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Comparative Quantification of Urban Physical Expansion's Contribution to Green Spaces Change in Kisumu and Eldoret Towns of Kenya

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Abstract

Despite their importance, urban green spaces are under severe threat and urbanization has been shown to be the main driver. Unfortunately, not much is known about how urbanization has played a role in the decline and more so in the cities of Sub-Sahara Africa (SSA). This study therefore sought to fill this gap by studying Kisumu and Eldoret towns of Kenya as cases with the objective of quantifying the impact urbanization on green spaces availability. Using supervised classification technique, multi-temporal data dated 1989-2019 was extracted from selected Landsat images and error matrix used to check on the validity of data. Results showed that while Kisumu and Eldoret towns experienced tremendous physical growth, green spaces shrunk rapidly. Built-up areas were found to have expanded by 742.30% and 2199.06% in Kisumu and Eldoret respectively from 1989 to 2019 with green spaces shrinking by 50.92% in Kisumu. However, there was a slight increase of 32.11% in Eldoret in the period 1989 to 2019. Findings further showed urban physical growth going beyond the towns' planned boundaries. This study therefore demonstrates that urbanization is a threat to urban green spaces and deliberate spatial planning interventions are needed urgently so that green spaces and associated benefits are protected to promote sustainability of urban areas.

Keywords: Urban Green Spaces, Availability, Urban Growth/Urbanization

INTRODUCTION

That urban green spaces are a premium quality commodity to the residents of urban areas cannot be overstated (Huang & Rozelle, 2002). Urban green spaces refer to those public and private lands in built-up areas that are overlaid with natural or man-made vegetation (Byomkesh et al., 2011). They include the public parks, botanical gardens, playing grounds, sports grounds, urban trees and vegetation, allotments, urban woodlands and forests.

Green spaces offer aesthetic values by beautifying the architectural pattern of cities and towns, improves the air quality of towns, conserves urban biodiversity, acts as carbon sinks, elevates ecotourism, provide employment opportunities and supports cohesion and social interaction of users (Mensah, 2015a; Wolch, Byrne, & Newell, 2014a; Davis et al. 2008; Jim & Chen, 2009). Urban green spaces also play a major role in the development of high-quality human settlements (Jim & Chen, 2009).

It is probably out of these reasons that Ebenezer Howard, the originator of the garden city model in urban planning, stresses the concept of incorporating urban green spaces such as parks and botanical gardens into landmasses of cities (Howard, 1902).

Ultimately, green spaces in urban landmasses becomes, 'the lungs of the city" (Jennings, 2012).

Unfortunately, urban green spaces have been on the decline all over the globe with varying rates of decline (Fuller & Gaston, 2009). A study conducted by Kabisch & Haase (2013), for instance, showed a 26% decrease in urban green spaces in the East European cities between 1990 and 2006. However, it is the urban green spaces in cities of Sub-Sahara Africa (SSA) countries that more pressure on green spaces is being experienced (Girma et al., 2019). Already, Ethiopia has lost about 1410.7 hectares of its urban green spaces to built-up areas in a period 2003 to 2016 was (Girma et al., 2019). In south Africa from the year 1992 to 2016 a loss of 2202 hectares was witnessed this came as a result of non-prioritization of green spaces (Munyati & Drummond, 2020). In Kumasi Ghana, green spaces reduced by 186.45 km^2 of land from 1986 to 2007 (Mensah, 2014).

This decline was associated with the demand of more space for residential purposes. Studies have shown that this pressure on urban green spaces emanates from the high rates of urbanization (Girma et al., 2019; Mensah, 2014). Urbanization is the major cause of loss of urban green spaces (Baycan-Levent & Nijkamp, 2009). Urbanization is termed as growth within an urban area or growth of the town beyond the set boundary such as urban sprawl (Ji et al., 2006). The variables of urbanization are physical expansion and population growth (Crompton, 2001; McDonald, Forman, & Kareiva 2010).

When urban areas grow, they lead to the translation of urban green spaces into built up areas and greatly damaging the urban environment such as parks and urban forests (Altay et al., 2012).

A research done in the European countries found that 9000 ha of urban green spaces were converted in built up areas and urbanization was mentioned as the main reason behind it (Romano & Zullo, 2016).

