ASSESSMENT OF THE IMPACTS OF DEVELOPMENT DENSIFICATION ON WATER SUPPLY: A CASE STUDY OF UPPER HILL AREA IN NAIROBI

BY

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DECLARATION

This research project report is my original work and has not been presented for the award of a degree in any other university.

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DEDICATION

I wish to dedicate this work to all the people who have touched and positively impacted on my life in one way or the other, over the course of time; in particular to my late parents who worked very hard in very humble circumstances to bring up ten great children, seeing all of us through various levels of education and most important, imparting upon us strong and lasting values of hard work, the strong bond of love and the fear of God as the beginning of all wisdom. I also wish to dedicate the work to my husband and two sons, for endless support and being there for me.

ABSTRACT

This study was carried out in Upper Hill area, an extension of Nairobi city's CBD, located to the south of the CBD. The aim of the study was to establish the impacts that higher density development has had on water supply in the study area. The study's objectives were to review the changes in development type in Upper Hill between 1990 to-date; examine the effect of increased development density on water supply reliability and make recommendations on the possible approaches to development densification, with a view to sustainable water supply in growing suburbs. The study used both qualitative and quantitative data, which was analysed and presented in form of frequency tables, pie charts and graphs. The study hypotheses were tested using chi-square. Primary data was collected through administering questionnaires to residential and commercial properties in the study area, conducting key stakeholder interviews and observation, while secondary data was collated from various existing materials.

According to the study findings, there has been a change in type of development in Upper Hill area, from the initial low density bungalows to higher density multi-storeyed mainly commercial, and a few residential buildings, and that this change has affected water supply in the area, necessitating use of other sources of water, other than NCWSC, including boreholes and water bowsers, and that available water supply from NCWSC is inadequate. The study concludes that the higher density development in Upper Hill has not been matched by enhanced supply of water.

The study recommends that NCC comes up with an integrated plan to guide the development of the area, coupled with commensurate upgrade of the service infrastructure, and facilitates an inter-organizational effort involving all the service providers and stakeholders, to come up with guidelines on service provision in all parts of the city experiencing similar growth; NCWSC should increase the volume of water available for the area while an assessment of the existing pipe network and whether there is need for its expansion is also recommended. Other water sources such as rain and storm water harvesting should be exploited.

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ACRONYMS

ACA	Abadare Conservation Area
ADB	Africa Development Bank
FDA	French Development Agency
AWSB	Athi Water Service Board
BCM	Billion Cubic Meters
CBD	Central Business District
EMCA	Environmental Management and Coordination Act
GDP	Gross Domestic Product
GIS	Geographic Information System
IWMI	International Water Management Institute
JICA	Japan International Cooporation Agency
KNBS	Kenya National Bureau of Statistics
KWW	Kabete Water Works
SDG	Sustainable Development Goals
NCAPD	National Coordination Agency for Population & Development
NCC	Nairobi City Council
NCC	Nairobi City County
NCWSC	Nairobi City Water & Sewerage Company
NEMA	National Environment Management Authority
NCEO	Nairobi City Environment Outlook
NEPAD	New Partnership for Africa Development
NWSC	National Water & Sewerage Corporation
NSSF	National Social Security Fund
SPSS	Statistical Package for the Social Sciences
UNDP	United Nations Development Program
UNECA	United Nations Economic Commission for Africa
UNEP	United Nations Environmental Program
UNIDO	United Nations Industrial Development
WB	World Bank
WCED	World Commission on Environment and Development
WRI	World Research Institute

CHAPTER ONE: INTRODUCTION

1.0 Background of the Study

Cities play an important role in national development, being powerful engines of growth, centers of innovation, finance, production, marketing, information, and knowledge production (Cloche et al, 2004). In 2008, the proportion of the world's population living in urban areas crossed the 50% mark (Patel & Burke, 2009). The current rates of urbanization suggest that in China, 870 million people - more than half the population, will be living in cities within less than a decade, and the capital of Botswana, Gaborone, will grow from 186,000 to 500,000 inhabitants by 2020 (Patel & Burke, 2009). It is estimated that with the current pace of urban population growth, 65% of the total world population will be urban dwellers by the year 2025 (Cloche et al, 2004) and almost 90% of urban population growth will be in Asia, Africa and Latin America (UNEP 2005).

One of the definitions of urbanization is 'the process of growth in the urban proportion of a country's entire population, not just the mere growth in the urban population' (Hope K.R. Sr, 2012). The growth of cities over time has been influenced by various factors including location, accessibility/transport modes, available resources and political influence among other factors. As cities grow, they metamorphose over time; this metamorphosis is shaped by various forces, which may be economic, social, physical/spatial, cultural, political, environmental and institutional in nature. Resultant changes bring about challenges and opportunities that require innovative planning interventions. Some of the challenges experienced in urban areas and in particular large cities include air pollution from vehicles, high energy consumption, traffic congestion, insufficient parking space, noise pollution, accidents and water shortages. In particular, large urban areas have very high water demand for domestic, commercial, industrial and other uses, leading to two related problems of inadequate water supply and water pollution from various urban activities (Muthoka et al, 1998). Urbanization has stimulated academics and policymakers to search for sustainable urban development options that can pre-empt major ecological and social upheavals. This is because though human settlements, especially the urban settlements have a positive contribution to the environment and development, they have a negative impact on the total environment and development process; studies have shown that most of the activities that have had adverse impacts on the natural environment are related to human settlement and related human activities.

Urban settlements in particular give rise to problems in the areas of service provision, infrastructure, resource extraction such as of building materials, water supply, energy, sanitation, waste disposal and transport; these in turn affect the health of the inhabitants (Muthoka et al, 1998).

One of the most significant changes taking place in Africa in recent times is the rapid growth of the urban population; Kenya like most of Africa is also experiencing rapid urbanization and urban growth. Kenya's total population rose from 10.9 million in 1969 to 38.6 million in 2009; urban population as a proportion of total population rose from 8.8% in 1970 to 20.9% in the period 2010 and is projected to rise above 36% by 2040. The country's urban population growth rate is projected to average about 4% beyond 2010 through to 2040 (Hope K.R. Sr., 2012). According to these data, one out of every five Kenyans currently lives in urban areas compared to one out of twelve in the 1960s. According to the 2009 Population and Housing Census results published by the Kenya National Bureau of Statistics (KNBS), the proportion of the country's total population that is urban was placed at 32.3%, surpassing the projection of 20.9% above (KNBS, 2010).

In the Foreword to the Nairobi City Environment Outlook (NCEO) of 2007, then Minister for Local Government Musikari Kombo noted that Nairobi, like many cities in Africa is experiencing rapid population growth; this combined with the fact that the city is also the economic hub of Kenya and, indeed, of the larger East and Central African region, means a higher number of inhabitants with lifestyles that demand high energy, more land for the built environment, and increasing consumption of natural resources. In order to mitigate the negative impacts of such growth, there is need for strategic planning to go in tandem with the pace of development. This can only be achieved through a solid information base to support decision making (UNEP, NCC, 2007).

In light of the above, the then Nairobi City Council (NCC) – now the Nairobi City County (NCC), has had to review development policy in various parts of the city such as Kilimani, Westlands and the Hill Area (including Upper Hill) to permit development densification, through higher site coverage and plot ratios, resulting in construction of high rise buildings. It is the effect of this higher density development on water in Nairobi's Upper Hill area that this study sought to assess.

1.1 Statement of the Research Problem

Nairobi city's population based on the 2009 census stood at 3.8 million (KNBS, 2009) and is projected to reach 10 million by the year 2030. This is in line with rising national urbanization, (Kenya's urban population in 2009 was placed at 32.3% of total population, translating to 12,487,375 people living in urban areas where most jobs are found, while 67.7 % or 26,122,722 people, live in the rural areas (KNBS, 2009). As the urbanization trend continues, urban population is being pushed further and further away from the CBD, and in turn, the urban poor are being pushed to the peri-urban areas to pave way for expansion of the Central Business District (CBD). In the case of Nairobi, expansion of the CBD is taking place towards Upper Hill, Kilimani, Westlands and Thika Super Highway neighborhoods. This rapid population growth is giving rise to rapid expansion of the city, both physically and through higher density development in some parts of the city, such as Upper Hill, the subject of this study.

The Hill area was originally a low density residential area comprising single dwelling units on fairly large plots of 0.5- 2.5 Acres (Nairobi Town Planning Liason Committee, 1993). However, since the late 1960s when the Ministry of Works building was constructed within the vicinity of the Community Building, (the only office development at the time), the character of the area has been changing rapidly from the low density residential development to largely high rise office blocks. This higher density development has however been taking place without adequate guidelines for the expansion/development of service infrastructure in tandem with the higher density development. There are also problems with management of the available resources, which problem is compounded by lack of technical and institutional capacity needed to increase service coverage, further, there is lack of comprehensive planning and foresight (Hagerlund, 2006). Some of the main challenges that are envisaged to have arisen from this higher density development in the study area include: traffic congestion and inadequate water and power supply.

Provision of safe, convenient and reliable water supply to households in the developing world has been the subject of vast and wide-ranging research for at least four decades. According to Thompson et al, most of this research has focused on the relationship between water and disease, the efficacy of water supply projects in improving health, the causes and consequences of differential access and control of water resources (particularly with regard to gender and wealth), and on the financing of water supply infrastructure.

Despite this wide array of research, relatively little is known about a number of key aspects of domestic water use. In particular, knowledge is scarce about the long-term trends and changes in household water use in any part of the world. This is as a result of lack of quality baseline information and cost and complexity of undertaking longitudinal and repeat studies, with most research on household water use being limited to short periods of one season or year. Where studies have attempted to examine changes over time, they have tended to be limited in scope, frequently concentrating on a single locality. Consequently, the dynamics and determinants of domestic water use remain only partly understood. Among the regions of the world, these research gaps are most acute for sub-Saharan Africa, the region whose population has the least access to improved water supply (Thompson et al, 1997). There is therefore need for further research in this line, to show changes in water use taking place over time, which information would be very useful to decision makers in the water sector. In Kenya, numerous studies have been carried out but their emphasis is water and sanitation in relation to health, and particularly in informal settlement; no study has been carried out to study the effect of increased development density on water. This study sought to assess the effect of development densification in Upper Hill (where the original low density bungalows have been replaced by multi-storeyed buildings with more occupants), on water supply in the area, and established that current NCWSC supply is inadequate.

The study findings are comparable to those of a study carried out in 1997 that looked at the changes in domestic water use in the three decades between 1967 and 1997, in selected towns and cities in Kenya, Uganda and Tanzania. Among other findings, the study established that urban populations had grown rapidly, and that per capita domestic water use in urban areas of East Africa had declined, decreasing on average from 98.7 litres per day in 1967 to only 54.9 litres per day 30 years later (Thompson et al, 1997). Whilst in 1967 practically all sampled piped households received 24- hour service delivery, in 1997, only 56 per cent of them benefited from the same level of service, almost 40 per cent received less than 12 hours service and roughly 20 per cent got one to five hours service per day. The study further noted that reliability of piped water supplies had declined significantly over the three decades period, in most of the study sites. The study also noted the introduction of private water sources such as kiosks and vendors, which in 1997 were used by almost 40 per cent of sampled households with piped water supply.

1.2 Goals and Objectives of the Study

1.2.1 Goal of Study

The goal of this study was to investigate the spatial-temporal changes that have taken place in development of Upper Hill area of Nairobi, and how these have affected water supply sources.

1.2.2 The Research Questions

The research questions included;

i) What changes in development type have taken place in Upper Hill area during the period 1990- to present?

ii) What is the effect of increased density development on the water supply reliability in Upper Hill?

iii) Are there any changes that have taken place in the water supply sources in Upper Hill over the study period?

iv) What are the recommended approaches to development densification with a view to sustainable water supply in growing suburbs such as Upper Hill?

1.2.3 Specific Objectives

The specific objectives of this study were to:

i. Review the changes in development type (bungalows, maisonettes and multi storied buildings) in Upper Hill area between 1990 to present.

ii. Examine the changes that have taken place in the water supply sources (NCWSC, borehole, water bowsers, NCWSC and borehole or NCWSC and bowser) in Upper Hill over the study period.

iii. Examine the effect of increased development density on water supply reliability (is it poor, fair, good or excellent?) in Upper Hill.

iv. Make recommendations on the possible approaches to development densification, with a view to sustainable water supply in growing suburbs, such as Upper Hill.

1.2.3 Research Hypotheses

Hypothesis 1

Ho: There is no significant change in the type of development (bungalows, maisonettes and multi-storied buildings) in Upper Hill area, in the period 1990 to present.

H1: There is a significant change in the type of development in Upper Hill area, in the period 1990 to present.

Hypothesis 2

Ho: There is no significant change in water supply sources (NCWSC, boreholes, bowsers, NCWSC and borehole or NCWSC and bowser supply) in Upper Hill over the study period.

H1: There is a significant change in water supply sources in Upper Hill area over the study period.

Hypothesis 3

Ho: There is no significant effect of increased development densification on water supply reliability (poor, fair, good or excellent supply) in Upper Hill

H1: There is a significant effect of increased development densification on water supply reliability in Upper Hill.

1.3 Justification of the Study

Cities are focal points in an economy where people come together primarily to exchange goods and services, and interact. They are “drivers” of societal development, places of dreams, nostalgia and imaginations. However, alarming growth of urban population and poor response of governments are a factor that partly contributes to a high rate of physical development mishap in cities (Wylie, 2007).

The City of Nairobi, like other cities in the developing world, is experiencing rapid growth and transformation. Some of the main challenges experienced everyday include unplanned and uncoordinated urban growth, inadequate infrastructure, pressure on utility services, deterioration of the urban environment and increasing poverty.

Upper Hill area in particular has experienced rapid growth in the last decade, following a review of the zoning policy by NCC to permit higher density development which has seen construction of high rise buildings in the area albeit, without commensurate expansion of the service infrastructure, leading to constraints on the service infrastructure.

Provision of a safe, convenient and reliable water supply to households in the developing world has been the subject of vast and wide-ranging research efforts for at least four decades; most of this research has focused on the relationship between water and disease, the efficacy of water supply projects in improving health, the causes and consequences of differential access and control of water resources (particularly with regard to gender and wealth) and on the financing of water supply infrastructure. Despite this wide array of research, there is relatively little information on a number of key aspects of domestic water use, including the long-term trends and changes in household water use in any part of the world. This is as a result of lack of quality baseline information and cost and complexity of undertaking longitudinal and repeat studies, with most research on household water use being limited to short periods of one season or year (Thompson et al, 1997). One of the major constraints experienced during this study was inadequate data on water consumption in the study area over the years; the data which was previously in the custody of Nairobi City Council (before the formation of NCWSC in 2003); seems to have been lost or destroyed at the time of transition and was thus unavailable. Another constraint experienced was in obtaining historical pictorial records of the study area. In undertaking this study, the researcher sought to gather information on the effect of development densification on water supply in Upper Hill, thus contributing in filling this knowledge gap in the local context.

This study herein is justifiable in that it documents the changes that have taken place in Upper Hill area, following the rezoning by NCC to permit higher density development, and the impacts of high-density development on the surrounding environment particularly in relation to water supply for the increased population. The information will be useful to various stakeholders in management/mitigation of resultant challenges experienced in the area and will serve to pre-empt similar omissions in the future. The study also provides information on what factors should be taken into consideration prior to development density enhancement. The results from this study will provide a body of information that can be used to formulate policies on urban planning; policy makers and planners will find this information useful in formulation of appropriate plans at both local and national levels.

This information comes at an opportune time as it will contribute to planning decisions including in the Integrated Urban Development Master Plan for the city of Nairobi (NIUPLAN) by the County Government and also towards the Nairobi Metropolitan Growth Strategy as well as the nation's Vision 2030, which aims at transforming

Kenya into a newly-industrializing, middle income country providing a high quality of life to all its citizens in a clean and secure environment by the year 2030. While several studies have been conducted in Kenya revolving around various aspects of urban development such as urban poverty, urban sprawl and urban growth, among others, none has been conducted, to the researcher's knowledge, to establish the effects of densification of development on water supply in Upper Hill.

