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Assessment of Land Cover Change using Landsat Data in the satellite city Area of Southern Rwanda

Egide Hakorimana[a, b, c, d], Alishir Kurban[a, b, c, *], Valentine Mukanyandwi[a, b, c, d], Nahayo Lamek[a, b,c,d] Nsengiyumva Jean Baptiste[a,b,c], Aboubakar Gasirabo[a,b,c,d], Richard Mind'je [a,b,c,d], Yu Liang[a.b], Xiao Hao[a,b]

[a]*Xinjiang Institute of Ecology and geography, Chinese Academy of Sciences, 818 South Beijing Road, Urumqi 830011, Xinjiang, China;*

[b]*University of Chinese Academy of Sciences, Beijing 100049, China;*

[c]*Joint research center for Natural Resources and Environment in East Africa, P.O Box 6392 Kigali, Rwanda;*

[d]*University of Lay Adventists of Kigali (UNILAK), P.O Box 6392 Kigali, Rwanda*

Corresponding author (E-mail: alishir@ms.xjb.ac.cn, *Tel: +86-1300-9679-594)*

Urbanization is among the factors which lead Land Cover Change, not only in the city as such but also in satellite cities. In this study, authors applied Landsat TM data to detect Land Cover Land Use Changes of Runda, a satellite city located in the southern province close to Kigali city, the capital city of Rwanda. The study used dataset ranges from 1990 to 2017.Thus, field observation and interviews with randomly selected households were–used for the study. Land Cover Land Use maps–for 1990, 2000 and 2010 were obtained from the Regional Centre for Mapping of Resources for Development which is the Land Cover Viewer database of East Africa and then, the restructured Land Cover Land Use Change map 2017 of Runda satellite city was obtained through image classification of the 2017 Landsat-8 imagery delivered by the United States Geological Survey (USGS). Five different classes of land use were therefore distinguished including forest land, grass land, crop land, wet land and settlement. The results of the present study showed that Runda satellite city recognized a rapid increase of settlement between 1990 and 2017. The rapid Urbanization of Kigali City, caused the migration of some population to Runda satellite city which is the key drivers of the detected changes on Land Cover Land Use patterns. Further assessment of natural, social and economic factors which could be the causal factors of land use change is suggested. The results of this study may be useful for land use planning and environmental protection.

Keywords: *Land Cover-land Use changes, Landsat, Runda Satellite city, Capital city, Rwanda.*

Introduction

Land Cover-land Use (LCLU) changes are a base of global change that directly affects the status and veracity of ecosystems, and in last term its capacity to control ecosystem services(Usha et al.). Land Cover-land Use changes therefore, for land management and planning oblige special attention due to their potentially negative consequences, creating trade-

offs between some ecosystem services(Liu et al.; Nelson et al.). Human transformation of the Earth's surface has an impact on all aspects of biological systems, including urban, the heat island effect, the river flow change (Storck et al.) changes in the global atmospheric circulation patterns (Werth and Avissar) and the extinction of species (Pimm and Raven).

Land Cove/Land Use change have a significant impact on the global ecosystem, studies have pointed out that the consequences of land use change may exceed the impacts of climate change arising from land use influences (Newbold et al.),(Haddad et al.). Land Cover and land Use change can be divided into two major categories of conversion and transformation. Conversion refers to a land-use type into another land use patterns; and the transformation means to retain the existing land use patterns that changed with the land attributes(Szejwach and Baulies; Liu et al.). The United States Environmental Protection Agency Studies show that(Sleeter et al.; Bariweni and Andrew), the main causes of Land Cover and Land Use change are: (1) Natural processes such as climate change, natural fires and pests; (2) a direct impact caused by human activities such as deforestation and road construction; (3) the indirect impact caused by human activities, such as water diversion leading to reduction.

United Nations Environment Program (UNEP) pointed out that land degradation and desertification in Africa, as well as deforestation related to human activity, is leading to soil degradation. That is the main reason to use and study Land Cover/Land Use change, since the African desertification process affects 46% of the African continent(Reich et al.; Ibrahim et al.). Land in Africa is seriously threatened; large-scale land degradation has been reported, whereby more than 43% of the area of land degradation can be defined as extreme desertification (Lawrence and Vandecar). The cause of desertification is not only due to natural Influencing factors, but also socio-economic factors, such as land use rights, marketing, policies and regulations, labor income, human health, policy incentives and political stability, etc. (Sivakumar and Stefanski).

