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THE EFFECT OF DIMINISHING URBAN GREEN SPACES ON ENVIRONMENTAL QUALITY IN KISUMU CITY

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ABSTRACT: *Green spaces contribute to aesthetics and environmental quality of life in urban areas. Kisumu City, the study area, has been experiencing demographic, environmental, economic, socio-spatial and institutional challenges leading to loss of green spaces. The main problem addressed by the study was dysfunctional use of green spaces leading to their loss, aesthetic value and low environmental quality. The study objective was to determine the effect of spatial change of urban green spaces on environmental quality. Data were both qualitative and quantitative and were collected through observation, interviews, questionnaires, photography, remote sensing and Geographic Positioning System (GPS). Qualitative research focused on site-specific analysis of urban and peri-urban neighbourhoods in Milimani and Nyalenda, respectively, which were purposively sampled. Results showed that area under green in 2005 was 44.8% while in 2004 it was 24.87% showing a decrease of 55.5%. However, in 2010, there was a temporary increase of green space of 51.82% due to demolitions to pave way for road expansion leading to decrease in carbon sink, resulting in increase in carbon footprint. This has led to low environmental quality. The study projects that by the year 2030, without proper planning interventions, the city will lose all its urban green cover. The research recommends the use of remote sensing for creating land-use inventory and monitoring systems. Citizen involvement in planning and management of urban green spaces is recommended because this will transform ecotourism in Kisumu City.*

KEYWORDS: Green Planning, Open Space, Land Use, Quality of Life, Change Detection.

INTRODUCTION

Urban areas are today experiencing high population growth thus sprawling into the rural regions (Mahesh, Nitim & Vivek, 2012; UNEP, 2011). This has had a negative impact leading to deterioration in both the built and physical environment. As a result of this, urban areas have experienced pressure on infrastructure and other important services such as health provision. Urbanization has caused a number of problems in most African cities today leading to low environmental quality (Mahesh *et.al.*, 2012; UN-HABITAT, 2009).

Planning for different land uses is invariably complex, involving many stakeholders with different priorities in decision making (Owino, Hayombe & Agong', 2014a). These land use decisions are important in land use control. They have a direct impact on urban green spaces. Different communities require productive land for various uses such as cultivation and physical development (World Economic Forum, 2011). Food production requires resources such as land, water and energy and all these are dependent on land use decisions. Good land use decisions are only possible if planning regulations are followed and implemented. Urban Environmental Quality (UEQ) on the other hand is also affected by land use decisions.

Various studies on the effect of planning decisions on UEQ have been carried out over a long period of time as observed by Li & Weng, 2007; Keiner, 2004; Wilson, Clay, Martin, Stuckey and Vedder-Risch, 2003; Abolina & Zilans, 2002.

Statement of the Problem

Green spaces and other public protected areas have been affected as a result of governments not being able to ensure that there is orderly and sustainable development in cities (Owino, Hayombe & Agong' (2014b). The main research problem is that environmental quality in Kisumu City is declining because of diminishing green spaces which has lead to decrease of their aesthetic value thus affecting the socio-economic structure of the local communities and ecotourism.

Study Objective

This study had a broad objective of determining the influence of spatial change of the area under urban green space on environmental quality in Kisumu City from the year 2005-2014.

Study Area

The study focuses on Kisumu City, which is the third largest in Kenya after Nairobi and Mombasa. It is located in Kisumu County which is within the Lake Victoria Basin (GoK, 1989). Kisumu was designated the first United Nations Millennium City in 2006 and had the challenge of meeting the Millennium Development Goals (MDGs). The vision of the city was to become a hub of knowledge, tourism and commerce in the East African region (UN-HABITAT, 2012). This dream has not been realized up to date.

METHODOLOGY

Case study strategy was adopted in this research as it sought to investigate and describe the study aspects in detail, contextually and holistically. It is a context specific phenomenon that may best be described and understood by the case research method. A case study is not a method, but a research strategy, which in detail investigates an area with the aim to provide an analysis of a phenomenon in a real life context, which highlights the theoretical issue being studied (Hartley, 2004).

Data Collection

Sources of data were both primary and secondary. The combination of these two techniques helped in balancing their strengths and weaknesses so as to achieve a higher degree of reliability and validity. Secondary data included reports from government ministries, materials from journals, reports and books. Primary data was collected through a number of methods namely observation, interviews, questionnaires, photography, Geographic Positioning System (GPS) and Remote Sensing which was used to collect geospatial data for Change Detection Analysis. These images were QuikBird, WorldView 2 and GeoEye (Figure 1, 2 and 3) which were of 50 cm resolution in multi spectral mode. These are very high resolution images suitable for Change Detection Analysis. The high resolution level of these three images justifies their use as opposed to other satellite images.

Figure 1: 2005 QuickBird Image of the Study Area

Source: DigitalGlobe, 2015

QuickBird image offers a good base for data which is useful in the analysis of land use changes, farming and forest land.

