SUSTAINABLE HOUSING DENSIFICATION IN KILELESHWA: NAIROBI, KENYA

BY

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DECLARATION

I declare that this thesis is my original work and has not been presented for a degree in any other university.

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DEDICATION

This project is dedicated to my wife Charity and my three lovely daughters Esther, Caren and Neriah.

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ABSTRACT

The world is rapidly urbanizing. Many nations all over the world are struggling with the critical challenge of planning urban systems that can accommodate and manage the dynamic processes associated with urban development change. The high level of urbanization has meant that many cities are facing enormous pressure to keep up with the needs of their swelling populations.

In Kenya, the rising urban population has brought along a number of challenges that are manifested in terms of urban sprawl, congested infrastructure, pollution as well crowding and densification of existing development.

Several studies have been undertaken on the various models of city growth and the merits and demerits that are associated with both compact city model and the horizontal city. The process of urban sprawl outward places enormous pressure on government to keep up with the infrastructure needs. There are also associated ecological foot prints, and this has made governments to promote housing and planning policies aimed at achieving urban densification or urban consolidation. This is in an attempt to halt the spread of populations outward into fringe suburbs, by focusing on rejuvenating and revitalizing existing buildings, roads and public spaces closer to the city centre in such a way to accommodate higher densities. This factor underlies the rapid transformation of Kileleshwa neighbourhood in Nairobi from low density high income zone to high density middle income zone within the last few years.

At the same time, the high property values closer to the city centre has put intense pressure on government and local authorities to enhance the density standards so that developers can be able to recoup their investments by increasing their output in terms of housing units per unit area of land. Two recent studies have been done in Nairobi's Zone 3, 4 and 5, in 2006 and 2011. Subsequent to these studies, areas such as Kileleshwa which falls under zone 4 have experienced increasing densities that in some instances are not even in accordance with policy. The resultant developments have strained infrastructural services which have not been expanded to support the growth. The negative impacts associated with the current densification programmes in our urban areas are a cause of concern that call for further study to establish the extent to which such programs do promote sustainable development as provided in our constitution as one of the national values and principles of governance.

This study was undertaken to determine the extent and nature of housing densification in Kileleshwa and examine the physical and ecological impacts of the densification process. Further, the study went to investigate the role of green designs and strategies in promoting sustainable development and the extent to which integrating these strategies within the development control framework can guide our cities towards sustainable housing densification. This was with the aim of developing an alternative intervening policy which can be advanced to guide sustainable densification process in Kileleshwa.

The study hypothesized that the current housing densification in Kileleshwa is unsustainable and requires alternative low impact strategies. The study objectives were thus: to determine the extent and nature of the housing densification in Kileleshwa; to examine the physical and ecological impacts of the densification process; to investigate the extent to which green designs and strategies can be used to mitigate negative impacts of densification process; and finally to develop an alternative intervening policy which can be advanced to guide sustainable densification process in Kileleshwa.

Sources of primary data included personal observation, land use survey, household surveys, key informant interviews, photography and mapping. Secondary data sources included journals, research materials, text books, government reports as well as internet sources. The data from the questionnaires was analyzed using statistical data analysis software, SPSS and consequently conclusions and recommendations were derived based on the study findings

The study found out that there is both vertical and horizontal housing density expansion in Kileleshwa. The densification process has significant physical and ecological impacts on the environment which include; water shortage, power shortage, traffic congestion, pollution, flooding and encroachment on riparian. Others include land use conflict, loss of urban green and insufficient community facilities. The study further found out that the City Council and NEMA as the main regulatory bodies lack sufficient legal, financial and human capacity to enforce green strategies suitable for sustainable densification programmes.

The study recommends that the Nairobi County Government should integrate green design strategies as mandatory requirements within the development control framework for all upcoming developments in the study area. It further recommends that development control in Kileleshwa should be streamlined and enforcement of planning regulations strengthened. Lastly, the study recommends that existing infrastructure in the area should be upgraded to accommodate the increasing population capacity.

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LIST OF ABBREVIATIONS

GOK	Government of Kenya
NCC	Nairobi City Council
WCED	World Commission on Environment and Development
RCMRD	Regional Centre for Mapping of Resources for Development
CBD	Central Business District
DTRCTDS	Draft Technical Report on Cape Town Densification Strategy
NEMA	National Environment Management Authority
KARA	Kenya Alliance of Residents Associations
NMT	Non Motorized Transport

CHAPTER 1

INTRODUCTION

1.1 Background

The world is rapidly urbanizing. Currently over 50% of humanity now lives in urban areas. In Kenya, urbanization rate is estimated at 3.9% according to Kenya Vision 2030. It is further estimated that by 2030, about 63% of Kenya's population will be living in urban areas. Nairobi city has a population of 3,138,369 people according to 2009 Housing and Population Census from an estimate of 300,000 in 1963. The entire Nairobi Metropolitan Region alone is projected to have a population of over 15 million by 2030 (GOK, 2007).

The magnitude of this urban growth in Kenya requires innovative approach to planning and urban management. Kenya has so far been unable to plan adequately in order to accommodate her increasing urban population. One of the challenges the country faces in this regard is that the rate of urbanization has been much faster than the rate at which affordable quality housing has been provided (GOK, 2007). It is estimated that out of a total 150,000 housing units required annually in urban areas, only an estimated 35,000 are produced according to vision 2030(GOK, 2007).

Every Kenyan has a constitutional right to clean and healthy environment (GOK, 2010). The state has a further responsibility to provide accessible and adequate housing to all citizens, and consequently the growing population must therefore be adequately housed.

The Nairobi Metropolitan Region currently has no urban redevelopment strategy in place to guide regeneration, densification and utilization of inner development potential (GOK, 2008). What is evident is ad hoc attempts by different agencies to bridge the housing gap through unregulated densification of housing estates without proper guidelines and coordination. This development challenge calls for planning and policy measures to ensure an urban growth strategy that will promote integrated and progressive urban development.

It is therefore important to explore new strategies and further examine practical design options and planning solutions to address the challenge of providing adequate housing for the rapidly growing urban population. The settlement schemes will need to be stepped up to cope with the demand. It is the intention of this study to investigate recent trend in densification of urban

housing with a view of proposing appropriate strategies and policies for sustainable densification in our urban housing.

1.2 Problem Statement

Land is a scarce and valuable resource. Whereas sustainable land use is a key aspect of vision 2030, a comprehensive land use planning and management policy to regulate management of this scarce resource has been lacking. The resultant developments in terms of uncontrolled developments, inadequate infrastructure, traffic congestions, and polluted environments are among the clear indicators of the deficiencies of our development control and planning frameworks to guide urban development in tandem with rate of urbanization

In an attempt to accommodate the growing urban population, a huge number of high density residential apartments have sprung up in many residential estates in our cities. Most of these lack basic infrastructure services, compromise on safety standards, and lack amenities for basic comfort, convenience and welfare of the residents. It is clear that the current densification trend is deficient in addressing issues of carrying capacity, optimum land utilization, vulnerability to climate change, inclusiveness in urban housing and the undue strain on existing infrastructure beyond the allowable loading. Lack of appropriate policy guidelines for densification strategies in our cities also compounds the problem.

Sustainable development is a key aspect among the national values and principles of governance for all state officers according to the Kenya constitution (GOK, 2010). It is therefore imperative for the planning professionals to analyze the current housing delivery systems with a view of identifying and providing practical guidelines for sustainable densification programs in our towns and cities.

Kileleshwa has experienced tremendous increase in housing density in the recent past. There is a rapid transformation of the area from low density high income land use to high density medium income zone. The area falls under Zone 4 according to the Nairobi City Development Ordinances and Zones (2006). Several studies have been undertaken in Zones 3, 4 & 5 in the recent past. The current development standards are based on 2006 study where walk up

apartments on Ground Coverage (GC) and Plot Ratio (PR) of 35% and 100% respectively are allowed on areas within the sewerage network. The 2011 study was aimed at generating further knowledge concerning the urban change processes in the study area and their implications for the city planning and sustainable urban development. This study identified a need to rezone the area further due to among other factors the increasing pressure on available land and high cost per unit area of land which justifies the need for further densification (CCN, 2011). The draft study report therefore proposes enhancement of development standards for the study area to G.C. of 35% and P.R. of between 100 to 200% (CCN, 2011).

The rising trend in housing densification in Kileleshwa has several planning implications that need to be investigated. The several challenges that were identified during the 2011 Land Use Study for the area, which include low infrastructure capacity, missing community, social and commercial facilities and traffic congestion are among the indicators that sustainability of the densification process need to be investigated. Whereas several studies have been undertaken to investigate land use change and the factors contributing to the increasing housing density, there exist a gap with regard to analysis of the impacts of increasing density, and the potential strategies that can be advanced to enhance sustainability of the ongoing process. It was the aim of this study therefore to analyze the impacts of this rapid densification process and further investigate strategies to promote sustainable developments within the study area.

1.3 Purpose of the study

Based on the above problem statement, the purpose of the study was to assess the planning implications of the emerging housing densification strategies by examining the associated impacts and propose intervening policy to guide sustainable densification process in the study area.

1.4 Study scope

The study was limited to Kileleshwa sub-location within Westlands constituency in Nairobi. It covers an area of about 5.2 Sq. Km with a population of 16,802 according to 2009 population

census and 4,592 households. This area has witnessed huge transformation in the recent past, from single dwelling on half acre plots to multiple user apartments and commercial blocks.

There are also fragile ecological zones within the study area especially along the Kirichwa river basin that require situational study to facilitate strategic intervention. The study then focused on the role of green designs and strategies in mitigating negative impacts of densification process and the extent to which these can be advanced for sustainable development.

1.5 Research Questions

i) What is the nature and extent of housing densification in Kileleshwa?
ii) What are the physical and ecological impacts of the densification process?
iii) To what extent can green designs and strategies be used to mitigate negative impacts of densification process?
iv) What alternative intervening policy can be advanced to guide sustainable densification process in Kileleshwa?

1.6 Research Objectives

The objectives of the study were:

i) To determine the extent and nature of the housing densification in Kileleshwa;
ii) To examine the physical and ecological impacts of the densification process;
iii) To investigate the extent to which green designs and strategies can be used to mitigate negative impacts of densification process;
iv) To develop an alternative intervening policy which can be advanced to guide sustainable densification process in Kileleshwa?

1.7 Research Hypothesis

Several factors are responsible for the densification process in our urban areas. This study sought to examine the related impacts of the process and the extent to which integration of green designs and other alternative strategies can be advanced to achieve sustainable housing densification.

The hypothesis can thus be stated: “The current housing densification in Kileleshwa is unsustainable and requires alternative low impact strategies”

1.8 Study Justification

Lack of appropriate policy framework to guide densification programs in our cities will have serious negative impacts on our urban environment. Despite attempts by local authorities to halt densification in city estates initially zoned as low density, the initial single family homes are already being illegally transformed into apartment blocks as witnessed in areas like Kileleshwa, Kilimani, Upper hill, Westlands and Spring Valley. Unfortunately, the implication of this is that the quality and quantity of services per capita have continued to decline rapidly. Water and drainage services are insufficient; traffic snarl ups are common due to inadequate carriageways; and most importantly loss of valuable urban green space without adequate replacement. If this situation persists, our urban system will become uninhabitable. For instance, it is estimated that traffic jams resulting in loss of man-hours, fuel and pollution costs our national economy Ksh 37 billion annually. The cost of living in overly congested environments is also heavy and further violates the constitutional right of citizens to a clean and healthy environment (GoK, 2010).

While densification is unarguably a more efficient use of scarce urban space, ad hoc and unplanned densification efforts will not only destroy sensitive neighbourhoods but also damage our business environment and overall quality of life. Previous studies have highlighted the development challenges that are attributed to the general area within Zone 3, 4 and 5. As attested by Munene (2005) in a study on Environmental Quality in Kileleshwa, there are numerous environmental problems associated with the current developments in the study area that requires further scrutiny to ensure sustainability. In proposing areas for further study, Munene (2005) stresses the need for further research on environment-development relationships and the need to come up with development requirements and specifications that do not compromise environmental quality. This calls for solution based approach rather than just diagnostic and descriptive strategies.

This study therefore sought to compliment these studies by undertaking a more detailed analysis of the developments at a micro level of site and plot model to assess the sustainability of the underlying structure. Examination of living environment of the residents was to generate important knowledge concerning development performance as well as user perspective of the densification process. The critical role of green densification strategies in promoting environmental quality was also examined and ultimately the aim was to develop an alternative

policy and framework that will promote densification in Kileleshwa and other neighbourhoods in sustainable manner.

The study was therefore academically, socially and economically significant in that it amongst other things:

i) Shed light on the nature of the ongoing housing densification in Kileleshwa,
ii) Help in understanding the impacts of the increased housing density, and also
iii) Enrich policy interventions with proposed strategies to guide the housing densification programmes in our rapidly growing urban areas.

1.9 Research Methodology

The research sought to understand the nature and extent of the housing densification process in Kileleshwa. This involved tracing the historical and current housing trend in the study area derived through literature review and collection of primary data. Review of past studies and existing research work on densification and land use process in the study area as well as review of the existing policy guidelines and legal framework was further undertaken to help understand the historical development and land use change processes in the area. The research further sought to identify how the increasing housing densification has impacted on the physical and ecological environment.

1.9.1 Research design

The purpose of the research design was to ensure that the evidence obtained effectively addresses the research problem and accurately describes the existing phenomenon. This study adopted a descriptive design to obtain information pertaining to the extent and nature of housing densification in Kileleshwa. The variables in this situation were population, number of households, and housing developments. Units of analysis were households and random parcels of land identified within the study area. Exploratory design approach was also applied to provide insight into the implications of the housing densification and help establish how green designs and strategies can be used to mitigate negative impacts of housing densification process.

The first stage involved carrying out a thorough literature review of the past studies on housing densification and the associated impacts of the development. The literature review helped the researcher to understand the study problem more clearly. The second step involved carrying out

reconnaissance survey to have good background knowledge of the study area, map the physical extent of the study and assist in establishing the sample design. The questionnaires were later administered with a view to collecting desired data and lastly data analysis was done for data collected from the field and literature review.

1.9.2 Source of data and data collection method

i) Secondary data: Saunders, Philip and Adrian, (2000) noted that secondary data is data, which already has been collected by someone else for another purpose. The research obtained data from text books, existing plans, journal, magazine, newspapers and internet from related literature.

ii) Primary data was gathered directly mainly through direct observation of the study area. Two main techniques for gathering primary data were used, that is inquiries and interviews. The research instruments used in collecting data were questionnaire, direct observation and interview schedule. In this study, the questions are structural and open ended. The questionnaire contains only relevant information for the study. Data gathered was recorded using field notebook, photography using digital camera and mapping. Features such as development impacts on environment and infrastructure, land use conflicts and other coping strategies in the study area were captured using direct observation. Relevant site survey and measurements was also carried out as well.

    a. Questionnaires were administered to a sample of respondents to generate data on user's views on the densification challenges, their impacts, infrastructure conditions and their adequacy. The study area has 4,592 households. Assuming a confidence level of 95% and 10.25% as margin of error, a sample size of 90 households was determined using a sample size calculator. Questionnaires were administered to the sample households.

    b. Focus group discussions; these were held with local residents, professionals, business people, small scale traders and other stakeholders within the study area.

c. Conducting interviews for key informants; these include key informants like Nairobi City Council technical officers, City Forward Planning, Planners, Architects and Environmental Impact Assessment Experts etc.

Reconnaissance survey was done prior to actual field survey in order to get general background knowledge that informed the design of research instruments. The research questionnaires and other tools were designed in such a way as to gather detailed information on the dynamics of the densification process, their impacts as well as proposals on how to control and develop a framework for sustainable densification process in the study area.

The data from the questionnaires was analyzed using statistical data analysis software, SPSS from where conclusions and recommendations were derived based on the study findings. Policy proposals for sustainable housing densification were also formulated in line with the recommendations.

1.9.3 Sampling design

In order to select sample strata for this research, the research used judgmental sampling as well as systematic sampling. Judgmental sampling basically means that the researcher selects cases best suited to answer the research questions (Saunders, Philip and Adrian, 2000). Systematic random sampling method was used to identify the sample household for the survey. This entails using base map for the area and randomly picking the starting point from where the subsequent sample units are determined by applying the sample interval.

For head of departments, the study employed key informant interview with those available through purposive sampling. In this approach those who are deemed to possess characteristics wanted or are in position to offer the required information were interviewed. While picking the household respondent, the research applied convenience sampling/ grab sampling. This is due to factors such as availability and willingness of respondent.

Out of the 90 questionnaires administered, 74 were filled and returned by the respondents, while 16 questionnaires were dropped or sent by email to identified residents who failed to respond. 32 plots were also randomly sampled for analysis from a list obtained from Nairobi City Council.

Figure 1.1 Sampling Design

Target population	Population	Sample
Households	Approx.4592	90
Developers/ per plot -	Approx.420 plots	32
Resident Association (KARA)		1
Policy Institutions- Nairobi City Council (County)		1
Ministry of Housing		1
Dept of Physical Planning		1
Provincial Admin. (Chief/Asst)		1
NEMA		1
Architects/ EIA-Lead experts/		5

Source: Author, 2013

1.9.4 Data Analysis and Data Presentation

This involved collation of collected information and verifying facts mentioned in the literature review. Analysis involved the use of techniques such as SPSS (Statistical Package for Social Sciences), use of various types of charts, use of tables, and making of maps, etc. The analysis of both the qualitative and quantitative data collected resulted to formation of simple frequency distribution and analytical table. All the gathered information was analyzed and presented using simple tables, scanned sketches, pie charts, bar graphs, maps photographs.

1.9.5 Data needs matrix

Table 1.1 Data needs matrix

Objective	Data needs	Expected results
A. *Determine the extent and nature of housing densification in Kileleshwa*	• Population data • Households data • Change in land use and subdivision • Development trends through local authority data on approved developments and actual developments	• Assess the population trends • Assess household growth trends • Examine the extent of land subdivision, and increase in number of dwelling units per hectare • Assess the extent of vertical increase in development heights
B. *Examine the physical and ecological impacts of the densification process*	• **Physical impacts?** a) How has densification influenced transport system? b) How has densification affected capacity of existing infrastructure (Water, power, sewer)? c) How has densification affected liveability in regard to: i. Thermal comfort / ventilation ii. Natural lighting iii. Congestion/ crowding iv. Safety/ security v. Privacy	• Analyze traffic volume over 20 year period. • Find out adequacy of infrastructure services. • Carry out built environment analysis to examine: i. Thermal comfort / ventilation ii. Natural lighting iii. Levels of crowding iv. Human safety/security v. Privacy

Objective	Data needs	Expected results
	• **Environmental impacts?** a) How has densification affected green open space? b) How has densification affected the following: i. Increased local temperature ii. Use of energy iii. Water resources iv. Surface water run-off v. Levels of indoor/ outdoor air pollution, vi. Solid waste management	• Find out the effect of densification on open spaces • Examine to what extent, densification has influenced these environmental factors
C. To investigate the extent to which green designs and strategies can be used to mitigate negative impacts of densification process;	• To what extent have the following green strategies been employed? i. Protection of green space ii. Protection of riparian areas iii. Efficiency in energy use iv. Efficiency in water use v. Use of green roofs/ walls vi. Reduction in impervious paving areas	• Assess the use of these strategies in Kileleshwa
D. *Develop and Intervening policy which can be advanced to guide sustainable densification process in Kileleshwa*	• What are the existing zoning policies and regulations? • What the views of the residents on current planning issues in the area	• Assess the effectiveness of the existing policies by reviewing outcomes. • Find out the level of awareness of the planning issues in the area, • Come up with alternative policy measures to guide growth and densification in the study area

Source: Author, 2012

1.10 Study Assumptions

The study proceeded on several assumptions:

i. That the current urbanization rate will persist for a long time and the projected demand for urban housing will continue to rise;
ii. That the study area represents housing densification programs in our urban areas reasonably well; and
iii. That the county governments have the technical capacity and political good will to adopt and implement the study proposals.

1.11 Definition of Key Terms and Concepts

1.11.1 Development

According to the Physical Planning Act (Cap 286), development means the making of any material change in the use or density of any buildings or land or the subdivision of any land which for the purpose of this Act is classified as Class "A" development; and, the erection of such buildings or works and the carrying out of such building operations, as the Minister may from time to time determine, which for the purposes of this Act is classified as Class "B" development(GOK, 1996).

1.11.2 Density

The maximum amount of development permitted or the maximum number of persons permitted to reside on any area of land expressed in dwelling units per hectare or persons per hectare (GOK, 1996).

1.11.3 Housing Densification

Housing densification means increasing the number of units of housing per square foot of land, either through building on vacant land or allowing taller and larger structures.

1.11.4 Indeliberate densification

Housing densification programs done without special planning or deliberation and mainly driven by economical objectives of profit maximization for developers and property owners.

1.11.5 Gross dwelling units per hectare (Gross du/ha)

The number of dwelling units per hectare of land calculated in a designated area on the basis of land used for residential purposes and other land uses such as industry, commerce, education,

transport and parks. Excluded are land-extensive land uses such as agricultural land and nature areas/reserves/parks (CTDSTR, 2009).

1.11.6 Net dwelling units per hectare (net du/ha)

The number of dwelling units per hectare of land calculated on the basis of land used for residential purposes including the garden and off-street parking, if any (CTDSTR, 2009).

1.11.7 Sustainable Development

Development that meets the needs of the present generation without compromising the ability of future generations to meet their own needs.

1.11.8 Sustainability

This is defined as the long-term maintenance of responsibility, which has environmental, economic, and social dimensions, and encompasses the concept of stewardship, the responsible management of resource use.

1.11.9 Carrying Capacity

Carrying capacity is defined as the number of individuals who can be supported in a given area within natural resource limits, and without degrading the natural social, cultural and economic environment for present and future generations.

1.11.10 Green building

A green building is a structure that is designed, built, renovated, operated, or reused in an ecological and resource-efficient manner. Green buildings are designed to meet certain objectives such as protecting occupant health; improving employee productivity; using energy, water, and other resources more efficiently; and reducing the overall impact to the environment.

CHAPTER 2
LITERATURE REVIEW

2.1 Case for Densification

As noted by Niemela *et al*, (2011) densification and compaction of urban areas has been suggested as a strategy to avoid or reduce urban sprawl. This therefore means that available land within urban areas is built on, rather than farmland or natural areas of urban fridge. Pauleit *et al* (2005) however highlighted that opportunities for densification which include: redevelopment of former industrial areas which have fallen into dereliction, infill development where other houses are built on low density residential areas, and inner urban open spaces, are built over with negative consequences for ecosystem process (Paule it *et al*, 2005) The amount and character of green surfaces determine ecosystem processes such as climatic energy balance, storm water runoff, carbon storage and biodiversity (Niemela *et al*, 2011). He further notes that while urban compaction seems desirable in order to reduce consumption of land as well as energy consumption and green house gas emission, it may compromise the ecological quality in the city and its adaptive capacity to climate change.

Inman (2009) on his part views densification as an organic part of how old cities which cannot expand horizontally have always grown. He goes on to say that while densification does affect views and open space, it also results in more people on the streets (hence usually a safer environment) more amenities, more choices, and higher property values. In addition densification produces a larger municipal tax base. While linking density with urban safety, Inman (2009) notes that city parks and shopping streets for example depend on the presence of large number of people. A desert park, un inhabited street are not only unattractive, but they even appear threatening and dangerous. He concludes by emphasizing that sufficient public amenities must be put in place from the beginning in order to attract buyers and tenants. According to Toderian (2008), by strategically increasing the number of dwelling units per acre, cities not only will go a long way toward meeting their sustainability objectives, but also will be competitive, resilient, and great places to live.

2.1.1 Key elements of compact city

As Acioly (2000) found out, a thorough analysis of intra-urban potential for growth and urban intensification provides a sound basis for pursuing the maximization of available land, infrastructure and public services, enhancing housing opportunities and local economic development. The final result is cities that tackle urban equity issues and which contain the key elements of a compact city-social and economic diversity, urbanity, vitality, high densities and mixed land use. However, he further argues that these densification strategies place the question of sustainable urban development at the forefront, but they do not provide evidence that they will be sufficient in themselves for reversing the trend of peripheral development and urban expansion towards the greenfield sites.

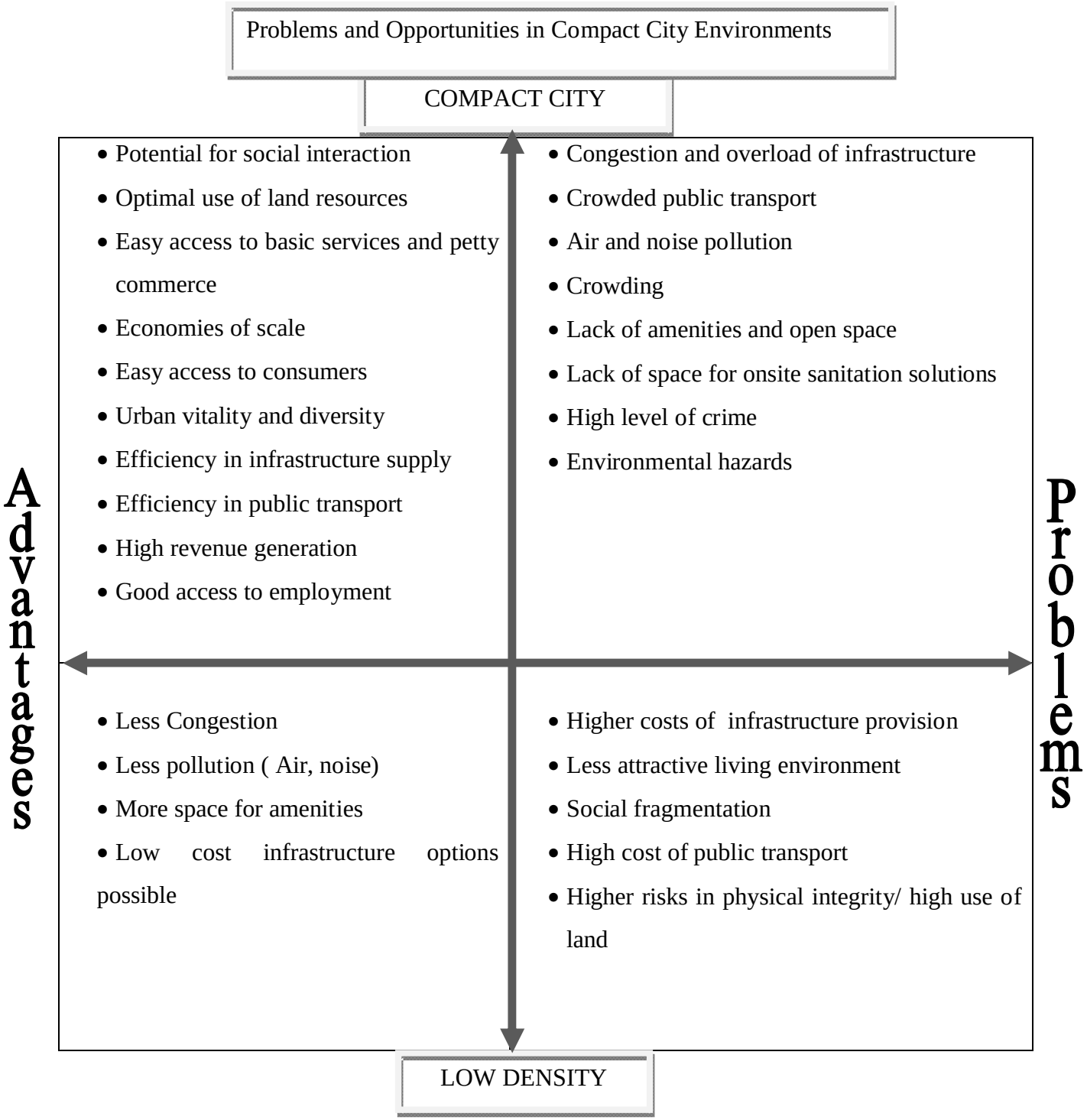
Acioly (2000) further notes that the active role of municipalities in guiding urban development processes paves way for sustainable urban management practices. Potentially there is an institutional, organizational and political environment conducive to policies that are socially equitable, economically efficient and environmentally sustainable. This may sustain compact city policies and assure their social acceptability whilst simultaneously creating mechanisms to manage and mitigate their adverse effects (Acioly, 2000). He further observes that in absence of good local governance, the environmental impacts from extremely dense urban environments- air pollution, noise, traffic congestion, health risks and lack of open public space- are exacerbated and constitute a clear threat to sustainable urban development. Indeed, the municipalities are currently incapable of playing their role because they lack capacity and autonomy.

The problem with low density land use pattern is not just high energy use, but a set of environmental and social problems according to Acioly (2000):

- *High per capita auto emissions (eg. smog, greenhouse gases),*
- *High per capita water use (eg. for lawn irrigation),*
- *High land requirement in both block size and the road system required to service it,*
- *High storm water pollution from extra urbanized land,*
- *High domestic heating/cooling energy due to lack of shared insulating effect when buildings are grouped together,*
- *Poor recycling rates due to the large costs involved in collection,*
- *High physical infrastructure costs(utilities, pipes, poles, roads etc),*

- *High social infrastructure costs (since cars are required for participation in social life)*

Figure 2.1 Problems and opportunities in Compact City



Source: Based on Acioly and Davidson 1996

Newman and Kenworthy, (1999) in exploring the impacts of high cost social infrastructure notes that when cars are required for participation in social life, the marginalized and excluded are largely the children, senior citizens, physically challenged and poor especially women. At the same time, it is apparent that if densification is not accompanied by an efficient transit and public transport management system, one can expect the exacerbation of congestion, the deterioration of quality of life and decreasing air quality.

2.1.2 Intelligent densification

The foregoing scenarios certainly call for an intelligent densification strategy. Acioly (2000) is of the view that proper management and accurate knowledge of the built environment are essential conditions for pursuing densification policies. Niemela *et al*,(2011) further points out that while urban compaction seems desirable in order to reduce consumption of land as well as energy consumption and green house gas emission, it may compromise the ecological quality in the city and its adaptive capacity to climate change especially if it is not well managed. Acioly, (2000) therefore note there should be mechanisms to manage and mitigate adverse effects that come with high density. He proposes "intelligent densification" policies that help the city to save energy, ease congestion, maximize population mobility and promote private sector participation in urban development. Rohracher (2004) further stated that intelligent planning should allow prospective house owners to adapt the building design to their wishes, allow sufficient availability of densified areas with low traffic, safe playground for children and still help stop people moving into the countryside around cities.

City of Tshwane (2005) in the report on the Tshwane compaction and densification strategy, 2005 states that densification and compaction is not an end in itself, but a means to achieve an overall efficient, integrated and sustainable metropolitan area. According to City of Tshwane (2005) the strategy should achieve a range of other goals which include: smart growth strategy that reduces sprawl and promotes growth that is balanced and fiscally, environmentally and socially responsible; and design guidelines for higher density housing. Design aspects of development should be given more considerations during development applications for higher density developments since through appropriate design and integration high densities could be much more desirable developments than lower densities without appropriate designs.

Funding the development and upgrading of the engineering infrastructure services as a consequence of the compaction and densification drive should be carefully considered and the extent to which the developers are kept responsible for these costs. From the environmental perspective, mitigation measures for negative impacts such as increase noise levels, increased pollution for example on water resources, alteration to the historic and cultural fabrics of residents and deterioration of urban green space should be well articulated. The report further notes other strategies like promotion of green building design, creation of more opportunities for public and non-motorized transport systems as well as engagement of meaningful public participation process as vital components in building success of urban densification programmes.

Table 2.1 Measures of density

Measure	*Definition*
Dwelling unit density	Number of dwelling units per hectare (du/ha)
Population density	Number of people per hectare (usually calculated by multiplying the number of units by an appropriate average household size).
Building density	Ratio of total floor area of buildings to the corresponding site (PR).
Gross du/ha	The number of dwelling units per hectare of land calculated in a designated area on the basis of land used for residential purposes and other land uses such as industry, commerce, education, transport and parks. Excluded are land-extensive land uses such as agricultural land and nature areas/reserves/parks.
Nett du/ha	The number of dwelling units per hectare of land calculated on the basis of land used for residential purposes including the garden and off-street parking, if any.
Gross base density	The average number of dwelling units per hectare across large city district areas or the City as a whole, excluding land-extensive uses such as agricultural and rural land and large nature areas/reserves/parks.

Source: Cape Town Densification Strategy Technical Report

As Goncalves & Umakoshi (2010) noted in the book " The Environmental Performance of Tall Buildings', the main arguments in favour of tall buildings around the world are population pressure on land, synergies that arise from the socio-economic relationship between proximity and density, and the efficiency of urban infrastructures servicing higher densities. On the other hand arguments against tall building are related to high energy consumption in building

operation, the risk of overloading the existing urban infrastructure, impact on the historical urban fabric and adverse impacts on the quality of the built environment and the dynamics of urban life.

2.2 Sustainable Development

Brundtland commission (1987) cited in Njuguna (2007) defines **Sustainable development** as **"**Development that meets the needs of the present generation without compromising the ability of future generations to meet their own needs" Glaeser (1984) further state that **Sustainable development** requires the following key factors:

- *Harmonization of consumption patterns and time use lifestyles,*
- *Appropriate technologies using ecologically compatible designs,*
- *Low energy use with emphasis on enhancing renewable energy sources,*
- *Fresh look at the way we use environmental resources with a view to preserve the same or recycle those that are recyclable,*
- *Ecological principles to guide land use and settlement patterns,*
- *Participatory planning and grass root activation,*
- *Deliberate actions towards preserving and improving the physical environment for the benefit of man and the environment itself.*

Njuguna (2007) further notes that sustainable development requires the recognition that most contemporary development processes have proved harmful to the environment and therefore are unsustainable. Sustainable development aims at raising the standards of living of a cross section of the society without disrupting their culture or the environment (Njuguna, 2007). It also aims at ensuring the satisfaction of their needs, a fair distribution of wealth and the prevention of exploitative business practices.

