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Determining Per Capita Value of Urban Green Spaces Provision: A Case of Eldoret Town, Kenya

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Abstract

Urban green spaces (UGS) form an important component of the urban environment. They provide a range of environmental, health, and social services that improve the quality of life in cities. The World health Organization recommends a minimum standard of 9m^2 of green space per capita in a sustainable City. Unfortunately, green spaces are not being provided to match the growing urban population. This study analyzed green spaces in Eldoret Central Business District (CBD) and its environs against its urban core population to determine whether the per capita green space available makes significant contribution to its urban life. The research used remote sensing data from Google earth taken in July 2014 and Spatial Analysis tool in ArcGIS 10.1. The results reveal that the available green spaces cover 465,567m^2, an area equivalent to 26% of the total study area, and a per capita value of 2.5m^2. The available green spaces therefore, do not make significant contribution to urban life due to its low per capita availability. They fall below the WHO recommended standard of 9 m ^{2} per capita, indicating a shortage of 6.5m ^{2} per capita green space- an equivalent of approximately 1,676,041 square meters of green space. As a result urban planning should focus more on expansion of green spaces especially within the Central Business District towards a sustainable town.

Key Words: Urban Green Spaces, Per Capita Green Space, GIS, Urban Environment, Sustainable Towns.

Introduction

Green spaces represent an essential component of any urban landscape. They include private and public open areas primarily covered by vegetation. The availability of green spaces in the urban landscape fosters sustainable development, provides solutions to environmental problems and consequently improves the quality of life in urban areas. Green areas contribute to quality of life of a city by increasing air quality, carbon sequestration, reducing urban heat island, and creating opportunities for inhabitants of a city to interact (Mc Pherson, 1998; Salcedo Rahola, Van Oppen & Mulder, 2009; Swanwick, Dunnet & Woolley, 2003) among other benefits. M'Ikiugu *et al.* (2012) suggest that the quality of a city's environment is manifested in its urban green spaces which reflect on the quality of life in it while Li, Wang, Paulussen and Liu, (2005) suggest that quantitative analysis of green space in urban areas is the first step in its planning and development towards a sustainable urban environment.

Benefits of Green Spaces

Urban Green Spaces provide a wide range of benefits ranging from ecological, health, social, economic to planning that consequently improve the quality of urban environment.

Green spaces are important in carbon sequestration (Mc Pherson, 1998). Atmospheric carbon can be bound in the soil as well as in both above and below the ground plant component (Demuth & Von Eitzen, 2013) while trees and vegetation absorb, deflect, reflect, refract and mask sound, reducing noise pollution, offering protection against hearing impairment and noise-induced stress (Sorensen, 1997).

Green spaces in urban areas that are well maintained and managed contribute to social inclusion and social justice by creating opportunities for inhabitants of a city to interact (Scottish Executive, 2001; Swanwick *et al.*, 2003). Byrne and Sipe (2010) suggest that the presence of green spaces in the dense urban environment makes it livelier and activities within the areas are more manageable and more enjoyable as people interact with nature. Well designed green spaces also provide pathways for people to travel either by foot or by bicycle for recreation or commuting (Scottish Executive, 2001).

Haq (2011) further reports that areas of a city with adequate green cover are aesthetically pleasing and attractive to both residents and investors. According to Sorensen (1997), the beautification of Singapore and Kuala Lumpar, in Malaysia resulted in increased foreign investment and rapid economic growth.

The benefits of urban green spaces cannot be underestimated and should therefore form part of the urban environment in sufficient quantities.

Green Space Availability

There is a wide variation in green space per capita globally. Cities distinguished for their urban green spaces have between 25 m^2 and 100 m^2 urban green space per capita (Chaudhry & Tewari, 2010). The minimum international standard recommended by the World Health Organization is 9 m^2 green spaces per city inhabitant (WHO, 2010).