More so in greater Dhaka Bangladesh green spaces are continuously decreasing over time and are ascribed to population increase (Byomkesh et al., 2012b). More so in Dalian, China a study found out that urban green spaces were reducing and this was leading to rise in temperature due to urbanization (Yang et al., 2017). Furthermore, in most developing nations, it is therefore expected that the rise in the rate of urbanization is bound to have a great implication on urban green spaces (Kestemont, Frendo & Zaccai, 2011).

Comparative studies on urbanization in Kenya and Ghana has, for instance, revealed that Kenya had a higher number of urban centers (350) and the urbanization rate had increased from 8% to 35% percent by the year 2007, which had in turn impacted negatively on urban green spaces (Otiso & Owusu, 2008). According to United Nation 2015 it is speculated that by 2050 the urban population will be 2.5 billion and this will occur from Asia and Africa, and 1.26 billion will be urban residents unlike the current 400 million dwellers (Profiroiu et al., 2020).

Yet very few studies have attempted to quantify this effect of urbanization on green spaces availability, or rather, decline (Cilliers et al., 2013; Du Toit et al., 2018) . Furthermore, most research conducted concerning the role of urbanization do not bring out the difference between various urban areas. Yet these green spaces are inaptly important especially in African urban areas where low levels of employment and high poverty oblige an increased dependence on urban green spaces for endowment of essential services e.g., water and food, (Anderson et al., 2013). As a consequence, lack of critical information makes it difficult for planners to make optimal decisions that can reduce the impacts of urbanization on green spaces (Van Herzele & Wiedemann, 2003).

The purpose of, this study therefore is to quantify effect of urban physical expansion's contribution to green spaces change in Kisumu and Eldoret Towns as case studies.

METHODOLOGY

Study Area

This study focuses on two towns in Kenya namely Kisumu and Eldoret.

Kisumu Town

Kisumu, officially known as Kisumu City, is a Kenyan inland port city on the eastern shores of Lake Victoria that doubles up as capital of Kisumu County. At an elevation 1131m the City County had a population of 397,957 in 2019 (KNBS, 2019). It is the second most important city after Kampala in the greater Lake Victoria Basin. Kisumu was designated as the first United Nations Millennium City in Kenya in 2006. The vision of the city was to become a hub of knowledge, tourism and commerce in the East African region (Obeng-Odoom, 2013).

Eldoret Town

Eldoret Town, is another principal Town in Western Kenya and the fifth largest in the country. It is the second most important city in Western Kenya after Kisumu and also serves as capital of Uasin Gishu County. Lying South of the Cherang'any Hills, the local elevation varies from about 2000 to 2100 metres above sea level (Gitari, 2017). The current population based on the 2019 census is 475,716. It is currently the fastest growing town in Kenya. Figure 1 shows the position of Kisumu and Eldoret in Kenya.

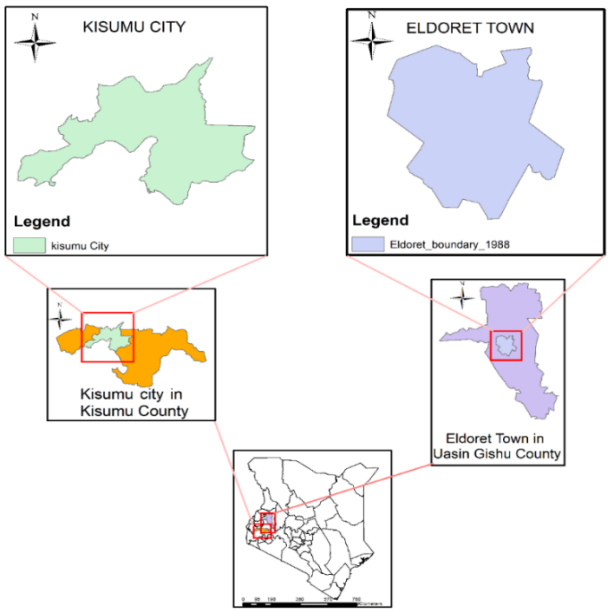

Figure 1: Position of the study areas in Kenya.