Figure 2: 2010 WorldView 2 Image of the Study Area

Source: DigitalGlobe, 2015

WorlView 2 provides full colour images for enhanced spectral analysis, mapping and monitoring applications. Similarly, the system supports for land use planning, disaster relief, exploration, defense, intelligence, visualization and simulation environments.

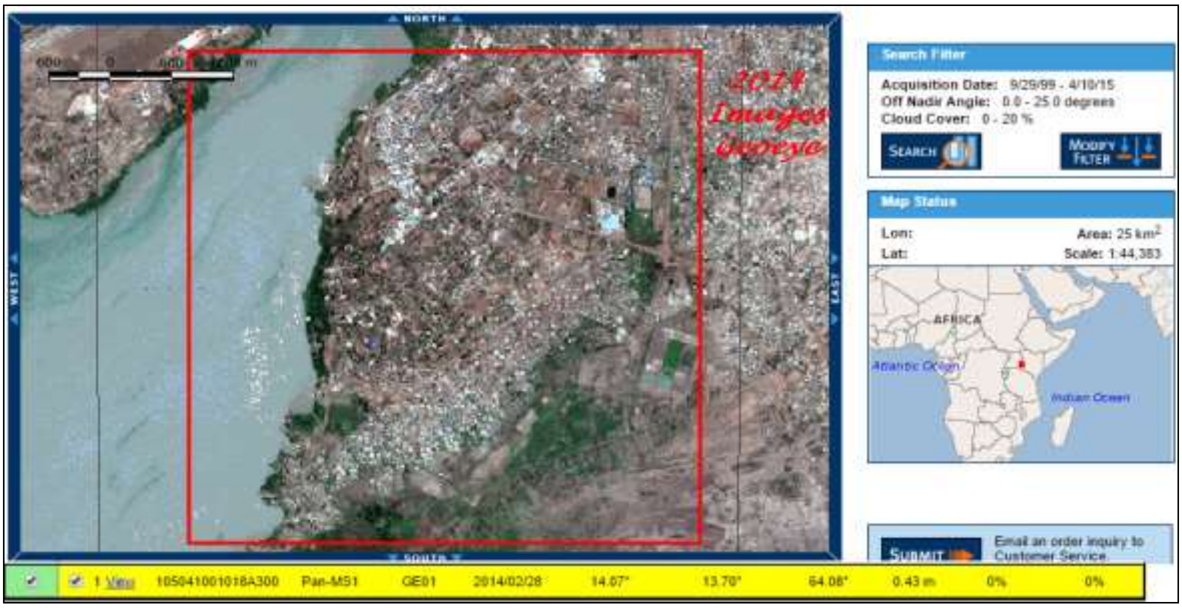

Figure 3: 2014 GeoEye image of the Study Area

Source: DigitalGlobe, 2015

GeoEye is the world's highest-resolution commercial color imaging satellite. It is very accurate and provides very detailed data.

Data Analysis

This research employed a variety of data analysis techniques based on the objective of the study. These included Change Detection Analysis, Geographic Information System, Time series analysis and Single Land Use Dynamic Degree Analysis

RESULTS AND DISCUSSION

Quality urban green spaces can improve property value. Studies show that the market value of a property decreases when its distance away from parks, greenbelts and other green spaces increases (Economic Fact Sheet, 2008). Well planned and managed public space also has a positive impact on nearby residential house prices. Studies in the Netherlands show that a garden bordering water can increase house prices by 11%, while a view of a park increases prices by 8%, and having a park nearby raises real estate value by 6%. In comparison, a view of an apartment block can reduce price by 7% (Luttik, 2000). By helping to increase the value of homes, parks and other public spaces generate increased taxes paid to government when properties are bought and sold (CABE Space, 2005).

Land Cover Change in Milimani and Nyalenda from 2005-2014

Data collected from the three satellite images were subjected to a Time Series Analysis from 2005, 2010 and 2014 (Table 1).

Table 1: Spatial Change in Land Use over Time on the Basis of Data Obtained during the Study

	2005		2010		2014	
Year	**Area in km^2**	**%**	**Area in km^2**	**%**	**Area in km^2**	**%**
Urban green	11.66	44.8	13.61	51.82	6.48	24.87
Tarmac roads	0.40	1.52	1.30	4.95	2.17	8.31
Bare land	0.16	0.63	0.15	0.584	1.95	7.46
Area under water	7.03	26.91	4.77	18.15	8.19	31.43
Built up area	6.76	25.98	6.39	24.34	7.19	27.57

In 2010, the proportions of various land types had tilted. For example, built up area decreased from 25.98% to 24.34% between 2005 to 2010. In 2014, built up area in all land types, played a primary role and increased to 27.57% (Figure 4.1). It decreased slightly from 25.98% in 2005 to 24.34% in 2010 as a result of densification. This was mainly in Milimani whereby bungalows were demolished to pave way for high-rise buildings for commercial use. It then increased to 27.57% in 2014 because of the high rate of development in Milimani and Nyalenda.

