URBAN GREEN SPACES AND POTENTIAL FOR EXPANSION IN ELDORET TOWN, KENYA

BY

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DECLARATION

Declaration by the candidate

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Declaration by the Supervisor

This thesis has been submitted with my approval as University supervisor.

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DEDICATION

I dedicate this thesis to my family.

ABSTRACT

Urbanization and its related environmental problems demand for sustainable urban planning and management policies to safe guard the quality of urban environments. Urban Green Spaces (UGS) form an important component of the urban environment. They provide many environmental, health, and social services that contribute to the quality of life in cities. Unfortunately, green spaces are not being provided to match the growing urban population. Analyzing the current status of green spaces in urban areas thus serves as a tool for their planning and development. In this study, the status of green spaces in Eldoret Central Business District (CBD) and its environs was analyzed in terms of quantity, green space per capita availability, their spatial distribution and typologies to determine whether they can provide the benefits of green spaces and identify potential sites for their expansion. The study integrated the theory of urban ecology with the concept of Garden City and Biophilic city. The study area was chosen purposively while stratified random sampling was used to select study sites. The research used remote sensing data from Google earth taken in July 2014 and Spatial Analysis tool in ArcGIS 10.1. The results revealed that the available green spaces cover 465,567 m^2 an area equivalent to 26% of the total study area. Per capita green space was calculated based on 75% of the urban core population data for 2010. Results show that green space per capita for Eldoret CBD and its environs is $2.5m^2$. The various typologies of green spaces were identified and their proportions within the total study area found to be: riparian green 5%, urban block green 7.6%, park green 0.3%, residential green 6.7%, roadside green 1% and institutional green 5.9%. Proportions of green spaces within their respective land cover zones include riparian 53%, urban block 18.4%, institutional 31.3%, parks 32.9%, residential 39.7% and roadside 0.07%. Typologies show traditional green spaces and a lack of innovative green spaces such as vertical green spaces. Results also show that green spaces are concentrated at the periphery in areas dominated by residential houses and institutions as well as parks, leaving the inner core with limited green spaces. Though it meets the minimum standard set by Cohen at 20% green space of total area, its per capita green space is not proportional to the minimum universal standard of $9m^2$ per capita green space recommended by World Health Organization (WHO). This shows that the existing green spaces do not make significant contribution to urban life due to their uneven distribution across the study area and its low green space per capita availability. As a result there is need to increase green space coverage especially within the urban core that is highly concretized. A map showing potential sites of green space increase was produced. This includes riparian and road buffer as well as gaps within parks. Other innovative green space potential sites such as traffic islands and wall greening are recommended.

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OPERATIONAL DEFINITION OF TERMS

Biophilic : A place that has preference to natural environment incorporating natural form and images into buildings and cityscape.

Built up/ grey areas: Areas under buildings, tarmac, pavement and other concrete surfaces.

Green space planning: Process of influencing, controlling or directing the creation of green spaces.

Greening: The act of planting vegetation cover within the urban environment.

Innovative ways: New ideas, ways of greening urban areas in the new age of technological innovation.

Livability: Physical conditions and spatial characteristics of a town that makes it a desirable place to live in.

Open space: Spaces designed for public use and related activities comprising parks, sports ground, city squares and other unbuilt spaces which may have green cover or paved.

Sustainable development: Development that promotes human health as well as air, water and soil quality and maintenance of biodiversity now and for the future.

Urban areas: Cities, municipalities or towns.

Urbanization: Growth of cities and towns in terms of densification and urban sprawl.

Urban green spaces: An area within an urban area that is predominantly covered by vegetation of any kind which is directly or indirectly available to users.

Urban ecosystems: Natural environment, built environment and socio-economic environment of urban areas.

Urban ecology: Study of urban ecosystems including humans living in cities and urbanizing landscape.

Urban transition: A shift from the rural to urban and from agriculture to employment to industrial, commercial, or service employment.

LIST OF ABBREVIATIONS

CBD	Central Business District
EMC	Eldoret Municipal Council
EATEC	East African Tanning Extract
GIS	Geographic Information System
GPS	Global Position System
ISODATA	Interactive Self Organizing Data Analysis
UGS	Urban Green Spaces
UNDP	United Nations Development Fund
UNDF	United Nations Population Fund
UHI	Urban Heat Island
UTM	Universal Transverse Mercator
WHO	World Health Organization

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CHAPTER ONE

INTRODUCTION

1.1 Background

The interest in urban green spaces has increased with the advent of the concept of sustainable development. Policy makers and urban planners therefore, recognize the need to monitor urban environments in terms of quality of life now and for the future. Urban planning does not only cover matters of built environment such as housing and transport network but also integration of green spaces into the physical urban landscape (Baycan-Levent *et al.,* 2009). Integration of green spaces into the urban fabric fosters sustainable development, providing solutions to environmental problems and consequently improves the quality of life in urban areas. M'Ikiugu *et al.,* (2012) suggests that the quality of a city's environment is manifested in its urban green spaces which reflect on the quality of life in it.

Adequate green spaces need to be uniformly distributed throughout the city area and their total area coverage should be large enough to meet the needs of the city dwellers (Haq, 2011). As a result, information on the availability, typology and spatial distribution of urban vegetation is of great value to support the development of sustainable urban policies (AGCI, 2011). According to Li *et al.,* (2005), quantitative analysis of green space in urban areas is the first step in its planning and development towards a sustainable urban environment.

From a global perspective a wide variation, both in coverage and per capita availability of green spaces exists. Cities renowned for their urban green spaces often have 20% to 40% coverage of total geographical area and 25 m^2 to 100 m^2 urban green space per capita respectively (Chaudhry *et al*., 2010). The minimum standard internationally recommended by the World Health Organization is a minimum of 9 m^2 green space availability per city inhabitant (WHO, 2010) and a standard of 20 % of the total urban area proposed by Cohen (1992) .

Developed nations have paid much attention to urban green spaces and various studies have been done in respect to green space. China having gained an increased awareness of benefits and the alarming decline of green areas, has undertaken institutional measures to conserve existing sites and develop new ones (Peng, 2003 in Jim, 2006). Australian cities have also adopted the roof greening concept with most being roof gardens or intensive green roofs (Williams *et al*., 2010). Though challenges to increasing the use of UGS exist, their potential as factors in climate change adaptation and mitigation is significant (Williams *et al*., 2010). The above trends show that many cities in the developed world are making effort to protect their green spaces, and some are retrofitting new types of green space.

In developing nations, adequate attention has not been paid to green space planning in urban development endeavors and because of this, the environmental quality of urban areas in developing countries is significantly lower than in developed countries (Faiz, 1993). Interventions are limited to street planning and which do not provide for future green space, thus most third world urban areas are commonly treeless (Olembo *et al.*, 1987).

In Africa, research conducted in several urban areas also reveals depletion of green spaces (Cillers *et al.,* 2012 ; Kestermont *et al.,* 2011). Depletion has been caused by among other factors 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). The depletion of green spaces has resulted in green spaces occupying a very small percentage of the total land space in many urban areas. Several towns in the Republic of South Africa have less than 10% of their total land occupied by green spaces (MaConnachie *et al.*, 2008) while in Lagos City (Nigeria) green spaces now 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 (Amoako *et al.*, 2011).

Africa's vulnerability to climate change has been attributed to deteriorating urban green spaces among other factors (JAD, 2014). Africa is reported to be the most vulnerable continent to climate change and climate variability, with increased mortality related to extremely hot weather and poor air quality found in most cities worldwide (JAD, 2014). Rainfall is expected to decline by 10% by 2050 in parts of southern and eastern Africa, sea levels projected to rise about 25 cm by 2050, with tidal waves and storm surges on the west and east coasts of Africa (JAD, 2014). The benefits of UGS cannot be underestimated and should therefore form part of urban life.

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. The scale of future urbanization is expected to pose further socio-economic, environmental and institutional challenges in all Kenyan cities if the requisite policy and planning frameworks are not in place (Ngayu, 2011). 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).

Urban planning in Kenya 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, promotion of human health as well as air, water and soil quality and maintenance of 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 empower 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 appropriate located public spaces and utilities, 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 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 *et al.,* (2012) reveals that Nairobi, capital city of Kenya has a low amount of green space, 9.86% of the total area compared to 18% limit set by Hanoi in Vietnam (Uy, 2006). The research further found that central Nairobi has inadequate green spaces in terms of size, composition, distribution and character resulting in low quality of life to its inhabitants. (M’lkiugu *et al.,* 2012). While WHO (2012) report on “Health Indicators of Sustainable Cities” states that Nairobi City has less than $1m^2$ per capita green spaces per inhabitant.

Improved understanding of the status of green spaces in built urban environments in cities and towns in developing countries which are expected to become yet more urbanized is important. In particular, there is need to determine the amount, typologies and distribution of green spaces within urban areas for purposes of determining areas deficient in them and sites with potential for conversion to UGS. Gomez *et al.*, (2011) suggests that the steps to visible provision of green spaces involves defining the typology of these areas as well as determining other sustainability indicators such as green space availability in square meters per inhabitant and percentage of surface area, and the surface area for each of the typologies recognizable.

Eldoret town, considered as one of the rapidly developing urban centers in Kenya (EMC, 2010) provides an opportunity for such a study. Past trends indicate continuous expansion in terms of size, structure, and density. The population has significantly increased from 19,605 in 1962, 216,356 in 2002 to 252,061 in 2009 (KNBS, 2009). Factors of growth have been attributed to natural increase in terms of births, immigration, industrialization and growth of institutions in the town (Cheserek *et al.*, 2012). However studies have not been done in Eldoret town to determine whether the amount of green spaces available is adequate for the increasing population and identify potential sites for expansion of green cover towards a sustainable city.

1.2 Statement of problem

Eldoret is one of the rapidly urbanizing towns in Kenya (EMC, 2010). 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; much of the area is covered with buildings, roads and other impervious surfaces leaving limited space for green cover.

The Strategic Urban Development Plan (2008-2030) for Eldoret town provides for green spaces in several ways; It proposes buffer zones-10-30 meters of green belt devoid of any development along major urban roads, riparian reserve of 6 m from the water body devoid of any human activity, and recreational parks minimum lot size-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.

Limited studies have been done in Eldoret town on the quantity of green spaces, typologies and there spatial distribution to determine whether the urban area provide adequate green spaces to improve the quality of life of residents and environmental well being. This information will help to promote sustainable urban planning of the town.

1.3 Broad objective

The main objective of this study is to analyze the existing urban green spaces within Eldoret CBD and its environs to determine whether the urban area provide adequate UGS to improve the quality of life of residents and environmental well being.

1.3.1 Specific objectives

i. To determine the amount and types of green spaces within Eldoret CBD and its environs.
ii. To determine the distribution of green spaces within Eldoret CBD and its environs.
iii. To identify potential sites for increasing UGS to enhance spatial, environmental and the residents quality of life.

1.3.2 Research Questions

i. How much green space is available in Eldoret CBD and its environs?
ii. What types of green spaces exist in Eldoret CBD and its environs?
iii. What is the spatial distribution of the various types of green spaces within Eldoret CBD and its environs?
iv. Which sites have potential to increase green cover within Eldoret CBD and its environs?

1.4 Justification

Urban green spaces are an integral part of any city landscape, providing city and its residents with numerous benefits including ecosystem services like carbon sequestration and temperature regulation in urban areas which mitigate the effects of climate change (Nowak *et al.*, 2006; Jim *et al.*, 2008), social services and health (Grahn *et al.*, 2003), as well as economic services like tourism and increased property prices (Chaudhry *et al.*, 2010). Green elements serve to reduce noise pollution, add aesthetic value to urban areas and provide outdoor recreation. The significance of green spaces in creating a livable environment therefore makes it an important measure in judging the sustainability of urban areas.

The Physical Planning Act cap 286 and Urban areas and Cities Act 2011 requires each County government to develop, protect and preserve all land for open spaces, parks, urban forests and green belts. However studies carried out previously show that urban areas in African cities have inadequate green spaces unevenly distributed within the urban landscape. To optimally integrate urban green space into sustainable urban development strategies in Eldoret town therefore requires an understanding of the status of available green spaces.

This information gap on green spaces needs to be filled to ensure proper planning, integration and management of urban green spaces towards sustainable cities. This study therefore provides a better understanding of the quantity, typology and distribution of green spaces in Eldoret CBD and its environs.

1.5 Scope of study

The study area in physical terms corresponds to the densely built area and its periphery, an area enclosed by Sixty Four street and Kerio Road to the North, Lumumba Road to the East, Sosiani River to the South and Kago Street to the West as delineated on the urban plan. Thus administrative boarders are not taken into account.

The research considered the following parameters within Eldoret Central Business District and its environs: total area of green space available, types of green spaces, population, green space per capita, built up areas and bare soil.

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. Built up areas and bare ground were also mapped.

1.6 Assumption

It was assumed that 75% of urban core population represents the daytime population in the Central Business District and its environs. It was also assumed that gaps represented by the reflection of bare soil on the satellite image had no specific applications or had specific applications but have not been performed.

1.7 Study Area

Based on the aim of the research, purposive sampling was used to select the study area. 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. Moreover it plays an important role as a transit area to Uganda besides having a heterogeneous and large population. Thus this focus area is ideal for analyzing the status of green space in Eldoret and determines its adequacy to influence the quality of life of its inhabitants. Studying only the Central District and its periphery rather that the whole city allowed the researcher to conduct an in depth analysis despite limited resources, while still covering the densely built area where green space availability may be limited. The satellite image classification method also required that the researcher has a prior knowledge of the study area and conduct ground truthing to validate the data hence purposive and careful selection of the study area. Wider area could have made a structural observation of the entire town difficult.

Comment [b1]: Should be in the methods

1.8 Background of Study Area

1.8.1 Location and size

Eldoret town is in western Kenya and is 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. The land rises from the River Sosiani valley both northwards and southwards from about 1800 meters on the extreme north and from below 2120 meters in the extreme south to beyond 2200 meters (EMC, 2010). The northern part of the town is marked by a steep slope known as Uasin Gishu escarpment (EMC, 2010). Geologically the area has volcanic deposits of granite *phonolite* resulting in the formation of red clay soils in the region. The town is currently the fastest growing town in Kenya and ranked the 5^{th} largest in Kenya (EMC, 2010).

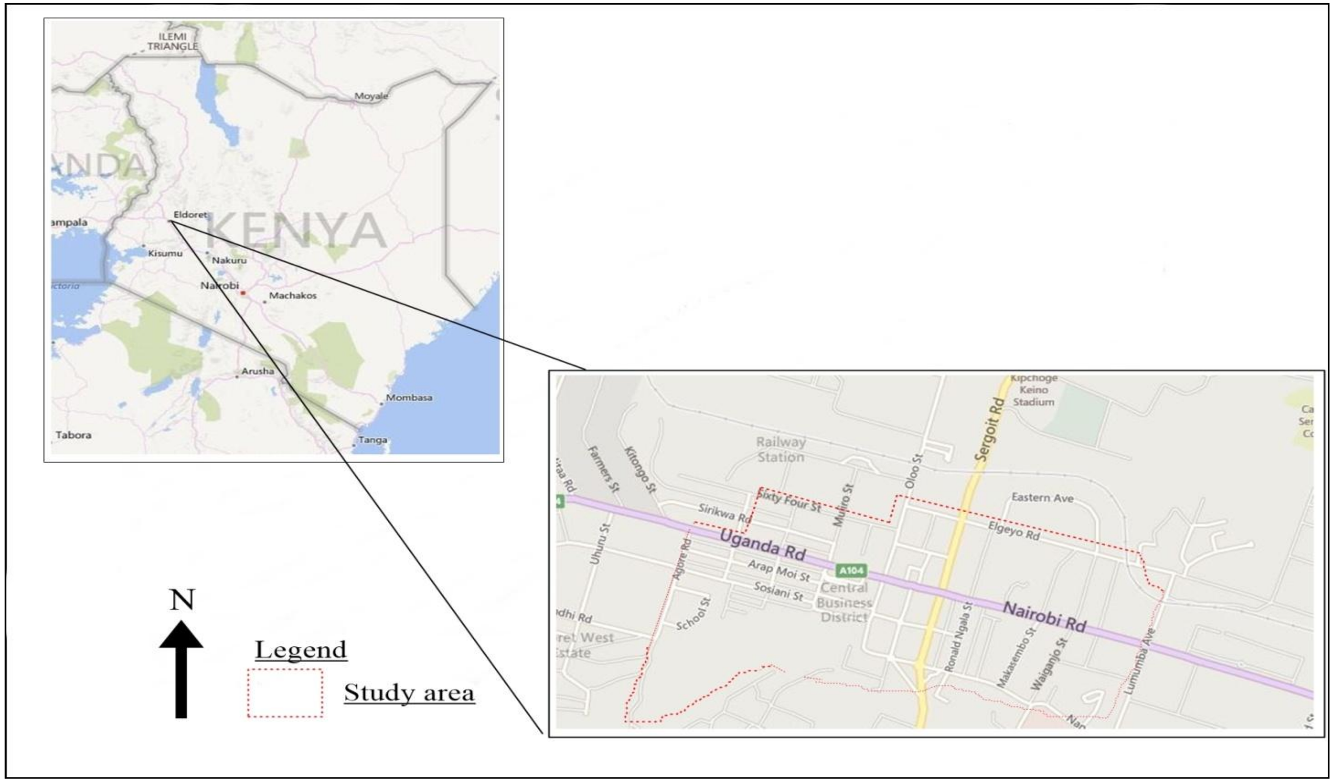


Figure 1.1: Location of Eldoret Town and the study area.

