Agricultural Sci. J. 51 : 1 (Suppl.) : 86-91 (2020) ว. วิทย. กษ. 51 : 1 (พิเศษ) : 85-91 (2563)

Land Use and Land Cover Change Detection using GIS and Remote Sensing Technology in Developing Country: A Case study of Gitega District, Burundi.

Audace Ntakirutimana [1], Chaiwiwat Vansarochana[2*]

[1]Master student, Naresuan University, Faculty of Agriculture, Natural Resources and Environment, Naresuan University, 65000, Thailand

[2]Assistant Professor, Naresuan University, Faculty of Agriculture, Natural Resources and Environment, Naresuan University, 65000, Thailand

* Corresponding author: ChaiwiwatV@gmail.com

ABSTRACT

Land Use and Land Cover Change detection is very important for decision-making especially in the areas of economic and environmental trade-off, and high political process for Sustainable Development Goals. GIS and Remotes sensing techniques were used for the detection of the change in land use land cover in Gitega District. This study aimed to assess the land use change using remote sensing data. Two satellite images for the year 2001 and 2019 were downloaded and used for detecting the LULC changes. Maximum likelihood classification was used in IDRISI Selva for images classification. Google Earth observation was made to collect the random truth points used for verification of image classification. The accuracy of image classification was checked using confusion matrix method and the overall accuracy has shown results of 92% for both classified images which indicated that the method of classification and images used for this study were very good. During this study period the Shrub and Agricultural Lands have showed an increasing trend by 23.86 and 12.60 % respectively, while Natural Vegetation (NV) had extremely decreased by 39.45% due to an increase of interest to cropland area. In Gitega District, there has been a significant land use change which was due to an increase in population with a high interest to agricultural activities which have resulted in an increase of Agricultural lands and thereby a high increase of Shrub Land by 23.86% over 18 years period. Consequently, this dramatic land use change increases the soil erosion and degradation which needs due attention of Government towards the soils conservations practices and effective land use planning.

Keywords: LULC, change detection, IDRISI selva

INTRODUCTION

Land degradation and soil loss are currently major environmental problems in Burundi. Poor land use practices and unmanaged systems have led to a significant change in land cover. Soil erosion rates and landslides and dried lands are negative Impacts that have furtherly quickened the effects of climate change. The lack of awareness on environmental issues was raised by repetitive civil wars causing human resource management challenges, by reducing investment related to land and increasing deforestation (UNDP, 2010). Improper agricultural system practices are known to decrease soil quality which in turn

reduces increase the loss of productivity, loss of organic elementary rich of the surface soil. Negative effects of population pressure on land use/land cover are no longer doubtful and some alarming signals light up in all corners of the country. These problems are mostly occurring in Gitega, actual political capital city of the country, which is among the densely populated district with shortcomings of continuous cultivation of already depleted soils, and limited availability of resources to farmers, all of it leading to the low crop productivity (Niyuhire, 2018).

Land use & land cover (LULC) changes are major issues of global environment changes, sometimes very hard and more complex to address. GIS and Remote Sensing technology are now proved to be very useful in generating, storing, and analyzing data used for mapping land use/land cover and environment changes pattern within certain determined space and time (Sarma, Krishna, Malini, & Rao, 2001). Over the past three centuries, increasing human beings have been seen as the most powerful and universal agent of shaping earth's surface and environment change (Andualem & Gebremariam, 2015; Ramankutty & Foley, 1999). Change detection in LULC is the process of assessing and identifying different states of a feature in landscape by observing it at different times (Singh, 1989). Basically, as results of human activities, the rate of changes in land use /land cover patterns is directly influenced by both the decrease and increase in number of a given population (Lambin, Geist, & Lepers, 2003).

