AN ASSESSMENT OF THE IMPACTS OF INCREASED LAND SUBDIVISION ON WATER SUPPLY INFRASTRUCTURE IN KAREN-LANGATA, NAIROBI.

BY

Philip Mbugua Kiama

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DECLARATION

This dissertation is my original work and has not been presented for a degree in any other university or any other award.

Signature _____ Date 21/01/11

Philip Mbugua Kiama

APPROVAL

I confirm that the work reported in this research project was carried out by the candidate under my supervision.

Signature _____ Date 21st January 2011

Dr. Peter Kamau

Signature _____ Date 26th January 2011

Dr. Abraham Ndungu

DEDICATION

To my family, thank you for your support

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ABSTRACT

Most governments all over the world adopt land use planning regulations that help protect the urban and natural environment, gear infrastructural investment with development and maintain as well as enhance property values. They use master plans, zoning regulations, subdivision regulations, building codes and other public policies to regulate urban planning and development. The results of unguided growth have made it clear that all too often the private developer fails to consider the interests of the larger community in his attempts to profit from his investments. Numerous community problems have resulted from such actions, including: poor location and siting of buildings, traffic congestion and unbalanced growth (UNCHS, HABITAT, 1996).

The Kenyan Government has in place a Local Government, which is mandated to regulate land development. However, regardless of their best efforts, land development continues to be a problem. This is because despite local planning authorities being empowered to control the use and development of land and buildings in the interest of proper and orderly development of their area of jurisdiction, land use in urban areas have witnessed abuse of land use planning regulations. In particular, there have been a lot of illegal subdivisions of land and mushrooming of unplanned settlements causing a severe deficiency in existing limited services.

The study aimed at finding out the impacts of increased subdivision on existing water supply infrastructure in Karen-Langata residential areas. The study was based on the assumption that lack of compliance to physical planning regulations and development controls will have a negative impact on the environment. Data was collected through administration of questionnaires and interviewing various stakeholders. Data was analysed under four main themes: identification of the building codes and zoning regulation for the study area; the type of development taking place in study area; the relationship between the planning regulation instruments and development in the study area and an assessment of the impacts of these developments on water infrastructure in

the study area. To carry out the study successfully, two types of data; primary and secondary, were used. Data was gathered through observation, oral interviews, questionnaire administration and photography. The study found out that there are various land use planning regulations and instruments which govern land use in Karen Langata. These include zoning regulations, building codes, subdivisions regulations as well as a Local Physical Development Plan specifically for the study area. However, the study revealed that despite the land use planning regulations being in place, subdivision and subsequent development of properties has continued to increase at a rapid rate resulting in negative impacts to the water supply infrastructure. Developments in the study area not only consist of residential properties but also commercial and institutional developments. These have placed pressure on the existing water supply infrastructure.

The study also ascertained that boreholes are the main alternative to NWSC water supply in the study area, which compensate for the shortfall in water supply. Nevertheless, the number of boreholes has exceeded the number required by the WRMA and pose a threat to the ground water resources in the study area.

To resolve these problems, this study has given several recommendations such as the augmentation of the NWSC water supply network and the enforcement of regulations concerning ground water use. The study also explores the use of alternative sources of water such as rain water harvesting. The study finally recommends collaboration between the NCC and the residents through KLDA to ensure that the LPDP is strictly adhered to.

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LIST OF ABBREVIATIONS

ADF	African Development Fund
CBS	Central Bureau of Statistics
CCN	City Council of Nairobi
EIA	Environment Impact Assessment
EMP	Environment Management Plan
LPDP	Local Physical Development Plan
GIS	Geospatial Information Systems
JICA	Japanese International Cooperation Agency
KLDA	Karen, Langata District Association
NCC	Nairobi City Council
MWI	Ministry of Water and Irrigation
NCA	Nairobi Conservation Area
NEMA	National Environment Management Authority
NWSB	Nairobi Water Services Board
NWSC	Nairobi Water and Sewerage Company
PPD	Physical Planning Department
UDC	Urban District Council
UNCHS	United Nations Centre for Human Settlements
UNEP	United Nations Environment Program
WAP	Water Allocation Plan
WRMA	Water Resource Management Agency

CHAPTER ONE: INTRODUCTION

1.1 BACKGROUND TO THE PROBLEM

Cities all over the world are experiencing the dynamic processes of urbanization and globalization. It is estimated that 50 percent of the world's population currently live in urban areas. It is further documented that 60 percent of the 2.3 billion people comprising the world's urban population live in metropolitan areas of developing countries (Nairobi Metro 2030 strategy). In Africa, the population living in urban centres was recenty established to be 327 million (UN Dept of Economic and Social Affairs/Population Division, 2003).

Kenya is one of Africa's fastest urbanizing countries (Nairobi Metro 2030 Strategy). The estimated annual rate of growth of the Kenyan urban population for the period of 1995-2000 is 7.05%, compared to an average 4.37% for African cities and 2.57% for the world (UNEP, 2000).

This fact is demonstrated in the growth of the population of Nairobi; from 8,000 in 1901, to 3.14 million in 2009 (CBS, 2010). During this period, the city boundaries have been extended at least 3 times, with Karen and Langata area being incorporated in 1963 making the area of the city nearly 690km^2.

Rapid urbanization has major implications on environmental resources in terms of solid-waste-generation rates, land-use patterns and settlement, and water consumption. In Nairobi, the population growth has over-stretched the resources to the extent that large sectors of the population have become squatters or live in slums. Kenya in 1960 had 7.4% of its population in urban areas, by the year 2010 it was expected that Kenya would have more than 50% of her national population in urban areas (Lee-Smith, et al. 1999). The current estimate of the urban residents in Nairobi who are living in make shift shelter

is 60 %. Thus, more than half of the urban residents live in inhabitable conditions. They dwell in peripheral urban areas, where they are exposed to unsanitary and overcrowded conditions as well as human-induced and natural disasters. Services such as the supply of safe drinking water, the disposal of solid waste, decent housing and transportation are lacking, which has led to a steady decline in health and environmental standards as well as an increased vulnerability to human-induced and natural disasters (UNEP, 2000).

In order to ameliorate these problems in our urban centers, there is a need to lay down strategies for quality urban planning and management. These are encompassed in urban policies such as metropolitan growth strategies, which are meant to help protect the urban and natural environment, gear infrastructural investment with development, maintain and enhance property values. Many cities the world over use master plans, zoning, subdivision regulations, building codes and other public policies to regulate urban planning and development. The first comprehensive urban plan of Nairobi City was commissioned in 1926, to recommend zoning arrangements. The 1948 master plan study was the basis for the development of guidelines for residential, industrial and other public purposes for the next 20 years (Thornwhite, Silberman and Anderson, 1948).

The Metropolitan Growth Strategy of 1973 for the development of Nairobi up to the year 2000 made ambitious development proposals, which have only been implemented in a piecemeal fashion over the last 30 years (Nairobi Urban Study Group, 1973). It recommended that the Karengata area should continue to be a high-income, low density residential area. It also proposed the setting up of a light industrial area north of Langata road. This was never implemented and the plan was not accompanied by service provision and housing development strategy for the area.

In 1988, the Nairobi City Council prepared a Structure Plan to guide development and introduced a Rezoning Ordinance which reduced the minimum allowable plot size for residential development to 0.4 hectares to the south and 0.2 hectares to the north of the Langata and Dagoretti roads. The strategy allowed for higher densities and greater

vertical development (taller buildings) within the centre and its peripheries. Nairobi City Council's intention was to make plots in the area more affordable to middle income Kenyans, to increase population and the income from rates and water service charges (JICA, 2005).

However, the Structure Plan was not accompanied by infrastructure provision commensurate to the level of development that was expected from these policy decisions. The smaller plot sizes did encourage an increase in residential development by upper-income Kenyans, who constructed large houses in estates such as Karen East, Karen Brooks, Ngong View, Karen Plains and areas around Ndege and Bogani roads. However, most of these estates have never been provided with water and other services and the residents have therefore had to provide these services themselves (Musebi and Wakeham, 2004). Currently no attempt has yet been made to re-examine, evaluate or improve the urban infrastructure services and utilities; hence the present environmental concerns (JICA, 2005).

1.2 STATEMENT OF THE PROBLEM

Karen is one of the prestigious residential areas in Nairobi. People have been attracted to live in this area because of its peaceful character, pleasing natural environment and diverse but harmonious population (Musebi and Wakeham, 2004).

However over the last three years, residents have witnessed increased land subdivision that will impact the natural environment and water supply infrastructure and change the distinctive character of the area. (Karengata LPDP). Its appeal to both international and local investors is also declining rapidly due to the negative effects of increased subdivision on the quality of its living environment.

The aim of this study therefore, is to assess the impact of land subdivision on the existing water supply infrastructure in Karen area.

1.3 JUSTIFICATION OF THE STUDY

Karen is a significant area of Nairobi which is an important city both within Kenya and internationally, and it has become a choice residential location for many international corporations and multinational agencies. It is also an important destination for tourists and international conferences.

Karen offers a number of opportunities that make it a good place to undertake a research study. The fact that there are still large plots of underdeveloped land remaining offers the possibility for intervention to demonstrate a more appropriate and environmentally friendly approach to land subdivision and development. In addition, the area has many pro-active, able and organised residents willing to contribute their resources in support of appropriate and against environmentally damaging development. It will therefore be most likely to succeed and be an example that others will be willing to follow.

The area is an asset to the city that can be creatively and sensitively utilised to play a vital role in attracting investment and improve the city's economy and by extension, the national economy. Karen's role as a high quality residential area is particularly pertinent in this respect. The availability of residential areas acceptable to investors is essential to the economy of the city but areas that were previously low density residential are rapidly diminishing as they are transformed for commercial and office use. This transformation, which began with the Upper Hill and Kilimani areas, is now extending to Westlands and Kileleshwa. The Metropolitan development strategy will provide a framework for the city as a whole in which the primary function of all zones of the city will be determined and development strategies prepared for them (Nairobi Metro 2030 Strategy).

1.4 RESEARCH QUESTIONS

The main question that this research sought to answer is: how has land subdivision impacted the water supply infrastructure in Karen?

To arrive at the answers to this molar question, specific questions addressing specific aspects of the research topic were:

1. What are the types of developments taking place in Karen?
2. How do these developments relate to building codes and zoning regulations?
3. What are the impacts of these developments on the water supply infrastructure and resources in the area?
4. Which integrated water infrastructure management measures need to be undertaken?

1.5 RESEARCH PREMISES

In an attempt to unravel the above problem, this research was guided by the following premise:

Lack of compliance to physical planning regulations and development controls will have a negative impact on water infrastructure.

1.6 OBJECTIVES OF THE STUDY

The main objective of the study was to establish the implications of increasing subdivision on the water supply infrastructure in Karen. The following were the specific objectives of the study:

1. To identify the building codes and zoning regulations for the area of study
2. To examine the type of development taking place in the Karen area
3. To determine how the development relates to the building codes and zoning regulations
4. To assess the impacts of these developments on the water resources and existing infrastructure in the area
5. To suggest an integrated water infrastructure management measures that need to be undertaken

1.7 SIGNIFICANCE OF THE STUDY

This study will be of great significance to the Nairobi City Council in dealing with and managing land uses which affect water infrastructure in other up-coming residential areas.

The report will assist the Nairobi City Council in determining whether the Local Physical Development Plan which has been prepared for the area will be adopted by the local residents. Also, this report will contribute towards the implementation of the development strategy for the Nairobi Metropolitan Area.

The research paper will also contribute to the pool of knowledge in the fast growing field of urban environmental planning, in Kenyan administrative and educational institutions. This study will also be of great significance to the various stakeholders including residents, aspiring developers, educational and religious institutions, business owners; all of whom have a visions for the future of Karen as a safe, peaceful and eco-friendly place to live, to bring up children and to visit.