(Source: Google Map, 2014)

1.8.2 Climate

Rainfall in Eldoret is high, reliable and evenly distributed with an annual average of 1223 mm. The amount that falls and the rainfall regime is influenced by altitude and wind direction.

Due to the high altitude around the town, temperatures are relatively low. The highest mean temperature is 27ºC and the lowest mean is 8ºC. Humidity is moderate, averaging 50 mg/m3.

1.8.3 Vegetation

Increasing scarcity of open spaces has limited the amount of vegetation cover in Eldoret town. With the sale of the large wattle tree plantation owned by Lonrho Company also known as the East African Tanning Extract (EATEC), the trees were cleared and the land subdivided for settlement. As a result there is now little forest cover around Eldoret town (EMC, 2010).

1.8.4 Drainage

River Sosiani transverses through the town from east to west providing water for both domestic and commercial use. There are two major dams along the river that provide piped water to Eldoret municipality. Water for use in the town is also harvested from Chebara Dam in Elgeyo Marakwet County (EMC, 2010).

Okalebo *et al.,* (2009) noted that River Sosiani was highly polluted and that informal artisans "jua kali" are among water polluters through discharge of oil, grease, discarded filters and burning of old tyres whose blockages affect open drains leading to floods in the flat areas. Since the town is considered downstream, storm water runoff is a common occurrence during rainy season. A green based approach can help mitigate against storm water runoff and excessive soil erosion (Okalebo *et al.*, 2009).

1.8.5 Population

The population of Eldoret town has continued to grow rapidly from 19, 605 in 1962 to 252, 661 in 2009. The high population growth rate has been attributed to natural increase, immigration, industrial and institutional growth of the town as well as municipal boundary expansion in 1988 that led to inclusion of large areas of land from the peri-urban into the area controlled by Eldoret municipality (EMC, 2010).

Comment [b2]: From where?

1.8.6 Physical infrastructure

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). These three roads intersect in the CBD and are the back bone of the town's spatial development. The road network within the CBD assumes a grid iron pattern. A series of roads join Uganda road at right angles. This includes Oginga Odinga Street, Kenyatta Street, and Oloo Street. Other streets are Nandi road, Ronald Ngala Street, Elijah Cheruyiot Street, Arap Moi Street, Tagore Road and Mitaa road (EMC, 2010).

The streets are characterized by congestion, limited parking lots, high volume of pedestrians and non motorized traffic (EMC, 2010). Some of the main roads have pedestrian walkways designed at the sides of the road. Uganda road has ample space on the shoulder for pedestrian walk ways. However a lot of conflicts arise from traders who have encroached on the pedestrian walkways to trade, the use of carts, and parking for "*matatus"* (EMC, 2010). A study by Mwangi (2008) reported in Okalebo *et al.*, (2009) on transport related problems in Eldoret identified encroachment of road reserves, fuel lead depositions along the materials and vegetation on the road verges as some of the problems. The study further revealed that levels of dust from earth and murram roads especially during dry spells were rising and causing respiratory diseases as well as damage to properties through deposition of dust. Other transport facilities available in Eldoret include rail and air transport.

Recreational facilities include parks and sports facilities. There are two recreational parks in Eldoret town, the municipal park that is closed to the general public and the Sosiani Park which is open to the general public. Sports facilities include 64 Stadium which is the largest in Eldoret and Kipchoge Keino. These provide space for football and athletics. Other small sports grounds are found in residential areas but are inadequate and poorly maintained. The situation is worse in the high density, low income residential areas such as Langas, Kamukunji and Munyaka (EMC, 2010).

Eldoret town has undergone changes by the nature of its functions as the nearby farms that used to give it its identity have given way to other land uses such as residential. Planning in conformity with the fast growing status is therefore a challenge. The CBD is congested with petrol stations, colleges, markets and bus-park. As a result there are inadequate public parks and open spaces for recreational activities in the town (EMC, 2010).

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

The term "green space" has its origin from the urban nature conservation movement and the European thinking about green space planning in United Kingdom (Dunnet *et al.,* 2002 *and* Swanwick *et al.,* 2003).

The meaning of the term green space is often confused with other terms in urban planning especially open space and public space (Mensah, 2014). Various authors have offered definitions to clarify and distinguish the meaning of green space from other concepts in the urban landscape. Manlun (2003) defines urban green spaces as "public and private open areas, primarily covered by vegetation, which are directly (active or passive recreation) or indirectly (positive influence on the urban environment) available for the users." Urban green space may also refer to everything in cities that has vegetation (Gairola, 2010). Jim and Chen (2003) describes urban green spaces as outdoor places with significant amounts of vegetation that exist in cities as semi-natural areas, managed parks and gardens, supplemented by scattered vegetated pockets associated with roads and incidental locations. Fam *et al.,* (2011) defined green space as all vegetated space including trees, shrubs, and grass while Kit Cambell Associates (2001) suggests that green spaces consist of any vegetated land or structure, water or geological features found in a given area.

In spite of the differences in the various definitions on green space, it can be deduced that green spaces in urban areas covers all areas that to some extent have some form of green vegetation either natural or artificial and not limited to urban parks and gardens (Mensah, 2014). It covers land that is made up of mainly unsealed, permeable, "soft" surfaces such as soil, grass, shrubs and trees which are publicly or privately accessible or managed (Dunnett *et al.,* 2002). Swanwick *et al.,* (2003) gave more insight into urban areas being made up of built environment and the external environment in between buildings. The external environment consisting of two entities, namely ‘green space’ and ‘grey space’ (Dunnett *et al.,* 2002). Green spaces occur along transport routes, as wetlands and woodlands, allotments, church yards, school ground, parks and gardens, while grey space covers land to a greater extent sealed, impermeable and “hard” surfaces such as concrete, paving and tarmac including areas planned for public enjoyment such as town squares, plazas and esplanades (Dunnett *et al.,* 2002 and Swanwick *et al.,* 2003). Swanwick *et al.,* (2003) classification therefore describes urban open space as a combination of both green spaces and grey spaces within an urban land that contribute to its amenity either visually or by public access. All open spaces that are accessible to the public are referred to public open spaces (Swanwick *et al.,* 2003).

Urban green spaces can therefore be said to be a sub set of urban open spaces, limited only to vegetative part of the urban environment especially the soft lands while urban open spaces encompass all aspects of green spaces in addition to those grey surfaces (hard lands) purposely made for human usage (Mensah, 2014).

In view of all these definitions and classification, for the purpose of this study green space represents an area within an urban area that is predominantly covered by vegetation either natural or planted, public or private, formal or informal which is directly or indirectly available to users. It is worth noting that green spaces are not necessarily defined by their surface area occupied by vegetation, but rather the presence of vegetation. This allows areas not traditionally regarded as urban green space, to be considered as well. The terms green space, green areas and green cover are used interchangeably.

2.2 The Concept of green space

This concept dates back to the Victorian era when parks and other green spaces were created as a reaction to the rapid industrialization of the time. This resulted to rapid population growth in urban areas rising from 20% in 1700 to 50% in 1851 (Conway, 1996). Pollution and health problems associated with the congested industrial city necessitated the creation of parks and other green spaces. These were to provide both passive and active leisure such as strolling, enjoying the greenery, public gathering and mustering of military troops (Olsen, 1986), and a relief from the toils of industrial labor (Platt, 2010).

In the 18th century, social reformers in the UK embraced the need for green spaces in urban areas and the first municipal park, Birkenhead in Merseyside, UK was opened in 1847 and more parks created thereafter. The public parks were aimed at providing the urban residents with green space that was good for their health, diffuse social tension as well as improve the general well-being of the residents (Dempsey, 2012).

As cities grew rapidly in the late 19th century there was an increased emphasis on integrating nature into the city landscape. Many early landscape architects, mostly Fredrick Law Olmsted (1822-1903), sought to improve the appearance of the city, improve health and provide areas for rest and recreation for the crowded urban population (Hough, 2004). Olmsted, who was responsible for New York’s Central park and the ‘Emerald Necklace’ in Boston, viewed his parks and parkways systems as means of extending the ambience of the countryside into the city. His work is viewed as the precursor to the modern concept of greenways; the spatial planning concept where a string of green areas are connected into a system of protected lands, managed for multiple uses including nature conservation (Fabos, 1995 and Ahern, 2000). The notion of bringing nature into the city expanded after Olmsted to include the idea of urban containment and buffering. Ebenezer Howard's (1850-1928) influential Garden cities of tomorrow (1902) outlined a model of a self-sustaining town. Howard promoted the idea of planned satellite communities surrounded by green belts, containing carefully balanced areas of residences, industry and agriculture. Green belts were designed to define the city limits and preserve the integrity of the countryside surrounding the London area (Howard, 1902).

Embodying the garden city ideal advocated by Ebenezer Howard and the large urban idea expounded by Fredrick Law Olmstead in the US (Wilson, 1989), green spaces have been increasingly designated in cities since 1880s to counteract negative environmental impacts of urban expansion and intensification (Fieng *et al.*, 2005).

The traditional concept of green spaces advanced by Howard changed with the advent of biophilic cities which seeks to include green elements such as green rooftops and vertical gardens in the urban environment (Fieng *et al.*, 2005).

A new approach to the creation and revitalization of communities arose in the USA in the early 1980s, new urbanism. This sustainable planning method aimed to create a city centered around sustainability in design that promotes a variety of transport options (including walking and biking), high density compact/design, and access to green and open spaces and efficient use of land through infill or redevelopment while maintaining the health of the community (Beatley, 2000). New urbanism promotes integration of housing, work place, commercial areas and recreation in a compact space easily accessible by walking (Beatley, 2000).

Dubbed "neo-traditional planning" the principles which define new urbanism can be applied to infill and redevelopment sites within existing urbanized areas to revitalize city centers and limit urban sprawl (Boeing *et al.,* 2014). These principles include among others; Compact development and walkable neighborhoods with clearly defined centers and edges. The centre should include a public space such as a square or green. Besides provision of open spaces such as parks, playgrounds, squares, and greenbelts should be in convenient locations throughout a neighborhood (Boeing *et al.,* 2014).

Green urbanism is another concept for zero-emission and zero-waste urban design which rose in the 1990s. It promotes compact energy efficient urban development to transform and re-engineer existing cities to be environmentally sustainable (Beatly, 2000). Guiding principles of green urbanism include integration of landscape, gardens and green roofs to maximize urban biodiversity and mitigate the urban heat island effect (Lehmann, 2010).

Toronto, a North American city, adopted a mandatory green roof requirement. The green roof bylaw mandates all new residential and commercial rooftops over 2000 m^2 of roof top space to install a green roof (Anonymous 1, 2009). Roof tops that are 5000 m^2 or less is expected to have a minimum of 20% green cover, while larger rooftops of 20000 m^2 or more the percentage rises to 60% (Anonymous 1, 2009).

A city with high quality and adequate green space epitomizes proper planning and management, a healthy environment for humans, vegetation and wildlife populations (Godefroid, 2001). The destruction of existing vegetation and inadequate green spaces consequently degrade the environmental quality, human health and quality of life (Jim, 2000).

2.3 Urbanization and green spaces

Urban areas cover about 4% of the global land areas (UNDP *et al.*, 2000) and it is predicted that continued growth will result in more than half of the world's human population living in urban areas (UNDP *et al.*, 2000). This growth is primarily a consequence of human population increase, development, and social trends, with the relative importance of these factors varying between regions (UNDP *et al.*, 2000).

Urbanization is expected to continue and more so in developing nations where the United Nations Population Fund (UNPF) projects that by 2030, 60% of the world's population will be found in urban areas (Breadsley *et al.*, 2009). This growth of urban populations is likely to demand and require large quantities of land to be used for housing, transport, and other infrastructure and social amenities. The expansion of cities results in loss of urban green spaces to built environment, in particular residential and commercial buildings (Gairola, 2010) while new green spaces are not being created at an equal pace. Local authorities have to make a choice between development of grey infrastructure and preserving some green spaces in the urban environment (Gairola, 2010). The urbanization takes the form of either densification of urban core or spatial expansion of urban areas outwards (Urban Sprawl) (Crompton, 2001). Densification of urban core takes the form of high population density and increase in the built environment (building structures) in relation to open space (Crompton, 2001) while Urban sprawl result to outward expansion of urban areas taking place in the fringes, peri-urban lands and agricultural lands (Crompton, 2001). A study by the European Environment Agency (EEA) on land use change in 25 selected areas across Europe reveals that 7.3% to 41.3% of areas classified as agricultural or natural were converted to urban land uses between 1950 and 1990, and within urban areas, the creation of new public green spaces did not keep pace with the growth of the built areas over the same period (EEA, 2002). Results of several other case studies also show that high population densities go together with low availability of urban green spaces and that sufficient availability of urban green spaces is more problematic in big cities (Baycan-levent *et al,* 2002).

Grant (2010) reports that cities in the world over are experiencing increasing signs of environmental stress, notably in the form of poor air quality, rising urban temperatures, excessive noise and rain water runoff. Research conducted in Colombo, Sri Lanka, reveals that the city's high rate of population growth and urbanization contributes to diminishing green space area, deterioration of air quality with increased emissions from mass traffic and industrial activities making Colombo the most polluted city in Sri lanka (Liyange, 2003).

Robinson *et al.,* (2015) acknowledges that Urban Transitions has left cities and towns with environmental challenges such as poor air quality, and urban heat island and predisposition to climate change effects. However urban transition can be influenced to achieve sustainable development. Without careful production of knowledge and action towards UGS adequacy, urban areas may be overwhelmed with environmental challenges. Such knowledge is inadequate in the case of Eldoret town.

Cities are striving to achieve sustainable urban transformation and various frameworks and practical steps have been designed to support transition towards sustainability. Robinson *et al.,* (2015) suggest that transition towards more sustainable, resilient and liveable urban development, nature based solutions could be adapted. This includes greening cities to reduce urban heat island intensity, urban biodiversity and improve air quality.

Other global concerns including green economy and retrofitting also provides frameworks for greening urban areas toward sustainability. The concept of green economy argues that many global crises associated with climate change food, energy and finance is because money is invested in a “brown economy” such as fossil fuels instead of green sector like renewable energy. A green economy therefore is one that results in improved human well being and social equity while significantly reducing environmental risks and ecological scarcities (UNEP, 2011). According to Jo and Pherson (2001) urban green spaces reduce energy consumption and carbon dioxide emission by reducing the need of fossil fuels for air condition in summer and heating in winter.

Green retrofitting of buildings is one of the most significant ways of greening cities and ensuring urban sustainability. Existing buildings that are partially or wholly occupied can be up upgraded to improve energy and environmental performance and improve quality of the space in terms of air quality and noise reduction (Wilkinson *et al.*, 2009). Biophilic designs provide opportunities to retrofit green in the built environment (Beatley, 2000).

Many developed nations have recognized the importance of green spaces in the urban environment and have paid special consideration to green space planning in their urban development. They have adopted integration of green space in urban development as a way of increasing green cover (Mentens, 2006). Studies conducted in different cities however, reveal some successful green space provision policies that can be emulated. In Germany for example, the adoption of roof greening has led to a reduction of surface runoff from the green roofs. A study in Brussels showed that extensive roof greening on 10% of the building resulted in a runoff reduction of 2.7% for the region and 54% for the individual buildings (Mentens, 2006).

Copenhagen-Denmark features some excellent examples of green space that compliment high density living. It has expansive urban green spaces and has an ambition to have accessible green structure of international standard (Caspersen, 2006). The city contains a variety of parks, plazas, walking trails, cycle routes and green streets. Coordination between planning at the local and regional level facilitated the development of green areas as well as the coordinated measures of the greater Copenhagen council which further strengthened this process (Byrne and Sipe 2010).