There is a very strong link between urban density and sustainability of the urban settlements. As Acioly and Forbes, (1996) argue "Resources need to be utilised efficiently. The use and occupation of available space and vacant land should be rationalised. Public utilities must be

efficiently managed .Municipal services must be financially sustainable and housing projects must fit into available land and be economically and environmentally sound" . Further to that, as Njuguna (2007) points out, where density of a city is below 500,000 inhabitants, the more the city grows sustainably. As that figure rises above 2 million inhabitants, the quality of urban life deteriorates, with dwindling job opportunities, adding to social, economic, political and other pressures (Njuguna, 2007). It is believed that low densities of below 30 inhabitants per hectare decrease the possibilities of human interaction. Inhabitants also lose a great deal on psycho-social stimulation. At the same time excessive densities of above 300 inhabitants per hectare mean greater overcrowding, speedier deterioration of the quality of life and excessive psycho-social stress, all of which are favourable conditions for insecurity, transmission of communicable diseases and soon.

Acioly and Forbes (1996) while analyzing the relationship between density and infrastructure cost argued that per capita costs of infrastructure decreases spectacularly when the population density is increased from 50-200 inhabitants/ ha. From 200-300 inhabitants/ ha per capita costs decrease but not significantly and tend to remain at the lowest values for 300-600 inhabitants/ ha.

2.2.1 Sustainable city

Toderian (2008) argues that strategic densification plays a critical role in improving the health of the planet by enhancing several pillars that support a sustainable city. He identified pillars of sustainable city as: a complete walkable community; low impact transportation; green buildings; flexible open space; green infrastructure; healthy food system; community facilities and programs; and economic development. These are discussed further in detail. Barnes (2002) further noted that sustainable communities need to be active, inclusive and safe; well run and environmentally sensitive; as well as being well designed and built.

Table 2.2 Sustainable communities

Sustainable communities: Home for all	
Active, inclusive and safe	Fair , tolerant, and cohesive with a strong local culture and other shared community activities
Well run	With effective and inclusive participation, representation and leadership
Environmentally sensitive	Providing places to live that are sensitive to the environment
Well designed and built	Featuring a quality and natural environment
Well connected	With good transport services and communications linking people to jobs, schools, health and other services
Thriving	With a flourishing and diverse local economy
Well served	With public, private, community and voluntary services that are appropriate to people's needs and accessible to all
Fair for everyone	Including those in other communities, now and in the future

Source: adapted from Barness

2.2.2 Walkable and well connected community

A sustainable community needs to be structured into complete, well-connected, mixed-use neighborhoods that allow residents to work, live, play, shop, and learn within a convenient walking or transit distance. While communities should be fashioned so that key natural features are protected, these should not be at the expense of many connections within neighborhoods to facilitate short trips between uses. A diverse mix of housing reflecting a range of incomes, family sizes, and ages should exist. Commercial areas should offer office, retail, and commercial space, in addition to residential and community amenities.

Density that is well designed and assembled makes transit and retail more viable, supports more schools and services close to homes, and supports the clustering of development so as to better preserve natural areas. Higher densities make walkability possible, and great design makes it enjoyable.

2.2.3 A Low-impact transportation System

A sustainable community should provide as many alternatives to the automobile as possible, including planning for convenient transit service, and supporting shared-car opportunities to reduce the need for single-person auto use. Parking strategies should gradually reduce car use and ownership, and parking design should minimize landscape disruption.

A sustainable community should also prioritize pedestrian and cyclist modes of mobility by linking all areas with a fine-grained network of paths, and by designing local streets to support all ways of getting around, rather than emphasizing vehicular needs. Streets should also address other environmental and social objectives such as storm water management, trees and bird habitat, urban agriculture, and playground areas.

Research has shown density to be critical in shifting transportation away from the automobile to other modes of travel. With 30 to 60 percent of climate-changing emissions coming from transportation, this is critical. Highly convenient rapid transit requires even more units per acre to be viable.

2.2.4 Green buildings

Most permanent buildings stand for 50 to 100 years, often with relatively few modifications, and their design significantly influences the impact their occupants have on the planet as they go about their daily lives. A sustainable community should be filled with green structures, which are typically promoted through green design regulations or guidelines or through green building rating systems. Examples of green building rating systems include: The Building Research Environmental Assessment Method (BREEAM), which is UK based, Leadership in Energy and Environmental Design (LEED) system from U.S.A. and Green Globes, a Canada based tool.

Density necessarily requires a high percentage of multifamily homes in a neighborhood. Multifamily residences can be significantly more energy efficient than single-family homes as they share walls and often more efficient building-scale heating or cooling systems. Furthermore, multifamily densities are required to make the provision of community services financially

viable. In other words, some of the best green design and technological approaches are highly dependent on mid to higher densities.

Components of green building design

i) **Energy efficiency and renewable energy**

Energy efficiency

Energy efficiency in green building is achieved through several strategies. One ways is management of energy waste though regular cleaning, maintenance and replacement of obsolete and energy inefficient technologies and systems such as air conditions, pumps, heaters, computers and other machines. Efficient appliances will make significant savings on the specific electricity bill. For example, the savings generated by low energy lamps reduces costs by a factor of 4 compared to incandescent lamps. By energy savings, there is another component of management of energy waste. By this we mean all economically interesting actions undertaken to reduce energy consumption, by for instance installing suitable equipment in electrical installations. The aim is also to consume energy in an optimal manner (e.g. recuperate heat lost in combustion gases or produce energy from waste). We should be aware that energy savings do not concern just electricity. Adopting some simple daily habits along with a judicious choice of equipment also enables us to control consumption of all other forms of energy (gas, heating fuel, etc.). In a green building, the main priority is to identify energy savings.

Some of the main measures that enable energy savings are:

- Good thermal insulation of all exterior components (walls, windows, roof, etc.)
- Eliminate thermal bridges and other energy leaks
- Good airtight seal on the exterior building envelope
- Reduction of thermal losses through ventilation
- Efficiency of a reduced-inertia boiler
- Optimised electricity management (reduction of installed power ratings, central management, use of lighting control equipment, etc.).

Renewable energy

Solar energy is the source of the water cycle and of wind. The plant kingdom, on which the animal kingdom depends, also uses solar energy by transforming it into chemical energy through

photosynthesis. Apart from nuclear power, geothermal energy and tidal power, solar energy is the origin of all other energies on Earth. Solar energy is also inexhaustible on a human timescale and hugely abundant. It is estimated that the Earth receives from the sun about 10,000 times the total amount of energy consumed by all of humanity. Solar power capture technologies can be split into three categories: Solar photovoltaic, solar thermal and solar thermodynamic. The use of solar power is of tremendous importance in a green building.

Solar heating systems can be installed in all types of buildings. Using solar power to pre-heat outside air before it is allowed to enter a building can considerably reduce heating costs both in residential buildings and commercial constructions. Solar heating systems are especially efficient for large buildings such as hospitals, hangars, school and gyms, as well as multi-storey residential buildings.

The vast majority of solar heating systems require the installation of solar walls. Such equipment can be installed on new or existing buildings. Solar walls require very little maintenance, feature no liquids or detachable parts other than the ventilators connected to the ventilation system. Moreover, solar walls can operate under cloudy conditions and at night time, even if their efficiency is much less. The ROI is two years due to the energy savings they produce.

Geothermal power is extracted from the ground for use in air conditioning, heating or transformation into electricity. Installing a geothermal heat pump system represents a major investment, but it enables users to make use of an inexhaustible source of energy that will provide 60 to 70% of the power required to heat or cool a building. Geothermal systems can be installed on new houses or renovation projects. This technology can therefore considerably reduce the use of fossil fuels or electricity, which emit much more greenhouse gases and which are generally less financially interesting in the long term. Geothermal technologies are naturally included in green building parameters. Geothermal systems present some major advantages. Effectively, underground heat is present everywhere on Earth. Geothermal energy comes from an almost continuous source that is not dependent on atmospheric conditions. The ease of extraction of this energy depends on the structure of the geological formations or the composition of the

rock beds. This technology is split into two categories: Deep geothermal or near-surface geothermal energy.

Alongside solar energy and geothermal energy, wind power is the third major source of green building energy. Today wind power is the least expensive clean energy to produce, which explains the strong enthusiasm for this technology. Current research could enable it to keep this comfortable head start for several years to come. Water or hydraulic power is mainly produced by the displacement or accumulation of fresh water or sea water. As it is everywhere, water plays an extremely important role in transporting the Earth's energy.

Biomass is generated by photosynthesis, where solar energy is stored by plants in the form of carbohydrates, as they use the carbon dioxide in the atmosphere. In a wide sense, the expression "biomass" refers to all living matter (the total mass of living matter). In terms of energy, biomass refers to all organic material that can become a source of energy in the form of biogas, biofuel or directly by combustion: Wood or organic agricultural or urban waste, etc. Biomass energy is used by the biogas, biofuel and wood industries.

ii) **Sustainable water management**

The availability of fresh water has become a matter of increasing concern in a context where developed and developing countries are engaged in a race to obtain resources that are inexorably becoming scarcer. A green building must therefore be designed to use water efficiently. Managing waste water, irrigation water and rain water are also essential for a sustainable approach. The use of mixer taps reduces water consumption as it is easier to control the temperature. Aerator tap fittings reduce the amount of water used without it being noticed during use. Waste through negligence is to be avoided. For example tens of millions of cubic metres of water are lost every year, because of inadequate seals on taps. Replacing unsuitable equipment and using water-efficient devices, communicating and raising user awareness are also potential sources for water savings. Rain water is an inexhaustible natural resource which has its place in the green building. Rain water is collected as it runs off a roof and is stored in a tank. Whether polluted or not, rain water is naturally slightly acidic (pH from 5 to 6), due to its carbon dioxide content, present in the atmosphere. This acidity means it should not be stored in plastic or metal containers. For domestic use, the ideal solution is a concrete or limestone tank that neutralises the natural acidity of rain water. Rain water is only rarely recuperated and often only used for

watering gardens. Its use should nonetheless be systematic both to unblock waste networks and to save on a resource that is becoming scarcer and is weighing on household budgets. A farmer's common sense has always encouraged them to put a container under the gutter pipe to recuperate rain water. If optimised, rain water collection can enable homes to be autonomous in water use, without it being visible or visually un-aesthetic. In certain buildings, rain water is recuperated, treated and reused in applications that do not require potable water. This kind of solution helps reduce fresh water needs in the public network, while avoiding the propagation of pollutants by run-off. Other solutions are available, such as green roofs, which not only store rain water, but also provide a green oasis in an urban environment along with many other benefits.

iii) **Green construction materials and components**

Green building materials offer variety of benefits to the building owner and occupiers. These range from reduced maintenance cost, energy conservation, improved occupant health and productivity and greater design flexibility. Building and construction activities worldwide consume 3 billion tons of raw materials each year or 40 percent of total global use (Roodman and Lenssen, 1995). Using green building materials and products therefore promotes conservation of dwindling nonrenewable resources as well as helping reduce the environmental impacts associated with the extraction, transport, processing, fabrication, installation, reuse, recycling, and disposal of these building industry source materials.

Green building materials are composed of renewable, rather than nonrenewable resources. Green materials are environmentally responsible because impacts are considered over the life of the product (Spiegel and Meadows, 1999).

According to Froeschle's (1999) the basic criteria for assessing green materials (and construction strategies) include: resource efficiency, indoor air quality, energy efficiency, water conservation and affordability

Table 2.3 Basic criteria for assessing green materials

Criteria	Products performance
Resource efficiency	• **Recycled Content**: Products with identifiable recycled content, including postindustrial content with a preference for postconsumer content. • **Natural, plentiful or renewable**: Materials harvested from sustainably managed sources and preferably have an independent certification (e.g., certified wood) and are certified by an independent third party. • **Resource efficient manufacturing process**: Products manufactured with resource-efficient processes including reducing energy consumption, minimizing waste (recycled, recyclable and or source reduced product packaging), and reducing greenhouse gases. • **Locally available**: Building materials, components, and systems found locally or regionally saving energy and resources in transportation to the project site. • **Salvaged, refurbished, or remanufactured**: Includes saving a material from disposal and renovating, repairing, restoring, or generally improving the appearance, performance, quality, functionality, or value of a product. • **Reusable or recyclable**: Select materials that can be easily dismantled and reused or recycled at the end of their useful life. For example, using inert demolition materials as a base course for a parking lot. • **Recycled or recyclable product packaging**: Products enclosed in recycled content or recyclable packaging. • **Durable**: Materials that are longer lasting or are comparable to conventional products with long life expectancies. • Use dimensional planning and other material efficiency strategies. These strategies reduce the amount of building materials needed and cut construction costs. For example, design rooms on 4-foot multiples to conform to standard-sized wallboard and plywood sheets. • Require plans for managing materials through deconstruction, demolition, and construction. • Design with adequate space to facilitate recycling collection and to incorporate a solid waste management program that prevents waste generation.

Criteria	Products performance
Indoor air quality	• **Low or non-toxic**: Materials that emit few or no carcinogens, reproductive toxicants, or irritants as demonstrated by the manufacturer through appropriate testing. • **Minimal chemical emissions**: Products that have minimal emissions of Volatile Organic Compounds (VOCs). Products that also maximize resource and energy efficiency while reducing chemical emissions. • **Low-VOC assembly**: Materials installed with minimal VOC-producing compounds, or no-VOC mechanical attachment methods and minimal hazards. • **Moisture resistant**: Products and systems that resist moisture or inhibit the growth of biological contaminants in buildings. • **Healthfully maintained**: Materials, components, and systems that require only simple, non-toxic, or low-VOC methods of cleaning. • **Systems or equipment:** Products that promote healthy IAQ by identifying indoor air pollutants or enhancing the air quality.
Energy efficiency	Materials, components, and systems that help reduce energy consumption in buildings and facilities. • Passive design strategies can dramatically affect building energy performance. These measures include building shape and orientation, passive solar design, and the use of natural lighting. • Develop strategies to provide natural lighting. Studies have shown that it has a positive impact on productivity and well being. • Install high-efficiency lighting systems with advanced lighting controls. Include motion sensors tied to dimmable lighting controls. Task lighting reduces general overhead light levels. • Use a properly sized and energy-efficient heat/cooling system in conjunction with a thermally efficient building shell. Maximize light colors for roofing and wall finish materials; install high R-value wall and ceiling insulation; and use minimal glass on east and west exposures. • Minimize the electric loads from lighting, equipment, and appliances. • Consider alternative energy sources such as renewable energy sources.

Criteria	Products performance
Water conservation	Products and systems that help reduce water consumption in buildings and conserve water in landscaped areas • Design for dual plumbing to use recycled water for toilet flushing or a gray water system that recovers rainwater or other nonpotable water for site irrigation. • Minimize wastewater by using ultra low-flush toilets, low-flow shower heads, and other water conserving fixtures. • Use recirculating systems for centralized hot water distribution. • Install point-of-use hot water heating systems for more distant locations. • Meter the landscape separately from buildings. Use micro-irrigation (which excludes sprinklers and high-pressure sprayers) to supply water in nonturf areas. • Use state-of-the-art irrigation controllers and self-closing nozzles on hoses.
Affordability	Considered when building product life-cycle costs are comparable to conventional materials or as a whole, are within a project-defined percentage of the overall budget. Several design tools exist to help measure the costs and environmental benefits of sustainable products and design strategies. An example is Building for Environmental and Economic Sustainability (BEES 2.0) which is a design tool used to measure the "environmental performance of building products by using the environmental life-cycle assessment approach. All stages in the life of a product are analyzed: raw material acquisition, manufacture, transportation, installation, use, and recycling and waste management. Economic performance is measured using the ASTM (standard life-cycle cost method) which covers the costs of initial investment, replacement, operation, maintenance and repair, and disposal."

Source: Based on Froeschle 1999

iv) **Reduction of wastes and toxic substances**

A good green building design helps the occupants to reduce the quantity of waste generated. It also offers solutions such as composting bins, to reduce the volume of matter going to landfills. The green architect also aims to reduce waste in terms of energy, water and materials used for the construction. This considerable reduces the volume of waste sent for disposal during the

construction phase. Green building avoids the systematic burial of materials retrieved from buildings at the end of their life by recycling and recuperating them. The extension of the useful lifetime of a structure also enables waste reduction.

The quality of interior air is an important factor in a green building. To do this, it must also seek to reduce volatile organic compounds (VOC) and other air impurities such as microbial contaminants. The ventilation systems must be well-designed to ensure suitable ventilation and air filtration, as well as to isolate certain activities (kitchens, dry-cleaning, etc.) from other applications.

During design and construction, the choice of construction materials and interior finishing products is made to reduce the amount of toxic substances in the building. In effect, many construction materials and cleaning products emit toxic gases such as VOC and formaldehyde. These gases can have a negative impact on occupant health. By avoiding these products, we can increase the quality of the interior environment in a building.

2.2.5 Flexible open space

The open space in a sustainable community should accommodate both community and ecological needs, including protecting key environmental areas or functions, enhancing habitat through urban landscape design, offering significant recreation opportunities for people of all ages, and providing places to grow food in the city (Toderian, 2008).

Density offers both benefits and challenges in this regard. Parks, community gardens, and other open areas compete for space in a high-density neighborhood. The land these uses occupy requires significant civic investment unless a developer has provided them as a condition of development. According to Barness (2002) one of the greatest barriers to increasing densities is lack of public space and play areas. However, through the use of green roofs, courtyards, and other exterior elements, well-designed density can provide strategic opportunities for outdoor space and locations to grow food. In addition, from a larger-scale view, focusing growth within higher-density areas permits the preservation of farmland, riparian areas, and other key uses on the edges of the community.

Open and green spaces design

Open spaces in neighborhoods are defined as 'any unbuilt land within the boundary or designated envelope of a neighborhood which provides, or has the potential to provide, environmental, social and/or economic benefits to communities, whether direct or indirect.' (Campbell, 2001). Open spaces are vital components of neighbourhood design and should accommodate community and ecological needs, including protecting key environmental areas or functions. They are the arena of neighbours' outdoor interactions consequently building the neighbourhood's sense of community, and in the micro ecological sphere setting its parameters and configuring its fundamentals (Khalid, 2008). In differentiating vegetated areas from non-vegetated areas Khalid (2008) bought the following typological classification:

a) Greenspace: a sub-set of open space, consisting of any vegetated land or structure, water or geological feature within urban areas.
b) Greyspace (sometimes referred to as "civic space"): a sub-set of open space, consisting of urban squares and other paved or hard landscaped areas with a civic function.

Table 2.4 Subsets of green space and grey space

Green space	Function
1) Parks and gardens	Areas of land, normally enclosed, designed, constructed, managed and maintained as a public park or garden. Their primary function is for informal activity or relaxation, social and community purposes, and horticultural or arboricultural displays. Some may also be designated landscapes of historical importance of national significance
2) Amenity greenspace	Managed and maintained landscaped areas with no designated specific use by people, but providing visual amenity or separating different buildings or land uses for environmental, visual or safety reasons. They may also be used, incidentally, as wildlife habitats.
3) Children play areas	Designated and maintained areas providing safe and accessible opportunities for children's play, usually linked to housing areas and therefore normally set within a wider green environment of amenity open space. The primary

	function of these areas is to provide safe facilities for children to play, usually close to home and under informal supervision from nearby houses.
4) Sports facilities	Designed, constructed, managed and maintained large and generally on flat areas of grassland or specially-designed artificial surfaces, used primarily for designated sports. The primary function of these areas is to accommodate practice, training and competition for recognized outdoor sports.
5) Green corridor	Routes linking different areas within a town or city as part of a designated and managed network and used for walking, cycling or horse riding or linking towns and cities to their surrounding countryside or country parks. The primary function of green corridors is to allow safe, environment-friendly movement within urban areas. Moreover, they support wildlife colonization and therefore habitat creation.
6) Natural & semi- natural greenspaces	Undeveloped land with little or only limited maintenance which have been planted with wild flowers or colonized by vegetation and wildlife. They also include woodland, railway embankments, river and canal banks and derelict land, which may in some cases be thought of as temporary natural greenspace. The primary function of natural greenspaces is to promote biodiversity and nature conservation.
7) Other functional greenspaces:	Essentially allotments, the yards of religious buildings and cemeteries.
Greyspace	**Function**
1) Civic squares and plazas:	Often containing statues or fountains and primarily paved, Sometimes providing a setting for important public buildings.
2) Market places	Usually with historic connotations
3) Pedestrian streets	Usually former roads which have been paved over and provided with seats and planters.
4) Promenades and sea fronts	Usually used for recreational activities. They have special value when located at historical areas.

Source: Based on Khalid, 2008

Ironside (2005) gives a detailed definition to sustainable residential greenspace as: “Greenspace fit for its purpose, responsive to evolving needs and changes over an extended period of time, not requiring an excessive input of resources.”

The role of open space in achieving sustainable neighbourhood can thus be formulated as belows; (Campbell, 2001, Ironside, 1999, Birkeland 2004)

- Encouraging sustainable lifestyles, for example by providing paths and cycle routes,
- Reduce the level of car reliance, by creating neighborhoods where walking is the natural
- and pleasurable means of access between activities,
- Enhancing local security and community by increasing the number of people on the streets and the design of the path itself,
- Making maximum use of existing features and assets,
- Strengthening the sense of place,
- Incorporating local or recycled materials,
- Encouraging community participation and involvement,
- Reducing inputs of non-renewable resources during construction and subsequent maintenance,
- Eliminating or reducing the use of herbicides and resources that affect other ecosystems,
- Encouraging habitat creation and native planting,

Sustainability goals associated with open green space include:

i) *Cutting green house gas emissions:* achieved by reducing the need to travel, reducing car reliance and increased energy efficiency in buildings;
ii) *Closing local resource loop:* achieved by reducing demand for non-renewable resources, reuse and recycling of resources, local water sourcing, treatment and aquifers recharge, local low input food production;
iii) *Enhancing local environmental quality:* promotes local distinctiveness and heritage, create an attractive public realm, enhance local habitat diversity ;
iv) *Creating a healthy environment:* improves local air quality, promotes an active lifestyle (especially walking), encourage consumption of fresh fruit and vegetables.

v) *Increasing street safety:* Reduce the chance of vehicle/ pedestrian accidents, reduce the fear of violence.

vi) *Increasing accessibility and freedom of choice:* Choice of transport mode for trips, and more facilities accessible locally.

vii) *Equity and social inclusion:* Choice of facilities within easy walking distance, viability of public transport.

viii) *Local work opportunities:* Accessible jobs for those tied to the locality, reduce transport emission.

ix) *Value of local community:* facilitate accessible social networks, promotes mental health.

x) *Increasing local self determination:* Increasing user/citizen control, management of decentralized systems.

2.2.6 Green Infrastructure

The green infrastructure of a city is comprised of natural and designed systems and elements of the city that function in ways analogous to natural processes in managing air, water, microclimatic and energy resources(Schneekloth, 2003). The most obvious part of this infrastructure are trees, open spaces, lawns and parks, and all places that have water-pervious surfaces and soil to support plant material. Green infrastructure strategies should be created for every sustainable community to address the supply and management of energy, potable water, and materials and the reuse or disposal of wastewater, stormwater, and solid waste. Denser development provides higher demand for energy for heating, lighting and cooling that makes innovative infrastructure systems financially viable. Waste energy from mixed uses can also provide opportunity for efficiency and utility investments (Toderian (2008).

Table 2.5 Functions of green infrastructure

Function of green infrastructure
Air quality improvement i) Vegatation reduces air pollution as it filters dust particles and pollutants attached to them, ii) Trees also absorb carbon.
Microclimate modification iii) Non-porous urban surfaces absorb and hold heat during warm weather, contributing to the "heat island effect" where temperatures can be 8-10% hotter than the surrounding countryside. This is much more severe in extensively paved high density urban areas. For example a study conducted in Los Angeles suggested that relatively minor green projects can make significant difference in both pollution control and heat reduction. Increasing the urban green space by 5% in Los Angeles and replacing dark roofs and asphalt with lighter surfaces including green roofs could lower overall temperatures by 4 degrees (F).(Lawrence Berkeley Laboratory, 2002) iv) Strategically planted trees serve as wind breaks, in part by lifting strong seasonal winds up and over the leeward structures and by breaking down strong winds patterns.
Storm water management v) Green infrastructure naturalizes the hydrological cycles in a city. The hard surfaces of the urban fabric increase the intensity of the runoff and the amount of pollutants in urban waters. This is because instead of water soaking into the ground it travels quickly into storm water drainage systems that flows into the rivers and streams, causing increased flooding and erosion. The green fabric on the other hand absorbs the water at the source, recharging the groundwater, filtering pollutants, and slowing down the water travel. This improves water quality and is cost effective.
Bio diversity vi) Green infrastructure encourages a rich variety of birds and animals. Wildlife in the city moves through riparian corridors along rivers, streams and large parks that have areas of native vegetation. The more we encourage wildlife in the city at appropriate places, the more varied and enriched will be quality of daily life.
Recreational opportunities vii) Urban green fabric acts a multi-use structure; active reaction and sports field, bicycle/nature trails, bird watching, school trips etc.

Source: Based on Schneekloth, 2003.

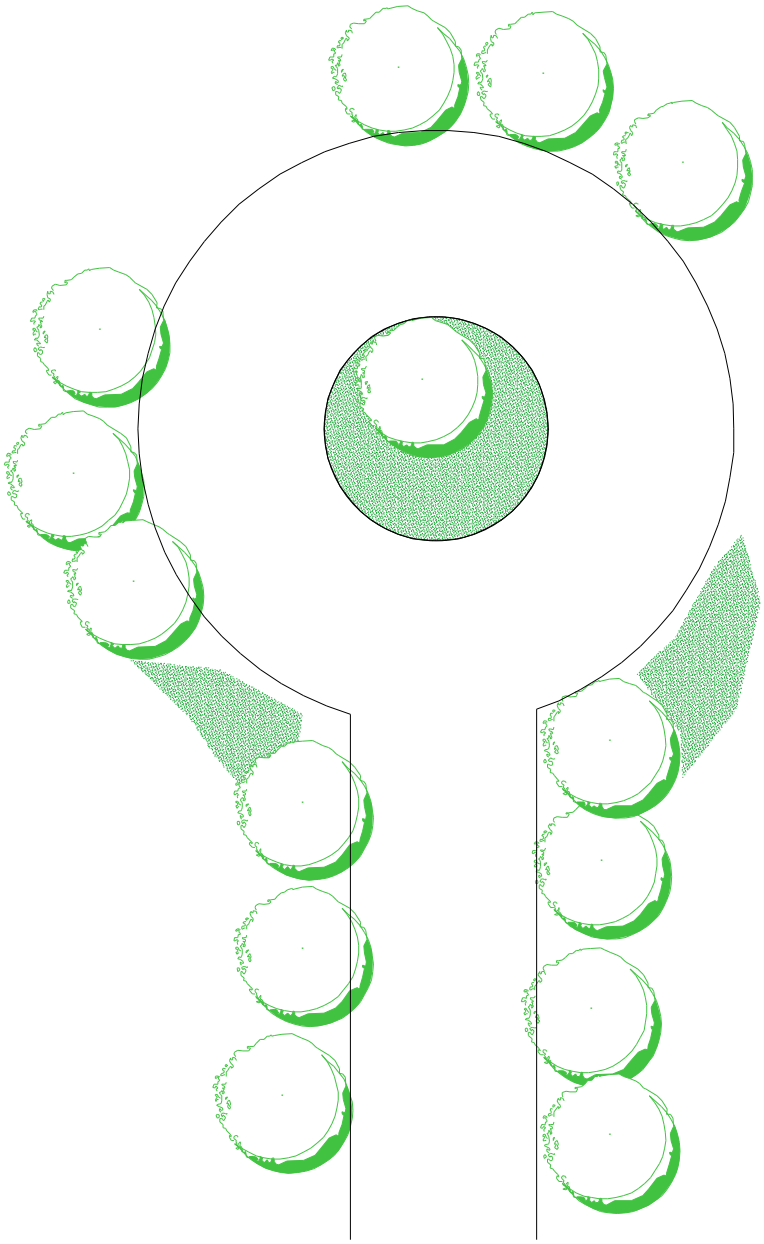
It is important to have regulatory provisions for preservation of green space. The main strategies in any section of the urban development should be to reduce paving and increase vegetation.

Schneekloth, (2003) proposes several site planning policies to help reduce excess paving:

- Density zoning; regulation of overall density in terms of units per acre, or percentage of acreage devoted to structures and hard surfaces,
- Cluster development; placing several buildings together surrounded by open space, rather than each unit being in the centre of its separate plot, can greatly reduce infrastructure costs including paving,
- Combined landuses; Zoning that allows residences and workplaces to coexist makes walking, biking, or public transit much easier for workers,
- Impervious surface limit; Set maximum percentage of the site area that can be impervious. This includes both paved and roofed areas. According to Schneekloth, (2003) a level of impervious surface of over 10% has serious impacts that require mitigation, and a level of over 30% will inevitably cause serious degradation of the ecosystem.
- Use of porous paving material; not all parking areas need to be paved. More permeable material like gravel or porous asphalt/concrete should be used. Others porous materials include grassed pavers (allow grass to grow on open cell of concrete), and wide joint paving blocks instead of continuous asphalt sheet.
- Cool asphalt with plants and reflective surfaces; to reduce heat increase from paving, plant shade trees along and also increase the reflectivity of pavement by mixing asphalt with light coloured stones that will make paving less heat absorptive.
- Street width limit; Oversized roads also have negative effects on traffic safety and quality of life of the local community. Research shows that real cause of most accidents is speed, and wide, straight, flat roadways encourage drivers to speed.
- Planted roundabout; paving the centre of roundabouts is no use to drivers and can be replaced by permeable, planted surfaces as a matter of policy.
- Storm drain inlet labeling; This will indicate where pavement runoff goes to increase community awareness and decrease public dumping of pollutants onto pavements and drains. Pavement water can also be directed into planted areas or bioswales-linear, planted drainage channels, that allow it to soak into the ground.

The other principle of minimizing urban hardscape is to replace impervious surfaces with more water absorbing materials. Vegetation is one obvious way of increasing permeability of our urban surfaces. Opportunities for increasing urban vegetation include; planting trees, greenwalls and use of ecoroofs. While tree are the most obvious part of the urban landscape, green walls and ecoroofs are less common.

Figure 2.2 Increasing urban green space by greening roads



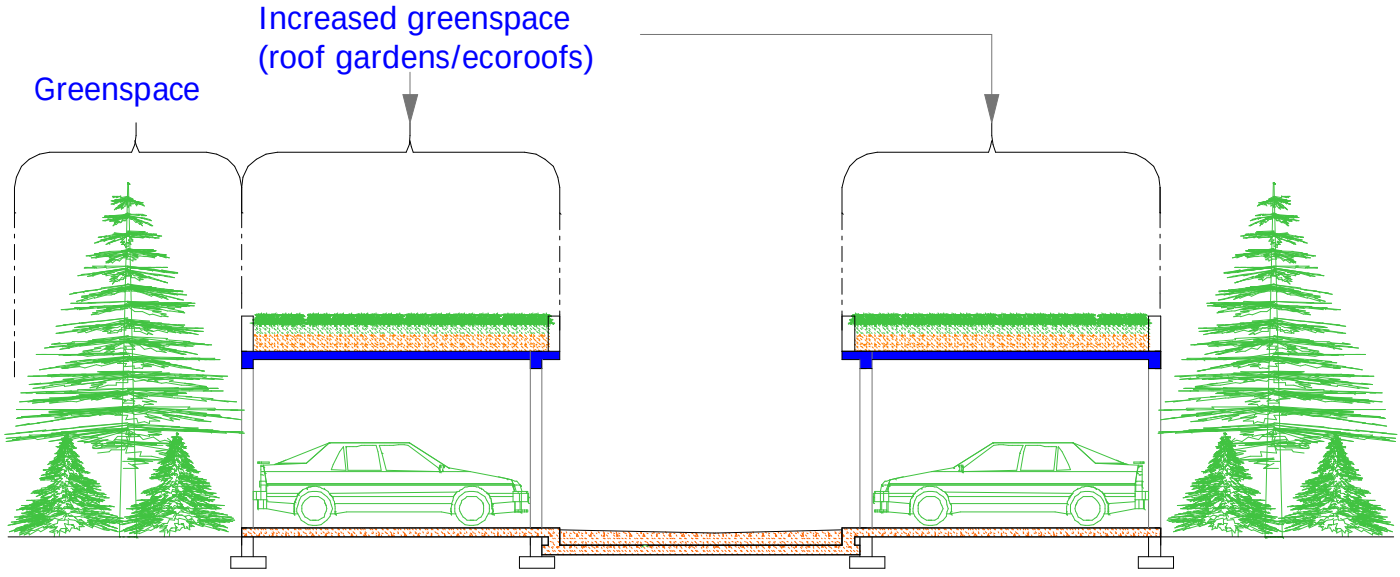
Source: Adapted from Schneekloth, 2003

Green walls offer effective alternatives to conventional landscape retaining walls. Examples include use of block wall material with gaps where plants root through the wall or interlocking circle or diamond –shaped units stacked like masonry with plants growing in between the gaps. Major advantages of green wall include: it deadens and diffuse noise, makes graffiti impossible, cuts heat and glare, holds or slows rainwater, traps air pollutants, and processes carbon dioxide, while providing food and shelter for wildlife (Schneekloth, 2003).

Ecoroofs involves covering the entire roof of a building with a continuous layer of growing medium as thin as 50milimeters (2 inches) that supports low maintenance vegetation. They are alternatives to conventional roof gardens that address the issues of low maintenance, hardiness and lightweight. On the other hand, conventional roofs are impervious to water, and exposed to high winds, they cause severe micro climate by absorbing or reflecting heat.