1.8 SCOPE OF THE STUDY

This study covers the area known as Karen-Plains-Forest Edge designated as zone 4 of the Karengata Local Physical Development Plan. The area occupies an area of $10km^2$ and is located within Karengata district. Karengata is found south west of Nairobi city between the city and the peri-urban areas of Ngong, Kiserian and Ongata Rongai. The boundary of the area is the Motoine River to the north, the Mbagathi River to the south, the Magadi and Forest Edge roads to the east and the city boundary with Kiambu district to the west. The area occupies approximately 56 square kilometres.

1.9 LIMITATIONS OF THE STUDY

This study was faced with problems such as time constraints. The Karen-Langata District Association officials had a large number of tasks and were busy therefore the interviews were short. However the researcher was able to access the information required. In addition, some of the data is compiled in such a way that it is difficult to relate it to a particular area of the city. For example, the data on rainfall patterns and soils which covers the whole of the city was adapted for the study area with some difficulty.

Furthermore problems were encountered in the field such shortage of adequate manpower to administer the questionnaires due to financial constraints. However the information acquired was enough for the study. Also there were some uncooperative respondents who made collecting data a challenge.

1.10 OPERATIONAL TERMS

Development

This refers to the activities or constructions carried out on urban land to increase its value.

Development Controls

This refers to those governmental actions or mechanisms which can be applied directly or indirectly to regulate developments taking place on land and are usually geared towards the interests, welfare and satisfaction of man.

Physical Planning

This refers to the ordering of urban land uses and constructions to enhance beauty comfort and convenience.

Zoning

This is defined as the demarcation of an urban area by ordinances and establishment of regulations to govern the use of zoned land.

Environmental Management

This includes the protection, conservation and sustainable use of the various elements or components of the environment.

Infrastructural Facilities and Services

This refers to all facilities and services provided in a sustainable neighbourhood. They include roads, sanitation and garbage collection, water, electricity, security, sewerage facilities, schools and housing.

1.11 CHAPTER OUTLINES

This report comprises of six chapters. Below is an outline of the contents of each of the chapters of the study.

Chapter 1 introduces and identifies the problem. It sets the objectives of the study, research questions and premise. It also justifies the study and gives the scope and importance of the study. The constraints that were faced during the study are also highlighted.

Chapter 2 reviews the existing literature related to the Land use planning regulations and instruments. It outlines the role of regulations for; zoning, building and subdivisions in land use planning in the study area. The chapter also identifies legislations and policies which govern land use in the study area. Finally the chapter provides a conceptual framework of urban management and environmental protection.

Chapter 3 describes the study area. It describes the location and extent of the area under study, its physical, socio-economic and ecological set-up. It identifies all information that is relevant to the area of study.

Chapter 4 deals with research design and methodology. It identifies the nature of data collected, sources of data and methods of data collection, sample design and how data collected was analysed and presented.

Chapter 5 deals with data analysis and discussion. The data collected is presented, analysed and discussed.

Chapter 6 summarizes the findings, draws conclusions and then gives recommendations for effective management of water infrastructure in the study area.

CHAPTER TWO: LITERATURE REVIEW

2.1 LAND USE PLANNING REGULATIONS

2.1.1 Definition of land use planning regulation

The definition of planning regulation is the control in the manner in which land is used and developed, mainly in urban areas. In urban planning, the publicizing of the need for observance of planning regulations in land development is an important function that the law performs. The main sources of authority for land use development control in Kenya are the various laws and regulations such as zoning regulations, building codes, by-laws and several statutes usually prepared by the central government, local authorities or their agencies (Barasa, 2007).

2.2 LAND USE PLANNING REGULATION INSTRUMENTS

Land use planning regulation instruments include the following; Zoning regulations, Building regulations, Subdivision regulations, Legislation (Laws and By-laws) and Policy (Development plan).

2.2.1 Zoning Regulations

Zoning is defined as the demarcation of an urban area by ordinances and establishment of regulations to govern the use of zoned land. Zoning rests on the constitutional powers of government to restrict and regulate actions which might injure public health, safety, or welfare (Barasa, 2007). Therefore the main objective of this regulation is to limit the adverse spill over effects, promote agglomeration benefits, to specify minimum health and safety requirements and to provide land for public goods and services. When adopted by the local authority, zoning ordinance divides the city or town into asset of homogeneous land use parcels for different types and densities of development.

Zoning is the control most frequently employed to regulate the use of land. In its traditional form, its purpose is to ensure a proper amount of land for all activities that must be performed in a contemporary community, to fix the best location for each and to avoid encroachment of incompatible uses. To meet these aims cities and municipalities may regulate the use of land and buildings by restricting areas to industrial, commercial, recreational, residential, agricultural and other purposes. Zoning limits the rights of private individuals since it involves the regulation by zones under the police power of such matters as:-

- plot sizes or bulk
- plot ratios/coverages
- building lines/setbacks
- buffer zones
- way leaves

There are various types of zoning, they include: Nuisance zoning, performance zoning, cluster zoning, exclusionary zoning, spot zoning, special purpose zoning and cultural area zoning.

2.2.2 Building Regulations

Building regulations limit or define the way new structures are to be built and the materials to be used (Barasa, 2007). They may also be applied to the maintenance and improvement of existing building. They may prohibit the erection of any structure or restrict the style of architecture, materials and the position of the building on the lot, or its distance from the street, its height or depth. Commercial, industrial and public buildings as well as residential buildings are all generally subject to codes. Initially, there were three main reasons for such regulations: fire protection, structural safety and sanitation. Technological advancement also influences regulations because they now specify the strength of materials and of structural parts as well as standards for plumbing, electricity, elevators, heating and ventilation.

2.2.3 Subdivision Regulations

Subdivision regulations govern the development of raw land for its zoned purpose in much more detail. Subdivision regulations define standards for layout and lot sizes, street improvement and procedures for assigning private land for public purposes. Subdivisions also provide the essential characteristics of land uses, street patterns and public utilities.

Subdivision of land prior to developments is one of the most important determinants of neighbourhood patterns. Once the size and shape of the lots have been defined, the essential character of land uses, street patterns and public utilities is determined. Lot sizes and shape also strongly affect the type, size, and quality of structures and the density of population. A major cause for the increased unapproved constructions e.g. extensions and gradual dilapidations of former planned houses into slums, for instance, Umoja estate are attributable to ineffective development control. The consent for development depends on the land tenure, locality and the fact that the application be submitted in the prescribed manner by the relevant approving authority. Subdivision of land, extensions, building plans, and change of user need approval before development (Gitau, 1996).

In Nairobi, the Nairobi City Council does not approve private developments applying lower standards even where the developments are meant to cater for lower income. The requirements of subdivision that would be approved by NCC according to UNCHS, (Habitat), 2001 include: -

i) The resultant sub plots should be accessible and adequately served with proper open space and social infrastructure.

ii) The proposed population density should be in accordance with the available services e.g. water sewers, roads and drainage.

iii) There should be planned and coordinated development in order to avoid uncontrolled and isolated developments.

iv) The local authority or central governments should share in the enhanced value that arises from the subdivision.

v) The regulation and planning of subdivision on the outskirt of cities are widely accepted as essential to development. Proper and timely planning of expansion can preserve the sound structure of the cities/urban areas in the long-term (UNCHS, HABITAT, 1999).

2.2.4 Legislation

The following are the main statutes used in Kenya to control urban land use:-

i) Local Government Act Cap 265, Laws of Kenya.

ii) Physical Planning Act No.6 of 1996, Laws of Kenya.

iii) Building Code.

iv) Public Health Act Cap 242, Laws of Kenya.

v) By-laws

Local Government Act Cap 265, Laws of Kenya

This is an Act of parliament which provides for establishment of local authorities for the purpose of local government; and for the functions of those authorities as well as for the matters connected therewith or incidental to those authorities.

Subject to this Act, the duty of every urban authority within its area of jurisdiction will have powers to:-

i) control or prohibit the subdivision or cutting up of land or subdivision of existing building lots into smaller areas.

ii) control or prohibit all businesses, factories, and workshops which by reason of smoke, smell, noise, vibration or other cause, may be or become a source of danger, discomfort or annoyance to the neighbourhood and to prescribe conditions subject to which such businesses, factories and workshops shall be carried on.

This is an Act of parliament for the preparation and implementation of physical development plans and connected purposes. This Act applies to all parts of the country and it repealed two separate Acts-Town planning Act and Land Planning Act, Laws of Kenya in order to make one law of planning, give local authorities more say in planning and bring about more detailed regulations in development. The Act is divided into a number of parts and it has five schedules. Part five deals with development controls.

Control of Development (Part 5)

Development has been defined in this Act as the making of any material change in the use or density of any building or land or subdivision of any land which is classified as Class 'A' development or the erection of such buildings or works in the carrying out of such building operations as the minister may determine from time to time classified as Class 'B' development. The local authorities are given powers under section (29) of this Act to:-

i) To prohibit or control the use and development of land and buildings in the interest of proper and orderly development of its area.

ii) To control or prohibit the subdivision of land or existing plots into smaller areas.

iii) To consider and approve all development applications and grant all development permissions.

iv) To ensure proper execution and implementation of approved physical development plans.

v) To formulate by-laws to regulate zoning in respect of use and density of developments.

vi) To reserve and maintain all the land planned for open spaces, parks, urban forests and green belts in accordance with approved physical plan.

Building code/Building By-Laws

Building code provides control on the construction, alteration and additions to all buildings. Building code provides building by-laws which specifies the standards for space about buildings, building lines, height of buildings, ventilations, circulation of air, size of habitable room, access, parking, electricity and structural safety of the building. It also provides for controls in the installation and modification of all aspects of sewerage system on any land (UNCHS, HABITAT, 1999). By-law 3(2) of the building code provides that the following operations shall be deemed erection of a building:

a. the alteration or extension of a building.
b. the changing of the use or uses to which land or a building is put.
c. increasing or reducing the number of dwellings in a building.

Public Health Act Cap 242, Laws of Kenya

This Act defines the general public health standards that the local authorities must adhere to. This Act provides that, ''Every local authority shall appoint one or more competent health inspectors to assist in carrying out the provisions of this Act within its area of jurisdiction''. The local authorities have responsibility of ensuring that the general health standards stipulated under or by the Act are adhered to through specific regulations. The primary duty of the local health inspector is to maintain public health standards. Failure to comply with the standards renders one guilty of an offence and thus subject to a fine (UNCHS, HABITAT, 1999). Public health standards must also be met in the construction and maintenance of buildings. The Act lists conditions defined as 'nuisances' and injurious to peoples' health. The Public Health Act Cap 242, Laws of Kenya, provides that every health authority should take all lawful, necessary and reasonable practicable measures for preventing or causing to be prevented or remedied all conditions liable to injurious or dangerous to health arising from the erection or occupation of unhealthy sites or on sites of insufficient extent or overcrowding or from constructing, or condition or

manner of use of any factory or trade premises and to take proceedings against such persons causing or responsible for the continuous of any such condition.

2.2.5 Karengata Local Physical Development Plan

The Karengata Local Physical Development Plan (LPDP) 2005-2015, was prepared in accordance with the Part IV of the Physical Planning Act, Cap 286, 1996. It was approved by the Minister for Lands and Housing and gazetted in August 2006. It was adopted by the City Council of Nairobi in September 2006 and the adoption was reaffirmed in February 2007. The LPDP replaces the 1988 Structure Plan and Rezoning Ordinance and provides the legal framework for all planning and development decisions in the Karengata area.

2.2.5.1 Area covered by the Plan

The LPDP covers the area known as Zone 12 of the City of Nairobi, which is also the area covered by the Karen Langata District Association. The area is located to the south west of Nairobi city, adjacent to the rapidly urbanizing peri-urban areas of Ngong, Kiserian and Ongata Rongai. It occupies an area of approximately 56 square kilometres and is bounded by the Motoine River to the north, the Mbagathi River to the south, the Magadi and Forest Edge roads to the east and the city boundary with Kiambu District to the west. In order to single the area out as a separate planning area it has been given the name Karengata.

2.2.5.2 Objectives and scope of the plan

The overall objective of the LPDP is to provide a development framework for: orderly, coordinated, harmonious and progressive development of the plan area to promote health, safety, order, amenity, convenience and general welfare of all inhabitants as well as efficiency and economy in the process of development.