Availability of different plans from the 1936 plan for green space development to date that put emphasis on the existence and accessibility to green areas have had a significant impact on development of Copenhagen. New plans that emphasize the values and benefits that relate to green spaces from an environmental and livable point of view have also been aligned to this development. Besides detailed plans for future enlargement of green space in corporation with relevant municipalities have been developed (Caspersen *et al.*, 2006).

Hangzhou-China has also been commended for retrofitting green space to the city's dense urban fabric. The municipal government has been greening all the available space. Land next to canals, railway lines, freeways, factories and even city streets has been turned into flowerbeds, ornate gardens and landscaped parks (Byrne and Sipe 2010). Due to its ambitious urban greening program, Hangzhou now has 166.5 $km^2$of green spaces, about 40% of the city area (Sang *et al.*, 2013).

2.4 Policies of green space planning in Kenya

In Kenya vast amounts of legislation and policies relating to most aspects of green spaces have been formulated. A review of national and local documents identifies the key issues, policies and drivers for planning and management of green spaces and other land uses in urban areas.

Kenya Vision 2030 aims to make the country a clean, secure and sustainable environment by 2030. One of its environmental goals is to increase forest cover and lessen by half all environmental related diseases by promoting environmental conservation, improving pollution management and the capacity for adaptation to global climate change (Kenya, 2007). Enhancing green cover contributes towards this goal by providing a sustainable environment through its ecological benefits.

The Draft Physical Planning Bill 2014 and The Physical Planning Act 286 both require each county government protect and preserve all land for open spaces, parks, urban forests and green belts in accordance with the approved physical development plan. Besides county authorities have been given powers to undertake development control to protect and conserve the environment. The local authorities are mandated to develop local physical development plans to deal with replanning and reconstruction of plan area including adjusting and altering area, shapes and provision of any land, road, street or right of way. This provides a framework to introduce retrofitting programs for green spaces in the highly compact urban fabric.

Urban areas and Cities Act 2011 also mandates boards of cities and municipalities to control land use, land development and zoning by public and private sectors for any purpose including recreational areas and parks and to promote a safe and healthy environment. Both private and public green spaces are developed to ensure a healthy urban environment.

The National Spatial Plan concept paper 2010 (NSPC), focuses on a number of areas including improvement of the state and quality of environment. It provides a framework for spatial distribution of activities on National space in an organized way while protecting the environment. It aims to identify and map out areas that require rehabilitation, regeneration and restoration. Green spaces play a key role in improving the quality of the environment. Identifying and mapping out green spaces in urban areas provides a framework for their restoration especially in areas where they have been depleted.

Specific spaces have been presented as green space. Open spaces, in particular parks and buffer zones, have been delineated as green spaces. Buffer zone of sufficient distances should be left between functions that cause undesirable health effects or accident risk on one hand and also impact positive activities on the other (NEMA, 2011). Planning standards for buffer zones include 10-30 meters of green belt on either side of urban ring roads and bypasses and green belts created to prevent pollution between conflicting and non compatible land uses such as between main roads and residential, industrial and commercial areas (Republic of Kenya, 2007). Recommended land requirements for parks is 1-2 hectares per 10,000 populations in an area of 100 persons per hectares density. Besides parks should be located within residential and commercial areas providing areas for sitting quietly with scented gardens, flower and shrub display (Republic of Kenya, 2007).

Other policies regarding highway development on the environment that promote occurrence of green areas include protection of exposed ground by tree planting, turfing of slopes, boulevards along transport corridors by planting trees and shrubs, and beautifying the entire road system by allowing flower selling business (Republic of Kenya, 2007). Riparian reserve is recommended to be between 2 m and 30 m of green space on either side of water course, while other green spaces recommended in urban areas include squares, lawns and play grounds. Minimum set back of dwelling for normal housing is 6 m in front, 3 m on the side and 4.5 m in the rear which should contain green cover. In commercial areas, building setbacks and traffic island should also be provided (Republic of Kenya, 2007).

Vegetables and other crops grown in back yards, in vacant lots of industrial estates, along canals, on grounds of institutions and on roadsides are recommended to make provision of carbon sink, greening of towns and for aesthetic value. However planning standards recommend that only short crops should be grown (Republic of Kenya, 2007).

Despite having policies and regulations related to environmental planning and management, Kenya has continued to experience planning challenges due to rapid urbanization and poor enforcement of planning policies (NSPC, 2010). Local authorities are overwhelmed to plan and provide key services including green space provision. This has accelerated environmental degradation. The inability to regulate the urban landscape is also evident in our urban areas. Increasing population has had a negative impact on the environment evidenced by among others deteriorating urban environment and climate change (NSPC, 2010).

Challenges to green space provision include inability of local authorities to explain to residents the importance of green spaces and poor enforcement of development controls caused by a lack of political will thus destroying green belts in African cities (Mensah, 2014). Besides, use of old master plans make it difficult to fight destruction of green areas. Urban planning approaches applied in Kenya are found to be inadequate since they adopted planning laws from the colonial administration. Set standards too high when it comes to development, in some cases prepared urban plans focus only on built up zones ignoring green environment (Cheserek *et al.*, 2012).

Studies have not been done in Eldoret town to determine the availability of green spaces within the areas recommended in the various policies and regulations of urban planning.

2.5 Typologies of urban green spaces

Various criteria have been used to classify urban green spaces including its size, its intended function, ownership and location. A review of literature reveals classification frameworks that do not lock planners into rigid categories-as new types of green space are always being developed (Byrne and Sipe 2010).

Traditional types of urban green include Public parks, plaza-green space, nursery, green buffer, Attached green space, residential green space, roadside green space, riparian green space and scenery forest (Kong and Nakagoshi 2006). Due to limited ground space, innovative types of green space have been introduced. These include green roofs and green walls (Beatley, 2011). Kong and Nakagoshi (2006) give a description of the various types of urban green spaces;

I. Public parks; are created in cultural and natural areas and include city park and natural reserve areas, sea shores, picnic areas, special sport areas or play grounds. They are open to the public and provide educational, pleasure, and recreational services and has natural and planted vegetation.

II. Plaza green space is open to the public and provides open space, recreational opportunities, with planted vegetation, a few trees, short shrub and grassland of low diversity.

III. Nursery includes areas for propagating and cultivating vegetation being supplied for urban greening.

IV. Green buffer constitute liner corridors with vegetation protecting high-voltage transmission lines, screening wind and cleansing pollutants.

V. Attached green spaces are attached to industrial, commercial, and utility land with planted vegetation of low diversity.

VI. Residential green spaces include all green spaces in residential areas such as housing gardens and playground providing aesthetic and recreation venues with planted vegetation.

VII. Roadside green spaces include linear corridors between the side walk and island patch in the crossroad with planted vegetation. May serve to buffer people from traffic, screen noise and solar radiation.

VIII. Riparian green spaces are linear corridors along the watershed, mostly with natural habitat type.

IX. Scenery forests are open to the public, protecting and preserving the flora and fauna and providing scenic beauty.

Besides these, typologies of green spaces recommended by the Urban Green Task Force (UK) include; Parks and gardens: country parks, natural and semi natural urban spaces; green corridors; outdoor sports facilities; amenity green space; play ground; allotments, community gardens and urban farms; and cemeteries and church yards (DTLR, 2002).

A research by Fuwape and Onyekwelu (2011) revealed the major forms of urban green spaces in African countries to include the following:

I. Semi-private space such as green space in residential, institutional and industrial areas;

II. Designated parks, street trees and roadside plantations;

III. Public green areas such as parks, botanical gardens, recreational gardens and outdoor play areas;

IV. Public and private tree plantations on vacant lots, green belts, woodlands and peri-urban farming;

V. Rangeland and forests close to urban areas;

VI. Natural forest such as nature reserves, national parks, and forests for ecotourism; and

VII. Trees planted for environmental protection and beautification.

The research further found that most city authorities put emphasis is given to urban trees. The governments of African countries collaborate with environmental agencies on tree planting exercises in urban areas to enhance greenery and air quality of those areas. According to the 2011 African Green City report, cities such as Lagos (Nigeria), Durban and Johannesburg (South Africa), Nairobi (Kenya) and Cairo (Egypt), emphasis on growing trees than other forms of green spaces (Mensah, 2014). Onyeka (2014) further reported that most green spaces in Africa were designed and planned by the colonial governments and early independent governments. County governments within the new frame work of devolved management in Kenya now have an opportunity to reinvent themselves to develop and enforce new ways to greening their cities other than just planting trees along the streets.

An understanding of different types of green spaces available provides useful information to develop and establish planning and management practices to cope with the diversity of green spaces to enhance their ability to contribute towards a livable urban environment.

Although a number of studies on green space typology have been carried out, there is limited information on green spaces typology in Eldoret town, which will ultimately hinder their planning management and conservation towards a sustainable town.

2.6 **Innovations in Green Space Creation**

Urban development and scarcity of land pose a challenge in creation of green spaces in cities and towns. There is need to device innovative ways of integrating green cover in urban development. Many cities have begun to take up the challenge of providing alternative more innovative forms of green space (Byrne and Sipe 2010). Byrne and Sipe (2010) argues that the concept of green space standards are inadequate and irrelevant and if our cities are to become more livable and ecologically viable in an environment where ground space is limited, there is need for alternative approaches to green provision.

Innovative forms of urban green space which have been propagated worldwide include: roof greening, vertical green spaces and living walls, sky gardens, and rooftop gardens for sustainable town planning (Beatley, 2010). These are not yet sufficiently known and adopted at the local authority level of most developing countries as they require advanced technology, expertise and finances (Byrne and Sipe 2010). As a result, such forms are non- existent or have been integrated only partially and unsystematically in urban development (Byrne and Sipe 2010). Identifying new innovative green spaces which can be applied to Eldoret town will contribute towards enhancement of its green cover quantity and per capita value.

2.6.1 Vertical greening

Limited ground space, buildings and high rise construction has caused vertical greening technology to become the most effective way of creating green spaces. It involves growing vegetation on, or adjacent to the unused sunlit exterior surfaces of buildings in cities (Skinner, 2006).

Vertical greening covers large areas of building walls that are otherwise not used. If 'greened', these surfaces can serve as cooling engines, air purifiers, carbon sinks and aesthetic value (Skinner, 2006). Opportunities for vertical greening in Eldoret town have so far not been identified. Such opportunities if utilized will enhance the amount of green cover especially where ground space around buildings is limited.

2.6.2 Green Roofs

Green roofs are vegetated roof covers constructed on top of a roof. The modern green roof originated at the turn of 20^{th} century in Germany, where vegetation was installed on roofs to mitigate the damaging physical effects of solar radiation on the roof structure (Kohler, 2003).

Roof tops are considered the greatest untapped open space opportunities' in cities. Most large institutional or residential buildings have flat roofs that could potentially be used for green space. Byrne and Sipe (2010) suggests that tops of schools, libraries, government office buildings, post office among others can all extend to over an acre. They can reduce ambient air temperature, energy use, and utility cost: purify air and water as well as extend the life of the roof.

Green roofs provide ecosystem services in urban areas, including improved storm-water management by collecting and retaining precipitation (Byrne and Sipe, 2010) Other potential benefits include better regulation of building temperature, reduced urban -heat island effect and increased urban wildlife habitat (Getter *et al.*, 2006). The sloping rooftops planted with grass and other plants inject a wild vegetated grassy view in an otherwise heavily built- up area.

Rooftop gardens are another important urban design that ensures urbanites connect with soil and plants. ‘Alternatives’, a non- profit organization in Montreal, Quebec, started rooftop gardens in many buildings around the city (Beatley, 2010). These gardens are lush and provide a dramatic green contrast to the stark grayness of buildings and tarmac. Green roofs provide opportunity for increasing green cover in the densified urban areas.

2.7 The role of green spaces

Urban green spaces provide many contributions to social and economic life, and to the local ecological and planning systems, and as a whole to the urban quality of life. They also contribute positively to some of the key agendas in urban areas like social inclusion, health, sustainability, and urban renewal (Baycan-levent *et al.*, 2009). Previous studies have highlighted the benefits of urban green spaces which can be grouped into various classes including ecological, health, social, economic, and planning functions (Onder *et al.*, 2011).

2.7.1 Ecological benefits

Urban green spaces generate significant multi-functional ecosystem services that contribute to improving the quality of urban environments. They play a central role in both climate-proofing cities and in reducing the impacts of cities on climate (Gill *et al.*, 2007).

Scientific studies predict a global temperature rise between 1.1^0 C and 6.4^0 C and an increase of extreme weather conditions due to climate change over the next century

(IPCC, 2007). This will have significant negative consequences on health and quality of life for urban dwellers. Green spaces are particularly important in climate change mitigation and adaptation to its possibly negative consequences. The ecosystems services provided by green spaces can, for example, reduce the predicted impacts on health and quality of life (Demuth and Von Eitzen, 2013). Bowler (2010) reaffirms that urban greening has been proposed as one approach to mitigate the human health consequences of increased temperatures resulting from climate change.

Urban 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 and Von Eitzen, 2013), as well as reducing energy consumption (fossil fuels) and carbon dioxide emission by reducing the need for air condition in summer and heating in winter (Jo and Pherson, 2001). This makes a small scale contribution to climate mitigation.

However, with urbanization process gradually replacing vegetated surfaces with impervious surfaces, energy exchanges are modified to cause an urban heat island (Gill *et al.,* 2007). Buildings, roads and other concrete surfaces absorb and store heat from the sun thereby raising urban temperatures. Reflective surfaces such as glass, heating and cooling systems, transport and industrial activities all contribute to heat in urban areas. Urban green spaces reduce the effects of UHI (Rahola *et al.,* 2009) as vegetation reduce intra-urban day time temperatures through transpiration of vegetation and evaporation from moist soil, as well as by casting shadows. The cooling effect can be felt not only within green spaces but also within neighboring housing (Bonan, 2008 and Demuth and Eitzen, 2013). An adequate amount of green is therefore necessary for reduction of day temperatures. A thermal performance of a small green space study by Oliveria *et al.,* (2011) in the densely urbanized Lisbon reveals that the garden was cooler than the surrounding areas either in the sun or in the shade. The cooling effect of green areas on the surrounding environment can therefore be enhanced by additional measures to conserve the available green spaces and increase green cover.

In addition, urban green spaces that are well planned can create or restore biological diversity from increased vegetation cover and connectivity of a city to its surrounding (Tzoulas *et al.*, 2007). Urban development destroys the existing ecosystem with the flora and fauna in that system destroyed, displaced or have to adapt to the new urban environment. As a result, the regions genetic diversity becomes threatened with extinction. Networks of green spaces such as street trees, green bridges and natural river systems can provide biological corridors for the migration, dispersal and genetic exchange of species in the wider environment (DCLG, 2006).

Motor vehicle traffic and industrial activities are two main sources of air pollution in urban areas. Urban green spaces cleanse the air of both particulate and gaseous air pollutants. Research has shown that vegetation in green spaces can filter up to 85% of suspended particles (Shan, 2007). Dust and smoke particles are trapped by vegetation thereby reducing air pollution. Plants absorb toxic gases from vehicle exhaust which are a major component of urban smog (Nowak *et al.*, 2006) significantly improving urban air quality. Improved air quality lower pollution load and improve health offering protection against respiratory diseases. Therefore, the higher the level of plant coverage and foliage, the greater the air purification results.

Noise pollution from heavy industries and traffic corridors is a common phenomenon in urban areas and can reach unhealthy levels. Haq (2011) suggests that green spaces in over-crowded cities can reduce the levels of noise depending on their quantity, quality and the distance from the source of noise pollution. Trees and vegetation absorb, deflect, reflect, refract and mask sound, reducing noise pollution. The leaves, twigs, branches, grasses and herbaceous plants absorb sound while trees and plants act as barriers that deflect and reflect sound (Sorensen, 1997). Reduction of noise exposure offers protection against hearing impairment and noise- induced stress.

The process of urbanization reduces the ability of urban areas to cope with surface water runoff in the event of heavy rainfall (Armson *et al.*, 2013). The impermeable surfaces increase surface runoff and reduce natural water absorption into soil. Rain water has to be channeled through the concrete surfaces which in turn results in increased flood risk, threatening properties and livelihoods. Urban green spaces provide the natural ground cover; this reduces runoff and increase natural infiltration controlling urban flooding (Hamin *et al.,* 2009). The planting of trees and provision of green roofs also increases interception levels (TCPA, 2007). It is estimated that cities with reasonable urban green space coverage, can naturally absorb two-thirds of storm water, preventing flood hazards while recharging surface and ground water (Demuth *et al.,* 2013).

