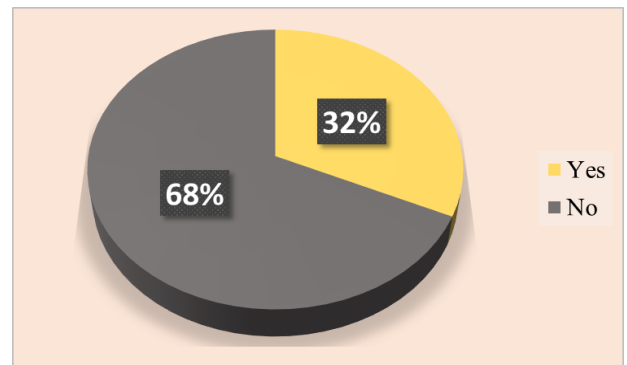
As shown in this figure, some people still have ideas that their family members and neighbors may testify for their land ownership. Meaning that there is a need to sensitize local people to know the best way of handling land related issues by GIS technologies’ intervention.

4.2.4. GIS tools and appreciation in Ntarama sector

During field survey for the research, it has been evident that most of the population did not hear about Geographical Information System (GIS) except some of the local leaders and a few number of people whom we realized that they heard a bit or enough about GIS. Even though we

realized that most of the population is not aware of GIS, they told that they are aware of some techniques in land management and some of them are of GIS purposes. This has been indicated by saying that while land registration, some were able to check ortho-photo image themselves while others appreciated a lot the role that the image may and will play in effectively managing land and its related disputes.

Figure 10: Appreciation of GIS technologies in Ntarama sector



Source: Field survey, November, 2019

GIS is a recently adopted technological tool in Rwanda in resolving conflicts. This research aimed at analyzing the role of GIS application in land management in Ntarama sector. At the field research we had to explore the current situation of land management; the contribution of GIS, if any, and by the end discuss the role that GIS can play if adopted, according to the skills acquired in GIS course and the literature survey conducted by the group while the research as it is discussed below.

Land is a basic and fundamental resource for all activities that everyone wishes to possess. The following section discusses each aspect of the land management in the sector with description of its current situation. The aspects are land use, land tenure and disputes over land and land management plan by local authorities.

Ntarama is characterized by various land uses including residential, commercial, public infrastructure, agriculture and breeding (small part). The dominant land use is residential. The most populated cell is Kanzenze, the one with large agriculture than others is Cyugaro cell whose characteristics are more rural than urban.

The sector has an urban characteristic due to the fact that most of the dwellers are immigrants than local natives, because of different opportunities provided by the area as described in the results previously. Most of the land is owned through purchasing while others are owned through inheritance by the parents to the children. In the sector, most of disputes are dominantly boundary-based. In the local natives, the disputes are frequently arising among family relatives.

Land management plan is established at the district level and is brought down to be implemented by local community without their intervention in decision making. Allocating the activities to land is according to the district consideration and will. For residential areas, building a house or any other house improvement require a license signed at the district level. In agriculture, land consolidation is practiced where by now.

Most of the land is scarce and infertile. This is indicated by the shortage of crop yield in quality and quantity as the time goes on. One among the problems is that crop yield is not proportional with the population

growth because the population grows faster than the ability of the environment to support them(NISR, 2018). For the improvement of crop yield, population is recommended to use manure fertilizers that why the government established one cow per family program and manure from bins and landfills. This land management (consolidation) is not effective and not even sustainable because most of the population refuse to implement it saying that their land is not suitable to the proposed activity and there is also an influence of customs and traditions where some people refuse for example to remove the forest for a proposed activity because it is the ancestors inheritance and cannot be changed by anyone.