Data and Data Acquisition Procedures

The data acquired for this study included trends in urban physical expansion which included mapping of changes in built-up area and urban green spaces sizes for the period 1989 to 2019. In this study, consideration was given to both public as well as those in private property. Public green spaces consisted of those that were expressly provided for in the two town's development plans. Private green spaces consisted of all the other green spaces within the urban area. This information was obtained from Landsat Satellite images of years 1989, 1999, 2009 and 2019. The Landsat program is the oldest Earth Observation Program, which is very useful for detailed analysis of land cover and land use changes, soils, and geology (Hu et al., 2013; Forkuor & Cofie, 2011). As such, Landsat images were the most appropriate for the determination of urban growth and urban green spaces change by this study in the study sites. The attributes of the imagery used are described in Table 1 and 2.

Table 1: Kisumu and Eldoret Town's image description

Landsat Imagery	Path/Row	Platform	Sensor	Spatial Resolution, Bands 4,5,2/5,6,3	Date of acquisition
Kisumu					
LandsatTM5	P170R060	Landsat 5	Thematic Mapper (TM)	30 m	3/1/1989
LandsatTM5	P170R060	Landsat 5	Thematic Mapper (TM)	30 m	2/2/1999
LandsatTM7	P170R060	Landsat 7	Thematic Mapper (TM)	30 m	1/1/2009
LandsatOLI8	P170R060	Landsat 8	Operational Land Imager (OLI)	30 m	1/30/2019
Eldoret					
Landsat TM5	P169R060	Landsat 5	Thematic Mapper (TM)	30 m	3/1/1989
Landsat TM5	P169R060	Landsat 5	Thematic Mapper (TM)	30 m	2/2/1999
Landsat TM7	P169R060	Landsat 7	Thematic Mapper (TM)	30 m	1/1/2009
Landsat OLI8	P169R060	Landsat 8	Operational Land Imager (OLI)	30 m	1/30/2019

Source: DRSRS (2019)

Study Design

Quantitative research design was used. Quantitative research design is a systematic investigation of phenomena by gathering quantifiable data and performing statistical mathematical and computational techniques (Black, 1998). Through this design, it was possible to examine the urbanization trends and the urban green space change. Quantitative research design is good in handling spatial analysis because what the computer can process is digital by nature and digital is often taken to mean numerical (Longley & Batty, 1997).

Target Population

The total number of urban population in the two towns that is Kisumu and Eldoret for the years 1989, 1999, 2009 and 2019 was obtained from the population census from Kenya Bureau of Statistics. The target population of the study was the towns of Kisumu and Eldoret and all green spaces in Kisumu and Eldoret towns.

Sampling Procedures

The Kisumu and Eldoret CBD is the major built-up area covering a larger spatial area and within it urban green spaces were selected. Besides the CBD Kisumu municipality has residential areas that include Manyatta A & B Kibuye, Kondele, Obunga, Riat, Milimani and Nyalenda A & B while in Eldoret municipality there are over 20 residential areas that is Kimumu, Langas Elgon view and Annex among others which results into smaller commercial centers. Green spaces within these small commercial areas also formed part of sampling frame.

Landsat is very useful for detail mapping of land cover, land use, soils, and geology is worth noting (Forkuor & Cofie, 2011). Therefore, in this study, Landsat satellite images were used since the images acquired were from 1989 to 2019.

Data Analysis Procedures

Satellite images collected were analyzed following these steps:

Image Processing

In order to extract data on physical expansion and spatiotemporal change of urban green spaces in Kisumu and Eldoret towns for the years 1989, 1999, 2009 and 2019, the images were rectified, georeferenced, layer stacked, resampling and enhanced using ERDAS. Furthermore, the images were clipped using the Kisumu and Eldoret boundary maps which were obtained from Urban Physical Planning offices in Kisumu and Eldoret towns using ArcGIS software. The images were ready for classification and the classes taken into consideration included; all the built up areas and green spaces in between the built up areas. This was achieved using supervised classification. Furthermore, the urban area patches were delineated as built-

up areas by picking those areas with a density of 20 hectares or more and this filtered out smaller non named patches of urban areas. The green spaces classified were only those in between the built-up areas.