Ecoroofs do not require flat roofs like conventional roof gardens but may be installed on roofs with slopes up to 30 degrees pitch (Schneekloth, 2003).

Figure 2.3 Increased green space through roof gardens and ecoroof



Source: Author, 2013

The environmental benefits of eco roofs are considerable: they improve building's thermal insulation, reduce the urban "heat island" effect by absorbing less heat, produces oxygen, absorbs and stores carbon dioxide, filters air pollution, provide wildlife habitat especially for birds, and absorbs upto 75% of rain falling on it, thus slowing storm water runoff. Ecoroof feature the following layers: a water proof membrane, a layer of insulation, a drainage layer and the growing medium or "substrate". Because of the poor and thin growing medium, the microenvironment requires plants that do well in thin, nutrient-poor substrate such as xerophytic plants.

2.2.7 A healthy food system

A sustainable community includes food stores and restaurants, along with the provision of community garden space in neighborhoods. Some studies have suggested that as much fuel is used in a year to get a family's food to the table as is used by that family for all their other activities put together. Furthermore, the visibility and celebration of food in a neighborhood is an excellent source of social and cultural vitality—an important aspect of sustainability that should not be overlooked. Dense developments support local food stores and restaurants, community gardens, and other creative food-producing ventures, thereby offering residents convenient access to basic provisions. As noted earlier, compact, sprawl-reducing density can also support regional preservation of key, nearby agricultural areas.

2.2.8 Community facilities and programs

A sustainable community should provide key community facilities to support a healthy lifestyle, and the creation of diverse and positive social experiences for people of all ages. This includes a high-quality public realm that is designed to promote safety and encourage residents to meet each other and build relationships (Toderian, 2008)

Denser development leads to a much stronger business case for both public (e.g., community centers, parks) and private (e.g., supermarkets, coffee shops) amenities and programs. It also fosters a public realm that is able to generate high-quality activities that encourage the interaction of neighborhood residents.

2.2.9 Economic development

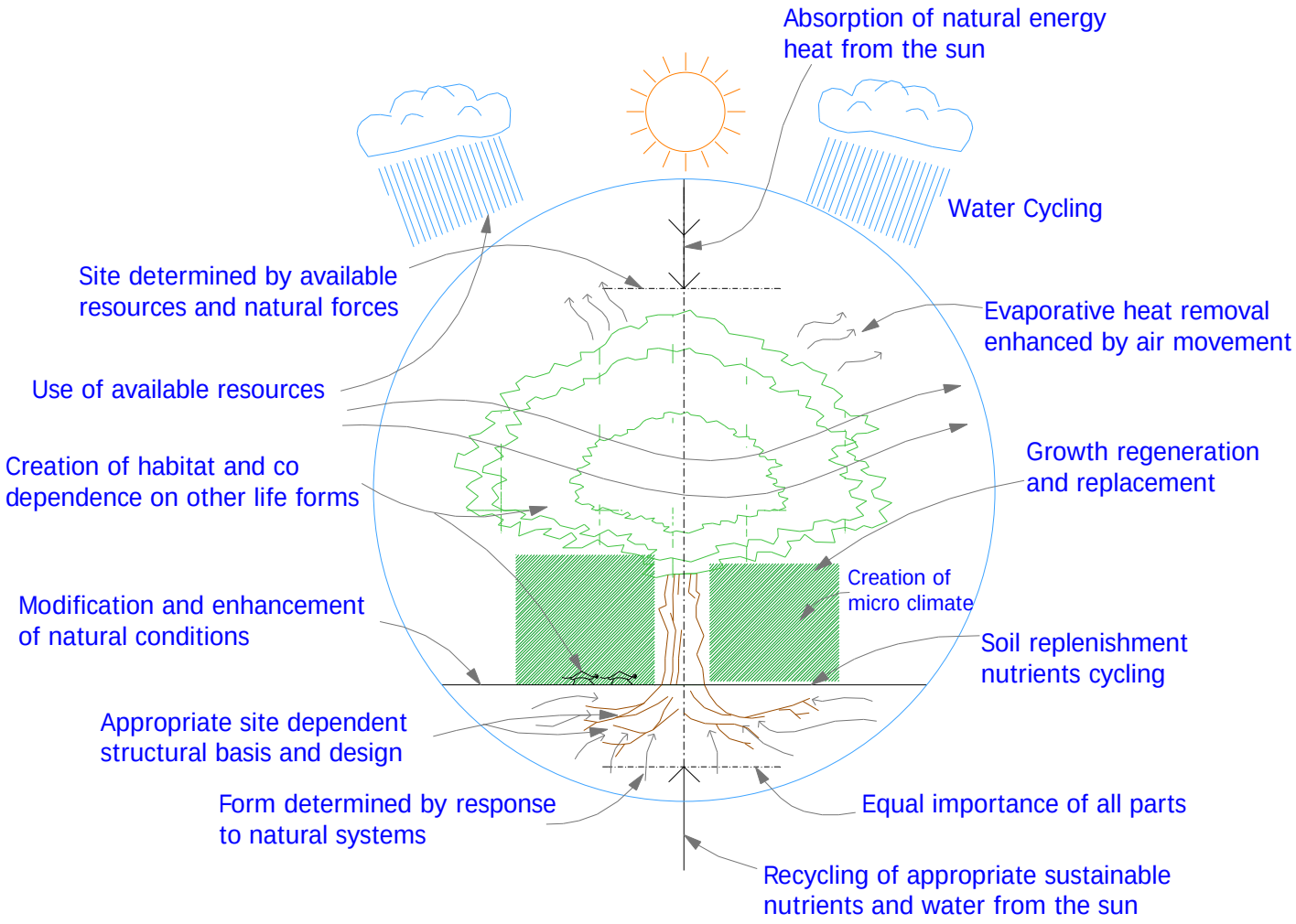
A sustainable community should offer many ecologically responsible opportunities for investment, businesses, and employment that will, in turn, support an economically diverse and prosperous community. A range of commercial (office and retail) facilities should be offered to maximize working and shopping opportunities. Well-designed density is vital to a strong economic foundation in any neighborhood as it brings a critical mass of local employees and customers to support a variety of community needs (Toderian, 2008)

2.3 Sustainable Designs

According to Watson & Labs (2003) sustainable design recognizes that human civilization is an integral part of the natural resources upon which all biological life of the planet depends. This places monumental understanding at the core of design of urban places and cities. Sustainable design should be inspired by and learn from the lessons of nature. A natural organism utilizes sunlight and rainwater as sustenance, has mechanisms to endure scarcity, produces nothing that is wasted and co evolves with its surrounding to reproduce life (Watson & Labs 2003). In other words;

- The natural organism makes use of immediately and locally available materials to construct itself and does so with economy and efficiency. The same strategy should be utilized in development to minimize global and local impacts on resources,
- The natural organism adapts to its environment through instinctive reaction and evolutionary process of generations. Through the ability to rationalize and mechanize, humans have the ability to adapt psychologically and physically in a matter of hours but often with little natural instincts or understanding of feedback and interrelationships with environment.
- The natural organisms maintain a sustaining relationship with its environment by a balance between its needs and available resources. Similarly sustainable designs adjusts demands, lifestyles and technologies to evolve a compatible balance with the natural and cultural systems within its environment.

Figure 2.4 Sustainable designs and natural organism



Source: Adapted from Watson & Labs, 2003

2.3.1 Sustainable tall building

The definition of the sustainable tall building should encompass architectural, engineering and planning issues, within the context of the building's environmental performance, urban impact and global sustainability (Goncalves & Umakoshi 2010). With regard to the impacts on the built environment, the design of the tall building should be part of a master plan and urban design strategy that considers density and socio-economic dynamics. The conditions must provide appropriate infrastructure and the insertion of tall buildings should create form and height

influenced by the overall urban morphology of the site and not compromise environmental quality (Goncalves & Umakoshi 2010).

At the building scale the basic guidelines are to reduce the demand for energy and water through design, while materials should be specified for durability and flexibility, considering locally sourced materials and labour skills. Passive strategies for cooling and heating of the building internal environment should be maximized depending on the local climatic requirements, and daylight penetration should also be maximized. In addition the building should operate towards zero carbon dioxide emission when considering heating, cooling, lighting and other mechanical and electrical systems.

Based on the principles of environmental designs and energy efficiency Goncalves & Umakoshi (2010) gave a proposal for environmental assessment of tall buildings structured in two parts: qualitative overview and quantitative analytical approach.

Table 2.6 Environmental assessment of tall buildings

Environmental assessment of tall buildings	
1. Urban context:	*Urban form and skyline:* to be part of a cluster of tall buildings, existing or planned. *Infrastructure and mobility:* to be supported by an efficient public transport system so that tall building does not impose any negative impact on urban mobility. In addition the use of automobiles should be inhibited by reducing the number of parking spaces in the development and promoting more sustainable means of transportation including bicycles and trips by foot. Besides transportation systems, the necessary support of other infrastructure utilities to respond to the demands of tall buildings, including provision of energy, water, communication systems and collection of wastes and sewerage should be in place prior to the development of the tall building.
	Building function versus local socio-economic structure: The basic functions and socio-economic activities brought by the tall buildings should be appropriate to vocation of the local context, possibly adding economic value and incrementing the social-economic dynamics of the place.
2. Ground conditions and	*Solar access and daylight availability to neighbouring buildings and open spaces:*Objective is to avoid the negative impact of the tall buildings on solar

environmental impacts	access and daylight availability to the neighbouring buildings. Solar access is critical issue for residential buildings, as is daylight availability for offices and buildings of other uses. In general the most relevant impacts of tall buildings on urban micro climate are extensive shadow casting, creation of wind turbulence, and reduction of skyview factor. Assessment of the impact of the tall building on the sky view factors from strategic points in the surrounding buildings such as windows from residential buildings and green and seating areas in public spaces should be done *Pollution dispersal:* the effects of the tall building on the air flow around buildings can have substantial contribution to pollution dispersion. *Quality of public space and pedestrian comfort:* Objective is to contribute to socio-economic vitality at street level and to the communication between public spaces, avoiding an oppressive impact on the pedestrian domain (due to difference in scale) and avoiding pedestrian discomfort through undesirable turbulence and overshadowing effects.
3. Well being	*Thermal comfort:* The objective is to achieve recommended levels of thermal comfort. A number architectural features and environmental strategies which can improve thermal comfort include form and orientation, solar protection in the design of facades to avoid direct solar radiation, creation of buffer zones between inside and outside environment with the design of atriums, double skins facades and other kinds of semi-open spaces. *Daylight and visual comfort:* the objective is to achieve recommended levels and good uniformity of daylight in working spaces. Architectural features and environmental strategies include form and orientation, depth of floor plate, floor to ceiling height, atriums, disposition of windows, shading devices, light shelves, special glass technology to control glare or innovative technical systems to incorporate daylight and control glare such as light pipes.
	Views, social interaction and privacy: Objective is to promote the social integration of the occupants and visual communication between inside and outside environment as well as among internal spaces. Architectural features include: spaces for communal use including leisure or cultural activities, atriums and gardens. The design of the layout and internal partitions whether open plan or cellular combined with depth of the floor plate and floor to ceiling height will also have an impact on views towards the outside.

		Acoustic comfort: Aiming at comfortable levels of noise. Architectural features include layout, design of internal partitions and finishing materials, density figures.
4.	**Energy and environment**	*Architectural features:* The objective is reduction of a building's energy consumption in comparison to local standards through architectural design. Architectural features and environmental strategies include form and orientation, façade technology, materials, depth of the floor plate, presence of gardens, atriums, balconies and other types of buffer zone, internal space sectorization and any other architectural particularity. *Adaptability to future changes:* The success of the environmental performance of the building in the near future will most likely depend on the adaptability of the design to accommodate changes of use, technology, environmental legislation, economic values and even climate change.
5.	**Environmental identity**	*Architectural expression:* Te objective is to achieve synthesis between architecture, environment and technology in order to achieve good environmental performance and identity. Architectural features and environmental strategies include: building form, design of the facades, organization of internal spaces and integration with technical systems. It is expected that the architectural concept will be informed by the principles of environmental design and the detailed design will be in accordance with the results of technical environmental assessments, carried out throughout the design process.

Source: Based on Goncalves & Umakoshi 2010

In multi –tenant tall buildings, it can be argued that the direct economic benefits of better environmental-performance buildings do not go to the initial investors and, for this reason, investment in more environmentally responsive buildings is not considered economically attractive. However the energy savings and the improved environmental quality can be attractive to tenants, with benefits such as marketability and securing/ future proofing investments to the investor (Goncalves & Umakoshi 2010). This therefore calls for change in attitude since there are economic advantages arising from improved productivity of satisfied occupants and reduction in overall costs of the environmental impacts of building operation.

2.3.2 Bioclimatic design at the site planning scale

Favourable microclimatic conditions can be created in and around buildings and outdoors spaces to dramatically increase comfort and reduce energy requirements (Watson & Labs, 2003). During cool winter periods the objectives are to protect outdoors spaces, entryways and structures from winter wind and to promote gain of solar heat. In summer (or overheated periods) the objectives are the reverse, to resist solar gain by shading and to promote cooling by ventilation (Watson & Labs, 2003). Several bioclimatic techniques at the site planning stage include:

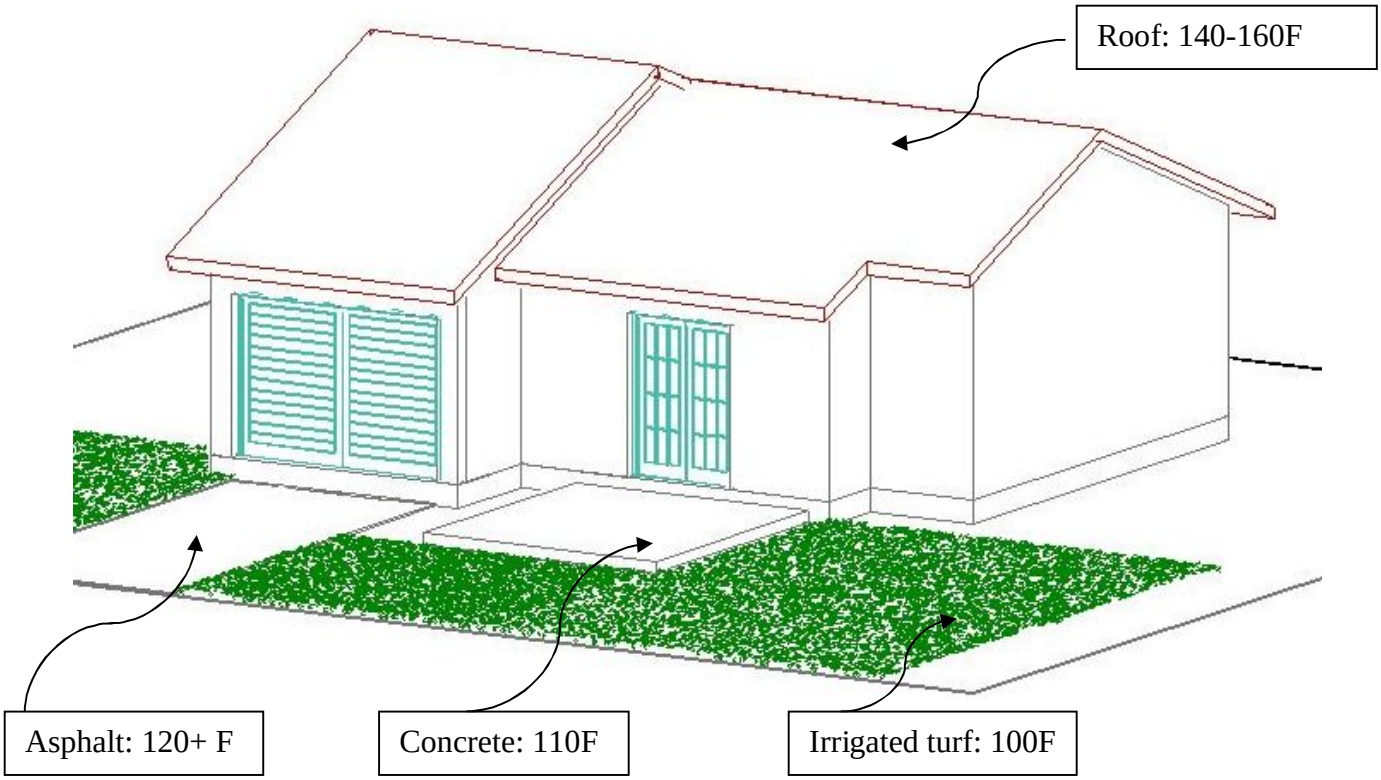
- Wind breaks during cooler periods using landforms, structures or vegetation,
- Sun shading during summer periods using landforms, structures, vegetation, or other sun shading elements
- Natural ventilation: this is a simple concept by which to cool outdoor spaces and buildings. Neighbouring landforms, structures or vegetation can be used to increase exposure to cool breeze during summer.
- Plants and water: several landscaping techniques provide cooling by the use of plants and water near building surfaces and outdoor spaces for shading and evaporative cooling. These include use of ground cover and planting for site cooling and maximizing on site evaporative cooling.

2.3.3 Use of ground cover and planting for site cooling

Neighbourhood air temperature can be kept low by minimizing the expanse of paving and by shading paved areas. Porous paving blocks should also be used instead of the asphalt. Porous concrete paving can be precast or cast on site. The difference in surface temperature between grass and asphalt can easily exceed 25 degrees (F). The relationship of lawn and other living ground cover surfaces to non-evaporating surfaces (driveways, streets, roofs etc) will in part determine neighbourhood air temperatures according to Watson & Labs (2003). Vegetation should be maximized and where possible man made surfaces such as streets and roofs should be shaded by trees.

Non-living surfaces are much hotter than grass since they don't dissipate heat through evaporation. A black roof is hotter than an asphalt driveway because the ground underneath the paving stores heat.

Figure 2.5 Surface temperatures on different surfaces

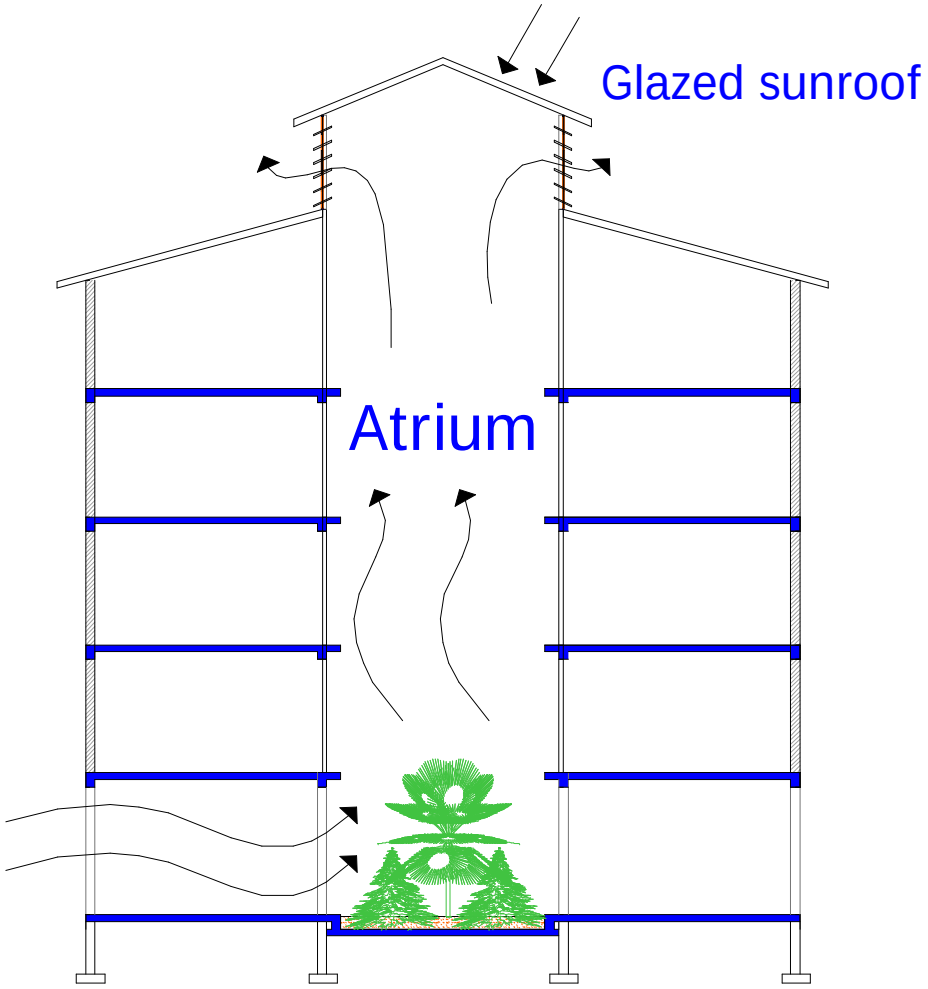


Source: Adapted from Watson & Labs, 2003.

2.3.4 Use of atrium or courtyard to provide onsite evaporative cooling mechanism

Since cool air is denser than warm air, the atrium creates a tank of air usually with a fountain at the bottom. This cool atrium provides a cool ventilation air supply. At the same time, the heat trapping effect of glazed sun roof at the top propels upward flow of warm air, drawing the cool air through the house.

Figure 2.6 Atrium



Source: Adapted from Watson & Labs 2003

2.3.5 Site design

Site designs for sustainable development require low impact planning, construction and property maintenance with strategies that do not alter or impair but instead help repair and restore existing site systems (Watson & Labs 2003). The following are general considerations that should apply to sustainable site design:

- Preserve and enhance the native landscape and its resources,

- Plan landscape development according to the unique features of the surrounding context rather than by overlaying standardized patterns and solutions,
- Understand the site as an integrated ecosystem with changes occurring overtime in dynamic balance, the impacts of development must be confined within these natural changes,
- Allow simplicity of function to prevail while respecting basic human needs of comfort and safety,
- Assess feasibility of development in long-term social and environmental costs, not just short term construction costs,
- Analyze and model water and nutrient cycles prior to development interventions,
- Minimize areas of vegetation disturbance, earth grading and water channel alteration,
- Locate structures to take maximum advantage of passive energy design and technologies to provide for human comfort,
- Provide space for processing wall wastes created on site (collection/ recycling facilities, digesters and lagoons) so that reusable/ recyclable resources will not be lost and hazardous or destructive wastes will not be released into the environment,
- Determine environmentally safe means of onsite energy production and storage in the early stages of site planning,
- Phase developments to allow for monitoring of cumulative environmental impacts of development,
- Allow the natural ecosystem to be self maintaining to the greatest extent possible.

The following factors should be considered in the site selection for high density residential development:

Carrying capacity: The site analysis should determine this capacity based on the sensitivity of site resources,

Density: Sitting of facilities should be weigh the merits of concentration versus dispersal. While natural landscape values may be easier to maintain if the facilities are carefully dispersed, concentration of structure leaves more undisturbed natural areas. This is also true on plot size level.

Slopes: Building on slopes considered too steep can lead to soil erosion, loss of hillside vegetation and damage to fragile wetland and marine ecosystems. Appropriate site selection should generally locate more intensive development on gentle slopes, dispersed developments on moderate slopes and no development on steep slopes.

Vegetation: Retain as much existing native vegetation as possible to ensure the integrity of the site. Natural vegetation is often an essential aspect of the visitors experience and should be preserved.

Site selection: should maintain large habitat areas and avoid habitat fragmentation and canopy loss. In some areas such as the tropics, most nutrients are held in the forest canopy, not in the soils. Loss of canopy therefore causes nutrients loss as well. Plants live in natural associations (plants communities) and should remain as established naturally.

Views: views are critical and reinforce a visitor's experience. Site location should maximize views of natural features and minimize views of visitors and support facilities.

Natural hazards: Sustainable development should be located with consideration of natural hazards such as precipitous topography, dangerous animals and plants, and hazardous water area. Site layout should allow controlled access to these features.

Access to natural and cultural features: Good site design practices can maximize pedestrian access to the wide variety of onsite and offsite resources and recreational activities. Low impact development is key to protecting vital resource areas,

Energy and utilities: Siting should consider possible connection to offsite utilities or more likely spatial needs for onsite utilities. The potential exists for alternative energy use in many places particularly solar and wind based energy systems.

Road design and construction: Unpaved surfaces are appropriate in areas of stable soils, lowers slopes and low traffic loads, but they require more maintenance. Permeable paved surfaces allow limited percolation of precipitation while providing better wear than unpaved surfaces. Permeable parking surfaces provide a means of recharging the local aquifer rather than creating accelerated storm runoff. Impermeable paved surfaces are needed for roads with the highest load and traffic requirements. Wherever possible recycled materials should be used in the construction of the road surface eg. crushed glass, shredded rubber tyres or recycled aggregate.

Figure 2.7 Permeable paved surfaces

Source: Adapted from Schneekloth, 2003

2.3.6 Site utilities

Utility systems need to be identified that do not adversely affect the environment. Impacts such as soil disturbance and intrusion on the visual setting need to be avoided. When utility lines are necessary they should be buried near other corridor areas that are already disturbed eg roads and pedestrian paths.

2.3.6.1 Storm drainage

In undisturbed landscape storm drainage is typically handled by vegetation canopy, ground cover plants, soil absorption, streams and water ways. In modified landscapes consideration must be given to the impacts of storm drainage on the existing natural system of drainage and the resulting structures and systems that will be necessary to handle the new drainage pattern. The main principles in storm drainage control are to regulate run off, to provide protection from soil erosion and to avoid directing water into unmanageable volumes. Removal of natural vegetation, topsoil and natural channels that provide natural drainage control should be avoided. An alternative should be to stabilize soils, capture runoff in depressions -which usually have plants that help store and clean water and help recharge local ground water supply- and revegetate areas to replicate natural drainage systems.

2.3.6.2 Water supply

Water is a nourisher of plants and animal life, a bearer of food, a prime element of industrial processes and a medium of transportation (Watson et al 2003). It is also an essential element of recreation, aesthetics and spiritual life. To ensure global, regional and local water resources can meet the demands of the future, all infrastructure, urban development and buildings require design for water conservation, collection, storage, treatment and re-use.

2.3.6.3 Garbage and solid waste prevention

An effective garbage prevention strategy requires that everything brought into a facility is recycled for reuse or recycled back into the environment through biodegradation (Watson et al 2003). Two basic sources of solid waste include materials purchased and used by the facility and those brought into the facility by visitors. Waste prevention strategies applicable include:

i) *Use products that minimize waste and are non toxic*
   Consideration should be given to materials or products that minimize waste disposal needs- e.g. purchasing materials with minimal packaging, buying in bulk, and replacing disposable products with durable reusable items. Use of plastics for packaging should be discouraged. When selecting materials and goods nothing should be purchasing that will ultimately become toxic and these should be substituted with non-toxic materials. Materials should be purchased locally wherever possible. Locally produced goods need less transport and less storage and have less packaging waste.

ii) *Recovery of nutrients from waste streams by composting, anaerobically digest biodegradable wastes or constructed wastelands and solar assisted aquaculture*
   Between 60-75% of the solid waste is bio-covertible (Watson & Labs, 2003). This can be done through several methods: Composting, is where large chunks of relatively inert material like wood chips are added to organic waste and aeration done to make the process work. On the other hand anaerobic digestion is a process where food waste, animal wastes and so on go through a fermentation process to produce a variety of useful by-products such as biogas and high quality organic solid and liquid fertilizer

iii) *Reuse material onsite or collect suitable materials for offsite recycling*
   This can be maximized through the purchase of products for which there is ready market as recycled materials. For example, glass beverage containers can be ground up and used

road and building construction. Efficient recycling requires sorting of materials and convenient bins should be provided at the facility for the materials being recycled, so that remaining residual waste is collected separately and disposed offsite.

Table 2.7 Sustainable design guidelines

Sustainable design guidelines
Spatial analysis
1. Systematically record the natural resources of site and region,
2. Allocate landuse according to productive potential and human social needs,
3. Understand the bio climatic design strategies for promoting winter heat gain and reducing summer overheating,
4. Use local resources to increase self reliance,
5. Explore natural processes as the genesis of material used and application of recylcled & new materials to constructions,
6. Value natural systems and processes.
Energy production and conversion
7. Use efficient equipment and appliances to reduce energy demand
8. Match energy quality to end use needs,
9. Promote day lighting in building design,
10. Consider biomass combustion,
11. Use annual cycle solar-thermal storage to balance seasonal excesses of heat and cold,
12. Generate electricity photovoltaically,
13. Install appropriate energy storage to buffer intermittent production of energy,
14. Harness wind/hydro/Geothermal sources of power to balance winter slump in solar resource,
15. Provide grid connection to regional electric utility storage,
16. Use metabolic energy to reduce capital energy intensity.
Water supply
17. Reduce water consumption by installing efficient fixtures and outlets,
18. Reduce water consumption by matching water quality to end use,
19. Collect rainwater for potable and process needs,
20. Collect surface runoff for process needs.

Sustainable design guidelines
Nutrient/ Waste recycling
21. Collect gray water separately from black water,
22. Use alga cultures/aquatic plants to remove nutrients, pollutants and pathogens,
23. Compost organic materials,
24. Consider anaerobic digestion of organic materials.
Food production
25. Match food production with human nutritional requirements,
26. Couple intensive food production to medium density residential development to complete a nutrient/ waste cycle,
27. Adopt organic and biodynamic farming techniques,
28. Maintain perennial polycultures for fruits and grain crops,
29. Use aquatic techniques for fish and algae production,
30. Exploit the synergistic potential of a systematic approach to food production,
31. Use "bioshelters" to modify climate for increased production,
32. Provide food storage from one season to the next for seasonal produce.
Materials
33. Value the energy invested in the production of materials,
34. Design for long life and easy eventual recycling of material constituents,
35. Maintain recycling centres for the accumulation and marketing source separated goods,
36. Value shape over mass in achieving strength and stability.
Shelter design
37. Locate building on sloping non-prime agricultural land,
38. Construct low rise dwelling units in attached clusters or rows,
39. Orient buildings and primary solar collectors for solar access.
40. Design structures for long life and adaptability,
41. Employ super insulated building techniques to reduce heat gains and losses,
42. Landscape for microclimatic amelioration.

Source: Based on Bruce Coldham, 2003

2.4 The Factors That Affect Densification and Their Implications

Draft Technical Report on Cape Town Densification Strategy (2009) highlights the following as major factors constraining and enabling densification and impacting on the form of densification (location, design and quality); policy, legislation and regulations, economic and market forces, social and lifestyle considerations, form and nature of the built environment, and technological issues.

Table 2.8 Factors affecting densification and their implications

Factors affecting Densification and their implications	
• Policy, legislation and regulations	*Land Use ,Zoning (density controls) and related policy* s These controls restrict land use, prescribe minimum plot sizes, building heights, plot ratio, coverage, setbacks, boundary lines and parking standards, and impacts significantly on the design and extent of buildings and related spaces. s Such controls form part of a zoning scheme, or are policy directives, endorsed by Council. s Existing zoning schemes and related regulations have had a direct and fundamental influence on densification and built form.
• Economic and market forces	s Market forces normally drive demand towards the middle/ high income, well serviced low density areas. This leads to land use invasion. s Reasons are security, good infrastructure, savings on maintenance, convenience, and profit maximization. s Market forces are a factor that can be positively used by the authority through various planning, regulations and incentive means to develop well-designed, qualitative and appropriately developed higher densities. This will be most likely in the middle to higher income section of the property market.
• Social and lifestyle considerations	s A lack of acceptance and social considerations affect the development of higher densities. These includes the following: § view of high-rise as unattractive buildings; § loss of identity or perceived built character of a home; § loss of privacy from overlooking buildings and windows; § overcrowding, noise and traffic congestion; § an accumulative impact on infrastructural service capacity; § depreciation of property values; and § loss of public open space. § the more complicated and costly management arrangement associated with shared block, co-operative and sectional title ownership.

• Form and nature of the built environment	s *Roads structure and layout:* Mobility oriented environments dominated by freeways and major arterials that segregate activities and focus on road based vehicle movement with very little access act as barriers to densification s *Surrounding land uses and environment:* Large mono-functional land uses do not encourage higher densities. Areas lacking integrated commercial and high order urban functions reduce the possibility of densification. Investment in higher-density development is also affected by a declining public environment, criminal activity, poor surveillance and insufficient parking. Certain mixed development areas that are perceived to be very noisy, unattractive and unsafe are also a deterrent.
	s *Infrastructure capacities:* Limited infrastructure capacity is a vital factor for the accommodation of higher-density development in the existing (older) areas of the City. The demand for increased infrastructural capacity with respect to densification patterns/trends requires strict coordination and planning for infrastructural upgrading and provision. Market forces often determine the provision of infrastructural services to locations of new housing and commercial developments (new growth areas). Older areas however also require infrastructural upgrading and expansion since these areas are often better suited to densification for reasons of location, diversity, mixed uses and access to public transport. s *Urban conservation:* There is a tendency for densification to be made difficult in heritage/ conservation areas due to public resistance, or objections, through the development application process.
• Technological issues	s *Road based private transport:* Increase in private car ownership and usage has enabled low density spread of the city. Accommodating the parking of private vehicles has also become an issue with the consumption of valuable urban space, especially at places of work and on residential properties. A sustainability crisis concerning city functioning and efficiency is emerging with continuous traffic congestion, insufficient parking, vehicle pollution, expensive road maintenance, rising fuel costs and a declining and unfeasible public transport system.

Source: Based on Cape Town Densification Strategy Technical Report

2.5 Theories of Urban Land use Structure

There are several models that have been developed to explain the urban land use pattern. We shall look at some classical as well as some contemporary models.