2.7.2 Health benefits

Green spaces can minimize health risks in urban environment such as air pollutants, noise and heat. They also have great potential for increasing psychological, physiological and social well being which contribute to reduced health care cost. Epidemiological studies by Green Space Scotland show that green space has a positive influence on general health of human beings (GS, 2008). The urban environment characterized by dense population, traffic noise and pollution expose inhabitants to stress inducing factors. Interaction with nature may therefore mitigate mental fatigue and facilitate recovery from stress (Cackoowwski *et al.,* 2003; Hartig *et al.,* 1991 and Kaplan, 2001).

The psychological, emotional and spiritual needs of urban inhabitants are derived from recreation, relaxation, spiritual and aesthetic experiences in green space (Maller *et al.*, 2005 and MEA, 2005). Access to green space is reported to improve mental health and recovery from chronic illness (Maller *et al.,* 2005 and Tzoulas *et al.,* 2007). Patients in hospital whose rooms were facing a park had a 10% faster recovery and needed 50% less strong pain relieving medication compared to patients whose rooms were facing a building wall (Haq, 2011). Semi therapeutic form of recreation may also be derived from use of urban green space such as relaxing, walking and taking part in outdoor sports (Chiesura, 2004). A 2007 Danish study demonstrates the importance of green spaces. These green features were found to be associated with lower stress levels and lower likelihood of obesity (Nielsen *et al.*, 2007).

2.7.3 Social benefits

Suitable quantity green spaces provide urban inhabitants with places for recreation, relaxation and other social benefits. 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). They provide venues for festivals, civic celebrations and theatrical performances thereby enhancing cultural life in cities. Urban green spaces may also provide safe playing areas for children (Hart, 1997). They also offer individuals space for personal and religious reflection. Byrne and Sipe (2010) suggests that presence of green spaces in the dense urban environment makes it livelier, activities within the area more manageable and more enjoyable as people interact with nature. A livelier street lined with trees makes walking easier, change perception of distance while making walking trips feel shorter and more manageable.

2.7.4 Planning benefits

Scottish Executive (2001), reports that well designed green spaces provide pathways for people to travel either by foot or by bicycle for recreation or commuting. A network of green spaces connecting residential, business, institutional, and leisure areas can help to improve the accessibility and attractiveness of local facilities and employment centers. Green spaces may also function as a boundary landscape separating areas of distinct socioeconomic characteristics (Baycan-levent *et al.*, 2009).

2.7.5 Economic benefits

Urban green space has economic values. Using vegetation to reduce the energy costs of cooling buildings has been recognized as a cost effective reason for increasing green space and tree planting in temperate climate cities (Heidt *et al.,* 2007). Plants improve air circulation; provide shade and evapo-transpiration. This provides a natural cooling effect and lower air temperatures (Haq, 2011). A study in Chicago has shown that increasing green cover in the city by 10% may reduce the total energy for heating and cooling by 5% to 10% (Soresens, 1997). Concrete surfaces in urban environments produce an urban heat island effect that causes discomfort and health problems, especially for those who cannot afford air conditioning. On the other hand, cooling air-conditioned buildings requires considerable amounts of energy, which is costly. This can be reduced by planting vegetation in the dense city centers (Sorensen, 1997).

Haq (2011) suggests that areas of city with adequate green cover are aesthetically pleasing and attractive to both residents and investors. According to Soresen (1997), the beautification of Singapore and Kuala Lumpar, Malaysia resulted to increased foreign investment and rapid economic growth. Urban green spaces increase property values and therefore, affect housing prices and housing values positively.

In awareness of the importance of green space for human well being and urban sustainability, the need for green space should first of all be met in terms of quantity and quality of green areas within cities and towns. Limited studies have been carried out to determine whether Eldoret town has adequate green spaces to provide these benefits to its inhabitants.

2.8 Potential opportunities for expansion of Green Spaces

Urban areas can be viewed from an entirely new, ecological perspective. The built environment can be transformed into a living landscape. Many cities posses few green spaces and those are usually arbitrarily located. Green areas –parks, gardens- become relegated to isolated pockets, linear walkways or derelict railway routes, but more often than not marooned in expanses of brick, concrete and tarmac (Johnston and Newton, 2004). Gupta *et al.,* (2011) acknowledges that land resources are becoming scarce in urban areas; planners have to go for high rise development. However high rise development area needs more amounts of green spaces to meet the needs of high density population. The fundamental structure of cities and towns is likely to remain unchanged as such what opportunities are there for enhancing the amount of green cover?

Johnston and Newton (2004) recommends creating a network of green buildings by introducing vegetation and its many related benefits into the actual fabric of urban areas. The skin of the city- its roofs, walls, streets and other hard surfaces can be transformed into living landscape as ecologically dead areas come alive again, becoming environmental assets in themselves.

Buildings in urban areas provide enormous areas of wall space. Much of it is appropriate for growing plants and may be utilized to increase green cover. Though challenges may exist, with special measures, design or construction techniques it can prove possible. There are also opportunities to establish plants in the joints between brick or fascia work of on specially built ledges and terraces (Johnston and Newton, 2004).

In addition, Beatley (2011) recommends that spaces around and between buildings and streets represent many opportunities to increase urban green cover. Including green corridors along road and paved surfaces, and increasing shrubs, trees and hedges within the city can provide the needed green cover (SCC, 2012). Jim (2004) proposes that green spaces should be allocated in the grounds of residential, office, government, institutional and community land use. While in Hangzhou, China green spaces are interwoven into just about any left-over urban spaces. Such opportunities are yet to be identified in Eldoret town as a way of enhancing green spaces.

Roofs present significant opportunities for greening buildings. Unused and unattractive roofs represent enormous wasted opportunities for improving the quality of urban environment. They include roofs of tall office blocks, schools, hospitals as well as block of flats (Gupta *et al.,* 2011).

Court yards also provide opportunities for green space enhancement. They can provide green space for work or relaxation or simply organized as attractive green areas to offer pleasing views from the home or office window (Johnston and Newton, 2004). Court yards can be defined as open areas surrounded by walls or buildings.

They may be located within large buildings such as an office, large home of hospital, or created by the juxtaposition of several buildings as in the case of blocks of inner city flats (Johnston and Newton, 2004).

Balconies and small terraces are standard architectural features that provide opportunities for greening. This means growing plants in relatively small containers which stand on the balcony floor or are fixed to walls of rails (Johnston and Newton, 2004). This sort of container gardening can be applied to other spaces too: Patios, stairs, porches and roof terraces. On buildings without balconies or terraces window boxes and other containers can be sited on the window ledges or attached directly to the wall (Johnston and Newton, 2004).

Various methods have been used to identify potential site for green space creation. This includes land suitability analysis and Multi criteria analysis. Handly *et al.,* (2003) suggests that the most reliable means of identifying appropriate sites is through the use of local knowledge and site survey including analysis of maps and aerial photographs. Through local knowledge and analysis of satellite images of Eldoret town, this study identified potential sites for expansion of green spaces. Information on potential sites is currently lacking and may hinder the expansion of green cover within Eldoret town.

2.9 Methods of mapping Green Spaces

A number of methods have been used in the field of urban green space mapping and analysis, all with diverse aims and results. Nowak *et al.,* (1996) reviews several methods of determining urban green cover from aerial photographs. They include; transect method, crown cover scale, dot method and scanning method which is more accurate, detailed and integrates well with Geographic Information System.

Mohd and Johari (2012) applied Object Oriented Image Analysis method to identify green spaces in Kuala Lumper while Beiranvand *et al.,* (2013) evaluated changes in per capita green space in Khovramabad using dot grid map and remote sensing data. Buyantuyey (2009) used landscape metrics computed from landsat derived maps to quantify the land use and land cover change in Phoenix Arizona from 1985 to 2005.

2.9.1 Remote Sensing and Geographic Information System

Remote sensing is the technique of deriving information about objects on the surface of the earth without physically coming into contact with them. Earth observations provide useful knowledge for better understanding of the landscape composition. Traditionally, aerial photographs have been used to capture the variability of surface cover types (Cui, 2011). However, high acquisition costs and narrow spectral resolution have limited the use of this application in monitoring urban environmental processes (Cui, 2011). With technological advancements, the use of satellites images has become an effective and efficient tool.

Remote sensing has been used successfully in many studies to map accurately the nature and spatial extent of vegetation cover in different environments (Gupta *et al.,* 2012). Remote sensing technology can capture land surface characteristic with larger spatial coverage and wider spectral ranges (Poushesh *et al.,* 2007). In addition it has made collection of data possible at a low cost. Poushesh *et al.,* (2007) reports that land surveying of urban green space have enormous costs and time consuming. Urban green space mapping using satellite images costs less.

Remote sensing imagery provides up-to date and comprehensive data in the visible, IR and thermal regions of electromagnetic spectrum. This imagery can be easily integrated into other types of geospatial data in a Geographic Information System

(GIS) environment. GIS facilitates data entry, analysis and presentation of spatial data taken by remote sensing (Parmeter, 2007) as such remote sensing has been used in many studies to collate different types of data, so that spatial overlay and analysis can be performed to answer questions such as where, why and how (Hashem, 2015).

Many remote sensing methods have been used to map the vegetation cover such as vegetation indices and image classification algorithms. Vegetation indices rely on the distinct characteristic of vegetation in terms of absorption and reflectance of electromagnetic radiation (Hashem, 2015). Most natural surfaces on the ground appear to have similar brightness in the red and near –IR part of the spectrum. The vegetation, however, strongly absorbs the red light by its photosynthesis pigments, while it reflects back the near-IR light or allows it to go through the leaf tissues (Datt, 1999). The Normalized Difference Vegetation Index (NDVI) is a ratio image differencing technique used to map vegetation cover. The normalized difference of reflectance from the near infrared and visible red bands is calculated from the image. It is expressed in the following equation:

$$\text{NDVI} = \frac{\text{Near IR Band} - \text{Red Band}}{\text{Near IR Band} + \text{Red Band}}$$

The NDVI discriminates green vegetation from other features since vegetation contains chlorophyll that absorbs red light for photosynthesis. At the same time the near infrared energy is reflected back. High NDVI signifies high vegetation cover. One of the problems in calculating vegetation indices is the effect of soil background which reduces mapping accuracy. Some algorithms attempt to minimize the effect of soil background resulting in the increase of algorithms sensitivity to variations to atmosphere (Leprieuu *et al.*, 1994). Another limitation of using vegetation indices is that they are only sensitive to the green vegetation and might not recognize non- photosynthetic vegetation (Drake *et al.,* 1999). A further limitation of using vegetation indices to estimate the vegetation cover is the problem of shade cast by either topography or by taller vegetation. This shade obscures the vegetation partially or totally and creates errors in vegetation cover estimation. An alternative method to map vegetation cover is the remote sensing technique pixel based image classification.

2.9.2 Pixel-based Image Classification

Pixel –based image classification helps identify the location of green space from which Landscape Metric Analysis can be applied to shade light on their landscape characteristics. Image classification is a process of assembling groups of identifiable pixels found in remotely sensed data into classes that match the required categories of user by comparing pixels to one another and those of known identity (Palaniswan *et al.,* 2006 in Manibhushan *et al.,* 2012). Mathematical rules are used to assign each image pixel to a single ground cover category. Baatz *et al.,* (2004) describes image classification as a task to assign image objects into user-defined classes. The classification produces a qualitative map where each pixel in the remote sensing image is allocated exclusively to one class. Bin *et al.,* (2003) suggests that to achieve accuracy, it is necessary to include both spatial (or structural) information as well as the spectral information. This can be achieved using human interpretation and the researcher's knowledge about study area. There are two main methods of image classification, unsupervised and supervised.

2.9.2.1 Pixel-based unsupervised image classification

Unsupervised classification method is used when insufficient data about the nature of the land cover types is available for the geographical area covered by remotely sensed image (Mather, 1999). In this case it is not possible to estimate the amount of green spaces available. In this classification, pixels with similar multi spectral responses in various spectral bands are grouped into clusters or classes that are separable statistically. Each individual pixel within the scene or image is compared to each discrete cluster of pixels to see the closest fit. The final result is a thematic map of all pixels in the image assigned to one of the clusters each pixel is most likely to belong to; the analyst then relabels and combine the spectral clusters into traditional information classes (Navulur, 2007).

2.9.2.2 Pixel- based supervised classification

The supervised classification method, however, is based on a prior knowledge of an area which includes the spectral signatures of land cover types. This knowledge is then used as an input for the classification process (Lillesand and Kiefer 2007).

Supervised classification uses pixels in the training samples to develop appropriate discriminate functions to distinguish each class (Shackford *et al.*, 2003). According to Lwin *et al.,* (2012), the procedure involves identifying spectrally similar pixels on the image by identifying ‘training sites’ of known targets, such as vegetation, and then extrapolating those spectral signatures to other areas of unknown targets.

2.9.3 On- screen digitization

On screen digitization is an interactive process in which a map is created using previously digitized scanned information. The user creates the map layer on the screen with the mouse and with reference information in the background. On- screen digitization may be used to trace features from an image to create new layers or themes (McGowan, 1998). In green space mapping On-Screen digitization is applied to create polygons for each green zone.

2.10 Theoretical Framework

Development of green spaces as a measure towards urban environmental sustainability is explained by the urban ecology theory. It is an emerging field that aims to understand how human and ecological process can co exist in human dominated systems and help societies with their efforts to be more sustainable (Mc Phearson, 2014). It seeks to enhance interaction among social and ecological systems in urban areas overtime and space (Young, 2009). Green spaces are the urban flora and a habitat to a variety of fauna and its enhancement in urban areas with intense human activities contribute towards an ecological sustainable urban environment.

The latest advances in urban ecological theory have provided ecological models that integrate different temporal and spatial scales that allow for an assessment of the components and dynamics of urban ecosystems (Moffat and Kohler, 2008). Components of an urban ecosystem include plants, animals and micro organisms and their nonliving environment interacting as a functional entity (MA, 2003). These interactions offer a flow of vital services (food, water or energy) to facilitate human life. Urban ecosystems such as plants provide important ecosystem services such as water purification, local food production, storm water absorption, urban heat island reduction and flood protection among others, enhance real estate value, improve human and mental and physical health and serve as important areas for recreation, contemplation and relaxation (Mc Phearson, 2014). If one of the social or ecological aspects is altered or removed from the system, it impacts the availability of other resources within the system (Pickett and Cadenasso, 2006). The process urbanization has led to increased building and pavements leading to low availability of green spaces in urban areas in turn degrading the condition of urban environment.

Enhancement of green spaces there means an improved ecosystem services in the urban environment.

Ecosystems especially plants require space and soil of adequate quality to ensure their ability to provide high quality ecosystem services (Brauman and Daily 2008). With limited ground space which is a result of densification of urban areas, there is a need to adopt innovative green spaces which use vertical space to enhance its cover. The growing urban population which is highly dependent on ecosystem services increases the demand for ecosystem services in particular those provided by green spaces (Brauman and Daily 2008). The capability of ecosystems, especially green spaces to provide ecosystem services to the increasing urban population is dependent on their structure and on their intactness. Hence their pattern and quality plays a major role in urban ecosystem services provision (Alberti and Marzluff 2004, Yapp *et al.*, 2010). Thus, the enhancement of urban green spaces in terms of quantity and distribution to facilitate the provision of ecosystem services is key in urban planning (Young 2010). In the context of current environmental challenges, it is valuable to constantly evaluate the form and function of urban ecosystems in order to achieve more livable, equitable and healthy urban environments in balance with earth's natural systems. An ecological framework especially on the quantity and typology and distribution of green spaces and opportunities for their expansion within an urban area can guide planners in this process.

2.11 Conceptual Framework

The integrated concepts of Garden city and Biophilic Cities relies on the urban ecological theory where interaction between nature, built environment and human environment is the guiding principle and appreciate the need for sustainable development of cities. In Garden Cities of To-morrow, Howard outlines the nature of a garden city that promised a clean environment, free from air and water pollution, and abundant parks and open spaces (Clark, 2003). It may appear that Howards proposal for garden cities have been bypassed in urban planning and the promise for a sustainable future compromised by urban sprawl and profit, however his proposal provides a basis for assessing how urban society relate with nature. His outline of a garden city includes large well watered garden, a large public park, streets lined with trees and bushes and homes with ample garden space for enjoyment and food production (Clark, 2003).

A Biophilic city is a green city with plenty of nature and natural systems that are visible and accessible to urbanites. It proposes that the design and planning goals of cities need to include nature (Beatley, 2010). According to Beatley (2011) a biophilic city is a diverse city full of nature, a place where in the normal course of work and play, and life residents experience rich nature –plants, trees and animals, their nature being either large or small.