Accuracy Assessment

In order to verify the classification result, ground control points (GCPs) were collected from the field using handheld Garmin Global Positioning System (GPS) and the knowledge of the study area were used. The collected ground control points (GCPs) data were stored in Excel and converted to shape file using Arc GIS 10.4 software for accuracy assessment.

Change Detection Analysis

Green spaces changes were determined by calculating the area of urban green space and the built up areas in all the classified images using the pixels. The maps were also compared with the latest information to detect changes and the town plans to get the information if the town's growth was according to the existing plans of Kisumu and Eldoret. Thereafter, the data were presented using maps and tables.

RESULTS

Urban Physical Expansion Rates

In order to determine urban physical expansion trends, the built-up areas for the years 1989 to 2019 with an interval of ten years was established. The year 1972 for Kisumu (and 1981 for Eldoret) was taken as the base year since it is the last time the towns were planned. Table 2 presents changes in urban size of Kisumu and Eldoret Towns. 7338.68 ha.

Table 2: Trends in urban physical expansion in Kisumu and Eldoret Towns

	Kisumu		Eldoret	
Year	**Built up area(ha)**	**% change**	**Built up area(ha)**	**% change**
1972 plan (1981 for Eldoret)	7338.68	Planned area	3532.73	Planned Area
1989	1316.20	0	391.59	0
1999	5740.02	336.11	1814.04	363.24%
2009	9236.43	60.91	3928.77	116.57%
2019	11086.38	20.03	9002.88	129.15%
Total change	**9970.18**	**742.30**	**8611.29**	**2199.06%**

Source: *Research Data (2019)*

From Table 2, it is evident that both towns have been growing steadily and Kisumu Town is growing at a lower rate than Eldoret town. It is also evident that it grew beyond the 1972 planned area in 2009. In 1989, the Kisumu Town had 1316.2 ha of its land built which increased to 5740.02 ha in 1999 and 9236.43 in 2009 representing an increase of 60.91%. Finally, there was an increase of 20.03% in 2019. The highest increase was recorded between 1989 and 1999 with an increase of 4423.82 ha. The urban built up area increased from 1316.2 ha in 1989 to 11086.38 ha in 2019, a net increase of 9770.18 ha (742.30%) in urban area from 1989 to 2019, suggesting a huge growth in urban growth of the town.

The built-up area in Eldoret Town, on the other hand, expanded from 391.59 ha in 1989 to 9002.88 ha in 2019 as can be seen in Table 2. This means that net increase in Eldoret urban area was 8611.29 ha from 1989 to 2019. The highest expansion of 129.15% was experienced between 2009 and 2019. The overall change of built up area is in the period considered by this study is 2199.06%.

Spatiotemporal Change of Urban Green Spaces

Table 3 presents results on the spatio-temporal changes of green spaces in Kisumu Town from the year 1989 to 2019. This considers all green spaces, both in public and private lands.

Table 3: Spatio-temporal change of urban green spaces in Kisumu and Eldoret Town

Year	Kisumu Total Green space area (ha)	% change	Eldoret Total Green space area (ha)	% change
1989	2794.05	0	1305.63	0
1999	2687.22	-3.82	2535.30	94.18
2009	2210.76	-17.73	2632.59	3.85
2019	1371.24	-37.97	1724.94	- 34.48
Total change	**-1422.81**	**- 50.92**	**419.31**	**32.11 Increase**

Source: *Research Data (2019)*

It can be seen from Table 3 that the amount of urban green spaces in 1989 was 2794.05 ha, which decreased to 2687.22 ha in 1999, then to 2210.76 ha in 1999 and finally to 1371.24 ha in 2019. This means that the total decrease was -50.92% between 1989 and 2019. There was a great decrease in the period 2009 and 2019 (-37.97%) which is attributed to urbanization as indicated in Table 4.

In Eldoret town, there was a slight increase of urban green spaces (3.85%) between 1999 and 2009. Moreover, between the year 2009 and 2019 urban green spaces experienced a substantial decrease as can be seen in Table 3. The overall change is 419.31 ha (32.11%).

Urban Expansion Patterns and Visualization of Urban Green Spaces

Figure 2 presents an analysis of te growth patterns and spatiotemporal changes of urban green spaces in Kisumu and Eldoret towns from 1989 to 2019.