1.4 Scope and Limitations of the Study

1.4.1 Scope of the study

This study which focused on the effect of development densification on water in Upper Hill area of Nairobi revolves around Upper Hill area which for purposes of the study is that area bounded by Valley Road, Procession Way, Lower Hill Road, Elgon Road and Hospital; this area is quickly becoming the office location of choice in the city of Nairobi. Many businesses have relocated to the area from the CBD, with corporate organizations now developing their office headquarters in Upper Hill. The growth of Upper Hill as a commercial hub is recent, largely having taken place over the last 20 years. Upto the late eighties, Upper Hill was a predominantly upper-middle class residential area, with mainly old colonial houses set on plots of 0.5 to 2.5 acres. Today, it is resplendent with neat, organized rows of high-rise commercial buildings housing blue-chip local and multinational companies; there are however a few modern apartment blocks and residential maisonettes in gated communities tucked in with these commercial multi-storied buildings. Today, the area is home to several local, regional and multi-national company headquarters; Equity Bank, The World Bank, Coca-Cola, City Bank, Price-Water-House Coopers, British American Insurance, CBA Bank, Blue Shield Insurance, IFC and Old Mutual Insurance, among other big names have developed or are renting impressive head-offices in Upper Hill. The subject of this study is confined to how the high density development and resultant higher population impacts on reliability of water supply in the area, and the water supply sources in use in the area.

1.4.2 Limitations of the Study

Certain limitations were encountered in the course of this study. One of the greatest challenges the researcher encountered in this study relates to access to and collection of data due to extreme data gaps and paucity. In particular, obtaining water consumption data from NCWSC for periods prior to 2004 when the water body was formed proved impossible as the data that was to be transferred from NCC to NCWSC is said to have been lost or destroyed; this was a great set back in the study as the researcher had intended to show the variation in consumption over time. To overcome this set back, the researcher shifted focus to water supply sources to the sampled properties in the study area, and adequacy of NCWSC supply. Obtaining information from building caretakers (there was no access to the owners) was also a challenge due to suspicion and low level of understanding; this was however overcome by clarity of explanations given by the researcher and research assistants who all had a good grasp of the subject of study. The researcher was therefore able to acquire the relevant data, which helped compile this study report. This research was also limited by the reluctance of some respondents to complete the questionnaires promptly and some even failed to complete them at all. This problem was solved by administering questionnaires to more people to compensate for those that were not filled.

Most past empirical studies on water have centred on water and health, it was therefore difficult to obtain comparable studies to the subject study, further, literature on urban development in Kenya in scattered form abounds but published data on categorizing and ranking of factors influencing the specific objectives of the study was difficult to come by, this gap was filled by wider reading and reference/inference to studies in East Africa.

1.5 Definition of Terms

Development Densification – Enhancement of development space per unit area of land usually achieved through higher plot ratios and plot coverage, resulting in higher buildings (in terms of floors).

Ecological Footprint: – The area of land needed to provide a city with the resources it requires to function and to remove its wastes.

Plot Coverage – Extent of plot/land covered by building(s) or structures expressed in percentage or ratio of built up area to plot area.

Plot Ratio – Ratio of buildings' total floor area (gross floor area) to the size of the piece of land on which they are built.

Service charge – a fee collected per unit area occupied basis, from occupants of a commercial building, to cater for collective services such as water, security, common areas cleaning and lighting.

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

Snowball Sampling Technique – This is a sampling method in which initial subjects with the desired characteristics are identified using purposive sampling technique, they then name others that they know have the required characteristics, until the researcher gets the number of cases required (Mugenda & Mugenda 2003).

Urbanization – This is the process of population concentration through multiplication of points of concentration and the increase in size of individual concentrations (Tisdale Hope).

Urban sprawl – This is the spreading of a city or its suburbs, often involving construction of residential and commercial buildings in formerly rural areas or otherwise undeveloped land in the outskirts of the city.

Water Bowser – Trucks that supply for sale, water to commercial premises (offices and businesses) and homesteads.

CHAPTER TWO: LITERATURE REVIEW

2.1 Introduction

In the course of history, cities have occupied an important role in national development, being powerful engines of growth, centers of innovation, finance, production, marketing, information, and knowledge production (Cloche et al, 2004).

The growth of cities over time has been influenced by various factors including location, accessibility/transport modes, availability of resources and political influence among other factors; these factors determine the rate of attraction of population to urban centers and thus their growth. As cities the world over grow, they metamorphose over time, this metamorphosis is shaped by various forces which may be economic, social, physical/spatial, cultural, political, environmental and institutional in nature. Resultant changes bring about challenges and opportunities, which require innovative planning interventions.

2.2 Globalization and Cities

There is an unequal urban growth taking place all over the world, but the rate of urbanization is very fast in the developing countries. In 1800 A.D., only 3% of the world's population lived in urban centers, but this figure grew to 14% in 1900 and in 2000, about 47% (2.8 billion people) of the world's people were living in urban areas (Cook et al., 2004)

Consequently, one of the most notable demographic trends in the latter half of the 20th century was the urbanization of populations in both developing and industrialized countries; this trend has continued in the first half of the 21st century. Worldwide, cities added more than 2 billion people from 1950 to 2000, and they are expected to add more than 2 billion more from 2000 to 2025; it is anticipated that as much as 95% of these increases will come in developing countries, especially Asia and Africa (Meinzen-Dick and Appasamy Paul). Whereas the populations of Europe, the Americas, and Oceania were by 1994 over 70% percent urbanized, Asia and Africa's were only 34% urban; these continents are projected to be 54-55% urbanized by 2025 (Meinzen-Dickand& Appasamy quoting from United Nations Population Division, 1996). While the rate of global urban growth is now actually declining (from 2.6% to 2.2% per year worldwide, and 3.8% to 2.9% in developing countries), the sheer number of people being added to cities will continue to grow rapidly (Catley-Carlson, 2000).

2.3 Urbanization in West Africa, a Case of Lagos City

It has been established that in West Africa, the rate of urbanization in the last few years is highest in the city of Lagos (UNEP, 2005). The city has had a persistent rate of growth with a resultant effect on the carrying capacity and ecological footprint of the city. Lagos is the economic focal point of Nigeria and its population is heterogeneous with people from most parts of the nation represented. Despite the relocation of the Nigerian Federal Capital to Abuja, Lagos remains strongly the commercial capital and nerve centre of Nigeria. Like Nairobi, Lagos harbors almost all the headquarters of multinational companies in the country. Unfortunately, Lagos, like many developing cities, is being bogged down along the development ladder (UNEP, 2005) due to a mismatch between population numbers and available service infrastructure.

2.4 Urbanization in East Africa and in Kenya

In the 40-year period between 1970 and 2010, the urban population of Eastern Africa rose from 11.2 million to 77.2 million; during the same period, urban population as a proportion of total population increased from 10% to 24% (Hope K.R. Sr, 2012 quoting from -UN-HABITAT and UNEP, 2010). In Kenya, the total population increased from 10.9 million in 1969 to 38.6 million in 2009 depicting an annual average inter-censal growth rate of between 2.9% and 3.4%. In the period between the decades 1970 and 2010, urban population as a proportion of the total population more than doubled rising from 8.8% to 20.9% and is projected to exceed 36% by the 2040. The country's urban population was growing at an annual average rate exceeding 7.9% in the period 1970–1980 and is projected to average about 4% beyond 2010 through to 2040. These data indicate that one out of every five Kenyans currently live in urban areas compared to one out of twelve in the 1960s (Hope K.R. Sr). The 2009 Kenya population census put the proportion of the total population that is urban at 32.3% (KNBS, 2010).

The rapid growth of the urban population in Kenya is the direct result of a shift in the balance between the urban and rural economies, which is closely linked to economic growth and to the changing patterns of demand for, and supply of employment. This is a depiction of urban bias or urban primacy in the country, as is the case in much of Africa. This urban bias/primacy remains very strong in Eastern Africa and its roots can be traced to the sub-region's colonial past (Hope, 1997; UN-HABITAT and UNEP, 2010). After independence, Kenya (and other African countries as well), sustained this urban bias as the local elite began to gain entry into these formerly exclusive European settlements.

The consequence was the continued development of commerce and industry; and the growth of transportation, communication, education, and other types of infrastructure in the urban areas.

2.5 Urbanization in Kenya

In 1962, only 7.8% of the population of Kenya was in towns with populations larger than 2,000 and this was unevenly distributed; indigenous towns were confined to the coastal area of Swahili-Arab culture as the subsistence economies and diffuse social organization among the people of the interior did not require towns (Morgan W. T. W, 1969). Historically, the growth of urban centers in Kenya was partly linked to colonization, which developed new centers to control and administer the colonized population and to exploit natural resources. It was in these cities that the newly established transport systems concentrated and it was toward these cities that the population drifted. Rural-urban migration has been and remains one of the major drivers of urban growth and labor migration has been an important factor of urban development; workers were needed for public infrastructure (runways, railways, and ports), administration (soldiers, clerks) or various private services such as house cleaners, cooks among others. Migration flows to urban centers accelerated in all parts of Kenya after independence, increasing the proportion of the urban population from 8% in 1970 to 19% in 1999 (UNEP 2009). Other contributors to the increasing proportion of urban population are the natural rate of annual population increase in urban areas, which is currently estimated at 3.6 per cent.

This historical evolution based on the colonial past, led to the urban areas (and cities in particular, and more so the capital cities) becoming dominant in Africa. Cities in Kenya therefore remain the focal point of both public and private sector activities and, as such, they have become the rational settling place for the population. It follows therefore, that the country's urbanization process has been dominated by the capital city, Nairobi, which, based on the 2009 census data, has 25% of the total Kenyan urban population compared to 21% in 1999, and is now six times larger than the next largest urban centre, Mombasa, compared to three times larger in 1999 (Hope K.R. Sr. 2012).

2.6 Global Water Availability

Water is an environmental resource, which is necessary both to support life and also to sustain economic activities across different sectors (agriculture, industry and domestic, among others). Currently, the world viewed as a whole, has sufficient water to meet municipal and industrial demands, which represent a small fraction of available water supplies (especially compared to agricultural water use) (Shiklomonov, 1999, quoted by Meinzen-Dick and Appasamy, 2011). Availability of sufficient quantities of water at a global or macro level on its own is however, not enough, water must be supplied where it is needed, when it is needed, and at a sufficient quality. These necessities pose the greatest challenge to urban water supply and create the greatest competition between water-use sectors.

The hydrological cycle provides periodic rainfall or snowfall to replenish the flow in rivers and streams, and augment the groundwater table (Meinzen-Dick and Appasamy, 2011). Water is therefore a renewable natural resource that can be utilized in a sustainable manner provided that long term "use" does not exceed natural replenishment. The total available water resources in a given basin or region is however fixed, and has to be shared among many users. The International Water Management Institute (IWMI) distinguishes between open basins, which have enough water to accommodate new users, and closed basins, where all available supplies are allocated to existing uses (Seckler, 1996). More and more water basins, even in once water-abundant areas, are regrettably, becoming "closed"; and to increase the water available for one use in a basin requires removing that water from other uses (including nature) or from other basins. The interplay is further complicated by timing of water demand, for example, much agricultural water use is seasonal. By contrast, municipal and industrial water demands are all year-round. In climates where rainfall or run-off is seasonal, supplying water in the dry season requires storage, generally in the form of groundwater reserves or surface reservoirs. Stored water is the most valuable (for agriculture as well as domestic and industrial uses), but also the most scarce (Meinzen-Dick and Appasamy, 2011).

2.7 Water Uses

Meinzen-Dick and Appasamy note that the major sectors of human water use are: (a) domestic consumption; (b) industrial production; (c) agricultural production (including livestock); and (d) recreational uses.

Although domestic and industrial uses are usually associated with urban demand (and agriculture with rural demand), a closer look indicates that all of these uses cut across rural, peri-urban, and urban divisions.

2.7.1 Urban Water Use

Urban water demand comes from both the people concentrated in cities who need water for various purposes (drinking, cooking washing etc) and urban economic activity such as industry and urban agriculture. Meeting the water demands of growing cities requires not only large quantities of high-quality water for domestic use, but also large volumes of water for industrial production. Although agriculture is still the largest user of water—accounting for an estimated 72% of water withdrawals worldwide and over 90% in low-income developing countries (Meinzen-Dick and Appasamy quoting from Rosegrant & Ringler, 1998), municipal and industrial demands are growing much faster. As an example, urban water demand in China was projected to grow 60% over the period 1999-2009, from 50 to 80 billion cubic meters (BCM), while industrial water demand would increase 62%, from 127 to 206 BCM (Meinzen-Dick and Appasamy quoting from Nyberg & Rozelle, 1999). In India, domestic water use of about 25 BCM in 1999 was projected to more than double by 2025 to 52 BCM,; while water demand by Indian industry and energy generation of about 67 BCM was projected to increase to 228 BCM by 2025. Thus, Indian domestic and industrial water withdrawals would more than double over the next 25 years, accounting for 27% of total withdrawals for the country by 2025 (compared to 17% in the mid-1990s) (Meinzen-Dick and Appasamy quoting from World Bank, 1998 and Rosegrant & Ringler, 1998).

2.7.2 Domestic Water Use

In most cases, societies and national policies accord the highest priority to water for direct human consumption, including drinking, cooking, bathing, and cleaning; perhaps this may be directly related to the fact that lack of access to sufficient water for drinking and bathing increases the spread of many water-borne and water-washed diseases, especially diarrheal and skin diseases. Per capita water need is generally placed at 5 liters per day for drinking, 10 for food preparation, 15 for bathing, and 20 for basic hygiene and sanitation—making a total of 50 liters/capita/day (Van der Hoek, 2001). Domestic water demand is however, not simply a multiple of the population size, as per capita demand increases with urbanization and rising incomes.

Rural water supply systems in India, for example, use a norm of 40 liters/capita/day for domestic users without household piped connections, where it is assumed that other water sources can be used for bathing and washing clothes.

Urban areas with piped water supply but no underground sewerage in India use 70 liters/capita/day, while India's urban areas with underground sewerage use 125 liters/capita/day, as in most major cities (MIDS, 1995). These norms refer to basic levels. In Europe, residential use averages around 200 liters/capita/day, and in the United States, 400 liters/capita/day (Meinzen-Dick and Appasamy quoting from Cosgrove and Rijsberman, 2000). By Indian standards, a population of one million people would require 14.6 million cubic meters per year delivered to the end-users for domestic water supply in rural areas; 25.5 million cubic meters for piped urban supplies with no sewerage; and 45.6 million cubic meters with sewerage.

Despite emphasis on importance of domestic water supplies, an estimated 1.1 billion people worldwide do not have access to an adequate quantity or quality of domestic water and at least 2.2 million people die annually of diarrheal diseases alone (WHO & UNICEF, 2000). This problem cuts across rural and urban divides. While in rural areas, women and children often walk several kilometers to collect water, urban dwellers are not necessarily better off. Both Lagos and Abidjan have average municipal water supplies of only 40-45 liters/capita/day for their entire populations. Nairobi has a mere 17.7 liters/capita/day, and Lome and Accra supply less than 10 liters (UNCHS, 1998). Even in cities with high average domestic water consumption, many people, especially those living in slums and peri-urban areas, do not receive an adequate share of the municipal supplies. A study in nine East African cities recorded a decrease from the late 1960s to the late 1990s in both the proportion of households with piped water at their homes, and the availability of water in the municipal systems. For those without household pipe connections, collection time for travel and queuing tripled from less than half an hour to more than an hour and a half per day, with private kiosks having the highest collection times (Thompson et al., 2000).

2.8 Water Based Waste Disposal

Another major urban water use is sanitation through foul drainage/sewerage. In cities of the developed world, most of the sewer pipes have been connected to waste water treatment systems before the wastewater is discharged in open waters (Paterson, 2007).

Centralized sanitation systems consist of sewer networks that transport wastewater from a household to a treatment plant and the effluent is discharged in the environment.

They are sometimes called conventional sanitation systems because they have been in existence and the dominant technology for many years, consequently, most institutions and policies that give sanitation services in cities both in the west and in developing countries are based on these systems. Proponents of centralized sanitation claim that they are more hygienic than traditional decentralized systems. Another advantage of centralized sanitation systems according to their promoters is that they are more convenient ("flush and forget").

2.9 Industrial Water Use

Apart from domestic use, water is an input into the economic development process. Industrial production requires water for production; the amount however varies depending on the industry and the technology used. Factories tend to cluster in cities, thus industrial demand forms a significant amount of urban water demand. Industries require water not only for the manufacturing process itself but also for cooling or cleaning, allowing the possibility of recycling water in factories.

2.10 Population and Water

The concentrations of humanity in urban areas because of rapid urbanisation, pose enormous challenges to the social, political, and physical environment, both in the urban and in the rural settings. According to Meinzen-Dick and Apassamy, two of the greatest challenges imposed on natural resources by rapid urbanization include the distribution of limited water supplies and the disposal of water-borne wastes; meeting urban water needs in particular, has serious economic, social, and political dimensions. As long as there is unused water available, meeting cities' growing water requirements poses primarily, only a technical and financial challenge. When water becomes scarce worldwide, however, meeting the water demand of urban areas for drinking, industrial, and other uses calls for shifting of regional water resources from rural to urban consumers. This creates rural-urban and sectoral competition over the allocation of water resources (Meinzen-Dick and Appasamy).