Built up area and green cover have the greatest changes in all the land use types. The built up area increased the fastest compared with others. From 2005 to 2014, that is over 9 years, the built up area had increased to 7.19 km^2, the average annual increase was 0.084 km^2. This shows that urban land during this period was growing rapidly. The maximum decrease rate in green cover, was from 11.66 km^2 in 2005 to 6.48 km^2 in 2014. Consequently, it became main object for urban land use change analysis.

Urban green land, waters and built up area appear to have different degrees of reduction. Green land increased in 2010 though the average rate of change was small. The increase was from 44.8% in 2005 to 51.82% in 2010. This was as a result of demolition of bungalows to pave way for new developments. Results indicate that the percentage of urban green area increased significantly in the five year period by more than 10%.

The area of green land in the study area apparently registered a severe reduction over the period under study. The reason for the increase in bare land from 0.584% in 2010 to 7.46% in 2014 is attributed to the clearing of vegetation mainly in Nyalenda after sale and subdivision of land. This is mainly done by developers when they intend to put up buildings for commercial and residential use. It also leads to reduction in urban green.

Descriptive statistics of these trend data were also calculated apart from Time Series Analysis. This was suitable for analysis of land use change over time from QuickBird, WorldView 2 and GeoEye images (Figure 4, 5 and 6) respectively.