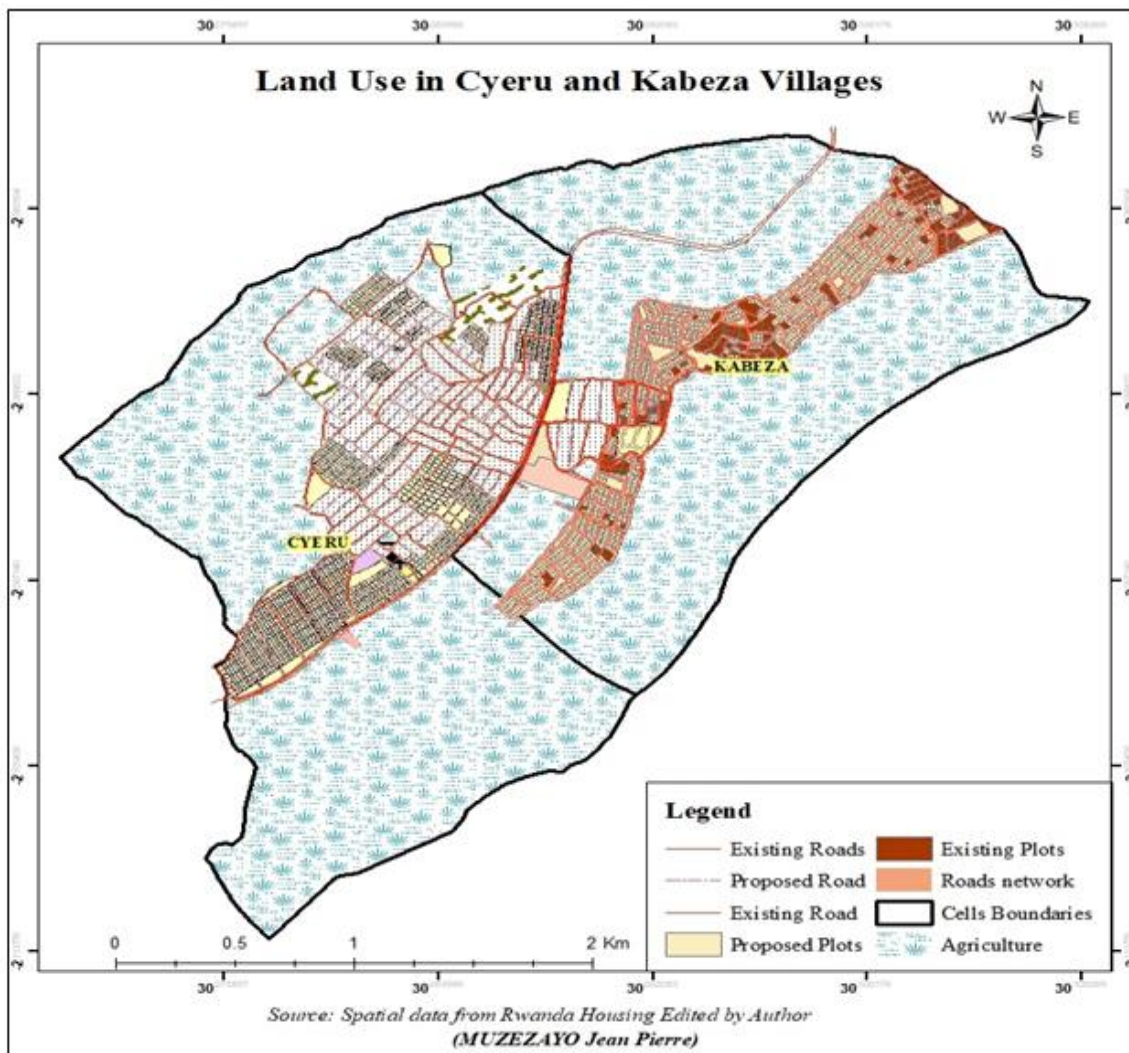


Figure 11: Current and proposed land use for Cyeru and Kabeza Villages

According to RNRA (2017)¹, zoning is defined as a tool used by planners and planning authorities to prescribe the acceptable use and form of development of and on an area of land. Zoning defines the use category of the land, prescribing allowable and non-allowable activities and developments on a parcel of land within a zone by applying GIS technologies. The zones are defined in the Master Plan

and determine the types of development that will be detailed at plot level in a Local Plan. Moreover, Rezoning is also possible in land use planning which is the process of the changing the approved use of land or the development requirements on land, as set out in the Master Plan and the Detailed Physical Plans.