Box 1: The case of Tiruppur town in South India highlighted below is an example of the challenges faced by rapidly industrializing cities, the world over.

Tiruppur's population rose from 235,000 in 1991 to 340,000 in 2001, with a predicted increase to 490,000 in 2011, increasing demand for both water supply and underground sewage. Much of this population increase is attributed to the fast growing hosiery industry, which employs over 200,000 people in the Tiruppur area and generates millions of dollars in exports. Water for the city's industries has been largely obtained from local groundwater, but this is being depleted. Some farmers have begun selling water to the city and industries, finding selling water more profitable than using it on their own farms; as a result, surrounding wells are drying up because of the increased extraction. Further, the effluents discharged by the hosiery industry's bleaching and dying units have polluted the river and local ground water and residents have to rely on water brought from distant sources. In collaboration with industry, a number of funding agencies are financing a 55 km pipeline to bring water from a local river to supply water for Tiruppur's municipality, industries, and wayside villages. The implementation of the project will reduce the exploitation of ground water, but will still result in the discharge of effluents. Farmers' organizations and community groups have opposed the pipeline.

Source: Ruth Meinzen – Dick and Paul Appasamy, 2011

12.10.1 The Case of Mbale, Uganda

The above scenario also applies for Mbale city in Uganda, which is located in a high precipitation area just west of a Rift Valley mountain range, where surface-water availability has traditionally been plentiful. However, increasing human activities in upstream catchments have meant that the city now faces water scarcity issues during the dry season. According to Uganda's National Water and Sewerage Corporation (NWSC), the dry season abstraction amounts from the Nabijo and Nabiyonga Rivers together would traditionally be 2,000 cubic meters per day and from the Manafwa River up to 5,000 cubic meters per day (Eckart et al., as quoted in Jacobsen et al, 2012). However, the intake from the Nabiyonga and Nabijo was discontinued in February 2012 due to lack of water.

One of the major threats to the sustainability of the surface-water resources in Mbale is the unauthorized abstraction and pollution of water by the increasing number of settlements upstream along the Nabijo and Nabiyonga Rivers. The impact of these settlements is severe competition for river water with the NWSC.

Limited hydrologic information makes planning difficult. With an estimated tripling of the population from 2002 to 2035, water demand will exceed capacity of existing sources. According to the 2002 census results, the total population of Mbale municipality was 70,437. The annual population growth rate was estimated at 4 percent, implying a population that will exceed 210,000 in 2035 or a tripling in a little more than 30 years (Eckart et al., as quoted in Jacobsen et al, 2012).

12.10.2 1997 Study on Changes in Urban Water Use in East Africa Over Three Decades.

A large scale, long-term, repeat, cross-sectional study of domestic water use and environmental health in East Africa was carried out in 1997, and the findings therefrom documented in the report titled 'Waiting at the Tap: Changes in Urban Water Use in East Africa Over Three Decades'. The study which used the landmark 1967 book 'Drawers of Water' (White et al) as a baseline, looked at the changes in domestic water use in the three decades between 1967 and 1997, in selected towns and cities in Kenya, Uganda and Tanzania (16 sites in nine towns and cities), with diversity in urban environments, living conditions and water service levels; the changes in urban water use were examined in terms of mean per capita water use levels at site and country level. The findings of this study revealed both positive and negative changes in water use in East Africa, in terms of levels and types of use, reliability, access and cost. The results indicated that while measurable improvements had been achieved in some quarters, there had been significant declines in others. Urban populations were noted to have grown rapidly, placing added pressure on already overstretched municipal services, limiting the long-term prospects for increasing per capita water use in the region (Thompson et al, 1997).

The first and most striking change noted in domestic water use in urban areas of East Africa was the dramatic decline in per capita use, which decreased on average from 98.7 litres per day in 1967 to only 54.9 litres per day 30 years later. The study further noted that reliability of piped water supplies had declined significantly over the three decades period, in most of the study sites. Different factors contributed to this situation, including a lack of system maintenance and the stress placed on existing network capacity by an ever-increasing urban population.

Whilst in 1967 practically all sampled piped households received 24- hour service delivery, in 1997, only 56 per cent of them benefited from the same level of service, almost 40 per cent received less than 12 hours service and roughly 20 per cent got one to five hours service per day.

The unpredictability of piped water supply in urban East Africa was noted in the study, to force many households to take precautions, which was evidenced by the increased number of sample households that stored water at home (from only 3 per cent in 1967 to 90 per cent in 1997), relying on these secondary and tertiary sources of water to cater for both short and longer-term shortages and the intermittent failure of their primary piped systems (Thompson et al, 1997).

Box 2.0: Changes in Municipal Water Service Reliability in Iganga, Uganda

When the original "Drawers of Water" study was conducted in Iganga, an urban site in south central Uganda with very high population density, investigators found that all sample households received adequate supplies of water 24 hours a day. Thirty years later, the municipal water system had deteriorated to an extent that only 13 per cent of households received piped water and even for this minority, water supply was inadequate, trickling from pipes for only a few hours each day. The supply was also irregular and some households reported being without piped water for up to three days at a time. The decline of the system had taken place over a number of years. As one respondent explained:

"During the 1960s and early 1970s the situation was good, but from the late 1970s the supply of water began to deteriorate. The situation worsened in the 1980s when water pumps and most of the distribution lines broke down. Of the four pumps operating in the 1960s, only one was still working by 1980." In addition to the shortage of functioning pumps, it was reported that water storage tanks were rusty and tended to leak, as did the distribution lines which dated back to the 1960s.

By the late 1980s in an attempt to compensate for these problems, alternative sources were developed. Private individuals began to drill boreholes and establish their own water kiosks. In 1998, these private sources were supplemented by kiosks built by Iganga town council.

Source: Thompson et al, 2000.

An important change in the nature of secondary water supply noted by the study was the introduction of private water sources such as kiosks and vendors, which in 1997 were used by almost 40 per cent of sampled households with piped water supply.

These private sources were particularly important in low-income areas such as Changombe and Temeke in Dar es Salaam, Tanzania, and Iganga in Uganda, where over 60 per cent of piped households used vendors as their primary source. The continuing unreliability of many municipal supplies and services, combined with the growing demand for water in most urban centres in East Africa, had contributed to the rapid rise of private water-vending, which was then (as it is today, over 15 years after this study was conducted), a booming business in many of the low- and medium-income study sites.

2.11 The Impact of Population on Water

Rising population calls for higher exploitation of natural resources; while environmental concerns are of importance, water is the most important common element in environment and development issues, indeed 'water is life'.

The impacts of population on the quantitative water needs of a locality are related to population density (that is, how the population is distributed geographically), and to the rate of increase or decrease in population growth.

Because population changes affect such variables as the economy, the environment, natural resources, the labor force, energy requirements, infrastructure needs and food supply, they will also affect the availability and quality of the water sources that can be drawn upon for use. While population is highly correlated with public water supply, issues of water quantity and quality are inseparable. If the quality of a water source is so degraded that restoring its quality for further use is not feasible, then the source is lost for all practical purposes. Remedial actions are costly, and prevention rather than remediation should be the goal. To achieve it, the various stakeholders including public, industries, and government agencies, among others must all play a positive role.

The amount of water used directly by individuals is related to various human attributes such as age, education, cultural background, religious beliefs, and financial status.

In general, more people use more water, the amount they use individually may however be reduced by education, the implementation of conservation practices, or technological improvements in water supply systems. Water sources in a specific region vary in the quantity and quality of water they contain at a given time, and in their rate and timing of replenishment.

If projected withdrawals to meet population growth exceed the ability of the water sources that may be called upon to meet them, then new sources must be developed, if that is possible; otherwise, cutbacks in water use will be required. On the other hand, water demand can be decreased only so far, until the decreases endanger public health, damage the environment, or adversely influence the region's economy.

Globally, it is estimated that by 2025, around 5 billion people, out of a total global population of around 8 billion, will be living in countries experiencing water stress and using up more than 20 per cent of their available resources (Arnell Nigel W.). In most low and middle-income countries, growth in urban population has occurred without the commensurate expansion in services and infrastructure deemed essential for an adequate and healthy urban environment; it has usually occurred with little or no effective pollution control and with forms of urban governance that do not meet their mandated multiple responsibilities (Hardoy et al, 2006). For example, hundreds of millions of urban dwellers lack piped water supplies and use contaminated, or water whose quality is not guaranteed, hundreds of millions more may have access to piped water but do not have a piped supply into their homes and have to rely on standpipes or other communal or public supplies to which access is often difficult and time consuming.

Large numbers of those with piped supplies only receive water intermittently and the quality of water is often poor (Hardoy et al). The world over, sanitation and waste management are closely related to human health. Rising population, improved standard of living, and high rural urban migration (which is responsible for development of densely populated informal settlements in urban and peri-urban areas with poor sanitation facilities), all pose great challenges in addressing sanitation and waste management. Apart from inadequacy of sufficient and quality water, other resulting environmental problems include pollution through dumping of waste into rivers, streams and other water bodies, further compromising scarce water supply (Government of Kenya, 2009).

Sustainable delivery of basic services continues to be an elusive goal for water and sanitation operators in developing countries. At present access to sanitation in the world is markedly less than water supply both in urban and rural areas. According to Thomas, (2007) mid-term assessments show that 1.1 billion people in the world do not have access to improved water sources, while 2.6 billion lack access to sanitation.

As a result, 6, 000 children die every day from diseases linked to lack of sanitation and 1.3 billion remain parasitized. The Millenium Development Goals (MDGs) were adopted in the early 90s by all world governments as a blueprint for building a better world in the 21st century. MDG 7 covers among others objectives, improvement in accessibility to sustainable and safe water and sanitation with the target to halve the proportion of people without sustainable access to safe drinking water and to improved sanitation, by 2015; specifically, MDG 7, target 10, aims to halve the percentage of people with no sustainable access to supply of portable water and a proper sanitation system, by 2015 (Thomas, 2007).

Kenya is classified in the category of water scarce countries facing huge challenges in the development and management of limited water resources, that need to deal with chronic water shortage, with the natural fresh water supply of only 647 cubic meters per person expected to fall to 245 cubic meters in 2025 (Owuor, 2006).

2.12 Development Densification

There is increasing recognition of the need to increase the density of commercial development, especially in the centers of our towns and cities; the world's fastest growing cities are built at high density, often favoring commercial tall buildings. Businesses cluster together in cities because there are clear commercial benefits from doing so, and they will continue to do so as long as those benefits outweigh the congestion and cost often associated with doing business in cities. According to Hepworth (2007), increased density leads to increased productivity in cities. In well-developed and thriving CBDs, land is scarce and at a premium and in many cases, building up is the only way to achieve increased density given land and conservation constraints. It is clear, therefore, that increased commercial density (and, in many cases, tall buildings) in the right locations can have positive economic impacts.

Most current government policies support the principle of building in towns and cities at higher commercial densities, strongly driven by the sustainability benefits that flow from higher density development, particularly when such development is centered on transport nodes. However, if density increases where transport capacity is already overstretched, additional density causes increased congestion and associated costs until the situation is corrected (Cook et al, 2004). If transport improvements are made in the long term as a result, then density can deliver its net benefits from reduced travel distances and times.

However, if not, then negative externalities from congestion and overcrowding may counteract any benefits. As new development increases density, transport and other infrastructure must keep up in order for benefits, in terms of time savings, to be experienced.

Densification is a central issue in determining the resultant forms of cities including their densities, size, building forms, and layout, how they can contribute to their sustainability and how this could be achieved. Higher density development reduces the amount of land used and consequently cost of services/amenities provision such as roads, water, electricity and sewerage, as available services serve higher populations. The human environment however has an impact on the biophysical environment; the level of its impact depends on a wide range of factors that include population size, levels of production and consumption, efficient use of resources and the technology used to extract and supply goods and services. The effectiveness of government and other organizations in preventing and repairing environmental degradation is also an important factor. Simply put, building up means less building out: an equivalent square meter of space can be accommodated on a smaller area of land.

More efficient use of land for commercial space leaves more green space for other uses, such as parks, which users can enjoy. Provided that it is close to transport nodes, high density commercial or mixed use development has the double advantage of both reducing the need to travel and encouraging the use of public transport, as many employees will only work a short walk away from their stop. Higher commercial densities in CBDs also encourage increased densities in surrounding areas. This is because with a more centralized, dense commercial area, residential and leisure facilities are also drawn in more tightly to that core, rather than being spread out to service widely dispersed businesses (Leyshon and Brace, 2007).

2.13 Effect of Development Densification on the Environment

The effect of development densification on the environment manifests through various environmental impacts. Though densification of development helps prevent urban sprawl horizontally thereby reducing pressure on green areas, agricultural and ornithological land uses among others, the most significant issue, however is the effecting of this densification sustainably, with the least ecological footprint possible in line with the principle of 'sustainable development' which promotes development that meets the needs of the current generation without depleting the resource base, thus compromising ability of future generations to meet their needs.

Management of urban proliferation is of great importance because it affects both the quality of life and economic development of an urban area, as most wealth is created in cities. Proper functioning of a metropolitan area is dependent on the quality of its infrastructure and the way in which the infrastructure is organized. With increasing urbanization, new needs are emerging in terms of service provision including:- water and its treatment, fighting pollution, waste disposal, energy distribution systems, communication and transportation networks, among others.

Functionality and sustainability of cities relies on effective adoption of city development and management policies, which advocate that, environment, housing, transportation, water, health, economic, waste management, city administration, security, education, and a host of other issues in cities, cannot be handled in isolation, one from the others.

Thus, good networking, particularly between these sectors must be allowed or considered in city governance and administration as revealed in the framework adopted by the Centre for Local Government, (Corang, and Cook, 2007). In a study by De Silvey, (2006) the need for cities to balance social, economic, and environmental resources was noted to be becoming increasingly critical. Traditional approaches to dealing with urban issues and reducing carbon emissions largely focused on increasing labor productivity, limiting use of land and urban space, decreasing energy use, boosting usage of alternative energy, and capturing and storing carbon. Advances in technology and Internet-enabled innovations, however, have made it possible for complex systems to be managed in radically different ways that enable cities to deliver enhanced services to residents, manage traffic flow and operate public transportation more effectively, and make better use of real-estate resources (De Silvey, 2006).

With regard to water, land development directly affects watershed functions. When development occurs in previously undeveloped areas, the resulting alterations to the land can dramatically change how water is transported and stored. Residential and commercial developments create impervious surfaces and compacted soils that filter less water, which increases surface runoff and decreases ground water infiltration. These changes can increase the volume and velocity of runoff, the frequency and severity of flooding, and peak storm flows. Moreover, during construction, exposed sediments and construction materials can be washed into storm drains or directly into nearby water bodies. After construction, development structures usually replace native meadows, forested areas, and other natural landscape features with compacted lawns, pavements, and rooftops. These largely impervious surfaces generate substantial runoff.

For these reasons, limiting or minimizing the amount of land disturbed and impervious cover created during development can help protect water quality.

2.14 Urban Development Densification in Kenya

The rapid urban population growth in Kenya, outlined above, has resulted in uncontrolled expansion of urban areas and rising costs of service provision for the country's increasing urban population. Inadequacy of funds has made it difficult for city and urban authorities to cope with the increasing demand for services such as water, garbage collection and sanitation services. Among the consequences of this scenario is a degraded urban environment and diminished quality of life in cities and towns in Kenya (UNEP 2009). Higher density development in the city of Nairobi has also not been well planned and managed by the central government and more particularly, NCC's planning department, in whose area of jurisdiction it is taking place. Some of this development has taken place without any planning guideline/regulation to guide/regulate it with the result that densification has taken place without commensurate expansion of support infrastructure including roads, electricity, water supply and waste management mechanisms, resulting in constraint on these services and subsequent adverse impacts upon the environment. Further, there has been lack of measures to marry this development with environmental concerns through tools such as EIA, EA and SEA, noting that in Kenya, the widespread use of these was only effectively enforced after enactment of the Environmental Management and Coordination Act (EMCA) in 1999 and formation of the National Environment Management Authority (NEMA) under Section 7(1) of the Act in 2003.

Densification of development comes with increased population numbers; densification without commensurate expansion of the service infrastructure results in strain of the said services with resultant impacts on their adequacy leading to issues such as water rationing, congestion on the roads, power supply constraints and increased solid and liquid waste loads. The strain caused on the service infrastructure by development density will manifest in environmental impacts such as air and noise pollution, resource depletion, traffic congestion, damage to infrastructure from increased storm water and solid and liquid waste management challenges among others; these impacts call for mitigation measures, to reduce development's ecological footprint on the environment.