If people do not have land and water use rights and accessibility, it is difficult consciously for conservation and management of land and water resources. They will focus on meeting short-term needs of economic development, and thereby cause damage to the ecosystem(Wu et al.).

Urbanization is a complex process; its impact on human life extends from rural to urban (Davis). Urbanization process in Rwanda with the increase of population and the development of social economy continues to accelerate(Tigabu, Berkhout and van Beukering). Mainly for the following aspects: the urban population is growing, land for construction and urbanization has improved rapidly, urban land significant change. This is because only the transformation or change Land Use patterns, human economic needs can be met. Remote sensing images have macroscopic features such as real-time, in the monitoring of land use change has been widely used, for trend analysis of land use change and urbanization providing data and technical support (Brown et al.),(Rawat and Kumar). This article aims to assess by using remote sensing technology, GIS tools and

statistical analysis the Land Cover and Land Use change of Runda due to Kigali city urbanization between the year 1990 and the year 2017, and output Land Cover/Land Use maps of the four years assessed, in order to provide decision-making basis for regional sustainable development.

Materials and methods

Description of the Study Area

Our study area namely Runda, is one of the satellite cities surround the city of Kigali. Runda is located at 1.58°S and 29.56°E, with a total area of about 51 km^2, it is an area situated at high altitude compare to its neighbouring areas. Gihara, Kabagesera, Kagina, Muganza and Ruyenzi are its respective cells.

The annual precipitation rate is 900 mm, with an average annual temperature varies between 20°C-21.6°C. There are four seasons: There are four seasons: the long rainy season from mid-March to mid-May; the long dry season from mid-May to mid-October; the short rainy season from mid-October to mid-December; and the short dry season from mid-December to mid-March (Nahayo et al.).

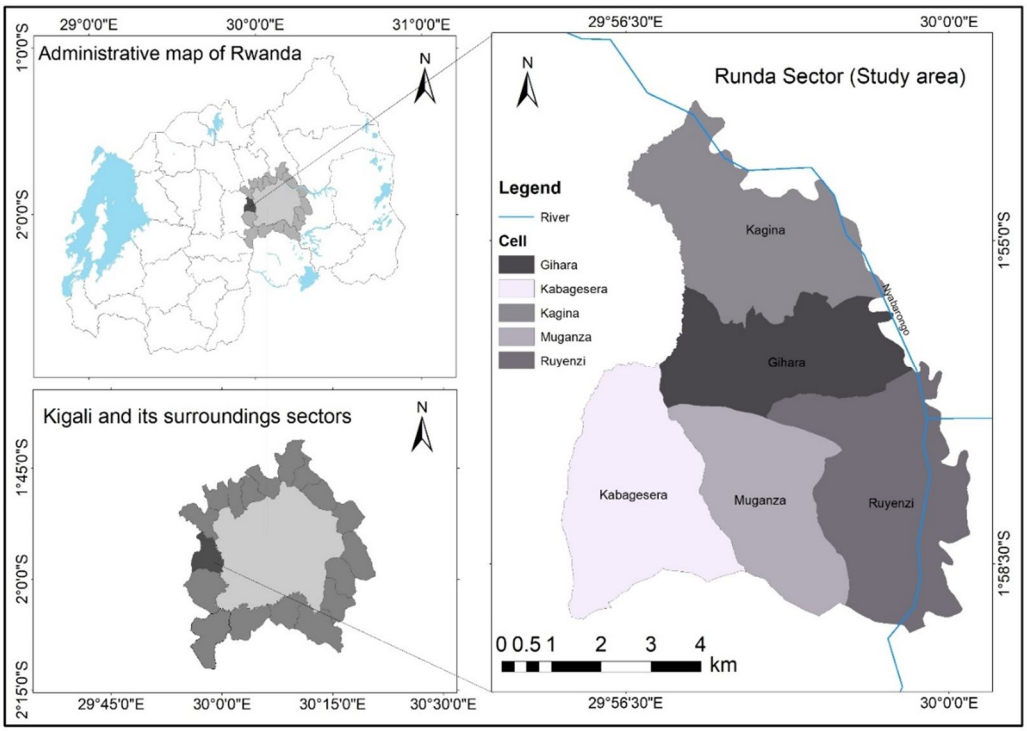

Figure 1. Runda satellite city Map

Data processing methodology

Landsat data

Land Cover/Land Use maps of Runda satellite city has been extracted from LCLU maps of Rwanda for the periods: 1990; 2000; 2010 with resolution of 30m, which acquired from the Regional Centre for Mapping of Resources for Development (RCMRD) Land Cover Viewer database of East Africa. The updated LCLU map 2017 for Rwanda , in which we extracted the LCLU map of