The specific objectives of the plan are to: replace the 1988 Structure Plan and Rezoning Ordinance; provide a basis for urgent action to stop inappropriate and illegal development; encourage development that preserves and enhances the area's natural environment; provide a basis for guiding investment and encouraging good quality development; improve infrastructure for the growing population; provide a framework for implementation, enforcement, monitoring and evaluation; provide information and experience to inform the preparation of the metropolitan development strategy.

2.2.5.3 Plan Contents

Part 1 includes the justification, vision and objectives of the plan, the methodology used to prepare the plan, the scope of the plan and the legal and institutional framework.

Part 2 contains a comprehensive analysis of the social, cultural, economic, environmental and physical aspects of the plan area, its development typology and public utilities, based on field surveys undertaken by the planning team during 2004. The main trends and issues arising from the analysis are identified and discussed.

Part 3 defines the spatial and strategic framework to guide new development in the area based on the trends and issues identified through the analysis of the existing situation described in Part 2.

Part 4 contains the implementation matrix setting out the actions that must be taken in order to implement the strategies described in Part 3. The proposed approach to implementation that continues the participatory process initiated through the preparation of the plan is also described.

Below is a summary of Part 3 of the LPDP, which describes the strategy to guide new development in the Karengata area.

2.2.5.4 Development strategies: The Management of Land use and Development

Most land in the plan area is in private hands and there is very little public land available for the development of public institutions and recreation. The continuing increase in land rates is encouraging sub-division and changes of user from residential to commercial or institutional.

The approach to be taken in the management of development is based on the premise that the dominant land use in the plan area is low-density residential. Therefore other uses, including high density residential, public purpose, educational or commercial will be permitted as required to support the dominant user.

All new development will be expected to conform to standards that will ensure that it is in accordance with the vision for the area and not only respects but enhances the area's natural environment.

Managing low-density residential development

All new residential development throughout the plan area will be required to meet the following standards to ensure that it will enhance rather than compromise the character and natural resources of the area and conform to the vision of Karengata as an "eco-suburb". The following are the Minimum plots sizes for residential development in the different zones will be strictly enforced. These are:

- Zone 1a. Miotoni, 0.2 ha
- Zone 1b. Windy Ridge - Kerarapon, 0.4 ha up to the area bordered by the Mbagathi river and all areas immediately fronting the Mbagathi river and 0.2 ha for the area adjacent to Kerarapon.
- Zone 2. Mbagathi, 0.4 ha.

- Zone 3. Bogani, 0.4 ha. May be lowered to 0.2 ha, when services to the area are improved
- Zone 4. Karen Plains - Forest Edge, 0.2 ha.
- Zone 5. Karen Triangle. Designated special planning area (no minimum plot size given)

i) One single dwelling unit plus staff quarters will be allowed per plot whether it is part of a multi -dwelling unit development or on an individual plot. The plot coverage will be 25% of the area of the plot and the maximum number of storeys will be two (ground plus one).

ii) Multi-dwelling unit developments will be permitted on plots of 4.0 ha and over, subject to the requirement that each dwelling unit occupies an area of land no smaller than the minimum plot size for the zone. (All standards relating to the one house per plot model described above, will apply). Land for access roads, communal facilities etc. will be in addition. All multi-dweller units will be subject to an Environmental Impact Assessment.

iii) Development approval will be subject to the availability of services, in particular water supply. Developers will be expected to employ rainwater harvesting, grey water recycling and the use of alternative energy sources to recommended standards.

Managing high-density residential developments

There are approximately 30 high density settlements in the area housing low income people. The largest of these is Kuwinda with some 800 units. Demand for low and medium income rental housing is increasing due to the increasing number of commercial activities in the area and the fact that many residents and institutions do not provide

sufficient accommodation for their domestic and ancillary staff. Educational institutions in particular do not provide sufficient accommodation for their students and staff.

The LPDP proposes a two pronged strategy to address this:

i) Existing high density housing: set up a committee to review existing housing and make recommendations for action to be taken. The review will address the following:

- The right of families without title to stay on land they have occupied for many years will be investigated with a view to formalizing their right to do so and enforcing the upgrading of structures and services.
- The upgrading of Kuwinda.
- All other high density settlements will be required to obtain approval from the NCC, subject to their meeting standards required for structures and services.
- All hostels will be required to obtain approval from NCC subject to meeting the standards relating to the number of rooms (maximum of eight), plot coverage (not more than 40%), height (one storey) and other standards relating to building materials and services. All applications for extension of user to include hostels will be required to obtain comments from neighbours.

ii) Increasing demand for high density housing: demand for affordable accommodation from low and medium income workers in the plan area will grow as development increases. This demand cannot be met entirely within the plan area. However the strategy will be to meet as much of the demand as possible in the following ways:

- Employers will be expected to house all permanently employed domestic and ancillary staff. This will be a condition of planning approval for all new development.

- All existing institutions will be required to meet the accommodation requirements of ancillary staff.
- Small numbers of low income accommodation constructed on private plots to the agreed standards will be acceptable as these have low environmental impact and would be subject to the owner occupier's supervision. A maximum of eight rental units will be permitted on plots of one acre and above, on condition that the total plot coverage of the main house, staff quarters and the rental units does not exceed 35% of the total area of the plot. Other conditions will relate to the location of the structure, the height (single storey), the availability of services and the type of materials to be used. All applications for extension of user for such development will be required to obtain comments from neighbours.

Managing land use for education, public purposes and recreation

There are numerous education and religious institutions in the plan area. Some institutions have not yet developed to full capacity and more pressure can therefore be expected. Many of these institutions serve a wider catchment area. In this respect, decisions regarding the suitable location of institutions that serve the city, the country or have an international status should be made on a city -wide basis. It is hoped that once the Nairobi metropolitan growth strategy is prepared it will address these issues.

A major problem in achieving the development of public facilities is the lack of public land in the plan area. Measures will be introduced to use the current requirements for surrender of a portion of subdivided plots more effectively to assemble land for public and recreational purposes. Measures to secure land for public use through land swaps and the provision of incentives to private landowners to contribute portions of their plots to a land trust, will be considered.

All institutions, public and private, will be required to meet planning standards relating to the availability of public utility services (water, sanitation, electricity), access, parking, plot coverage, height etc. All developments must be governed by the "nuisance principle" i.e. that they do not interfere with the quiet enjoyment of the residential properties close to them.

The LPDP contains recommendations for the development of education and religious facilities and public purposes in the plan area to support the local population. These include:

i) Educational facilities

- Primary schools: there are two public primary schools in the plan area but planning standards require nine to meet the needs of the population of the plan area (c. 36,000). As private primary schools are bridging part of the shortfall, an additional two public primary schools are required.
- A minimum plot size of 4.7 ha is required for one primary day school. All primary schools should have nursery units.
- Secondary schools: Planning standards require five public secondary schools to meet the needs of the population of the plan area. Private secondary schools are already bridging part of this shortfall but for equity purposes, two public secondary schools should be provided. A minimum plot size of 6.9 ha is required for one secondary boarding school including staff housing.
- Colleges and universities: in view of the fact that these categories require large amounts of land and that the plan area already contains a large number of tertiary educational institutions, further development of such institutions will be subject to meeting a minimum requirement of 20 ha of land.

ii) Religious institutions: many religious institutions in the plan area have other uses besides the worship function. These will be required to apply for extension of user to accommodate this land use. The religious institutions offering the worship function only will be required to have a minimum plot size of 1.0ha while those offering other services such as education and health, should meet the requirements for these users.

iii) Special homes: this group includes children's and old people's homes. In the plan area, it is recommended that a minimum of 1.2 ha is required for a children's home while 0.8 ha is required for an old people's home.

iv) Health institutions: the plan area is only served by one public health centre which is inadequate since it not only serves the plan area but also the surrounding areas and the wider city and its capacity is greatly overstretched. It is proposed that it be upgraded to a sub-district hospital. Private medical practitioners will be encouraged to open clinics in the plan area to help fill the current gap. Such clinics will be required to either operate from the existing designated commercial areas or in residential premises that meet NCC standard requirements for professional offices.

v) Administrative centres: the District officer for the area is currently based in Kibera. Due to its size, the area should be upgraded to divisional level and a District administrative centre located in the Karen triangle.

vi) Community centres: a modern community centre able to function variously as a periodic curio market, training centre, social hall and meeting place for neighbourhood associations will be located in the Karen triangle together with other administrative functions.

vii) Recreation and open space: this is a broad category of land use that has significant impact on the protection and enhancement of natural and cultural amenities in the plan area. It also has a strong bearing on the vision of the area as an eco-suburban tourist destination. In the plan area, the river valleys and forested areas are particularly in need of conservation as important wildlife habitats and areas of biological diversity.

Managing land use for commercial development

Commercial development incompatible with a high quality residential use is occurring throughout the plan area. Most of this development is on private land fronting main roads, on road reserves and at main road junctions. Some recent commercial developments are indicative of trends that are more appropriate to the plan area. These include: small-scale office complexes in which separate office units share common facilities in a garden setting, small-scale "boutique" hotels and bistro-type restaurants.
The strategy for managing commercial development in line with the vision for the plan area is twofold:

a) To ensure that existing developments that do not meet these requirements will be subject to review and appropriate action taken

b) To ensure that all commercial developments conform to a high quality residential area and have a low negative environmental impact.

All existing commercial development will be treated as follows:

i) All unauthorized kiosks and similar development on road reserves will be given notice and removed. Legitimate kiosks will be relocated in planned locations at neighbourhood centres where traffic hazards can be eliminated and public health and security issues can be addressed.

ii) All commercial developments on plots that do not have approval for change of user will be issued with enforcements notices.

iii) All commercial developments that have approval for change of user will be reviewed in terms of the type and quality of the development, their compatibility with the zone in which they are located, conformity to planning standards and the conditions attached to their approval.

iv) All existing light industries e.g. Sigma Feeds and petrol stations should be subject to annual environmental audits.

v) The three existing flower farms in the plan area: Karen Roses, Sian Roses and Kordes Roses occupy plots designated for agricultural use but are basically commercial activities. These farms will be allowed to remain in the area as long as they continue to supply themselves with water and are subject to regular and satisfactory environmental audits.

All new Commercial development will be required to meet planning standards relating to the availability of public utility services (water, sanitation, and electricity), access, parking plot coverage, height etc. All commercial developments must be governed by the "nuisance principle" i.e. that they do not interfere with the quiet enjoyment of the residential properties close to them.

Due to servicing limitations, commercial developments will only be permitted in the following areas:

i) A district service centre incorporating high quality office accommodation, high quality shopping outlets and a transport interchange will be located in Zone 5, the Karen triangle, which will be comprehensively planned and serviced for the purpose.

ii) Neighbourhood centres at Karen, Hardy, Park Place and Jubilee Plaza will be enhanced and developed within strictly proscribed boundaries to provide for the daily shopping needs of local residents. An additional shopping centre will be considered as part of a comprehensive development along Langata road adjacent to the Catholic University.

iii) The following commercial enterprises may be located in any zone provided that they comply with the planning standards and the nuisance principle described above:

- Domestic scale office complexes: subject to their meeting the conditions relating to the availability of public utility services, plot coverage, access and parking. They will require an EIA and comments from neighbours.
- Home based enterprises and cottage industries will be permitted in all zones on condition that they meet planning standards (including an EIA if applicable), and have received comments from neighbours.
- Small scale retail outlets: local neighbourhood associations will identify suitable locations and will ensure conformity with agreed standards.
- Conservation and eco-tourism facilities: including restaurants and small "boutique" hotels will be permitted in all zones on condition that they meet planning standards, are guided by the nuisance principle and have received a no objection from neighbours. (Bars and health clubs will only be allowed if they are part of the facilities offered by hotels or recreational clubs and receive a comment from neighbours.
- Agricultural based enterprises on private plots, such as dairy farming, horticulture, poultry farming, horse rearing and training etc. will be expected to conform to the by-laws related to such activities and to the nuisance principle.