2.15 Development Densification in Upper Hill, Nairobi

Land availability in the city of Nairobi is becoming more and more constrained; there are currently very few sites/plots still undeveloped in the CBD. Vacant sites notably include those owned by the National Social Security Fund (NSSF) at the junction of Uhuru Highway and Kenyatta Avenue and along Loita Street next to Barclays Plaza, another privately owned vacant site is found at the junction of Taifa Road and City Hall Way, while NCC owns several sites currently used as parking such as that along Taifa Road (next to the High Court) and another at the junction of Taifa Road and Harambee Avenue (also fronting Aga Khan Walk, opposite Uchumi Supermarket's Aga Khan Walk Branch). The scarcity of undeveloped land within the CBD coupled with rising demand for office and retail space has resulted in extension of commercial land use to suburbs such as Westlands, Parklands, Upper Hill and Kilimani; this shift has been reinforced by increased vehicular and pedestrian congestion in the CBD, forcing corporate organizations as well as government bodies to relocate to areas outside the CBD. This trend is also being witnessed in most of the other large towns in Kenya (Mombasa, Kisumu, Nakuru, Eldoret, Kakamega, Nyeri and Thika among others), which have in the past few years experienced rapid urbanization coupled with development of higher density buildings (higher ratios and coverages achieved through vertical densification in higher buildings).

The higher density development has however not been well planned and managed by the central government and more particularly, the planning departments of local authorities/county governments in whose areas of jurisdiction it is taking place, including NCC.

Some of this development has taken place without monitoring for adherence to the existing planning guidelines/regulations, with the result that densification has taken place without commensurate expansion of support infrastructure including roads, electricity and water supply and waste management mechanisms, resulting in constraint on these services and subsequent adverse impacts upon the environment. Further, there has been lack of measures to marry this development with environmental concerns through tools such as EIA, EA and SEA, noting that the widespread use of these was only effectively enforced after enactment of the Environmental Management and Coordination Act (EMCA) in 1999 and formation of the National Environment Management Authority (NEMA) under Section 7(1) of the Act in 2003.

As a matter of national interest, there is need for the national government to strengthen operations and funding levels of the county governments with a view to devolving development to the counties, so as to stem the flow of population to the capital city – Nairobi, causing unending strain on the service infrastructure. This devolution of operation can be achieved through the existing legal framework under the new constitutional dispensation, under which the Urban Areas & Cities Act of 2011 came into being.

The nature of development taking place in Upper Hill area just outside the city's CBD in the last twenty years is a good example of development densification; land previously occupied by single dwelling unit bungalows is now developed with multi-storeyed residential and commercial buildings with the highest (currently under construction) going 45 floors. Densification of development in Upper Hill area of Nairobi highlights economic issues of great importance not only for the city of Nairobi but also for the national economy. Upper Hill is home to several international organisations that need both a competent and qualified workforce and an attractive working environment with a commensurately well-developed service infrastructure. In comparison, cities such as Kampala in Uganda are trying to attract companies into their country (Paterson, 2007).

Some of the recommendations of the 1991-3 Nairobi Town Planning Liason Committee on the replanning and rezoning of Hill and Kilimani areas included the following;

(i). Raising of minimum plot sizes from 0.04 to 0.2 Hectares.

(ii). Minimum road reserves of 15 meters.

(iii). Introduction of basement car-parking for all office, commercial and apartment developments - the enforcement was to be done by City Planning and Architecture (City Council)

(iv). A comprehensive traffic management plan was to be worked out by the City Engineer (City Council).

(v). Cost of infrastructural development i.e. road widening, water and sewer reticulation was to be met by developers.

(vi). Flexibility on mixed development to be observed when users are compatible.

(vii). The Water and Sewerage Department (City Council) should review and update the sewerage and water situation periodically taking into account the changing development trends, the increasing population and the intensity of development (NCC, 1999).

While some of the above may have been observed, most of them have not been adhered to and of particular interest to this study is point number (vii) above, which the study confirms is not the case in Upper Hill. For example, roads which were designed for a low density residential neighbourhood soon proved too narrow and are currently being widened to deal with rampant traffic jams; these roads, which are now receiving higher population numbers, need to be provided with pedestrian walkways, cyclists' routes and street lights. Status of the sewerage lines require to be assessed to determine if they are adequately servicing the increased levels of sewage discharge from the higher population associated with the higher density development. The developments also generate high volumes of surface water run-off which exert pressure on the existing road network and drainage systems. Other infrastructure services that require attention are electricity, effective and efficient means of solid waste management (though fortunately much of the solid waste handling is managed privately) and accessible facilities for fire-fighting and other emergency services; it is also noted that the area is not served by any open spaces for relaxation.

2.16 The Kenyan Urban Development Legislative Framework: From the 'Old' to the 'New'

Analysts have cited weak urban governance and management frameworks as the major impediment to Kenya's realization of a sustainable urban development. There exists a multiplicity of parallel agencies such as the Ministry of Lands, Department of Physical Planning, the NCC, NEMA, Kenya Roads Board and the NCC's Environment Department, whose duplication of duties, further complicates governance of urban areas.

2.16.1 The Urban Areas and Cities Act (2011)

In adherence to the new constitutional order and its requirements, the Urban Areas and Cities Act of 2011, was enacted. This Act effects Section 184 of the Constitution, which requires enactment of requisite legislation to provide for the classification, governance criteria and the management of urban areas, cities and towns. According to the Act, there shall be established a Cities Board which amongst other functions will control land use, land development, land subdivision and zoning by public and private sectors within a framework of spatial and master plans for towns, cities and municipalities under County Governments, and facilitated by the County Transition Authority. According to the Act, planning and development control will be undertaken by the different rural and urban managers at the different levels of urban and rural governance set out in the Act.

Analysts contend that the full implementation of the Urban Areas and Cities Act 2011 will be controversial as it divests county government functions and allocates them to boards of cities, municipalities and towns created under the Act.

2.17 Master Planning for the City of Nairobi

The first Master Plan was developed in 1927 to capitalize on Nairobi's strategic location as the hub of the Kenya Railway Line. The second Master Plan was implemented in 1948 with the aim of making Nairobi more attractive for industrial investment. The 1973 Master Plan was developed by the Kenyan Government, World Bank and United Nations in order to formulate a metropolitan growth strategy for the city; this Master Plan covered the period upto 2000, and has until now, not been replaced by a new one. NCC has now, with assistance from the Government of Japan through its agency, Japan International Cooperation Agency (JICA), undertaken a study on the Integrated Urban Development Master Plan for the city of Nairobi (NIUPLAN).

The proposed Master Plan will integrate all the existing Master Plans of various infrastructures within the city of Nairobi and its surrounding, including urban transport, railway, airport, power, water supply, sewerage, telecommunication and solid waste management infrastructures (NCC, 2015).

2.18 Athi Water Service Board

Athi Water Service Board (AWSB) oversees water provision in the Nairobi and environs region, covering an area of 3,810 square kilometers with a population of 5.5 million people and a population density of 8,472.48 persons per square kilometer.

AWSB ensures the provision of quality and affordable water and sewerage services in its area of jurisdiction through its twelve (12) appointed Water Services Providers (WSPs) namely:

1. Nairobi City Water and Sewerage Company (NCWSC)
2. Thika Water and Sanitation Company
3. Limuru Water and Sewerage Company
4. Ruiru-Juja Water Sanitation Company
5. Kikuyu Water Company
6. Karuri Water and Sanitation Company
7. Gatundu Water and Sewerage Company
8. Githunguri Water and Sewerage Company
9. Gatanga Community Water Scheme
10. Kiambu Water and Sanitation Company
11. Karimenu Community Water and Sanitation Company
12. Runda Water Company.

2.18.1 Athi Water Services Board's Master Plan for Developing New Water Sources for Nairobi City and 13 Satellite Towns

Access to safe water in adequate quantities is now a fundamental human right, enshrined in the Constitution of Kenya. The Athi Water Service Board (AWSB) with support from World Bank and the French Development Agency (AFD) came up with a Master Plan for developing new water sources for Nairobi City and Satellite Towns, which was officially launched by then Prime Minister of the Republic of Kenya, Right Honourable Eng. Dr. Raila Amolo Odinga on 18th September 2012. The plan provides least cost development options to be implemented in five phases between 2012 and 2030, to ensure adequate supply of safe water to Nairobi city and Satellite Towns up to the year 2035; options that are sequenced to incrementally meet Vision 2030 targets and beyond (up to the year 2035). The overall goal of the Master Plan is to develop pragmatic, practical and cost effective solutions using diverse water sources to ensure safe, sustainable and reliable water supply (AWSB, 2012).

The Water Supply Master Plan provides a blue print for investing in water supply infrastructure to fulfill the short, medium and long term water demand for Nairobi City and 13 Satellite Towns including Kikuyu, Ruiru-Juja, Kiambu, Karuri, Githunguri, Mavoko, Ngong, Ongata Rongai (inclusive Kiserian), Thika, Gatundu, Limuru, Tala and Kangundo, and aims at addressing a growing water supply infrastructure deficit. Investments in water supply infrastructure have lagged behind since the completion of the 3rd Nairobi Water Supply Project in 1994 to the level where the water demand in the Nairobi Metropolitan area now far outstrips supply. At the moment about 65% of the city population receives safe and adequate water. The remaining 35% are either under-served or receive no service, with water supply deficit standing at 170,000m3/day (or about 23% of the demand), in 2012. This deficit will rise to 280,000m^3/day (33% of demand) and 970,000m3/day (63% of demand) by 2017 and 2035 respectively if water supply expansion as proposed by this blue print is not implemented.

The Master Plan proposes optimal use of the existing facilities, an increase of surface water storage sources, diversification of water sources (surface water, groundwater, rainwater harvesting), development of local or mixed water supply systems for Satellite Towns, and reduction of physical water losses along the system – intakes, transmission pipes, treatment works and distribution schemes (AWSB, 2012).

Implementation of the above Master Plan is critical as Nairobi continues to face major uncertainties in assessing the gap between future water demand and supply based on population, income, and water consumption per capita projections. Other sources of uncertainty include the impact of future climate variability and climate change, adding to the degree of uncertainty about projected water supply and demand. Recent decentralization of the governance system creates additional uncertainties about future conditions for bulk water supply to Nairobi. The new Constitution of Kenya resulted in a stronger role for lower levels of government by allocating to county governments the responsibility for public works and services, including water and sanitation. Water resources cross counties and regions, and, while they will remain a national resource, there is need for agreement on specific management arrangements. For Nairobi, which imports most of its water from the Tana basin outside Nairobi County, any disagreements on this might cause uncertainty about the access to, and the cost and reliability of these surface water resources (Eckart et al., as quoted in Jacobsen et al, 2012).

2.18.2 Progress made and Challenges Faced

It is noteworthy also, that the scenario is not all negative, and that there have already been attempts to expand the overall water supply situation for Nairobi. Among the achievements is the expansion of infrastructure to keep pace with population growth, in particular through the construction of the Thika Dam and associated water treatment plants and pipelines during the 1990s; the transformation of the municipal water department into an autonomous utility in December 2003 (NCWSC); and the more recent reduction of water losses – technically called non-revenue water – from 50% to 40%. Challenges however still abound, including poor quality and intermittent water supply (only 40% of those with house connections receive water continuously); the loss of storage capacity in reservoirs behind dams through siltation accelerated by erosion in the Abadare Range, lack of access to adequate sanitation in slums which house a fairly large number of the city's population; blockages of sewers resulting in overflows;
and unused capacity in the city's largest wastewater treatment plant in Dandora (NCC, JICA, Nairobi Urban Master Plan draft, 2014).

2.19 Conceptual and Theoretical Framework

This study focuses on the effect that development densification in Upper Hill area has had on water supply, considering that this higher density development has resulted in a higher population in the area, albeit during day time hours as many of the developments are under office use.

It is noteworthy that Kenya is categorized as a water scarce country and therefore has no additional water reserves to draw from. Historically, Upper Hill area was a low density neighbourhood with single dwelling units constructed on fairly large plots of 0.5 to 2.5 acres.

Studies of the 'ecological footprint' of urban areas, – the area of land needed to provide a city with the resources it requires to function and to remove its wastes, show that cities affect a geographic area vastly greater than their own surface area; an urban centre's ecological footprint contributes significantly to biodiversity loss, both locally and at the global level (Mwathe K. M, 2007). It is therefore necessary, in the course of development, to strike the required balance; on the one hand people need to meet their basic requirements in order to achieve development, while on the other hand, there are resources upon which people depend, in order to meet their needs.

Historical documentation shows that humanity once lived harmoniously with nature but this trend is negatively changing over time, with a tendency of people to damage or deplete the very natural resources upon which they depend, unless mechanisms are put in place to ensure that this development happens in a way that does not deplete the resource base (Mwathe from WCED, 1987).

The above imbalance calls for an integrated view, acknowledging that environment and development are closely related, and that indeed, they are different faces of the same coin. On one hand, the environment provides the natural resources for the process of development (Mwathe quoting Muthoka et al., 1998). On the other hand, the development process modifies the natural resources and environmental quality to meet human needs. The goals of both environment and development are the same: to improve human well-being. However, the type of development adopted can cause problems such as destruction of the environment that sustains it and lowering the quality of life which it endeavours to enhance (Mwathe, 2007).

It is therefore mandatory to adopt and practice the principle of 'sustainable development' that produces no lasting damage to the biosphere, and to particular ecosystems; the principle of 'sustainable development' is defined as "development that meets the needs of the present generation, without compromising the ability of future generations to meet their own needs" (WCED, 1987). It is development that seeks to improve people's lives without depleting the resource base, a concept further enhanced by Sustainable Development Goals (SDGs) 6, 7, 8, 9, 11, 12 and 17 which call for sustainable water and sanitation, energy, economic growth, industrialization, cities, consumption and production patterns and strengthening of the means of implementation and revitalise Global Partnership for Sustainable Development, respectively, by the year 2030. If the present and future generations are to be assured of quality living, then development must be sustained by the environment and must in turn, not destroy the natural resources, especially land and other natural resources such as water, flora and fauna.

Consequently, the environment cannot be viewed in isolation from development. The two must be addressed as one integrated system (Muthoka et al., 1998).

Water on its part is a unique natural resource as it is one of the substances in nature with no substitute, yet all living organisms – both plant and animal - need a regular intake of water in varying quantities, to survive.

The hydrological cycle permits its flow in different forms though the quantity of water in the cycle remains the same. Although water covers 71 per cent of the earth surface, only 1 per cent is fresh water needed by people to sustain life, health and productive activities (Muthoka et al, 1998). Considering fixed water supply and rising population, there is need to conserve this natural resource not only to sustain life in the current but also in generations to come.

These specific relationships between development densification and water are captured as follows:

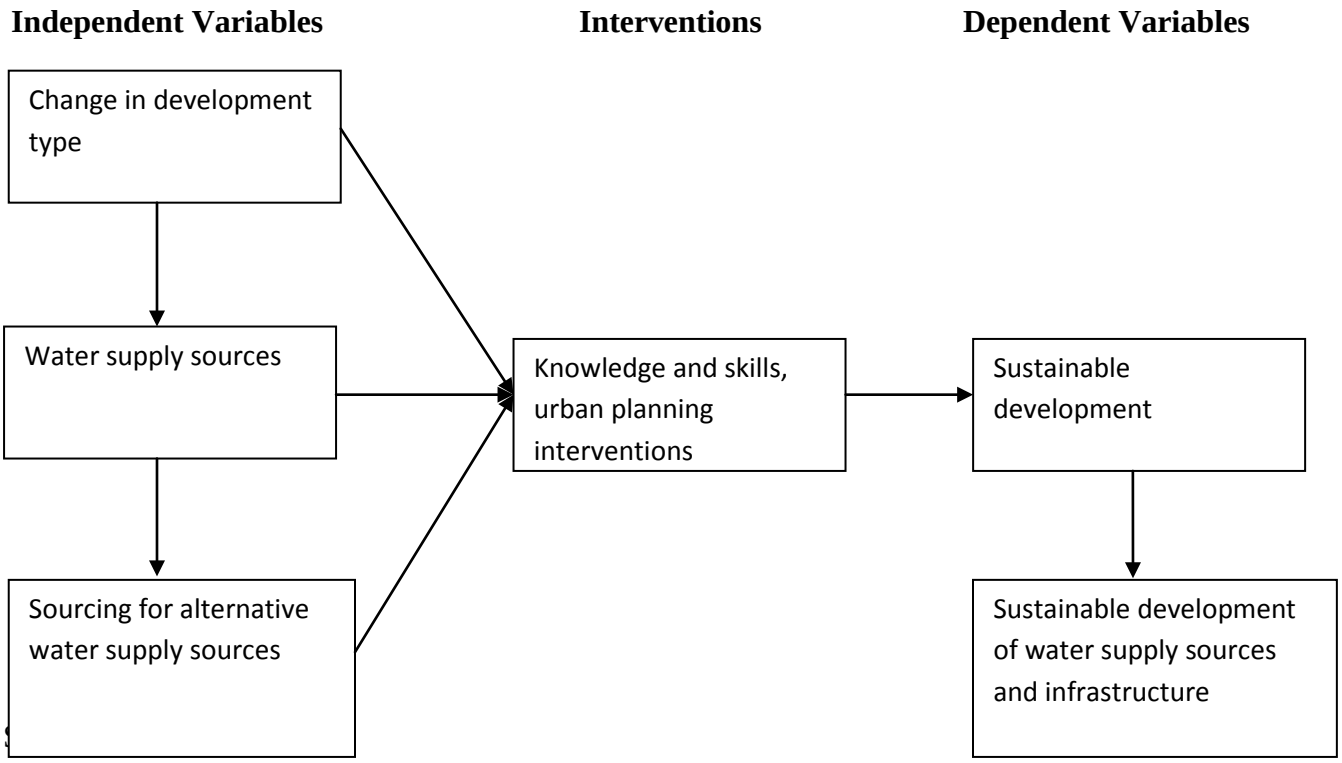

Figure 2.1: Perceived Impacts of Densification on Water Resources in Upper Hill; Source: Researcher, 2014.