Runda satellite city, was obtained through image classification of the 2017 Landsat-8 imagery delivered by the United States Geological Survey (USGS) global visualization(USGS) using the supervised maximum likelihood classification method (Otukei and Blaschke) in ENVI software version 5.2 (Exelis Visual Information Solutions, Inc., a subsidiary of Harris Corporation, Boulder, CO, USA)(Basnet and Vodacek). By using ENVI software, TM images were radio metrically calibrated to link pixels intensities to physical parameters. Image was also atmospherically corrected to retrieve the surface reflectance from the image by removing the atmospheric effects to improve the significant accuracy of image classification. The relevant atmospheric correction parameters in practice are often difficult to determine correctly, usually approximate solution is obtained (Rodgers).

Chavez cost method is an image-based atmospheric correction method that uses only cosine values of solar zenith as parameters, which is used to correct the effects of atmospheric gas absorption and Rayleigh scattering. Using this method, the DN value of the image is converted to radiance and reflectivity.

$$L_\lambda = GAIN_\lambda \times DN_\lambda + BIAS_\lambda \quad (1)$$

and

$$\rho_\lambda = \frac{\pi \times L_\lambda \times d^2}{ESUN_\lambda \times cos\theta} \quad (2)$$

where, Lλ is the cell value as radiance, DN is the cell value digital number, GAIN is the gain value for a specific band, and BIAS is the bias value for a specific band. Where, the unit less planetary reflectance ρλ, d represent Earth-Sun distance in astronomical units, solar exoatmospheric irradiance is explained by $ESUN_\lambda$, and θ is solar zenith angle. These parameters are derived from the literature.

In this study, the maximum likelihood method was selected, and the spectral characteristics of some known land use types were extracted. Take them as a "training sample"; then calculate the statistical eigenvalues of the various types according to the training samples, and establish the classification discriminant function; and finally, the pixel feature vector is substituted into the discriminant function by pixel to find the probability of belonging to each class, and the pixel to be discriminated belongs to a group with the largest probability of discriminating the function.

To determine the classification results, the land use of Runda satellite city was analyzed using pixel-by-pixel statistics and comparative methods; changes in characteristics, by analyzing the driving factors of land use change, to explain the process of migration to Runda satellite city and the relationship between land uses.

Statistical data

The statistical data about the migration of population from Kigali city to Runda, has been collected during the survey conducted while we were on field work in Runda satellite city in November 2017. The Survey conducted have selected randomly the population to be interviewed. In total we have interviewed 555 persons about the duration they have stayed in Runda, their origin before coming in Runda and the reason why they have relocated from the previous living area. Among the 555 persons, as Runda satellite city has 5 cells, in each cell we interviewed 100 persons except in

Ruyenzi sector which seems to be the biggest cell and with a big number of populations compare to other cells of Runda satellite city.

Results and Discussion

Characteristic of LCLU in Runda satellite city

The changes in land use in Runda satellite city from 1990, 2000, 2010 and 2017 are shown in the following findings (Table 1 and Table 2). The results show that from 1990 to 2000, from 2000 to 2010 and 2010 to 2017 land use types have undergone great changes.

Table 1. Land Use Distribution (Years 1990, 2000, 2010 And 2017)

	1990		2000		2010		2017	
Land use type	Area (ha)	%	Area (ha)	%	Area (ha)	%	Area (ha)	%
Forestland	26719	47.040	17970	31.637	10530	18.538	4619	8.134
Grassland	3579	6.301	686	1.208	2058	3.623	2631	4.633
Cropland	21173	37.276	32905	57.930	41986	73.918	45383	79.918
Wetland	5309	9.347	5221	9.192	2206	3.884	3180	5.600
Settlement	21	0.037	19	0.033	21	0.037	974	1.715

Table 2. LCLU change detection from 1990-2017LCLU

Type	1990-2000		2000-2010		2010-2017	
	area	%	area	%	area	%
Forestland	-8749	-15.40	-7440	-13.10	-5911	-10.40
Grassland	-2893	-5.09	1372	2.42	573	1.01
Cropland	11732	20.65	9081	15.99	3397	6.00
wetland	-88	-0.15	-3015	-5.31	974	1.72
settlement	-2	-0.004	2	0.004	953	1.68

As shown in the results (Table 1 and table 2), Runda has known changes from 1990 to 2017 in Runda satellite city, in each category of LCLU as analysed. Forest land from 1990 to 2000 known a change of 15.403% which equal to 8749 ha, from 2000 to 2010 known a change of 13.093% which equal to 7440 ha and from 2010 to 2017 forest land known a change of 10.4% which equal to 5911 ha.