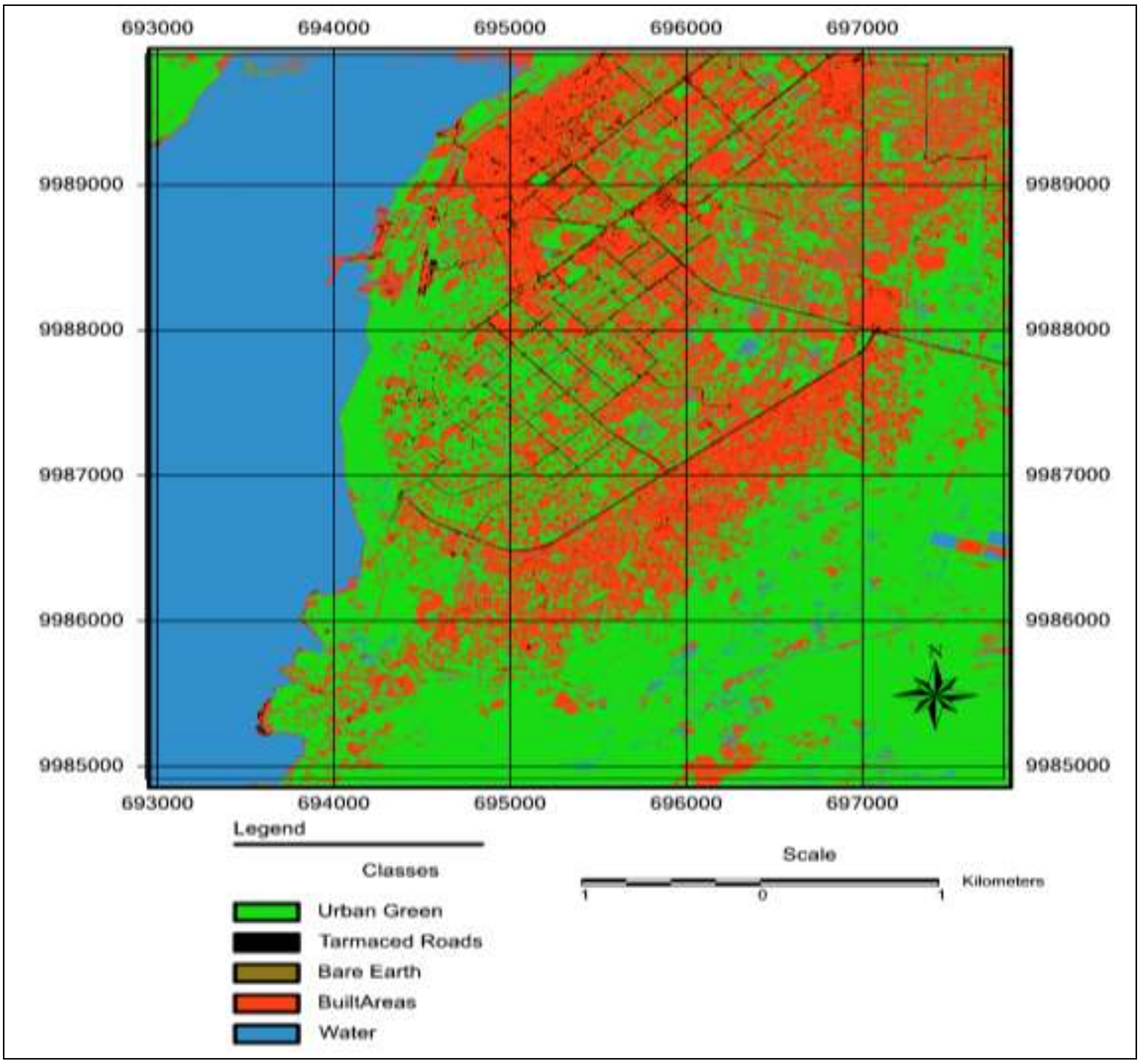

Figure 4: Land Use Classes in Milimani and Nyalenda in 2005

From this computation on the land use change over time, it is evident that greater change was recorded in 2014 compared to that of 2005 and 2010. This calls for a much more coordinated approach to restrain change of land use without following laid down regulations and procedures.