Generally, in most developing countries like Burundi, population growth has been a dominant cause of land use and land cover changes than other influencing forces (Turner, Meyer, & Skole, 1994) (Meyer, Meyer, & BL Turner, 1994). Due to increasing demands of food production, agricultural lands are quickly expanding at the expense of natural vegetation and grassland (Lambin et al., 2003). Land degradation, soil erosion as well as depletion of natural resources, barren land are most important shortcomings of the ever-increasing populations in Gitega district, living on subsistence agriculture which uses poor and traditional farming system of productivity. Therefore, this study aimed to assess the land use/land cover change using remote sensing data and GIS technology for generating dataset supporting decision-making in sustainable land use planning, environmental trade-off, and high political process for Sustainable Development Goals Sustainable

Study Area Description

Gitega District is the seat of Gitega Province and political capital city of Burundi located in the center of the country, at a specific geographic grid reference location of "03° 25' 35" South Latitude and 29° 50' 37" East Longitude. Its total area is 315 km^2 and has a total population of 150,151 with a density of 476 inhabitant per km^2 (ISTEEBU, 2014; Republic of Burundi & MDC, 2013). The landscape area is generally rugged with large plateaux rising between 1,600 – 2,000 meters (Republic of Burundi & MDC, 2013) , which are closely dispersed hills and narrow dissected with bedded gorges and valleys and some moderate plains. Climate comprises the subtropical highland oceanic climate and tropical savanna climate depicted by summer and winter (Merkel, 2018). The summers are much rainier than winters and the average annual temperature is 20°C with the lowest minimum temperature of 10 °C and the highest maximum temperature of 26°C(Republic of Burundi & MDC, 2013). The area receives about 1,130 mm of the average annual rainfall with the least amount of 3 mm in July and the greatest amount of 173 mm in April (Niyuhire, 2018; Republic of Burundi & MDC, 2013). The landscape is thoroughly cultivated in its plains, valleys and some marginal sloped hills and tops of the hills to produce subsistence foods for population (**Figure 2).**

MATERIAL AND METHOD

The land use is one of the most import factors that lead to degradation of land, soil losses and surface erosion in the highland. Two satellite images were downloaded from the site of United States Geological Survey (https://earthexplorer.usgs.gov/), by considering the time between 2001 and 2019. Landsat 7 ETM+ image and Landsat 8 OLI/TIRS both at the path (172) and row (062) with spatial resolution

of 30 m x 30 m, acquisition date (10-01-2001 and 7-23-2019). The satellite images were classified based on using ground truth and Google Earth linkage with IDRISI Selva Software and results are shown in (Figures 3 and 4).

Image enhancement & composite generation

Image enhancement is the process of making an image brighter and more interpretable for a specific application. In this study, image enhancements concerned radiometric correction, spectral enhancement and principal component analysis using ATMOSC model embedded in IDRISI software to enhance identification of each of the land cover types (Eastman, 2009; Lillesand *et al*., 2015). Then composite generation, which is an image transformation technique specifically tailored for data containing more than one band was made. Basically, using False color composite with 3 bands (Green, Red and Blue) earlier image classification gave five LULC types: Built-up Area, Natural Vegetation, Agricultural Land, Trees Cover and Shrub Land.

Image classification

Supervised classification which is the method of land use classification using the sample polygons from the known land cover types was applied in this study. Thereby, ground truth control points connected with GIS software for synchronizing Google Earth and images was also done and the land use information was obtained by selecting a training sample according to spectrum features. Finally, Maximum likelihood classification was used to map the land use/cover of Gitega District for two the period of 2001 and 2019. After classifying the image, the accuracy assessment of classification was checked using ground control points and Google Earth aerial image.

RESULTS AND DISCUSSION

Using supervised and Maximum Likelihood classification methods, two LULC cover Maps have been produced for two correspondingly reference years 2001and 2019. Final image classification method has given five categories of LULC classes which are: Built-up Area (BA), Natural Vegetation (NV), Agricultural Land (AL), Trees Cover and Shrub Land (SL). Furthermore, the detection and Spatial analysis methods have been applied to describe the LULC patterns in Gitega District by calculating overall land use changes and the rate of change. The two LULC Maps of Gitega District and related summary of statistical change analysis results are presented in (Figures 3, 4 and table2.)

Accuracy Assessment

A Confusion Matrix method was selected to be used for this study. The classification results have been compared and analyzed statistically using 25 ground truth control points data representing different LULC of the area using GIS software. Producer's Accuracy User's Accuracy and Overall Accuracy were calculated and resulted are recorded in (Table 1). The overall accuracy has shown results of 92% for both classified images and indicated that the method of classification and images used for this study were good (Rwanga & Ndambuki, 2017).