In Africa, research conducted in several urban areas reveals low green space coverage (Cilliers, Cilliers, Lubbe & Siebert, 2012; Kestermont, Frendo & Zaccai, 2011). Consequently Africa's vulnerability to climate change has been attributed to, among other factors, deteriorating urban green spaces (JAD, 2014).

Low green space coverage has been attributed to poor enforcement of development controls, lack of political will, high rate of urban sprawl and densification, operation of old planning regulations, lack of priority to green spaces in development and inadequate finances (Menash, 2014). Several towns in the Republic of South Africa have less than 10% of their total land occupied by green spaces (MaConnachie, Shackleton & McGregory, 2008) while in Lagos City (Nigeria), green spaces are reported to occupy less than 3% of the City's landmass (Oduwayo, 2013). Kumasi city (Ghana), once considered the garden city of West Africa, now has a small fraction of green space which together with other open spaces constitute about 10.5% of the total land area of Kumasi (Amaoko & Koroboe, 2011).

A UN report estimated that Kenya's urban population will expand to 38 million by 2030 (UN, 2003). Majority of Kenyans are therefore expected to live in urban areas within the next 20 years (Ngayu, 2011). Urbanization is expected to pose further socio-economic, environmental and institutional challenges as land use patterns in Kenyan cities and towns have undergone rapid change with the ratio of built up areas to green spaces increasing (Ngayu, 2011). Policy makers and urban planners therefore need to monitor urban environments in terms of green space coverage.

In Kenya, urban planning is guided by the planning principles which include keeping the environment clean and beautiful as well as environmental preservation through maintenance of green spaces. Development plans are drawn up to ensure equal access to green and open spaces; promote human health as well as air, water and soil quality;

and maintain biodiversity (Republic of Kenya, 2007). The Physical Planning Act 286; Urban Areas and Cities (No 13 of 2011), and the Draft Physical planning Bill 2014 require boards of cities and urban areas to develop Local physical development plans to provide spatial development framework for the respective areas to guide sustainable development. The purpose of the plans is to provide for appropriately located public spaces and utilities, and promote environmental sustainability by providing opportunity for greening among others. Other policies that promote creation of green spaces are contained in Kenya Vision 2030, National Spatial Plan 2010 and the Planning Handbook 2007.

Despite having policies, most urban areas in Kenya struggle with the challenges of implementation and enforcement of these policies leaving urban areas with limited green areas and vulnerable to various environmental problems (NSPC, 2010).

Research by M'lkiugu, Kinoshita and Tashiro (2012) reveals that Nairobi, capital city of Kenya, has a low amount of green space of 9.86% of the total area. According to WHO report (2012), Nairobi has less than $1m^2$ green space per capita value.

Eldoret town is one of the rapidly urbanizing towns in Kenya (EMC, 2010) at a rate of 7-8% (Okalebo *et al.*, 2009). The pace at which land is being consumed by urban development is a major concern. The Central Business District (CBD) and its environs is intensively used with much of the area covered by buildings, roads and other impervious surfaces leaving limited space for green cover.

Past trends indicate continuous expansion of Eldoret in terms of size and structure, with intensified urbanization. The population has significantly increased from 19,605 in 1962, 216,356 in 2002 to 252,661 in 2009 (KNBS, 2009) and is projected to reach 584,782 people by 2030. Growth has been attributed to natural increase in terms of births, immigration, industrialization and growth of institutions in the town (Cheserek, Syagga & Olima, 2012). Under these circumstances of rapid development, the provision of green spaces is not a high priority compared to other necessities such as housing, industrial and infrastructural provisions.

Available green spaces within the town include public parks, private green spaces and natural vegetation. Studies have not been done in Eldoret town to determine whether the amount of green spaces available is adequate in terms of per capita value to improve the lives of the increasing population and environmental wellbeing as well as determine the green space shortfall.

