ASSESSMENT OF URBAN SPRAWL AND AGRICULTURAL LAND IN MUSANZE CITY USING REMOTE SENSING AND GIS TECHNOLOGIES

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ABSTRACT

Musanze District is among the districts with high potentiality of agricultural productivities. However this District is facing the problem of decrease of agricultural land due to the urban population growth and development of sprawl which put pressure on agricultural land within the urban city boundaries and urban fringe area. In this research, satellite images of Landsat Thematic Mapper (TM) 2003 and Landsat Enhanced Thematic Mapper (ETM+) 2016 have been used to study the urban sprawl and to assess the impact of urban sprawl on agricultural land in Musanze City in Musanze District. Maximum likelihood supervised classification and post classification change detection techniques were applied for monitoring the urban sprawl in this study area. The ground truth data were collected by using GPS (Global Positioning System) for image classification and overall accuracy assessment of the classification results. Other different data were used to perform this study such as administrative entities shapefiles, google images and Digital elevation Model (DEM). From 2003 to 2016 there was significate conversion of agricultural land into urban land where area for urban area was increased from 475 Ha to 865 Ha (increase of 7.09% in 13 years) while the agriculture land decreased from 4900 Ha to 4352 Ha (decrease of 9.96% in 13 years). Meanwhile forest area increased between the study periods from 2.27 % to 5.15 % of the study area.

Keyword: *urban sprawl, Agricultural land, change detection; urbanization; land cover; GIS and remote sensing*.

I. Introduction

Urban sprawl is usually defined as the spreading of a city and its suburbs over rural land (agricultural and forested) at the fringe of an urban area (Patacchini, Zenou, Henderson, & Epple, 2009). All sprawl leads to loss of limited resource, which is land. Over the years, sprawl has directly contributed to the degradation and decline of natural habitats such as farmland, open spaces, wetlands and woodlands (Haregewoin, 2005). Urban sprawl has been criticized for the inefficient use of land resources and energy and large-scale encroachment on agricultural land (Manish & Tripaphi, 2014).

Urban growth of the past 30 years has largely resulted in crowded slums and sprawling settlements in the urban fringe (UN-Habitat, 2015). Therefore, as cities extend into rural areas, large tracks of land are developed in leapfrog low density patterns (Frumkin, 2002). According to a report by UNFPA (2007), the space taken up by urban localities is increasing faster than the urban population itself. The above report Indicates that between 2000 and 2030 the world's urban population is expected to increase by 72% while the built-up areas of cities could increase by 175% (UNFPA, 2007). This is increase of built up areas will cause encroachments of settlement of inhabitant lands and decreases on agricultural lands.

Rwanda is facing high population growth of 2.4% per annum in 2014, with an average urbanization growth rate of 6.4% per annum (Government of Rwanda and GGGI , 2015). The expected growth of the urban population would exacerbate pressure on land, settlements, physical infrastructure and resources (NISR, 2012). The development of cities of Rwanda and growth of urban populations are coupled with unbalanced urbanization combined with scarcity of land that causes urban sprawl, inefficient use of land and inadequate housing and services for many residents (MININFRA, 2013).

The challenge of urban sprawl is particularly important for Rwanda, which is a country with one of the highest population densities, a challenge which is even more significant due to its small territory (MININFRA, 2015). In addition to this, the increase of urban population causes the increase demand of urban land and the unavoidable transformation of agricultural land in the proximity of urban centers.

According to Housing Policy (MININFRA, 2015) the increasing demand for land for development and economic growth has to be well-balanced with its efficient land use. Rwanda Housing Policy 2015 recommended initiatives to promote a controlled urbanization as a solution to ease pressure on land. However, urbanization is an inevitable process due to economic development and rapid population growth that contribute to the expansion of Musanze City (GISTECH Consultants, 2014).

Food scarcity and continuous loss of agricultural lands are issues of global concern (Shalaby, Ali, & Gad, 2012). Rwanda was not lest left behind of these global issues. According to NISR report (NISR, 2012) Rwanda has one of the highest population densities in Africa with 415 inhabitants per square kilometer; the density of the population will continue to grow regardless of the measures currently taken to mitigate its evolution. While In the next twenty years, the country population density is projected to be 667 inhabitants per square by 2032, Musanze district had exceeded this projected rate by 2012 where the gross density was 695 habitants per $km^{2.}$.

Despite the initiatives of the government of Rwanda aimed at guiding urbanization in a way to efficiently use and manage its natural resources while promoting sustainable land and social economic development (MININFRA, 2015), the National Informal Upgrading Strategy revealed that the country faces the peripheral sprawl of urban mansion-type family homes combined with the transformation of the use of agricultural land for individual residential development (MININFRA, 2015).

The reliable and updated information on spatio-temporal pattern of urban sprawl is a perquisite for the sustainable urban development planning and management (Manish & Tripaphi, 2014). Rwanda National urbanization policy (MININFRA, 2015) identified Geographic information systems based mapping, aerial photographs and remote sensing as a key role in quantifying developable land, good land use planning, not exceeding the consumption of agricultural land where food security would be comprised, informing physical planners for modeling expansion cities to mitigate the risk of urban sprawl, resource depletion and the effects related to environmental degradation in urban peripheries, Planning for the most sustainable use of developable land.