2.5.1 Classical models:

Some of the classical models reviewed here below include Concentric Growth Model, The Sector Model, and Multiple Nuclei Model

a) Concentric Growth Model

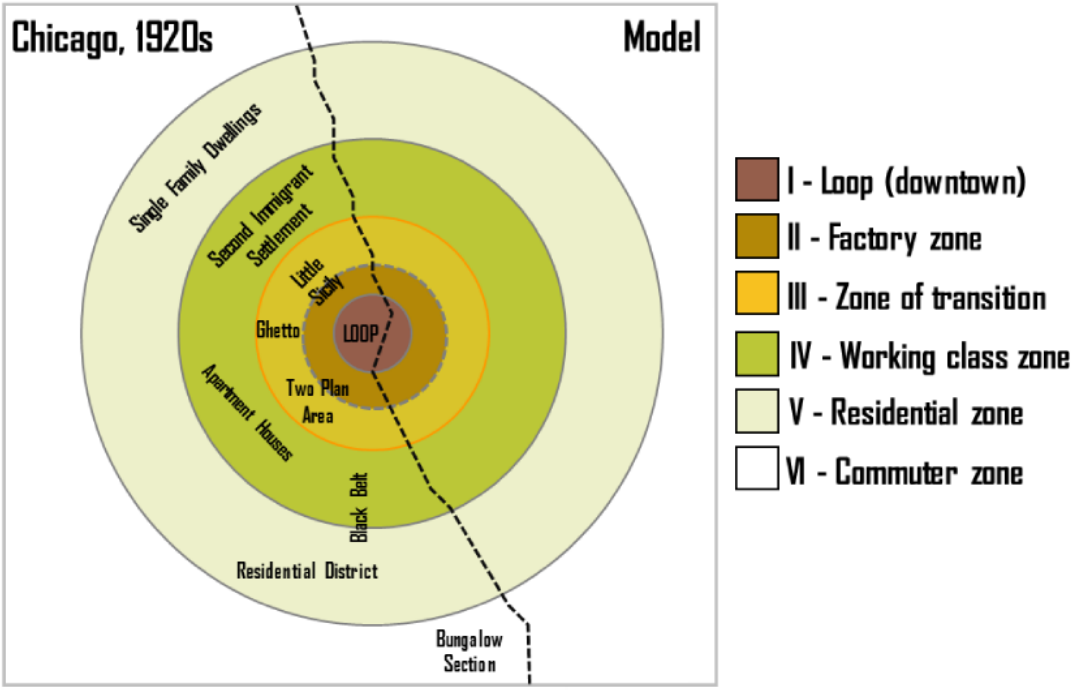
This was developed by Burgess in 1924 where he used the concept of plant ecology as had been presented by the University of Chicago and applied ecological terms such as Invasion, Competition, Dominance and Succession to groups of people (Gathuri, 2007).

According to this theory:

i) City grows outward in concentric rings
ii) City has a single centre, otherwise known as the CBD (Central Business District)
iii) Around the business centre is an area of older industry and beyond that are residential areas
iv) It is assumed that the poor cannot afford to commute long distances, and also that they must live in the older and cheaper houses near the centre, so low class residential are near the CBD
v) The wealthy live in a commuter zone outside the city proper
vi) Best describes the pre-automobile (pre 1920) pattern of North American cities but is still useful today in describing patterns in the older parts of our towns.

The urban area according to the theory is divided into concentric zones.

Figure 2.8 Concentric growth model



Source: Adapted from Burgess, 1925

- **Zone I**: Central Business District (called the "loop" in Chicago) where most of the tertiary employment is located and where the urban transport infrastructure is converging, making this zone the most accessible.
- **Zone II**: Immediately adjacent to the CBD a zone where many industrial activities locate to take advantage of nearby labor and markets. Further, most transport terminals, namely port sites and railyards, are located adjacent to the central area.
- **Zone III**: This zone is gradually been reconverted to other uses by expanding manufacturing / industrial activities. It contains the poorest segment of the urban population, notably first generation immigrants living, in the lowest housing conditions.
- **Zone IV**: Residential zone dominated by the working class and those who were able to move away from the previous zone (often second generation immigrants). This zone has the advantage of being located near the major zones of employment (I and II) and thus represents a low cost location for the working class.
- **Zone V**: Represents higher quality housing linked with longer commuting costs.
- **Zone VI**: Mainly high class and expensive housing in a rural, suburbanized, setting. The commuting costs are the highest. Prior to mass diffusion of the automobile (1930s), most of these settlements were located next to rail stations.

There are several criticisms of this theory. The model is too simple and limited in historical and cultural applications since it was developed for American cities and has limited applicability elsewhere. The model was also developed when American cities were growing very fast in demographic terms and when motorized transportation was still uncommon as most people used public transit. The concentric rings are also not always clear and sometimes there are no functional differences in land use patterns from one ring to another. One zone can have more than one land use. The concentric model further assumed a spatial separation of place of work and place of residence, which is not always true.

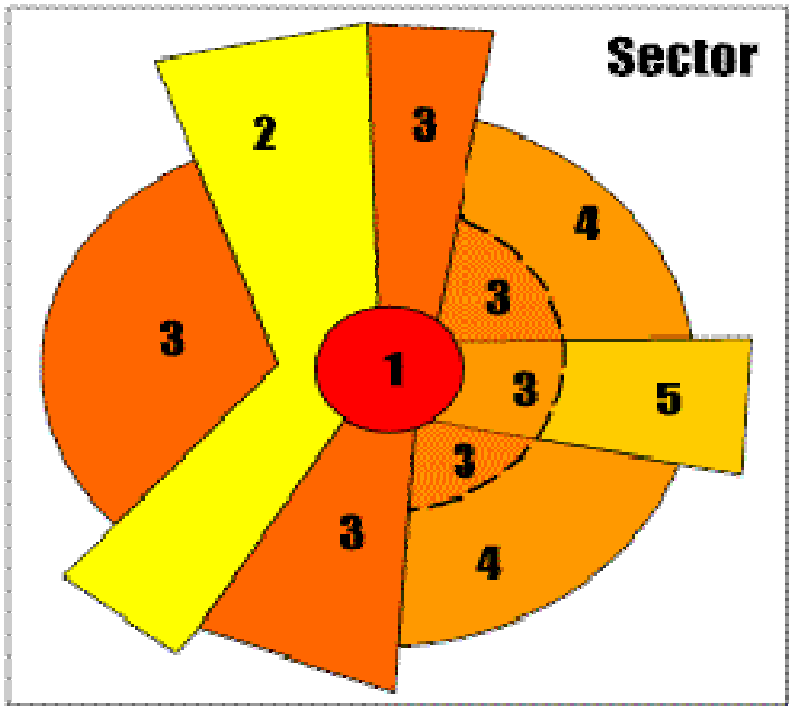
b) Sector theory

The model (also known as the Hoyt model or sector model), developed in 1939, took into account the effect of transportation and communication on a city's growth. His thoughts were that rents could remain relatively consistent in certain "slices" of the model, from the downtown center all the way to

the suburban fringe, giving the model a pie-like look. It has been found that this model works especially well in British cities. Communication axes are mainly responsible for the creation of sectors, thus transport has directional effect on land uses. From the sector representation the Burgess transitional process is still part of land use changes, but there exist axes along which urban activities are oriented.

Sector theory recognizes the existence of land use zones, but suggests that there are sectors or wedges of land uses in the city due to the emergence of star-shaped transportation routes, such as bus lines and streetcar lines. As such, the industrial facilities would lie in a sector along the rail lines coming into the city centre and poorer people live adjacent to industrial area near their jobs. The rich who can afford private cars or public transport live on the opposite side of town far from the industry and poor, while the middle income live in between the high and low income.

Figure 2.9 Sector model



Source: Adapted from Chapin, 1965

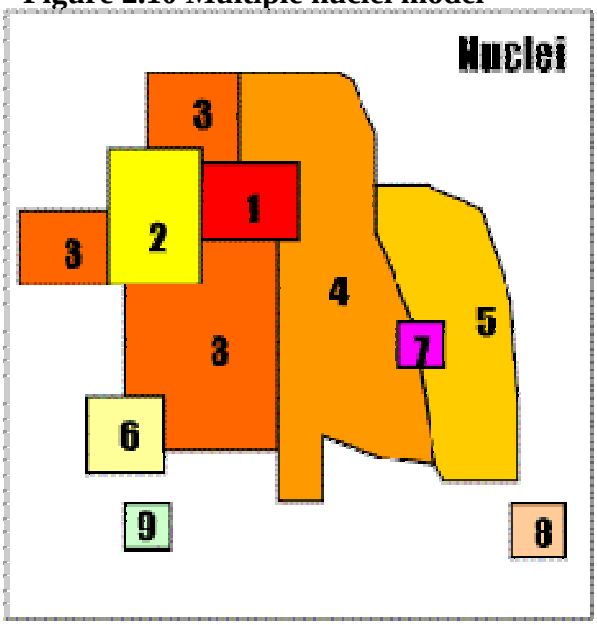
Hoyt suggested that areas of highest rent tended to be along the main communication lines. The wealthy who could afford the highest rent choose the best sites and competition was based on the ability to pay (Gathuri, 2007). Once an area had developed a distinctive land use it tended to retain that land use and the growth of that city sector extended outwards.

This growth model however does not explain land use succession for example middle income housing invading high income residential neighbourhood like the case in the study area.

c) The Multiple Nuclei Model

Multiple Nuclei Model was advanced by Chauncy Harris and Edward Ullman in 1945. The model combined the concentric and sector theories, refined the two, and incorporated outlying shopping malls, industrial areas and large residential suburbs.CBD no longer has a monopoly on retail and commercial activities since outlying malls and industrial parks compete with it. Industries also move to the edge of the city where land is cheaper.

Figure 2.10 Multiple nuclei model



LEGEND

1. CBD
2. WHOLESALE AND LIGHT MANUFACTURING
3. LOW-CLASS RESIDENTIAL
4. MIDDLE-CLASS RESIDENTIAL
5. HIGH-CLASS RESIDENTIAL
6. HEAVY MANUFACTURING
7. OUTLYING BUSINESS DISTRICT
8. RESIDENTIAL SUBURB
9. INDUSTRIAL SUBURB

Source: Adapted from Chapin 1965

The theory postulate that large cities develop by peripheral spread not from one central business district. There are several nodes of growth, each of specialized use. The separately expanding use districts eventually coalesce at their margins. The land use pattern of the city is therefore built around several nuclei or nodes and not one single centre.

Light manufacturing and wholesaling are located along transport outer edge of city, Heavy industries are surrounded by lower income. The theory is founded on four basic factors:

i) Interdependence of certain types of activities and their need for close physical proximity
ii) Natural clustering tendency among certain types of activities that find mutually profitable to locate together,
iii) The appearance of centers to accommodate activities that may have no particular affinity for one another, but are inimical to other uses by virtue of the traffic they generate,
iv) Related factor of high rents or high land costs for the most optimum sites which have the effect of attracting or repelling users in the process of nucleation. Some activities are thus forced to move to the periphery of the city where land is cheaper.

This model has several advantages: location of each nuclei reflects its economic needs e.g Heavy industry locates close to the port or transport artery; the different centres attract growth and encourage further development; and all nuclei grow until they merge and form one large urban area. The model recognizes many of the realities of contemporary metropolitan land use pattern and is most applicable to new and fast growing cities like Nairobi.

Criticism

- The concept may not be totally applicable to oriental cities with different cultural, economic and political backgrounds
- There is negligence of impact of height of buildings,
- Abrupt division between zones is sometimes non-existent,
- There is no consideration of influence of physical relief and government policy.

The Multiple Nuclei Model like the other two growth models still does not explain land use succession and rapid densification growth pattern like what is happening in the case in the study area.

d) Bid Rent Theory

The bid rent theory is primarily attributed to Alonso (1964) and Muth (1969) and explains relationships between distance from the city centre and house prices (Trusell, 2010). The theory states that rents are bid upwards close to the city centre as households attempt to minimize transportation costs. Transportation costs in this case refer to direct costs (bus fares and fuel costs) and the opportunity costs of commuting (lost working time, or leisure time). Residents living close to the city centre have to travel less to get to work or entertainment centres and this

decreases disutility. Conversely rents are lower away from the city centre because transportation costs for the residents there are high. Thus through competition to minimize transportation costs, rent becomes a negative function of distance from the city centre. (Trusell, 2010).

The main assumptions of the Alonso's bid rent model are:

1. Cities exist on a featureless plain without rivers, hills or other obstacles that might affect commuter prices;
2. Transportation costs are a linear function of distance from the city centre that is the marginal decrease in rent per unit of distance from the city centre corresponds with a one on one increase in transportation costs;
3. Assumes that the CBD contains the vast majority of employment and all other employment is distributed evenly throughout the metropolitan area.

The main assumption is that in a free market the highest bidder is likely to be the one who can obtain the maximum profit from that site and so can pay the highest rent (Gathuri, 2007). Competition for land is therefore keener at the centre of the city. Land users, whether retail, office, or residential, all compete for the most accessible land within the CBD. The amount they are willing to pay is called bid rent. This can generally be shown in a "bid rent curve", based on the reasoning that the most accessible land, generally in the centre, is the most expensive land. Commerce is willing to pay the greatest rent in order to be located in the inner core. The inner core is very valuable for these users because it is traditionally the most accessible location for a large population. As a result, they are willing and able to pay a very high land rent value. They maximize the potential of their site by building many stories. As one travels farther from the inner core, the amount that commerce is willing to pay declines rapidly.

Industry, however, is willing to pay to be in the outer core. There is more land available for factories, but it still has many of the benefits of the inner core, such as a marketplace and good transportation linkages. As one goes farther out, the land becomes less attractive to industry because of the reducing transportation linkages and a decreasing marketplace. The inner-city areas are also very densely populated (with, e.g., terraces, flats, and high rises), while suburbs and rural areas are more sparsely populated (with semi-detached and detached houses) because land is not attractive there.

Rent in economic terms is the payment made for factors of production. Factors of production include land, labour, capital and entrepreneurship (Gathuri, 2007). Rent therefore includes

payment for factors of production that the landlord has used to construct a house recapitalized as monthly payments (Kingoriah, 1977). The high land rent payable near the inner city lead to more intensified land utilization to obtain the maximum profit in order to afford the high rent. This partly explains the recent densification trend in Kileleshwa where high land values have been pushed for higher development densities.

2.5.2 Contemporary models

Economic, cultural and political factors have interacted to create a contemporary spatial form. (Fainstein & Campbell, 2002). Economic restructuring of the last three decades has transformed the shape of cities and regions. Production and population have been decentralizing, while economic control has become increasing concentrated in multinational firms and financial institutions. The new logic of production, employment and distribution has engendered changes in landuse and social occupation, it has caused reordering of the urban hierarchy and of the economic and political link between places. (Fainstein & Campbell, 2002).

For example the displacement of the manufacturing based economy by the information based economy has been accompanied by corresponding decline in industrial and increase in service employment (Castell, 1996). These have resulted in rapid growth of financial and producer services sector within cities at the top of the urban hierarchy and flight of industries and population from others. Several theories have attempted to explain this transformation.

a) Liberal economic theory

This theory emphasizes market competition as the driving force of economic change and structure in cities. To grapple within competition that can produce at lower costs, manufacturers move their factories to location with cheap labour, replace labour with capital or shrink their wage and benefit bill. (Fainstein & Campbell, 2002).

Spatial configurations associated with mainstream economic theories:

i) Declining industrial centres; manufacturing departs to suburban areas and peripheral regions so as to take advantage of cheaper land and labour costs, less burdensome regulation, weaker or non-existent unions and government incentives.

ii) Global cities; the term “global city” refers to those cities in which control of the world financial systems rests and where business service sector sells its products to the globe. These

cities are however not protected from unemployment and neighbourhood deterioration. They contain both the rich and the poor.

iii) Expanding and contracting regions; Expanding regions are ones that because of the good business climate and governmental investment, they are benefiting from the shift of industry. Contracting regions suffer from absolute industrial structures and sociopolitical systems that business regards as inhospitable to their profit maximizing goals.(Fainstein & Campbell, 2002). In many cities redevelopment strategies have been successful in creating a revitalized core (Frieden Sagalyn 1989). Revitalized areas have experienced increased growth. In Kileleshwa for example enhancement of zoning densities has attracted unprecedented growth in the area compared to some areas of the city where conservative approach has been adopted (e.g. Karen area in Nairobi)

b) New Urbanism

New urbanism is an umbrella term for comprehensive regional strategy. It attempts to promote a unified design theory for an entire region from the small scale (building block, street) through the intermediate scale (corridor, neighbourhood, district) to the large scale (regional infrastructure and ecology) (Kelbaugh, 1997). New urbanism covers important ideas and proposals for downtown and inner city neighbourhood as well as an interest in overall regional planning. It advocates a strategy that recognizes and celebrates what is unique about a place history, cultures, climate and architectures (Kelbaugh, 1997).

c) Pedestrian Pocket or TOD (Transit Oriented Development)

This model emerged in1980s and was developed by Peter Calthorpe. It is a development model for a small walkable community that mixes low-rise, medium density housing for a variety of households types with retail, civic, recreational and employment centres along a main street-all within about a one-quarter mile radius of a central transit stop for a bus or railsystem. (Kelbaugh, 1997). This tight node may be surrounded by a secondary area or belt of more conventional single family homes separated by natural buffers but connected by pedestrian and vehicular links.

d) Traditional Neighbourhood Design (TND)

Also known as ”Neotraditionism” is a term that embraces architectural as well as town planning precepts (Kelbaugh, 1997). Neotraditionism was conceptualized by Stanford Research in 1985 and was defined as a non-ideological selection of what is considered to be the best for home environments. It is very similar to TOD but TNDs are more rigorous about architectural typology, style and detail. TND originated more with traditional notions of city, town, type and architecture but with a strong environmental record. Neotraditionism tries to incorporate pragmatically whatever works best (Burns, et al 1997). While the two models share a great deal at the scale of the town or neighbourhood, they differ in that TODs are predicted more on regional transit and open space systems, while TNDs are more rigorous about architectural typology, style and detail.

e) Compact city model

According to Marcotullio (2001) the compact city model suggests a variety of norms including urban density over decentralization, open space protection over completed built up areas, mixed land uses over exclusive zoning, vital downtowns and central business districts containing high percentage of residential uses over strictly commercial spaces and high use of public transit over individual transportation. Admirers of European cities have often advocated the compact city concept. According to Tim Beatley (2000) in his analysis of how European cities are implementing green strategies, the compact city model is a natural extension of the European city model. Historically, European cities have been fundamentally more compact, with a distinct separation between urban and rural zones. These cities are walkable, have good public transit, and are generally much less reliant on the automobile as opposed to, for example, American cities and regions. (Marcotullio, 2001)

Compact city strategies are varied and include compact growth strategies, national transportation and location policies. Compact strategies include a city structure or comprehensive plan that gives clear priority to compactness, large block or open space or green wedges come close to urban neighborhoods, strong emphasis on infill development and intensification and more efficient use of abandoned or underutilized land within the urban core and high level of mixing and integration of functions. Key to much of the compact city argument, however, are transit

oriented transportation systems that prevent usage of the automobile and restrict travel times for commuters (Marcotullio, 2001).

The compact city model and strategies have found their greatest advocates in Europe according to Marcotullio (2001). Within Europe the compact model has found its best elaboration in the northern cities of Germany Denmark and the Netherlands. The Dutch urban system, for example, boasts a modest 13 percent of land devoted to cities, despite its high population density. An important part of this ordered development is the long history of supporting compact urban development strategies within these countries, enhanced by a culture of and environmental need for planning on a regional scale.

2.6 Case studies

2.6.1 Cape Town Densification Strategy

Cape Town Densification Strategy (2009) was prepared by Densification Task Team which was endorsed by the Planning and Environment Portfolio Committee and establishment to oversee the preparation of the densification strategy for Cape town. The strategy was based on the following considerations regarding density:

- Density offers more housing choices, and accommodates different kinds of lifestyles.
- Density makes better use of the City's limited resources, and cuts infrastructure costs.
- Density helps protect the environment; by concentrating people in the urban environment, natural spaces and habitats are conserved.
- Density makes neighbourhoods more safe, as there are more 'eyes and ears' on the streets; criminals prefer quiet, desolate places.
- Density supports more transport options, because there are enough people to make public transport viable.
- Density offers a better lifestyle for people who cannot drive, such as elderly, very young, or disabled people.
- Density builds communities with better access to schools, work, parks and services.

Five different approaches to densification were considered. These are: constructing attached or detached second dwellings; increasing the number of units by building extra floors, or increasing the size of the building; consolidating vacant or developed properties, and then

redeveloping them at higher densities; subdividing land; and building on vacant or underused land. The densities range from 100 dwelling units per hectare for attached single storey at Mountain Rd and Woodstock to 250 dwelling units per hectare at Marine Circle, Table View beachfront.

Cape Town's Densification Strategy was aimed to make the city more efficient and more sustainable as well as offer a broader range of living environments. This is by avoiding 'one-size-fits-all' plan but instead have highrise development where it is appropriate while in other areas allowing small scale densification in keeping with the character of the neighbourhood.
Overall, the strategy aimed to increase the average density of the city as a whole, and to identify those locations that are more suited to higher-density development.

Figure 2.11 Generic considerations for densification

Level of densification	***Consideration***
Medium to high levels of densification	**1. Access to a safe, secure and efficient public transport system** Medium to high densities need to be aligned with and support the development of a viable public transport system. **2. Land use integration** Proximity to places of employment, services and facilities is required if the higher-density areas are to generate the benefits of concentration. **3. Access and proximity to public open spaces** High-density development should be located near urban open spaces (such as squares and promenades), recreational green spaces (parks and sports fields) and natural resource areas (nature areas and reserves, river corridors and wetlands, mountain and natural views) and coastlines (beaches and sea views) to provide physical and psychological relief from the higher-density environments and to off-set the lack of private open space.
All forms of densification	**4. Infrastructural capacity** Densification should not be supported where water, waste water and storm water capacity is reaching points of absolute constraint and the cost implications of rectifying the situation are too high for the private sector or not planned for within a five year time frame.

	5. Land use character The general land use character of an area is important when considering the suitability of higher-density development. Urban areas (existing or planned) characterised by a diverse land use mix (including different types of residential development) are best suited as locations for higher densities. If an area is solely single- dwelling residential it is less suitable for higher density development of a different form than where there are flats and mixed land use development.
	6. Natural environment Higher-density development areas should not negatively impact on the landscape and scenic aspects of the surrounding natural environment, or on the operation of natural systems. The location, orientation, scale, height, and design of higher-density development in scenic and sensitive landscapes should be adjusted so as not to negatively impact on the surrounding natural environment. In locations next to productive agricultural areas, lower densities may be a more preferable interface to absorb the impacts of farming activities while mitigating the negative 'urban shadow' effect on abutting productive agriculture.

Source: Based on Cape Town Densification Strategy Technical Report, 2009

Figure 2.12 Examples of densities in Cape Town and other cities

Urban densities in Cape Town	
Mountain Rd, Woodstock (attached single storeys):	100 dwelling units per hectare (nett)
Rustenberg square, Rondebosch (four to five storeys):	107 dwelling units per hectare (nett)
Marine Circle, table View beachfront:	250 dwelling units per hectare (nett)
Springfield terrace, Woodstock (three storeys)	166 dwelling units per hectare (nett)
Urban densities in other cities	
London (Warwick square):	125–200 dwelling units per hectare (nett)
Amsterdam (old Quarter):	75–100 dwelling units per hectare (nett)
Mykonos (Greece):	200 dwelling units per hectare (nett)

Source: Based on Cape Town Densification Strategy Technical Report, 2009

2.6.2 São Paulo, Brazil

Figure 2.13 Density management in Sao Paulo, Brazil

With a population of about 9.4 million (1991) living in an area of 149,300 ha and a density of 63 in habitants/ha, São Paulo is one of the largest cities in the world. Greater São Paulo, with 38 municipalities, was expected to reach 25 million inhabitants in the beginning of the next century. In the period 1989 – 92, the city experienced an innovative planning process related to density.
The increase of building densities in residential and non-residential areas was one of the back bones of a strategic urban development plan based on the argument that there are strong relations between the production of built-up space, densification and demand for infrastructure. A careful analysis and inventory of the different zones of the city was carried out to detect where the existing infrastructure and services could cope with increased density of land use. A series of indicators were developed to establish the relationship between the accepted capacity of the available infrastructure and services, and the built-up area. The existing spare capacity must be translated into potential square meters of built-up space. This densification potential was called “stock of space”.

Transport, road, water, drainage, electricity and sewage networks were systematically assessed. Transport deserved special attention since the location of origins and destinations of journeys are simultaneously affected by any change in land use. The road system of the city centre was congested and almost saturated with traffic towards the inner city, up to 2000 vehicles during the peak hour of the morning. Many passengers commuted: 30,000 passengers during the morning peak. The drainage system showed an indirect relationship with density. Increasing building densities made the urban surface impermeable, bringing flood risks. The water, sewage and electricity systems were assessed through their three sub systems: production (capture, treatment, generation), main distribution (primary network, collectors, sub stations) and local net works. The plan utilized the concept of floor area ratio called locally coefficient of use/maximization – CAU (Coeficiente de Aproveitamento Unico). The plan adopted CAU = 1 for the whole urban area of the city as a unique floor area ratio. This means that the building might reach a built up area equal to the area of the plot.

The CAU index relates the built-up area to the plot size and determines the area for which the building right is free of charge. The CAU was used as a starting point to define the zones possible to have increases in density (CAU 1) and those which do not fulfil the criteria. The guiding principle for densification was the availability of infrastructure and their capacity to absorb consumption increases. In general, the urban areas with poor water supply, lacking sewage, and with insufficient roads and inadequate public transport were defined as areas where it was not possible to increase densities. In an area where the limit of the infrastructure was almost reached, the plan would stimulate diversification of land use and guide the land occupation densification. The zone presenting a low density of power, roads, public transport and a high stock of development space was defined as an area for potential densification.

The crucial innovation of the plan was the management of the stock of the space. An information system was established to monitor the registration, processing and periodic dissemination of changes in use, density and occupation throughout the 15 densification zones.
The municipality would act as a bank. The stock of space would correspond to credit in infrastructure, and the consumption of space in the form of built-up area would represent the debts of the client, individuals and private developers. The local government linked this potential for increasing building densities with mechanisms to foster housing production.

To stimulate social housing production, a partnership based urban operations called inter linked and social interest operations, similar to the floor area ratio have also been used. A municipal housing fund is linked to these operations and becomes an urban management tool to promote the most desirable physical and functional organization of the city. The operations are used when private land or public land has been occupied by unauthorized settlements. In both cases, the owner requests a change of the CAU of the plot where the settlement is situated or of another plot he owns elsewhere in the city. The land is carefully valued before and after interventions are carried out. Infrastructure and building costs are implemented by the owner who pays with housing units to the local government and receives in exchange densification possibilities or development rights on the plot where the project takes place or in another plot he owns.

Source: Based on Acioly and Davidson, 1996

2.7 Legal Frameworks, Policies and Institutional Frameworks

2.7.1 Legal Frameworks and Policies

i) **Constitution of Kenya**

The constitution addresses various factors on housing and sustainable development. These factors are addressed in various chapters. Chapter 42 stipulates that every person has the right to a clean and healthy environment which includes the right to have the environment protected for the benefit of present and future generations through legislative and other measures. Chapter 43 deals with economic and social rights which include the right to accessible and adequate housing, and to reasonable standards of sanitation; and clean and safe water in adequate quantities. Moreover, chapter 69 (1) directs the state to ensure sustainable exploitation, utilisation, management and conservation of the environment and natural resources, and ensure the equitable sharing of the accruing benefits; and further to eliminate processes and activities that are likely to endanger the environment. Chapter 10 (2) (d) lists sustainable development under the national values and principles of governance which bind all state organs, officers and public officers.

ii) **Physical Planning Act 1996**

Development planning in Kenya is guided by the Physical Planning Act 1996. It provides for the preparation, implementation and enforcement of physical development plans, and mechanisms that should guide and enforce development control by local authorities and NEMA.

The act also provides a framework for conflict resolution through liaison committees and mechanisms for community participation in planning. Section 29 directs that subject to the provisions of this Act, each local authority shall have the power to control development-

(*a*) to prohibit or control the use and development of land and buildings in the interests of proper and orderly development of its area;

(*b*) to control or prohibit the subdivision of land or existing plots into smaller areas;

(*c*) to consider and approve all development applications and grant all development permissions;

(*d*) to ensure the proper execution and implementation of approved physical development plans;

(*e*) to formulate by-laws to regulate zoning in respect of use and density of development; and

(*f*) to reserve and maintain all the land planned for open spaces, parks, urban forests and green belts in accordance with the approved physical development plan.

Further, according to section 30 (1), no person shall carry out development within the area of a local authority without a development permission granted by the local authority under section 33. The City Council of Nairobi that is therefore mandated to formulate and enforce development controls in Kileleshwa but it has limited capacity.

iii) **Public Health Act (Cap. 242)**

The Act primarily aims to control and regulate conditions that are likely to be injurious or dangerous to human health. Part IX, section 115, of the Act states that no person/institution shall cause nuisance or condition liable to be injurious or dangerous to human health. Section 116 requires that Local Authorities take all lawful, necessary and reasonably practicable measures to maintain their jurisdiction clean and sanitary to prevent occurrence of nuisance or condition liable to be injurious or dangerous to human health. Such nuisance or conditions are defined under section 118 and include nuisances caused by accumulation of materials or refuse which in the opinion of the medical officer of health is likely to harbour rats or other vermin. The environmental management plan (EMP) advices the proponent on safety and health aspects, potential impacts, personnel responsible for implementation and monitoring, frequency of monitoring, and estimated cost.

The public health department that is mandated to enforce this act has not been able to enforce it so that pollution levels particularly to the wet lands can be mitigated.

iv) **Sessional paper no 3 of 2004 on National Housing Policy**

The policy has made several provisions with regard to shelter provision. National Housing Policy as articulated in Sessional Paper No. 3 of 2004 addresses the deteriorating housing conditions countrywide and aims to bridge the shortfall of housing stock arising from demand that far surpasses supply, particularly in urban areas. The policy under section 41(a,k, l) aims to ensure that legislative and regulatory instruments governing land-use planning, administration and management are regularly reviewed and harmonised to promote housing development and ensure development control is upheld and intensified to avoid illegal developments and construction; encourage where possible settlement patterns that minimize the cost of providing infrastructure

and other services; and facilitate re-planning and re-development of existing housing estates that do not provide for maximum permissible or highest and best use of land.

v) **Urban Areas and Cities Act, 2011**

One of the principal legislations that are going to govern the management, operations and delimitation of urban cities and urban areas under the constitution is urban Areas and Cities Act, 2011. The chief mandate of this Act is to guide classification of urban areas, governance and management of urban areas and participation of the residence in the governance of urban areas. The critical bit of this Act is on governance and management of urban areas (Section, 41). Moreover, section 41 addresses the issue of integrated development planning. Under this, the board in collaboration with other entities is allowed to formulate development plans for urban areas.

vi) **The Building By laws**

The Building Code (The Local Government (Adoptive By-laws)) Order 1968 envisage buildings that satisfy conditions related to: submission and approval of building plans (clauses 5, 7, 9 and 10); siting and space about buildings, means of access, external passages, building line, access to plot and frontage (clauses 17, 18, 19, 20, 21, 23, 25, 26); use of building materials, testing of materials and protection of persons and property (clauses 33, 34 and37); drainage of sites, preparation of sites, and identification of plot boundaries (38,39 and 42); provision of refuse disposal, water supply, ventilation of buildings, height of rooms, sewage and waste water disposal, fire escape considerations among others.

These standards are rigid and do not address the emerging technologies of construction. Enforcement of this code has not been effective.

vii) **Kenya Vision 2030**

Kenya Vision 2030 is new long-term development blueprint for the country. The aim of Kenya Vision 2030 is "the globally competitive and prosperous country with a high quality of life by 2030." It aims at transforming Kenya into "a newly industrialising, middle income country providing a high quality of life to all its citizens in a clean and secure environment" The Vision is anchored on three key pillars: Economic; Social; and Political Governance. One critical area

that is examined is on housing and urbanisation. Kenya Vision 2030 aims to provide the country's population with adequate and decent housing in a sustainable environment. The 2030 Vision also aspires for a country firmly interconnected through a network of roads, railways, ports, airports, water and sanitation facilities and telecommunications. Furthermore, to ensure that the main projects under the economic pillar are implemented, investment in the nation's Infrastructure will be given the highest priority.

viii) **Environmental Management and Coordination Act, 1999**

An ACT of Parliament to provide for the establishment of an appropriate legal and institutional framework for the management of the environment and for the matters connected therewith and incidental thereto. Section 1 outlines general principles like every person in Kenya is entitled to a clean and healthy environment and had the duty to safeguard and enhance the environment. The next is on environmental planning. The act stipulates that there should be national environment action plan. Further it deals with protection and conservation of the environment. The greatest tool that this act provides for is environmental impact assessment.

There has been weak enforcement of this act due to a number of reasons. For example there has been inconsistency in terms of provisions of riparian reserve. In this case the act provides a different measurement while other acts also stipulate different one. Thus, there is need to synchronise these related acts.

ix) **Water Act of 2002**

The Act provides for the management, conservation, use and control of water resources and for the acquisition and regulation of rights to use water. It further provides for the regulations and management of water supply and sewerage services. The Act provides for the regulation of river lines, catchments areas, and protection of wells and springs.

2.7.2 Institutional Framework

i) **Ministry of Land, Housing and Urban Development**

This is the government agency responsible for providing policy direction, national standards and coordination of all matters concerning lands, housing and urban development. The agency in responsible for putting in place policies and initiating laws that ensure sustainable land

management, promote sustainable housing for all and foster orderly urban development in the country. Its mission is therefore to facilitate the sustainable and orderly management of land and improve on housing conditions for socio-economic development.