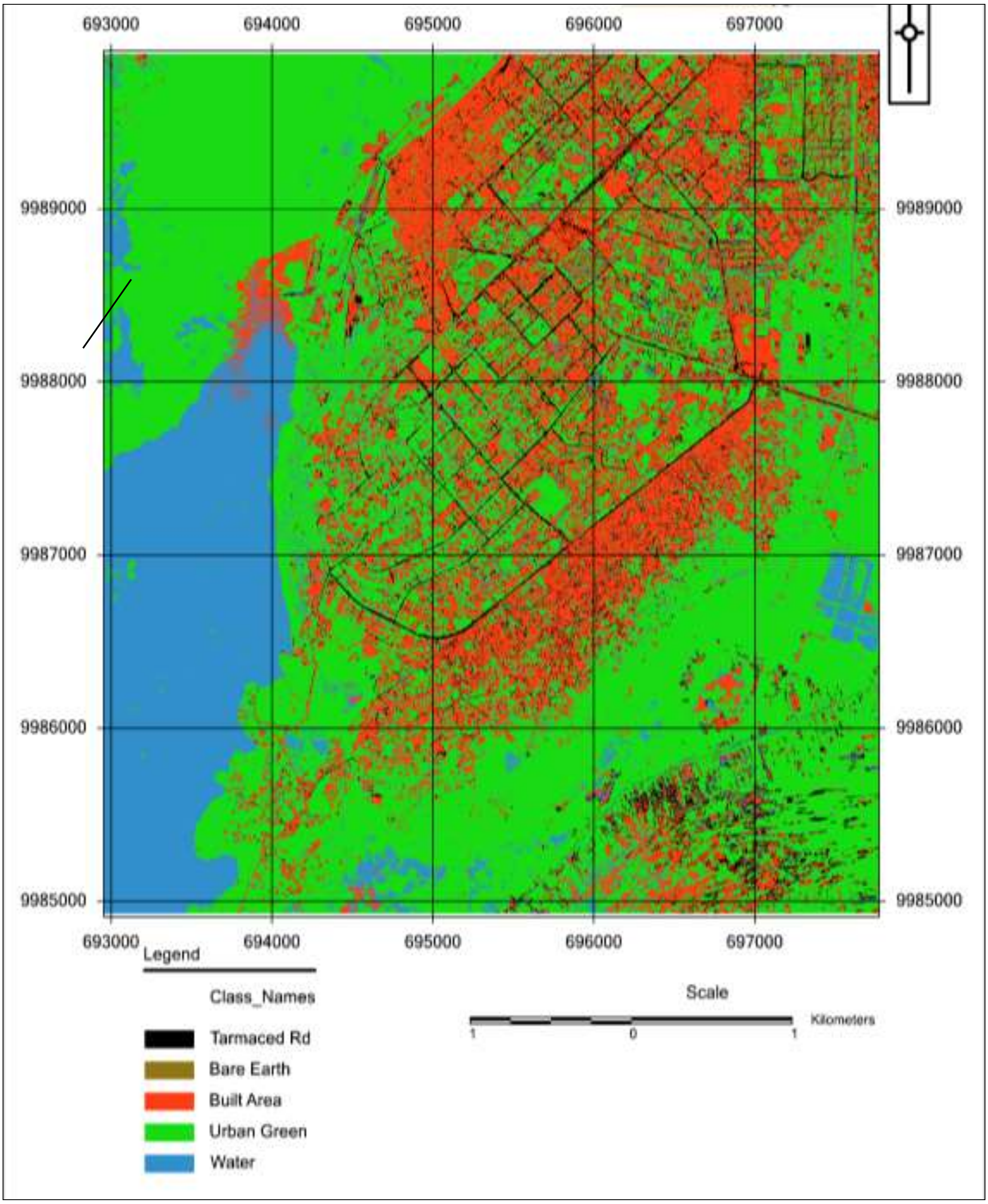

Figure 5: Land Use Classes in Milimani and Nyalenda in 2010

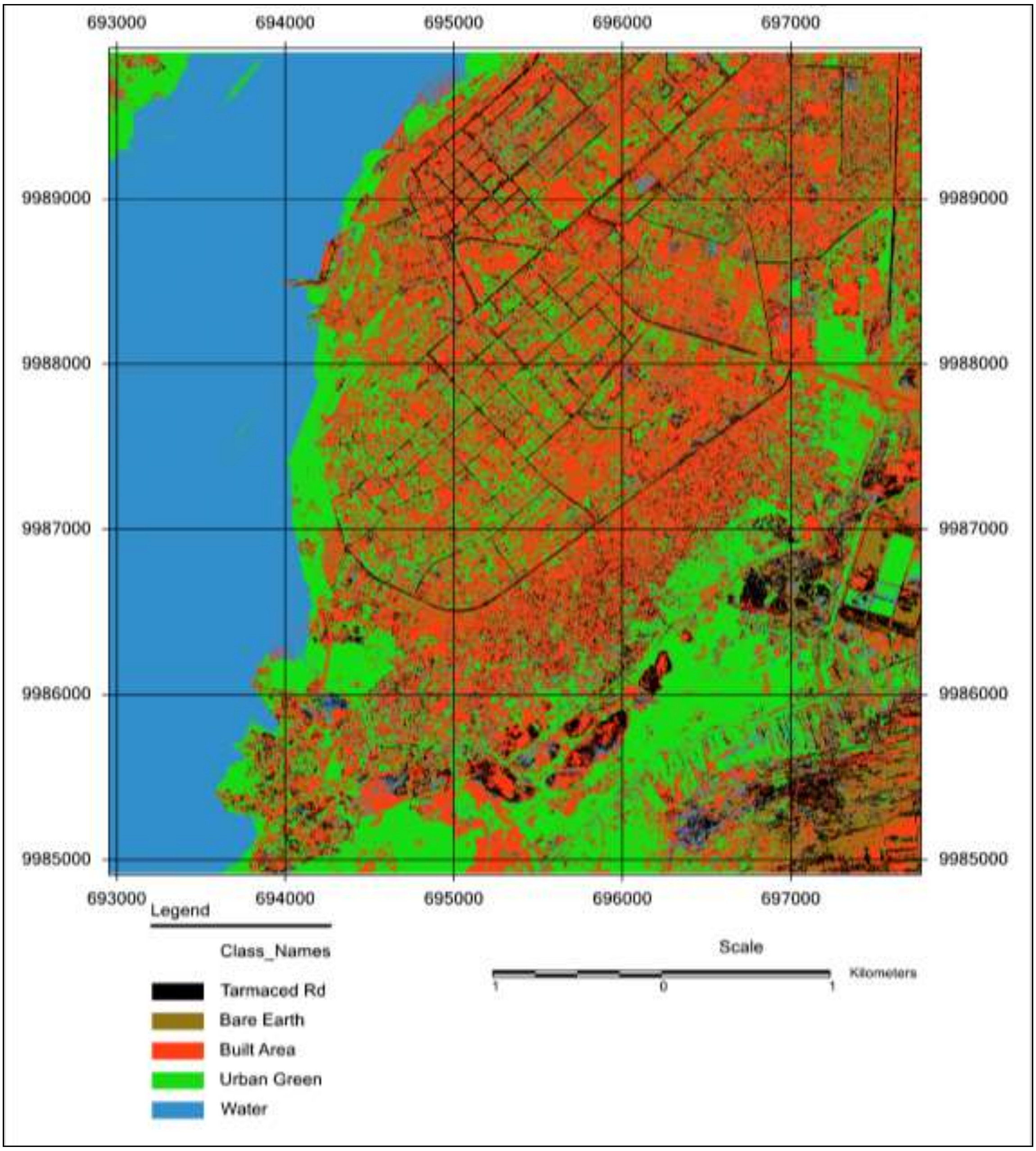

Figure 6: Land Use Classes in Milimani and Nyalenda in 2014

The statistics were generated from the confusion matrix of the classified 2005 image of Quick Bird. In the confusion matrix and the ground truth regions of interest were generated from the true image and compared against the classified image with five classes, namely bare land, urban green, area under water, built up areas and tarmac roads.

The classified classes were reduced by a combination processes after sieving and clumping from twelve (12) to five (5) main classes namely urban green, area under water, bare land, tarmac roads and built up areas. It was established that the urban green comprised 44.8% of the study area. The same procedure was followed in classification of images in the year 2010 and 2014 respectively.