For Grassland we have observed a change of 5.093% which equal to 2893 ha from the year 1990 to 2000, from 2000 to 2010 it known a change of 2.415% which equal to 1372 ha and from 2010 to 2017 the gain was 1.010% which equal to 573 ha.

For cropland, we observed the increasing of the terrain where from 1990-2000 the gain was 20.655% which equal to 11732 ha, from 2000 to 2010 we observed the gain of 15.987% which equal to 9081 ha and from 2010 to 2017 the gain was 6.000% which equal to 3397 ha.

For the wetland, the changes acquired as follow: from 1990 to 2000 we observed the change of 0.155% which equal to 88 ha, from 2000 to 2010 the changes were 5.308% which equal to 3015 ha and from 2010 to 2017 the changes were 1.716% which equal to 974 ha.

For the settlement the changes observed from 1990 to 2000 was loss of 0.004%

which equal to 2 ha and from 2000 to 2010 we observed a gain equal to the loss of the past 10 years and from 2010 to 2017 this gain increases considerably because it the period where people started quitting Kigali city to its boundaries, the gain was 1.678% which equal to 953 ha.

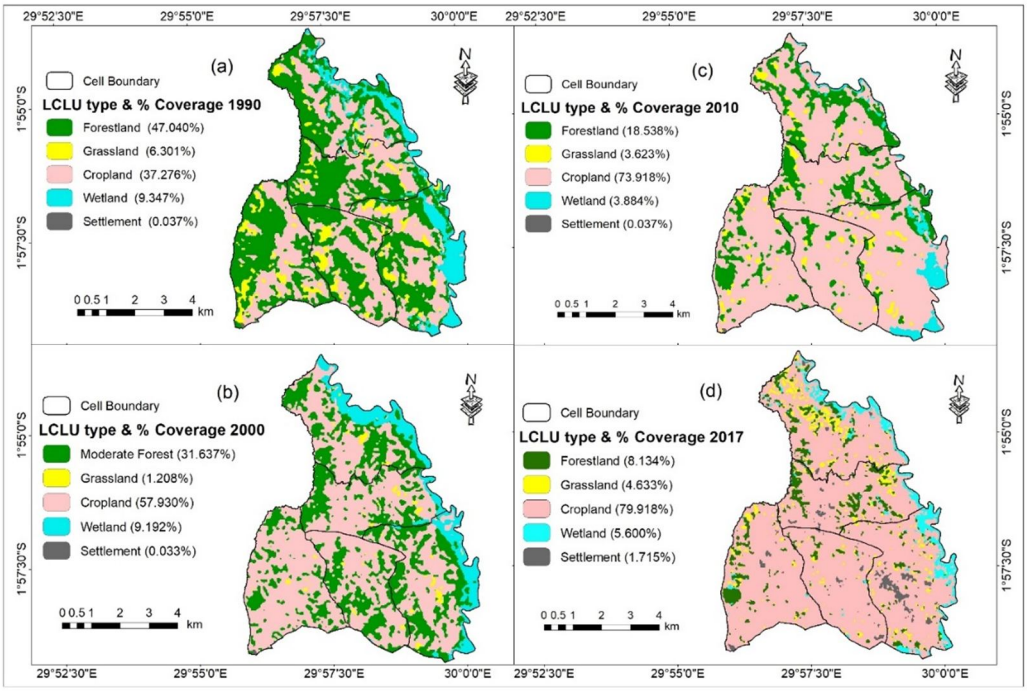

Figure 2. LULC images classification

Migration Statistical analysis

To understand well the migration from Kigali city to Runda satellite city phenomena, we have conducted a survey which helped us to understand how population has increased and this by the end affected LCLU of Runda sector. By the use of Origin Pro and SPSS software, we arrived to analyse the corrected data during our field work in the month of October to December 2017. As shown in the results (table 3), we have classified people in four different categories about the duration which they stayed living in Runda satellite city. The first category is for those who stayed less than 2 years; in this category we found that 312 among 555 interviewed people have stayed in less than 2 years which equals to 56.33% of interviewed persons.