The Strategic Urban Development Plan (2008-2030) for Eldoret town provides for green spaces in several ways. It proposes buffer zones of 10-30 m of green belt devoid of any development along major urban roads, riparian reserve of 6m from the water body devoid of any human activity, and recreational parks minimum lot size of 0.25 ha (Cheserek *et al.*, 2012). However, observational evidence reveals that these open spaces do not have adequate green cover and worse still some of these guidelines have not been adhered to. Uncontrolled urban activities such as buildings, car washing and repairs adversely affect the riparian reserve along river Sosiani and Munyaka stream.

This scenario makes the town vulnerable to the effects of climate change and other environmental problems such as urban heat island, floods from surface runoff, poor water and air quality, destruction of habitats for insects and birds as well as reduced ability of urban environment to sequestrate carbon. Flooding is a common phenomenon in the town during rainy seasons as drainage channels remain blocked due to siltation (Okalebo *et al.*, 2009). These are problems that could be mitigated through increased green cover. The aim of this study is therefore to provide insight into the current status of UGS in Eldoret and the future needs in line with population projection.

Decision makers need reliable information about UGS with relation to population for informed decision making.

Materials and Methods

The Study Area

The area lies within Eldoret town in the North Rift, Kenya; the administrative center of Uasin Gishu County. It is about 312 km North West of Nairobi on the main Kenya – Uganda railway line and along Africa's Great North Road. It traverses latitude 0^0 $31^'$ North and longitude 35^0 16' East and lies at an altitude of 2085 meters above sea level. Rainfall in Eldoret is high, reliable and evenly distributed with an annual average of 1223 mm. Highest mean temperature is 27ºC and the lowest mean is 8ºC. Increasing scarcity of open spaces has limited the amount of vegetation cover in Eldoret town. River Sosiani transverses through the town from east to west providing water for both domestic and commercial use. The population of Eldoret town has continued to grow rapidly from 19, 605 in 1962 to 252, 661 in 2009. The road networks in Eldoret are radial focusing on the CBD. Uganda road traverses the town from south-east to north-west, while Kisumu and Iten roads from south to north (EMC, 2010).

The unit of analysis in this study was the Central Business District of Eldoret town and its environs covering an area of 1,930,276 m^2 (Google Earth Map taken on July 2014). The study area combines local recreation area including Sirikwa Hotel, residential areas such as Doctors quarters and institutional areas like Central Primary School as well as the business center in tight space. Eldoret town plays an important role as a transit area to Uganda besides having a heterogeneous and large population. Thus this focus area was ideal for analyzing the status of green space in Eldoret and determining its adequacy to influence the quality of life of its inhabitants.

Sampling Technique

The study area was selected based on the researchers' knowledge about and purpose of the sample. Purposive sampling was therefore used to select the study area with particular characteristics which would best enable the researcher to answer the research questions. Stratified random sampling was then applied to select ground training sites. Stratified technique has been used to determine study sites where there are varying levels of spatial complexity (Lo, 1986) thus generating more representative samples of the whole study area.

Lo (1986) compared sampling techniques for land cover assessment and concluded that stratified random sampling provides the best results. The stratification was done on the basis of green cover/ land cover classes. These classes were generated after literature review and field survey. The clusters provided sample sites where the sample training sites were drawn through random walk and GPS readings.

Data and Data Sources

Data required for the study included; green spaces, where they are found and their quantity in meter squared. Data on non green areas and population was included. A Google earth image taken on July 2014 with a spatial resolution of 5.56 m^2 was used to get an overview of the study area. The urban plan for Eldoret town acquired from Uasin Gishu County urban planner was used to determine the boundary of the study area.

Data for green spaces was almost non-existent other than what was provided for in the urban strategic plan. Field observation was used to determine the available green spaces. All forms of land cover within the study area with vegetation were selected as green space by their nature, whether trees, shrubs or grass regardless of their location and status whether natural or planted, private or public, formal or informal.

The human population data for the study area was obtained from the Uasin Gishu County Bureau of statistics office based on the Kenya Census 2009 report. The urban core population data for Eldoret town

(252,661 persons) was used to determine the per capita green index.