2.2.5.5 Ensuring development conforms to the Karengata Local Physical Development Plan

"Development is inevitable. Karengata is one of the few areas within the city boundary of Nairobi where plots of land are still available and is therefore subject to great pressure from developers".(G. Alder - Karen Langata District Association, 2010)

KLDA welcomes development that is in conformity with the Local Physical Development Plan (LPDP) for the area.

However, the mechanisms for ensuring that development is in conformity with the LPDP have not yet been put in place. These mechanisms are described in Part 4, of the LPDP, the Implementation Strategy, which states that:

> *"The LPDP will only be successful if it is implemented. To do this it is essential that all key stakeholders are involved in the implementation and are committed to do so. It is recommended that the partnerships created through the drafting of the LPDP will continue into its implementation, monitoring and evaluation.....It is intended that the engagement framework will provide a pilot to demonstrate collaborative local development planning and management in the city."*

However, the setting up of these implementation arrangements is still being discussed with the NCC, more than two years after the LPDP was gazetted and approved by the NCC Town Planning Committee.

The situation at present is that the NCC does not have the resources, and in some cases the commitment, to control development in the plan area and KLDA has neither the powers nor the resources to do so. Therefore development control depends on individual residents or associations of residents to play their part in conserving the area's environment and ensure that all new development is in accordance with the LPDP.

2.3 CONCEPTUAL FRAMEWORK

Urban sustainable development is based on sound urban environmental planning and management. The goal of urban environmental planning and management is to improve and maintain the wellbeing of people as well as improve and or maintain the wellbeing of the ecosystem products to achieve the highest possible standards of living of its people. Thus urban environmental planning is concerned with the whole system, defined as the people within their ecosystem. People are supported by the ecosystem because it provides all the necessary resources needed by human beings to function. In this conceptual model figure 2.1, these resources are; Air, Water, Land and Energy.

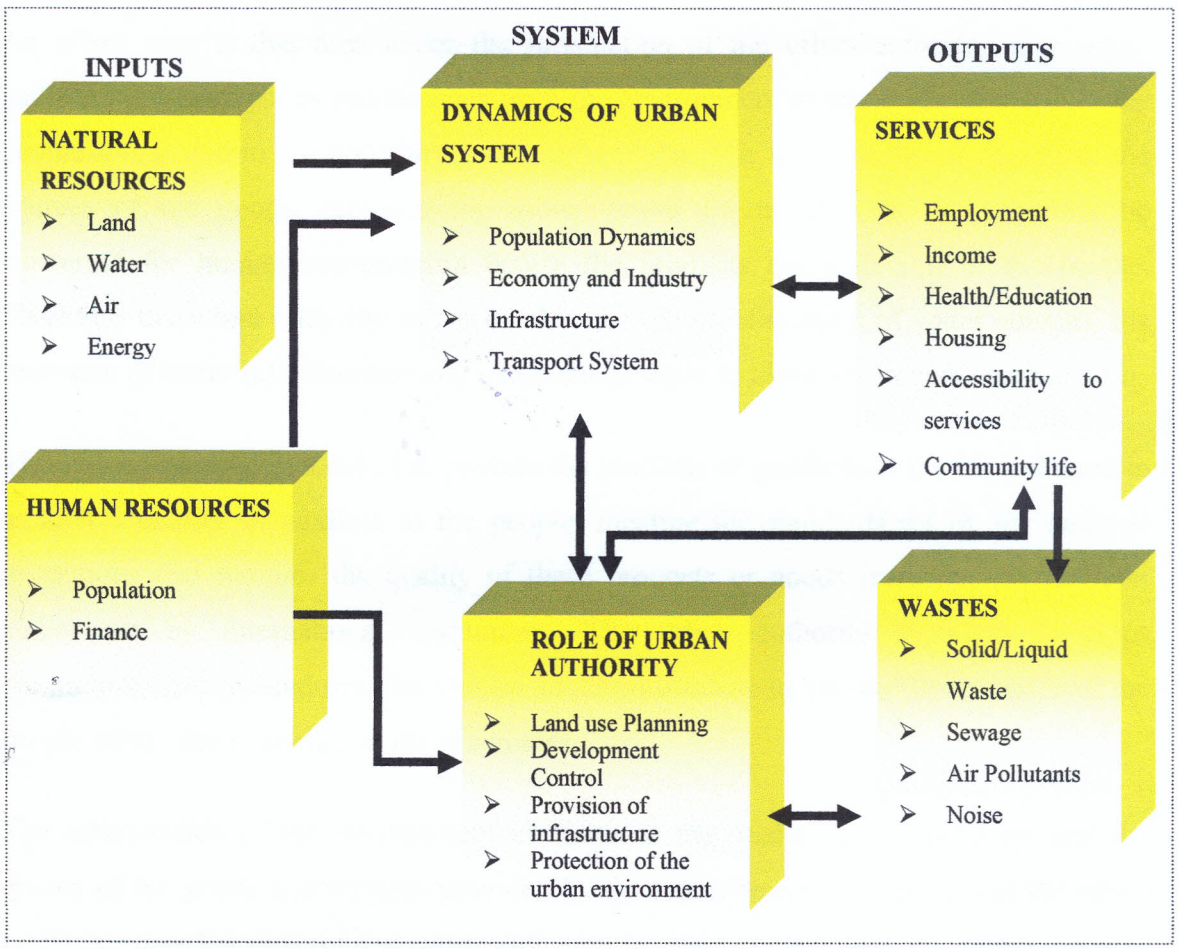


Figure 2.1 System framework has been developed by Newman *et al.* (1996). It is based on extended urban metabolism model (EUMM).

Kenya in 1960 had 7.4% of its population in urban areas, by the year 2010 was is expected that Kenya will have more than 50% of her national population in urban areas (Lee-Smith et al 1999), The current estimate of the urban residents in Nairobi who are living in make shift shelter is 60 %. Thus only 40 % of the urban residents are registered rates payers UNCHS, 1999). Thus Nairobi municipality has enough resources (financial and human) to provide environmental products of water and reticulated sewerage system and solid waste management systems for 40% of its residents. This scenario means that only 40% of the population in Nairobi is catering for the entire population of Nairobi. In reality the 40% are subsidizing the cost of providing environmental products for the other 60% of the residents of Nairobi.

An urban area is that area under the jurisdiction of the urban authority. The urban authority provides goods and services from the environment to satisfy the demand of the people living within the boundary of the urban area. The urban authority identifies the sources of the goods, provides the infrastructure for transferring the goods to be converted for human consumption before the products are delivered to the people. Therefore the urban authority is responsible for the identification of water sources, the provision of water infrastructure and treatment of water to allow for human consumption.

The urban authority undertakes to provide the products or goods from the environment in as high a quality as possible to the people, meeting the standards set by the national institutions that monitor the quality of these products or goods from the environment and/or set by international institutions. The urban authority therefore develops programmes and procedures and sets up an administration to handle the demands of the people within the boundary of the urban area.

The deterioration of the environment in terms of the quality of the products and the quality of the goods and services provided by the environment is a concern of the urban authority. It is the duty of the urban authority to enact procedures and programmes to correct the deterioration of the quality of environmental products. Environmental

planning in urban areas is therefore the identification, allocation and management of the ecosystem products.

Below is a table elaborating on the role of the urban authority/municipality in identification, allocation and management of water resources.

Table 2.1: Role of Municipality in Urban System

ENVIRONMENTAL RESOURCE	ROLE OF MUNICIPALITY
Water	• Identify the sources of water • Treat water to make it portable • Provide infrastructure for water supply • Provide regulations for the provision of water resources • Allocate water to all water users • Set and collect rates for water use • Set water quality standards • Monitor the quality of the water against agreed standards • Maintain the water reticulation system • Provide infrastructure for wastewater. • Treat wastewater before it enters into the natural system • Plan future demand for water • Plan future demand for wastewater

Source: ***UNCHS, 1999***

CHAPTER THREE: THE STUDY AREA

3.1 LOCATION AND EXTENT

This study covers the area known as Karen-Plains-Forest Edge designated as zone 4 of the Karengata Local Physical Development Plan. The area occupies an area of 10km^2 and is located within Karen Langata. Karen Langata is found south west of Nairobi city between the city and the peri-urban areas of Ngong, Kiserian and Ongata Rongai. Karengata covers an area of approximately 56 square kilometres. In order to single the area out as a separate planning area the Ministry of lands give it the name Karengata District.