Land use land cover change detection

The Landscape of Gitega District is mostly characterized by cultivation and barren land. The main LULC classes detected are Built-up Area (BA), Natural Vegetation (NV), Agricultural Land (A) and Shrub Land (SL). Satellite image of 2001 indicated that; Natural Vegetation, Shrub Land and Agricultural Land, Trees Cover and Built-up Area cover about 46.38%, 31.57%, 18.42%, 2.30 % and 1.31% respectively. However, there is some significant change shown in 2019, Shrub Land showed high coverage with 55.44% followed by Agricultural Land with a total coverage of 31.02% whereas Natural Vegetation has highly shown an important decrease with a total coverage of 21%. As shown in (Table 2), two types of land use /land cover showed high increase are Shrub Land and Agricultural Land if comparing spatial distribution of land use land cover in both years (Figure 3 and 4). The classification has indicated that there is an increase of Shrub

Land and Agricultural Land by 23.86% and 12.60%, while Natural Vegetation decreased significantly by 39.45%, this is caused by an increase in population i.e. 136,562 inhabitants in 2008 to 150,151 inhabitants in 2012 and estimated to 155,005 people in 2019 (Republic of Burundi & MDC, 2013). According to Polisi et al (2017), 90 percent of the population resides in rural areas in Burundi. This in turn has resulted in substantial pressures on rural natural resources and rural land degradation through substantial fragmentation of croplands for vital livelihood needs (Niyuhire, 2018). Built-up Area and Trees cover have also low increase by 2.31% and 0.66% respectively.

Some previous researches have shown quite similar findings in Burundi. Collins et al. (2013) found out that the population growth and the reliance of rural households on subsistence farming has increased farmlands, with average land holdings per household decreasing from 0.7ha in 1979 to less than 0.5ha in 2009 (Nargiza Ludgate, 2015). CIA World Factbook (2014) showed the proportion of Agricultural land in Burundi which comprises of 39% of arable land, 16% of permanent crops, and 19% of permanent pasture. Forests occupy 7% of the total land area. 87% of the arable land is under food crops, the majority of which is consumed by households 80% (Nargiza Ludgate, 2015). Collins et ali. (2013) have concluded that unprecedented conversion of land cover created other agro-ecological challenges: soil erosion because of overgrazing and hillside farming, the expansion of agriculture into marginal lands, deforestation fragmentation. Finally, upon these research findings, the increase in population is expected to result in increase in interest to crop production, which in turn leads to the conversion of grasslands to croplands and Shrubland and/ or barren Lands as related shortcomings.

CONCLUSION AND RECOMMENDATIONS

GIS and Remote sensing technology are widely effective tools used for land use change detection analysis. The Land use and Land Cover (LULC) change detection has been done using Satellite Imagery data acquired from USGS official site and classified with IDRISI Selva software. The results of this study indicate high increase are Shrub Land and Agricultural Land by 23.86% and 12.60% respectively, while Natural Vegetation has extremely decreased by 39.45% over 18 years for study period. However, other slight increase was identified in Built-up Area and Trees cover classes, by 2.31% and 0.66% respectively. The crop production demands were highly increased because of the important population growth causing continuous cultivation in the landscape. Subsequently, that poor subsistence farming system increases a fast conversion of grasslands to agricultural, and provoke soil erosion leading to soil loss, land degradation. Therefore, decision makers and administrative Authorities need due attention towards these dramatic Changes happing in Gitega Landscape and refine new policy of soil conservation for the enhancement of the sustainable Land use management. This can be achieved by promoting joint management of domanial afforestation, intensifying livestock production and promoting coverage plants, fighting erosion and soil loss, promoting animal husbandry to permanent stability and sensitization through training session that will bring about a sufficient awareness of the farmers and households.

REFERENCES

Andualem, T. G., & Gebremariam, B. (2015). Impact of land use land cover change on stream flow and sediment yield: a case study of Gilgel Abay watershed, Lake Tana sub-basin, Ethiopia. *Int. J. Technol. Enhanc. Merg. Eng. Res, 3*, 28-42.