For this purpose, the temporal dynamics of remote sensing data can play an important role in monitoring and analyzing land cover changes. Accurate and up-to-date land cover change information is necessary to understand both human causes and environmental consequences of such changes (Aboel Ghar, Shalaby, & Ryutaro, 2004).

There is a continuing demand for accurate and up-to-date land use/land cover information for any kind of sustainable development program where land use/land cover serves as one of the major input criteria. As a result, the importance of properly mapping land use/land cover and its change as well as updating it through time has been acknowledged by various research workers for decision-making activities (Shalaby, Ali, & Gad, 2012).

Urban sprawl causes loss of agricultural land, which results in substantial changes in agricultural ecosystems. Monitoring these changes and planning urban development can be achieved using multi-temporal remotely sensed data, spatial metrics and modelling (Yikalo & Pedro, 2010).

The up to date and accurate information on urban expansion is very much required for urban decision making (MININFRA, 2009). Therefore, determining the trend and the rate of land cover conversion is necessary for the development planner to establish rational land use policy (Shalaby & Tateishi, 2007).

It was realized that the implementation of Musanze District development plan is mainly challenged by the National indicators which are global and not reflecting entirely realities of every District, therefore, not helping local levels to have reliable measures and lack of baseline data. The present study used GIS and Remote Sensing to assess the extent of urban sprawl and its impact on agriculture land in Musanze City and surround areas over 13 years' from 2003 to 2016. The results of the study will help the planners and decision makers to known the status and baseline of urban sprawl and its impact on agricultural land and to make sustainable land use plans and mitigation measures to prevent the proliferation of informal settlements at the same time responding to the expected city expansion in Musanze District.

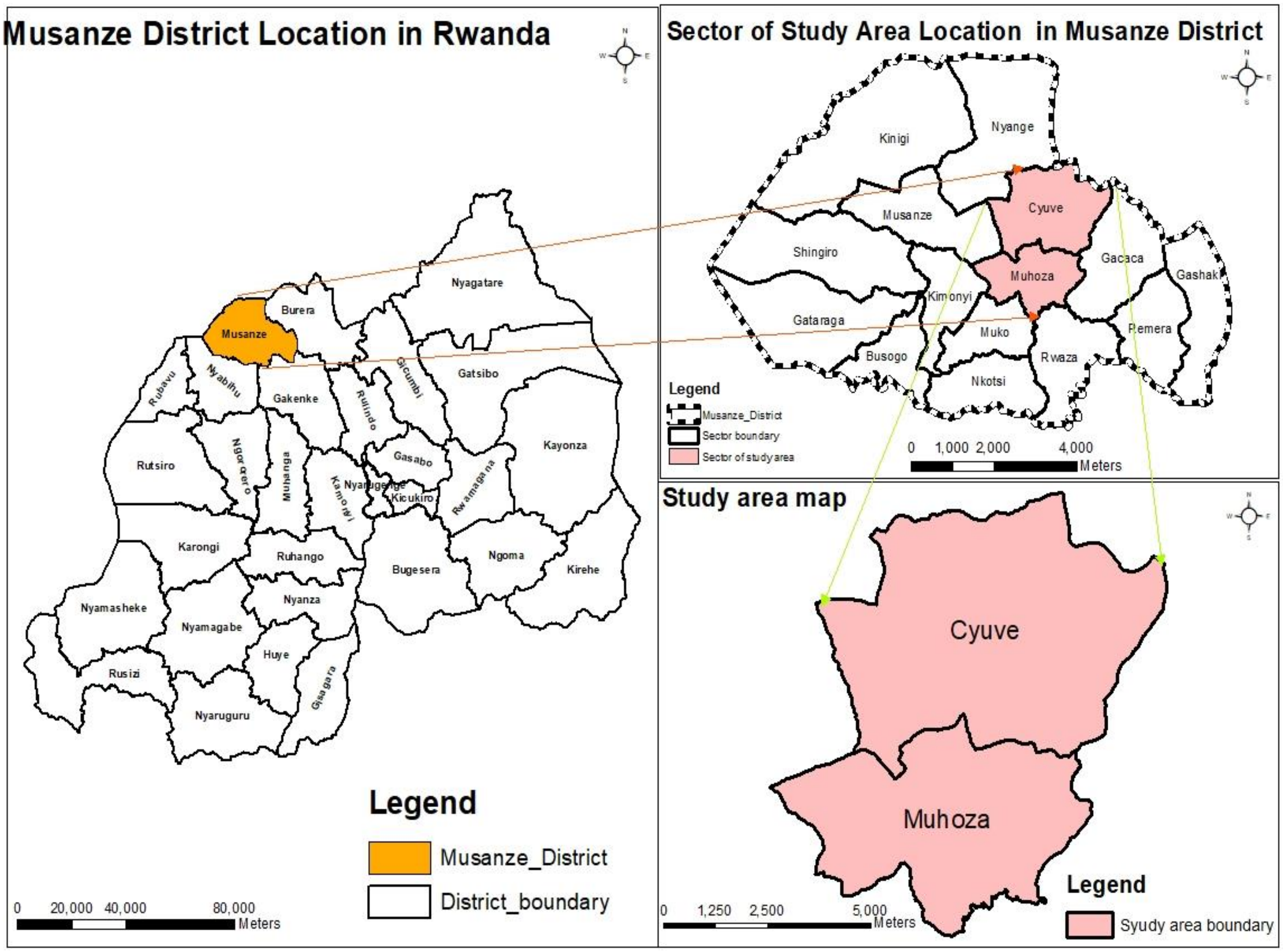
The objective of this study is to perform the assessment of urban sprawl on the agricultural land in Musanze city using GIS and remote sensing. This study also tucle on land use/land cover mapping, analysis of urban land use land cover change in 2003 to 2016 and monitoring of the impact of urban sprawl on agricultural land.