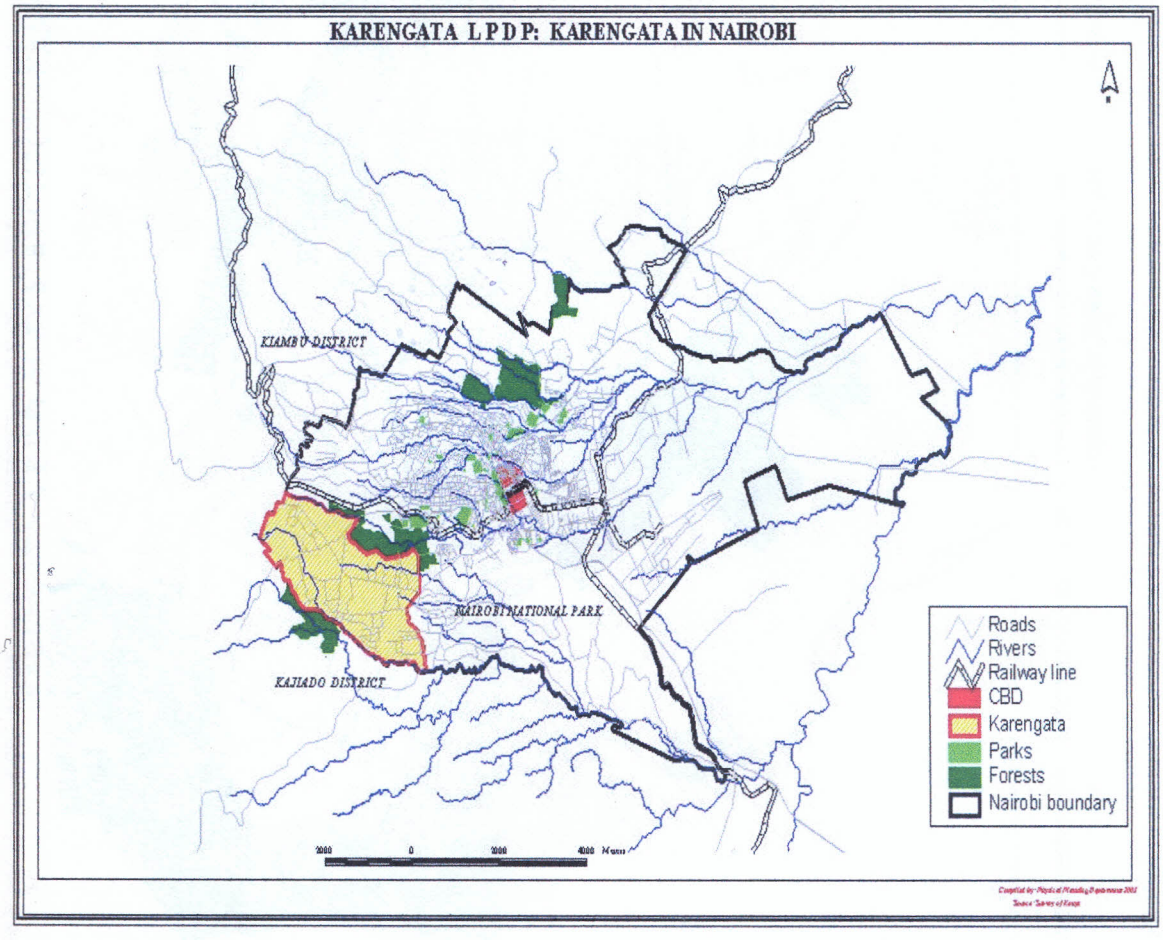


Figure 3.1 Location of Karengata district within Nairobi Province

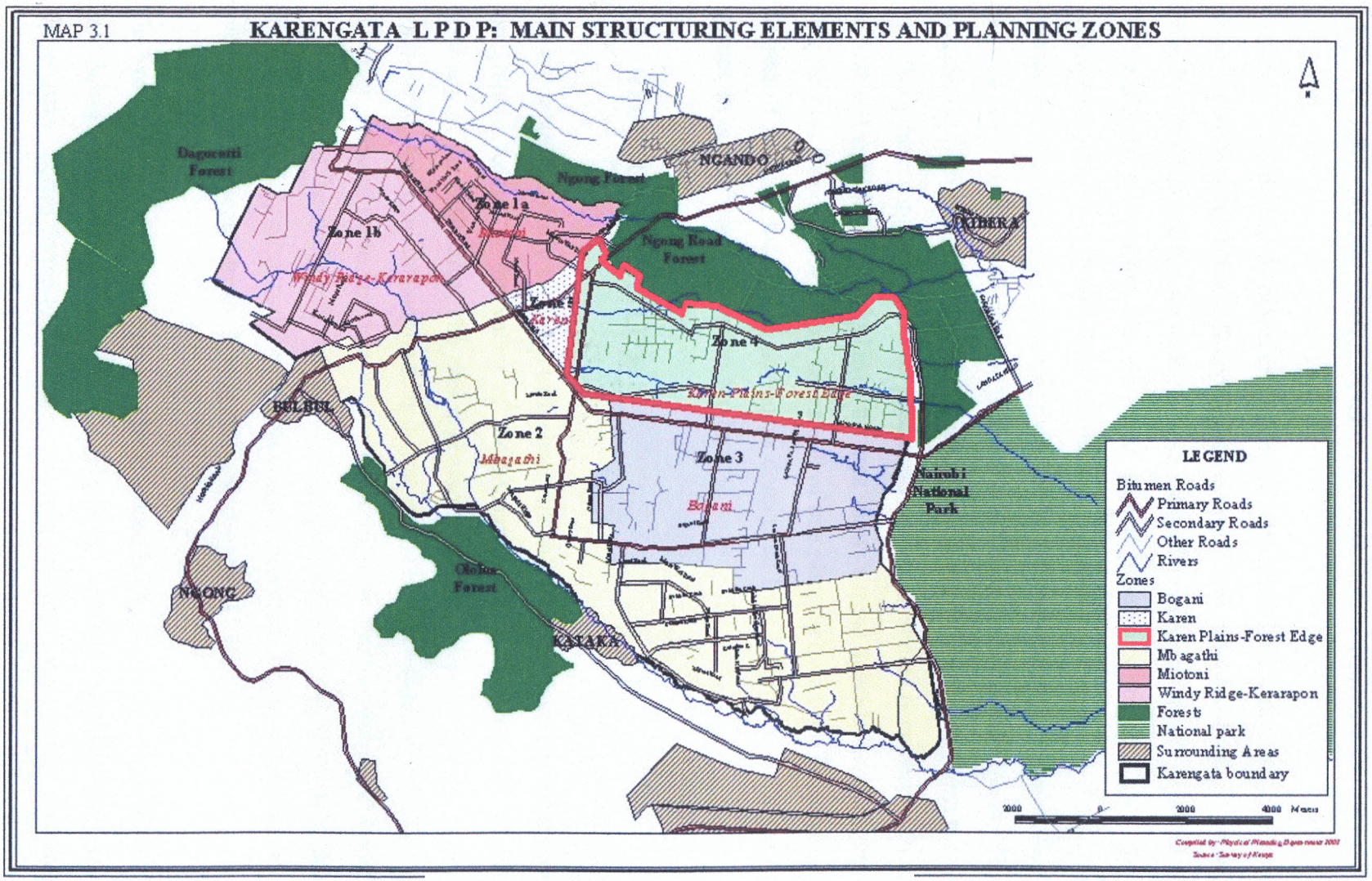


Figure 3.2: Zone 4 as shown in the Karengata LPDP

3.2 VEGETATION, TERRESTRIAL BIODIVERSITY AND ECOSYSTEMS

The area is predominantly plains and grassland with shrub land, woodland, riparian forest along the Mbagathi, Mokoyeti and Motoine rivers and patches of forest around Tree Lane, Forest Road and Mwitu Estate. These forested areas together with Ngong Road and Ololua Forest ecosystems are important genetic reservoirs in the area. The forest ecosystems are rich in wildlife, particularly primates, birds and invertebrates. A comparison between aerial photography taken in the area in 1948 and 1998 shows that the area covered by grasslands has reduced by 21% and that covered by woodland has increased by 31% in the same period. The area occupied by indigenous forest has reduced but mainly been replaced by exotic species so that the total area occupied by forests has not reduced significantly. The plan of the area shows a trend towards increased tree cover over the past five decades mainly as a result of tree planting by private landowners. As in the rest of Nairobi, the area is nowadays dominated by a large number of exotic plant species especially among trees and shrubs.

3.3 GEOLOGY AND RELIEF

The topography is fairly subdued, with elevations falling to the east. The most prominent topographic feature is the valley of the Mbagathi River, which forms the southern boundary of the study area. The area is characterised by extensive faulting, running in a north-south direction and conforming to the rift system. Faulting is of Pliocene age. However, some of these faults have been rejuvenated by neo-tectonic activity and in the western part of the study area represent a seismic active zone. The volcanic rocks of the area thicken rapidly westwards towards the edge of the Rift Valley, where the maximum thickness is represented by the Ngong Hills (Karengata LPDP).

The hydrogeology of the study area is characterised by the presence of a thick layer of the hard Mbagathi Phonolitic Trachyte. Aquifers in this area are mainly located within the Upper Athi Series formation. Initially, the groundwater prospects for this area were

fairly good with moderate yields being obtained from boreholes drilled to relatively shallow depths upto 150m.

The situation however changed dramatically due to the over-abstraction of groundwater caused by the high numbers of boreholes in the area.

3.4 SOCIO-ECONOMIC AND CULTURAL ANALYSIS

3.4.1 Population dynamics

In 2009, the population of the Karengata area was 33,303 (2009 census). However, this figure does not give a complete picture as it does not include the daytime population that results from the daily influx of people who travel from other parts of Nairobi to the numerous institutions or to work in the area. However, if this figure is used as the base and a growth rate equivalent to the growth rate of the city as a whole is applied, the current population of the area would be 40,945.

Table 3.1: Population projections of Karengata Area

	Base Year (1999)	2005	2009	2015
City growth rate of 4.7%	25,882	35,691	40,945	51,459

Source: Barreh, J K (2004).

3.4.2 Economy

The above analysis shows that the study area provides numerous employment opportunities. Institutions employ many staff both permanent and casual. The security firms are also a major employer in the area. The increase in office accommodations and service industries is creating more employment as is the increase in tourist related activities. But the study area's most significant contribution to the economy of the city is as a desirable place to live. Nairobi is an important city internationally and a choice location for many international firms and agencies.

CHAPTER FOUR: RESEARCH DESIGN AND METHODOLOGY

4.1 NATURE AND TYPES OF DATA

Data on the nature and characteristics of the physical planning and development control mechanisms operating in Karen were collected. The history and trends in the performance of the Nairobi City Council was also investigated. Various land use planning regulation instruments were assessed. These included; zoning regulations, building regulations and subdivision regulations. Also assessed was the legal framework for urban land use. The laws governing urban land use include; Local Government Act (CAP 265), Physical Planning Act (No.6 of 1996), Public Health Act (CAP, 242), Building By-laws and various other By-laws. Development control regulations were assessed in relation to the various developments taking place in Karen.

Information on the effectiveness of the Karen Langata District Association in assisting the NCC to enforce development control mechanisms was collected. The data collected was then compared to the provision of facilities and services such as water and sewerage. The actors in the provision and maintenance of the above facilities and services and any flaws related to their provision were identified. Investigations were also carried out on the working relationship between the developers, the planners and the council officials.

Any existing problems, what has to be done to solve them and their persistence is of interest. Views of all stakeholders on how the existing situation could be improved were sought.

4.1.1 Types of Data

To realize the above, two types of data were collected; primary and secondary data.

- Primary Data: This consisted of first hand information collected from the field through observation and interviewing the various stakeholders.
- Secondary Data. This consisted of second hand information collected from published material.

4.2 SOURCES OF DATA

Two sources of data were explored, they were;

- Primary sources: This includes interviews with council officials on various issues relating to the study area. In addition, interviews with the people of Karen were carried out to obtain first hand information on the problems of the study area. Field observations were also included in this source of data.
- Secondary sources: These included the local physical development plan and published booklets on Karen.

4.3 METHODS OF SAMPLING

4.3.1 The Sampling frame

The sample population consisted of the residents of Zone 4 in Karengata and the developers. Zone 4 was chosen because it was experiencing the highest number of sub-divisions below the legal minimum (Karengata LPDP). Therefore the impacts of this activity on the water infrastructure would be the most visible in this area.

4.3.2 Sampling methods

The following sampling methods were adopted;

Random Sampling

This was used to select respondents from among the residents and from the developers. The residential plots were selected on a random basis and their owners interviewed.

Purposive Sampling

This was used to select respondents especially those from the Ministry of Water and Irrigation and Water Resources Management Authority who had relevant information on the study topic.

Snow ball sampling

This was used to lead the researcher from one key informant to another, especially in the Nairobi Water and Sewerage Company, who had relevant information on the study topic.

Sampling Size

A total of thirty respondents were sampled. This was arrived at by considering the population of the study area and calculating a suitable sample size. The sample included the household heads, and developers. Time constraints as well as the financial constraints were also included in the decision for a suitable sample size.

4.4 METHODS OF DATA COLLECTION

The following methods of data collection were employed;

4.4.1 Intuitive Observation

This involved using spontaneous pre-scientific observation to study or observe any flaws in planning, provision and management of facilities and services. Photography was also employed to take pictures of scenes where environmental degradation and illegal land uses are observed.

4.4.2 Questionnaire Administration

Questionnaire administration was employed where a large population sample was interviewed, or in cases where the predetermined respondents were not available for interview, at the right time. The questionnaires were applied mostly on the households and developers on such issues as efficiency in management and provision of facilities and services by the Nairobi Water and Sewerage Company (see appendix A).

Open ended questions were also used to encourage respondents to give answers in their own words so as to reveal their feelings about the state of facilities and services provided to them. Close ended questions were also applied in cases where the answers were short and general.

4.4.3 Interviews

This involved direct personal conversations with pre-determined respondents, especially key informants and developers from whom data was collected. Exploratory interviews were applied to explore a variety of pre-selected topics with the respondents. Many facets of the interviewees' concerns were explored, treating subjects as they came up in conversations and pursuing interesting leads. More specific questions were also asked but

largely in an open ended format. They were questions about specific topics included in the interview guide (see appendix B). The exact manner and sequence in which the questions were asked was determined in the course of the interviews. This method was used to acquire detailed information on more complex and detailed issues especially from the hydro-geologists.

4.4.4 Photography

Photography involved capturing the real situation on the ground and representing it on paper in pictorial form for easier understanding.

4.5 DATA ANALYSIS AND PRESENTATION

Descriptive statistics were employed in data analysis and presentation. It involved computation of averages and means and percentages of the statistical data collected. Interpretation was employed in which case meanings are assigned to the findings. This helped in deciding what conclusions were justified. Methods of data presentation included bar graphs, maps and photographs.

CHAPTER FIVE: RESULTS AND DISCUSSIONS

This chapter analyses and discusses the data collected in the field under various themes. The chapter begins by examining the type of development taking place in the study area. It determines how the development relates to the building codes and zoning regulations. It further assesses the impacts of these developments on water resources and existing infrastructure and finally suggests integrated water infrastructure management measures for these impacts.

5.1 HISTORICAL ACCOUNT OF THE DEVELOPMENT OF KAREN-LANGATA

1910s -1930s

In 1913, Karen Blixen who was among the pioneer settlers in Kenya established her farm near the Ngong Hills; 20 kilometres from Nairobi town. She had six thousand acres of land, part of which was a coffee plantation and the rest indigenous forest, grassland and land on which farm workers and their families lived.