Beatley (2010) outlines the essential elements of a biophilic city. It is a biodiverse city, a place that learns from nature and emulates natural systems, incorporates natural forms and images into its buildings and cityscape, and designs and plans in conjunction with nature. It preserves natural features that already exist and works towards restoring and repairing what has been degraded or lost. It provides for ecological networks and connected systems of urban green space from green rooftops to green walls and side walk gardens (Beatley, 2011). Beatley (2011) further suggests that compact dense cities lay the foundation for biophilic living and planning for the compact urban form holds the potential to profoundly reduce the amount of land consumed and the impact on regional ecosystems while expanding access to green elements. He further suggests that planting trees and other forms of vegetation in the spaces around and between the buildings and streets in a city represent many opportunities to increase urban green and an essential step in forming the urban nature. However a significant challenge in the dense urban environments is to reimagine the many existing hard surfaces as opportunities to insert green life.

An organization in San Francisco, "Permeable Landscape as Neighborhood Treasure" has managed to convert the hard surface roadway and sidewalk space and to create green permeable spaces in their place, notably two thousand square feet of paved surface was replaced with flowers, grasses, and trees and their accompanying beautiful hues, scents, and insect life (Beatley, 2011). Other ways of greening the city includes installing clinging plants and vines on walls and fences, de-sealing portions of driveways to create green planting strips, and of course planting trees (Beatley, 2011).

Other biophilic units include buildings and homes of which much of daily life and work occurs. Beatly (2011) further suggests that hospitals, schools, offices, homes and apartments can also be biophilic. This may include courtyards in the buildings and gardens with plants. Other opportunities proposed for urban greening in dense urban environment include vertical and elevated environments. These spaces include rooftops and building facades, balconies and window openings, terraces and fire escapes.

There is no one city that exemplifies all aspects of biophilic city. However some aspects of these emerging practice of biophilic urban design and planning can be adopted to transform cities from grey and lifeless to green and biodiverse. This concepts offer direction to creating urban green space.

The conceptual framework is summarized in Fig 2.1

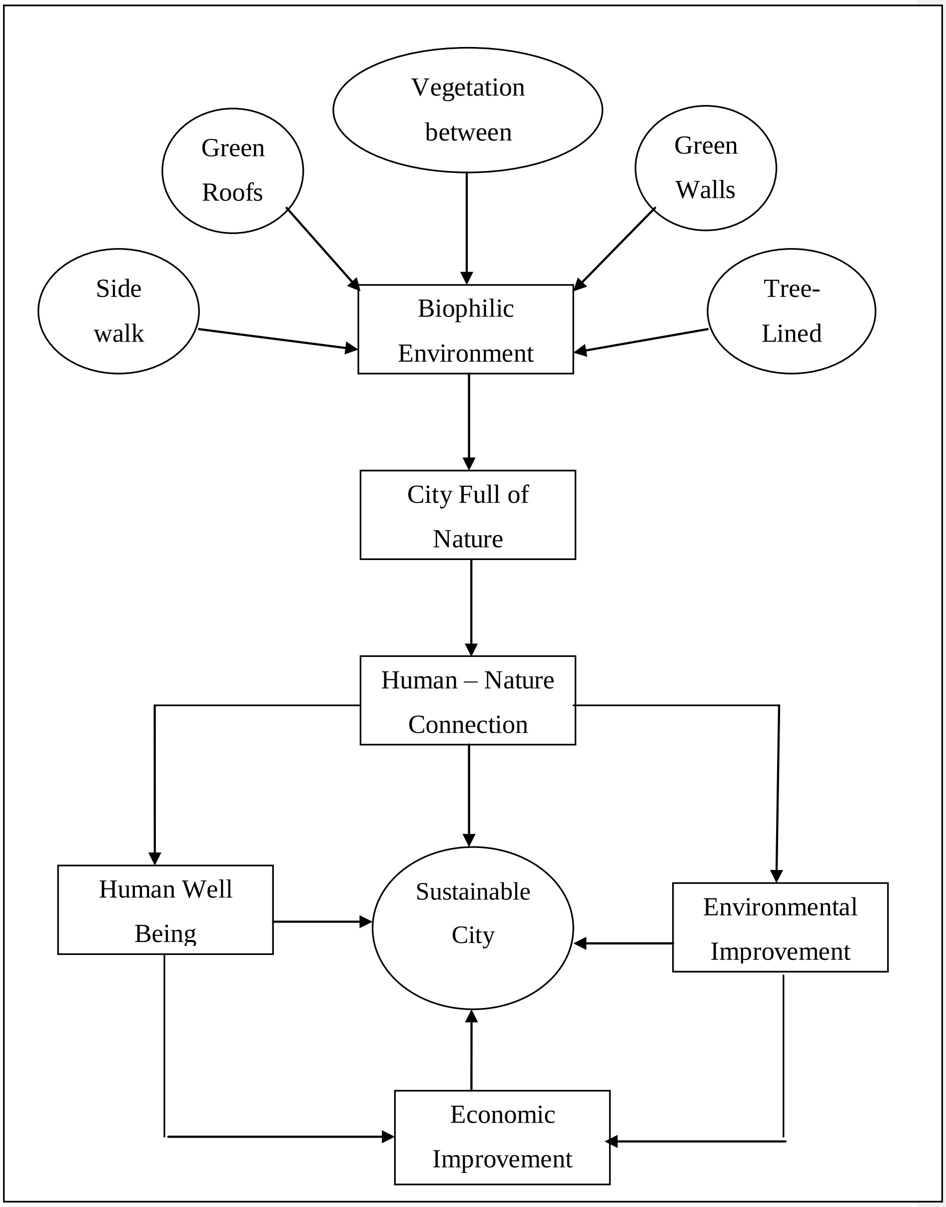


Figure 2.1 Conceptual framework (Source: Author, 2015)

CHAPTER THREE

MATERIALS AND METHODS

3.1 Research Design

The research design provides a structure upon which research questions are answered (Kerlinger, 2004). The study identified green spaces within Eldoret town,their distribution, typology and potential sites for green spaces expansion. The study was divided into three components: data collection, data analysis and data interpretation. Remote sensing data was combined with GIS data layers to estimate amount of green spaces and to quantify urban green spaces available within Eldoret CBD and its environs. Documented literature from government documents such as census report, urban plan, and journals were examined.

The methods detail how particular data were collected and analyzed to answer the research questions. The techniques used to collect data were observation, Global Positioning System (GPS) and satellite imagery. Spatial Analysis tools in Geographic Information System were used to analyze the data.

3.2 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 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. It generates more representative 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.

Figure 3.1 illustrates the research procedure.

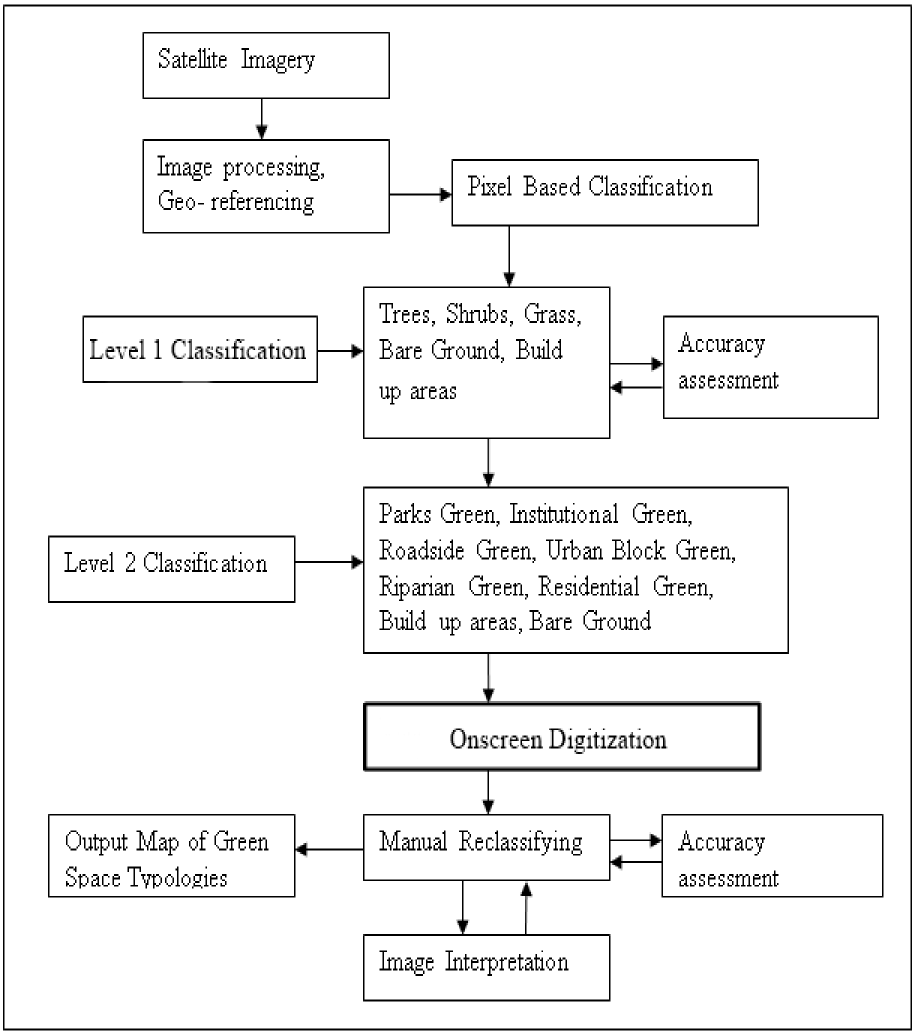


Figure 3.1: Research Procedure **(Source: Author, 2015)**

3.3 Data and Data sources

Data required for the study included; types of green spaces, where they are found, their sizes as well as potential sites for green space expansion. Data on built up areas, road network and rivers and population was included.

I. Google earth image taken in July 2014 with a spatial resolution of 5.56 $m^2$was used to get an over view of the study area.

II. The urban plan for Eldoret town acquired from Uasin Gishu County urban planner was used to determine the boundary of the study area.

III. 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.

IV. 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.

3.4 Data collection

3.4.1 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.

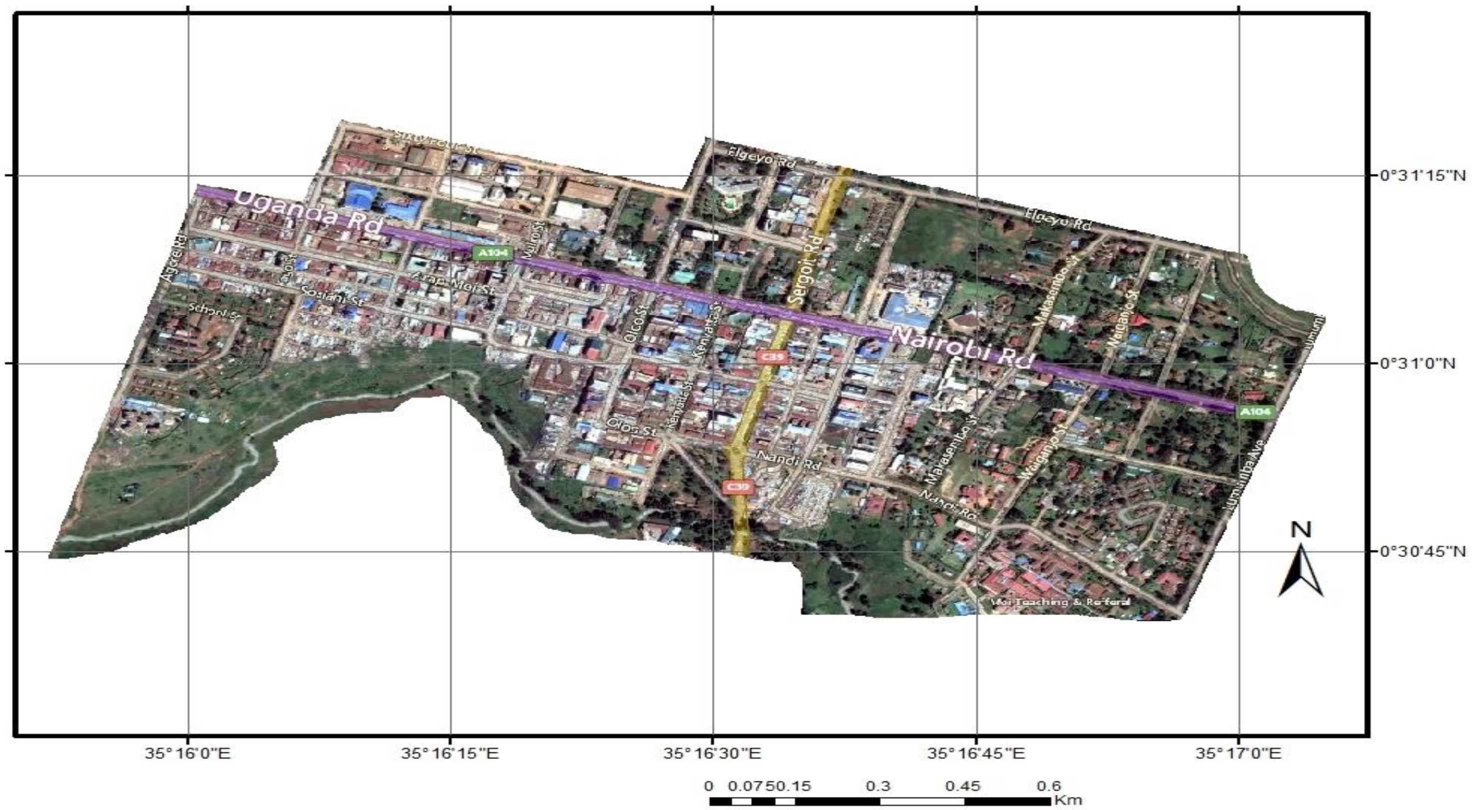


Figure 3.2: Raster image of study area; Eldoret CBD and its environs measuring approximately 1930276 m^2

(Source: Google Map, 2014)

3.4.2 Developing green space classification scheme

A review of existing literature, land use plan for Eldoret town and field observations provided a framework to distinguish different types of green spaces and enabled the researcher to develop a new, expanded classification for the urban green spaces adapted to Eldoret CBD and its environs. This included built up areas and bare ground. Classification decision tree was then constructed at two levels, level 1 giving a general description of land cover type to the more specific classes at level 2.