When applying zoning regulations to a development application, the following factors should be considered:

- Population Density
- Site and physical attributes of the land involved.
- Existing uses and zoning of neighboring property.
- Traffic and transportation.
- Risk and suitability analysis on the land for the permitted use.
- Character of the neighborhood of the community.
- Effect of the permitted use on the land in the surrounding area.
- Any potential decrease in property values.
- Any economic and cost benefit analysis.
- Existing sectoral guidelines on the current land use

Land subdivision is the process of dividing land into two or more parcels in order to obtain a higher density of use. GIS intervenes more to make in use those process with the following guidelines:

- Land subdivision and consolidation should follow the implementation of a proposed land use in a particular area by the master plan prepared using GIS technologies.
- Land subdivision shall respect the allowed plot size according to the land use zoning guidelines, standards for land use categories and/or specific local zoning regulations. In residential zones, the plot size should be subjected to the acceptable area for obtaining a building permit.
- For each land use type, minimum and maximum land/plot sizes should be prescribed and well designed using GIS applications.
- Responsible institutions, at national and local government levels, should introduce economic incentives to promote land consolidation and disincentives to deter land fragmentation and land speculation.
- Create awareness within the communities on the importance of land consolidation. For example, providing awareness on the need to ownership of land in the form of shares instead of sub-dividing the parcel into unproductive/uneconomic sizes.

Buffer areas are legitimate planning tools. They are used to separate land uses to ensure long-term protection of both areas impacted upon and areas used for the conflict generating activity. Examples of such activities include industries, sewage treatment works, abattoirs, tanneries, composting plants and rendering works; and intensive animal and plant production facilities (such as feedlots, piggeries and poultry sheds). The principle of separating conflicting uses is also applied to the protection of natural resource areas (such as nature conservation reserves, streams, water supply storage areas and forest reserves)².

Results from the field survey made clear that actually, Ntarama is implementing the land management plan from the district level basing to the master plan provided. The local community participation in land management plan is low which is remarkable in implementation because the

population doesn't appreciate the way the plan have been made without their participation and most of the time plans are not good for them. To make the plan sustainable, it requires the involvement of all population in order to get true information to help making the plan and also to have the help from the population in safeguarding and maintaining the plan in place.

The following figure illustrates different kinds of participation that take place in Ntarama sector. The involvement of the population is judged by looking on different social criteria such as the economic level (level of wealth) for the social influence, education level and other social factors that determine the level of participation from information gathering and disseminating to monitoring and evaluating.

The major challenges in land management has been observed to be categorized in two categories: the first for local authority, the second for local community. Local authority faces major challenges in land management most related to lack of accuracy and assuredness over spatial distribution and information about the land situation. Other is lack of sufficient skills and knowledge for some authorities on good land management.

For local people, the challenges for good land management are many and various and include: Poverty , Land scarcity, Lack of correct and appropriate land related information for the planners, Mindset of not willing to prefer the new plans from the government ,Low level of awareness on good land management, land disputes among relatives and neighbors, high tax for land parcel and which is unequal among the population, low involvement in decision making, being told what to implement without negotiation.

According to the results from field survey, it has been obvious that GIS has not been used before, in land management of the sector except some of its techniques and tools that had been used while land registration. So the next section is going to discuss how GIS may contribute to the land management in Ntarama sector to make it effective and sustainable.

In Ntarama sector, there is a growing need for spatial data and spatial analysis. This is why GIS is needed and it is very useful to handle land management problems. GIS is a technological tool that helps in decision making by indicating problems and showing better way for the solution. For effective decision making and sustainable land management and development, GIS contributes in planning for the future. The allocation takes into account economic aspects (existing ones and propose good allocation for new ones), socio-economic activities and environmental factors for the sustainability. The factors to assess include: physical factors and socio-economic factors (both existing and know what new may be adopted).