Eastman, J. R. (2009). IDRISI Taiga guide to GIS and image processing. *Clark Labs Clark University, Worcester, MA*.

ISTEEBU. (2014). Rerecensement général de la population et de l'habitat burundi 2008 In I.-M. d. F. e. d. l. P. d. D. Economique (Ed.). Bujumbura.

Lambin, E. F., Geist, H. J., & Lepers, E. (2003). Dynamics of land-use and land-cover change in tropical regions. *Annual Review of Environment and Resources, 28*(1), 205-241.

Lillesand, T., Kiefer, R. W., & Chipman, J. (2015). *Remote sensing and image interpretation*: John Wiley & Sons.

Merkel, A. (2018). Gitega Climate, . Retrieved from https://en.climate-data.org/

Meyer, W. B., Meyer, W. B., & BL Turner, I. (1994). *Changes in land use and land cover: a global perspective* (Vol. 4): Cambridge University Press.

Nargiza Ludgate, a. S. J. T. (2015). *Project "Integrating Gender and Nutrition within Extension and Advisory Services" (INGENAES), Burundi Landscape Analysis*. Retrieved from https://vdocuments.mx/document/integrating-gender-and-nutrition-within-agricultural-women-incomes-and.html

Niyuhire, M.-C. (2018). Integrated soil fertility management for bean-maize based farming systems in Gitega Province, Burundi: Understanding and enhancing the agronomic and economic benefits of organic and mineral inputs.

Ramankutty, N., & Foley, J. A. (1999). Estimating historical changes in global land cover: Croplands from 1700 to 1992. *Global Biogeochemical Cycles, 13*(4), 997-1027. doi:10.1029/1999gb900046

Republic of Burundi, E. C. d. P. a. l. a. f. d. p. d. A. à. l. D. e., & MDC, à. l. L. c. l. P. A. s. t. d. (2013). *Vision de la commune : « Gitega havre de paix et de prospérité avec une population en bonne santé, épanouie et éprise d'un développement durable »*. Gitega: Republic of Burundi Retrieved from http://www.provincegitega.gov.bi/Documents/PCDC%20Gitega%20II%20final%20ok.pdf.

Rwanga, S. S., & Ndambuki, J. M. (2017). Accuracy Assessment of Land Use/Land Cover Classification Using Remote Sensing and GIS. *International Journal of Geosciences, 08*(04), 611-622. doi:10.4236/ijg.2017.84033

Sarma, V., Krishna, G. M., Malini, B. H., & Rao, K. N. (2001). Landuse/Landcover change detection through remote sensing and its climatic implications in the godavari delta region. *Journal of the Indian Society of Remote Sensing, 29*(1-2), 85-91.

Singh, A. (1989). Review article digital change detection techniques using remotely-sensed data. *International journal of remote sensing, 10*(6), 989-1003.

Turner, B., Meyer, W. B., & Skole, D. L. (1994). Global land-use/land-cover change: towards an integrated study. *Ambio. Stockholm, 23*(1), 91-95.

UNDP, R. o. B. a. (2010). *Project: Burundi Empowerment to prepare its second national communication to the United Nations Framework Agreement on Climate Change*. Bujumbura, Burundi