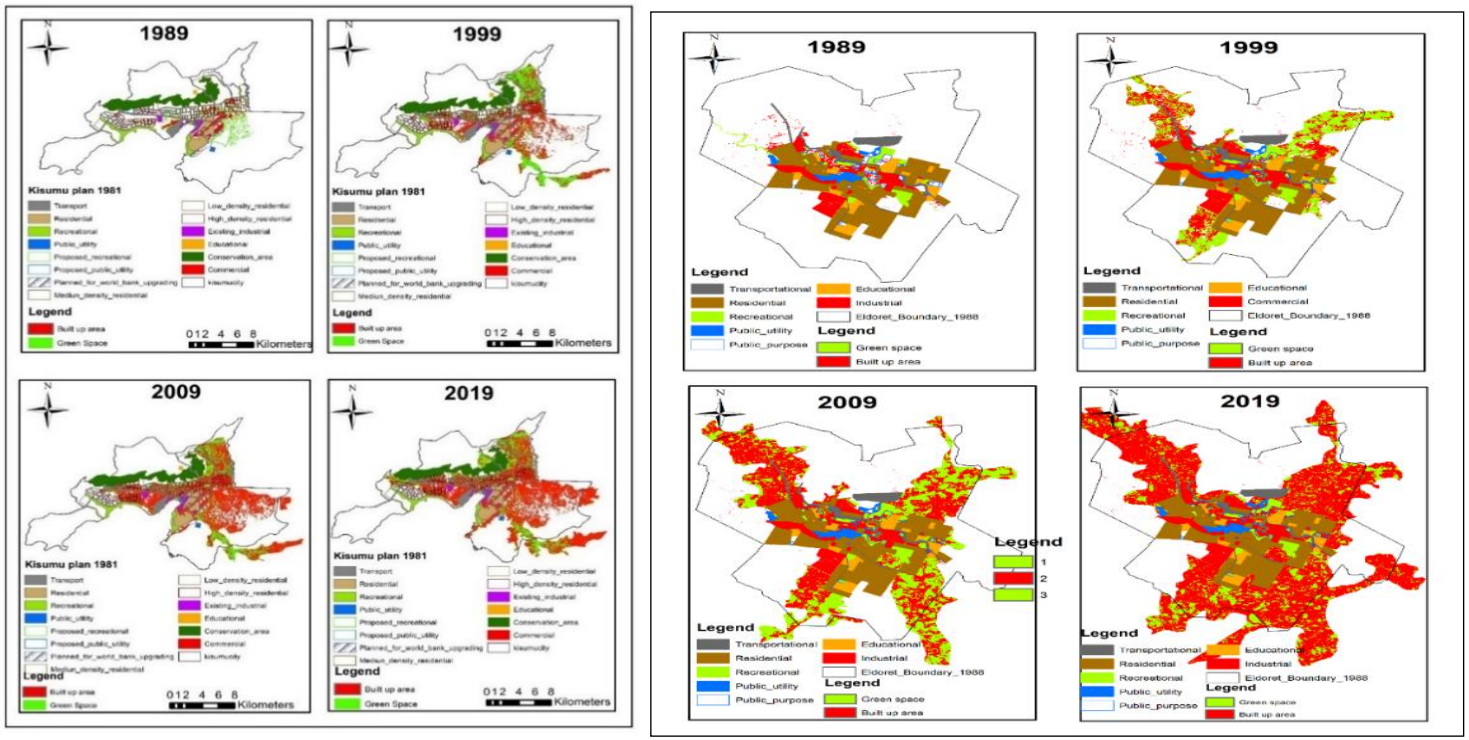

Figure 2: Urban expansion patterns, spatiotemporal change of urban green spaces under laid by the 1972 and 1981 Plans in Kisumu and Eldoret Towns, respectively.