The mandate encompasses policy making, standard setting, national planning, regulation, coordination, inspection, monitoring and back-up technical support relating to lands, housing and urban development and to promote and foster sustainable human settlement and manage works on government buildings.

ii) **Ministry Devolution and Planning**

The Devolution and Planning Ministry was formed through Executive Order No. 2 of May 2013 released by the President which lists functions and responsibilities for the new Ministry. The ministry is responsible for over 15 semi-autonomous government agencies, 10 constitutional commissions and independent Offices. These include National Development Planning and implementation of Vision 2030. In addition to Vision 2030, the Nairobi metro 2030 is a document that was published in 2008 by the Kenya Government as a strategy document outlining how the government will prepare and enforce an integrated spatial growth and development strategy within the Nairobi metropolitan region. This involves actualization of integrated strategic programmes for the provision of social, economic and infrastructural services within the metropolis.

iii) **Nairobi City County**

The City Council of Nairobi was created by an Act of parliament, Cap 265 of the laws of Kenya to provide essential services that includes water, sewer, refuse collection, and public safety to residents of the city. It is now under the Nairobi County headed by an executive Governor who is elected on five year terms. Governance and management of urban areas and cities is guided by The Urban Areas and Cities Act of 2011. Functions of urban areas and cities include preparation and implementation of integrated development plans. Section 36.(1) stipulates that every city and municipality established under this Act shall operate within the framework of integrated development planning which shall be the basis for-

i) the preparation of environmental management plans;
ii) the preparation of valuation rolls for property taxation;
iii) provision of physical and social infrastructure and transportation;

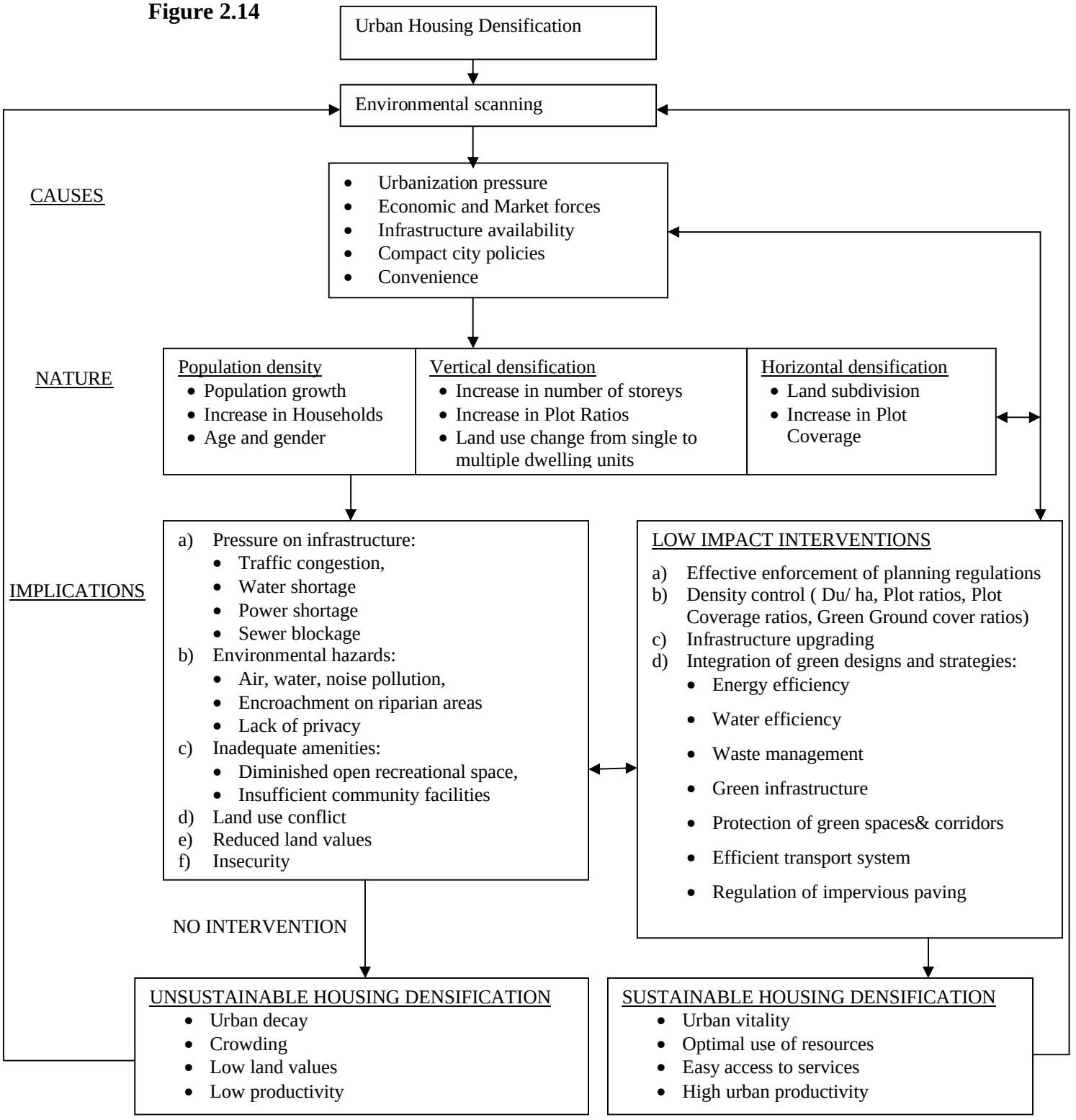
iv) preparation of annual strategic plans for a city or municipality;
v) disaster preparedness and response;
vi) overall delivery of service including provision of water, electricity, health, telecommunications and solid waste management; and
vii) the preparation of a geographic information system for a city or municipality;

iv) **National Environment Management Authority (NEMA)**

The National Environment Management Authority (NEMA) is established under the Environmental Management and Coordination Act (EMCA) No. 8 of 1999, as the principal instrument of government in the implementation of all policies relating to the environment. It therefore mandated to safeguards and enhances the quality of the environment through coordination, research, facilitation and enforcement, while encouraging responsible individual, corporate and collective participation towards sustainable development. NEMA came up with a strategic plan for the year 2010-2013which builds on the national priorities as spelt out in Vision 2030 and it contains definite robust programmes and actions that focus on ways and means of improving our environment.

2.8 Conceptual Framework

Figure 2.14



Source: Author, 2013

The above diagram shows a conceptual framework developed to aid in understanding the issues under study. The first step in understanding the urban housing densification is environmental scanning to establish the causes, nature and implications of densification. Urbanization pressure, market forces, infrastructure availability and enabling policies, legislations and regulations normally influence neighbourhoods towards high densities. The process normally leads to increased population and household density in the area, and increased dwelling units expressed spatially in form of vertical growth and horizontal compaction patterns of development.

The densification process results in increased pressure on infrastructure, environmental hazards, land use conflict, reduced land values and insecurity. This phenomenon if allowed to continue unchecked leads to urban decay, crowding, erosion of land values, low economic productivity and thus unsustainable development.

Situational analysis will therefore call for interventions to address the identified causes, nature and negative implications with a view to formulate policies and strategies for sustainable housing densification. Selected instruments and tools should be reviewed on a regular basis through further analysis to assess effectiveness in addressing densification challenges. The ultimate goal is to guide developments towards enhancing urban vitality, optimizing use of scarce resources, increasing access to services and increasing economic productivity.

CHAPTER 3

BACKGROUND TO THE STUDY AREA

3.1 Introduction

The city of Nairobi, like many other major urban centres in Kenya, owes its birth and growth to the Uganda Railway (K'Akumu, 2002). The town was first settled in 1896 as a transport depot with the clean water and cool climate being main attraction (Gathuri, 2007) . The site was also halfway between Mombasa and Port Florence (now Kisumu).The railhead reached Nairobi in May 1899 on its route to the present day Kisumu that was then part of what is Uganda. The moving of the railway headquarters from Mombasa to Nairobi by its chief engineer, Sir George Whitehouse resulted in the subsequent growth of Nairobi as a commercial and business hub of the then British East Africa protectorate (Situma, 1992).

The colonial administration which had established their administration base in Machakos also moved to Nairobi in 1899 (Gathuri, 2007). By 1900 Nairobi had already become a large and flourishing place with the settlement consisting mainly of the railway buildings and separate residential quarters for Europeans and Indians. The latter were mainly the labourers employed on the construction of the railway. There was practically no African Settlement at the time (Akumu & Olima, 2007) By 1901 the population had grown to about 8,000 people occupying an area of about 3.84 Sq.Km. (Awalla 2007).

In 1900, the colonial government published the Nairobi Municipal Committee (NMC) regulations. These defined the urban centre as ''the area within a radius of one and a half miles from the offices of the sub-commissioner of the then Ukamba Province'' (Morgan, 1967, p. 102). A small number of settlers had began settling in the urban centre at the time, particularly in Kabete and Westlands (Akumu & Olima, 2007).

With the construction of the railway in progress, it became essential to designate a mid-way site where a well-equipped maintenance depot would be built. When the railroad arrived in Nairobi, the Chief Engineer acting on recommendation of the engineer in charge of the site selection team, Guildford Molesworth, exercised powers vested in him under the Land Acquisition Act of India (1894) and obtained for the use of the railway authority the whole plain south of Nairobi river swamp to the Ngong River. In addition, a strip of land on both sides of railway line, 3.2km wide was deemed to be railway land. The designated land areas came under absolute ownership

and control of the railway authority according to the statute. In 1907 Nairobi was made the capital of Kenya. Later in 1950, Nairobi was made a city (Akumu & Olima, 2007).

By 1909 much of the internal structure of Nairobi, especially the road network in the Central Business District (CBD) was already established. In 1927, the boundary of Nairobi was extended to cover 30 square miles or 2537 ha as a result mainly of the rapid growth of the urban centre both in terms of population and infrastructure (Akumu & Olima, 2007).

From 1928 to 1963, this boundary remained the same with only minor additions and excisions taking place. In 1963 the boundary of Nairobi was extended to cover an area of approximately 266 square miles or 68,945 ha (Akumu & Olima, 2007). Since then there has been progressive increase both in population and the physical boundary to its current population of over 3 milion people in an administrative core area of about 696 Sq.Km. The entire Nairobi Metropolis is about 32,000 Sq.Km (Nairobi Metro 2030,2008:XV).

Table 3.1 Population of Nairobi between 1906-1999

Year	Area(Ha)	Population	Increase (%)
1906	1813	11,512	-
1928	2537	29,864	159.4
1931	2537	47,919	60.5
1936	2537	49,600	3.5
1944	2537	108,900	119.6
1948	8315	118,976	9.3
1963	68,945	342,764	28.5
1969	68,945	509,286	48.6
1979	68,945	827,755	62.5
1989	68,945	1,324,570	62.6
1999	68,945	2, 143,254	55.2

Source: Adapted from Akumu & Olima, 2007

3.2 Emergence and growth of residential segregation in Nairobi

When Nairobi was made the capital city of the then British Protectorate in 1905 replacing Mombasa, it attracted an influx of British settlers due to its cool climate free from malaria mosquito. Certain spatial patterns also began to emerge once the railway authority located its headquarters in Nairobi (Akumu & Olima, 2007). For instance, the railway station, a shopping centre and subordinate staff housing were established on level land with black cotton soils. Senior railway officers put their homes up on the hill to the west. European colonial officials also established their homes on the hill. When the East African protectorate headquarters was moved from Mombasa to Nairobi in 1905, Sir Donald Stewart, the Commissioner, himself occupied the house of the former chief railway engineer at the hill (White, Silbermann, & Anderson, 1948). All Europeans who lived in this urban centre created their residences away from Asians and Africans. This pattern soon led to exclusive European residential settlements at Muthaiga, Upper Parklands, Westlands, Loresho, Kileleshwa and Kilimani, among others. Meanwhile, part of the Asian population that had been discharged from railway employment established shops not far from the railway station, an area that came to be known as the Indian Bazaar. The Asian buildings were used both for business and as living quarters (Akumu & Olima, 2007). The few Africans who worked for the railway were given subordinate housing while others lived in shanty villages in the eastern part of
Nairobi (Obudho, 1987).

The period between 1905 and 1950s witnessed major social stratification in Nairobi and the city sorted itself into distinct residential segregation zones. The European settlers moved to the greeny areas on the western side of the city characterised by very rich tropical vegetation, well drained red soils and large plots where they built large expansive single storey houses. These include posh areas of Kilimani, Kileleshwa, Westlands and Loresho, The East African Railways Corporation at that time acquired a lot of land in these prime locations and built many houses for its expatriate managers. Most of these houses built during that period still dot the exclusive neighbourhoods of Kileleshwa, Kilimani, Spring valley and Upper hill occupying huge parcels of land ranging from one to five acres. The Africans on the other hand moved to Eastlands, while Asians moved to Indian Bazaar area on Central Nairobi.

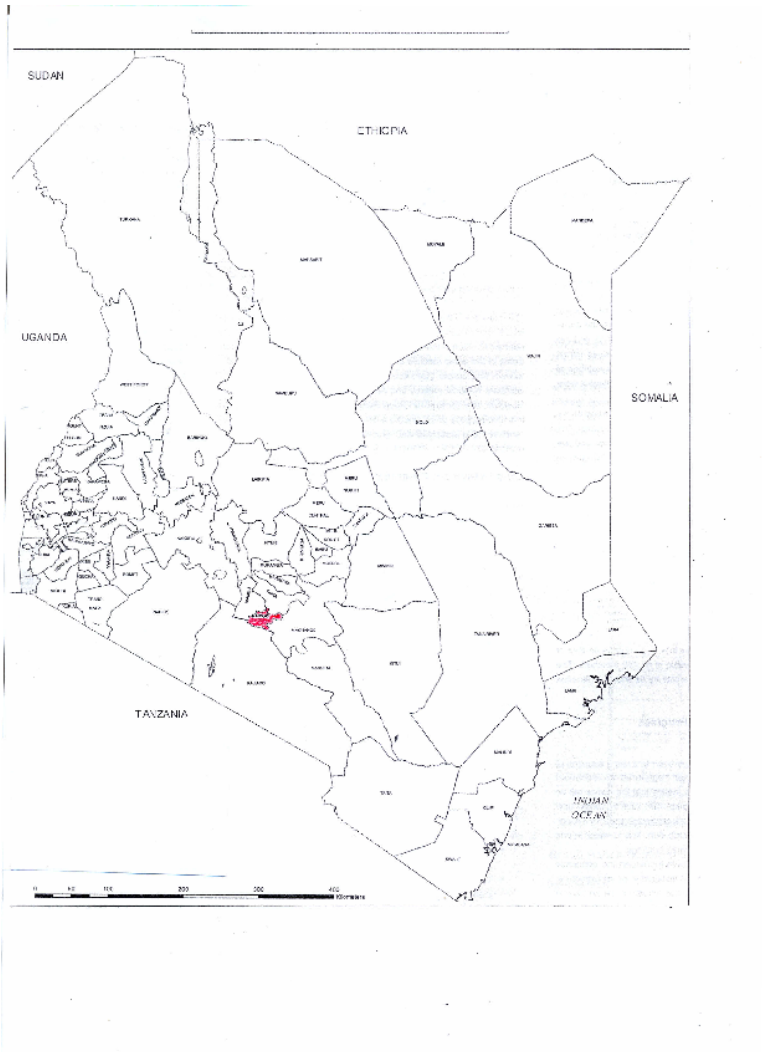
In 1912, owing to three plague outbreaks in the Indian Bazaar, Simson Commission was formed which recommended racial segregation with Indians, Africans and Europeans living in separate areas.(Gathuri, 2007).

3.3 Study Area

The study area is Kileleshwa sub-location in Kileleshwa location of Westlands constituency. It covers an area of approx 5.2 sq.Km with a population of 16,802 according to 2009 population census. There are 4,592 households and a population density of 3,210.

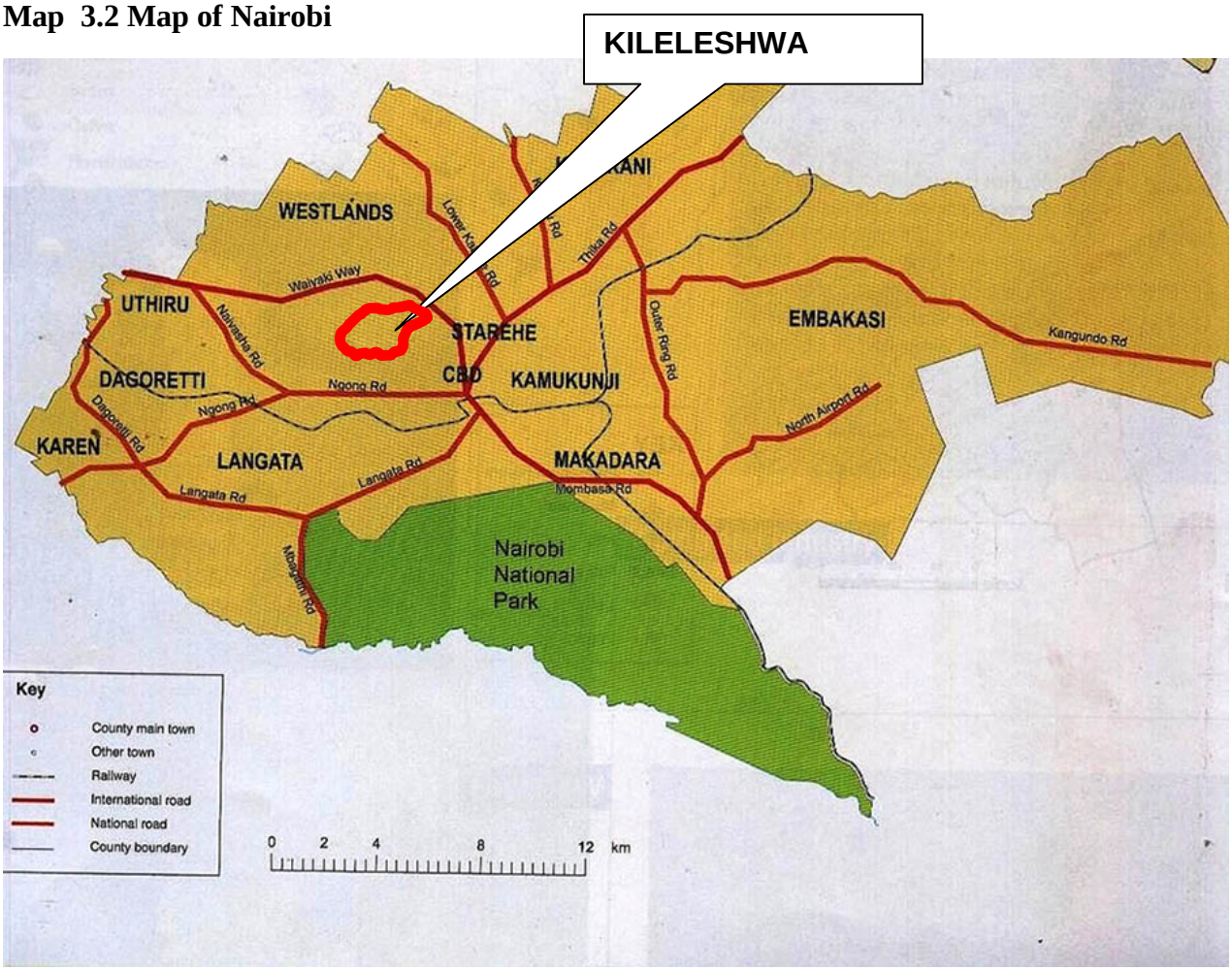
Kileleshwa falls under Nairobi City Council's Planning Zone 4 which covers Spring Valley, Riverside Drive, Kileleshwa, Kilimani, Thompson and Woodley/ Ngong road.

Map 3.1 Map of Kenya showing location of Nairobi



Source: GOK, 2012

Map 3.2 Map of Nairobi



Source: GOK, 2012

Plate 3.1 Upcoming apartments within study area

Along Kandara Rd

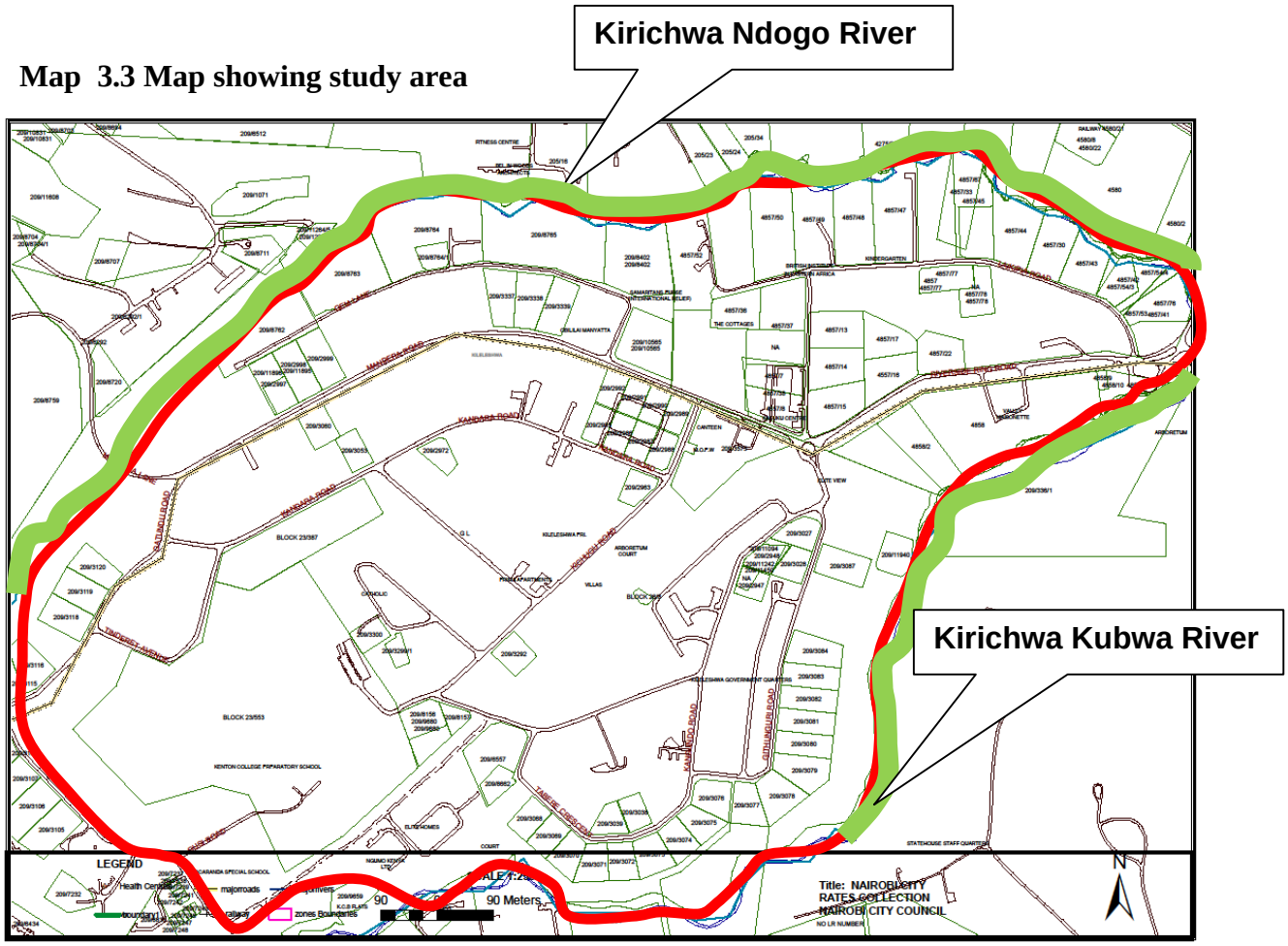
Source: Author

Along Kandara Rd

Along Mandera Rd

Source: Author

Map 3.3 Map showing study area



Source: Nairobi City Council (2011)

Plate 3.0-1 Pre-independence single storey houses along Mandera Road

Source: NHC,2009

Source: NHC, 2009

Table 3.2 Population distribution by sex, number of households ,area, density and constituencies

	Male	Female	Total	Households	Area in Sq.Km	Density
Kenya	19,192,458	19,417,639	38,610,097	8,767,954	581,313.2	66
Nairobi	1,605,230	1,533,139	3,138,369	985,016	695.1	4515
Westlands	124,748	122,354	247,102	75,427	97.4	2538
Kileleshwa (Location)	12,207	14,995	27,202	7,743	9.0	3009
Kileleshwa (Sub-Location)	7,389	9,413	16,802	4,592	5.2	3210

Source: Kenya National Bureau of Statistics (2010)

3.4 Climate and weather

Climatic conditions of the study area compares favourably to that of the wider Nairobi city.

At 1,795 metres (5,889 ft) above sea level, Nairobi enjoys a moderate climate. Nairobi has a subtropical highland climate. The altitude makes for some cool evenings, especially in the June/July season when the temperature can drop to 10 °C (50 °F). The sunniest and warmest part of the year is from December to March, when temperatures average the mid-twenties during the day. The mean maximum temperature for this period is 24 °C (75 °F)

Table 3.3 Monthly average temperatures, sunshine, rainfall and humidity for Nairobi

Summary of average yearly weather data for Nairobi						
	Low temp (degrees C)	High temp (degrees C)	Sunshine (hours)	Rainfall (mm)	Humidity (am)	Humidity (pm)
Jan	12	25	9	38	74	44
Feb	13	26	9	64	74	40
Mar	14	25	9	125	81	45
April	14	24	7	211	88	56
May	13	22	6	158	88	62
June	12	21	6	46	89	60
July	11	21	4	15	86	58
Aug	11	21	4	23	86	56
Sept	11	24	6	31	82	45
Oct	13	24	7	53	82	43
Nov	13	23	7	109	86	53
Dec	13	23	8	86	81	53

Source: *www.nairobicity.go.ke*

The city is located at 1°17•S 36°49•E and occupies 696 square kilometres (270 sq mi)

3.5 Zoning policies

The first strategic policy for Nairobi was contained in 1948 Nairobi Master Plan (Omwenga, 2008). The Nairobi Master Plan for the colonial capital (1948) was prepared by Thorton White and was inspired by the colonial planning approach. The plan based on the European model of urban form advocated for racial segregation (Obudho, 1997). The housing areas for Europeans and Asians were defined while Africans were to be housed next to areas designated for industries. The plan was prepared when the population of Nairobi was 109,000 and with an anticipated growth rate of 5% it was anticipated that by 1975 the population of the city would grow to 270,000 (Gathuri, 2007).

The second and last strategic plan was the 1973 Nairobi Metropolitan Growth Strategy which lapsed in the year 2000(NCC, 2011). There have been several sectoral development plans thereafter but the same target specific action zones and are not well coordinated.

The 2006 Local Physical Development Plan for Zone 3, 4 and 5 is the current policy guideline that covers Kileleshwa, Kilimani, Woodley, Parklands, Westlands, Lavington, Thompson, Loresho, Riverside and Spring Valley. The policy review provided for the development of high rise block of multi-family residential flat units in the areas that were formerly for single family housing per plot (Omwenga, 2008).

3.5.1 Planning policy

The study area is within Zone 4 of Nairobi according to Nairobi City Development Ordinances and Zones (2006). The city of Nairobi is divided into 21 zones. Zoning according to NCC (2011) is the separation of land uses in order to avoid incompatible developments that can course harm to human life. It is the physical division of urban community into districts or zones for the purpose of regulating the use of land and buildings, height and bulk buildings, plot coverage and density population. The main purpose of zoning is therefore to direct and regulate development or redevelopment of a town in appropriate directions and ensure proper uses of land and buildings with a view to creating a healthy, efficient and stimulating living environment.

Table 3.4 Zone 4 planning policy

Zone	Areas Covered	GC (%)	PR (%)	Types of Development Allowed	Min Area (Ha)
4	Spring Valley Riverside Kileleshwa Kilimani Thompson Woodley	35(s) 25(u)	100 (s) 25(u)	Residential (Apartments allowed on sewer only) – Four Storey max.	0.05

Source: NCC (2006)

The current development standards are based on 2006 study where walk up apartments on Ground Coverage (GC) and Plot Ratio (PR) of 35% and 100% respectively are allowed on areas within the sewerage network. However the intense pressure of development on the ground is such that the growth has by far outpaced the 2006 planning standards. Many developments are beyond the stipulated policy in terms of block heights and dwelling units in a unit piece of land.

Nairobi City Council later commissioned another study in 2011 aimed at generating further knowledge concerning the urban change processes in the Zones 3, 4, 5 and their implications for the city planning and sustainable urban development. This study which is still in draft has identified a need to rezone the area further due to among other factors the increasing pressure on available land and high cost per unit area of land which justifies the need for further densification (CCN, 2011). The 2011draft study report is of the view that the existing standards for the area are quite conservative and further proposes a rezoning to enhance higher densities. The draft study report therefore proposes enhancement of development standards for the study area to G.C. of 35% and P.R. of between 100 to 200% (CCN, 2011). The study further identified several challenges within the study area, which include low infrastructure capacity, missing community, social and commercial facilities and traffic congestion among others.

The proposed structure according to the draft 2011 Land Use study Report has zone 4 split further into 17 sub zones. The study areas fall under sub zone 4D1 and 4 D2.

Table 3.5 Proposed zone 4 spatial policy framework as per 2011 study

SUB ZONE	AREA/DESCRIPTION	GC	PR	MIN AREA (HA)	TYPE OF DEVELOPMENT	POLICY ISSUES/REQUIREMENTS
4A1	Peponi road, General mathenge rd, General mathenge lane, canalized stream, Brookeside rd, Lower kabete rd.	35 35	1.5 1.0	0.2 Ha 0.05 Ha	Apartments, Single Dwelling	Use of Solar Energy Water Recycling Separation of waste Rainwater harvesting Provision of a lift 2 cars per apartment
4A2	General mathenge drive, boundary zones 3 &4, mathare river, brookeside road, general mathenge drive.	25	2.5	0.2 Ha	Single Dwelling	On site sanitation
4B1	All first row plots fronting Waiyaki way on either side where there is a slip road to All Africa Confrence of Churches (AACC).	50	2.5	0.2 Ha	Offices	Discourage spread of commercial along Waiyaki way Same conditions of green building to apply Observe acceleration and de-acceleration lanes
4B2	s Lower Kabete Rd, Karuna Rd, school lane, boundary zone 4B1, Muguga green primary, muguga green rd, brookeside rd, boundary 4&5, canalized river, brookeside rd. s Ring road, boundary 4B1, St. Micheal road, boundary 4&5, Nairobi river, ring road.	35 35	1.0 2.00	0.05 Ha 0.2 Ha	Single Dwelling Apartments	Use of Solar Energy Water Recycling Separation of waste Rainwater harvesting Provision of a lift 2 cars per apartment 20% Greenery.
4C	Nairobi River, Ring rd, Kirichwa Ndogo, Boundary 4&5, Kirichwa ndogo, ring rd	35 25 35	1.0 2.5 1.5		Town houses Single dwelling Apartments	No more Office Developments along River side drive Rehabilitation of the riparian. Green building conditions apply.
4D1	Kirichwa Ndogo, ring road, St. Georges P. School, Kirichwa Kubwa, Mazeras rd, migoiri rd, Nyeri rd, Gatundu rd, boundary 4&5, Kirichwa ndogo.	35 35	2.00 1.00	0.3 Ha 0.03 Ha	Apartments Town houses/ Single dwelling.	Riparian regulation Above conditions of green building apply.

SUB ZONE	AREA/DESCRIPTION	GC	PR	MIN AREA (HA)	TYPE OF DEVELOPMENT	POLICY ISSUES/REQUIREMENTS
4D2	Kirichwa Ndogo, Gatundu Rd, Nyeri rd, Gitanga rd, Muthangari drive, Kirichwa ndogo	35 35	1.0 1.5	0.05 Ha 0.2 Ha	Single Dwelling Apartments	Above conditions of Green building Rehabilitation of riparian
4D3	Gitanga Rd, Boundary 4, , Methodist Guest House, Kirichwa Kubwa	35 35	1.0 0.2	0.03 Ha 0.2 Ha	Residential Single Dwelling Apartments	As above Rehabilitation of riparian
4D4	Bernard Estate	35	0.75	0.3Ha	Residential Single Dwelling	No apartments
4E	Galana Rd, Chania Rd, Chaka Rd, Lenana Rd, Agwings Kodhek rd, Menelik rd, Chania Ave., Chaka rd, Lennana rd. From Chaka rd/argwings kodhek rd junction along argwings road to Hurlingham shopping centre: All plots fronting the road on both sides. Hurlingham shopping centre	50 50 50	3.0 2.5 2.5	0.2 Ha 0.2 Ha 0.2 Ha	Commercial Offices Commercial	Above conditions for commercial areas apply
4F	Lenana Rd, Rose Avenue, St Georges schools, Woodland Ave., Dennis Pritt Road, Zone 4 boundary, State hse Ave., Ralph Bunch rd, Lenana rd.	35 50	1.0 0.75	0.2 Ha 0.03 Ha	Single Dwelling Apartments:(2 Floor & an attic)	Special planning area: maintain existing character
4G	Dennis Pritt Rd, St. Georges schools, Kirichwa Kubwa, Ole Odume Rd, Ngong Rd, city mortuary round about, valley road, Ralph Bunche rd, Denis Pritt rd.	35 35	1.5 1.0	0.2 Ha 0.03 Ha	Apartments Single dwelling	Above Conditions of Green Building apply 20% Greenery Onsite parking Rehabilitation of riparian
4G1	Ole Odume Rd, Kirichwa Kubwa, Naivasha Rd, Riara Rd, Sweedish School, Naivasha rd, Ole odume rd	35 35	2.0 1.0	0.2 Ha 0.05 Ha	Apartments Single dwelling	Above Conditions apply Maximum 6 levels Rehabilitation of riparian
4G2	Riara Rd, Naivasha Rd up to the Swedish school boundary, Riara rd. Includes Dagoretti commercial node.	50	2.5	0.2Ha	Commercial	Need for Detailed Planning of the Dagoretti Commercial Node. Conditions of Commercial node similar to Westlands CBD apply.