Table 1: Factors and parameters of suitability analysis

FACTORS	PARAMETERS
PHYSICAL	Slope
SOCIAL	Health facilities
	Roads connection
	Schools
ENVIRONMENT	wetlands
	Forests
	Rivers

Note that Land suitability analysis can be performed in a GIS through the use of a number of Multiple Criteria Evaluation (MCE) (BIZIMANA, 2011). Based on the same source, MCE is defined as: weighting of independent criteria in terms of judged relative importance or judged relative value. The MCE techniques include for example: Boolean overlay, Arithmetic overlay, weighted overlay.

Finally, this result into the creation of final land suitability map. This map is the one on which all decisions about land management should be based; because it illustrates all areas and their capability to support development activities, from the restricted areas to all development activities, to the areas suitable for development activities.

For the future planning, Ntarama sector is growing both in population size, spatially, and economically. It is the attractive area due to its geographical location and services influenced by district policy. According to the authorities, the future of Ntarama sector should be easily adopting residential area as an extension of Nyamata town where Bugesera headquarters is located. Normally, basic

infrastructures are dominant available than other sectors. This comes in fact that the sector is the close hinterland of the buffer zone of the area planned and implemented for international airport and it is actively connected to road networks which facilitate the transportation of both goods and services.

With different company, studies to prepare subdivision and layout plan have been prepared. In Ntarama sector, there are Kayenzi site located in a small part of Cyugaro cell studied by L.S.E.C. Ltd (Land Surveying and Engineering Company Limited), Site Kabaha covering some villages of Kanzenze cell. Therefore, in BUGESERA district, physical plan is a critical component of Land use management success. Holding this physical plan requires an integrated effort by mobilizing the citizen with policymakers' aid for its implementation success.

In NTARAMA Sector, like many other Sectors remain in district there is a confusion of settlements, and land mismanagement from an increase of human made in urbanization. The confusion of settlement make dangerous hazards with a disturbances act quickly and with great effect to the demography like, the exposures to injury and house destroyed by the windstorms in different sectors.

As definition, suitability analysis is a GIS-based process used to determine the appropriateness of a given area (land resource) for a specific use, i.e. agriculture, forestry, business, urban development, livelihood projects, etc. Beside, site selection is known as a process to evaluate the best location for a specific land use or activity. GIS is more important in the analysis of social, economic, environmental and phy.