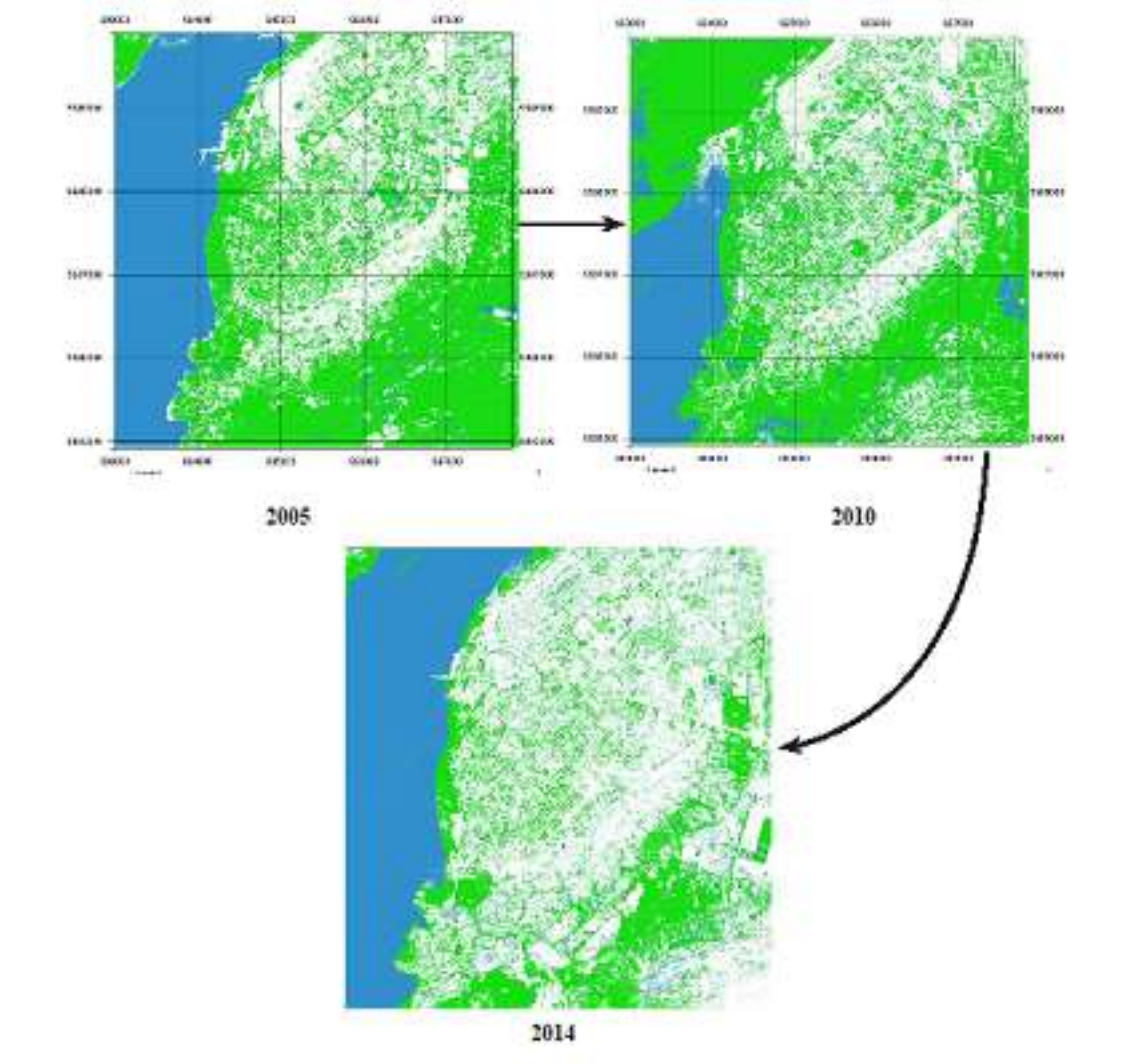

Figure 7: Spatiotemporal Changes in Urban Green and Lakefront Areas in Milimani and Nyalenda in 2005 to 2014

According to characteristic analysis of area change in Nyalenda and Milimani, the study found the characteristics of land use change as follows.

In 2005, the distribution of urban green, tarmac roads, bare land, area under water and built up area in the overall structure of the study area, the largest proportion is green area (Figure 7) of nearly 44.8%.

Analysis of Land Use Change from 2005 to 2010

Land use unit is always changing. But in the process, there are key problems encountered: namely land use conversion from one form to another, the process of conversion itself, and the extent of conversion. Evidence of land use changes are the high rise buildings for commercial use which can be noticed within the study area. All of these parameters were considered in this study.