Urban Expansion Patterns

From the figure, it can be seen that growth in Kisumu was within the township boundary in accordance to the 1972 town plan presented in Figure 2 in 1989. It can be further seen that from the Figure that the urban area expanded towards the southeast side of the town between the year 1989 and 1999, where the low, medium and high-density residential areas started to develop. The planned area for residential, transport and commercial areas also were developing. In 2009 to 2019, Kisumu town expanded further towards eastern part. New developments appeared to dominate in the central part of the town during this period and there was almost no growth in the northern part. In 2009 built-up areas had taken up the area planned like proposed recreational land cover and land uses according to the 1972 plan of the town.

As at 1989, there was very minimal built-up area in Eldoret town (Fig.2). Development was only within the town boundary as presented in Figure 2. Further, Eldoret town expanded in all directions. The growth pattern can be classified as linear since the growth followed the major roads like Uganda, Eldoret-Kisumu, and Eldoret-Iten roads. In 1999, growth was still within the town and a little growth was witnessed outside the town boundary towards the northeastern part of the town. In 2019 the town had grown in all directions except the west side of the town and the area designated for public purpose and utility had fully developed. Urban expansion between 2009 and 2019 extended towards the northern part of the town and also the southern part. It was however not strictly following the town plan.

Visualization of the urban green space change in Kisumu and Eldoret towns

Change detection analysis showed a sizeable reduction in green spaces in the last 4 decades in Kisumu town as shown in Figure 2. In 1989 the green spaces were abundant especially in the core of the town. However, the green spaces had experienced loss in 1999 as evident Figure 2. In 2009 and 2019 the urban green spaces had reduced and taken up by the built-up areas.

Visual impression of the changes in urban green spaces between 1989 and 2019 in Eldoret Town presented in Figure 2. Change detection analysis showed a sizeable increase of urban green spaces from 1989 to 2009. Reduction of urban green spaces was only witnessed between 2009 and 2019 in Eldoret town as shown in Figure 2.

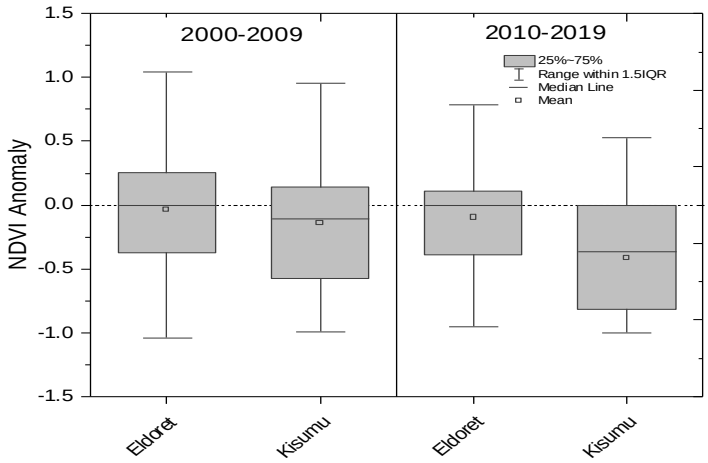

Figure 3: NDVI anomaly of urban green spaces in Kisumu and Eldoret Towns from the year 2000 to 2019

Figure 3, gives a representation of NDVI analysis of Kisumu and Eldoret towns from the year 2000-2019. In 2000-2019. The two towns show an overall trend of reducing or negative NDVI through time. This shows that the green spaces in Kisumu and Eldoret towns have been on the decline and the decrease is experienced more in Kisumu town.

DISCUSSION

Urban Expansion Patterns and Spatiotemporal Change of Urban Green Spaces in Kisumu and Eldoret Towns

The results indicated that Eldoret and Kisumu towns have been expanding since 1989. Overall, Kisumu and Eldoret towns expanded by 742.30% and 2199.06% respectively. In both towns the direction of urban expansion is linear as shown in Fig.2 for Kisumu, the findings showed Eastward expansion while in Eldoret town the expansion follows major roads and new developments in the suburbs and leapfrog development.