Data Collection

Satellite Image Acquisition

The satellite image of the area representing Eldoret CBD and its environs was clipped from the google earth image. It was then geo-referenced and the projection transformed to WGS 1984 Universal Transverse Mercator (UTM) projection.

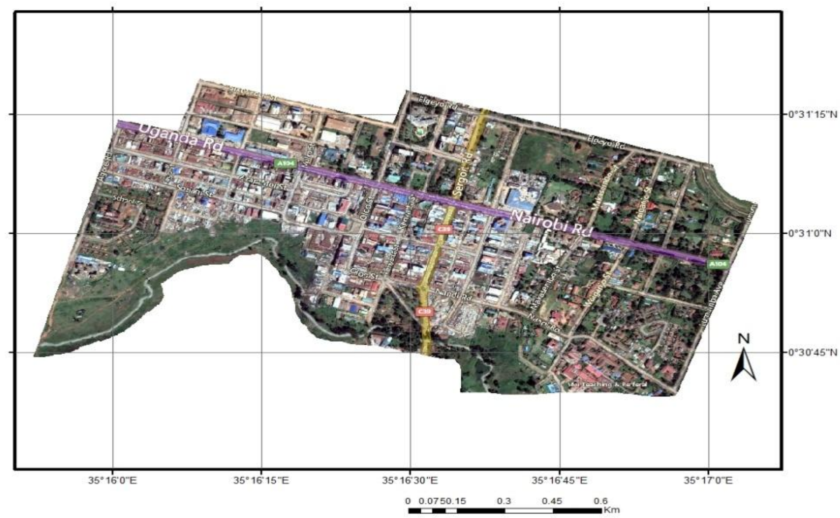

Figure 1. Raster Image of Study Area; Eldoret CBD and its Environs Measuring Approximately1930276 m^2
Source: Google Map (2014)

Ground Training Sites

Through extensive fieldwork, stratified random sampling was used to map training sites in the field using GPS. Approximately twenty five training samples for each class were gathered. The classes included trees, shrubs, grass and bare ground and built up areas. According to Green and Congalton (2004), large volumes are required to adequately represent each classification within the image. The training sites were recorded which in later stages were used in the image classification as well as to assess the accuracy of resulting greenery and land cover maps.

Satellite Image Classification

The aim of this classification was to extract the green areas in order to determine their availability and quantity. Color was selected as the segmentation parameter based on previous studies which recommend color as more effective in differentiating land cover type than shape. A true color image broken into three bands (Red, green, blue) was thus used. Supervised classification was performed on the raw satellite image.

Supervised Pixel Classification

Supervised pixel classification was used to identify the general land cover types. All green cover (Trees, shrubs and grass) plus built up area and bare ground were extracted. Water was not included as a separate class because few water bodies are present in the study area. The location of those present (River) is well known and were masked out from the study area.

The training sites mapped in the field were used as training samples to train the classifier to recognize land cover classes based on their spectral signatures as found in the image. All pixels in the image outside the training sites were then compared with the class discriminants and automatically assigned to the class they are closest to. All the image pixels were therefore assigned either to tree, shrub, grass, bare ground or built up classes based on spectral information. This process was aided by prior knowledge of the study area that was achieved through ground truthing and familiarity with the features. After classification, vegetation classes produced from pixel image classification were grouped together as one single class (green) and bare ground and built-up areas as (Non-green)

Analysis of Green Spaces

Various landscape metrics were developed to aid the analysis of green spaces within Eldoret CBD and its environs. McGarigal (2002) describes them as algorithms that quantify specific spatial characteristics of patches, classes of patches, or entire landscape mosaic. Two landscape metrics were adopted to determine urban green space per capita within the study area (Table 1).