Table 2: Land Use Change from 2005 to 2010

Land Area (km^2) in 2010	Land Types	Urban green	Tarmac roads	Bare land	Area under water	Built up area	Raw totals	Class total
		Land Area (km^2) in 2005						
	Unclassified	0.00	0.01	0.00	0.02	0.00	0.04	0.04
	Urban green	0.02	8.14	3.01	2.01	0.05	13.22	13.23
	Tarmac roads	0.01	0.45	0.07	0.62	0.13	1.28	1.28
	Bare land	0.05	0.02	0.01	0.08	0.00	0.15	0.15
	Area under water	0.01	0.88	3.26	0.40	0.02	4.57	4.57
	Built up area	0.07	1.57	0.33	3.60	0.17	5.73	5.74
	Class total	0.16	11.06	6.67	6.73	0.37	0.00	0.00
	Class changes	0.11	2.93	3.41	3.13	0.24	0.00	0.00
	Image difference	-0.01	2.16	-2.10	-0.99	0.91	0.00	0.00

The characteristics of the number and structure of land use changes can help to discover the trend and evolution of urban land use. Information of current land use in the study area shows the features of conversion among urban green, tarmac roads, bare land, area under water and built up area and other land-use types from 2005 to 2010 (Table 2).

The area of urban green that converted into built up area and tarmac roads are 0.07 km^2 and 0.01 km^2 respectively. Those converted into unused land were 0.02 km^2. The overall changes of urban green land is 0.11 km^2. The area of bare land converted to built up area and urban green was 0.33 km^2 and 3.01 km^2 respectively. Overall change was 3.41 km^2, with reduced area of 2.10 km^2. Area under water which converted to urban green was 2.01 km^2. Its area reduced to 0.99 km^2. The area under water that did not convert remained at 0.40 $km^{2.}$

Analysis of Land Use Change from 2010 to 2014

With the process of urbanization, commercial and residential areas grew rapidly. Based on the original scope and area, built up land registered a continuous increase.

Table 3: Land Use Change from 2010 to 2014

		Land Area (km2) in 2010						
	Land Types	**Urban green**	**Tarmac roads**	**Bare land**	**Area under water**	**Built up area**	**Raw totals**	**Class total**
Land Area (km2) in 2014	**Unclassified land**	0.04	0.01	0.00	0.01	0.03	0.08	0.09
	Urban green	4.50	0.18	0.00	0.62	0.92	6.22	6.23
	Tarmac roads	1.17	0.27	0.00	0.12	0.54	2.11	2.11
	Bare land	0.98	0.19	0.02	0.14	0.53	1.86	1.86
	Area under water	3.24	0.57	0.12	0.45	3.47	8.22	8.24
	Built up area	3.60	0.07	0.00	3.24	0.46	7.01	7.02
	Class total	13.53	1.29	0.15	4.58	5.96	0.00	0.00
	Class changes	9.03	1.02	0.13	1.34	2.49	0.00	0.00
	Image difference	-7.30	0.82	1.71	2.43	2.28	0.00	0.00

In the core and peripheral areas of the city appeared a series of new external development base and expansion area. The land types and area of land use change from 2010 to 2014 in Kisumu city are as shown in Table 3 above.

From 2010 to 2014, the urban land had expanded rapidly. Built up area increased from 5.96 km^2 to 7.02 km^2, and the area under water, tarmac roads, urban green land transformed into built up area of 3.24 km^2, 0.07 km^2, and 3.60 km^2, respectively. Urban land was mainly stimulated by traffic conditions namely transport and accessibility, so commercial land use with convenient conditions continued to expand from the CBD to Milimani and Nyalenda.

Urban green, tarmac roads, bare land, area under water and built up area all had different increases. Urban green land was always facing a downward trend whose area decreased from 136.83 km^2 to 114.09 km^2 during 2005-2010. Urban green land converted into relatively large proportion of built up area. The area of conversion to tarmac roads and bare land was relatively small. With the process of urbanization, urban green land surrounding the city was occupied continuously. Convenient traffic provided excellent conditions for people, which lead the direction of changing from urban green land to built up area mainly for commercial development. Waters of the lake were often land filled, eventually occupied by green land or commercial areas thus converted to urban land use. From analysis of the image, underutilized areas mainly open spaces were often converted into new built up areas thus reduction in their acreage.

Analysis of Land Use Change from 2005 to 2014

Table 4 shows change detection of the various land use classes from 2005 to 2014 covering the entire period of study.

Table 4: Land Use Change from 2005 to 2014

Land Area (km^2) in 2014	Land Area (km2) in 2005							
	Land Types	**Urban green**	**Tarmac roads**	**Bare land**	**Area under water**	**Built up area**	**Raw totals**	**Class total**
	Unclassified	0.01	0.00	0.00	0.00	0.01	0.02	0.02
	Urban green	8.02	0.44	0.02	0.96	1.56	11.00	11.01
	Tarmac roads	0.05	0.13	0.00	0.02	0.19	0.39	0.39
	Bare land	0.02	0.01	0.05	0.01	0.07	0.16	0.16
	Area under water	3.03	0.07	0.01	3.28	0.35	6.74	6.75
	Built up area	1.98	0.62	0.08	0.45	3.52	6.66	6.67
	Class total	13.12	1.28	0.15	4.73	5.69	0.00	0.00
	Class changes	5.10	1.15	0.11	1.45	2.17	0.00	0.00
	Image difference	-2.10	-0.89	0.01	2.01	0.99	0.00	0.00

The urban green is the most active type which converted to other land use types, including tarmac roads and built up areas. Meanwhile, the area of urban green converted to tarmac roads was 0.05 km^2. The area of urban green that did not convert was 8.02 km^2, and the area converted to built up land was 1.98 km^2 over the period of study. On the whole, change area of urban green was 5.10 km^2 in this period, and the decrease area is 2.10 km^2.