II. *Methods and* materials

1. Study area

The study area is limited to two sectors of Musanze District where the urban activities are concentrated. Those sectors are Muhoza and Cyuve with an estimated area of around 55 Square Km. Musanze urban areas located in Musanze District (one of 6 secondary cities in Rwanda) Nothern Province. It is one of the largest and fastest growing urban cities in Rwanda due to its locality of central hub for businesses, trade, and touristic destination. According to NSIR 2012, it has 28% of their population living in urban areas with urban population growth of 3.2% against the District growth of 1.8% and National growth of 2.5%.and It is expected to have 236,638 populations in 2020 from 102,082 populations in 2012 (NISR, 2012).

Study area map



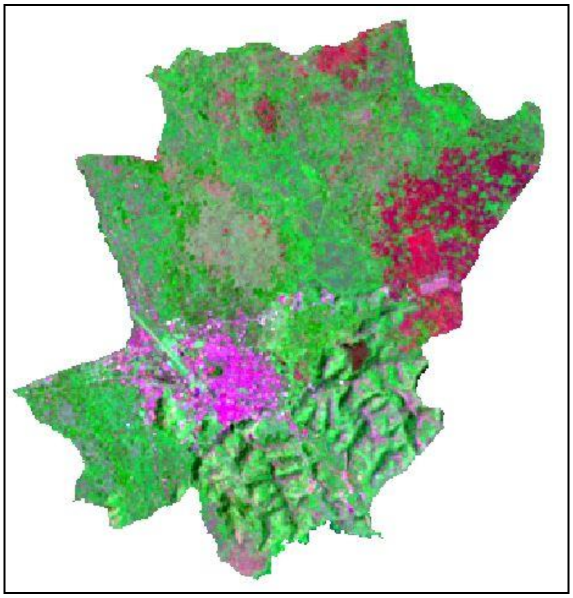
Map 1: Map showing the study area

The Volocanic National Park with its famous mountain gorillas, the Buhanga eco-park, fertile land and the Ruhondo Lake are found in Musanze and make the city a popular destination for national and international tourists. At least 91% of the population is engaged in agriculture. Musanze is considered as a country granary (Rugazura & Murugesan, 2015).

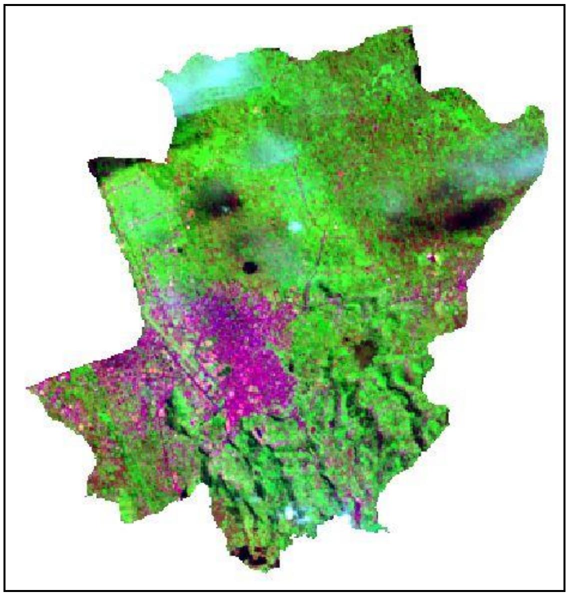
The highest point of the study area has an average elevation of 2068 meters, while the lowest has around 1666 meters. The city is ringed most of the way by volcanoes, with some suburban sprawl in different sectors of urban area.

2.2 Materials and methods

The materials used for this study are satellite images of 2003 and 2016 for Musanze city and its surrounding and Digital Elevation Model (DEM). In this study Landsat imageries of ETM+ and OLI were employed and acquired in the same season and the same level of resolution for the years 2003 and 2016. Thus, it was conducive for comparison of changes and patterns occurred in the time under discussion.



Landsat 7 (2003)



Landsat 8 (2016)

The images were downloaded from the United States Geological Survey (USGS) and spatially referenced in the Universal Transverse Mercator (UTM) projection with datum World Geodetic System (WGS) 1984. The images were extracted to Tiff formats for processing and the detail of image properties are summarized in table below.

Table 1: The characteristics of land-sat satellite data used in this study

Sensor and spacecraft ID	Sensor ID	Downloaded date	Spatial resolution	Number of bands	UTM zone	Path/Row	Producer
Landsat 7	ETM+	February 2018	30m	9	35	173/61	USGS
Landsat 8	OLI	February 2018	30m	11	35	173/61	USGS

The ground truth data that was collected using Global Positioning System (GPS) for image classification and overall accuracy assessment of the classification results. Other different data were used to perform this study such as administrative entities shapefiles, google images, etc.