After the First World War, the British government offered large tracts of farmland in the area to demobilized personnel to encourage them to come to Kenya to develop the colony. They built houses of timber and local stone, quarried in the area, stored rainwater from their roofs, dug their own latrines and used firewood for cooking and heating water.

1940s -1960s

In 1945, after the Second World War, the land was subdivided into 5-40 acre parcels and sold to ex-British forces and colonial government officials. In the 1950s, the Nairobi Urban District Council (UDC) attempted to impose building by-laws in the area but these were strongly opposed by residents who considered that they were restrictive. One

resident in a letter to the East African Standard in May1959 wrote, "The proposed by-laws are standard practice in Britain but to apply them to Kenya is utterly mad".

In 1963, Nairobi UDC became the Nairobi City Council (NCC) and the city boundary was extended to include Karen Langata thus making it subject to the same by-laws as the rest of the city.

1970s and 1980s

Nairobi city was growing fast and the infrastructure required to support it was inadequate. Initially, the Karen Langata area did not experience problems because the demand for water supply and sanitation services was met by the residents themselves. Demand for water could be met by tapping into the aquifer and sewage could be dealt with through septic tanks and soak pits. In 1987 the NCC took over the responsibility for supplying water to the area from the city's main supply. In 1988, the NCC prepared a Structure Plan for the area and introduced a Rezoning Ordinance which reduced the minimum plot size to one acre south of the Langata and Dagoretti roads and to half an acre, north of these roads.

The NCC's rationale was to make plots available that were more affordable to middle income Kenyans, to increase the population of the area and the income from rates and water service charges. However the reduction in minimum plot size would require the infrastructural services to also be improved so as to match the increased demand. The local residents opposed this decision because the existing infrastructural services such as mains water and sewerage could not meet the anticipated increase in demand. The local residents also argued that the NCC would be unable to ensure that development took place according to NCC standards. This proved to be the case as, for example, at Karen Plains, where the land was subdivided and plots sold without a proper layout plan or services in spite of NCC regulations requiring developers to provide roads and drainage to adoptive standards before title deeds were issued.

During this period, the area was increasingly becoming the location of choice for more affluent Kenyans to build houses for residential use. The main attraction was the availability of large plots and the pleasant environment that had not yet succumbed to the problems caused by uncontrolled development in other parts of the city. Plate 1 shows the pleasant environment that appealed to developers.

Plate 1 Aerial Photo showing Low density housing

However in the past few years, the increased rate of development resulted in the degradation of the natural environment as well as putting an enormous strain on the natural resource base. Sub-division to the minimum plot sizes and below continues throughout Karengata, while the City Council is only able to provide a fraction of the daily water demand. Changes of use from residential to commercial continue to increase rapidly. The area is now experiencing abuse of both the land transfer and the planning approvals systems. Regulations are continuously flouted and development is taking place haphazardly with little or no control by the city authorities.

In the study area, development is taking place in a haphazard manner and contrary to zoning regulations. The main issues affecting Zone 4: Karen Plains and Forest Edge

include: subdivision of property below the required minimum plot size; rise in the number of commercial enterprises and growth of slum dwellings.

Extensive subdivision below the currently permitted minimum plot size of 0.2 hectares is occurring throughout the study area. Currently, developers are increasingly subdividing their properties without obtaining approval from the NCC and selling them to home owners who develop them (see plate 2). Many of these developments are taking place in ecologically sensitive areas such as the riparian reserve along the Mokoyeti River and have a negative impact on water resources.

Plate 2: Plate showing plots for sale that have been subdivided without approval from NCC. (Source: field survey, 2010)

Developers are also carrying out change of user from residential to commercial on an *ad hoc* basis, leading to a rise in the of commercial premises in unsuitable areas, many with negative environmental impacts. For example, there are small-scale commercial enterprises such as vehicle repair and building materials outlets that are being established in residential areas. This will result in the character of the residential areas being altered and will lead to conflicts in land use (noise, pollution, security, resource use etc.) and increased pressure on water infrastructure.

Furthermore, there is proliferation of informal trading activities such as kiosks, bars, curio shops and hawker's stalls on road reserves and at road junctions. The location of

these activities on these areas compromises road safety, smooth traffic flow, causes aesthetic pollution and poses a security risk.

Plate 3: Curio shop built on a road reserve along North Langata road adjacent to Mamba Village in Karen.
(Source: field survey, 2010)

The final issue facing the study area is the growth of slum dwellings, such as Kuwinda slum, Maasai village among others. These settlements were created to accommodate low income groups such as construction workers, small-scale traders, house helps, gardeners, security guards and employees of the many institutions in the area who were not provided with lodgings by their employers. The housing units found in these settlements are old and, in most cases, very dilapidated structures which have developed over the years to house extended family members and tenants. In some cases these structures are on large agricultural plots that have been in the same family for generations e.g. Kampi Kisii, or on land without formal title e.g. Kuwinda. In most of these locations, water is in very short supply with tenants relying on handouts from neighbours, buying water by the *debe* or using polluted rivers and ponds. Sanitation is mainly through pit latrines, many of which are poorly maintained and in some cases pose a serious health hazard.

Plate 4 Poorly planned high density housing in Kuwinda Settlement (Source: field survey, 2010)

The residents' opposition to the imposition of development control in the early 1960s now changed to a desperate request for more control to stop illegal and irregular development and for an improvement in water supply to reduce the rapid depletion of ground and surface water resources. In 2003 KLDA formulated a development strategy for the area based on environmental principles.

In 2004 the Physical Planning Department (PPD) of the Ministry of Lands agreed to undertake the preparation of a Local Physical Development Plan (LPDP) for Karen and Langata to provide a guiding legal framework for the development of the area. The plan was prepared by the PPD with the participation of residents, the NCC, the Ministry of Water and the National Environment Management Authority (NEMA), among other key stakeholders.

The LPDP was launched by the Minister for Lands and published in the Government Gazette in August 2006. The Planning Committee of the NCC approved it later the same year. Its implementation was intended to continue the collaborative approach initiated through its preparation. But the implementation arrangements envisaged in the LPDP have not yet been put in place. Negotiations continue between KLDA and the NCC to agree on the approach to be taken, while development which is not in accordance with the plan accelerates.

5.2 AN ASSESSMENT OF THE IMPACTS OF THESE DEVELOPMENTS ON THE WATER RESOURCES AND EXISTING INFRASTRUCTURE IN THE AREA

The Nairobi Water and Sewerage Company (NWSC) which took over as the main water supplier of Nairobi from the NCC has also been unable to manage the water supply and is currently providing between 9% and 18% of the estimated demand.(source, NWSC 2010) Developers are therefore forced to tap into the area's rapidly decreasing ground and surface water resources.

Abstraction from rivers and the sinking of boreholes are increasing. Many boreholes are being drilled illegally and extended to tap deeper levels, posing a latent threat to Nairobi's aquifers. Boreholes have become big business and the supply of 'clean borehole water' from Karen and Langata supplements the inadequate supply in other parts of the city.

In addition, individual sanitation arrangements such as septic tanks have not always been adequate leading to increasing pollution of rivers and land. If the increase in development is not matched by regulation of the use of boreholes and an improvement in water supply and sanitation services, it will have a devastating impact on the ground and surface water resources of the area. (Ngaruya, 2010)

Other natural resources such as forests and indigenous vegetation are being destroyed to make way for development. Natural wetlands and drainage channels are also being affected by increasing development, which is causing flooding in many areas during the rainy season. Larger and more expansive houses are being constructed on increasingly smaller plots leaving little room for adequate sanitation arrangements or the planting of trees.

5.2.1 Water Supply

An inadequate supply of water to residents is the most critical single impediment to sustainable development in the study area. Despite the completion in the late 1980's of the NCC managed Karen and Langata Distribution Project, mismanagement, vested interest and theft from illegal connections has meant that supply has declined since the project was completed. The NWSC, which took over the NCC as the water undertaker for Nairobi, currently supplies between 1,880 and 2,350 m^3/d or 20 to 25% of the actual demand of water which is 9,430m3/d (NWSC). As a consequence, residents have come to rely on alternative sources of water, including groundwater and surface water sources, and harvested rainwater. Data acquired from the field shows that:

- 93% of the respondents believed there were problems with NWSC water supply;
- 87 % of the respondents interviewed relied on both borehole water and rainwater as alternative sources of water.

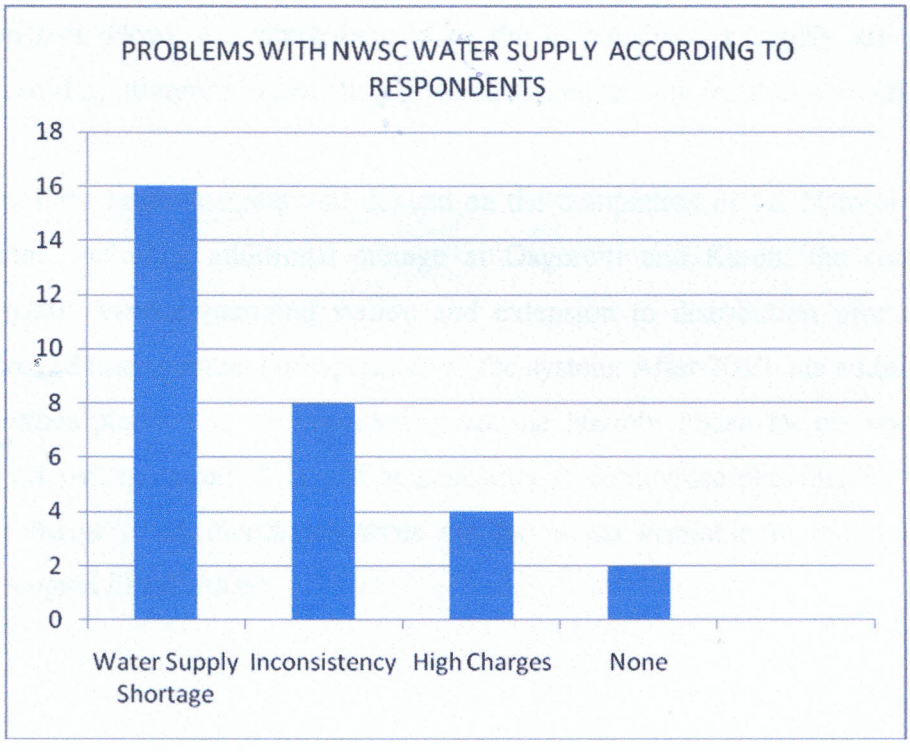


Figure 5.1 Respondents opinion on water supply by the NWSC

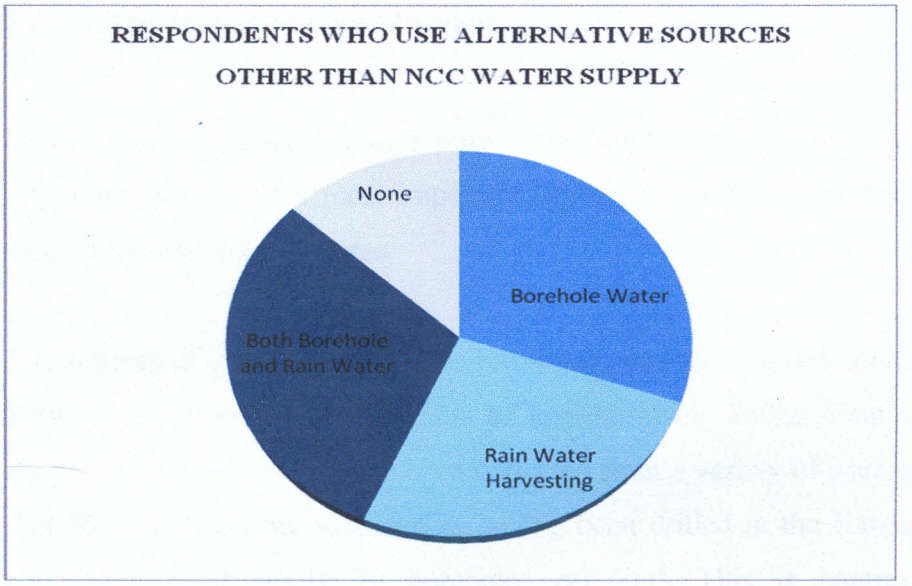


Figure 5.2 **Pie chart showing respondents who rely on ground water and rain water harvesting for domestic use.**

Previous NCC water supply mismanagement is acknowledged to have been the principal impediment to operational efficiency. The NWSC is currently planning to effect improvements in the "near future", although no plan of operations has yet been published. However, improvements to the existing water supply are expected to be achieved by streamlining existing systems and improving institutional infrastructure.