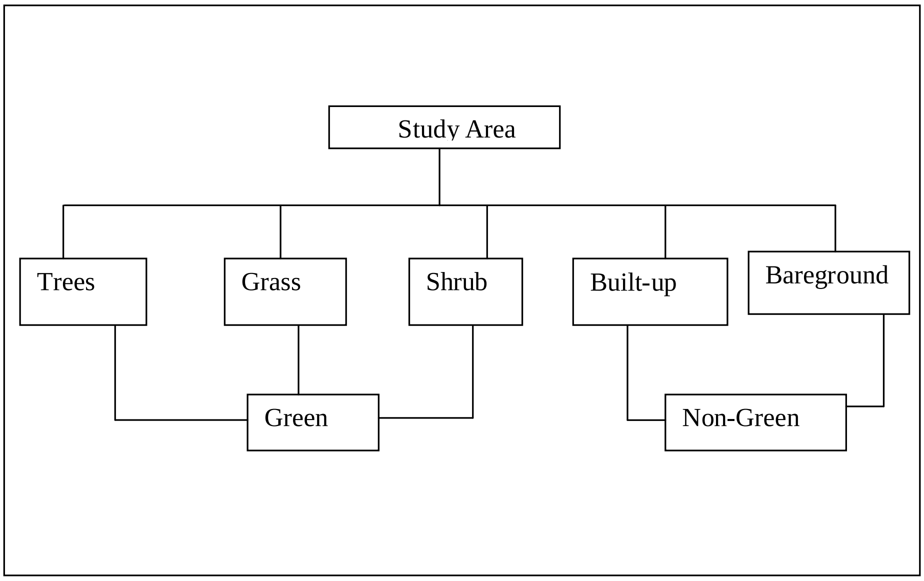
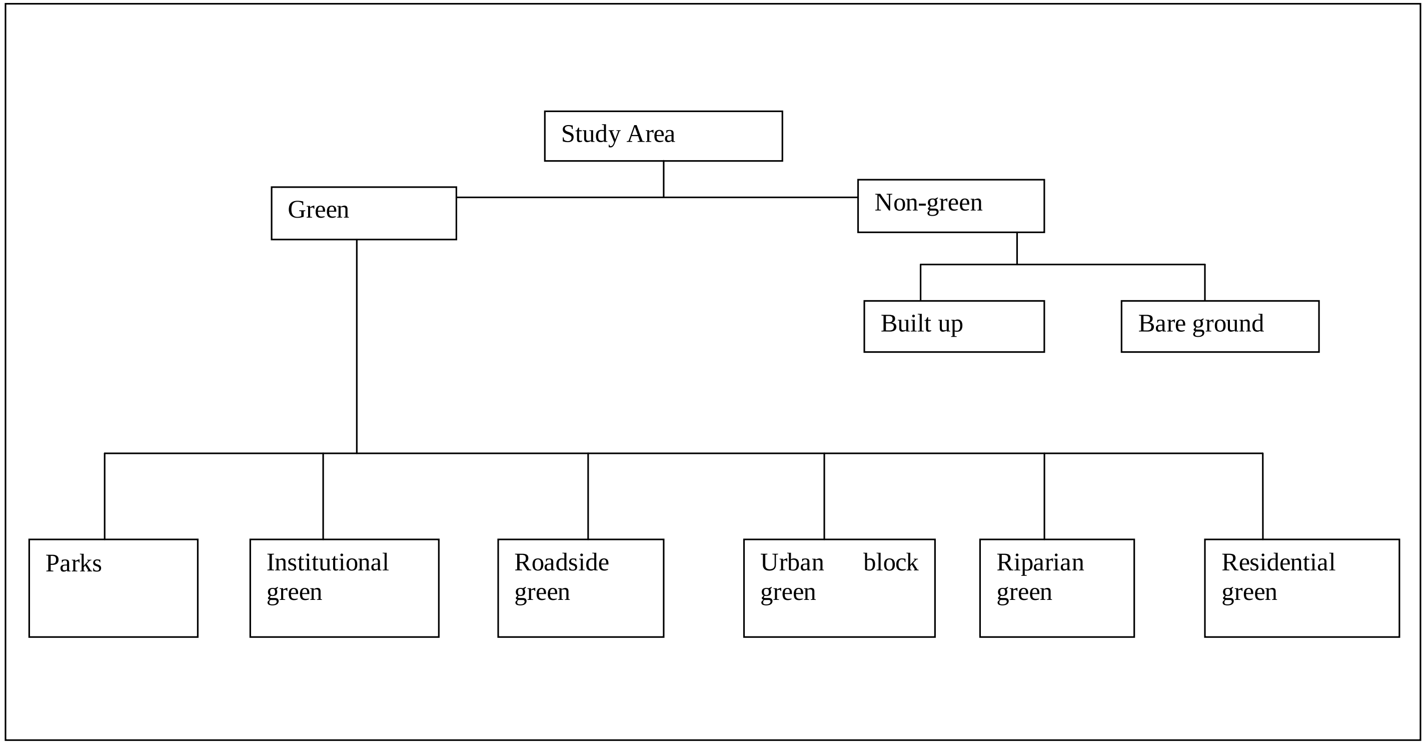


Figure 3.3: First level classification.

For purposes of green space typologies determination, the five classes were aggregated into green and non-green consisting of trees, grass, shrubs, built-up and bare ground. Non-green was masked and the green further used to classify typologies of green spaces.



Fig**ure 3.4: Second level classification.**

The second level classifications produced six typologies of green spaces including parks, institutional green, roadside green, urban green, riparian green and residential green.

The description of these classes including built up areas and bare ground designed for examination of the satellite image includes:

I. Park green- outdoor designed spaces dominated by the presence of vegetation. Delineated and managed by the county authorities .These provides for pleasure and recreation.
II. Institutional green- outdoor spaces dominated by vegetation and located in the adjacent area of public buildings such as schools, hospitals, churches, library and public administration building such as police line.
III. Roadside green- Include street trees, shrubs and plants either in a row or dotted .They can serve to buffer people from traffic, Screen noise, and solar radiation.
IV. Urban-block green- includes outdoor green spaces not included in other categories, being widespread in small patches all over the highly concretized area of the CBD. May include vacant lots, patches and dotted trees. These may serve as buffer, screen noise and solar radiation.
V. Riparian green- vegetated land on each side of a river. May act as buffer zones to control pollution and surface erosion.
VI. Residential green- Include housing gardens which allow for various recreational facilities such as resting, playing and socializing activities.
VII. Built-up areas- include areas covered by buildings and all surfaces sealed with impervious materials such as concrete, asphalt and pavement.
VIII. Bare ground- areas covered with soil.

Consequently the study area was subdivided into six land cover zones for ease of further analysis namely Parks, Institutional, Roads, Urban block, Riparian and Residential

The different typologies of urban green space were also identified during the field survey and recorded using a digital camera.

3.4.3 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. 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.

3.5 Satellite Image classification

The aim of this classification was to extract the green areas in order to determine their availability, quantity and spatial distribution and to further reclassify and map out the typologies. 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. Both supervised and unsupervised classifications were performed on the raw satellite image.

3.5.1 Supervised pixel classification

In this first 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). Bin *et al.,* (2003) acknowledges that separation of green area and built area is one of the popular uses of remote sensing data because they can easily be recognized with a high resolution. The green spaces available and their spatial distribution were then identified on the image.

3.5.2 Pixel based unsupervised classification

Secondly, a pixel unsupervised Interactive Self-Organizing Data Analysis (ISODATA) image classification was performed on the raw image to classify the greens. The initial five classes were created as signature set data. These were reclassified and six distinctive types were identified based on their spectral signature and location. These are Riparian green, urban block green, institutional green, park green, residential green and roadside green in separate layers. The layers were grouped together to represent types of green spaces.

3.5.3 On screen digitization

For easier analysis, the pixel format was converted to vector format through on-screen digitization. Polygons for each urban green zone were created, grouped by the same land use properties. This included the urban block green, institutional green, park green, and residential green zones. Buffer polygons were created around riparian green and roadside green at a distance of 10 meters and 6 meters respectively as set in the Eldoret Strategic Urban Development Plan 2008-2030. The digitized map was then overlaid with green cover map. This process provided a full visualization of typologies of green space and for the various typologies of green spaces to be separately identified.

3.6 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. The landscape metrics adopted by the researcher to quantify urban green spaces within the study area are described in Table 3.1.

Table 3.1: Landscape metrics and their description

Landscape Metrics	**Description**
Total Area (TA)	The total area of the study area
UGS Availability (UA)	The total area occupied by UGS
Percentage UGS Available (PA)	The percentage of total area occupied by UGS
Typologies of UGS (TU)	Classes of UGS identified
Proportional typology of UGS (PTM)	The percentage of area of UGS occupied by a specific type of UGS
Proportion of built up area	Areas occupied by buildings, concrete and other sealed surfaces.
Proportion of bare soil	Areas occupied by bare soil

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

The standards used in this study to evaluate the current green space status include 9 m^2 per capita green availability recommended by WHO and 20% plot coverage proposed by Cohen (1992). 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 allowed for the estimation of green space areas (m) and calculation of percentage of green space available as well as the proportions of typologies.

Due to overlapping of vegetation cover (tree cover located above shrubs) and reflectance confusion, total coverage was larger than 100%. The coverage was therefore normalized before calculations were done by dividing the different coverage classes with the sum of all classes. From these values the total percentage of available green cover was calculated using the formula;

PA = ——

Where;

PA=Total percentage of available green cover (%)

TGA =Total urban green area (m^2)

TLA =Total land area (m^2)

The proportion of each green space typology in the study area was also calculated and presented in tables. The results were expressed as a percentage of the total area of each zone as well as in Meter squared, these calculations allowed for performance of various comparative analyses between zones. Formula;

PGS =—— × 100

Where; PGS = Percentage of green within the zone

GZ = Green available within the zone in meter squared

TZA = Total area of zone in meter squared.

To analyze the adequacy of green spaces, their total areas were spatially analyzed against the population. To calculate per capita green space, the total area of all green space categories was found as well as the population of inhabitants. Per capita green space was then estimated through the following formula:

P = ——

Where;

P = Per capita green space

TGS = Total green space

PN= Population

A GIS map was generated to gain a visual understanding of the spatial distribution or green spaces across the study area. The distribution pattern of UGS was examined manually using visual identification of UGS by the researcher on the raw image and the classified result, how they vary across the study area in size, shape and typology.

To gain a general understanding of the typologies of green spaces across the study area, the green space distribution map was overlaid on the digitized map showing the various land cover zones.

Statistical data generated was used to answer the research questions. The thesis is therefore both descriptive and statistical combining quantitative and qualitative aspects. Quantitative component include area of green spaces in terms of meter squared and percentages while qualitative components include typologies and distribution of green spaces available.

3.7 Accuracy assessment

Accuracy assessment of image classification is critical in understanding the potential utility and the possible impact of error in the classification of the intended application. It compares the derived classification results with the ground reference data (Warner *et al.,* 2009). To assess the accuracy of the classified map, a set of GPS readings of randomly selected points from ground truth data was compared with the classified data in a Confusion Matrix. A kappa index of agreement was then derived.

3.8 Identification of potential sites for expansion of UGS

To identify potential areas for expansion of urban green space, a site selection criterion was developed using Boolean operators and buffer method.

3.8.1 Criteria for site identification

The parameters used included;

I. River buffer- 6 meters on either side of river and stream

II. Road buffer- 30 meters on either side of major road network

III. Parks

Green space potential was applied to the gaps within each zone to account for deficiency in green space in each zone as well as built up areas that could be retrofitted to have green cover. The gaps were selected with an assumption that these areas had no specific application or had specific applications but have not been performed. They included sites that ought to be green spaces as per the Physical Planning Act 2015 and The Planning Handbook and Eldoret town Strategic Development Plan 2008-2030 regulations but are not yet adequately covered by vegetation as such as well as areas ideal for green spaces but not yet recognized by the local authorities as opportunities for green cover. The gaps were identified by bare soil reflection which was different from impervious surface on the satellite image. These areas were confirmed by ground truthing. Potential areas for expansion were also identified based on literature review and field survey and applied to areas not identifiable on the satellite image. This included vertical greening systems such as walls and traffic island, spaces between buildings and parking space identified as potential sites.

CHAPTER FOUR

RESULTS

4.1 Introduction

This chapter reports the outcomes of data analysis. Urban green space patterns were extracted using Pixel Image Classification Technique and On Screen Digitization for the data of 2014 satellite image using ArcGis 10.1 software. The classification results were then analyzed to determine the amount of green available, their distribution and typologies.

4.2 Green space availability

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

The result of 1st classification was an image showing the three basic vegetation classes; trees, shrubs and grass including built up area and bare ground (Fig 4.1).

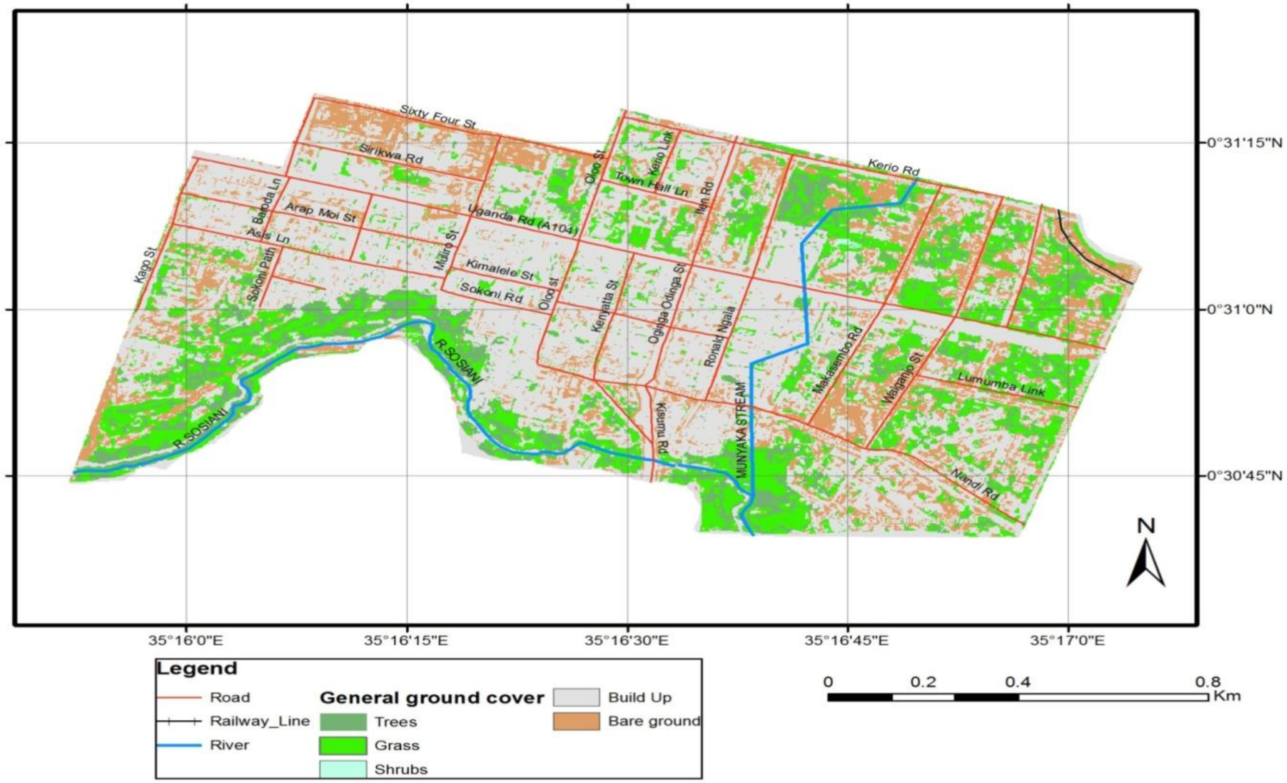


Figure 4.1: Three basic vegetation types including Built up area and bare ground

(Source: Google Map, 2014)

Statistical analysis revealed the following proportions of each class.

Table 4.1: Proportion of vegetation types plus built up area and bare ground

Class	***No of pixels***	***Area (m^2)***	***Proportion (%)***
Grass	56869	315768	18 %
Shrub	619	3437	0.2 %
Trees	26324	146361	8.3 %
Built up	177654	986434	56.2 %
Bare ground	54755	304030	17.3 %
Total	3167221	1756030	100%

The image was further reclassified to produce a detailed binary classification scheme distinguishing between green and non-green (built up) areas as well as determine distribution of green cover (Fig 4.2).

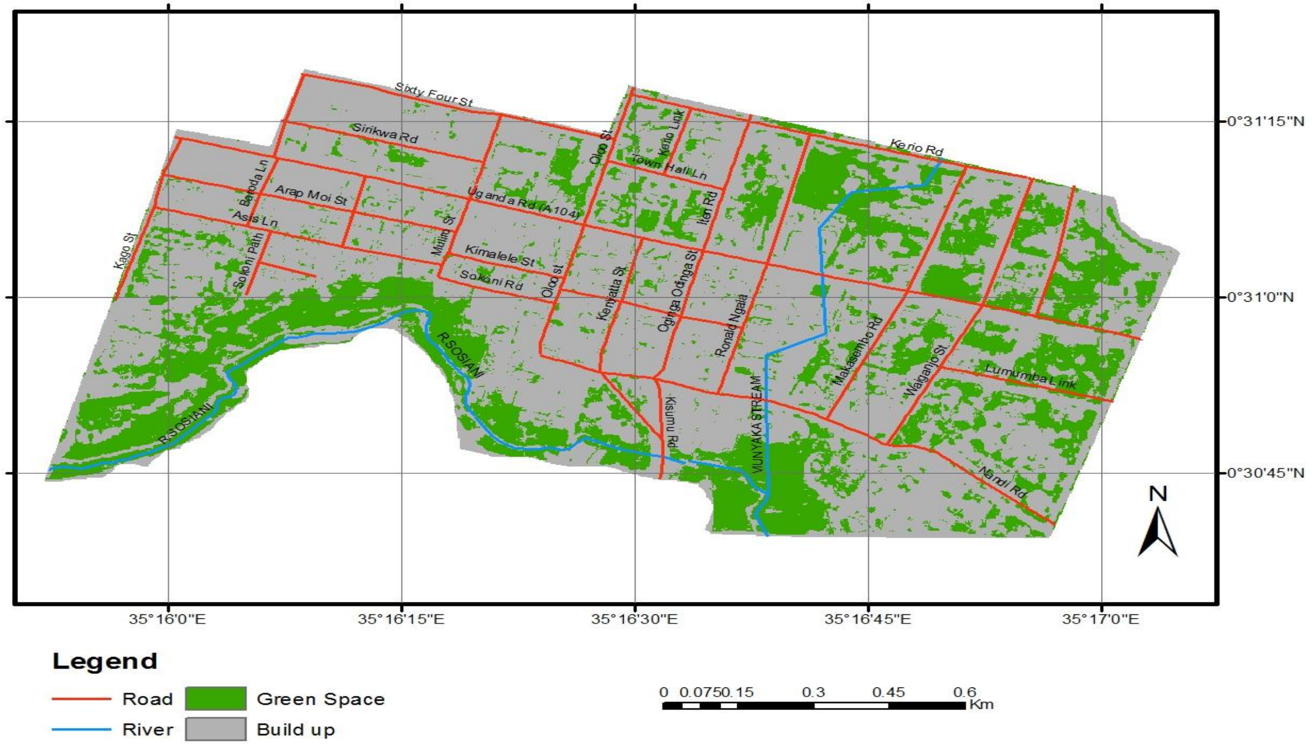


Figure 4.2: Green and Non- Green areas

(Source: Google Map, 2014)

Statistical analysis revealed the following proportions of green and non-green areas (Table 4.2)

Table 4.2: Proportion of green and non-green cover

Class	***No of pixels***	***Area (m2)***	***Percentage***
Green areas	83812	465566	26%
Non green areas	232409	1290464	74%
Total	**316221**	**1624285**	**100%**

4.3 Typologies of Urban green space

To interpret further and visualize the different urban green spaces classes another layer was created. Fig 4.3 shows the typologies of UGS identified within the study area.