CHAPTER THREE: RESEARCH METHODOLOGY

3.1 Study Area

3.1.1 Nairobi City

The study area is situated in Upper Hill area, in the city of Nairobi, in Nairobi County. Nairobi which is the capital city of Kenya is situated in the south-central part of the country, and the County of Nairobi is one of 47 counties in the country. Nairobi takes its name from the Maasai phrase “enkare nairobi”, which means “a place of cold waters”, the area was originally grazing land and a livestock watering point, with no permanent African settlement (UNEP, NCC, 2007). The city of Nairobi owes its early development and growth to the Kenya Uganda Railway; the railhead reached Nairobi in June 1899 and by July it had become the headquarters of the Kenya Uganda Railway (Rakodi 1997, as quoted in NCEO). This led to Nairobi’s growth as a commercial and business hub of the British East Africa protectorate (Mitullah 2003, quoted in NCEO). By 1900, Nairobi had become a large and flourishing place with the settlement consisting mainly of the railway buildings and separate areas for Europeans and Indians, the latter mainly comprising the labourers engaged in building the railway. Nairobi, as an urban centre was officially defined in 1900 under the Nairobi Municipal Community regulations and it became the capital of Kenya in 1907 (Mitullah 2003, Rakodi 1997, both quoted in NCEO).

The population of Nairobi grew from 8,000 people in 1901 to 118,579 in 1948 (Rakodi 1997 as quoted in the NCEO). By 1962, the city had a population of 343,500 people, although some of this growth could be attributed to extension of the city’s boundaries. Between the 1948 and 1962 censuses, the population grew at an average rate of 5.9 per cent per annum, compared with 7.6 per cent in the previous 12-year period. The city’s population grew to 3.8 million according to the 2009 census (KNBS 2009), exerting pressure on the available resources. Although it covers only 0.1 per cent of Kenya’s total surface area, Nairobi already had about 8 percent of the country’s total population in 2001 (CBS 2001) and 25 per cent of Kenya’s urban population (UN-Habitat 2001). Population growth is partly explained by net migration into the city, which in the ten year period between 1979 and 1989 was 772,624 (NEMA, 2003 as quoted in NCEO). The forces motivating rural-urban migration to Nairobi include better economic prospects, opportunities for higher education, higher wage employment, and the attraction of Nairobi as a market for goods and services.

Figure 3.1: *Map of Kenya Counties showing location of Nairobi County*

3.1.2: Upper Hill Area

The specific study area is Upper Hill area, which is an extension of the city's CBD, located approximately two kilometers from, and to the South of the CBD. It stretches all the way from Uhuru Highway up to Kenyatta National Hospital and from Nyayo Stadium roundabout at the start of Bunyala Road, all the way to Valley Road. Upper Hill lies at coordinates 01^0 18' 05" S 36^0 49' 03" E (Latitude -1.3015, Longitude 36.8175). There are three categories of land ownership in the Upper Hill area - Government land, Kenya Railways Corporation land, and private land (leaseholds). The Hill area is currently characterized by mixed development of residential and high-rise office blocks. The original residential user was low density with large plots of between 0.5 of an acre to 2.5 acres or more accommodating a single dwelling house and domestic quarters usually sited in the middle of the plot (United Nations, 2006). It is these residential plots that were acquired from the original holders (government, Kenya Railways and NSSF) for office development, following change of user from residential to commercial, and re-development into intensive use through high rise office buildings.

Information obtained from NCWSC indicates that there has been no change in the pipe network laid way back in the 1940s, or the NCWSC 18,000 cubic meters water storage tank that serves Upper Hill area (Hill tank). The NCWSC water consumed in Upper Hill area is from the Kabete Water Works (KWW) and is stored in the 'Hill tank' reservoir put up in 1948, the flow from the tank is by gravity. NCWSC information further indicates that the original bungalows in Upper Hill were served by overhead tanks (placed in the ceilings) only, and that the supply was available twenty four hours a day.

The study will specifically cover the area of Upper Hill stretching between Lower Hill Road, Procession Way, Elgon Road, Valley Road, Rulph Bunche Road and Hospital Road, in Upper Hill area of the city of Nairobi, as shown in the map below.

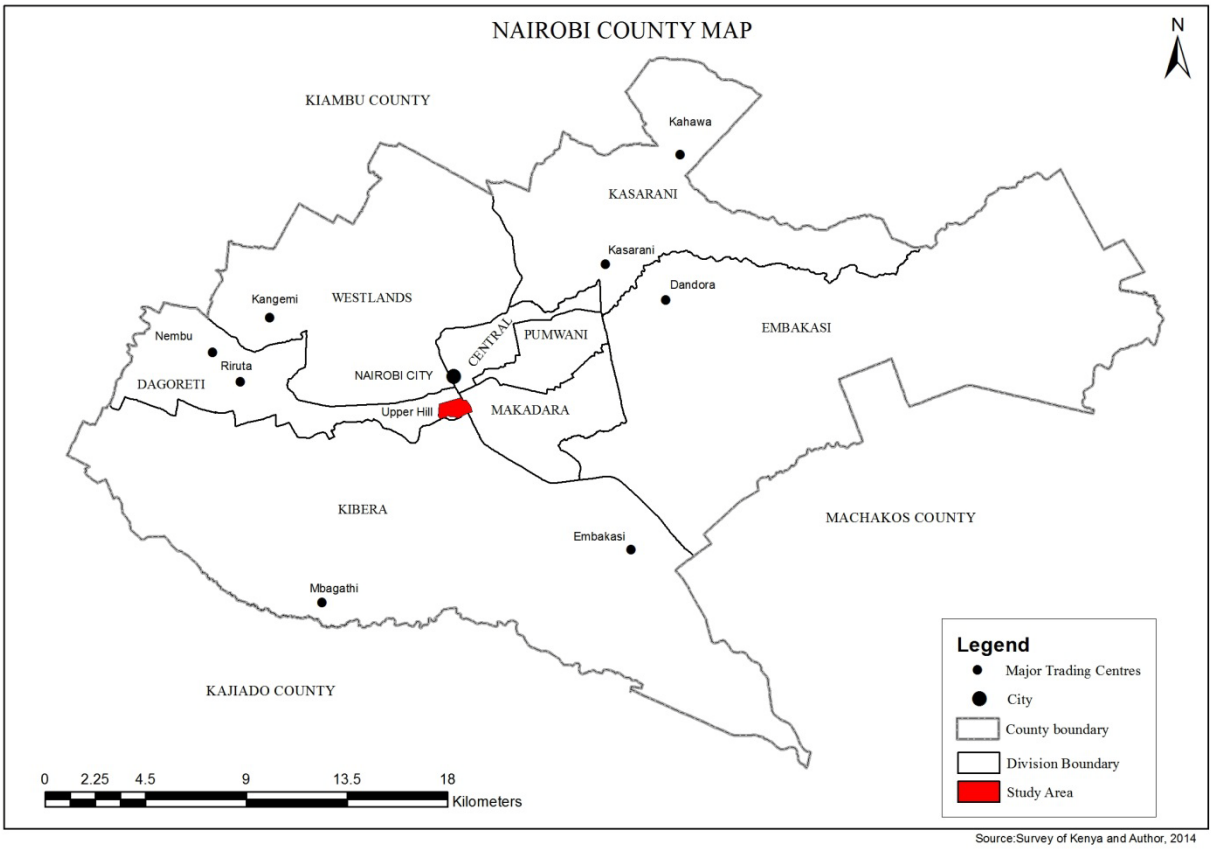

Figure 3.2: *Nairobi County Map showing position of the study area within the county.*

Figure 3.3: *The Specific Study Area in Upper Hill.*

Accommodated in the wider Upper Hill area are office blocks occupied by international companies and organizations such as Coca Cola East and Central Africa office, Ernst & Young, World Bank, IMF and British Council among others, there are also local corporate organizations such as British American Insurance Company, UAP Insurance, CIC Insurance, Equity Bank, CBA Bank and Kenya Commercial Bank, among others. There are also public and social facilities including two hospitals - Kenyatta National Hospital and Nairobi Hospital; three recreation facilities - Nairobi Club, Public Service Club, and the Railway Club and several newer privately run food and beverage outlets such as Upper Hill Springs and Visa Place. In addition, there is one primary and one secondary school – Nairobi Upper Hill Junior Academy and Upper Hill Secondary School respectively and two public parks - Uhuru and Central Parks (UNEP, 2009).

The onset of higher density development in Upper Hill and Kilimani areas of Nairobi begun in the early 1990s. Rapid changes of user were taking place in these areas, from predominantly residential use to high-rise office blocks at the Hill Area, and to commercial and professional office blocks in Kilimani. Such changes required guidelines to facilitate harmonious development and to ensure provision of adequate infrastructure to support these developments. It is in light of the above that a small Task Force comprising some officers of the Secretariat of the Nairobi Town Planning Liaison Committee was appointed to study the two areas and to formulate policy guidelines for development in the two areas. During the exercise the Task Force reported the progress of the work to the Committee which finally endorsed the recommendations, aimed at taking into consideration the infrastructural and social amenities, in order to respond to the development pressure in these areas (UNEP 2005).

3.2 The Study Design

The study applied both qualitative and quantitative study designs; qualitative design was used in collection of data that could not be subjected to statistical tests such as perceptions on water supply reliability, opinions, reviewed information such as legislative framework and policy documents. Quantitative design on the other hand was used to collect data that could be statistically tested and analysed, such as change in development type and water supply sources; the data after analysis is presented in form of tables, pie charts and graphs among other forms of statistical presentations.

3.3 Sampling Frame/Study Popoulation

The sampling frame comprised all the buildings within the 14 subsections (based on existing roads) of the study area, which were derived from a map prepared for KNBS's 2009 Population and Housing Census, by Ramani Geosystems; the information on the map was adjusted to take into account buildings that came up after 2009. The sampling frame was 150 buildings; out of this population, sample buildings were sampled using simple random sampling method. In addition to this were representatives of NCC and NCWSC, the two lead agencies most relevant to the study; interviewees from these organizations were selected through purposive sampling method.

3.4 Sample Size and Sampling Procedure

3.4.1 Sample Size

A sample of 75 buildings was derived out of a population of 150; the sample size from which data was collected through questionnaires was calculated based on the population of buildings within the study area using the sample size calculator, at a margin of error of 8%, confidence level of 95% and a response distribution of 80%. Six people were interviewed from NCC and NCWSC.

3.4.2 Sampling Procedure

Due to the nature of the target population which comprised developments/buildings in Upper Hill, the researcher used simple random and purposive sampling methods; the former allows for random selection of samples from the population, while the latter is a sampling technique that allows the use of cases/persons that have the required information with respect to the objectives of the study (Mugenda and Mugenda, 2003). Purposive sampling was used to locate six persons with relevant information, drawn from NCC and NCWSC. To come up with the sample, the study area was divided into 14 sections (A-N as shown if Figure 3.4) based on existing roads; commercial and residential buildings in each sub-section were totaled and samples randomly selected from within the sections; depending on the total number of buildings in each section, buildings were selected using simple random sampling, with more samples picked out of the sections that had more buildings. A total of 75 buildings were selected (residential and commercial), to which questionnaires were administered. Interviewees from NCC were as directed through the Planning Department and those from NCWSC were as directed through various Department heads.

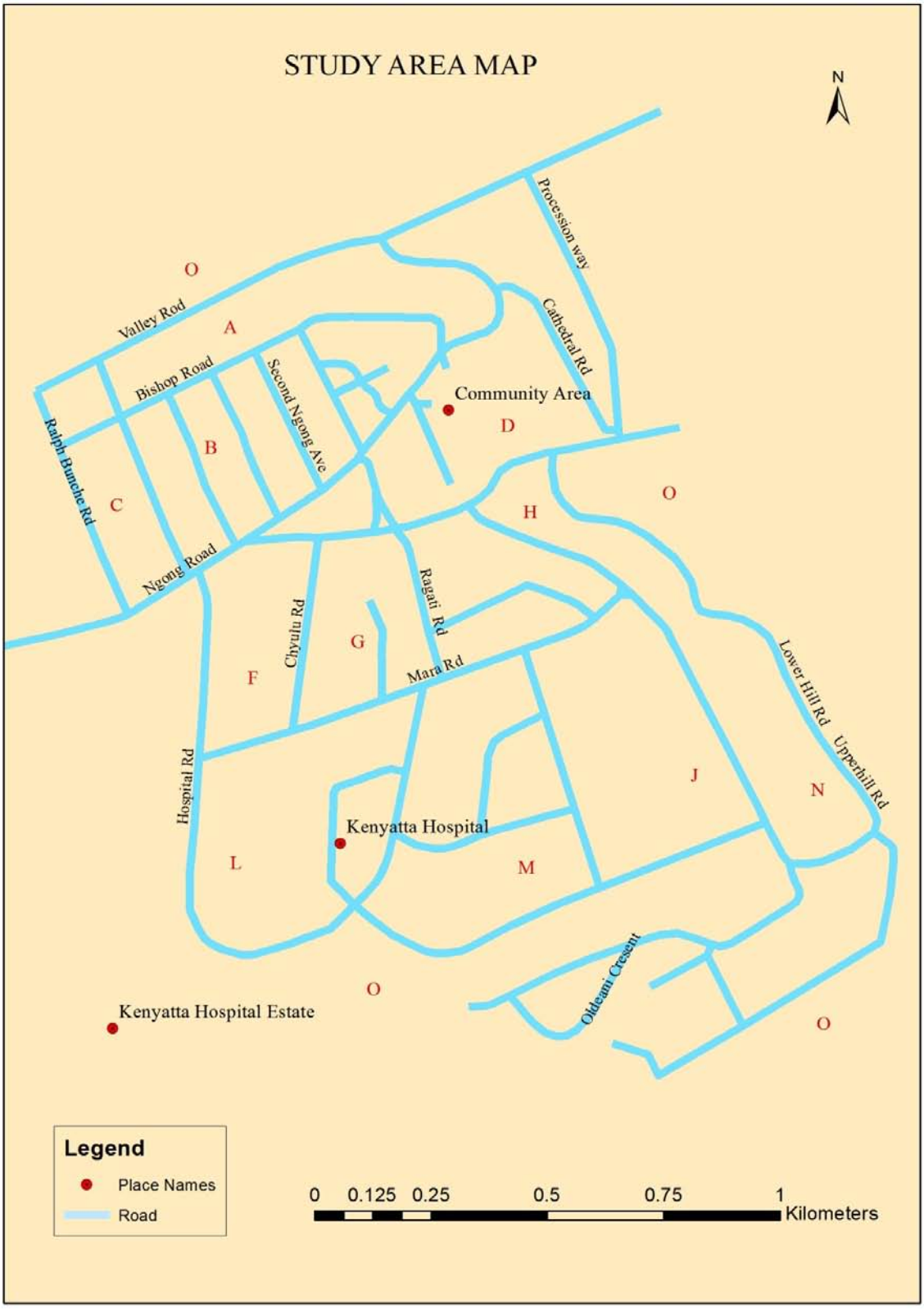

Figure 3.4: *The study area showing the 14 sub-sections A-N into which the study area was subdivided and buildings selected using random sampling.*

3.5 Sources of Data

Data sources refer to places from where data was acquired during fieldwork. Field data was obtained primary and secondary sources. Primary sources of data refer to the first hand information sources such as households, offices, businesses and institutions who volunteered information to the researchers on request. Secondary sources of data refer to such information sources as books, journals, newspapers and other secondary materials.