Bare land converted to the other three types was small proportionately thus, the largest area remained bare land without changing. The areas that converted into green land and built up area were 0.02 km^2 and 0.08 km^2 respectively. Bare land did not convert to tarmac road during this period. The area under water that did not convert to other land uses was 3.28 km^2. The overall change of area under water was 1.45 km^2. Meanwhile, the increased area was 2.01 km^2. The area of built up land converted to urban green, tarmac roads, bare land and area under water was more or less. Overall change was 2.17 km^2, with an increase of 1.32 km^2. Area of tarmac roads which converted to urban green was 0.441 km^2, and the area converted to built up land and bare land was 0.62 km^2 and 0.01 km^2, respectively. Overall change was 1.15 km^2. Meanwhile, the area under tarmac roads decreased to 0.89 km^2. Based on the above analysis, each type of land use registered varying degrees of change during this period.

Throughout the study area, developers rushed to secure land for commercial development as opposed to recreational use. This resulted in decreased urban green and as a result, increase in ecological footprint. This is because of clearance of vegetation and forests which acts as carbon sinks. Clearing of the vegetation and forest would otherwise pave way for buildings at the expense of green space.

Table 5: Land Cover Change of Urban Green over Time

Time in years	T_0	T_5	T_9	$T_{n1=15}$	$T_{n2=25}$	$T_{n3=35}$	$T_{n4=45}$
	2005	**2010**	**2014**	**2020**	**2030**	**2040**	**2050**
Area in km²	11.66	13.61	6.48	5	0	-6	-11

Urban green land drastically converted into other land uses during the study period 2005-2014. This illustrated that urban land use in the study area was in a development stage. This calla for strengthening of the efficiency of land use and land exploitation in the years to come.

Regression analysis has been used to depict the relationship between urban green and time. This is for the purpose of prediction of the area under urban green in the future. The line of best fit indicates that the relationship between area under urban green and time is very strong. It is a negative relationship meaning that if planning intervention measures are not put in place, the city will lose all its green space by 2030 (Figure 8).

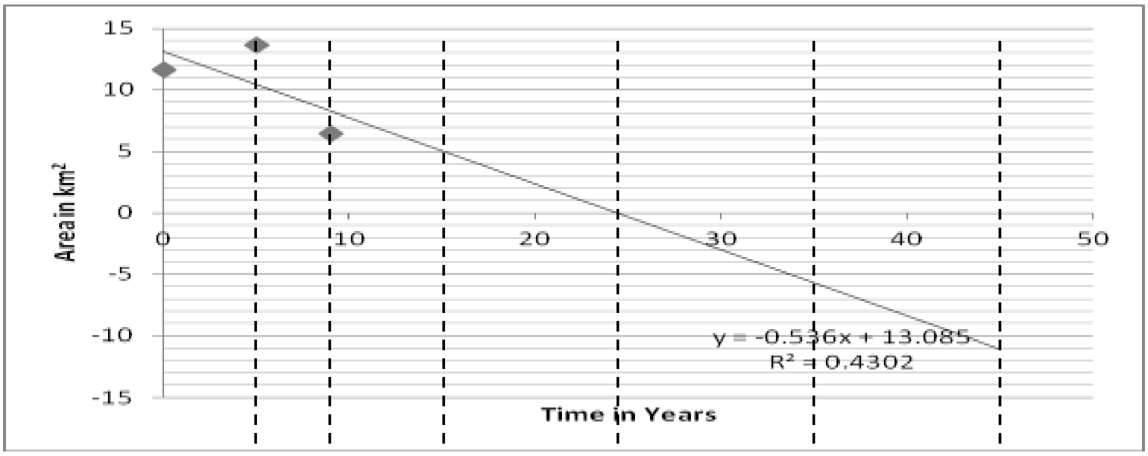

Figure 8: Scatter Chart on Land Cover Change of Urban Green over Time

The coefficient of determinacy (R^2) indicates that 43% of the variability between the two variables (area under green and time) have been accounted for and the remaining 57% can be attributed to the lurking variables namely areas under built up areas, tarmac roads, water and bare land.

CONCLUSIONS

In conclusion, results have shown that urban and environmental planners have two important tools to guide the city growth of the future, regional planning legislation and the cost effective techniques of using high resolution satellite imagery. This would go a long way in enhancing the urban environmental quality and aesthetics thus improving the quality of life for the inhabitants of the city.

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