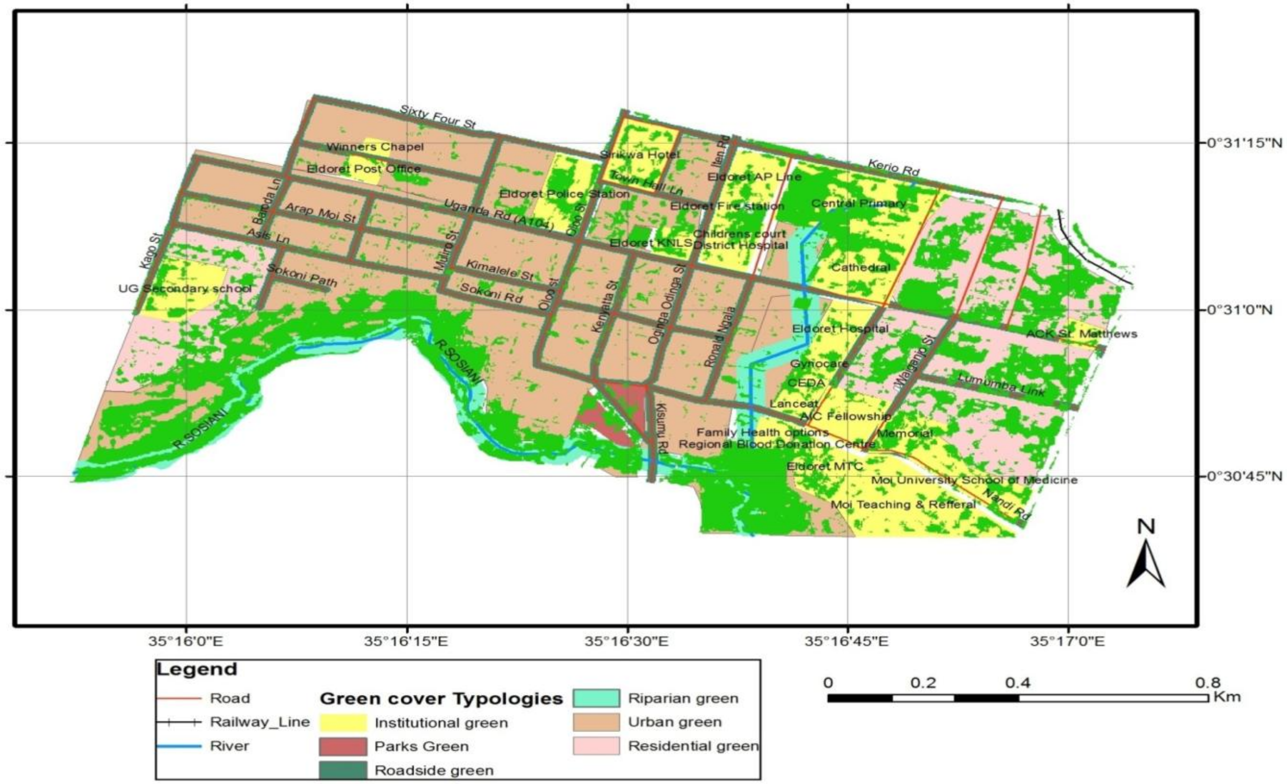


Figure 2.**3**: Spatial distribution of urban green spaces superimposed by typologies of land cover zoning to distinguish the typologies of green space

(Source: Google Map, 2014)

Statistical calculations revealed the following proportions of the various types of green spaces. -

Table 4.3: Proportions of the various types of green spaces

Typology of UGS	*Quantity in area (m^2)*	*Proportion to area of study%*
Riparian green	96682	5%
Urban block green	146245	7.6%
Institutional green	113580	5.9%
Park green	5377	0.3%
Residential green	129326	6.7%
Roadside green	19621	1%
Total	**510831**	**26%**

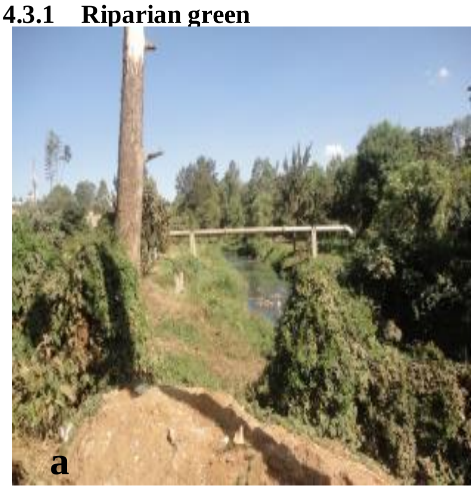
The proportion of green areas within the various land cover zones was also calculated and results presented in table 4.4

Table 4.4: Green areas within various land cover zones

Land cover zone	*Total area of zone m^2*	*Total green space within zone m^2*	*Percentage of green within zone*
Riparian	181078	96682	53%
Urban block	794952	146245	18.4%
Institutional	362456	113580	31.3%
Parks	16352	5377	32.9%
Residential	325883	129326	39.7%
Road networks	249555	19621	0.07%
Total	**1930276**	**510831**	**100%**

The images below show selected sites of different types of green spaces within the study area.

4.3.1 Riparian green



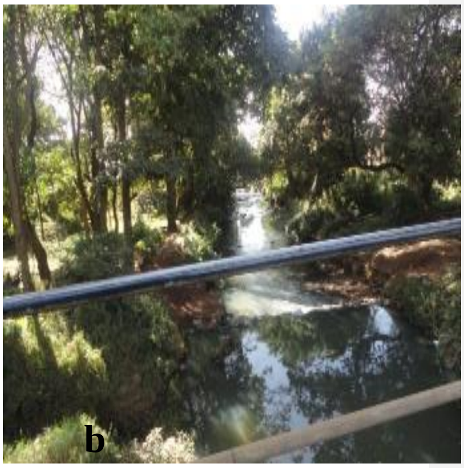


Plate 1: a) and b) Sosiani river; Natural habitat made of trees and shrubs on both sides of the river (Source: Author ,2014)

4.3.2 Institutional Green

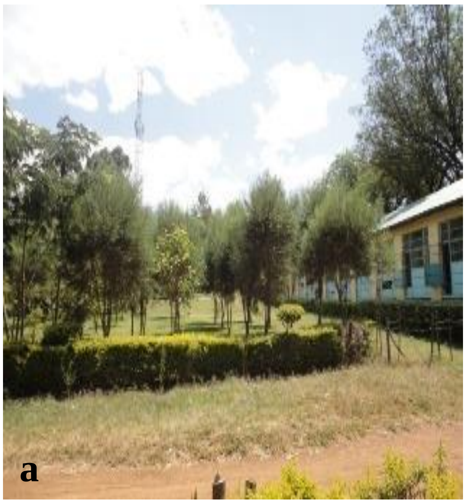


Plate 2: a) Central Primary: Planted trees, shrubs and grass**.** b) Eldoret hospital: Shrubs and flowers **(Source: Author, 2014)**

4.3.3 Park Green

Plate 3: a) Municipal park: Grass and trees. b) Nandi park: Patches of grass and scattered trees (Source: Author, 2014)

4.3.4 Residential green

Plate 4: a) Government quarters with trees and grass. b) Doctors quarters with planted vegetation and scattered trees (Source: Author, 2014)

4.3.5 Urban Block Green

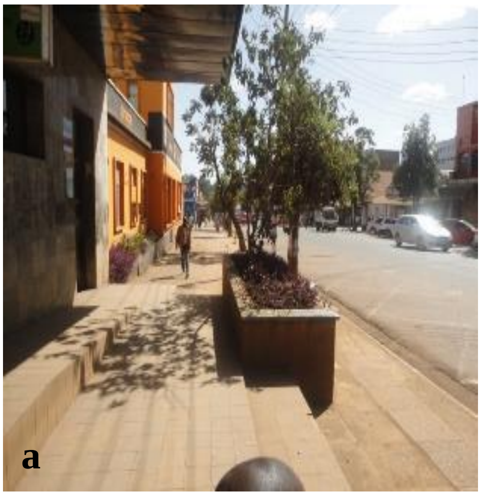


Plate 5: a) Stand alone trees outside Kenya commercial Bank b) Planted vegetation attached to **Standard Chartered Bank Building (Source: Author, 2014)**

4.3.6 Roadside green

Plate6: a) Nandi roadside with trees, shrubs and flowerbeds b) Uganda road side consisting of patches of grass and trees. (Source: Author, 2014)

4.4 Spatial distribution of urban green spaces

Area calculations based on the developed maps indicated that 26% of the total area of Eldoret CBD has green cover. Despite this average, most green spaces are located in the periphery, especially in the eastern and southern parts of the town leaving the inner core (urban block) with a few scattered patches. These are residential areas, institutions, riparian and where public parks are located (Nandi Park and Municipal Park) (Fig 4.4).

4.5 Potential areas for expansion of green spaces

A map containing potential areas after applying site selection criteria is shown in Fig 4.4. This map shows areas within the study area where green space can easily be expanded. The map indicates spaces spread within Nandi Park and a possible linear green space along major roads, River Sosiani and Munyaka stream.

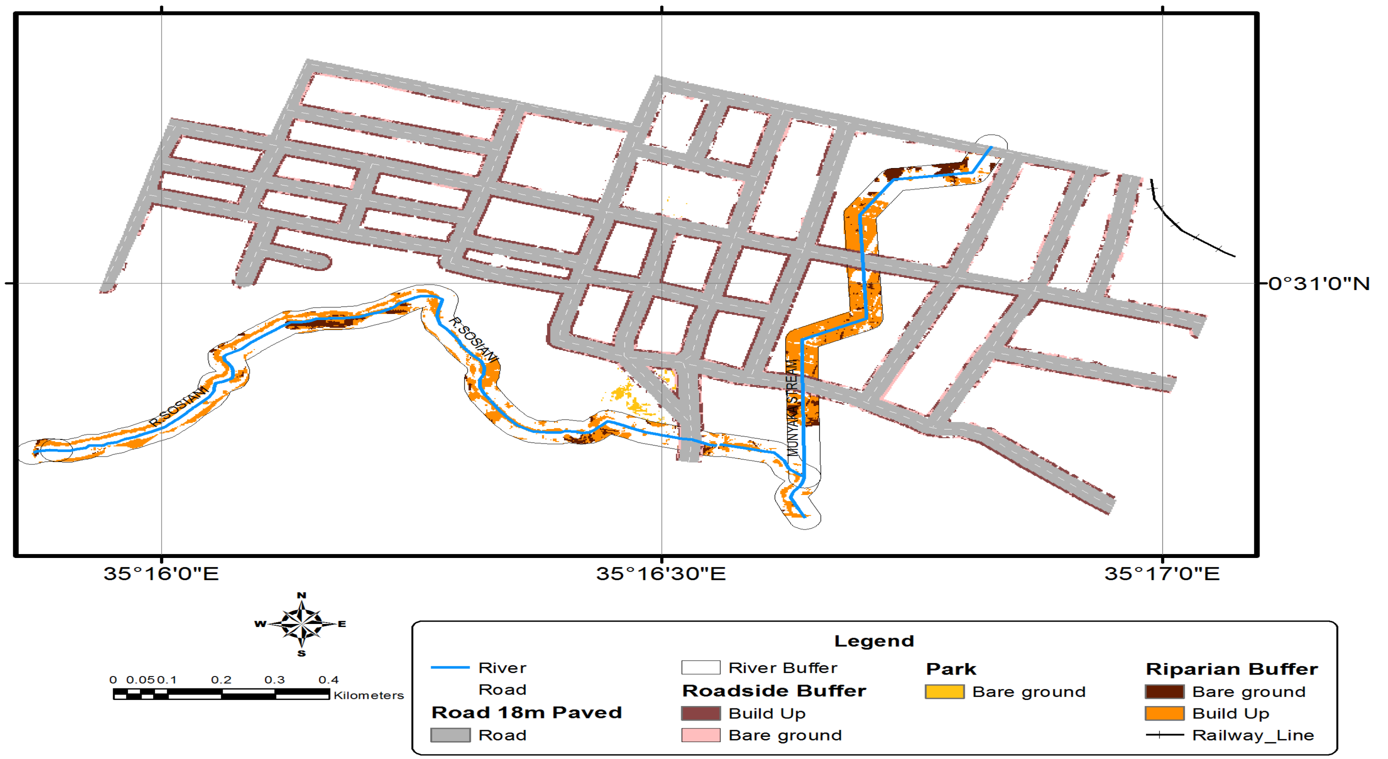


Figure 4.4: Potential sites for green expansion: Built up areas to be retrofitted with small trees and bare ground that could be converted into green cover.

(Source: Google Map, 2014)

Statistical analysis revealed potential sites for expansion of green space account for the following percentages:

Table 4.5: Proportion of potential sites

Land cover zone	***Total area of potential sites m^2***	***Proportion within total study area (%)***
Park	3597	0.2%
Roadside	105,996	5.5%
Riparian	84395	4.3%
Total	193988	10%

Innovative opportunities for expansion of green space identified in the field include:

Plate 7: Exterior wall area of Barclays Bank building provide space that can be used be used for vertical greening. (Source: Author, 2014)

Plate 8: Traffic island along Uganda road provides space that can be retrofitted into green space island. (Source: Author, 2014)

Plate9: Nakumatt Building Parking space lacks vegetation provides opportunity for standalone trees. (Source: Author, 2014)

Plate10: a) Spaces between buildings intersecting Kago Street without green cover can be enhance by planting small trees and flowery plants. b) Paved walk way along Oloo Street can also be retroffited with street trees. (Source: Author, 2014)

4.6 Accuracy Assessment

Classification confusion matrix of the classified image had an overall accuracy of 86.7% and a Kappa Coefficient of 0.8114.

CHAPTER FIVE

DISCUSSION AND CONCLUSION

5.1 Introduction

This chapter explains the significant findings of the study by providing a commentary based on the results in Chapter 4. The findings of the results are then related to the results of previous similar studies. The implications of the results are then elaborated, conclusions are presented, and recommendations made at the end of the chapter.

5.2 Green space availability

The results show that green space coverage in Eldoret CBD and its environs is 26% (Table 4.3) which translates to a per capita value of 2.5 m^2 based on the urban core population. The percentage available is high when compared to values reported for other African cities. Amaoko and Koroboe (2011) found that Lagos city (Nigeria) and Kumasi city (Ghana) had 3% and 10.5% green space respectively. The spatial coverage available also indicates that green space availability in the study area exceeds the 20% standard set by Cohen (1992). This may be exaggerated since most of this green space is found in areas inaccessible to the public such as residential and institutional areas. This is an indication that most of the green spaces are not directly accessible to the public, but only to members of these institutions and residence. Besides some of these areas are found along streams and roads and hence not safe for leisure and recreation. However, such green spaces are useful for other green space functions such as carbon sequestration, habitat for birds and insects as well as aesthetic (Beatley, 2011). The 26% coverage may not also be adequate given the high population within the town. This is evident by the low per capita value.

In terms of per capita availability, it falls below the standard ($9m^2$ per capita green spaces) recommended by WHO (Gomez *et al.*, 2011). The per capita value reveals a high population and reduced green cover. Other studies have revealed that a high population density goes together with low availability of green spaces (Baycon-levent *et al.*, 2002). Large populations in urban areas demand and require large quantities of land to be used for housing, transport, and other social amenities leaving limited space for green cover (Gariola, 2010).