3.5.1 Primary Data Sources

Primary data was obtained from various residential and commercial compounds/buildings (comprising offices and business premises) in Upper Hill and from key informants at NCC and NCWSC. The data was collected through a participatory approach by use of questionnaires, oral and formal interviews conducted with the various respondents and interviewees respectively; the people interviewed in each sampled building were largely the caretakers or building managers who are the persons in charge of running the buildings on a day to day basis, thus being responsible for ensuring that there is water and other utilities in the buildings. Persons interviewed at NCC were from the Planning Department, as directed by the head of the Department; those at NCWSC were from the head office's Operations Department, the Manager in charge Upper Hill and also persons from the IT and billing sections. Data collected includes age of buildings, height of buildings, previous use of the land before building came up, the number of people in the buildings at peak hours, sources of water supply, views on the adequacy of NCWSC water supply in the area as well as pertinent historical information on the study area and water supply infrastructure.

3.5.2 Secondary Data Sources

Secondary sources of data included desktop studies from various books and past studies related to the subject of study, as well as legislative and policy documents on zoning and other areas of interest to the study. The information collected helped build the literature review and identify the research gap. These sources included relevant books, past publications of government and local and international non-governmental organizations including legislations and policy documents, unpublished reports of the NCC, journals prepared by various scholars, newspapers and magazines.

3.5.3 Research Instruments

Different reliable instruments were used to collect data in the field; these included structured questionnaires, which were administered in the residential and commercial buildings to obtain information addressing the research questions, and structured interview guides used to interview key informants from NCC and NCWSC. Field surveys, observation and photography were also used as reliable instruments to observe and record the actual situation on the ground, in terms of development.

3.6 Methods of Data Collection

3.6.1 Questionnaires

One set of questionnaires was prepared and administered by giving to the stakeholders to fill. The questionnaires were administered to landlords/building managers for both residential and commercial buildings in the study area. Through these questionnaires, the researcher was able to obtain diverse and critical information necessary for this study and the subject herein. Seventy five questionnaires were administered in the study area, with one questionnaire administered per property/building; of these, sixty were duly filled and returned to the researcher. As stated above, the study area was divided into 14 sub-sections (A-N), divided by existing roads, for convenience of data collection, this was done purely for ease of dealing with the area and recording location of each sample and was found convenient as the existing roads already created these sections. The buildings were chosen randomly from each of the sections, the number of samples taken was dependent on the total units in each section. The total number of units in each sub-section was determined from mapping data for the 2009 Population and Housing Census obtained from KNBS, and visual observation for buildings that may have come up after 2009.

3.6.2 Oral Interview Guides

These are schedules designed to help direct the interview through an oral engagement with the stakeholders. This tool targeted those with technical knowledge on the subject matter; the tool is usually intended to extract information from small numbers of people and enhance generation of information from knowledgeable people on the issues. This instrument was used to obtain information from representatives of NCC and NCWSC.

3.6.3 Observation schedule

This is an important tool in obtaining information about physically observable attributes of an area of study; for this study, these included the actual buildings, their sizes in terms of the number of floors, old and new buildings as well as buildings under construction and vacant plots. The physical attributes were used to obtain and document information about the nature of development in the study area.

3.6.4 Photography

Photography was used to capture and present the physical and visual record of the actual types of developments subsisting in the study area. Several striking images were taken which showed the actual situation on the ground during the time of study; the photographs display a skyline characterized by tall buildings, totally different from the bungalows that prevailed twenty five years ago.

3.7 Methods of Data Analysis

After gathering of data, it was sorted and categorized into quantitative (change in development type from bungalows to other types of development and water supply sources – NCWSC, boreholes and water bowsers) and qualitative data (perceptions of respondents on reliability and adequacy and satisfaction with water supply), arranged in themes for ease of handling and analysis. The data then underwent editing, coding and verification before analysis as per the study objectives. The quantitative data was analyzed using R statistical package, while the qualitative data analysed through descriptive tools, was used to build on the findings. Descriptive statistics such as distribution tables of frequencies, percentages and mean and standard deviation were used to describe general characteristics and study variables.

Two null hypotheses were tested using *chi-square* to determine significance of results, using the following formula:

$X^2 = \sum i\ (Oi-Ei)/Ei$

Where Oi is the observed number of cases in category i

Ei is the expected number of cases in each category.

The hypotheses subjected to chi-square testing stated that:

Hypothesis 1

Ho: There is no significant change in the type of development (bungalows, maisonettes, high rise buildings) in Upper Hill area, in the period 1990 to present.

Hypothesis 2

Ho: There is no significant change in water supply sources (NCWSC, borehole, bowser, or combinations of these) in Upper Hill over the study period.

The parameters used to measure the variables were the different types of developments for hypothesis 1 – bungalows, maisonettes and high rise/multi-storeyed buildings and the different water supply sources for hypothesis 2 – NCWSC supply, borehole, water bowsers, NCWSC and borehole or NCWSC and bowser).

The third hypothesis stating that **'**There is no significant effect of increased development densification on water supply reliability (poor, fair, good, excellent) in Upper Hill' was not subjected to statistical test.

CHAPTER FOUR: DATA ANALYSIS, PRESENTATION AND DISCUSSION

4.1 Introduction

This chapter is a summary of data analysis, presentation and interpretation of the findings, including the response rate, types of developments on which the data was collected and the presentation of the findings, given against each of the study objectives. Data analysed was as derived from the respondents feedback through the questionnaires as well as interviews conducted with key informants at NCWSC and NCC. Descriptive as well as inferential statistics have also been used in data analysis in the study.

4.2 Response Rate

The sample size was 75 out of a population of 150, a total of 75 questionnaires were thus administered to randomly selected properties, randomly selected from each of the 14 sections, numbered (A-N) that the study area was divided into; out of these, 60 were returned, duly completed, translating to 80% response rate. Response rate is the percentage of subjects who respond to questionnaires (Mugenda & Mugenda, 2003). A response rate of 80% is considered favourable, and is interpreted to show that the respondents were representative of the total target population.

4.3 Changes in Development Type in Upper Hill Area between 1990 to the Present

This study looked at the effect of development densification on water, it is therefore necessary to understand the type of developments that prevailed twenty five years ago, against the developments found in the area today; development densification for purposes of this study means enhanced density in terms of number of floors. Upper Hill area was initially a residential area housing government employees, in bungalows built on large plots on a single dwelling basis; these bungalows were built in the 1960s and in the 1970s. The origin of Upper Hill goes back to a strategic development plan/master plan contained in the 1948 Nairobi Master Plan, and the city's last strategic plan – the 1973 Nairobi Metropolitan Growth Strategy; the plan was however poorly implemented and its policy measures were not enforced. The guide to Nairobi City Development Ordinances and Zones divides Upper Hill into six blocks: Blocks 1, 2 and 3 are designated for offices; Block 4 for residential while Block 5 is institutional (Kenyatta National Hospital is within this Block). Block 6 allows mixed developments comprising institutional, hotels and offices. In a study conducted in 2012 entitled 'Managing Expansion of Commercial Districts for Sustainable Development:

A Case Study of Upper Hill Area in Nairobi Kenya', Macharia noted that these zoning regulations are not being observed on the ground as there was no defined development plan, resulting in haphazard developments. Upper Hill falls within Development Zone 1E where the ground coverage for offices is given as 60% and plot ratio ranges between 250% and 300%. The Ground Coverage for residential is 35% and the plot ratio is 150%. The types of developments allowed in the zone are given as commercial/offices/residential with the minimum plot area provided as 0.05 Hectares (Macharia, 2012).

Originally, the Hill Area was a low density residential area but since the late '60's when the Ministry of Works building was constructed within the vicinity of the Community Building (the only office development at the time), the character of the area has been changing rapidly from the low density residential development to mainly high rise office blocks. The development of both Government and private office blocks has now accelerated and with the City Commission having rezoned the area for commercial and office development, intensive development is expected. Such development however, has been taking place without adequate guidelines for the development of the area (NCC, 1999).

The results of this study show a major change in development type, from what was originally on the plots where questionnaires were administered, as presented in Figure 4.1; the plots were initially developed largely with residential bungalows while some were not developed. This has changed substantially and currently the plots are developed with multi-storeyed commercial buildings, characterized by large numbers of people working or visiting the premises during peak hours (8 am to 5 pm).

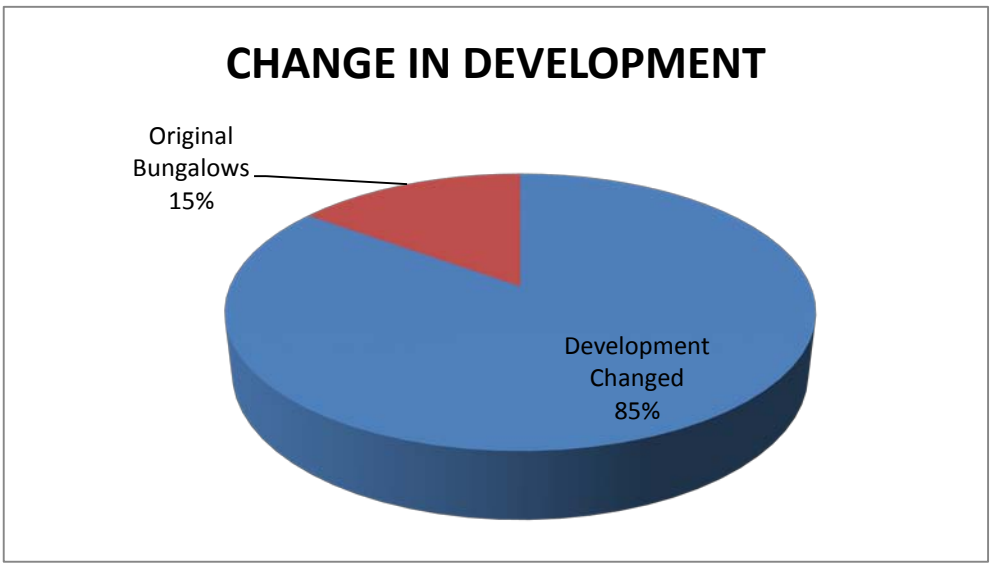

Figure 4.1: Change in development type; Source: Field Data, 2014

4.3.1 Hypothesis testing

The following hypothesis was being tested;

Ho: There is no significant change in the type of development (bungalows, maisonettes or multi-storeyed buildings) in Upper Hill area, in the period 1990 to present.

H1: There is a significant change in the type of development in Upper Hill area, in the period 1990 to present.

A chi-square test was carried out to test the significance of these results and the following values were obtained:

$X^2 = \sum i\ (Oi\text{-}Ei)/Ei$

Where Oi is the observed number of cases in category i

Ei is the expected number of cases in each category.

There were two variables (original bungalows and other types of development) against which expected values were formulated and observation made, based on field data collection using questionnaires. It was expected that 80% of respondents would say there was no change in development, while 20% would say there is change in development. The observed values are as follows:

Table 4.1*:* Change in development type observed values

	Development type changed	No change in development type
Observed number of respondents	51	9
Expected number of respondents	12	48

Source: Field Data, 2014

The values were then calculated as shown below;

$X^2 = \{(51-12)^2/12\} + \{(9-48)^2/48\}$

$= 126.75 + 31.688 = 158.4375$

The Tabular Value was extracted from the Chi square distribution table. The formula used to arrive at the value was (df,∞) where df means degree of freedom.

Degree of freedom refers to the number of frequencies minus the number of parameters of the fitted distribution.

df= K-1 where K refers to the number of variables

Therefore K=2-1

$= 1$

$\infty = 0.05$

Tabular value = 3.841

Therefore the null hypothesis which states that there was no change in development type in Upper Hill area was rejected, while the alternative hypothesis which states that there was a significant change in development type over the study period was accepted.

According to respondents in the study area, most of the newer office and multiple-occupancy residential buildings have been put up on sites that were initially occupied by bungalows (most of which were formerly owned by Kenya Railways) and a few maisonettes; it is noteworthy however that the maisonettes still standing today were constructed later than the bungalows, and were presumably put up on previously vacant land; this result is presented in Figure 4.2.

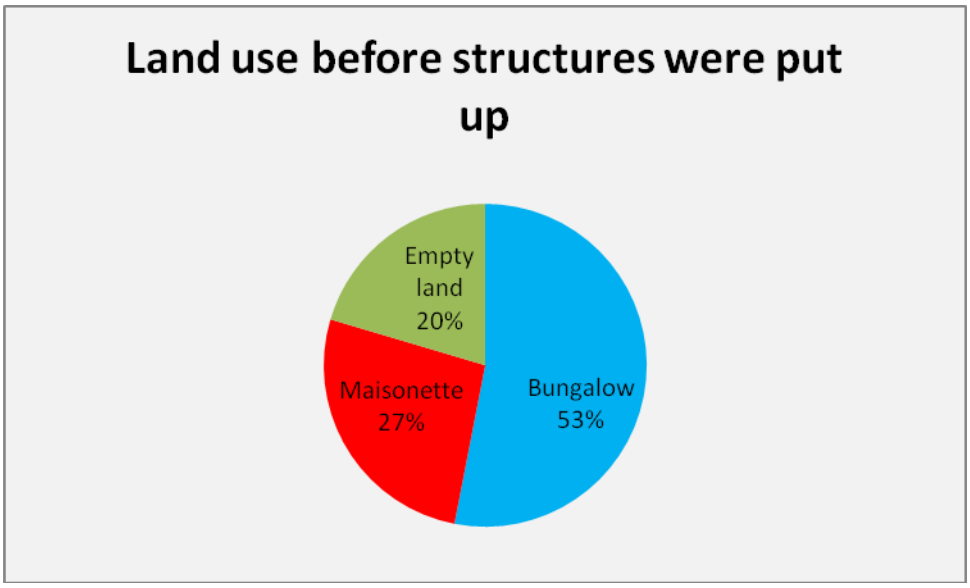

Figure 4.2: Previous use of land on which sampled newer buildings now stand; Source; Field Data, 2014

According to the respondents, 53% of the new buildings have been built on plots that were initially occupied by bungalows, 27% by maisonettes and 20% on initially vacant plots; meaning that the bungalows and maisonettes were demolished to pave way for development of the high rise largely commercial and a few residential buildings that now characterise Upper Hill. This result presented in Figure 4.3, depicts a shift from low density (bungalows and maisonettes) to high density developments ranging in height from a maximum of four floors in residential developments to 45 floors in the building being put up by Britam (currently under construction). This finding further shows that no new bungalows are being put up as the previously vacant land is now developed with high rise buildings.

In the period from 1990 onwards, shortage of office space in the city's CBD, brought about by increased demand for premium office space by blue chip local and multinational companies resulted in development of multiple storey commercial buildings in Upper Hill to meet this demand, leading to the above transformation of Upper Hill. The study established that the area has rapidly changed into the commercial office location of choice, with only a few residential developments such as Upper Hill Gardens, Fairview Apartments, Kugeria Flats, Hillside Apartments and Bamboo Gardens. Most of the sampled properties have been in existence between two and fifteen years. Interestingly, only seven of the buildings where questionnaires were administered have been in existence for more than twelve years (some for about twenty years) and four of these buildings are maisonettes (including Gate 13, Kugeria Flats and

Maisonettes). The study further established that most of the sampled buildings were built well after 1990.