Makvat showed that traditional data collection methods such as demographic data, census and sample maps were not satisfactory for the purpose of urban land use management (Maktav, 2005). Accurate information of land use and land cover change is therefore highly essential to many groups. To achieve this information, remotely sensed data can be used since it provides land cover information. Remote sensing refers to the science or art of acquiring information of an object or phenomena in the earth's surface without any physical contact with it. And this can be done though sensing and recording of either reflected or emitted energy or the information being processed, analyzed and applied to a given problem (Campbell, 2002). In almost any classification process, it is rare to find clearly defined classes that one would like. Before collecting training samples, the land cover classes should be known so as to make the classification easier (Bekalo, 2009). In our case, we defined 3 classes as described below:

Table 2: Land covers classes' nomenclature

Land cover classes	Description
Urban areas	Consists of Urban fabric, Industrial, commercial and transport units, Mine, dump and construction sites, communication utilities and artificial non-agricultural vegetated areas.
Agricultural areas	Arable land, Permanent crops, Pastures and Heterogeneous agricultural areas, Inland wetlands, open spaces with little or no vegetation, bare rocks, sparsely vegetated areas.

In order to examine and assess environmental and socioeconomic applications such as: urban change detection and socioeconomic variables, image classification results with better accuracy are mandatory. Image classification refers to the extraction of differentiated classes or themes, usually land cover and land use categories, from raw remotely sensed digital satellite data (Weng, 2012). Image classification using remote sensing techniques has attracted the attention of research community as the results of classification as the backbone of environmental, social and economic applications (Lu et Weng, 2007). Pixel-based classification methods were used in this study. This method automatically categorizes all pixels in an image into land cover classes fundamentally based on spectral similarities (Qian, 2007). These types of classifiers develop a signature by summing up all pixels. Thus, the developed signature contains the necessary things found in the training pixels but does not contain the influence of mixed pixels (Weng, 2012). According to Tadesse (Tadesse et al., 2003), there are two primary types of pixel-based classification algorithms applied to remotely sensed data: unsupervised and supervised. In our study we have used the supervised one.

With supervised image classification the analyst has previous knowledge about pixels to generate representative parameters for each land cover class of interest. The Maximum Likelihood classification, under the category of supervised classification, which is the most widely used per-pixel method by taking into account spectral information of land cover classes (Qian, 2007) was applied.

During post classification, it is the good time to detect changes based on the comparison of independently classified images (Singh, 1989). Maps of changes were produced and show a complete matrix of changes from times T1 to time T2. Based on this matrix, if the corresponding pixels have the same category label, the pixel has not been changed, or else the pixel has been changed (Xu, 2009). Image differencing as one of the most extensively applied change detection method was also applied. It is applied to a wide variety of images and geographical environment. In this technique, images of the same area, obtained from times T1 and T2, are subtracted pixel wise.

It is generally conducted on the basis of gray scale which used to show the spatial extent of changes in the two images. A threshold value is required for the gray of difference image in order to examine the changed and unchanged regions (Xu, 2009).

In order to determine the extent and rate of change in the land cover dynamics of the region, the simple numerical model was used, and the following variables were computed: Total area (Ta), Changed area (Ca).

Ca= Ta (t2)-Ta (t1);

Where, T1 stands for initial state (year), and T2 stands for the final state (year).

To complete this task well, some software were used. Among the used software we can say ENVI 5.1 for remote sensing data processing, ArcGIS 10 for GIS data processing, Dia 0.97.2 for chart Diagramming. Also, other software such as Microsoft word and excel was used consecutively for document compilation, data computation and making chart.

2.3 Urban change study approach

The objective, data availability, skills capabilities, time, and budget are major factors to define a given research method and approach (NKOMEJE, 2017). In any situation, whether it involves location data or any other spatial information, you can simply use question-model-analyze-interpret approach. Throughout the case study as defined in this project, the study followed the below-summarized workflow to carry out the project.