SUB ZONE	AREA/DESCRIPTION	GC	PR	MIN AREA (HA)	TYPE OF DEVELOPMENT	POLICY ISSUES/REQUIREMENTS
4H1	Ngong Rd, Joseph Kangethe, NPC Woodley, Police lines, Along NCC deport, Joseph Kangethe centre, Along boundary of Toi primary schl and Moi Girls, Kibera drive, kabarnet rd, Ngong rd.	35 35	1.5 1.0	0.2 Ha 0.05 Ha	Apartments Single Dwelling	Maximum 4 levels Conditions of green buildings apply.
4H2	Jamhuri Phase II: Ngong rd, Joseph Kangetherd, Police line, railway line, boundary zone 4, Ngong road.	35	1.5	Existing Plots	Residential	Maximum 4 levels
4I	Kibera drive, Kabarnet Rd, Boundary of zone 4, Kibera drive.	35 35	1.5 0.75	0.2 Ha 0.05 Ha	Apartments -4 levels maxm. Single Dwelling	Maintain existing character All other conditions apply

Source: NCC (2011)

CHAPTER 4

EXTENT AND NATURE OF DENSIFICATION

4.0 Introduction

This chapter presents the findings of the study on sustainable housing densification in Kileleshwa in Nairobi, Kenya. The data has been presented using tables and graphs with interpretation provided. Findings from open-ended questionnaires were also presented in prose. In the case of data from the interview guides, content analysis was used to present the findings in a prose form in reflection of the relevant themes.

4.1 Extent of Housing Densification

The housing developments in Kileleshwa area which was an exclusive European housing zone were characterized by low density and high income single dwelling units. However the scenario in this area has changed rapidly over the last few years with noticeable change from low density high income housing to medium income high density residential neighbourhood characterised by walk up apartments and office blocks. The area has limited commercial and community facilities and the infrastructural services designed for the initial low density land use have not experienced the necessary expansion in line with the dynamics of growth happening in the area.

Plate 4.1 Upcoming apartments in the study area

Along Githunguri Rd

Source: Author 2012

Table 4.1: Population Distribution by Sex, Number of Households, Area and Density in 2009

	Male	Female	Total	Households	Area in Sq.Km	Density
Kenya	19,192,458	19,417,639	38,610,097	8,767,954	581,313.2	66
Nairobi	1,605,230	1,533,139	3,138,369	985,016	695.1	4515
Westlands	124,748	122,354	247,102	75,427	97.4	2538
Kileleshwa (Location)	12,207	14,995	27,202	7,743	9.0	3009
Kileleshwa (Sub-Location)	7,389 (44%)	9,413 (56%)	16,802	4,592	5.2	3210

Source: Kenya National Bureau of Statistics (2010)

The current population density for Kileleshwa sub location stands at 3210 persons per sq.Km (or 883 households per sq.Km) compared to 2538 persons per sq.Km (or 774 households per sq.Km) for Westlands constituency and 4515 persons per sq.Km(or 1417 households per sq.Km) for Nairobi. The population density for the entire country stands at 66 persons per sq.Km and 15 households per sq.Km

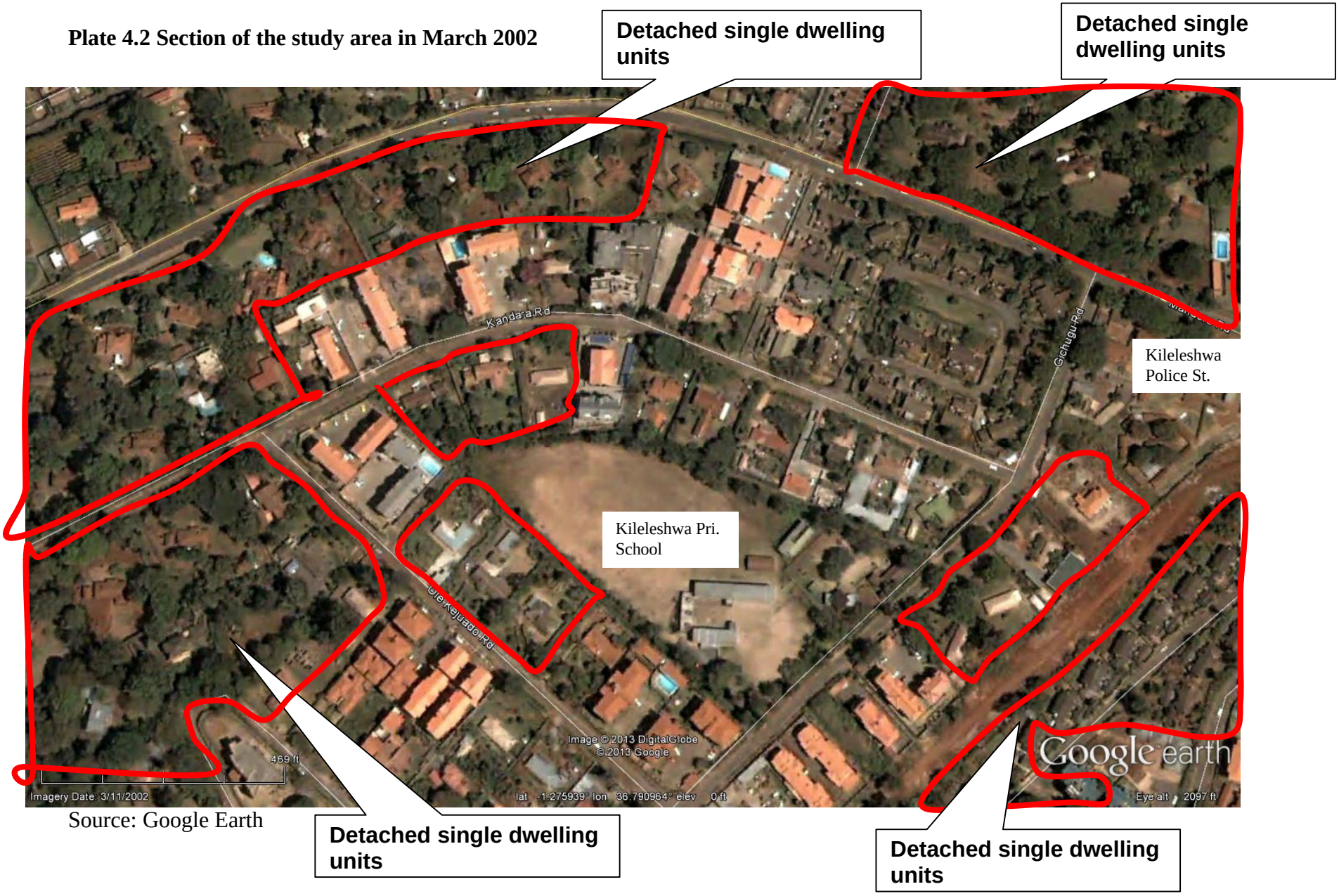
Table 4.2: Population and Households Growth trends in Kileleshwa Sublocation

Year	Male	Female	Total	Households	Area in Sq.Km	Density
1999	5,992	5,977	11,969	3,361	5.2	2302
2009	7,389	9,413	16,802	4,592	5.2	3210
% Growth	23.3%	57.5%	40.4%	36.6%		39.4%

Source: Based on Kenya National Bureau of Statistics (2001 & 2010)

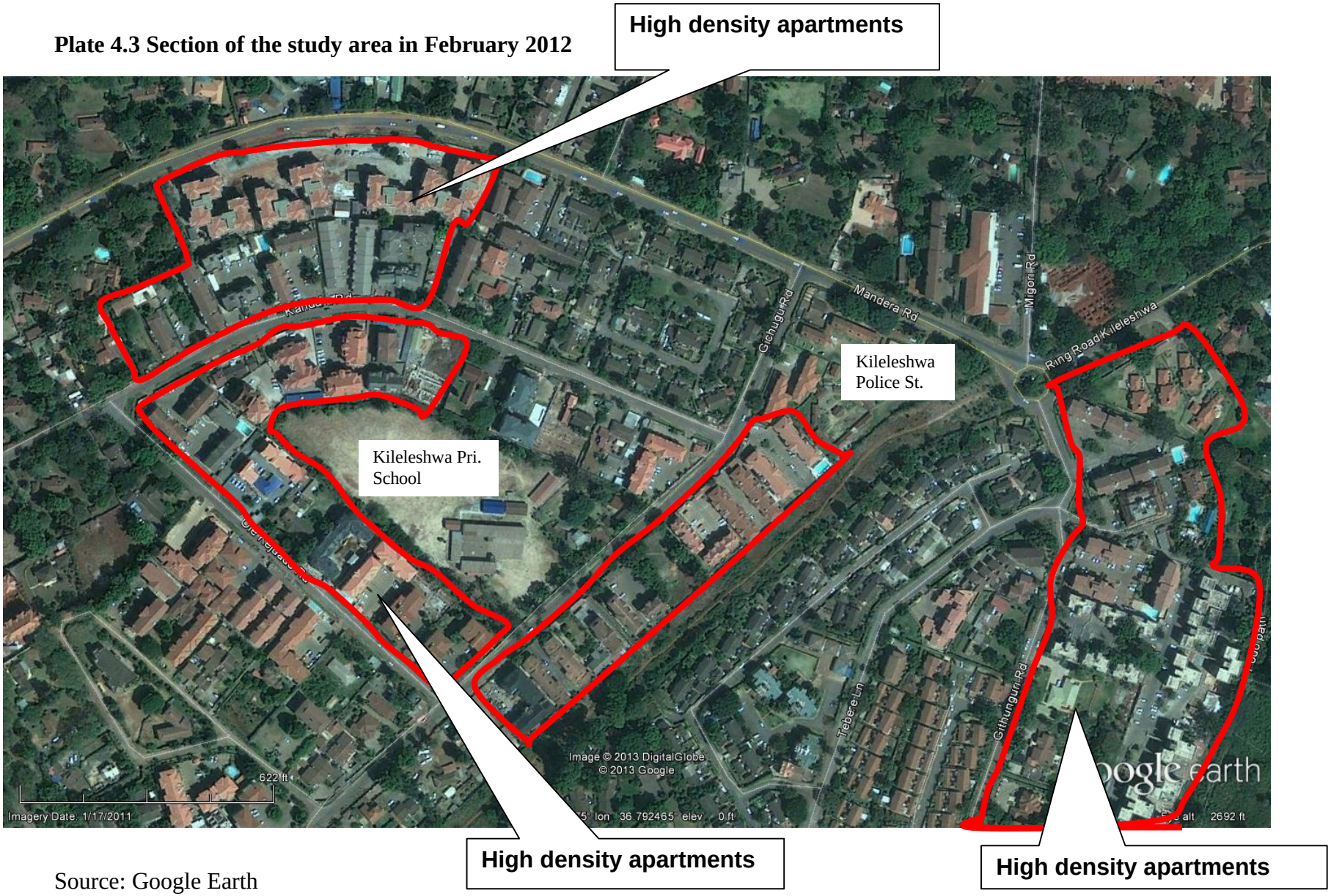
From Table 4.2, Kileleshwa has witnessed a total population growth of 40.4% for the 10 year period and an increase in number of households by 36.6%. The population density has also increased by 39.4% over the same period.

Plate 4.2 Section of the study area in March 2002



Source: Google Earth

Plate 4.3 Section of the study area in February 2012

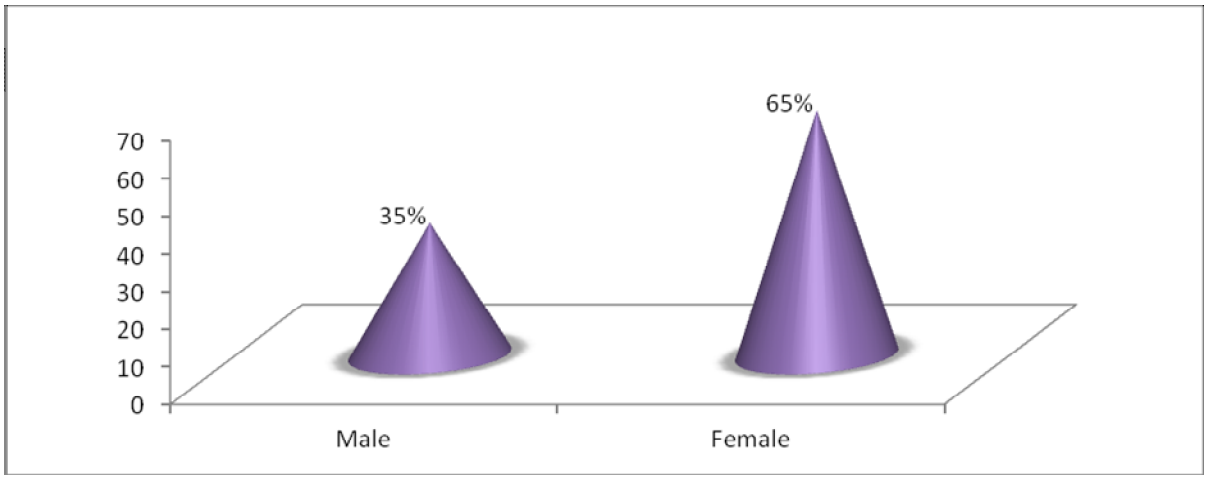


Source: Google Earth

4.1.1 Gender

The study sought to establish the gender characteristics of the population.

Figure 4.1 Gender of the respondents



Source: Field survey, 2013

From the findings, 65% of the respondents who participated in the study were female while the rest (35%) were male. The 2009 census data for Kileleshwa indicate females to be 56% while male comprise 44% of the population (KNBS, 2010). This illustrates that there are more female than male living in Kileleshwa.

4.1.2 Age

The study sought to find out the distribution of the population by age.

Table 4.2 Age of the respondents

	Frequency	Percent
below 30 years	29	39.2
30-40 years	44	59.5
51-60 years	1	1.4
Total	**74**	**100.0**

Source: Field survey, 2013

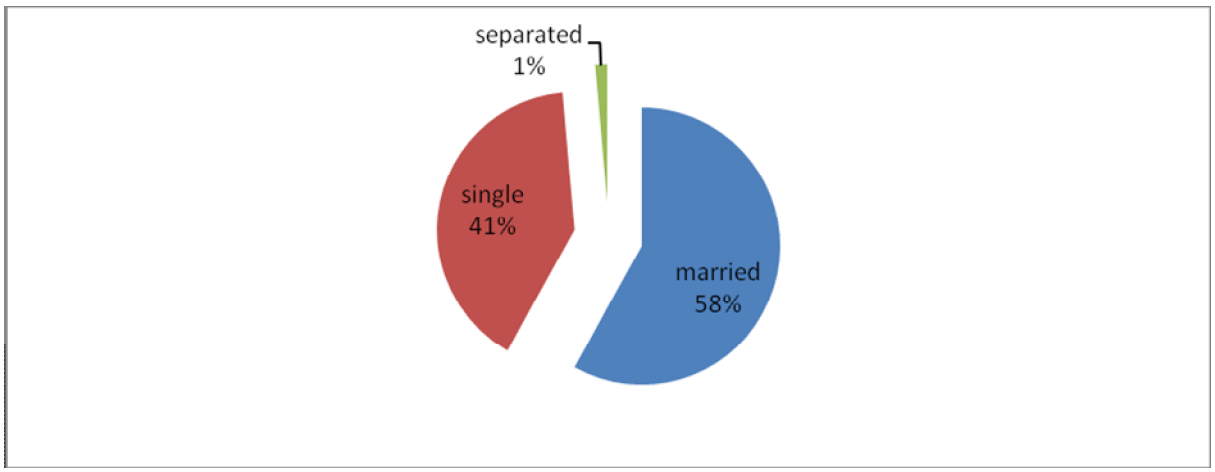
According to the results in table 4.2, majority of the respondents (59.5%) were aged between 30-40 years, 39.2% were aged below 30 years while 1.4% were aged between 51-60 years. This

implies that majority of people living in Kileleshwa are aged between 30-40 years hence they are in the middle age group.

4.1.3 Marital status

The study sought to find out the marital status of the area population.

Figure 4.2 Marital status of the respondents



Source: Field survey, 2013

From the findings of the study, 58% of the respondents who participated in the study were married while 41% were single. This illustrates that majority of the people living in Kileleshwa, were married.

4.1.4 Level of education

The study also sought to find out education level of the area population.

Table 4.3 Level of education

	Frequency	Percent
Post graduate degree	14	18.9
Graduate degree	47	63.5
Secondary education	9	12.2
Primary education	2	2.7
Informal education	2	2.7
Total	**74**	**100.0**

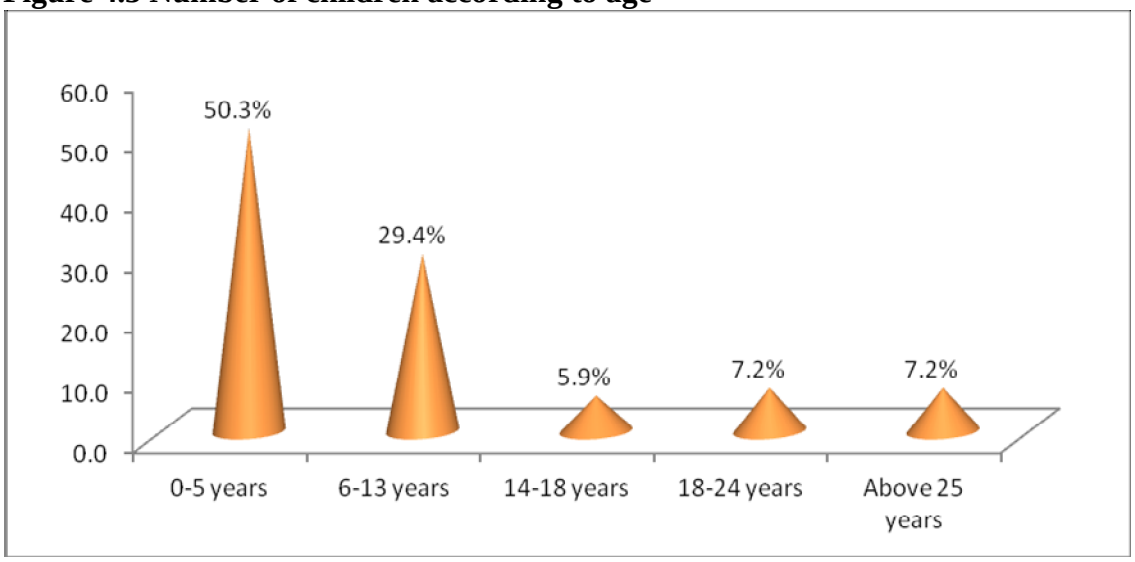
Source: Field survey, 2013

As shown in table 4.3 above, majority of the respondents (63.5%) had graduate degree, 18.9% had post graduate education, 12.2% had secondary education as their highest level of education while 52.7% had primary education and informal as their highest level of education respectively. This implies that majority of the respondents had graduate degree and post graduate degree thus they had sufficient knowledge to participate in the study.

4.1.5 Number of children according to their age

The study further sought to find out the number of children and their age group.

Figure 4.3 Number of children according to age



Source: Field survey, 2013

According to the findings, majority of the respondents (50.3%) had children who were aged between 0-5 years, 29.4% had children who were aged between 6-13 years, and 5.9% had children who were aged between 14-18 years while 7.2% had children who were aged between 18 and above 25 years. This implies that majority of people living in Kileleshwa have young families with children who were aged between 0-5 years of age.

4.1.6 Duration of living in Kileleshwa

The study in this area sought to establish the duration that the respondents had lived in Kileleshwa.

Table 4.4 Duration of living in Kileleshwa

	Frequency	Percent
0-2 years	34	45.9
3-5 years	34	45.9
6-8 years	2	2.7
9-10 years	4	5.4
Total	**74**	**100.0**

Source: Field survey, 2013

According to the results in Table 4.4, majority of the respondents (45.9%) had lived in Kileleshwa for duration of between 0-5 years, 5.4% had lived in Kileleshwa for duration of between 9-10 years while 2.7% had lived in Kileleshwa for duration of between 6-8 years. This implies that majority of the residents have lived in Kileleshwa for duration of between 0-5 years.

4.1.7 Previous place of residence

The study further sought to establish the previous place of residence of the residents. From the findings of the study, majority of the respondents migrated from others estates within Nairobi. Githurai, Hurlingam, Ruaraka, Langata, Buruburu, Nyayo Estate and Umoja were some of the places where the respondents had lived before moving in to Kileleshwa.

4.1.8 Reasons for staying in Kileleshwa

The study in this area sought establishes the reasons why the residents preferred staying at Kileleshwa.

Table 4.5 Reasons for staying in Kileleshwa

	Frequency	Percent
proximity to town centre	16	21.6
proximity to place of employment	8	10.8
Affordability	15	20.3
Security	29	39.2
Prestige	6	8.1
Total	**74**	**100.0**

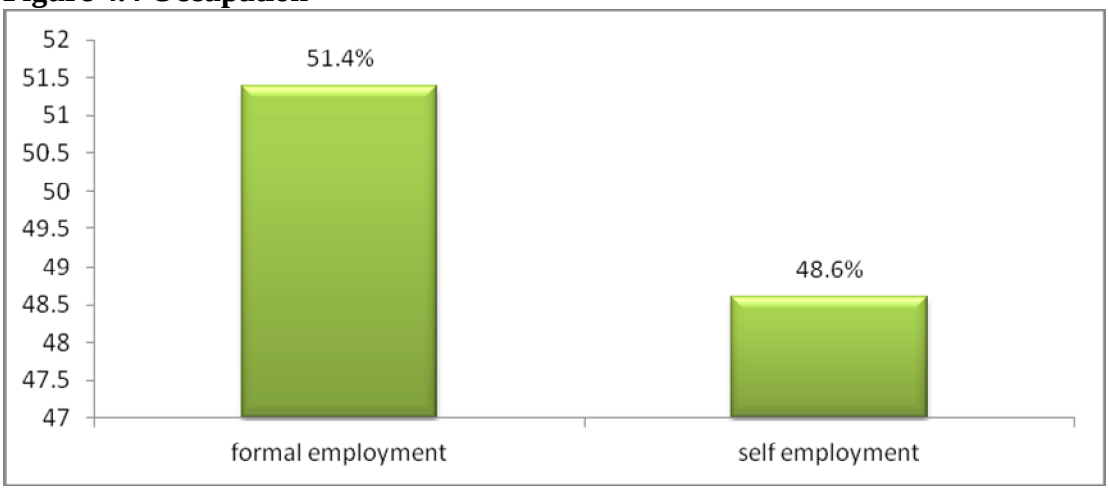
Source: Field survey, 2013

According to the results in Table 4.5, most of the respondents (39.2%) indicated that they preferred staying in Kileleshwa due to security, 21.6% indicated proximity to town centre, and 20.3% indicated affordability while 10.8% and 8.1% indicated proximity to place of employment and prestige as the reasons for staying in Kileleshwa respectively. This implies that majority of people preferred living in Kileleshwa due to security and proximity to town centre.

4.1.9 Occupation

The study sought to establish the occupation of the residents in this area.

Figure 4.4 Occupation



Source: Field survey, 2013

According to the results in Figure 4.4, majority of the respondents (51.4%) were in formal employment while 48.6% were in self employment.

4.1.10 Monthly Income

The study further sought to establish the monthly income of the area population.

Table 4.6 Monthly Income

	Frequency	Percent
below 20,000	13	17.6
20,001-50,000	12	16.2
50,001-100,000	22	29.7
100,001-200,000	10	13.5
above 200, 000	17	23.0
Total	**74**	**100.0**

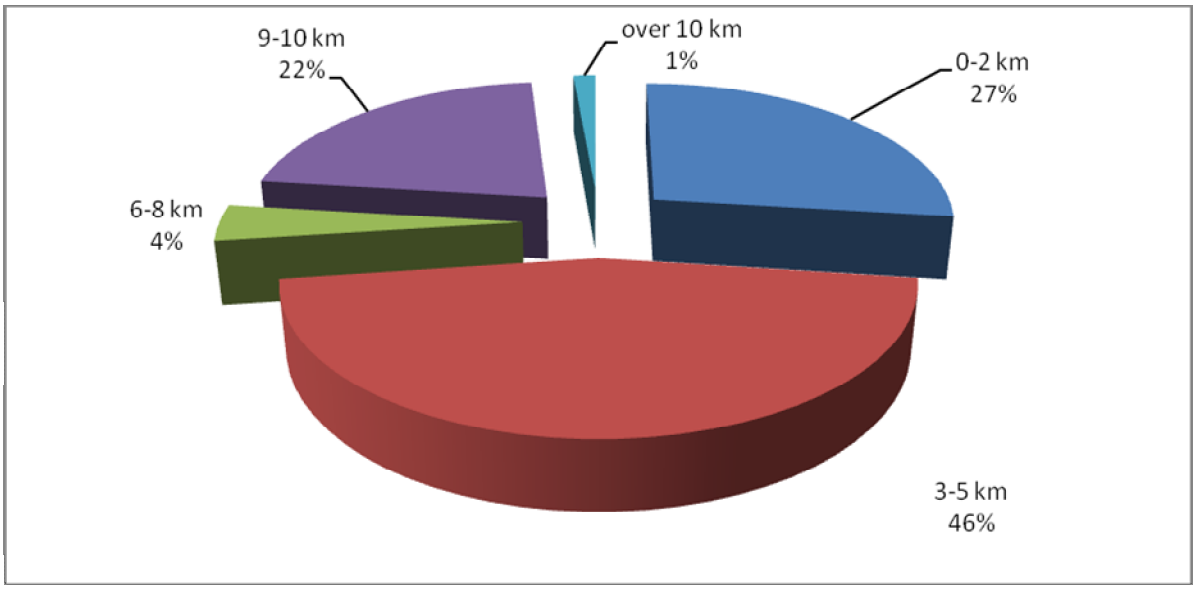
Source: Field survey, 2013

According to the findings, most of the respondents (29.7%) indicated that they had an income of between Ksh 50,001-100,000, 23% had an income of above Ksh 200,000, 17.6% had an income of below Ksh 20,000, and 16.2% had an income of between Ksh 20,001-50,000 while and 13.5% had an income of Ksh 100,001-200,000. This implies that majority of residents in Kileleshwa had an income of between Ksh 50,001-100,000.

4.1.11 Distance to the place of work

The study also sought to find out the distance to the place of work in Kilometers from Kileleshwa.

Figure 4.5 Distance to place of work



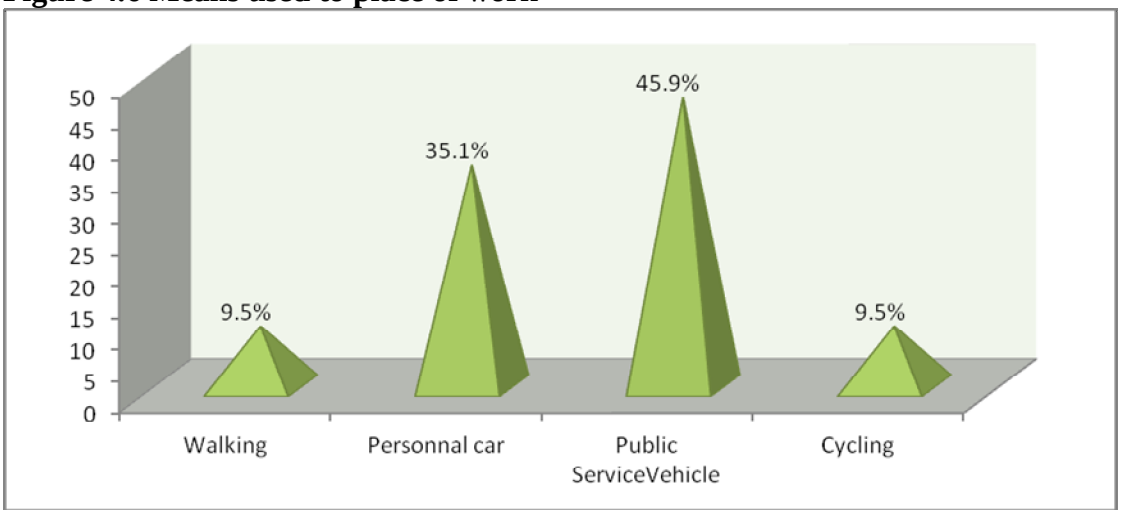
Source: Field survey, 2013

From the findings of the study, most of the respondents (46%) indicated 3-5 Km as the distance from Kileleshwa to their work place, 27% indicated 0-2 Kms and 22% indicated 9-10Kms as the distance from Kileleshwa to their work place while 4% and 1% indicated 6-8 Kms and over 10 Kms as the distance from Kileleshwa to their work place. This implies that majority of the residents covered a distance of between 3-5 Kms to their place of work from Kileleshwa.

4.1.12 Means used to the place of work

The study sought to find out the means used by the residents to get to their places of work from Kileleshwa. The findings are provided in figure 4.6 below.

Figure 4.6 Means used to place of work



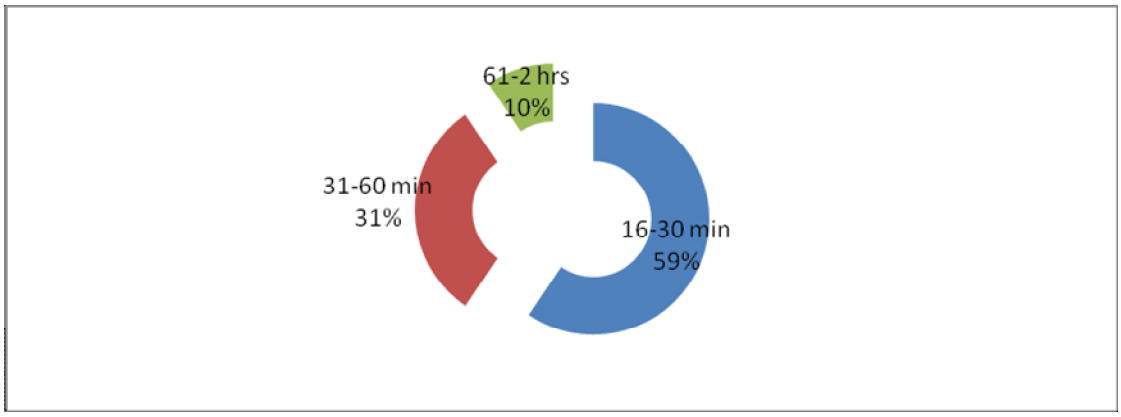
Source: Field survey, 2013

According to the findings, most of the respondents (45.9%) indicated that they used public service vehicle to get to their places of work from Kileleshwa, 35.1% used personal cars while 9.5% walked and cycled to their places of work from Kileleshwa. This implies that majority of the residents used public service vehicles and personal cars to get to their places of work from Kileleshwa.

4.1.13 Time spent on average to reach to the place of work/business

The study in this area sought to find out the time spent on average to reach to the place of work/business by the residents. The findings are provided in figure 4.7 below.

Figure 4.7 Time spent to reach place of work/business



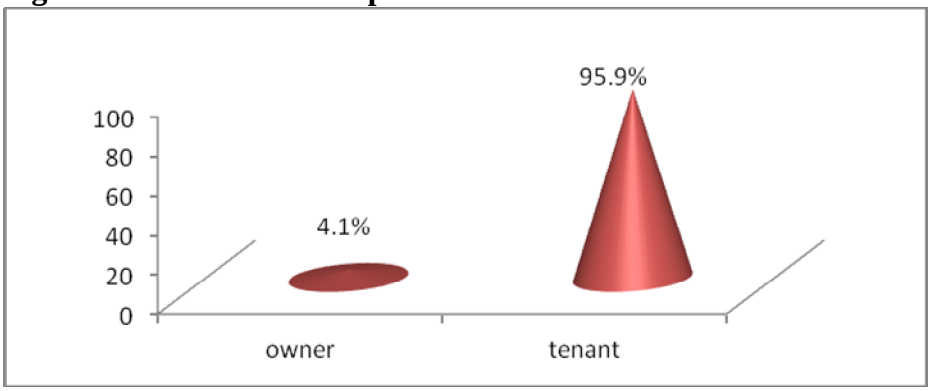
Source: Field survey, 2013

According to the findings, majority of the respondents (59%) indicated that they spent between 16-30 minutes on average to reach to the place of work/business, 31% spent between 31-60 minutes on average to reach to the place of work/business while 10% indicated that they spent between 61 minutes to 2 hours on average to reach to the place of work/business. This implies that majority of the residents spent between 16-30 minutes on average to reach to the place of work/business from Kileleshwa.

4.1.14 House ownership status

The study also sought to find out the house ownership status in Kileleshwa. The findings are provided in figure 4.8 below.

Figure 4.8 House ownership status



Source: Field survey, 2013

From the findings of the study, majority of the respondents (95.9%) indicated that they were tenants, while the rest (4.1%) were owners. Thus majority of the Kileleshwa residents are tenants. For the House owners (3), the study also sought to find out the purchase/ construction cost of the houses at Kileleshwa. From the findings, most of those who owned the houses had purchased or constructed them at a cost of between Ksh 18-25 millions and had purchased or construction them between the years 2010 and 2012. Further, the study found out that those who owned the houses sourced the finances from employers housing schemes and from their personal savings.

4.1.15 Monthly rent payable

The study further sought to find out the monthly rent payable by the tenants in Kileleshwa. From the findings of the study, majority of the tenants (26.4%) indicated that they paid rent of between Ksh 0-25,000, 25.8% paid rent of between Ksh 25,001-50,000 while 32.7% indicated that they paid rent of between Ksh 50, 001-75,000 with 13.1% and 2.1% paying rent of between Ksh 75,001-100,000 and above 150,000 respectively. This implies that majority of tenants in Kileleshwa paid rent of between Ksh 50,001- 75,000.