Figure 12: Identification of current land use cover

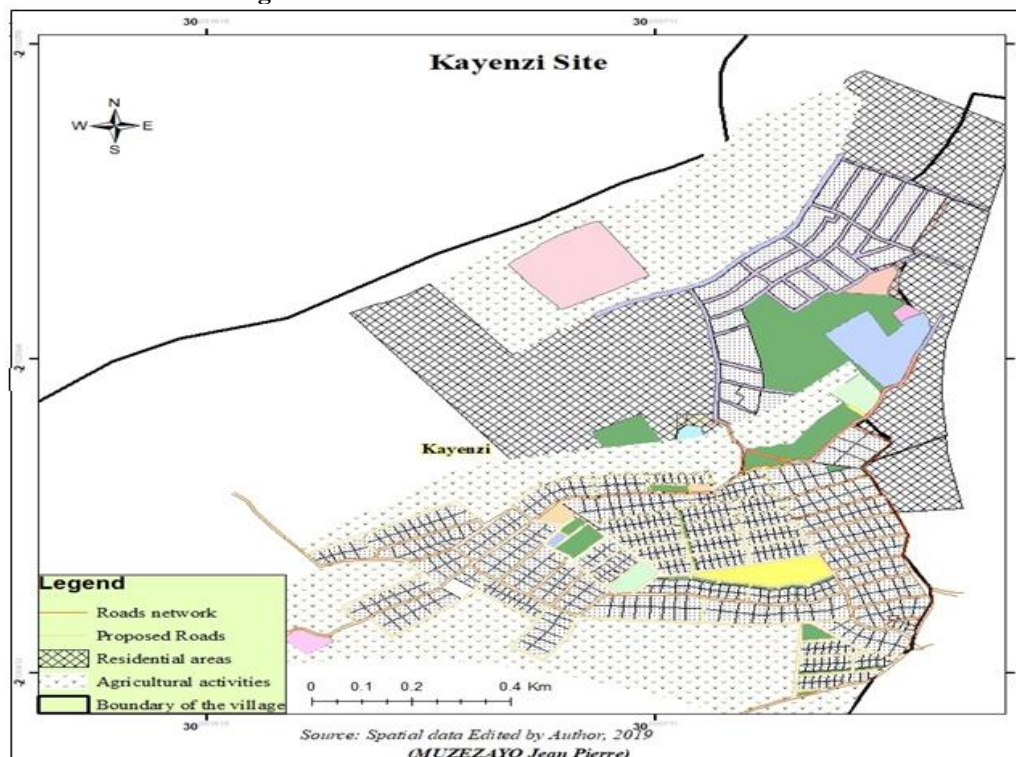
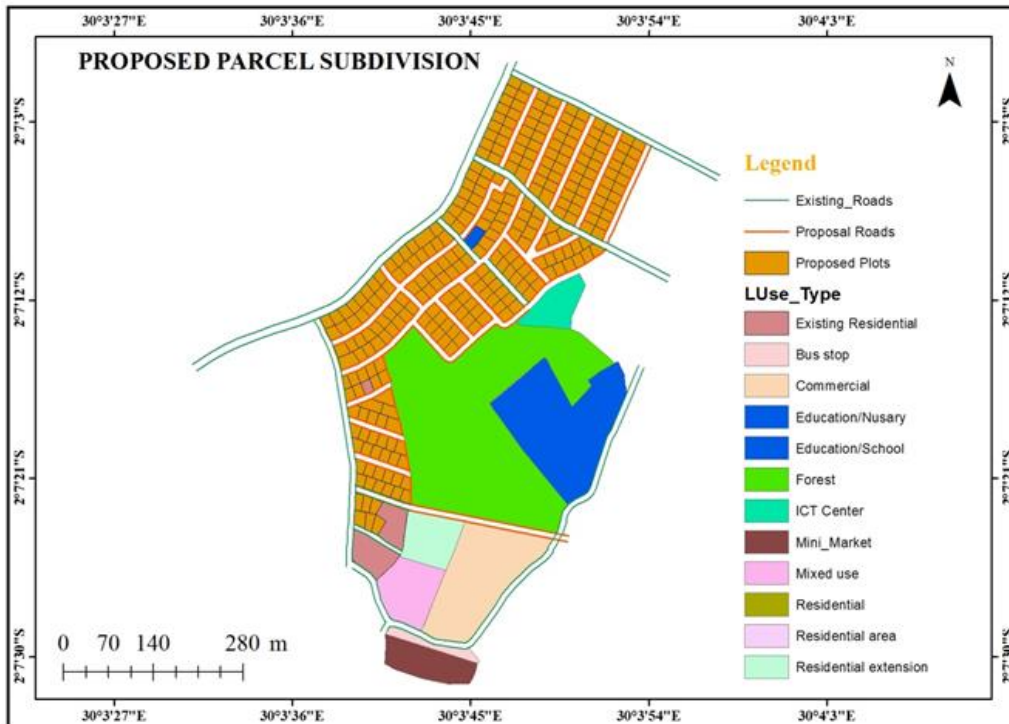


Figure 13: Example of Parcel subdivision



▪ Zoning plan in Kayenzi site

i. Housing Typology

The building blocks of the KAYENZI site are the three basic house categories, namely: Category A, Category B and Category C. each form of houses indicates the construction type according the personal capacity. Every row of buildings is arranged that all buildings are faced on the road, each column is straightly subdivided into two rows such each house is ready access for infrastructures.