Long-term improvements will depend on the completion of the Nairobi Phase III water system, including additional storage at Dagoretti and Karen, the completion of the Kenyatta Avenue pumping station and extension to distribution pipework as well as improved management and operation of the system. After 2010, the additional bulk water resources planned to be provided under the Nairobi Phase IV or Northern Collector Project will be required. It will be necessary to commence planning for this in the very near future if additional resources are too made available in the post 2010 period. (Karengata LPDP 2006)

5.2.2 Abstraction of ground water

Due to the lack of an adequate piped water supply, ground water resources remain an important, possibly the most important, source of domestic, institutional and irrigation water supply in the study area.

The sources of ground water in the Karengata area are aquifers found in the Upper Athi Series with an estimated thickness of approximately 260m. Data for boreholes, their depths and test discharges has been collected from a variety of sources. These data show that 552 boreholes are recorded as having been drilled in the Karengata area, giving a concentration of nearly 10 boreholes per km^2. This is contravenes the WRMA requirement that states that all boreholes should be separated by a distance of 800m, which translates to one borehole per km^2 (Water Resources Management Rules, 2007).

There are currently 24 boreholes within the 10 km^2 occupied by the study area. Existing groundwater users in the area include the following: Privately-owned boreholes serving single plots; Water supply company boreholes; Institutional boreholes typically operated by religious groups; School boreholes; Privately-owned boreholes supplying commercial water sellers and Club and hotel-owned boreholes (see figure 5.3). It is estimated that 6,960m^3 (source: Ministry of Water and Irrigation) is pumped from these boreholes every day to meet the estimated demand of 9430m^3 from the residents.

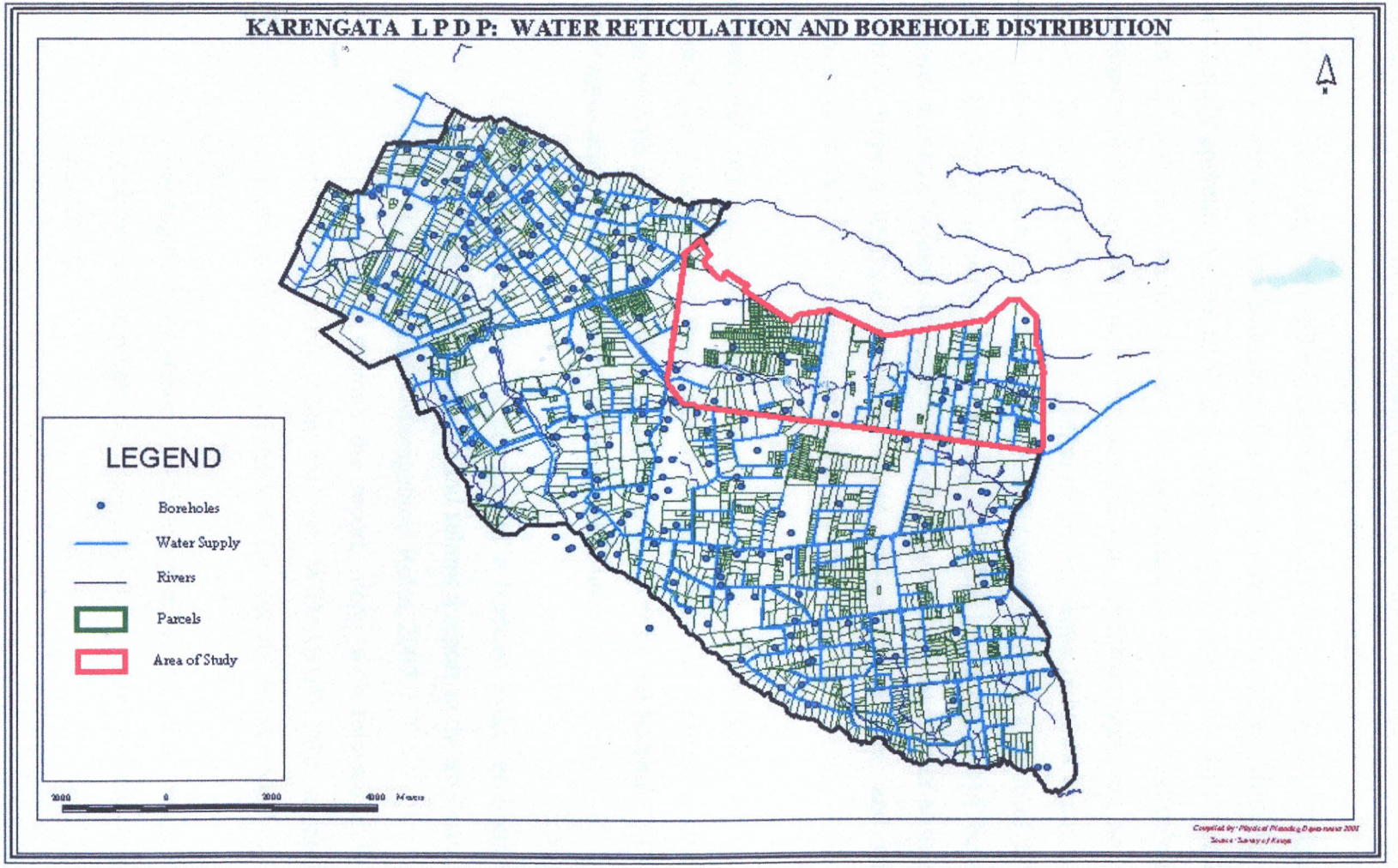


Figure 5.3: Water Reticulation and Borehole Distribution

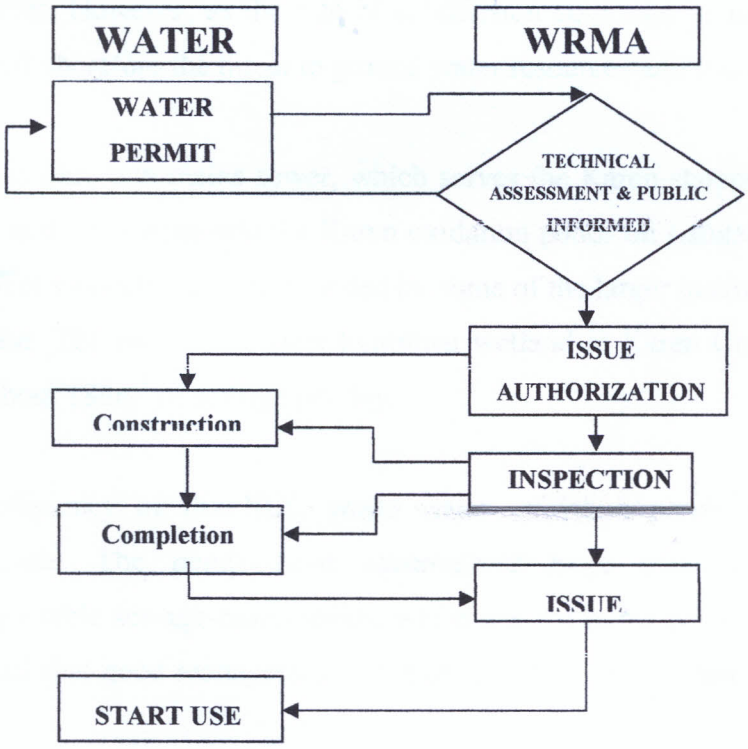
The researcher interviewed 3 borehole operators; which included; a privately-owned borehole serving a single plot, a water supply company and a privately-owned borehole supplying commercial water sellers. The boreholes serving a single plot withdraws 1 to 2 m^3 per day, while the borehole supplying water sellers withdraws $60m^3$ per day. The water supply company known as W & K water supplies distributed 1 to 2 m^3/day to 30 households. All the boreholes were not subjected to an EIA as stipulated in the Environmental Management and Coordination Act. Therefore, there are no mitigating measures in place to ensure that depletion of ground water does not occur. Already, a number of older boreholes in the study area that were drilled to a depth of 120 m have dried up. This is due to water levels in the aquifer falling below the base of the hole as the shallower aquifers become depleted. Continued growth of groundwater abstraction will inevitably have a negative impact on older, shallower boreholes, and will impart economic costs on borehole operators and the Karengata residents.

Groundwater resources are monitored by the Water Resources and Management Authority. They are managed through permits; these are issued for drilling a borehole and for the volume of water the owner proposes to pump from the borehole. The existing permit application process takes the following procedure:

1. Applicant engages the services of a licensed hydro geologist to assess availability of the resource, and submit a report to the applicant, based on the "Water Resources Management Rules, 2007.
2. The Applicant submits the report, along with relevant duly filled in application forms from the set WRMA001D (for assessment and authorization) and WRMA001A for permit, to the local sub-regional office
3. Sub-regional (or regional, depending on class) office assesses that the application is in order, and applicant is advised on what fees to pay for the assessment

4. Applicant at the same time is advised to notify the public of the intention to construct groundwater abstraction works
5. Applicant pays requisite charges and the application (including evidence of notification and payment) is sent to the WRMA regional office for technical assessment
6. Technical committee deliberates and decides whether to issue authorization or not. An authorization will be issued along with applicable conditions
7. Applicant constructs the works (well or borehole) and submits the Borehole Completion Report (WRMA009A) or Well Completion Report (WRMA009B) to WRMA.
8. WRMA technical committee assess and grants groundwater abstraction permit based on borehole/well performance, applicant's requirements and available resource
9. Applicant officially authorized to become a water user, according to the conditions of the permit.

Figure 5.4 The water permit application flow chart (ref. WRMA)



The Borehole Permit issued by WRMA after successful application, will state the maximum pumping rate and the maximum number of hours pumping allowed per day. Permits are typically valid for a 10 year period, unless varied by WRMA. However, there are very few physical checks made on existing boreholes in the study area. Very few boreholes are fitted with flow meters or a means by which groundwater levels may be measured, though meters and water level access tubes are now a requirement stipulated in the Authorization to Drill a Borehole (Source WRMA: Nairobi WAP Report). Therefore, WRMA is unable to regulate ground water abstraction which has resulted in over abstraction from boreholes in the study area. According to WRMA the total abstraction rate for Karengata is 18,216 m^3/day which exceeds the recommended value of 10,000m^3/day (Nairobi WAP report).

5.3.3 Sanitation

In the study area, liquid waste and sewage is disposed of mostly on-plot through soak pits and septic tanks. The utility of septic tank systems is sensitive to soil conditions: black cotton soils drain poorly, while red soils drain well. Septic tank systems are only environmentally sustainable at low densities and should not be in close proximity to boreholes. However, as the rate of subdivision continues to rise, more septic tanks are required; therefore the threat to ground water resources will increase.

There is only one mains sewer, which serves the Karen shopping centre and the health centre and discharges into the Karen oxidation ponds on Langata road. All other sewage treatment works have been provided by some of the larger institutions in the area for their own use. The medium-sewage treatment wetland at Karen Country Club, estimated to treat about 180m^3 of sewage per day.

The efficiency of the NCC waste water oxidation ponds along Langata road are inadequate. The ponds have accumulated huge quantities of unpleasant, non-biodegradable sewage-based solids, which are not removed periodically for incineration or burial that good management practice calls for. The environment impact of untreated

wastewater, particularly the risk of contamination of the North Mokoyeti River (Including downstream utilities such as Mamba Village and the Jolly Roger), is significant.