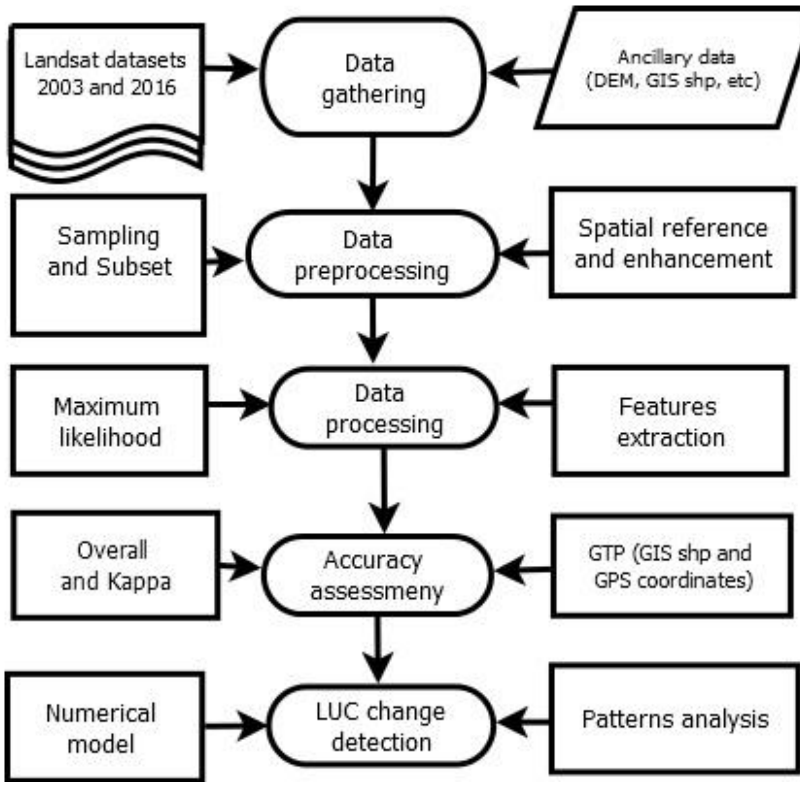
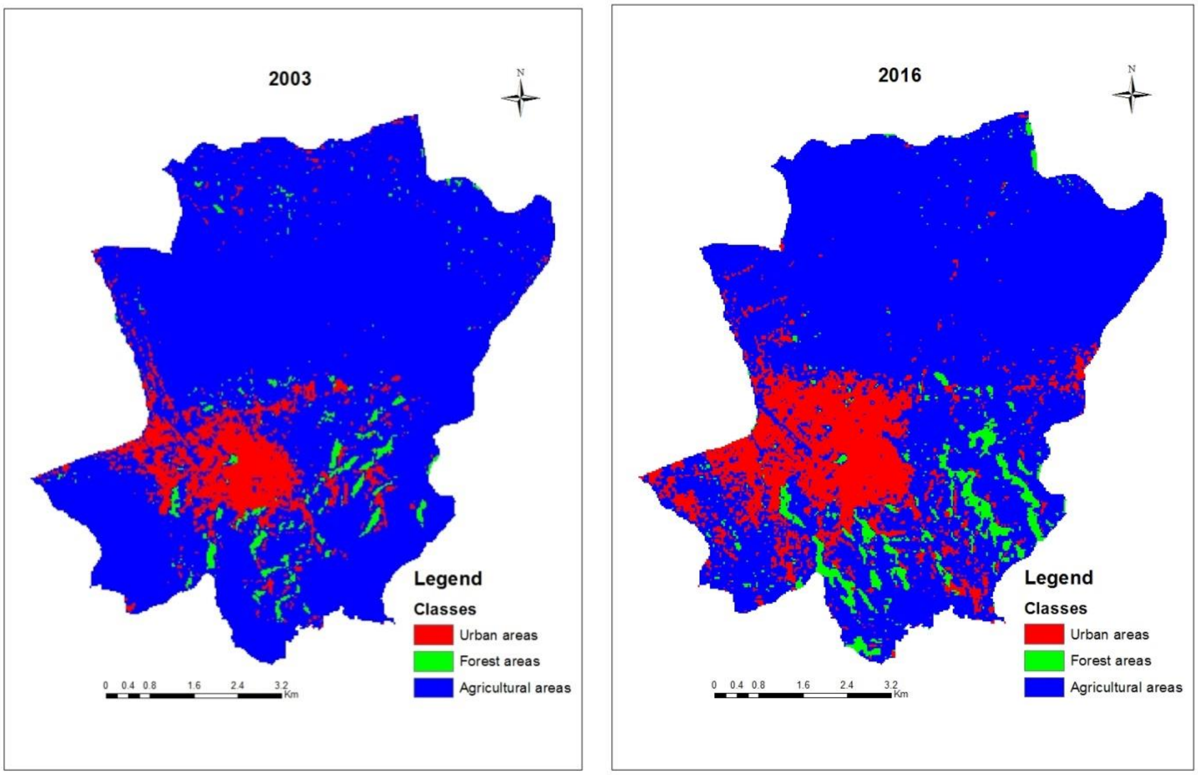


Chart 1: Research approach flowchart

III. Results and Discussions

3.1.Classification results

The land cover maps generated after running a maximum likelihood supervised classification as well as a post classification algorithm are presented in the figure below. As shown from the figures, there has been an increase of urban areas with respective values 8.64 % of the study area in 2003 to 15.73 % in 2016. Forest areas have also shown a consistent increase between the study periods from 2.27 % to 5.15 % of the study area. However, there have been decreases of agricultural areas as clearly shown in classification results. In 2003 agricultural areas covered 89.09% of the study area. According to the classification results, agricultural land was the most dominant land cover class in the study area but showed a continuous decrease from 89.09 % by 2003 to 79.13 % in 2016. Because of the successive decrease of agricultural areas, built up areas have dynamically increased in the study periods. This could be due to an increase of population growth associated with high demand for land and urban supplies.



Map 2: Land use and land cover extraction maps for the years 2003 (Left) and 2016 (Right)

The table below presents a summary of areas and percentage of land cover classes in the time span of 13 years.