Figure 14: Example of a proposed zoning

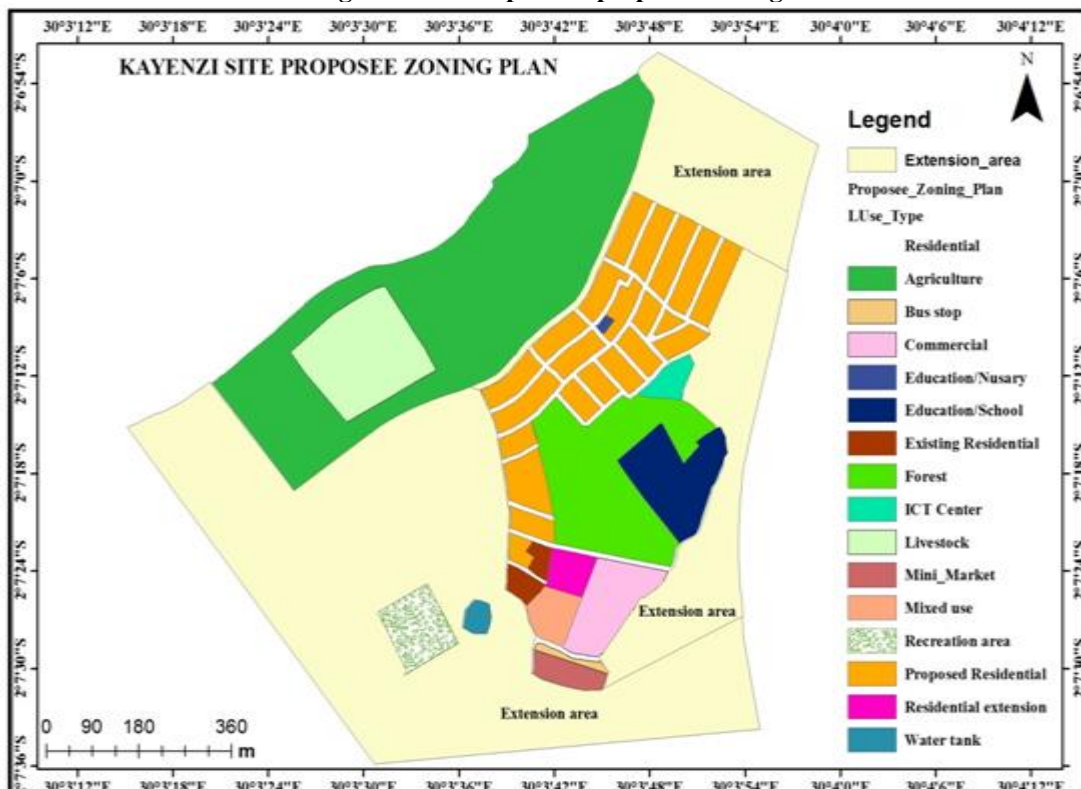


Figure 15: Current existing and