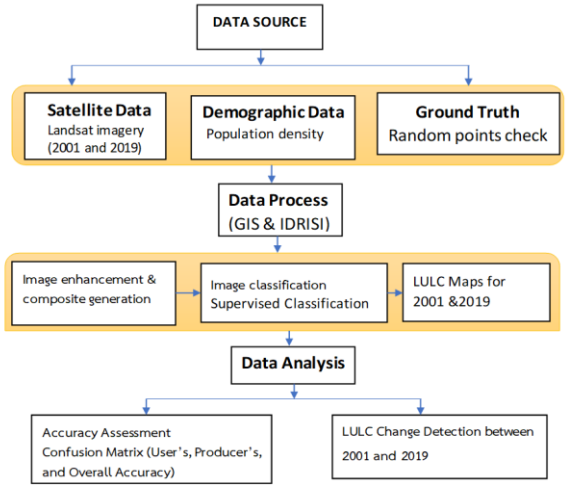

Figure 1 Methodology Flowchart

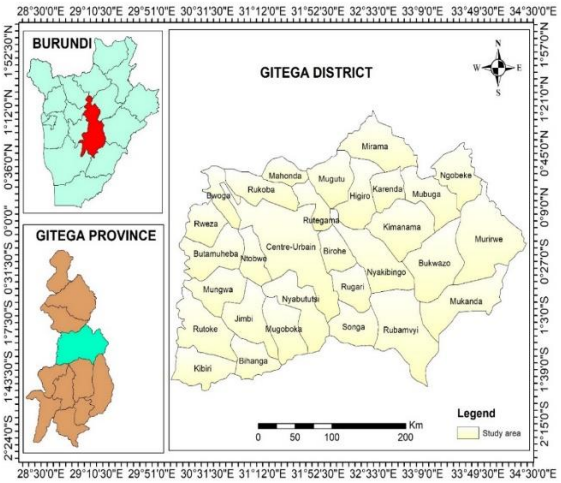

Figure 2 Gitega District Location Map

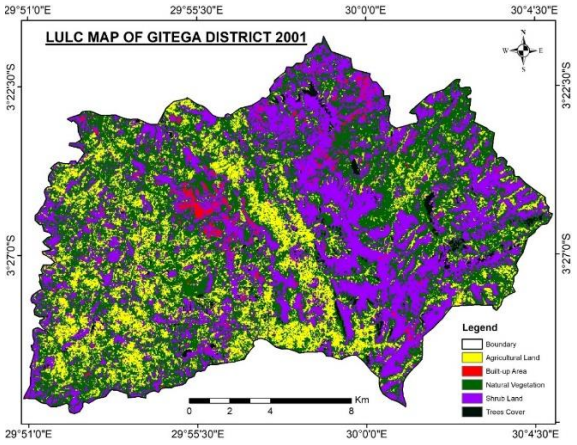

Figure 3 Land use and land cover Map of Gitega District 2001

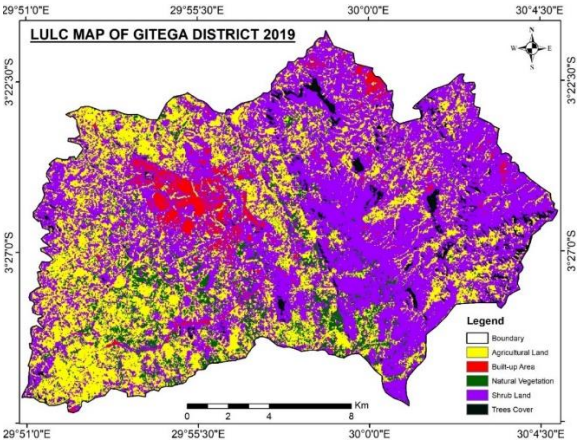

Figure 4 Land use and land cover Map of Gitega District 2019

Table 1 Confusion Matrix showing classification accuracy assessment

Variables	Built-up Area	Natural Vegetation	Agricultural Land	Trees Cover	Shrub Land	Total	User's accuracy (%)
Built-up Area	1	0	0	0	0	1	100
Natural Vegetation	0	3	0	0	0	3	100
Agricultural Land	0	0	10	0	0	10	100
Trees Cover	0	0	0	1	0	1	80
Shrub Land	0	1	1	0	8	10	80
Total	1	4	11	1	8	25	
Producer's Accuracy (%)	100	75	90	100	100		
			Overall Accuracy				**92**

Table 2 Summary of Land use land cover change detection in Gitega District.

Land use Type	LULC 2001		LULC 2019		Change detection in % from 2001 to 2019
	Area km^2	% of area	Area km^2	% of area	2019-2001
Built-up Area	4	1.31	11	3.63	2.31
Natural Vegetation	141	46.38	21	6.93	-39.45
Agricultural Land	56	18.42	94	31.02	12.60
Trees Cover	7	2.30	9	2.97	0.66
Shrub Land	**96**	**31.57**	**168**	**55.44**	**23.86**