This confirms results from a research done in Eldoret from 1979 to 2006 showed that Kapsoya built-up area had grown by 242.5%, Pioneer by 97.9% and Kipkaren by 137.9% (Wafula & Gichuho, 2013).The growth in the two towns is triggered by the increase in urban population. According to Angel et al., (2011) about assessment of global expansion, it was found out that cities are growing at twice their population growth rates and the urban areas are now covering an average of 0.5% of the earth's land area. In addition, urban areas in developing countries will face an increase from 300,000km^2 in 2000 to 770,000km^2 in 2010 and will increase to 1,200,000 km^2 in the year 2050 (Angel et al., 2011). The percentage of people living in urban areas will increase from 50% in 2010 to nearly 75 % by 2150. The population of people living in urban areas has surpassed the population outside the town. As urbanization increases, the urban green spaces are being infringed and they are being lost because the land meant for urban green spaces is being consumed by the need for urbanization.

Kisumu and Eldoret towns are among the rapidly urbanizing towns in Kenya in terms of population and physical expansion (Ngetich, Opata, et al., 2014). Rise in population leads to allocation of more land towards residential expansion (Surya et al., 2020). This is expected to continue in the next 20 years (Ngayu, 2011).

This sprawling growth experienced is clearly not in line with the town plans. The main reason is that there are many unapproved plans in place and because of this, growth was only guided by the older 1981 plan. From the key informant interviews at the department of physical planning, Kisumu and Eldoret towns have experienced urbanization problems that are associated with imprudent spatial planning approaches, weak planning policies and non-implementation of plans this is according to the physical planners in Kisumu and Eldoret.

Furthermore, the results indicated that urban green spaces have been decreasing from 1989-2019 by 1422.81 in Kisumu town and from 2009-2019 by 907.65 in Eldoret town this trend of reduction is similar to findings in China Jinan city, where loss of urban green spaces was associated with urban growth (Byomkesh et al., 2012b).

Despite being among the fastest growing towns in Kenya, Eldoret town still has a lot of undeveloped lands (Korir et al., 2015). This is the reason why there was slight increase in urban green spaces in Eldoret town from 1989 to 2009. In addition, most of the land is zoned under agricultural land use thus a lot of instances of green spaces. New developments in the region require application for change of user from agricultural to commercial from (Ngetichet al., 2014).

According to Ghosh, (2019), physical expansion has a great effect on the land cover, for example leads to conversion of agricultural and forest lands to urban dwellings. As the built up area increase the

urban green spaces also reduce this is because the green spaces were converted into built up areas. This is similar observation made in Addis Ababa where loss of urban green spaces from 19639-14920 ha was witnessed (Woldegerima et al., 2017). To explain this, Teferi & Abraha (2017) found that built up areas expanded in Addis Ababa and reduction of urban green spaces declined including the urban forests. Another research by Girma et al. (2019) found out that 1410.7 ha of land had been converted to built-up areas. This seems to agree with observations by Wiechmann & Pallagst (2012) that increase in urban growth brings about translation of many urban spaces into buildings that involves the massive conversion of green environment, parks and green spaces. Haaland & van den Bosch (2015) concurs findings noting a decrease in urban green spaces that is attributable to urban growth and whose increase has led to conversion of lands reserved for green spaces to other uses of urban green space was converted to build up area.

Physical growth of built up area and urbanization of the town core constitute of the major reasons for the decline of urban green spaces and the conversion of green space to built-up. Therefore, the physical expansion due to imprudent spatial planning, weak planning approaches and non-implementation of urban plans is the main variable that led to decline and change in urban green spaces in Kisumu and Eldoret towns.

CONCLUSION

Kisumu and Eldoret towns have experienced urban growth 742.30% and 2199.06% respectively over the study period of 1989 to 2019. In addition, urban green spaces have been decreasing over time in Kisumu (-50.92%) and a slight increase (32.11%) in Eldoret town. Moreover, the urban physical growth (expansion) is leading to the decrease of urban green spaces through conversion of green areas to built-up. These green spaces should be rescued from conversion to other land uses as a result of urbanization. Also, urban expansion is not going according to the plan of the towns and therefore it is getting a growth of its own.

RECOMMENDATION

The urban planners and policy makers should ensure that plans are regularly reviewed, approved and implemented so as the towns can have a plan to follow other than taking a growth of their own as seen in this study.

Urban planners and city managers should demonstrate a great commitment to monitor the developments and the effects of land use change as a result of urbanization in the urban areas so as to reduce the urban green space conversion to built-up areas.

Finally, the county governments should plan for green spaces and ensure adequate resource and land allocation like facets of urban development.

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