proposed land use in Ntarama sector

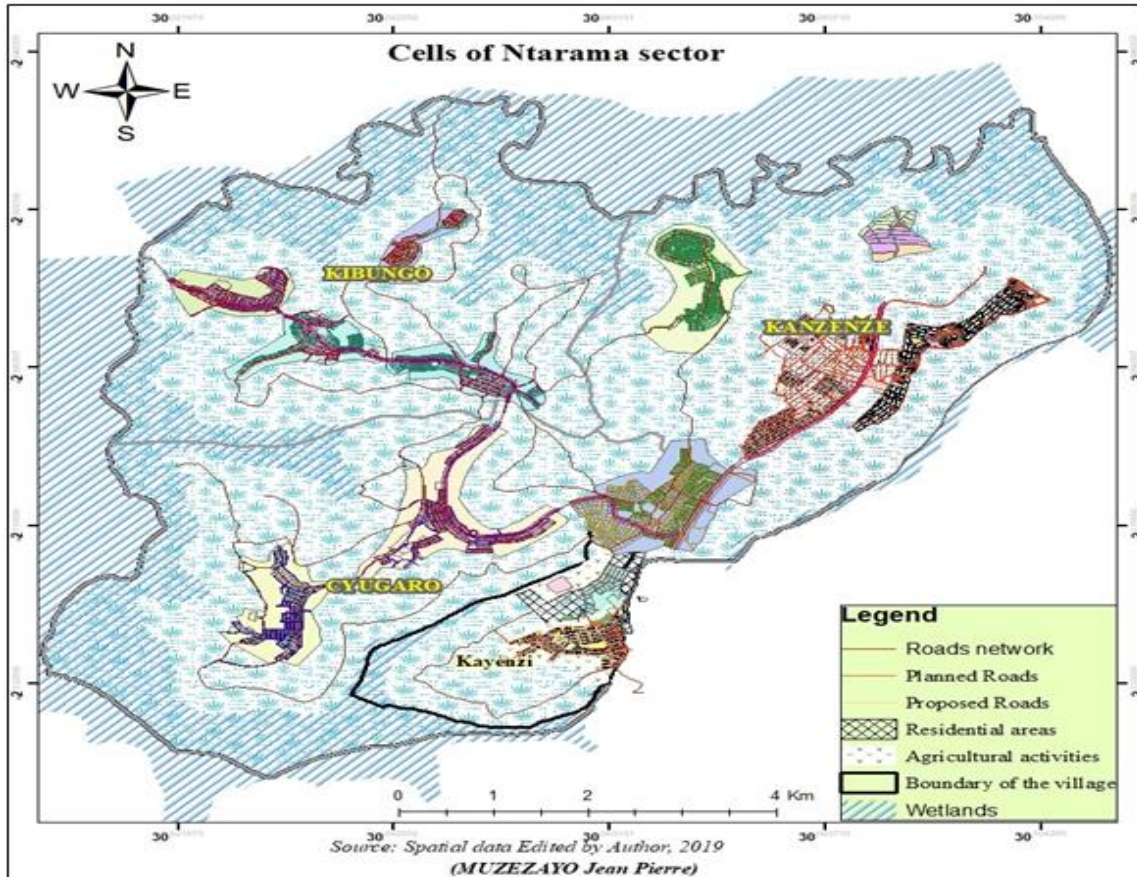
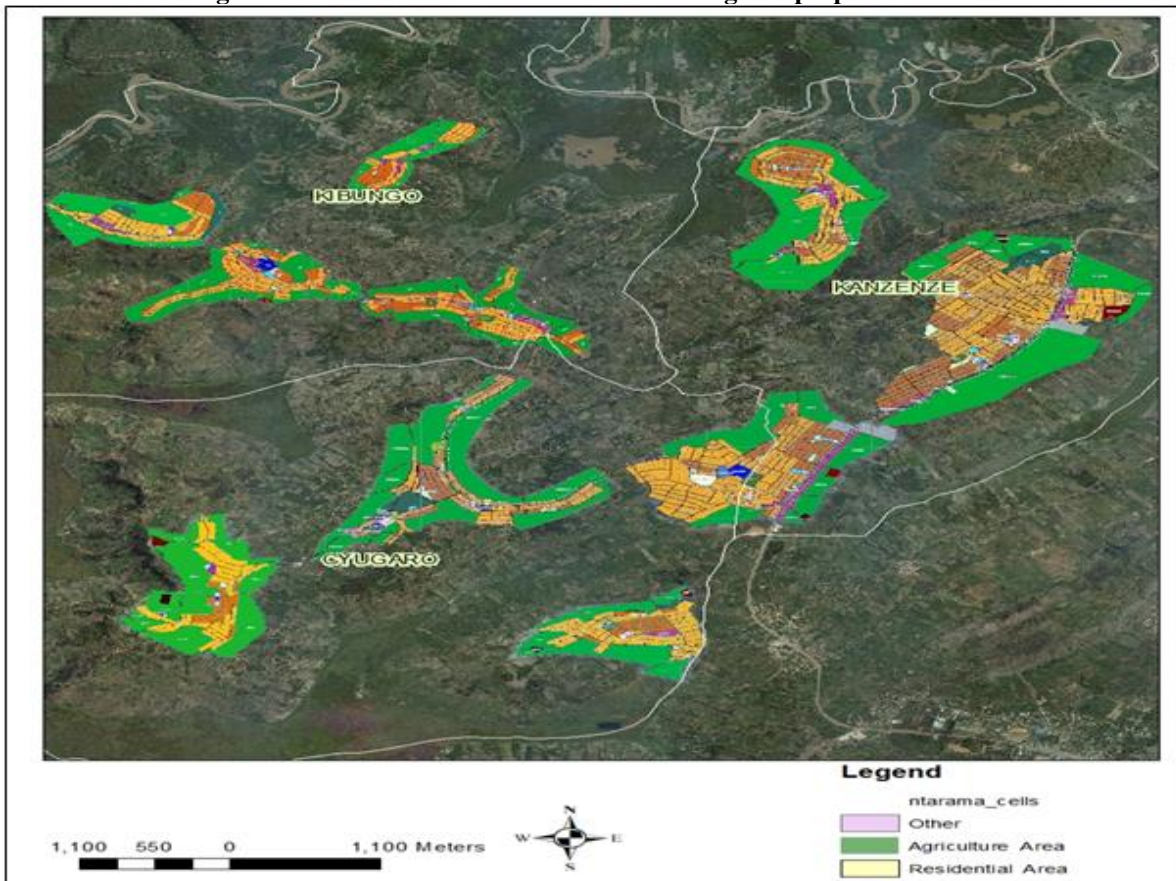