Table 3: Area statistics of the land use and land cover units from 2003-2016

Land cover classes	2003		2016		Change 2003-2016	
	Area in Ha	%	Area in Ha	%	Area in Ha	%
Urban areas	475	8.64	865	15.73	390	7.09
Agricultural areas	4900	89.09	4352	79.13	-548	-9.96
Forest area	125	2.27	283	5.15	158	2.87
Total area	**5500**	**100**	**5500**	**100**		

As indicated in table above from 2003 to 2016 there was significate conversion of agriculture land into urban land where area for urban area was increased from 475 ha to

865 ha (7.09% in 13 years) while the agricultural land decreased from 4900 Ha to 4352 Ha (-9.96% in 13 years).

3.2.Accuracy assessment

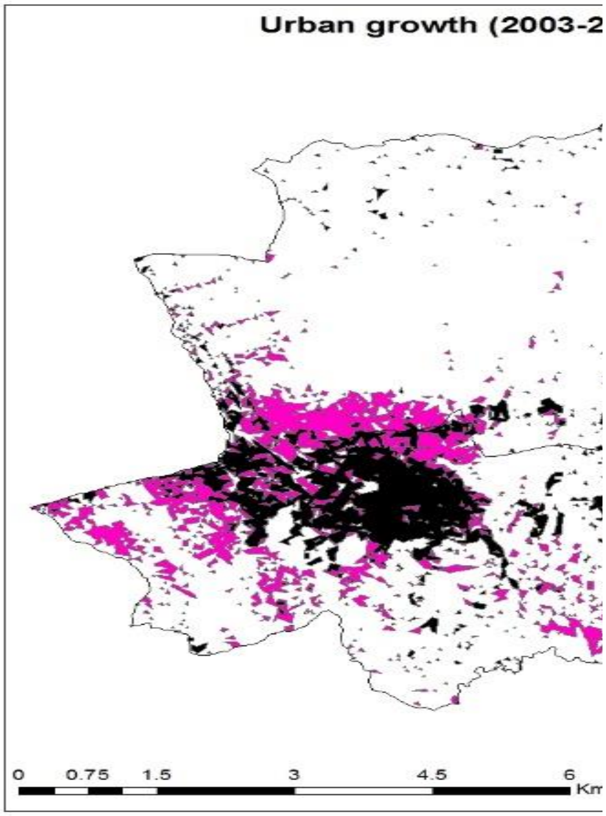
Overall accuracy also called total accuracy is measured by calculating the proportion class pixel relative to total tested a number of pixels (Total accuracy =Total corrected/Total tested) and sometimes multiply by a hundred (100). About Kappa coefficient accuracy, this is generally thought to be a more strong measure than simple percent agreement calculation since κ takes into account the agreement occurring by chance (University, 2013).

The assessment showed an overall accuracy derived from the stratified random sampling method for both classified images as follow: 0.89 or 89% and 0.92 or 92% 0.98 for 2003 and 2016 respectively. Moreover, some categories have similarities, and this is because the probability that a reference pixel correctly classified is determined by the producer's accuracy. The probability that a classified pixel from the (LC) map accurately corresponds with the referenced data is determined by the user's accuracy (Jensen, 2005), while the Khat Coefficient (K) or Kappa statistic measures the difference between the true agreement of classified map and chance agreement of random classifier compared to reference data (Kiefer RW Lillesand TM, 2004).

The Kappa statistics waves in the range of 0.84 – 0.89. The 2003 image has been classified at 0.84, and 2016 has been classified at the level of 0.89. It is stated that Kappa values of more than 0.80 indicate good classification performance (NKOMEJE, 2017).

3.3.Land cover changes of Built up areas

The increment in infrastructure development of Musanze city from time to time has played a major influence for the expansion of built up areas. The main focus of this study was to perform an assessing of the spatial extents of built up areas within the time span of 13 years. The map below shows the urban growth of the study area.



Map 3: Built and non-built-up areas between 2003 and 2016

Understanding LUC (Land Use Change) change is more than merely looking at the total area of certain land uses that appeared or disappeared. Also, the change in structure and the underlying reasons for this change are important. It is the complete picture of different elements that provides insight into land use changes. For this reason, we have focused on **appearance and disappearance** to measure the change.

In this section, we provide an overview of observed changes in the area in the 3classes mentioned above. Results from this include:

a) Total area per land use in initial date,

b) Total area per land use in final date,

c) Absolute change in area per land use from initial date to final date,

d) Surface share per land use in initial date,

e) Surface share per land use in final date,

f) Increase or decrease from initial date to final date per land use function, expressed relative to the original (initial date) amount of land use for that function,

g) Increase or decrease from initial date to final date per land use function, expressed as a percentage of the total land area. The above mentioned map has been produced based on appearance and disappearance of the urban (Built up) area in different years.

The map directly shows the status of the built-up areas in the city. It presents direct information about the built-up status of Musanze city, but to analyze and understand this map wisely, the following figure must be taken into consideration.