4.1.16 Type of house

The study sought to find out the type of houses where the residents lived in. The findings are provided in Table 4.7 below.

Table 4.7 Type of house

	Frequency	Percent
Apartment	51	68.9
Maisonette (detached)	5	6.8
Maisonette (row houses)	2	2.7
Bungalow (detached)	4	5.4
Bungalow (row houses)	12	16.2
Total	**74**	**100.0**

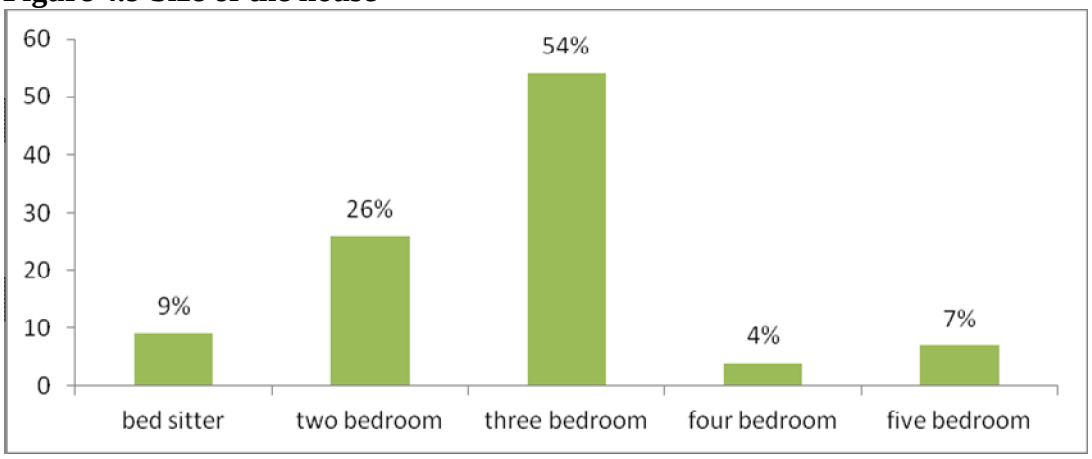
Source: Field survey, 2013

From the findings of the study, majority of the respondents (68.9%) indicated that they lived in apartments, 16.2% lived in Bungalow (row houses) while 6.8%, 5.4% and 2.7% lived in Maisonette (detached), Bungalow (detached) and Maisonette (row houses) respectively.

4.1.17 Size of the houses

The study further sought to find out the size of the houses where the respondents lived in. The findings based on 23 respondents who lived in Maisonette or Bungalow are provided in figure 4.9 below.

Figure 4.9 Size of the house



Source: Field survey, 2013

From the findings of the study, majority of those who lived in Maisonette or Bungalow (54%) indicated that they lived in three bed roomed houses, 26% lived in two bed roomed houses while 9%, 7% and 4% lived in bed sitters, five beds roomed and four bed roomed houses respectively.

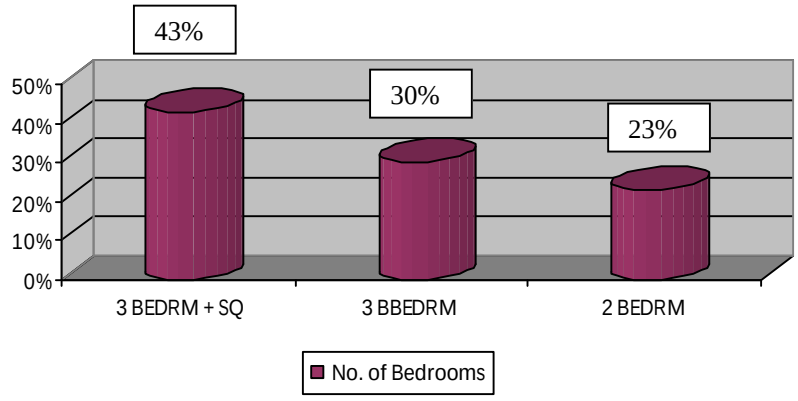
4.1.18 Number of storeys of the apartments

The study sought to find out the number of storeys of the apartments including ground floor in Kileleshwa. From the survey, 50% of the plots were 4 and 5 storey blocks of apartments, 37 % were higher than the recommended five storeys and one block has ten storeys. This illustrates increasing height to accommodate high density in Kileleshwa.

4.1.19 Sizes of apartments

From the survey, majority of the units were 3 bedroom apartments with separate servant's quarter at 43%, then 3 bedrooms without servants quarter at 30% while two bedroom apartments accounted for 23% of the surveyed units. This illustrates there is more supply of 3 bedroom apartments with separate servant's quarter.

Figure 4.10 Sizes of apartments

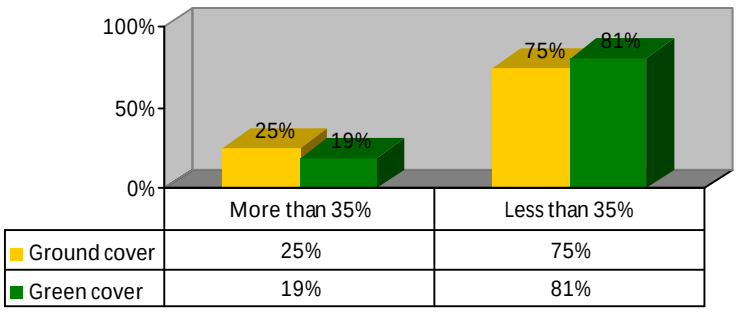


Source: Field survey, 2013

4.1.20 Ground coverage and Green cover

The study further sought to find out the Ground Coverage and amount of space left as Green Cover as a result of developments in the study area. The findings are provided in figure 4.11 below.

Figure 4.11 Ground coverage and Green cover



Source: Field survey, 2013

From the survey 75% of the plots had a G.C of less than 35% while 25% had a G.C. of more than the allowed 35%. However, most of the ground space is taken up by parking and impervious surface. 81% of the plots had a ground green cover of less than the recommended 35% and only 19% of the plots had a green cover of more than 35%. This illustrates that most of the ground space is being taken up by parking and impervious surface.

4.1.21 Plot Ratio

From the survey 84% of the plots had a P.R. of more than the allowed 100% while 16% had a P.R. of 100% and below. This illustrates increasing pressure on land as a result of increased built up space.

4.2 Nature of housing densification

4.2.1 Vertical densification

Densification in Kileleshwa is mainly characterized by highrise apartments to accommodate increased housing units per hectare. From the survey, 50% of the sampled plots were 4 and 5 storey blocks of apartments, 37 % were higher than the recommended five storeys and one block has ten storeys. This illustrates increasing height to accommodate high density in Kileleshwa. This can further be illustrated by analyzing transformation of land use of Plot No. 209/6491 along Mandera Road.

Plate 4.4 Redevelopment from single dwelling units to multi dwelling apartments

2009- BEFORE REDEVELOPMENT

Source: NHC 2011

2011- AFTER REDEVELOPMENT

Source: Author 2013

Table 4.8 Redevelopment of L.R.No. 209/6491

PARTICULARS	DESCRIPTION		
Apartments	Plot No. 209/6491	After Redevelopment 	Before Redevelopment 
	Plot Area (M2)	**14,253m2(1.4Ha)**	**14,253m2(1.4Ha)**
	Ground Cover	**4,012.68m2**	**1,250 m2**
	Total Built up Area	**20,063.4m2**	**1,250 m2**
	Total no. of houses	**105**	**5**
	Total no. of Storeys	**5**	**1**
Plot ratio-P.R	Council provision	After Redevelopment	Before Redevelopment
	100%	**141%**	**9%**
Ground Coverage-G.C	**35%**	**28%**	**9%**
Housing Density	**35units/ha** (under review)	**74units/ha**	**3.5units/ha**
			

Source: Adapted from NHC 2011

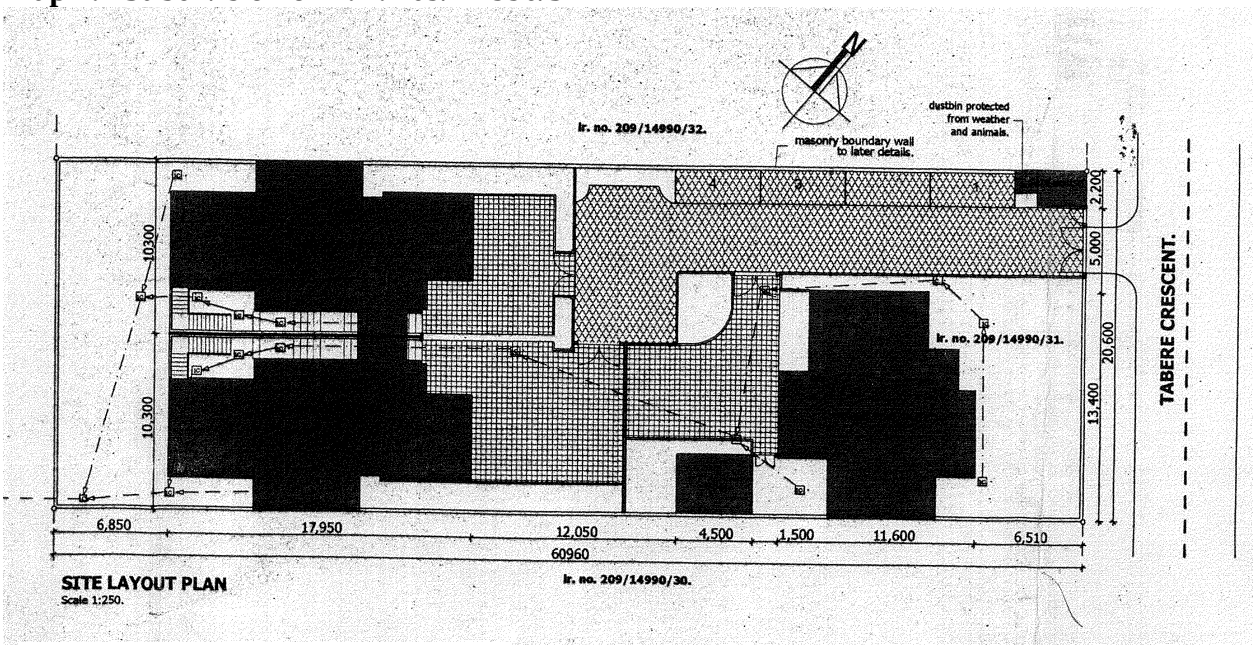
The increase in density from 3.5 to 74 units /ha. contributed 100 additional housing units.

From the survey, majority of the units were 3 bedroom apartments with separate servant's quarter at 43%, then 3 bedrooms without servant's quarter at 30% while two bedroom apartments accounted for 23% of the surveyed units. This illustrates there is more supply of 3 bedroom apartments with separate servant's quarter in the newly constructed apartment blocks.

4.2.2 Horizontal densification

This is where plots are subdivided and separate dwelling units constructed in parcels that were initially for single dwelling unit. From the survey 12.5 % of the surveyed plots had two or three storey town houses constructed on parcels initially occupied by single units.

Map 4.1 Subdivision of L.R. 209/ 14990/31



Source: Nairobi City Council 2013

4.2.3 Plots acreage

Study sought to find out the acreage of majority of plots in Kileleshwa.From the survey, 41% of the plots were ½ acre plots, 28 % were ¾ acre plots, 16% were ¼ acre plots while 15% were above one acre in size. This illustrates that there has been increased land subdivision in Kileleshwa to increase density.

4.2.4 Reasons behind rapid increase in housing density in Kileleshwa

The study further sought to find out the reasons behind rapid increase in housing density in Kileleshwa and the following reasons were highlighted; its close proximity to the CBD, availability of infrastructure like sewage and road network, low density area with large pieces of land and high property value due to its historical identity as an exclusive residential area. The growing middle class has also created demand for serviced residential area

CHAPTER 5
IMPACTS OF HOUSING DENSIFICATION

5.0 Introduction

This study sought to examine the physical and ecological impacts of the housing densification in Kileleshwa. A survey was carried out to assess the status, adequacy and challenges of accessing infrastructural facilities in the area, basic amenities, community facilities, and other emerging environmental issues. From the survey, the following challenges have arisen as a result of development in Kileleshwa; challenges in controlling developments, narrow and inadequate road networks, overwhelmed infrastructure systems such as piped water, sewerage lines, storm water drainage, illegal land subdivisions and changes in land use and increased water demand leading to drilling of boreholes. Other environmental challenges include illegal use and development on riparian reserves, noise and air pollution from construction sites and motor vehicles as well as increased generation of solid waste.

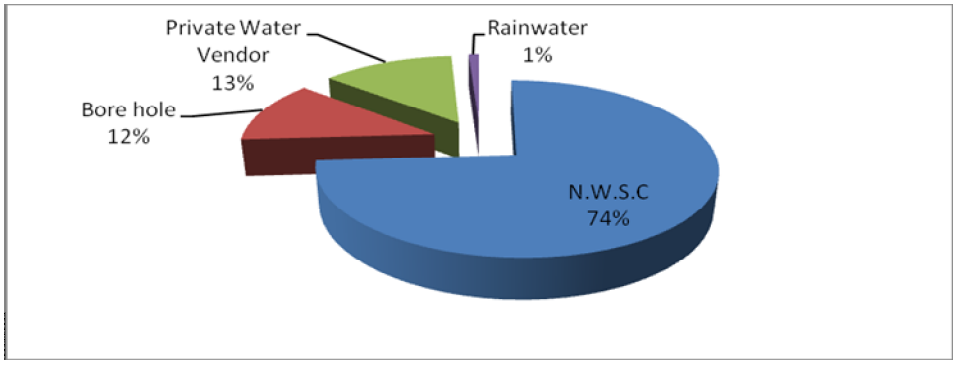
5.1 Water

Majority of the respondents indicated that households in Kileleshwa safeguard against water shortage through over head water storage tanks while others safeguarded against water shortage through underground water tanks and bore holes.

5.1.1 Sources of water

The study in this area sought to find out the Sources of Water in Kileleshwa. Findings are presented in figure 5.1 below.

Figure 5.1 Source of water



Source: Field survey, 2013

From the study findings, majority of the respondents (74%) indicated that Nairobi water and Sewerage Company was the source of water at Kileleshwa while 13% and 12% indicated that private water vendors and bore holes were the source of water at Kileleshwa. This implies that Nairobi water and Sewerage Company was the main source of water at Kileleshwa.

5.1.2 Water shortage

The study also sought to find out whether the households in Kileleshwa experienced Water shortages. Findings are presented in table 5.1 below.

Table 5.1 Water shortage

	Frequency	Percent
Yes	18	24.3
No	56	75.7
Total	**74**	**100.0**

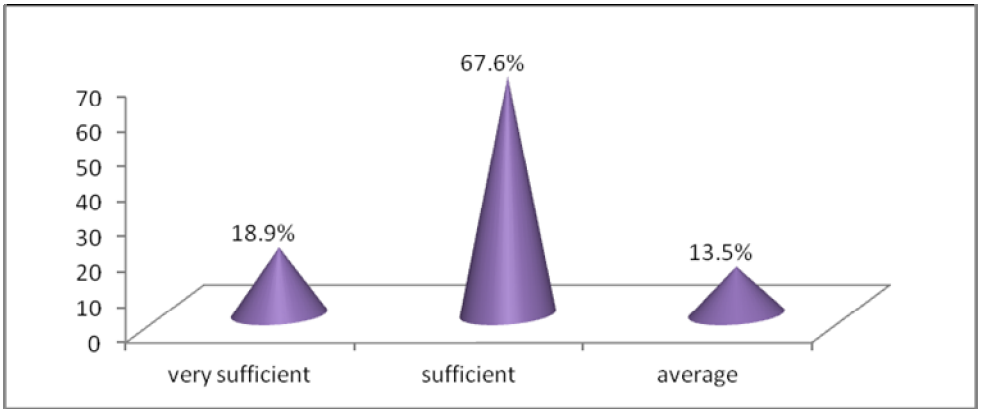
Source: Field survey, 2013

From the study findings of the study, majority of the respondents (75.7%) indicated that households in Kileleshwa do not experience water shortage.

5.1.3 Sufficiency of water supply

The study further sought to find out whether the households in Kileleshwa had sufficient water supply. Findings are presented in figure 5.2 below.

Figure 5.2 Sufficiency of water supply



Source: Field survey, 2013

From the study findings of the study, majority of the respondents (67.6%) indicated that households in Kileleshwa had sufficient water supply while 18.9% and 13.5% indicated that households in Kileleshwa had very sufficient and averagely water supply. This implies that there is sufficient water supply among the households in Kileleshwa.

5.1.4 Safeguard against water shortage

The study also sought to find out how the households in Kileleshwa safeguard against Water shortage. Findings are presented in table 5.2 below.

Table 5.2 Safeguard against water shortage

	Frequency	Percent
Over head water storage tanks	58	78.4
Underground water tanks	9	12.2
Bore holes	7	9.5
Total	**74**	**100.0**

Source: Field survey, 2013

From the study findings of the study, majority of the respondents (78.4%) indicated that households in Kileleshwa safeguard against water shortage through over head water storage tanks while 12.2% and 9.5% safeguarded against water shortage through underground water tanks and bore holes respectively. This implies that over head water storage tanks were used to safeguard against water shortage among the households in Kileleshwa.

5.2 Storm water drainage

Increased development and expansion of impervious surface layer has led to increased storm water generation and flooding. This is aggravated by development on riparian reserves particularly along Kirichwa Ndogo and Kirichwa Kubwa rivers.

Plate 5.1 Paved surface for parking and play

Source: Author 2013

Plate 5.2 Encroachment on Kirichwa Kubwa riparian reserve

Source: Author 2013

Plate 5.3 Boundary wall destroyed by flooded Kirichwa Ndogo river

Source: Author 2013

5.3 Transport system

5.3.1 Traffic congestion

From the findings of the study, majority of the respondents (55.4%) indicated that there were traffic congestions on roads in Kileleshwa while 44.6% indicated that there were no traffic congestions on roads in Kileleshwa. This implies that that there were traffic congestions on roads in Kileleshwa. From the findings of the study, majority of the respondents (77%) indicated that they experienced the highest level of traffic congestions from 7-8 AM while (13.5%) indicated that they experienced the highest level of traffic congestions from 5-6 PM. This implies that roads in Kileleshwa experienced the highest level of traffic congestions from 7-8 AM and 5-6 PM when many people are going to and from their workplace/ business place. Most of the respondents (42.4%) further indicated that increase in the number of vehicles was the major cause of traffic congestions on roads in Kileleshwa while 41.1% cited that inadequate roads were the causes of traffic congestions on roads in Kileleshwa. This implies that increase in the number of vehicles and inadequate roads were the major cause of traffic congestions on roads in Kileleshwa.

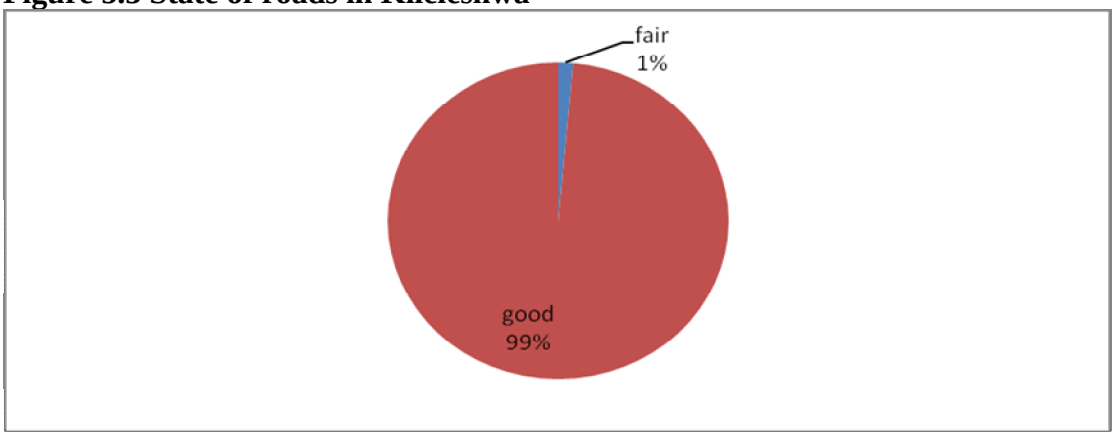
Plate 5.4 Traffic on the newly constructed link road

Source: Author 2013

5.3.2 State of roads in Kileleshwa

The study sought to find out the state of roads in Kileleshwa. Findings are presented in figure 5.3 below.

Figure 5.3 State of roads in Kileleshwa



Source: Field survey, 2013

According to the findings, majority of the respondents (99%) indicated that the state of roads in Kileleshwa was good. This was attributed to the recent upgrading of the roads in the area and construction of the missing link road from Chiromo to Yaya Centre.

5.3.2 Traffic congestion

The study further sought to find out whether there is traffic congestion on roads in Kileleshwa. Findings are presented in table 5.3 below.

Table 5.3 Traffic congestion

	Frequency	Percent
Yes	41	55.4
No	33	44.6
Total	**74**	**100.0**

Source: Field survey, 2013

From the findings of the study, majority of the respondents (55.4%) indicated that there is traffic congestion on roads in Kileleshwa while 44.6% indicated that there is no traffic congestion on roads in Kileleshwa. This implies that there is traffic congestion on roads in Kileleshwa.

5.3.3 Time when traffic congestions are high

The study also sought to find out the time when roads in Kileleshwa experienced the highest level of traffic congestion. Findings are presented in table 5.4 below.

Table 5.4 Time when traffic congestion is high

	Frequency	Percent
7-8 am	57	77.0
8-9 am	7	9.5
5-6 pm	10	13.5
Total	**74**	**100.0**

Source: Field survey, 2013

From the findings of the study, majority of the respondents (77%) indicated that they experienced the highest level of traffic congestion from 7-8 AM while (13.5%) indicated that they experienced the highest level of traffic congestion from 5-6 PM. This implies that roads in

Kileleshwa experienced the highest level of traffic congestion from 7-8 AM and 5-6 PM when many people are going to and from their workplace/ business place.

5.3.4 Causes of traffic congestion

The study also sought to find out the causes of traffic congestion on roads in Kileleshwa. Findings are presented in table 5.5 below.

Table 5.5 Causes of traffic congestion

	Frequency	Percent
Increase in the number of vehicles	64	42.4
Poor states of roads	25	16.6
Inadequate roads	62	41.1

Source: Field survey, 2013

From the findings of the study, most of the respondents (42.4%) indicated that increase in the number of vehicles was the major cause of traffic congestion on roads in Kileleshwa while 41.1% cited that inadequate roads were the causes of traffic congestion on roads in Kileleshwa. This implies that increase in the number of vehicles and inadequate roads were the major causes of traffic congestion on roads in Kileleshwa.

5.3.5 Facility to minimize use of private vehicles in the estate

The study also sought to establish the most important facility that would minimize use of private vehicles in Kileleshwa estate. Findings are presented in table 5.6 below.

Table 5.6 Facility to minimize use of private vehicles

	Frequency	Percent
Provide efficient public transport system	36	48.6
Provide rail services	34	45.9
Provide safe and secure pedestrian lanes	4	5.4
Total	**74**	**100.0**

Source: Field survey, 2013

From the findings of the study, most of the respondents (48.6%) indicated that providing efficient public transport system would be the most important facility that would minimize use of private vehicles in Kileleshwa estate while 45.9% indicated that provide rail services would be the most important facility that would minimize use of private vehicles in Kileleshwa estate. This implies that providing efficient public transport system and rail services would be the most important facilities that would minimize use of private vehicles in Kileleshwa estate.

5.4 Power shortage

On the challenges facing the residence of Kileleshwa in accessing and utilizing sources of energy, most of the respondents indicated that there were frequent power blackouts in the area. This was occasioned by overloaded transformers which have not been upgraded to accommodate the increased electricity demand.

5.4.1 Type of energy used for domestic purposes

The study also sought to find out the type of energy used for domestic purposes among households in Kileleshwa. Findings are presented in table 5.7 below:

Table 5.7 Type of energy used for domestic purposes

	Source	Cooking	Lighting	Cost per month
Electricity	KPLC	48.6	99.1	Ksh 1500-2500
Kerosene	Total	5.4	18.9	Ksh 500-1200
Charcoal	Vendors	20.3	0.0	Ksh 500-1200
LPG gas	Total	96.2	5.6	Ksh 1500-2500
Bio gas	N/A	23.0	1.2	Ksh 500-1200
Firewood	N/A	0.0	0.0	N/A
Wind	N/A	0.0	0.0	N/A
Solar	N/A	0.0	36.2	N/A

Source: Field survey, 2013

From the study findings of the study, majority of the respondents (99.1%) indicated that households in Kileleshwa use electricity from Kenya Power and Lighting Company for lighting

at a monthly cost of between Ksh 1500-2500 while 96.2% of the households in Kileleshwa use LPG gas for cooking at a monthly cost of between Ksh 1500-2500. This implies that households in Kileleshwa use electricity from Kenya Power and Lighting Company for lighting and LPG gas from Total Kenya for cooking. On the challenges facing the residence of Kileleshwa in accessing and utilizing sources of energy, most of the respondents indicated that there were frequent power blackouts in the area. This was associated with persistent breakdown of the transformer that serves the area.

5.5 Community facilities

Facilities initially meant for lower population have not been upgraded to accommodate the increased population. These include facilities like schools, shopping centre, fresh produce markets and health facilities. The study sought to find out the challenges facing the residence of Kileleshwa in accessing the facilities. Most of the respondents indicated that they had challenges in taking their children to school and later going back to their houses to attend to other duties due to traffic jam, others felt some facilities like the hospitals were far, and there was shortage of fresh produce in the nearby retail centre. Kasuku shopping centre is the only shopping facility in the neighbourhood.

Plate 5.5 Kasuku Shopping Centre

Source: Author 2013

5.5.1 Distance and means to community facilities

The study sought to find out the distance from Kileleshwa to different facilities and the means used to get to these facilities. Findings are presented in table 5.8 below.

Table 5.8 Distance and means to community facilities

	Distance in KMs				Means of transport to the facility			
	0-1 km	**2-5 km**	**5-8 km**	**Over 80 km**	**walking**	**Cycling**	**Personal car**	**Psv**
Shopping center	83.8	5.4	8.1	2.7	39.1	14.9	12.2	33.8
Fresh produce markets	83.8	1.4	0.0	14.9	39.2	14.9	12.2	33.8
Nursery school	93.2	6.8	0.0	0.0	44.6	14.9	8.1	32.4
Primary school	81.1	12.2	2.8	4.1	40.5	14.9	8.1	36.5
Secondary school	51.4	35.1	5.5	8.1	6.8	14.9	12.2	58.1
Universities	29.7	56.8	9.5	4.1	8.1	14.9	18.9	58.1
Dispensary	62.2	28.4	1.4	8.1	8.1	14.9	18.9	58.1
Health center	51.4	46.6	0.0	0.0	8.1	14.9	18.9	58.1
Hospital	28.4	43.2	21.3	8.1	81.1	12.2	2.8	4.1
Social hall	35.1	40.5	16.3	8.1	51.4	35.1	5.5	8.1
Churches/mosques	66.2	32.4	1.4	0.0	29.7	56.8	9.5	4.1
Police post	73.0	14.9	8.1	4.1	62.2	28.4	1.4	8.1
Public play ground	33.8	43.2	8.1	14.9	28.4	43.2	21.3	8.1
Recreation	47.3	25.7	14.9	12.8	35.1	40.5	16.3	8.1

Source: Field survey, 2013

From the study findings, majority of the respondents (83.8%) indicated 0-1 Km as the distance from Kileleshwa to the Shopping center and fresh produce markets. 93.2% indicated that the distance from Kileleshwa to Nursery school was 0-1 Km while 81.1%, 73%, 66.2% and 51.4% indicated that the distance from Kileleshwa to Primary school, Police post, Churches/mosques, Dispensary and Health center was 0-1 Km respectively. 56.8% of the respondents further %

indicated that the distance from Kileleshwa to the Universities was 2-5 KMs. On the other hand, majority of the respondents (81.1%) indicated that they walks to the hospitals while 62.2% and 51.4% indicated that they walked to the police post and social hall respectively. 56.8% further stated that they walked to the Churches/mosques while 58.1% used public service vehicles from Kileleshwa to the Universities, Dispensary and Health centers. This implies that the distance from Kileleshwa to the Shopping center, fresh produce, Nursery school, Primary school, Police post, Churches/mosques, Dispensary and Health center was 0-1 Km. Further, majority of the respondent's walks to the hospitals, police post, social hall, Churches/mosques while others used public service vehicles from Kileleshwa to the Universities, Dispensary and Health centers.

5.5.2 Challenges in accessing the community facilities

The study sought to find out the challenges facing the residents of Kileleshwa in accessing the facilities. Most of the respondents indicated that they had challenges in taking their children to school and later going back to their houses to attend to other duties due to traffic jam, challenges with means of transport for those who use public service vehicle, insecurity at night mostly after 10 PM, some facilities were very far like the hospitals, there were shortage of fresh produce in the market sometimes and traffic jams.

5.6 Land use conflict

This was evident as a result of construction of apartment blocks on plots adjacent to schools and other low density development. This affects the aesthetic nature of the previously leafy suburb that is being replaced by concrete jungle of highrise apartment blocks. Lack of adequate strategic shopping centres has also caused mushrooming of shops, bars and restaurants adjacent to residential houses.

Plate 5.6 School adjacent to an apartment block along Kandara road

Source: Author 2013

5.7 Pollution

Construction sites are the major sources of dust and noise due to heavy construction machinery and debris. Fumes from the high number of motor vehicles also contribute to air pollution and increased generation of solid waste also end up polluting rivers and damaging the fragile ecosystem.

Plate 5.7 Polluted river basin

Source: Author 2013

5.8 Disposal of liquid waste

The study in this area sought to find out how households in Kileleshwa disposed the liquid waste. Findings are presented in table 5.9 below.

Table 5.9 Disposal of liquid waste

	Frequency	Percent
Nairobi water and Sewerage company	43	58.1
Septic tank	23	31.1
Pit latrine	8	10.8
Total	**74**	**100.0**

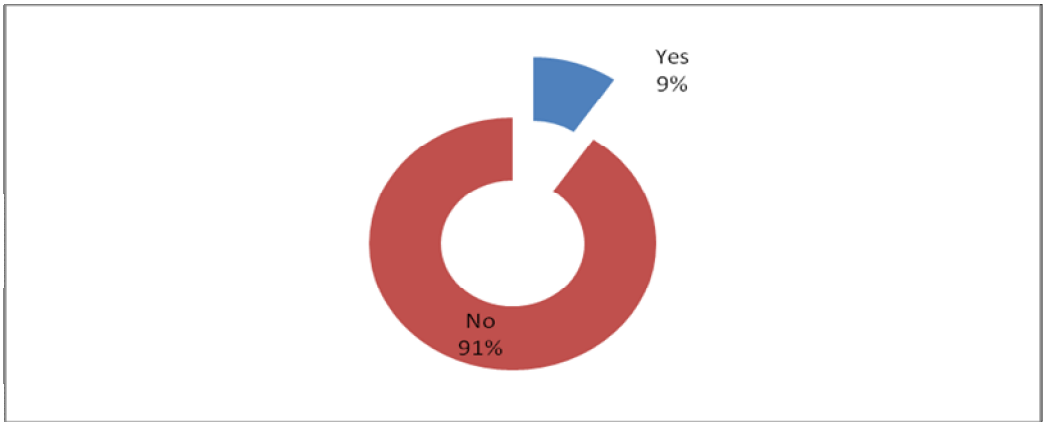
Source: Field survey, 2013

From the findings of the study, majority of the respondents (58.1%) indicated that households in Kileleshwa disposed the liquid waste through Nairobi water and Sewerage Company, 31.1% through Septic tank while 10.8% disposed the liquid waste through Pit latrine. This implies that Nairobi water and Sewerage Company and Septic tanks were used to dispose the liquid waste among the households in Kileleshwa.

5.8.1 Blockage of sewerage system

The study also sought to find out whether households in Kileleshwa experienced blockage of sewerage system. Findings are presented in figure 5.4 below.

Figure 5.4 Blockage of sewerage system



Source: Field survey, 2013

From the findings of the study, majority of the respondents (91%) indicated that households in Kileleshwa do not experience blockage of sewerage system.

5.9 Reduced ecological value of land

Environmental degradation arising from impacts of increased development on the area has reduced the ecological and aesthetic value of the previously low density residential area on large tracks of land.

Plate 5.8 Apartments in the study area

Along Kandara rd.

Along Ring rd.

Along Olenguruone Avenue

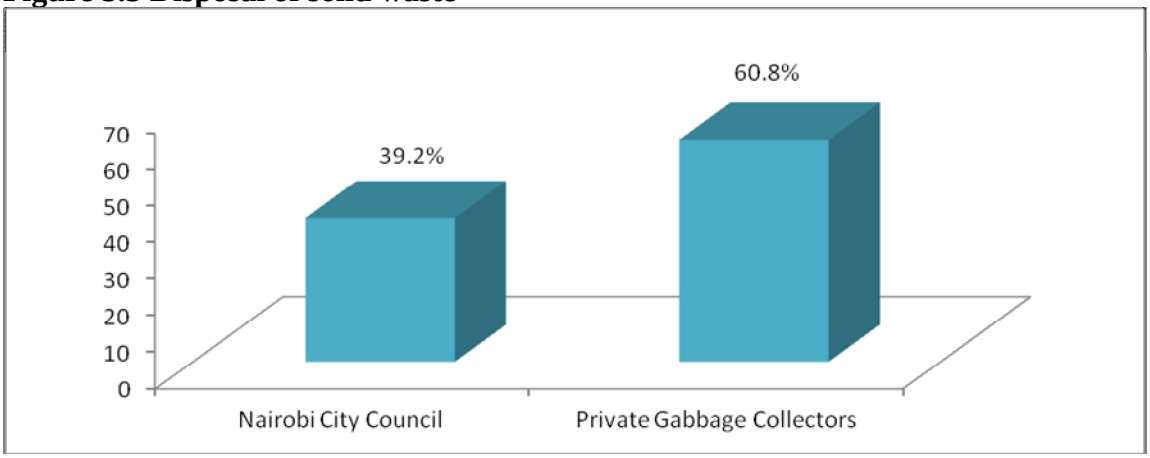
Source: Author 2013

5.10 Solid Waste

5.10.1 Disposal of Solid Waste

The study sought to find out how households in Kileleshwa disposed the solid waste. Findings are presented in figure 5.5 below.