Figure 16: Panoramic View of Ntarama existing and proposed land use



V. CONCLUSION AND RECOMMENDATIONS

5.1. CONCLUSION

This research was aiming to analyze and investigate the role of GIS application in land management in Ntarama sector of Bugesera district. In order to achieve this main objective, the specific objectives and related questions were formulated. During the research, land use in Ntarama sector has been planned for the future use. Basing to the maps of physical plan and district strategic reports results from the interviews conducted during field research as provided above, we assume that land use management in Ntarama sector is well planned.

As my opinion for the results of my work done, basing to the main objective of assessing the role that GIS technologies can play in mapping the land use planning and management in Ntarama sector, it is more evident that if GIS is well adopted in Ntarama sector, it may resolve challenges facing land management by allocating the activities practiced on the land according to the area suitable for it. It provides sustainable land management and well developed without physical or social constraints. To assess this suitability of Ntarama sector, different parameters and objectives have been set. Those parameters are for instance wetlands, forests, roads, rivers, topography, wetlands, schools and health one of the important key parameters compatible with GIS technologies during planning for basic infrastructures development.

5.2. RECOMMENDATIONS

As urban development takes place within the areas of Ntarama sector located in Bugesera district for instance, IDP Village models or any other grouped settlement, there are the very dynamic trends over its land; meaning that there is a need of very strong land management to master the trends by encouraging the positive ones and offsetting the negative ones.

To achieve this, researcher recommend that:

- GIS as a very important and cost effective tool in land management should be adopted in land management of Ntarama sector and be used at each stage of planning.
- The local authorities should increase the mobilization and sensitization of community on why and how the management of land is crucial and they have to be well trained about the usage and importance of GIS in good and sustainable land management
- Urban development and environmental conservation bureau should be strengthened in order to approve and monitor all new socio-economic activities generated.
- Ensure, by Bugesera district, that urban growth does not impact negatively on locations that are topographically developable and livable; and those suitable areas that do not harmfully impact upon areas of environmental significance within Ntarama sector.
- Bugesera local government authorities have to increase the level of local community participation in land management plan and take into consideration their ideas.
- The local government also has to increase the awareness of good land management in the local community and

should increase the number of workers in charge of urban planning and land management both on Sector and District level to sustain proper land use management systems.

ACKNOWLEDGMENTS

My deep sense of gratitude is due to **Dr. MANIRAKIZA Richard** for his valuable guidance, collaboration, constructive suggestions, encouragement and his dedication which helped me to come to the successful completion of this work.

Conflicts of Interest

The authors declare no conflicts of interest

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