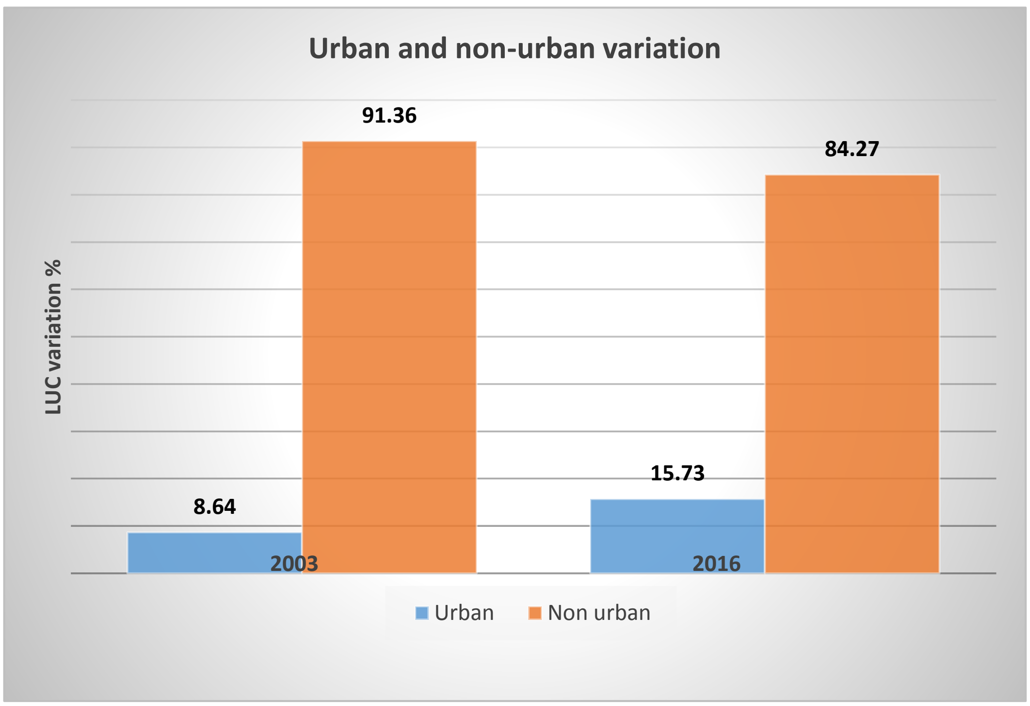


Figure 1: Urban land and non-urban land variation

The LUC categories that were analyzed in this study for the period 2003-2016 includes only the more generalized first level: Built up areas, Agriculture areas and Forest areas. As shown in the figure above, there are only two classes presented which are urban land and non-urban land that combines forest and agriculture lands. The numerical model method was used to calculate land use changes. According to Bruce and Maurice (1993), Land-use changes during a certain period can be shown by calculating the average changing ratio of the land-use model in the researched region (P & Maurice, 1993). The principle of this theory is based on a general mathematical calculation for finding some changes over time. The results in the figure above showed that only urban land was estimated at 8.64% in 2003 and 15.73 % in 2016 with an increase of 7.09%. In contrast, non-urban areas were 91.36% in 2003 and 84.27% in 2016 with a decrease of -7.09%.

3.4 Spatial Trend of urban Change

The resulting map provides a means of generalizing transition trends of built up areas for easy interpreting complex land change patterns. It is evident that the transition intensity of built up areas was more intense in the center of the city which is slightly located in the south east of the study area. The trend has shown a growing (sprawling) of built up areas towards the North, West, south west, and somehow towards south relative to other directions. Thus, the trend and extent of changes in built up areas are likely to continue with the rapid development of infrastructure, touristic activities and increasing of population.

IV. Conclusion and recommendations

This study has shown that information from satellite remote sensing and integrated with GIS can play a useful role in understanding the nature and extent of changes in land use/ land cover, where they are occurring and monitoring these changes at local scale. The change detection analysis performed in this research allowed for the monitoring of land use/ land cover changes overtime and space. The analyses provide valuable insight into the extent and nature of changes that has taken place in the Musanze city from 2003 to 2016.

The dynamics of land use/land cover change pattern have been identified by analyzing the multi-temporal satellite images of 2003and 2016 in a RS and GIS platform. The quantitative evidences of land use dynamics revealed the dynamic growth of artificial surface. Conversions of land from agriculture to urban land represent the most prominent land cover change. The estimated area was 8.64% in 2003 for built up surface while agricultural lands were at 91.36% of the study area. This was different in 2016 where built up area increased to 15.73%. However, the agriculture land decreased and attained

84.27% of the study area. The extent of urban change is likely to continue with the rapid development of infrastructure, touristic activities and increasing of population. This change would continue if the planner and policymaker will not in place the measures to prevent the urban sprawl. The majority of changes in urban built up surface occurred in most direction of the city; however, in the recent times, the intensity was higher at the north, west, south west and slightly in the south of the study area. During image processing and post processing as well as simulations, Landsat images were used and some errors occurred because the resolution level doesn't allow a net distinguishability of ground features. It is highly recommended to further researches to use the Very High Resolution Images (VHRI) in order to distinguish accurately land use and land cover features.

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Bibliography

Aboel Ghar, M., Shalaby, A., & Ryutaro, T. (2004). Agricultural Land Monitoring in the Egyptian Nile Delta Using Landsat Data. *International Journal of Environmental Studies, 1*(6), 651-657.