A comparison of the average per capita green space available with the International standards shows a shortage in green spaces within Eldoret CBD and its environs especially within the urban block. 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. Table 5.1 illustrates the great difference between green spaces in Eldoret CBD and the International standards.

Table 5.1: International standards of Green space per capita

	Green space per capita
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 *et al.*, 2011

By analyzing the proportion of green spaces available within the various land cover zones, it was noticed that residential and institutional zones contain sufficient amounts of green cover to improve the quality of life within those zones. This could be due to planning regulations which promote sizable set-backs and gated compounds with restricted access (The Planning Hand Book, 2007). Observational evidence shows that most set-backs within these zones were occupied by grass, planted flowers and isolated trees. These provide areas for relaxation, play, social interaction, experience of serenity and ultimate contact with nature.

The results also show that the riparian area has only 53% green cover. This could be attributed to encroachment by human activities such as *jua-kali* artisans that have led to destruction of vegetation cover. According to The Planning Handbook of Kenya (2007), riparian reserves should have a minimum of 2 meters and maximum 30 meters of green cover on either side of the water course to act as a buffer zone to control pollution, surface erosion and squatter intrusion. The strategic urban development plan (2008-2030) for Eldoret town also provides for riparian reserve of 6 meters from the water body devoid of any human activity (EMC, 2010). To achieve the set standard, green space must be increased by 27% to attain total green cover of the riparian area.

Another key result is the urban block zone which is characterized by intensification of commercial buildings, road networks and other concrete surfaces. This zone has 18% of its total area covered by green space. It forms the CBD or town center and the results show that this part of the town has inadequate green cover based on the standard set by Cohen (1992) of which any given geographical area should have at least 20% green cover. This finding agrees with Azwar *et al.*, (2009) who found that even though Kuala Lumper is endowed with large scale metropolitan parks and forest reserves, some areas in the city still lack green spaces especially within the city center. Studies conducted in Manchester city center also revealed that the city center had less green space provision than other areas in the greater Manchester (Gill *et al.*, 2007). The low availability of green cover within the urban block indicates that concretization of urban areas is responsible for inadequate green spaces. Low availability of UGS also indicates that the CBD is vulnerable to environmental problems such as urban heat island, besides visitors and those who work within the town centre are likely to have little interaction with green space. The small patches of green spaces making up the overall vegetation cover across the city center provide minimal benefits. These include stand alone trees and planted vegetation attached to some buildings that provide shade for pedestrians as well as aesthetic value. Larger patches could be introduced to promote ecological processes and provide for leisure and recreation. According to Byrne and Sipe (2010) the highly densified parts of cities and towns can still afford adequate green space by adopting new innovative methods. Retroffiting may allow pavements to be widened, planted with trees to offer shade. One green roof top per urban block as suggested by Beatley (2011) could also be adopted. Each city building should be assessed to determine the extent to which green roofs could be incorporated. Chicago, for example, now has more than 500 green roofs. Green walls could particularly be beneficial as they provide net gain for the urban green without subsequent increase in surface.

Urban green at the roadside zone (Plate 6) shows the presence of scattered green along the major roads: Uganda road, Nandi Road, Kerio Road and Kago Road which connect the center with the periphery of the CBD. The results also reveal that the roadside buffer has 0.07% of its total area covered by green and largely dominated by spontaneous vegetation (not planted) including isolated trees, grass and shrubs. According to the Strategic Plan of Eldoret town, the road buffer should be 10-30 meters of green belt devoid of any development. The percentage of green cover available indicates the zone has inadequate green and has been encroached on by development. Observational evidence revealed illegal structures and bare ground on road reserves. This could have reduced the amount of green cover.

5.3 Typologies of Urban green space

In terms of typologies, different types of green spaces exist in Eldoret town CBD and they vary in ownership, shape, size, accessibility and maintenance level. Their composition shows traditional types of urban green including riparian along River Sosiani and Munyaka stream; Nandi and Municipal Parks; residential green such as in Kapsoya Estate; Institutional green including Central Primary School, ACK St Mathews church, Moi Teaching and Referral hospital, Kenya National library, Uasin Gishu High School and Sirikwa Hotel and roadside greens along Uganda road, Nandi road and Iten road. Like in most African cities, these types were designed and planned by the colonial governments and early independent governments (Onyeka, 2014).

Nandi park is a designated public park and is maintained by the county government and is the only one of its kind. The Municipal Park though delineated as a public park has since been closed from public use. This leaves those who dwell in the CBD with little or no opportunities to interact with green space. The riparian area along the rivers is protected though site observation revealed that part of it has been encroached on by human activities. The remaining sites with green spaces are smaller patches spread within the urban block contributing to the wider character of the area. Though they may not be significant individually but taken collectively they contribute positively to the urban environment. Nakagoshi *et al.*, (2006) argued that even green areas that are small in size are potential sites of green networks in cities, providing daily opportunities for contact with nature.

From the results of types of green spaces in Eldoret CBD, it is evident that there is a lack of innovative types of green spaces such as traffic island greens, rooftop greens and other forms of vertical green spaces like green walls that would provide avenues for city aesthetics, and traffic and noise buffers. Innovative green spaces are not sufficiently known to the local authorities of most developing countries and as a result, such forms are non-existent or have been integrated only partially and unsystematically in urban development (Byrne and Sipe, 2010). Besides, local authorities lack technological skills and funds to adopt such green spaces.

5.4 Spatial distribution of green space

Results from the analysis of data on the spatial distribution of green spaces shows gaps in the provision of green spaces in Eldoret CBD, and identifies potential locations that may have low levels of accessibility. Visual interpretation of the satellite images reveal that green spaces are concentrated in the periphery, especially in the North Eastern areas of the town where green spaces are found in residential and institutional zones including areas around Moi Teaching and Referral hospital, Central Secondary School and St Mathews ACK church. The densely built up area at the center of the town has low levels of green cover.

These findings are similar to those of Rous *et al.*, (2013) who found out that in Iasi City, areas with the highest percentage of urban green were at the periphery of the city especially areas with private houses or areas where parks and public gardens were located. At the same time the findings showed that areas with lowest percentage, less than (20%) were located in areas with high concentration of commercial buildings, pavements and transportation networks in this case the urban block zone covering the city center. This confirms that densification of urban core result in loss of urban green spaces as seen in (Gairola, 2010). This further signals an increase in urban heat, limited interaction with green environment for city dwellers as well as allowing no further development of green spaces. The compactness of the surface area results in reduced free space that can be covered by vegetation.

As a result of the unequal distribution of green spaces, inhabitants in the periphery and especially within institutions and residential areas have more access and contact with nature. This grants them opportunities for recreation and other benefits compared to the CBD which only has small, scattered patches within the urban block. Apart from the parks, institutional and residential greens, the remaining areas do not show any pattern in planning or formation as they appear arbitrary in space and place, indicating piecemeal or natural occurrence.

McConnachie and Shackleton (2010) acknowledges that the distribution of green spaces within towns is frequently uneven, and influenced by attributes such as location relative to commercial core while Chona *et al.*, (2012) showed that urban green spaces are limited within the urban core of many cities in the United States. Beatley (2011) recognizes the great inequities in the distribution of nature and green spaces in cities today and suggests that this could be overcome by the designing of biophilic cities.

5.5 Potential for expansion of Green spaces

The proposed map for the Eldoret Central Business District and its environs clearly shows areas where green spaces can be easily expanded. These sites are identified by the bare soil reflectance and some built up areas that could be retrofitted to include green cover are spread across the study area with critical areas being riparian, parks and roadside. An analysis of these areas reveals that there are several gaps that could be turned into green space (Fig 4.11). These potential sites can increase green cover in the towns CBD by approximately 10%. When adopted, this can increase opportunities for town dwellers to enjoy nature and benefits of UGS.

It is important to note that areas delineated as green spaces in Eldoret spatial development plan 2008-2030 are not adequately developed as such and therefore still provide opportunities to increase green cover. Poor maintenance of these spaces has led to gaps without green cover identified by bare ground. Besides poor enforcement of development controls has led to destruction of green spaces and hindered integration of green spaces in development.

The formal parks cannot be increased in size or altered extensively, however improvements to the CBD must be made irrespective of the current areas of green space, by creating smaller pockets of green space. Planting stand alone trees or shrubs along both sides of the road network in the CBD gives a good scenic view as well as provides shade to the people walking through the footpaths. Trees would overlay impermeable surfaces in the parking lots and pavements while small sized trees and flowers could be planted on traffic islands as suggested by Neema *et al.*,(2013). These can provide an effective tool to mitigate the UHI effect as well as provide a buffer for noise and dust pollution within the urban environment. Traffic islands along Uganda road could be retrofitted into a Green Island, while buildings with expansive walls such as the Standard Bank and Barclays Bank buildings could adopt wall greening.

In addition, provision of more trees, shrubs and grass along the riparian areas would ensure total green cover and provide habitats for small animals and insects. More trees and grass could also be planted in the parks, especially in Nandi Park which has patches of bare ground. Philips and Moore (2012) indicate that large trees have a relatively small footprint on the ground making them suitable for dense urban cities besides; grass is not good at storing water, providing cooling or supporting biodiversity. Byrne and Sipe (2010) suggests that the presence of green areas in compact and dense conditions make the environment livelier, activities within the area more manageable and more enjoyable as people interact with nature.

Figure 5.1 shows the initiatives that can be applied to the potential sites towards enhancement of green spaces within Eldoret CBD and its environs. Implementing the proposed initiatives would ensure that residents afford benefits of UGS. While it is expected that local authorities should aspire to meet the provision of the standard, it is recognized that this will be more difficult in some urban contexts than others. Local authorities are therefore encouraged to determine for themselves the most appropriate standards.

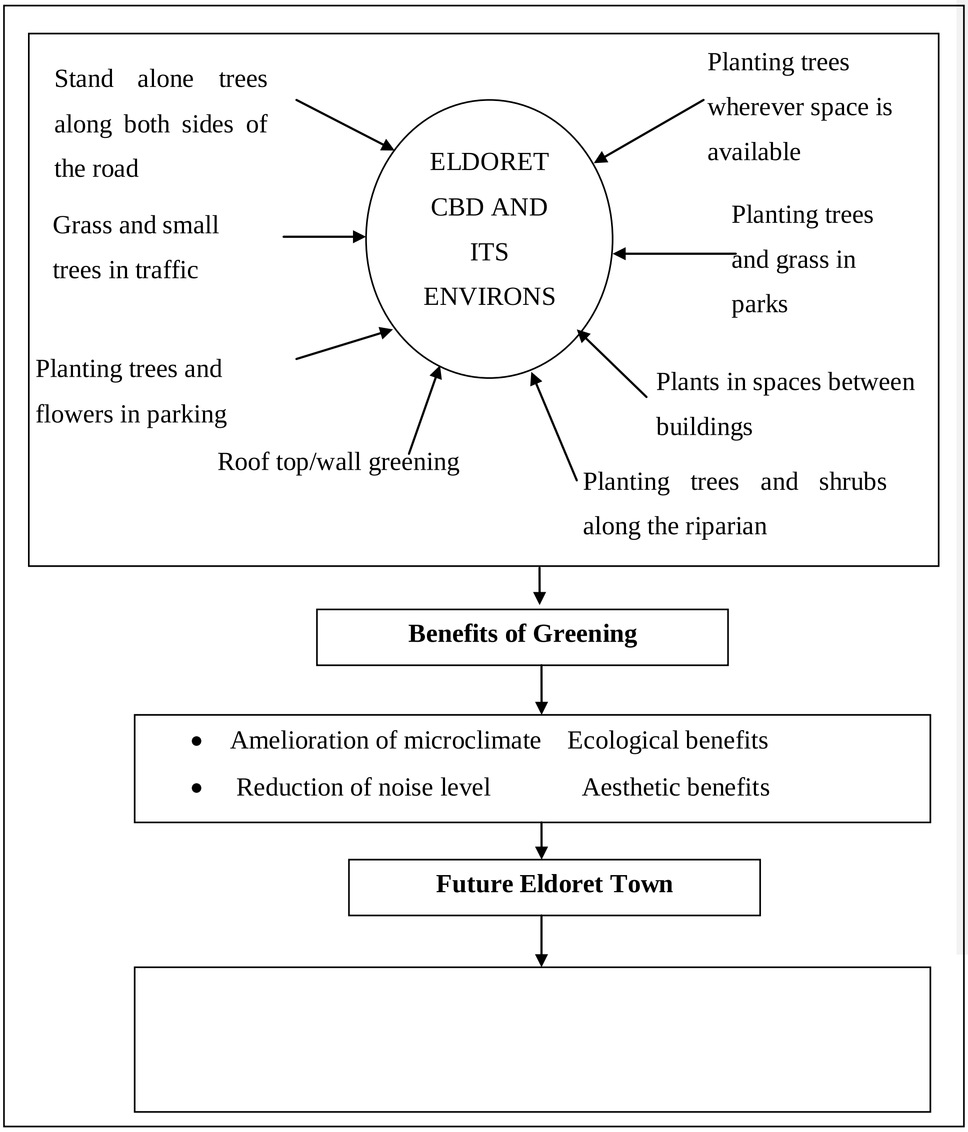


Figure 5.1: Model for greening Eldoret CBD and its environs (Source: Author, 2015)

5.6 Conclusion

Green spaces constitute an important land use and land cover in the urban environment. Its functions and forms vary within cities and the provision of green space has been an increasing concern for enhancing the livability of urban areas.

Comment [b3]: Meaning not clear

This study provides baseline information on the quantity, typology and spatial distribution of green spaces within Eldoret CBD and its environs. It reveals that there is 26% green coverage in Eldoret CBD and its environs and a per capita value of 2.5 m^2. The per capita green space available is below the standard set by WHO (9 m^2 per capita). The spatial distribution shows that urban green is concentrated in the periphery especially on the western side of the area of study while the urban core that is highly concretized has low levels of green cover. This indicates an uneven distribution of green spaces. The types of green spaces available in the Eldoret CBD indicates a dominance of the traditional types such as parks, residential, riparian and roadside green and a lack of innovative green spaces such as vertical green. The CBD and its environs have potential sites that may be converted to green cover. These include gaps within riparian, road reserves and parks as well as built up areas that could be retrofitted to include green cover.

In order to meet ecological, social, health and economic needs of cities and its citizen, green spaces need to be adequate in quality and quantity. Besides green spaces need to be uniformly distributed throughout urban areas, and the total area occupied by green spaces should also be large enough to accommodate the rapidly increasing urban population.

The implication of findings is that concerted efforts by County Government of Uasin Gishu and policy makers in preserving green spaces should be directed towards enhancing green spaces within the urban block, riparian areas and roadsides that have limited 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 Physical Planning Act cap 286, Urban areas and Cities 2011 and Draft Physical Planning Bill 2014 which in most cases are violated. There may be need for new policy to retrofit potential areas and create innovative green spaces like wall greening.

Global policies should be considered as opportunities to promote urban green spaces. Global concerns should be domesticated as a collaborative framework for urban green space improvement.

The Green City concept and Biophilic City concept should be embraced to reinforce sustainable development of urban green spaces.

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. Draft Physical Planning Bill, 2014 provides a framework for development of Local Physical Development Plans. The results of this study is in tandem with the requirement of Local Physical Development Plans which shall consist of GIS-based maps and descriptions that indicate the manner in which the land in the area may be used. In this case it shows areas to be used as green spaces.

The results obtained will be used as a basic tool in decision making process of Eldoret town and other towns with similar structure to achieve an optimum sustainable urban environment.

5.7 Recommendations

Based on the findings of this study, the following recommendations would be useful if adopted:

1. Urban green spaces available within Eldoret CBD and its periphery are mainly the traditional types. Innovative types such as green roofs and wall greening should be adopted to enhance green cover especially within the urban block which has limited ground space to provide adequate green cover. Rooftop and wall greening provide net gain of green space without subsequent increase in surface area.
2. Spaces between buildings could also be decorated with flowery plants and small trees. This could mitigate UHI effect as well as beautify the CBD. Residential and institutional zones could be improved by planting more flowers, grass and trees.
3. Riparian reserves along river Sosiani and Munyaka stream should be cleared of all development and rehabilitated by planting trees and other plant cover.
4. There should be private-public partnership between the county government and owners of private buildings to adopt innovative green cover within the CBD such as vertical greening.
5. County authorities should revise and enforce some of their land use management regulations to ensure that all new developments catered sufficiently for green spaces to correct the past mistakes.

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