Table 1. Landscape Metrics and their Description

Landscape Metrics	Description
Total Area (TA)	The total study area
UGS Availability (UA)	The total area occupied by UGS

Adopted and modified from M'Ikiugu *et al.*, (2012)

The standards used in this study to evaluate the current green space status included 9 m^2 per capita green availability recommended by World Health Organization. To establish the total amount of green spaces, the area for each of the green surface categories was calculated from the sum of the surface pixel counts converted into meter squared. This provided the estimate green space areas in meters squared. To calculate per capita green space, the total area of all green spaces was worked out as well as the population of inhabitants. Per capita green space was then estimated through the following formula:

$$P = \frac{TGS}{PN}$$

Where; P = Per capita green space; TGS = Total green space; PN= Population

Results and Discussion

Green Space Availability

Green spaces constitute an important land cover in the urban environment and the provision of green space has been an increasing concern for enhancing the sustainability and livability of urban areas.

The results of satellite image classification covered most of the visually green areas without discriminating between privately owned, public, formal and informal green spaces.

The classification produced a detailed binary classification scheme distinguishing between green and non-green (built up) areas (Fig 2).

Figure 2. Green and Non green
Source: Google Map (2004)

The results show that green areas cover 465,567 m^2 -an area equivalent to 26% of the total study area and a per capita green space value of 2.5m^2. This falls below the standard (9 m^2 per capita green space) recommended by WHO (2010) indicating a shortage of 6.5 m^2 per capita green space an equivalent of approximately 1,676,041 square meters of green space. There is need to increase the amount of green space at least 4.5 times the existing situation to reach the minimum set standards of 9m^2 per capita.

The per capita value reveals a low green cover against a high population in the Central Business District. Other studies have revealed that a high population density goes together with low availability of green spaces (Baycan-Levent, Vreeker & Nijkamp, 2002). Large populations in urban areas require large quantities of land for housing, transport and other social amenities leaving limited space for green cover (Gairola, 2010). The Central Business District is highly concretized resulting in green spaces occupying a small percentage of the total land space. Low availability of UGS leaves the CBD vulnerable to environmental problems such as urban heat island, floods from surface runoff, besides visitors and those who work within the CBD are likely to have little interaction with green space (Okalebo *et al*., 2009). The ability of the urban environment to sequestrate carbon is also reduced (Mc Pherson, 1998). In order to meet ecological, social, health and economic needs of cities and its citizens, green spaces need to be adequate in quality and quantity. The total area occupied by green spaces should be large enough to accommodate the rapidly increasing urban population (Gairola, 2010).

A comparison of the average per capita green space available with the International standards shows low availability of green spaces within Eldoret CBD and its environs. Table 3 illustrates the great difference between green spaces in Eldoret CBD and the International standards

Table 3: International standards of Green space per capita

	Green space per capita
Eldoret town	2.5 m^2
European Union	26 m^2
World Health Organization	9 m^2
France	18 m^2
Latin America	10 m^2
National Institute of America	14 m^2
Germany	10 m^2

Source: Gomez, Jabaloyas, Moreno, De Vicente and Valcuende (2011)

Implication of the Study to Research and Practice

The implication of these findings is that concerted efforts by the County Government of Uasin Gishu and policy makers in preserving green spaces should be directed towards enhancing green spaces within the Central Business District that have low green cover. A wide range of policies are available to county governments to create and protect urban green spaces. Enhancing green spaces require compliance and enforcement of these existing regulations. These include the Physical Planning Act cap 286, Urban areas and Cities 2011 and Draft Planning Bill 2014 which in most cases are violated. There may be need for a new policy to retrofit potential areas such as traffic island and create innovative green spaces like wall greening.

Conclusion

This study reveals that Eldoret CBD and its environs have a green space per capita value of 2.5 m^2 per inhabitant which, however, is below the standard set by World Health Organization (9 m^2 per capita). The methodology and the results of this study show that GIS technique when used with high resolution satellite imagery is useful for the extraction of information like urban vegetation which is an important attribute for assessing the quality of urban environment. It further illustrates the potential of remote sensing and GIS in urban green space mapping in the often dynamic urban environment, providing important information for sustainable urban planning to ensure the existence and maintenance of a sufficient amount of green spaces. The results obtained can be used as a basic tool in urban green space planning of Eldoret town and other towns with similar structure to achieve a sustainable urban environment.

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