Bekalo, M. T. (2009). Spatial metrics and Landsat data for urban landuse change detection: case of Addis Ababa, Ethiopia.

Campbell, J. B. (2002). *Introduction to remote sensing.* Taylor & Francis.

Frumkin, H. (2002). Urban sprawl and Public Health. *Public Health report May- June 2002, 117*, 201.

GISTECH Consultants. (2014). *Musanze Land Use Master Plan.* Musanze: Musanze District.

Government of Rwanda and GGGI . (2015). *National Roadmap for Green Secondary City Development.* Kigali: The Global Green Growth Institute.

Haregewoin, B. (2005). *Urbanization and Urban Sprawl.* Stockholm: The Royal Institute of Technology,.

Ikirezi, M., Munt, & Ian. (2015). *An Assessment Of Land Use Planning In Rwanda.* Rwanda: USIAD Rwanda.

Jensen, J. (2005). *Introductory Digital Image Processing* (3rd ed.).

Kiefer RW Lillesand TM, C. J. (2004). *Remote Sensing and Image Interpretation* (5 ed.).

Lu, D. a. (2007). A survey of image classification methods and techniques for improving classification performance. *International Journal of Remote Sensing*, 823–870.

Lu, D., Mausel, P., Brondizio, E., & Morean, E. (2004). Change Detection Techniques. *International Journal of remote Sensing, 25*(12), 2365-2407.

Maktav, D. E. (2005). Remote sensing of urban areas. International Journal of Remote Sensing. *International Journal of Remote Sensing*, 655–659.

Manish, K., & Tripaphi, D. K. (2014). Spatial Monitoring of Urban Growth of Nagpur City (India) Using Geospatial Techniques. *Journal of Settlements and Spatial Planning, 05*(02), 91-98.

MININFRA. (2009). *Update Version of the National Human Settlement policy.* Kigali: Government of Rwanda.

MININFRA. (2013). *Urbanization And Rural Strategic Plan 2012/13-17/18.* Kigali City: Ministry of Infrastructure.

MININFRA. (2015). *National Housing Policy*. Kigali: Government of Rwanda.

MININFRA. (2015). *National Informal Settlement Upgrading Strategy.* Kigali: Government of Rwanda.

MININFRA. (2015). *Rwanda Habitat Iii Report.* Kigali: Government of Rwanda.

MININFRA. (2015). *Rwanda National Urbanization Policy*. Kigali: Republic of Rwanda.

Musanze District. (2013). *Musanze District Development PlaN 2012/2013-2017/2018.*

NISR. (2012). *Fourth Population and Housing Census.* Kigali: Government of Rwanda.

NKOMEJE, F. (2017). *Urban dynamics investigation based on Land use and land cover change using landsat imagery: Case study of Kigali city, Rwanda.* Nanjing, Jiangsu, China.

P, B., & Maurice. (1993). Rural/urban land conversion: estimating the direct and indirect impacts. *Urban Geography, 14*.

Patacchini, e., Zenou, y., Henderson, J., & Epple, D. (2009). Urban sprowl in Europe. *Brooking-Wharton papers on Uban Affairs*, 125-149.

Qian, J. Z. (2007). Comparison of pixel-based and object-oriented classification methods for extracting built-up areas in aridzone. *In ISPRS Workshop on Updating Geo-Spatial Databases with Imagery & The 5th ISPRS Workshop on DMGISs*, (pp. 163–171).

Rugazura, E., & Murugesan, R. (2015). Opportunities for Rural Development in Musanze. *International Journal of Business Management and Economic Research, 6*(4), 231-248.

Shalaby, A., & Tateishi, R. (2007). Remote Sensing and GIS for Mapping and Monitoring Land cover and land use changes in the Nothewest coastal of Egypt. *Applied Geograpyh, 27*(2007), 28-41.

Shalaby, A., Ali, R. R., & Gad, A.-A. (2012). Urban sprawl impact assessment on the agricultural land in Egypt using remote and GIS: A cas study, Qalubiya. *Journal of Land Use Science*, *7* (3), 261-273.

Singh, A. (1989). Review Article Digital change detection techniques using remotely-sensed data. International Journal of Remote Sensing., *10*, pp. 989–1003.

Tadesse, W. C. (2003). Improvement of land use and land cover classification of an urban area using image segmentation from Landsat ETM+ data.

UNFPA. (2007). *The Social and Sustainable Use of Space: Unleashing the Potential of Urban Growth. State of the World Population 2007.* NEW YORK: UNFPA.

UN-Habitat. (2015). *Urban Development and Management.* UN-Habitat.

University, T. A. (2013, May 15). Accuracy Assessment of an Image Classification in ArcMap Available. Retrieved from https://www.youtube.com/watch?v=FaZGAUS_Nlo

Weng, Q. (2012). *Remote sensing of impervious surfaces in the urban areas: Requirements, methods, and trends. Remote Sensing of Environment.*

Xu, L. Z. (2009). The comparative study of three methods of remote sensing image change detection. *17th International Conference on Geoinformatics,* (pp. 1–4).

Yikalo, H., & Pedro, C. (2010). Analysis and Modeling of Urban Land Cover Change in Setúbal and Sesimbra, Portugal. *Remore Sensing, 2*, 1549–1563.