The inadequacy of the NCC waste water oxidation ponds has also resulted in the establishment of substandard raw sewage treatment facilities to cater for the increased demand for sewage disposal. One such facility has been set up in a disused quarry in a residential estate within Ongata Rongai Town. This unlicensed plant has been in operation for 15 years and has caused deterioration of air quality in the surrounding area which has impacted the neighbouring community negatively.

A formal sewerage system has been planned but not constructed. The sewage master plan for the area states that a 14 km of trunk sewer was to have been laid by the year 2000 and an additional 16 km by the year 2005. The proposal was to sewer Dagoretti and Langata roads first and thereafter Bogani and Ndege roads. The existing Karen area gravity sewer was to join a trunk sewer along the Motoine River, and this and the Bogani road areas were to have been covered by the year 2010. However none of these proposals were realized and the residents continue to rely on septic tanks to cater for their waste.

CHAPTER SIX: CONCLUSION AND RECOMMENDATIONS

6.1 CONCLUSION

Subdivision and subsequent development in the study area has proceeded with disregard to planning regulation, existing water supply infrastructure and services. This trend begun with the introduction of the 1988 Structure Plan by the NCC, which reduced the minimum allowable plot size for residential development in Karengata. This basis of this decision was to allow plots to become affordable to middle income Kenyans. However, the infrastructure for the area particularly water supply infrastructure, was not expanded to accommodate the increased population. The result was uncontrolled subdivision of land and inefficient provision of water and sanitation by the NWSC resulting in undue pressure on ground water resources.

6.2 RECOMMENDATIONS

The final objective of the study was to propose integrated water infrastructure management measures that can be undertaken to address this problem. In order to enhance service provision by the NWSC and protect ground water resources, the study proposes the following measures.

6.2.1 Improving the management of water resources

It has been noted that public water supply is inadequate and this has resulted in the over-exploitation of the ground water resources through both private and commercial boreholes. The consequences of uncontrolled borehole drilling and groundwater abstraction are serious and will need to be closely monitored.

Therefore it is necessary to make provision for the improved management and more equitable use of ground and surface water resources, and the promotion of rainwater harvesting.

Improving the management and more equitable use of ground water

Improved regulation of borehole drilling and abstraction in the plan area and throughout the Nairobi Conservation Area (NCA). Proposed measures to be taken to achieve this include:

- Approval of all new boreholes to be conditional on an EIA, which should include an assessment of the effect of new boreholes on groundwater resources in the area in general and on neighbouring boreholes in particular.
- Condition of approval should include regular abstraction and water level monitoring.
- Approval of new boreholes should be limited to domestic uses and public water supply.
- Existing irrigators and commercial tanker operators be regulated
- Renewal of permits should be subject to constant monitoring and reviews of the ground water levels.
- Existing borehole owners can be encouraged to share water with their neighbours at a fee in order to reduce number of boreholes that are drilled.

In addition the following proposed measures need to be undertaken to provide more accurate information on the reliability of the ground water resource and the risk of resource depletion and aquifer damage

- A physical ground survey of all boreholes in the Karengata area. This will both update geographical data for Zone 4 boreholes and provide information on the uses to which water is put in the area. It is proposed that the Ministry of Water and Irrigation (MWI) undertake this task.

- A programme to monitor static water levels, water quality and abstraction throughout the Nairobi Conservation Area. This can be undertaken/by the Water Resources and Management Authority (WRMA).

Improving the management and more equitable use of surface water

Surface water resources are limited to abstractions from the Mbagathi and Motoine rivers. To protect this resource and safeguard the surface water resources in the Nairobi Basin, the following measures are proposed for consideration by WRMA:

- Define the Mbagathi and Motoine river catchment areas using Geospatial Information Systems (GIS) and draw up regulations and controls on catchment use. In doing so, the water catchment area will be conserved for future generations.

- WRMA should reassess surface water permits and renew those that continue to follow the conditions and withdraw those that have been abused or exceeded.

- WRMA should also ensure that each new application for a surface water permit, or renewal of an existing permit, is evaluated in the light of known residual flows in the river in question and that permits are not issued where these would adversely affect downstream users.

- Implement a surface water resources monitoring strategy which can include a water quality survey to establish the significance (if any) of agro-industrial pollution in watercourses in and upstream of the Karengata area.

Encouraging rainwater harvesting

The following are proposed measures to encourage rainwater harvesting in line with Sessional Paper No.1 of 1999 on water policy.

- All new construction in the study area should be required to include a component of roof rainwater capture and storage. This would allow households to have an alternative source of water other than borehole water, thereby conserving groundwater resources. In line with this, the NCC should develop guidelines and regulations for the collection, storage and use of rainwater.

- Standards should be drawn up for water collection and storage by the Ministry of Water and Irrigation in liaison with the Kenya Bureau of Standards. Advice and guidance may also be obtained from the Kenya Rainwater Association or the Regional Land Management Unit.

- Developers ought to be explicitly encouraged to invest in substantial rainwater harvesting and mains water storage facilities, instead of spending money on sinking boreholes.

6.2.2 The management of public utility services

There is minimal provision of public utility services in the study area. The public water supply is inadequate to meet demand; this means that most residents have to employ their own resources to provide themselves with water.

The following measures should be undertaken by the local community and the public authorities for the improvement of public water supply services in the plan area.

Improving the public water supply

In tandem with the above measures to improve the management of ground and surface water resources, the NWSC programme to improve the piped water supply to the plan area is as follows:

Table 6.1 Programme to improve the piped water supply

Immediate plans

Strategy	Status
i. Putting in place an effective water rationing programme	This has been achieved despite the following interruptions: a. In pumping hours b. Manipulation of control valves

Source: Nairobi Water and Sewerage Company

Mid-term/intermediate plans

Strategy	Status
ii. Installation of non-return valves on the distribution system between Kabete and the Dagoretti Reservoir	–Tenders have been awarded.
iii. Identification and repair of all non-functioning control valves	–Work on identification has started and should be complete
iv. Replacement of vandalized / non-functional fire hydrants	– Most of them are missing – Problems of airlocks in high areas
v. Completion of Kenyatta Avenue pumping station	– Tenders awarded and work started – Ground preparation on-going
vi. Swabbing of Ruiru Dam pipeline	– Tenders awarded (Centurion Engineers, 7/2/05)
vii. Installation of standby pump at Kabete water works	– Already in place
viii. Re-routing of Kikuyu Springs No. 1 Pipeline (which leaks heavily and passes through farmland)	– Documentation on-going
ix. Development of 5 Boreholes (Miotoni Lane, Gitiba 2, Leake's, Denkin Dura and Bangua's)	– Currently under consideration by NWSC, NWSB and the Ministry of Water and Irrigation

Source: Nairobi Water and Sewerage Company

Long-term plans

Strategy	Status
x. Reinstatement of Sasumua Dam following its collapse	– Currently being considered by NWSB – Funds made available from ADF
xi. Laying of parallel water lines: – a. Between Gigiri and Kabete b. Between Kabete and Dagoretti Reservoirs.	– Possibility being looked at based on viability – Feasibility studies in progress

Source: Nairobi Water and Sewerage Company

The NWSC is currently preparing a detailed plan based on the above, but including estimated costs and a time frame for implementation.

In addition to the measures proposed above, the NWSC should be encouraged to plan for the extension of reticulation to cover areas not already covered. Priority will be given to areas where sub-division to 0.2 ha is planned or has already taken place.

Improving Sanitation

In the absence of sewerage reticulation, the following measures are proposed to ensure adequate and hygienic sanitation in all parts of the plan area.

- Approval of septic tanks for all new developments should be subject to criteria relating to soil conditions, plot size, disposal facilities for exhausters etc. As a general rule, plots underlain by near-surface Nairobi Trachyte and black cotton (sodic alkali soils) should be restricted to lower density due to the restricted ability of such environments to sustainably handle the effluent.

- Immediate improvements to the management of the Karen oxidation ponds are proposed in order to maximise the treatment capacity of this facility. These improvements include:
    a) Active management to ensure periodic cleaning of floating and precipitated solids, and discharge measurement;

    b) Fencing of facility to eliminate the health hazard it poses at present;

    c) Regular monitoring of effluent quality to ensure that this is not a hazard to environmental health;

    d) Updating of register of approved dischargers to this facility

e) NCC to provide their exhauster tankers to empty the septic tanks.

- The recycling of waste water should be promoted, including :

a) On-plot separation of grey and black water for alternative uses

b) Constructed wetlands, such as that developed at the Karen Country Club for waste water recycling particularly for multi-unit housing developments, institutions, and other facilities where relatively large volumes of liquid waste are likely to be generated on a regular basis.

c) Review and revise in the light of the current and proposed development, the sewerage master plan for the area.

d) Implement the first phase collector sewer and treatment ponds

6.3 AREAS FOR FURTHER RESEARCH

- There is need for partnership between KLDA and the NCC to enforce the Local Physical Development Plan prepared for Karengata.

- The WRMA should address its weakness in enforcing compliance to the Water Resources Management Rules, 2007. The fact that there are more boreholes than is environmentally sustainable will mean future water users will not be able to utilize ground water

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APPENDICES

APPENDIX A: HOUSEHOLD QUESTIONNAIRE

Hello, my name is Philip Mbugua Kiama, a student of Kenyatta University pursuing a masters degree in Environmental Planning and Management. I am conducting a research thesis on the Impacts of increased subdivision on existing water supply infrastructure in Karen Langata District.

I would like to request your assistance in the research by providing relevant information in this questionnaire. Your information will be treated with greatest care and objectivity. Hence your response will be highly appreciated.

General information

- Age……..
- Sex……...
- Occupation……..

1) a) Approximately, what is the size of the plot in which you stay?

□ Less than half of an acre

□ A half of an acre

□ An acre and above

b) How many houses are accommodated on your plot?.....

c) Is your house connected to the Nairobi Water and Sewerage Company supply network?

□ Yes

□ No

If yes, how many times in a week do you receive water from NWSC?

□ Once a week

□ Twice a week

□ More than twice a week

d) Do you obtain water from the following sources apart from the NWSC?

□ Borehole Water

□ Rain Water harvesting

Please comment on the quality of the above sources

.....

.....

.....

2) What is your opinion on the rate of subdivision and developments taking place in your area?

……

……

……

……

……

……

……

……

3) What general problems do you experience with provision and maintenance of the following services?

a) Water

Problem(s)……

……

Cause (s)……

……

Possible solution (s)……

……

b) Sanitation

Problem (s)……

……

Cause (s)……

……

Possible solution (s)……

……

c) Others

specify……

……

APPENDIX B: INTERVIEW SCHEDULE

(The information acquired from this interview will be used strictly for academic purposes and will be treated as confidential)

A. Nairobi City Council

1. What is the nature of development in Karengata?
2. What are the causes of the rate of subdivision in Karengata?
3. How effective is the Karengata LPDP in regulating land use in Karengata?
4. What are the constraints to effective regulation of land use in Karengata?
5. What is the impact of existing development structure on provision of water?
6. What is the state of water supply infrastructure in Karengata?
7. What are the constraints to the provision of water supply services in Karengata?
8. What can be done to enhance water supply in Karengata?

B. Nairobi Water and Sewerage Company

1. What is the state of existing water supply infrastructure in Karengata?
2. What is the volume of water supplied by the company to Karengata?
3. Is the volume of water supplied able to meet the demand of Karengata residents?
4. Does the rate of subdivision experienced in Karengata affect provision of water by the company?
5. What are the constraints encountered by the company in provision of water?
6. How can these constraints be overcome?

C. Karen Langata District Association

1. What is the nature of development in Karengata?
2. What are the causes of the rate of subdivision in Karengata?
3. How effective is the Karengata LPDP in regulating land use in Karengata?
4. What is the impact of existing development structure on provision of water?
5. What is the state of water supply infrastructure in Karengata?
6. What are the constraints to the provision of water supply services in Karengata?
7. What can be done to enhance water supply in Karengata?