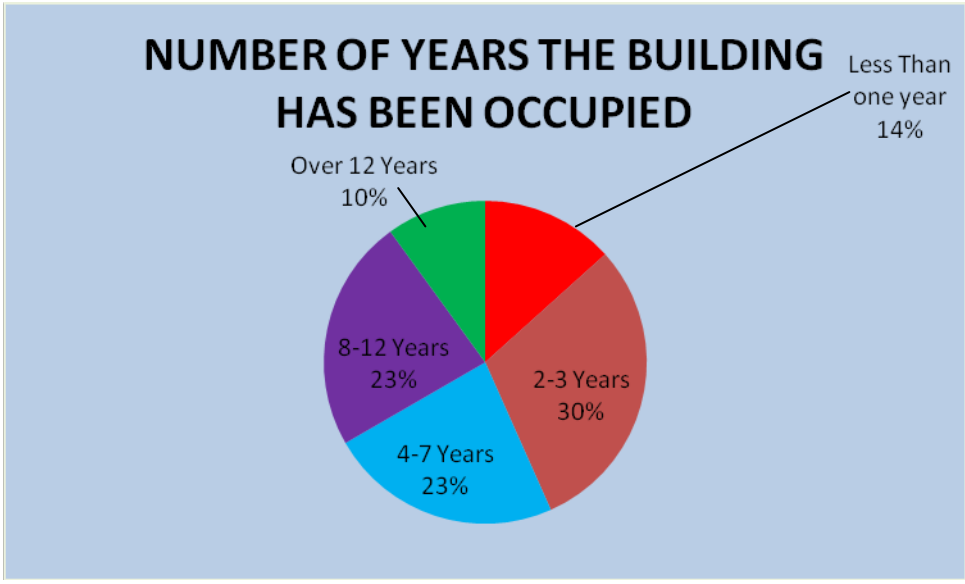

Figure 4.3: Number of years the sampled buildings have been occupied; Source: Field Data, 2014

Upper Hill area has also experienced a change in the nature of property development in terms of height from the initial bungalows and a few maisonettes to the currently predominantly high-rise buildings.

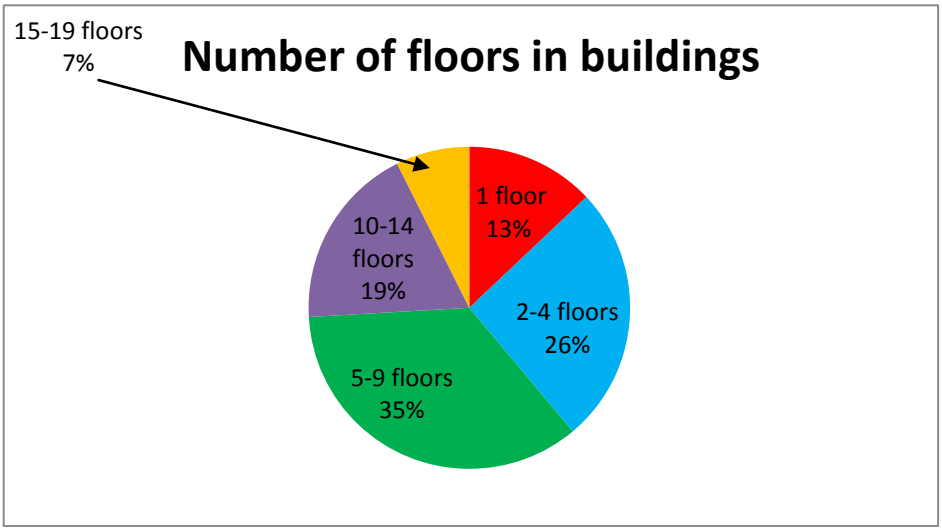

Figure 4.4: Number of Floors in sampled buildings; Source: Field Data, 2014

The study established that 61% of the buildings developed in Upper Hill have five floors and above and 87% have two floors and more, with only 13% having one floor (single storeyed or bungalows). This tendency is driven by the high demand for office space by both local and international companies, and the need to maximize on the use of land, a constrained resource in the area and the city in general. The study also reveals that the buildings are developed on plots ranging in size between 0.5 to 1.5 Acres.

Table 4.2: *S*ize of land occupied by sampled buildings in Upper Hill.

Size of land (Acres)	Frequency (f)
0.5-1.0	17
1.0-1.5	26
1.5-2.0	6
2.0-2.5	7
Over 2.5	4
Total	60

Source: Field Data

Due to the shortage and high cost of land, coupled with the high demand for office space in Upper Hill, property developers have resorted to construction of high rise structures to maximize on the use of the available land. This is a practice that has been on the rise and more high rise buildings are currently being constructed in Upper Hill area. For example, UAP Insurance is putting up a 33 storey (with 3 basements) while British American Insurance Company (Britam) is currently constructing a 45 storey building along Hospital Road in Upper Hill, which will be among the tallest buildings in East and Central Africa. The construction is currently undergoing as shown in Plate 4.1 below and is scheduled to be completed by August 2016. Kenya Commercial Bank recently completed its 24 storey building along Hospital Road in Upper Hill. The World bank also recently moved into a prime office location along the same road within Upper Hill, in a new 15 storey building.

It is therefore evident that there has been a significant change in development type in Upper Hill from low density residential buildings (largely bungalows and a few maisonettes) to high rise commercial buildings. This trend is expected to continue as companies and organizations continue to seek office premises in the area, driven out of the CBD by congestion and inadequate infrastucture such as parking and a clean and condusive working environment.

Plate 4.1: The 45 storey office building being put up in Upper Hill by Britam; Source: Field Data, 2014

Plate 4.2: New KCB Centre in Upper Hill; Source:Field Data, 2014

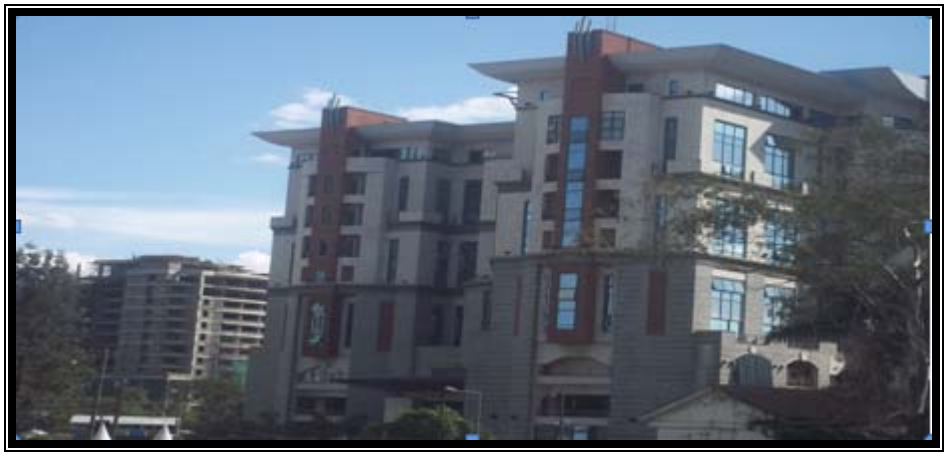

Plate 4.3: Equity Centre in Upper Hill; Source: Field Data, 2014

Plate 4.4: New World Bank offices in Upper Hill; Source: Field Data, 2014

4.4 Changes That Have Taken Place in Water Supply over the Study Period

Ground and surface water both play an important role in water supply for Nairobi. The principal source of water for Nairobi is surface water from the Tana River drainage basin (Foster and Tuinhof 2005, as quoted in NCEO, 2007). Freshwater is also found in the three main rivers that flow through Nairobi, the quality of this water is however poor and not fit for use in untreated form. These rivers are the Nairobi, Mathare and Ngong rivers, and their tributaries – Gitathuru, Kasarani, Riara, Kamiti, Mbagathi, Mutuari and Ruiruaka. The bulk of water supply for Nairobi comes from the neighbouring counties of Kiambu, Murang'a and Nyandarua through Thika, Ndakaini, Sasumua and Ruiru Dams, as well as the Kikuyu Springs. Over time water supply for the city has failed to meet demand. The current estimated water demand for Nairobi is 650,000 m3/day compared to the production of 482,940 m3/day (WRMA 2010 as quoted in NCEO, 2007).

The difference between production and demand has been widening over time due to population growth, inadequacy of the carrying capacity of the distribution network and climate shocks.

Water supply in Upper Hill area has been from the NCC mains water supply line, managed by the NCWSC. Information on their website indicates that NCWSC was incorporated in December 2003 under the Companies Act Cap 486. It is a wholly owned subsidiary of NCC. The mandate of NCWSC is to provide clean water and sewerage services to the residents of Nairobi County, in a financially sustainable manner and within Government regulations. The City has an estimated population of 3.8 million, which is projected to grow to 4.5 million by 2018/19; this population will need water as a basic need. NCWSC's five year strategic plan aims at providing the company with a strategic direction and assisting it achieve efficacy in tandem with the planned international and national water sector goals of the government of Kenya. The water supply line in Upper Hill was designed to serve a residential area that was Upper Hill but due to the increased development in the area and resultant higher population, there has been an increase in water demand which has put pressure on the available water resource in Upper Hill, challenging supply adequacy.The original water supply plan catered for a small population of residents in the area who were adequately served by the existing water mains. However due to development densification in the area, water demand has increased substantially, which has seen property owners/managers resort to alternative water supply sources, to serve the higher population and operations in their buildings. Information obtained from NCWSC indicates that there has been no change in the pipe network laid way back in the 1940s, or the NCWSC 18,000 cubic meters water storage tank that serves Upper Hill area (Hill tank). The NCWSC water consumed in Upper Hill area is from the Kabete Water Works (KWW) and is stored in the 'Hill tank' reservoir put up in 1948, the flow from the tank is by gravity. NCWSC information further indicates that the original bungalows in Upper Hill were served by overhead tanks (placed in the ceilings) only, and that the supply was available twenty four hours a day.

Figure 4.5 shows the different sources of water to sampled buildings, according to respondents.

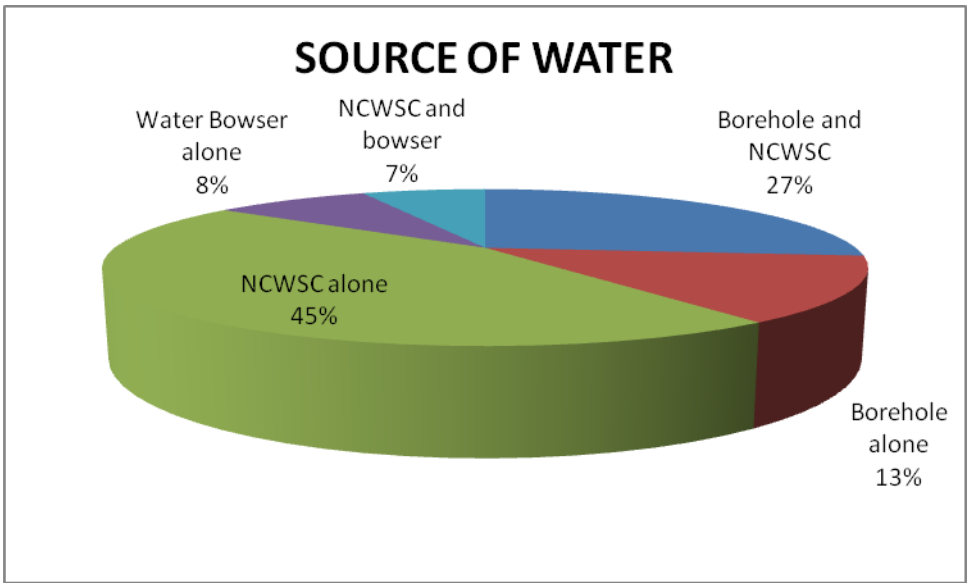

Figure 4.5: Water supply sources in the buildings; Source: Field Data, 2014

The study findings show that 45 % of the respondents rely on NCWSC water alone, 27% on both NCWSC and borehole supply, 8% on water bowsers alone,7% on NCWSC and bowser supply and 13% on borehole water alone. Though a good proportion of the respondents depend on water supply by NCWSC alone (45%), those supplenting this supply with other sources or using entirely different sources are a significant 55%; this is compared to a situation when every property depended on water from the Nairobi City Council/Commission during the sixties, seventies and eighties; further, water was supplied 24 hours a day, on a daily basis, without rationing. Today, the supply is rationed and water is supplied to the area twice a week (on Mondays and Thursdays). As a coping mechanism, most building have underground water storage tanks to store water for use during the days when there is no supply from NCWSC, large buildings like NSSF and NHIF have enourmous water storage facilities to cater for the high number of occupants (238,157 and 446,500 litres respectively). The tanks installed are of adequate capacity to ensure water is available for use in the buildings, even on days when there is no supply. This is compared to small storage tanks (of as little as 500-1,000 liters capacity) placed in the building roofs that served the old bungalows.

The above finding for Upper Hill area is a reflection of the situation in the city of Nairobi in general. Nairobi presents a classic case of how the gap between water supply and demand might grow over time; since 1985, the population of Nairobi has grown from approximately 1.2 million in 1985 to 3.2 million in 2010 (Eckart et al, 2012).

During the same period, water demand grew slightly faster, from 203,000 cubic meters per day to 579,000 cubic meters per day (AWSB, 2012 as quoted in Eckart et al, 2012). In 2009, Nairobi experienced a crisis as water levels in the main reservoir became very low and water supply to the city had to be severely rationed (Eckart et al., 2012).

The above findings are also comparable to those of a study carried out in 1997 that looked at the changes in domestic water use in the three decades between 1967 and 1997, in selected towns and cities in Kenya, Uganda and Tanzania. The study results showed that urban populations had grown rapidly, placing added pressure on already overstretched municipal services, limiting the long-term prospects for increasing per capita water use in the region, and that per capita domestic water use in urban areas of East Africa had declined, decreasing on average from 98.7 litres per day in 1967 to only 54.9 litres per day 30 years later (Thompson et al, 1997). Whilst in 1967 practically all sampled piped households received 24- hour service delivery, in 1997, only 56 per cent of them benefited from the same level of service, almost 40 per cent received less than 12 hours service and roughly 20 per cent got one to five hours service per day. The study further noted that reliability of piped water supplies had declined significantly over the three decades period, in most of the study sites. Different factors contributed to this situation, including a lack of system maintenance and the stress placed on existing network capacity by an ever-increasing urban population. The unpredictability of piped water supply in urban East Africa was noted in the study, to force many households to take precautions, which was evidenced by the increased number of sample households that stored water at home (from only 3 per cent in 1967 to 90 per cent in 1997), relying on these secondary and tertiary sources of water to cater for both short and longer-term shortages and the intermittent failure of their primary piped systems (Thompson et al, 1997).

An important change in the nature of secondary water supply noted by the study was the introduction of private water sources such as kiosks and vendors, which in 1997 were used by almost 40 per cent of sampled households with piped water supply. These private sources were particularly important in low-income areas such as Changombe and Temeke in Dar es Salaam, Tanzania, and Iganga in Uganda, where over 60 per cent of piped households used vendors as their primary source.

The continuing unreliability of many municipal supplies and services, combined with the growing demand for water in most urban centres in East Africa, had contributed to the rapid rise of private water-vending, which was then (as it is today, over 15 years after this study was conducted), a booming business in many of the low- and medium-income study sites. The situation is worse today, with most parts of the city of Nairobi receiving water on a permanent rationing programme, as noted in the study area which receives water on Mondays and Thursdays only.

The study herein found that more than half of the respondents who source water from NCWSC alone were from residential developments and offices operating in Bungalows or Maisonettes (where the user has been changed from residential to office) in the study area; this is explained by the fact that the residential developments are realtively smaller (mostly built on one or two floors) compared to commercial buildings rising to as many as fourty floors (Britam Centre), thus housing more people, translating to higher levels of water consumption. A number of the sampled buildings have boreholes dug in their compounds which create an alternative water supply source. A few of the sampled properties actually rely on borehole water alone and do not use water from NCWSC, they have sunk boreholes and fitted water purification machines which ensure the water is safe for use. This ensures constant supply of water, in light of rationed supply by the NCWSC. Some properties in Upper Hill rely on water supplied by water bowsers, this calls for regular refilling of their tanks, to maintain supply. Some properties were noted to be on both NCWSC and bowser water supply with the bowsers supplying water to these properties when NCWSC supply is not available; this has proved relatively expensive as property managers have had to grapple with high costs of water supplied by the water bowsers. Depending on demand and other factors not in the control of the water users, the water bowsers may fail to supply water, greatly inconveniencing the building owners/managers and the occupants.

Though it was not possible to obtain consumption data from NCWSC, it is apparent that the rapid development of higher density buildings in Upper Hill in the last two decades has resulted in inadequate water supply in the area by NCWSC, necessitating the need for alternative water sources which building owners and managers have variably resorted to as narrated above and as shown in figure 13.0 below.

This alternative water supply comes with its costs for example, the high cost of digging a borehole, the high cost of obtaining water from the water bowsers and the high risks attached to consuming water from the bowsers since the exact sources of such water is not always verified. This directly impacts on the overall monthly cost of running and maintaining the buildings. The above finding reveals the water supply challenges that property managers in Upper Hill have had to grapple with and calls for urgent action to address the challenge.

4.4.1 Hypothesis Testing

A chi square test was undertaken to establish the significance of the results of this objective. The variables were listed and the null hypothesis which states that 'there is no significant change in water supply sources (NCWSC, borehole, bowser, NCWSC and borehole or NCWSC and bowser supply) in Upper Hill over the study period' was tested using chi- square to establish whether there has been a significant change in water supply sources in Upper Hill area or not, over the years. The hypothesis test was done using the formula;

$X^2 = \sum i\ (Oi-Ei)/Ei$

Where Oi is the observed number of cases in category i

Ei is the expected number of cases in each category.