Table 3. Responses about the duration stayed in Runda satellite city

Answers	Frequency	Percent
stay < 2 years	312	56.22
stay 2-3 Years	85	15.32
stay 3-4 years	99	17.84

Stay 4 <	59	10.63
Total	**555**	**100**

The second category is the persons who stayed between 2 to 3 years and we found that 85 persons among 555 stayed in Runda satellite city only the period between two to three years and this number equal to 15.32% of the interviewed persons. The Third category are those who stay in Runda satellite city for a period between three to four years, and these are 99 persons among 555 interviewed which equal to 17.84%. The Fourth category is for those who stay in Runda more than 4 years, these are 59 persons among 555 persons interviewed which equal to 10.63%. Considering the period of our survey, these numbers show that a big number of people who are staying in Runda have occupied this area between 1990-2017 year which is the period our research.

In the results (table 4), we have asked the questions related to the origin of our respondent to Runda satellite city. The questions were to know if they stay in Runda because it the place where they were born means their father's land, other question was to know from where they were living before coming in Runda satellite city.

The results show that in 555 persons interviewed, 418 persons relocated from Kigali city, and this equal to 75.3%, 123 relocated from other parts of the country which equal to 22.2% and 14 of them are staying in Runda because it is their father's land which equal to 2.5% of interviewed persons.

Table 4. The origin of respondent before coming in Runda satellite city

Answers	Frequency	Percent
relocated from Kigali city	418	75.3
relocated from other provinces	123	22.2
My father's land	14	2.5
Total	**555**	**100**

In the results (table 5), we have evaluated the reason on which the population has relocated from their origin to Runda satellite city. In 555 interviewed persons, 139 said that the houses in Runda are cheap for them comparing to their origin place, this number equal to 25.05% of total respondents. 274 persons said that they have built their own house in Runda, this number equal to 49.37% of the total respondents. 128 persons said that Runda is near to Kigali city, it means they can access their job easily at any time, this number equal to 23.06% of the total respondents. 14 persons said are locally born in Runda satellite city, this number equal to 2.52% of total respondents.

Table 5. The reasons of respondents for relocating to Runda satellite city

Answers	Frequency	Percent
House location is cheap here	139	25.05
I built a house here	274	49.37
Is near my job	128	23.06

My father's land	14	2.52
Total	**555**	**100**

Conclusions

The Driving Factors of Land Cover/ Land Use Change: As the capital of Rwanda, Kigali must experience an expansion of the city area, increase the internal employment rate and attract international investment in commercial, industrial and service sectors, to enhance their economy, but also must make prevision for present and future residents, which will continue to rise as the population grows, increasing the need to provide accommodation and activities. This planning of the city, become a problem of some residents who are living there without their own house because more the population growth in the city increase, the rent cost increase too. The overall planning of Kigali City exercises some impact into environment, land use, infrastructure, cultural and socio-economic factors, and predicts economic and demographic development and provides opportunities and constraints for surrounding area of this city. To achieve the above objectives, the government has set different stages for the Master Plan and described in detail the design, strategy and action programs that will guide the planners and citizens of the surrounding area to have more detailed areas in the future planning and practical measures.

Thus, changes in land use significantly represent the important role that human activities play in the Runda satellite city. In addition, considering the natural situation of the Runda satellite city, agriculture in the region was occupy a dominant position, and with the population growth and socio-economic development, construction land area will gradually increase, and the process of urbanization will accelerate. From 1990 to 2017, the Runda satellite city, after the 1994 genocide, led to a shift in land use due to factors such as construction of new houses of population moving from the Kigali city.

Our findings show a significant increase in construction land between 2000 and 2017, and the reduction in green area due to the implementation of urban renewal after the 1994 genocide. Between 1999 and 2009, as the Rwanda government developed a city and its surroundings master plan, the demolition of all buildings outside the planning area resulted in a reduction in construction land which conducted this city to be expensive and the movement of population to its surrounding, because it is the place where they can find affordable house to rent or where they can find a land where they can build their own house. Rwanda, as a developing country, its population continues to grow and land use is low and urbanization is still increasing.

As shown earlier, factors such as population growth and urbanization have led to radical changes in land use; thus, our recommendations go to the involvement of interdisciplinary stakeholders and policy framework to take care of this phenomena of migration, in term of land use planning and environmental protection, also further research can conduct their assessments on analysis of Rwanda's natural social and economic factors which could be, the causal factors of Land Cover/Land Use change.

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Conflicts of Interests

Authors have not declared any conflict of interest

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