Figure 5.5 Disposal of solid waste



Source: Field survey, 2013

From the findings of the study, majority of the respondents (60.8%) indicated that households in Kileleshwa disposed the solid waste through private garbage collectors while 39.2% disposed the solid waste through Nairobi City Council. This implies that private garbage collectors were used to dispose the solid waste among the households in Kileleshwa.

5.10.2 Efficiency of the waste collection services

The study further sought to find out how the respondents rated the waste collection services in Kileleshwa. Findings are presented in table 5.10 below.

Table 5.10 Efficiciency of the waste collection services

	Frequency	Percent
Fair	26	35.1
Good	39	52.7
Very good	9	12.2
Total	**74**	**100.0**

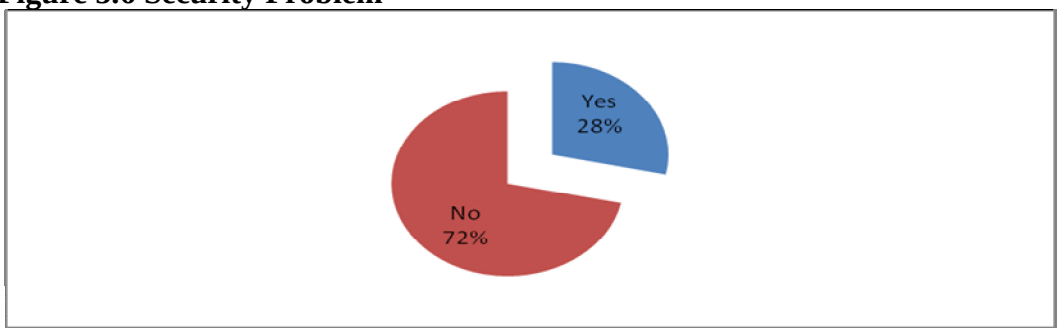
From the findings of the study, majority of the respondents (52.7%) rated waste collection services in Kileleshwa as being good, 35.1% rated the services as fair while 12.2% rated the services as being very good. This implies that waste collection services in Kileleshwa are good.

5.11 Security

5.11.1 Security Problem

The study in this area sought to establish the whether the respondents had experienced any security problems since they occupied the house they live in. Findings are presented in figure 5.6 below.

Figure 5.6 Security Problem



Source: Field survey, 2013

From the findings of the study, majority of the respondents (72%) indicated that they had not experienced any security problems since they occupied the house they live in while 28% indicated that they had experienced security problems since they occupied the house they live in. This implies that the residents had not experienced any security problems since they occupied the house they lived in. For those who had experienced security problems, the study found out that break in and carjacking were the most experienced security problems in the estate.

5.12 Livability

The study in this area sought to find out how the residents rated the provision of facilities which affects livability in residential environment. The responses were rated on a five point Likert scale where: 1 – Very good 2 – Good 3 – Fair 4- Poor and 5- Very poor. Findings are presented in table 5.11 below.

Table 5.11 Provision of facilities to improve livability

	Mean	Std. Deviation
Ventilation	4.57	0.773
Natural lighting of the rooms	4.53	0.789
Room size	4.27	0.588
Internal thermal comfort/temperature	4.37	0.681
Parking space	4.23	0.952
Open green space	4.00	1.232
Children play area	4.23	0.917
Safety guard rails (in walk ways, stairs, terraces, balconies	2.43	1.209

Source: Field survey, 2013

From the study findings, majority of the respondents indicated that ventilation was very good as shown by the mean score of 4.57, natural lighting of the rooms, Internal thermal, Room size,

Parking space, Children play area and Open green space were good as shown by the mean scores of 4.53, 4.37, 4.27, 4.23 and 4.00 respectively. However, safety guard rails (in walk ways, stairs, terraces, balconies provision were inadequate as indicated by a mean score of 2.43.

5.12.1 Facilities to enhance accessibility and safety

The study also sought to find out whether the following facilities to enhance accessibility and safety were provided in Kileleshwa. Findings are presented in table 5.12 below.

Table 5.12 Facilities to enhance accessibility and safety

	Yes	No
Access for people with disability	21.6%	78.4%
Lift	1.2%	98.8%
Fire fighting equipments	84.1%	15.9%
Internet/ data	54.9%	45.1%
Central/ aerial TV	32.4%	67.6%
CCTV	55.4%	44.6%%

Source: Field survey, 2013

From the study findings, majority of the respondents (78.4%) indicated that buildings in Kileleshwa does not allow access for people with disability, 98.8% cited that buildings in Kileleshwa do not have lifts while 84.1% indicated that buildings in Kileleshwa have fire fighting equipments. Further, 54.9% of the respondents indicated that buildings in Kileleshwa had Internet/ data, 67.6% indicated that buildings in Kileleshwa do not have Central/ aerial TV while 55.4% of the buildings in Kileleshwa had CCTV. This implies that majority buildings in Kileleshwa do not allow access for people with disability, lifts, do not have Central/ aerial TV but have fire fighting equipments, Internet/ data and CCTV.

CHAPTER 6
ROLE OF GREEN DESIGNS AND STRATEGIES IN SUSTAINABLE DENSIFICATION

6.0 Green designs and strategies in development projects

The study found out that sustainable communities should be filled with green structures, which can be typically promoted through green design regulations or guidelines. Unfortunately, there are no clear guidelines for regulatory authorities to enforce comprehensive green design regulations at development approval stage and during construction.

From the interview conducted, protection of existing green spaces according to Nairobi City Council's Forward planning department is addressed by ensuring development permits are only issued to those who have observed the requisite greenery. Minimizing excess (impervious) paving is addressed through encouraging land scaping and planting flowers, while use of green infrastructure is addressed through encouraging environmental friendly technologies. Minimizing energy use is addressed through encouraging energy saving lamps, solar panels and use of natural lighting while waste management is addressed through leasing recycling companies and waste collectors. The responses are indicated in table 6.1.

6.1 Key objectives

Some key objectives of green strategies were identified as below:

6.1.1 Energy efficiency

Sustainable housing development should address energy efficiency through strategies such as energy efficient technologies and appliances, use of natural day lighting, good ventilation and good thermal insulation of building components (walls, windows, roof etc). Use of renewable energy sources like solar panels for heating and lighting as well as use of solar walls should be encouraged.

Passive design strategies should be employed to enhance energy use in buildings. These include shape of the building and orientation to maximize day lighting. Use of light colours should also be maximized for roofing and wall finish to control excessive solar heating thereby reducing the need for mechanical cooling.

Table 6.1 How green strategies are addressed in development projects

Strategy	Response from	
	City Council of Nairobi	**NEMA**
1) Protection of existing green spaces	Development permits are issued to those who have observed the requisite greenery	Objecting to any proposed projects on these spaces
2) Minimizing excess (impervious) paving	Encouraging landscaping with more greenery	Encouraging landscaping with more greenery
3) Use of green infrastructure (Green ecoroofs, green walls, tree planting).	Encouraged	Advising on environmentally friendly technologies
4) Minimizing water use		
5) Minimizing energy use	Encouraging use of natural light by large windows	Encouraging energy saving lamps and solar panels
6) Minimizing private car usage	Encouraging public transport	Hard to manage
7) Waste management (Reduce, Reuse and Recycling strategies)	Encouraging recycling of waste	Licensing recycling companies and waste collectors
8) Storm water control	Reduction of paved areas and tree planting	Roof harvesting and design of storm drains
9) Protection of green corridors and riparian reserves	-Enforcement of riparian laws	Allowing development at least 30 meters from the riparian line

Source: Field study, 2013

The study sought to find out how the Nairobi City Council and National Environment Management Authority (NEMA) ensure energy efficiency in buildings in Kileleshwa. From the findings of the study, the regulatory bodies encourage large windows and use of energy saving lighting bulbs as a way of addressing energy efficiency. Solar panels are also encouraged.

Majority of the respondents (99.1%) indicated that households in Kileleshwa use electricity for lighting at a monthly cost of between Ksh 1500-2500 while 96.2% of the households in Kileleshwa use LPG gas for cooking at a monthly cost of between Ksh 1500-2500. This implies

that households in Kileleshwa use electricity for lighting and LPG gas for cooking. Most of the respondents however indicated that there are frequent power blackouts in the area. This therefore means that strategies to reduce energy use by encouraging alternative sources of energy are not effective in Kileleshwa.

6.1.2 Sustainable water management

Green buildings should be designed to use water efficiently by managing waste water for reuse, using water efficient plumbing devices and rainwater harvesting. Water consumption should also be minimized by matching quality with end use. Gray water should be collected separately from black water and recycled on site for use such as landscape irrigation and cleaning.

From the study findings, majority of the respondents (74%) indicated that Nairobi Water and Sewerage Company was the source of their water, and that the supply was sufficient according to 67.6% of the respondents. However majority of residents (78.4%) use overhead water storage tanks to safeguard against water shortage. Others also source for the commodity from private water vendors and bore holes. From interviews with the regulatory authorities, there are no mechanisms to ensure residents use the scarce water resources sustainably, neither is there requirement for separation of gray water from black water.

6.1.3 Protection of green spaces

Sustainability goals associated with green open spaces include cutting green house gas emission, creating rich neighbourhood for play and recreation and improvement of air quality. Green space also helps to control flooding by allowing water infiltration to replenish underground aquifers.

Protection of open space is usually done using Ground Coverage (G.C.) ratio to regulate the proportion of the plot that is built up. From the survey 75% of the plots had a G.C that is within the allowed 35%. However, most of the ground space is taken up by parking and impervious surface. The study further found out that 81% of the plots had a ground green cover of less than the recommended 35%. This illustrates that most of the ground space is being taken up by parking and impervious surface.

6.1.4 Green infrastructure

Green infrastructure comprises natural and designed systems and elements of a city or development that function in ways similar to natural processes in managing air, water, microclimatic and energy resources. These include trees, open spaces, lawns, parks and all places that have water pervious surfaces and soil to support plant material. The role of green infrastructure includes; air quality improvement, micro climate regulation, and storm water management and recreation opportunities. Green infrastructure can be enhanced by greening roads, having planted round abouts, use of green walls, eco-roofs, and use of porous paving material.

Vertical densification and cluster development that involves placing buildings together and leaving large open space rather than housing units sprawling across the plot can greatly reduce infrastructure costs such as paving as well as create adequate green open space.

NEMA and Nairobi City Council reported encouraging green infrastructure and environmentally friendly technologies. There is however lack of a framework to facilitate compliance. There are no requirements for developers to install green walls, green roofs or use porous paving materials for roads and parking areas.

6.1.5 Green construction materials

Renewable construction materials should be used rather than non-renewable materials. Energy invested in the production of materials should be valued. Use of locally available materials saves energy and resources in transportation. It is also important to design for long life and easy eventual recycling of material constituents. Reuse and recycling of construction and demolition materials should be promoted.

From interviews with the regulatory authorities, there are no mechanisms to ensure residents use renewable or local construction materials. Though recycling of waste is encouraged by the City Council, there are no mechanisms for enforcement of the same.

6.1.6 Waste management

An effective waste management strategy should ensure that waste generated in a facility is recycled for reuse or recycled back into the environment through biodegradation. Use of products that minimize waste and are non toxic should be encouraged. Waste should also be sorted at source and convenient bins provided to separate biodegradable and recyclable materials from other waste.

From the findings of the study, majority of the respondents (60.8%) indicated that households in Kileleshwa disposed the solid waste through private garbage collectors while 39.2% disposed the solid waste through Nairobi City Council. Separate bins for different types of wastes are however not provided.

Observation on site and interviews with built environment professional however showed there is lack of capacity to enforce the necessary green strategies as envisioned by NEMA and city council. Existing green spaces are rapidly disappearing and the area slowly transforming into concrete jungle. The more construction takes place the more the creation of impervious surfaces. Use of Ground Coverage regulation as a tool to ensure adequate site greenery has also failed since the open undeveloped space is taken up by paved walking and parking spaces. The authorities also lack legal instruments to ensure green infrastructure, minimize water use, minimize energy use, and minimize private car use. This indicates the need to come up with clear regulations to operationalise green strategies for sustainable development.

6.2 Role of NEMA and Nairobi City Council in development

The study sought to find out the role of National Environmental Management Authority and Nairobi City Council, now under Nairobi County Government in regulating and guiding development in the city. From the findings, Nairobi City Council formulates development policies and enforces development control by reviewing and issuing development permits. National Environmental Management Authority (NEMA) undertakes regulatory responsibilities on sustainable development through Environmental Impact Assessment and monitoring compliance to environmental regulations.

6.2.1 Efficiency in achieving organizational goals

The study further found out that National Environmental Management Authority and Nairobi city council have not fully achieved their goals due to challenges like inefficient development control and resistance by developers to comply with regulations and guidelines. Other challenges faced by National Environmental Management Authority and Nairobi City Council in enforcing and ensuring adherence to environmental standards were highlighted as; ignorance of members of the public on development procedures, overlapping mandates with different stakeholders and low funding for regulatory agencies for adequate monitoring and follow up on ongoing developments.

6.2.2 Enforcement of the environmental guidelines and regulations in Kileleshwa

The study in this area sought to find out how the National Environmental Management Authority and Nairobi City Council rated the Enforcement of the environmental guidelines and regulations in Kileleshwa. From the findings of the study, majority of the respondents (89%) stated that guidelines and regulations in Kileleshwa have been partially enforced due to lack of adequate man power to monitor and control development and lack of financial support to upgrade the existing services.

6.3 Zoning and planning guidelines and regulations in Kileleshwa

The study further sought to find out whether the current zoning and planning guidelines and regulations in Kileleshwa were sufficient to safeguard against the negative impacts of development in the area. From the findings, the current zoning and planning guidelines and regulations in Kileleshwa were not sufficient to safeguard against the negative impacts of development in the area due to the fact that development tread is faster than the guiding policies and regulations and slow enforcement of development regulations due to lack of adequate manpower.

6.4 Satisfaction with the current housing development

The study also sought to establish in general whether the residents were satisfied with the current housing development in Kileleshwa. From the findings of the study, all of the respondents (100%) indicated that they were satisfied with the current housing development in Kileleshwa due to; building which are well spaced and good security in the area, good ventilation in the

houses, availability of the facilities like garbage collection, water, lighting and access to facilities like shopping malls, hospitals and schools. This illustrates that on the overall, the residents of Kileleshwa are satisfied with ongoing development but there is an expressed need to come up strategies to reduce the impacts of the developments.

CHAPTER 7
SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

7.1 Synthesis

The study found out that Kileleshwa has experienced rapid densification over the years. The area which at independence was an exclusive European housing zone characterized by low density and high income single dwelling units has changed rapidly over the last few years with noticeable change from low density high income housing to medium income high density residential neighbourhood characterised by walk up apartments and office blocks. The current housing densification trend is therefore mainly vertical in nature though there are some that take horizontal character.

The study found out that the close proximity of Kileleshwa to Nairobi Central Business District, security and availability of infrastructure are the main factors contributing to people migrating to Kileleshwa. Majority of residents are in the middle age group of between 30- 40 years with at least a graduate degree. This means the residents have sufficient knowledge about planning and environmental matters affecting them. Further, the study found that most residents have young families with children who are aged between 0-5 years of age. Adequate provision of schools, hospitals, recreation areas and children play areas is therefore an important priority for Kileleshwa.

Further, the study found out that the increased housing density has significant physical and ecological impacts. These include; water shortage, power black outs, traffic congestion, land use conflicts, insufficient community facilities, encroachment on riparian reserves, pollution, and increased storm water generation. The existing infrastructure, commercial and community facilities that were designed for low density land use have not been expanded to accommodate the increasing density which stands at 883 households per sq. Km.

The study also endeavored to investigate the extent to which green designs and strategies can be used to mitigate negative impacts of densification process. Strategies aimed at enhancing energy efficiency, sustainable water management, protection of green spaces, use of green infrastructure and construction materials and sustainable waste management should be used to sustain low

impact housing densification. However the study found out that the City council and NEMA lack sufficient legal, financial and human capacity to enforce the necessary green designs and strategies. Most of the existing ground spaces are taken up by paving and impervious surface leaving insufficient green spaces and play areas. This means the Ground Coverage ratio fails to protect the fragile green spaces or minimize excess (impervious) paving. Encroachment on riparian reserves is evident from the study findings, as well as flooding due to lack of effective storm water control strategies.

The study further found that there are no requirements for developers to use green infrastructure (Green ecoroofs, green walls, tree planting) and also the regulatory authorities, lack mechanisms to ensure residents use the scarce water resources sustainably. Strategies to reduce energy use by encouraging alternative sources of energy are also not effective in Kileleshwa.

The study found that regulatory authorities also lack capacity to minimize use of private motor vehicles. Traffic congestion is therefore experienced particularly from 7-8AM and 5-6PM. Further, the regulatory authorities also lack mechanisms to ensure residents use renewable or local construction materials, or ensure efficient waste management strategies through waste reduction, separation, reuse and recycling of waste.

The study further found out that, the current zoning and planning regulations in Kileleshwa are not sufficient to safeguard against the negative impacts of development in the area. This is due to the fact that sufficient integration of policies and guidelines for green designs within the development control framework is lacking.

Lastly, the housing densification in Kileleshwa has a positive implication of increasing housing stock in the area. From the study, the residents positively identify with the ongoing development and majority expressed satisfaction with the current housing development in Kileleshwa. However, but there is an expressed need to integrate green strategies to reduce the negative impacts of the developments.

7.3 Conclusion of the study

This study sought to investigate strategies for sustainable housing densification. To achieve this, the study pursued the general objectives to determine the extent and nature of housing densification in Kileleshwa, Nairobi and examine the related impacts of the densification process. The study also sought to investigate the extent to which integration of green designs and strategies can be advanced to achieve sustainable housing densification. The study pursued the argument that the current housing densification in Kileleshwa is unsustainable and requires alternative low impact strategies.

To achieve this, the study got data from secondary and primary sources. The study established that Kileleshwa has experienced rapid transformation over the years from low density single dwelling units on large pieces of land to high rise multiple user apartments mostly inhabited by middle age and middle income residents with young families.

The study also established that close proximity of Kileleshwa to Nairobi Central Business District, as well as security and availability of infrastructure are the main factors contributing to people migrating to Kileleshwa.

The study also established that the rapid housing densification has significant physical and ecological impacts. These negative impacts include water shortage, intermittent power supply, traffic congestion, land use conflicts, insufficient community facilities, encroachment on riparian reserves, pollution, and increased storm water generation. There is however the positive impact of increasing the area housing stock.

The study also established that green designs and strategies can be used to mitigate negative impacts of densification process. These are strategies aimed at enhancing energy efficiency, sustainable water management, protection of green spaces, use of green infrastructure and construction materials and sustainable waste management. However the regulatory authorities lack sufficient legal, financial and human capacity to enforce the necessary green designs and strategies. There is lack of efficient mechanisms to protect the fragile green spaces, minimize excess paving, prevent encroachment on riparian reserves, prevent flooding, use green infrastructure, ensure residents manage water resources sustainably or use energy efficiently.

The study further established that, the current legal instruments are not sufficient to safeguard against the negative impacts of development in the area. This is because integration of policies and guidelines for green designs and strategies within the development control framework is lacking.

Lastly, the study established that the residents are satisfied with the current housing development in Kileleshwa, but expressed the need to integrate strategies to reduce the negative impacts of the developments.

7.4 Recommendations of the study

The study established that the rapid housing densification in Kileleshwa has significant physical and ecological impacts. Further, it was established that green designs and strategies can be used to mitigate negative impacts of densification process. However, integration of policies and guidelines for green designs and strategies within the development control framework is lacking. The current legal instruments are also not sufficient to safeguard against the negative impacts of development in the area. Consequently, the following recommendations are proposed to be integrated within the new building code which is still in draft format. These are intended to guide development in Kileleshwa and also provide general policy guidelines to ensure sustainable housing densification in Kenya.

7.4.1 Density regulation

The study recommends that the Nairobi County Government should streamline development control in Kileleshwa and ensure strict enforcement of planning regulations. Adequate man-power to monitor and control development should also be provided. The number of housing units allowed per hectare should be clearly provided for all upcoming high-rise apartments and not rely on Plot Ratio to generate the density.

7.4.2 Green spaces

There should be a clear definition of green ground cover and paved ground cover. Green ground cover should not be less than 30%. Porous paving materials should also be used for onsite parking and planted grass to increase greenery. Estate service charges should also used for

greening roads through tree planting, landscape and lawn maintenance. Environmental Impact Assessment and monitoring should also be done strictly for all upcoming development.

7.4.2 Infrastructure upgrading

The government should further provide adequate funds to improve the infrastructure services in the area. Road network within the estate should be expanded to reduce the traffic jams and facilities for piped water and sewer lines upgraded as well. Safe and secure pedestrian and bicycle lanes to encourage non-motorized transport modes should be provided and strategies put in place to streamline public transport service.

7.4.3 Green infrastructure

Sufficient amount of trees and green cover should be provided to be not less than 30% of the plot and strictly enforced. Perimeter walls should also incorporate green design for climbers and other green cover. Roof covers for buildings, walkways and parking spaces should be eco roof to regulate micro climate.

7.4.4 Efficiency in water use

Rainwater harvesting and collection of surface runoff for pavement cleaning and gardening irrigation should be incorporated in development proposals and strictly enforced. Gray water should also be collected separately from black water.

7.4.5 Efficiency in energy use

Sufficient natural and day lighting in building design should be provided and the building code strictly enforced with regard to siting of building away from adjacent boundary walls or other buildings to ensure adequate clearance for lighting and ventilation. Harnessing of solar power for water heating, street lighting and other domestic use should also be incorporated in development proposals. The building mass should also use reflective materials and bright colours for roof and wall to reduce heat gains and losses in building. Use of energy efficient appliances and energy saving lamps should also be promoted through sensitization and public awareness.

7.4. 6 Transport system

The Nairobi County Government should provide an efficient fixed schedule-fixed route public transport system to reduce on use of private car usage. This will reduce traffic congestion and pollution and energy consumption associated with private motor vehicles. Further to that,

adequate, secure and well lit lanes for pedestrians and other non-motorized transport modes should be provided in all the roads in Kileleshwa to increase permeability and mobility in the area.

7.4. 7 Waste management

Development proposals should integrate use of renewable and recyclable materials as much as possible to minimize waste. Waste collection companies should provide facilities for disposing different wastes separately. Organic waste should be separated for onsite garden use while reusable and recyclable waste should be dispatched to recycling companies. More recycling companies should be licensed and given tax and other incentives to encourage environmental conservation.

7.4. 8 Storm water control

Paved areas should be reduced and trees planted to control surface run off. This should be done by enforcing the minimum green ground cover. Proposals for rainwater harvesting should also be incorporated in development proposals. Adequate finances should also be provided by the government for greening roads through tree planting and maintenance of green ground cover on road reserves. Storm water drainage channels should be cleaned and well maintained and riparian laws fully enforced to protect fragile wetlands.

7.4.9 Land use conflict

A development plan should be prepared for Kileleshwa considering current population growth and emerging land uses to determine broadly feasible structure of land use pattern for the area. This should cover adequate provision for residential, commercial, public purpose, recreation, education and roads requirements for a long term period of up to 2030. Missing facilities like shopping centre, schools, health centre and community social halls should be provided to avoid land use conflict.

The study further recommends that the government should facilitate more housing to accommodate the increasing urban population and reduce congestion in the cities and residential estates.

Table 7.1: Proposed Sustainable Housing Densification strategies

Proposed Sustainable Housing Densification strategies			
Goals	**Strategy**	**Action**	**Actor**
1) Protection and expansion existing green spaces	- Clear definition of green ground cover and paved ground cover- Green ground cover should not be less than 30% -Porous paving materials to be used for onsite parking. At least 50% of onsite parking to be of porous materials -Estate service charges to be used for greening roads through tree planting, lawn maintenance and drainage cleaning. -Environmental Impact Assessment and monitoring to be done strictly for all upcoming development.	-Green ground cover should not be less than 30%. - At least 50% of onsite parking to be of porous materials. -Ensure clean/well maintained estate roads, lawns, channels. -EIA Licenses to be issued prior to commencement.	-Nairobi County Government /NEMA ” -Nairobi County Government /KARA -NEMA
2) Minimizing excess (impervious) paving	-Encouraging landscaping with more greenery - Clear definition of green ground cover and paved ground cover -Porous paving materials to be used for onsite parking -Parking areas to be covered with green roof slabs/covers	-Green ground cover should not be less than 30% - At least 50% of onsite parking to be of porous materials, -Green roofs to be used as trade off for less green ground cover so long as no green cover less than 20% is allowed.	-Nairobi County Government -NEMA
3) Use of green infrastructure (Green ecoroofs, green walls, tree planting).	-Perimeter walls to be made green walls -Green roofing materials to be used such as ecoroofs	-Use of live fence to be encouraged. Solid perimeter walls beyond 1.2m height to be made green with climbers and wall shrubs. - Green roof as above.	-Nairobi County Government /NEMA
4) Minimizing water use	-Reduce water consumption by installing efficient fixtures and outlets, -Collect rainwater and surface runoff for gardening and irrigation, - Collect gray water separately from black water,	-Use of efficient fixtures to be encouraged-public awareness -Underground water storage equivalent to 200gullons per dwelling unit as approval condition.	-Nairobi County Government /NEMA

5) Minimizing energy use	-Use efficient equipment/ appliances, energy saving lamps to reduce energy demand. -Ensure sufficient natural day lighting in building design; large windows and strictly enforcing building code. -Install appropriate energy storage to buffer intermittent production of energy. -Harness solar power for lighting and water heating. - Use well insulated building materials to reduce heat gains and losses. -Use reflective materials and bright colours for roof and wall to reduce heat gains and losses in building	-Use of efficient appliances to be encouraged-public awareness. -Strict enforcement of building code; building line, window sizes, siting of building. -Solar energy for street lighting and water heating as development conditions. -Use of appropriate materials & colours as approval conditions.	-Kenya Power -Nairobi County Government - Kenya Power -Nairobi County Government
6) Minimizing private car usage	- Provide efficient fixed schedule-fixed route public transport system - Provide efficient train service - Provide adequate, secure and well lit lanes for pedestrians and other non- motorized transport modes	-Efficient PSV road & rail transport system. -Pedestrians/NMT lanes on all roads.	-Nairobi County Government ”
7) Waste management (Reduce, Reuse and Recycling strategies)	-Use renewable and recycled construction material -Encourage recycling of organic waste for onsite garden use; compost pits License more recycling companies and waste collectors	-License waste collectors with proved capacity for waste separation and recycling	-Nairobi County Government /NEMA
8) Storm water control	-Reduce paved areas and increase tree planting -Collect rainwater and surface runoff for gardening and irrigation -Green roads through tree planting, lawn maintenance and -Stormwater drainage channels cleaning and maintenance - Enforcement of riparian laws and respecting for water catchment areas	-Green ground cover not less than 30%. - 50% of onsite parking to be of porous materials. -Surface water storage as approval condition. -Ensure clean/well maintained estate roads, lawns, channels. -Ensure no construction within 30m from riverline	-Nairobi County Government /NEMA

9) Protection of green corridors and riparian reserves	-Enforcement of riparian laws -Allowing development at least 30 meters from the riparian line	-Ensure no construction within 30m from riverline.	-Nairobi County Government /NEMA
10) Minimizing land use conflict	- Strictly enforcing planning regulations - Provide missing basic facilities like shopping centre, schools, health centre and community social halls	-Integrated development plan –Capturing missing communal facilities	-Nairobi County Government
11) Reducing traffic congestion	- Provide efficient public transport system to discourage private vehicles - Provide overpasses at intersection/junction of major roads - Provide adequate, secure and well lit lanes for pedestrians and other non- motorized transport modes	-Efficient PSV road & rail transport system. -Functional overpasses -Pedestrians/NMT lanes on all roads.	-Nairobi County Government

Source: Author, 2013

7.5 Recommendations for further studies

Further research on sustainable housing densification needs to be carried out to examine the multiple implications of the development. This study dwelt mainly on physical and ecological factors and this therefore calls for further study on socio-economic and cultural implications of housing densification. The time limitation for this study could also not allow in-depth analysis of the carrying capacity of the area and further research to scientifically assess the carrying capacities of existing infrastructural facilities like piped water network, sewerage lines and electricity connectivity network is recommended. At the same time the findings were based on a relatively small sample that may have influenced the nature of results that were obtained. There is need therefore to expand on the sample size and carry out similar research in other estates to allow us draw conclusions and provide information that is sufficient for policy development.

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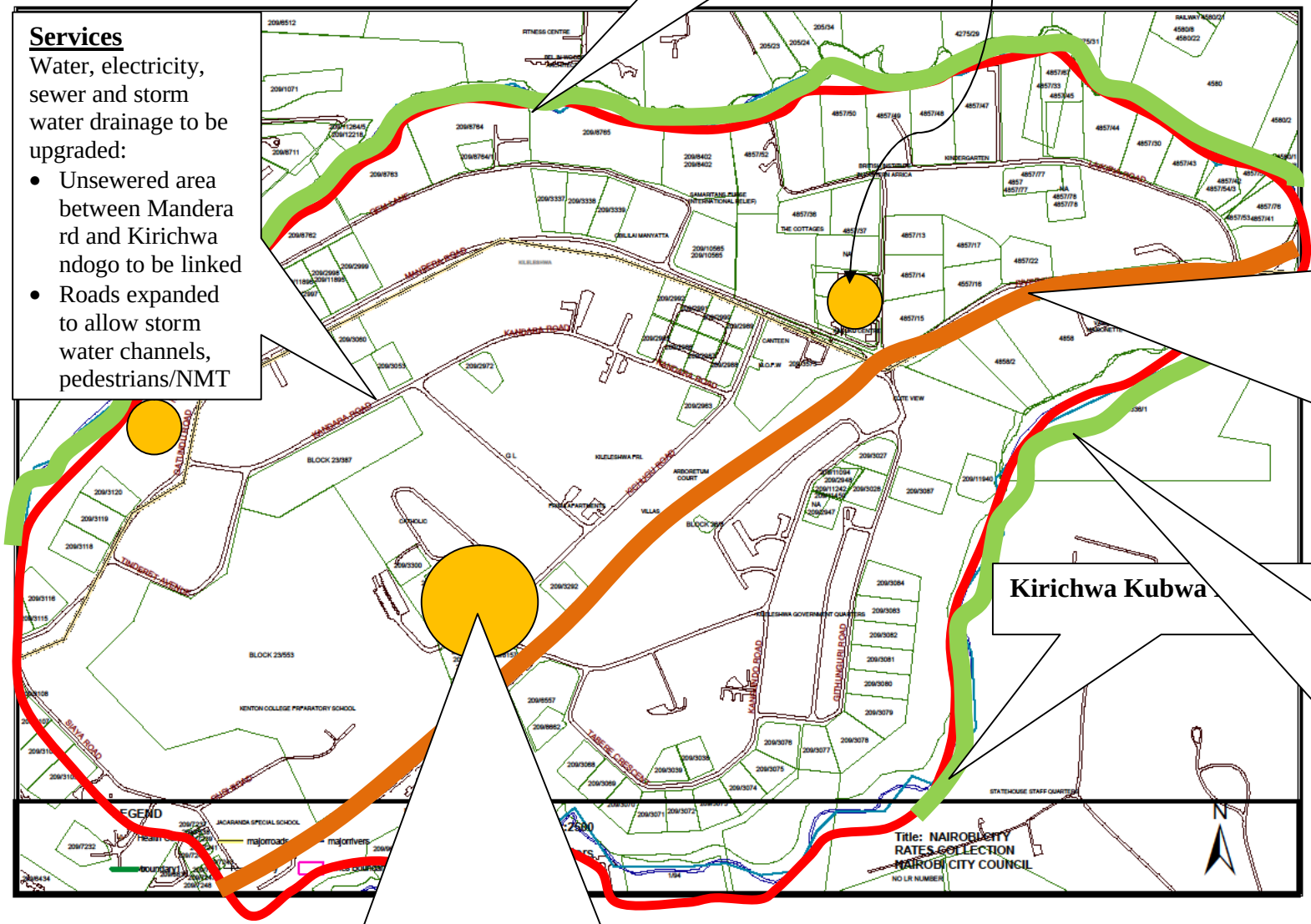
Appendix 1.1- Proposed Interventions



Services
Water, electricity, sewer and storm water drainage to be upgraded:

- Unsewered area between Mandera rd and Kirichwa ndogo to be linked
- Roads expanded to allow storm water channels, pedestrians/NMT

Roads Upgrade
Newly constructed Ring rd and Olenguruone rd and all major roads should be provided with:

- adequate, secure and well lit pedestrian lanes,
- Solar street lighting
- Sufficient green furniture
- Estate service charges to be used for tree planting, lawn maintenance and drainage cleaning.
- Provide overpasses at intersections/junctions.

Protection of Riperian Corridors
Riperian corridors along Kirichwa Ndogo and Kirichwa Kubwa should be protected through;

- Strict enforcement of riparian laws,
- No development within 30m distance from riparian line,
- Regular cleaning and planting of trees along corridors.

Commercial facilities
Additional commercial nodes are proposed at the intersection of Ringroad and Kieni Road and Mandera road and Kandara road junction to provide essential low order goods.

Source: Author, 2013