There were five variables against which expected values were formulated and observation made based on field data collected using questionnaires. It was expected that 60% of respondents would say water supply is excellent, 20% would say the supply is good, 15% would say the supply is fair, 5% would say the supply is poor and 0% would give no response. The observed values are tabulated as shown in the table below:

Table 4.3: Observed values of water supply status perception

	Poor	Excellent	Good	Fair	No response	Total
Observed number of respondents	15	9	14	16	6	60
Expected number of respondents	3	36	12	9	0	60

Source: Field Data, 2014

The values were then calculated as shown below;

$X^2 = \{(15-3)^2/3\} + \{(9-36)^2/36\} + \{(14-12)^2/12\} + \{(16-9)^2/9\}$

$= 48 + 20.25 + 0.33 + 2.77$

$= 71.358$

The Tabular Value was extracted from Chi square distribution table. The formula used to arrive at the value was (df, ∞) where df means degree of freedom.

Degree of freedom refers to the number of frequencies minus the number of parameters of the fitted distribution.

$df = K-1$ where K refers to the number of variables

Therefore $K = 5-1 = 4$

$\infty = 0.05$

Therefore from the Chi square distribution table, the theoretical value is 9.488

Since the calculated (Empirical) value (71.358) is greater than the tabular (theoretical) value (9.488), the null hypothesis which states that 'there is no significant change in water supply sources is rejected, while the alternative hypothesis which states that there is a significant change in water supply sources in Upper Hill is accepted. There is therefore statistical evidence that there is significant change in water supply in Upper Hill area.

4.5 Effects Of Higher Density Development on Water Supply In Upper Hill

No hypothesis testing was carried out for this objective; the data collected here was based on people's perceptions on adequacy and levels of satifaction with water supply in the study area, against a backdrop of the number of people occupying the sampled buildings at peak hours. The rapid development of high rise buildings in Upper Hill has resulted in an increase in population (day time) in the area, with some office buildings housing over 250 people during peak hours.

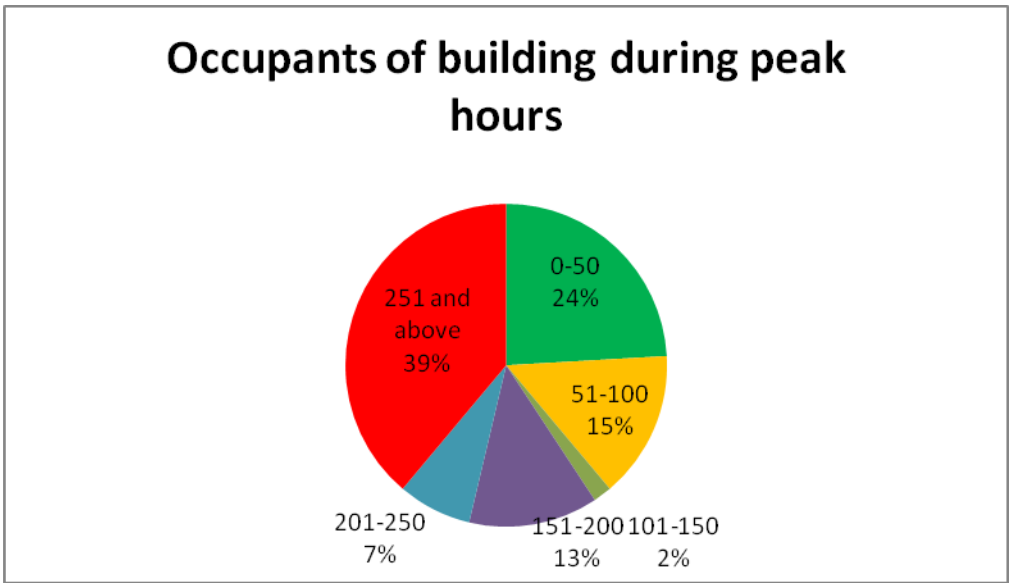

Figure 4.6: Occupants of commercial buildings in Upper Hill during peak hours; Source: Field Data, 2014

This high population requires constant supply of water for various uses in the buildings (the largest consumption being in the washrooms), and has therefore exerted pressure on the water being supplied by NCWSC leading to supply under a rationing programme that sees the area receive water on only two days in aweek (Mondays and Thursdays). Consequently and as noted above, property owners have been forced to resort to alternative water sources such as boreholes and water bowsers. This is indicative of the fact that the amount of water available for supply in the area is inadequate.

4.5.1 Peoples' Perceptions of the Water Supply Situation in Upper Hill

During the study, most respondents (32%) described the water supply by NCWSC in Upper Hill as fair while a 27% termed the supply as poor. Only 24% of the respondents termed the supply as good and a further 17% viewed it as excellent, as shown in figure 15.0 below. This is attributed to the increased density of development in the area that has not been matched by water supply enhancement or upgrading of supply infrastructure; some respondents pointed out the need to upgrade the supply infrastructure in line with changed development density.

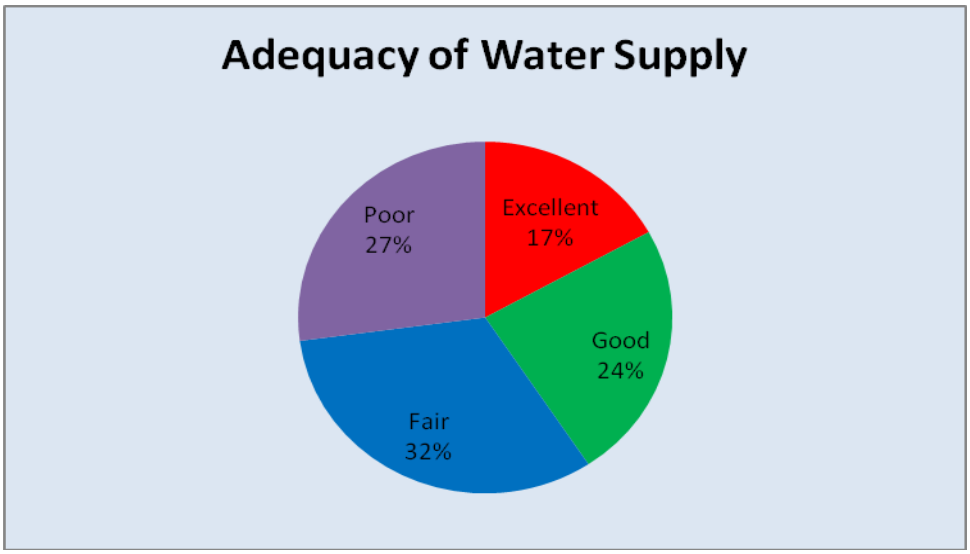

Figure 4.7: Adequacy of Water supply in Upper Hill; Source: Field Data, 2014

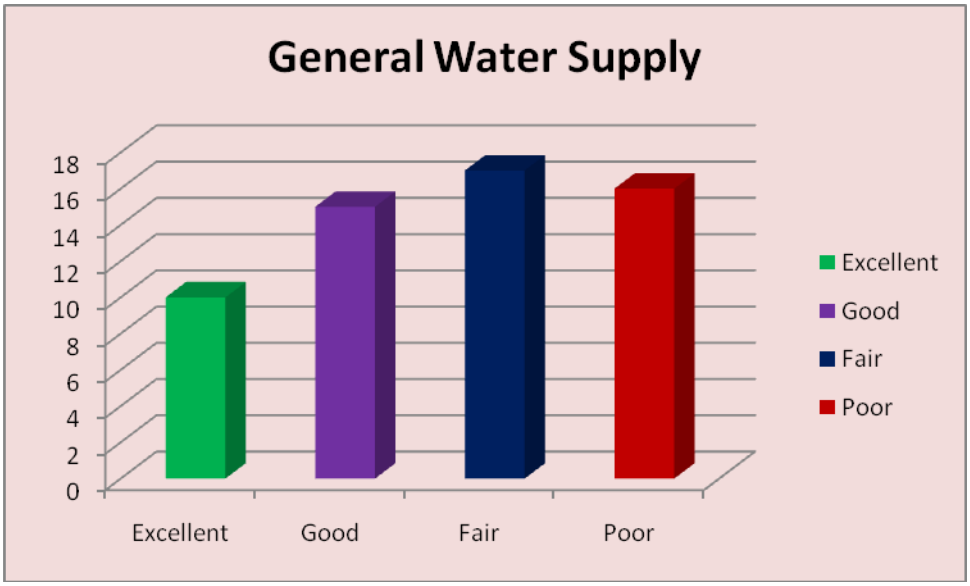

Figure 4.8: General water supply Perception in Upper Hill; Source: Field Data, 2014

Respondents who said their water supply is excellent or good are notably those from residential developments in Upper Hill or those whose offices are located in bungalows and maisonettes that were initially residential. Respondents from high rise office buildings on the other hand, rated the water supply as fair and a substantial number even rated it as poor.

4.5.2 Level of satisfaction with water supply in Upper Hill

Water is an important resource in life sustenance, and is of even greater importance in an urban setting where it has multiple uses over and above drinking and cooking, such as cleaning and running of sanitary facilities. It is the responsibility of urban authorities to ensure proper, efficient, safe and adequate supply of water to all people living in their areas of jurisdiction. According to the respondents in Upper Hill, the water supplied to the area by NCWSC is not adequate and most of them are dissatisfied.

Table 4.4*: General view of respondents on water supply in Upper Hill*

Level of Satisfaction	Frequency	Percentage
Very dissatisfied	17	28.3
Dissatisfied	30	50
Satisfied	13	21.7
Very satisfied	0	0

Source: Field Data, 2014.

The study found that 50% of the respondents expressed dissatisfaction with water supply to the area, 28.3% were very dissatisfied while 21.7% said they were satisfied and 0% were very satisfied. These perceptions are attributed to the inconsistency of water supply which inconveniences property owners/managers, forcing them to seek alternative water sources. Water is supplied to the area only twice a week, prompting property owners to not only construct water storage tanks to ensure water availability on days NCWSC does not supply, but also seek alternative supply sources from water bowsers or sinking boreholes. This has increased the cost of running the properties and particularly commercial buildings, making them quite expensive to run; this directly impacts on the cost of occupying premises in these buildings, through higher 'service charge' levied on tenants.

CHAPTER FIVE: SUMMARY OF FINDINGS, CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

This chapter answers the study's research questions posed as a guide to the study objective, which was to assess the effect of development densification on water, specifically in Upper Hill area of Nairobi. This chapter is a summary of the findings, conclusion and recommendations.

5.2 Summary of Key Findings

5.2.1 General

The study established that there has been a change in type of development in Upper Hill area of Nairobi, towards higher density development through a shift from the initial low density bungalows to development of high rise mainly commercial, and a few multiple occupation residential buildings, and that this change from low to high density development has affected water as a resource in the area, through higher consumption necessitating water rationing and use of additional supply sources. This was established through three main variables, namely (i) change in development type (ii) water supply sources and (iii) satisfaction in available NCWSC water supply. This study data collection was conducted through use of questionnaires and observation schedules; 60 respondents filled the questionnaires. Content analysis was used to analyse the data. This method was chosen because of its strength in simplifying results and removing subjectivity; data was classified in various themes for ease of analysis; the data was thereafter analysed using R statistical package to generate results, which were depicted in form of graphs, pie charts and frequency tables.

5.2.2 Actual findings

5.2.2.1 Change in Type of Developments in Upper Hill

The study objective here was to review the changes in development type in Upper Hill between 1990 and the present; the null hypothesis tested stated that 'there is no significant change in type of development in Upper Hill in the period 1990 to the present'. This study found that the type of development prevailing in Upper Hill area has changed over the last two and a half decades from the largely single dwelling bungalows on large plots to multi-storeyed buildings, largely for commercial use (offices, retail outlets and hotels), but also a number of storeyed residential developments comprising maisonettes and apartments.

This is depicted in the results which showed that 53% of the new buildings have been built on plots that were initially occupied by bungalows, 27% by maisonettes and 20% on initially vacant plots; meaning that the bungalows and Maisonettes were demolished to pave way for development of the high rise largely commercial and a few residential developments that now characterise Upper Hill area. Further, none of the previously vacant plots have been developed with new bungalows; this clearly shows the shift from low density (mostly bungalows and a few maisonettes) to high density developments ranging in height from four floors in residential developments to 45 floors in commercial (specifically Britam Centre currently under construction).

The basis of this shift from low to high density development goes back to 1979 when the then Nairobi City Commission through the Department of City Planning & Architecture zoned the Hill area as an extension of Nairobi's CBD, as Zone 1A, with designated land uses including commercial, residential, hotel and institutional development. The 1979 rezoning strategy was prepared as a land use rationalization and rezoning strategy for the CBD up to the year 2000. In 1995, the City Council of Nairobi, in consultation with the Ministry of Lands, approved a re-planning and rezoning policy for certain parts of the city; this land-use policy designated and expanded commercial centres to Upper Hill, Hurlingham, Yaya, Valley Arcade and Lavington shopping areas.

It further outlined policy guidelines on granting change-of-use permission to residential hotels and professional offices integrated with residential developments. This predominantly affected residential properties situated in development zones 3, 4 and 5 (comprising Upper Parklands/ Highridge, Kilimani/Thompson, Lower Parklands, Lavington, Benard, Loresho, and Kyuna residential areas). The foregoing had been preceded by the Westlands and Museum Hill rezoning policy approved in May 1988 to extend Westlands commercial centre, allowing for higher densities and greater vertical development (taller buildings) within the centre and its peripheries (NCC, 1999).

This finding in Nairobi's Upper Hill area is similar to the situation in most of the other larger towns in Kenya (Mombasa, Kisumu, Nakuru, Eldoret, Kakamega, Nyeri and Thika among others), which have in the past few years experienced rapid urbanization coupled with development of higher density buildings (higher ratios and coverages achieved through vertical densification in higher buildings).

In Nairobi, development of these multi-storeyed office/business blocks is widespread and has expanded outside the CBD to areas such as Upper Hill (the research study area), Kilimani, Parklands, Westlands and several other city suburbs (UNEP, NCC, 2007). This is as a result of a need to meet the increasing demand for office and business space in peaceful working environments away from the hustle and bustle of the CBD. Increasing challenges of congestion in terms of human and vehicular traffic, limited parking space and high rents in old design buildings lacking modern conveniences, have acted as drivers of this movement out of the CBD/city center. The demand for office space in Upper Hill Area is attributed to various factors, including the following:

(i). Lack of appropriate office space in the CBD
(ii). Inadequate car-parking facilities in the CBD
(iii). General congestion in the CBD
(iv). High rents in the CBD
(v). Noise and air pollution in the CBD
(vi). Lack of a quiet and serene working environment in the CBD

Consequently, Upper Hill has become a favorite choice for development of offices for multinational companies like Coca Cola; missions like the Japan Embassy, British High Commission and the European Union; international financial institutions like the World Bank and International Finance Corporation; Insurance companies like the British American Insurance Company, UAP, Blue Shield and Geminia Insurance; high end hotels like Crowne Plaza; and an array of banks' headquarters including Commercial Bank of Africa, CITI Bank, Kenya Commercial Bank and Equity Bank (Macharia, 2012). Despite these massive investments in development of high rise commercial buildings, the authorities have not responded by providing services commensurate with this type of development and investment.

Plate 1.1: – *Pictorial presentation of Upper Hill skyline;* Source: Macharia, 2012

5.2.2.2 Changes that Have Taken Place in Water Supply Sources in Upper Hill.

The study objective here was to review the changes in water supply sources in Upper Hill between 1990 and the present; the null hypothesis tested states that 'there is no significant change in water supply sources in Upper Hill in the period 1990 to the present'. The study established that unlike in the old days of the government and public institutions owned bungalows when residents relied solely on NCC/NCWSC water stored in overhead (above the ceilings) storage tanks, buildings in the area are now using additional water supply sources such as boreholes and water bowsers to supplement supply. Study results show that 55% of the respondents have alternative water supply sources, while 45% depend purely on NCWSC supply, which is supplied on a rationing programme, being supplied two days a week. Further, while there were very few boreholes in the area before 1990, there are several properties (such as NSSF, Bishops Garden Towers and KMA Centre) which have resorted to sinking boreholes to supplement NCWSC supply. It can therefore be concluded that NCWSC water supply in the area is currently not adequate to sustain substantial expansion in the development of increasingly larger capacity domestic and commercial buildings, with water demand in the area currently exceeding the available supply, leading to rationing.

This has seen property owners resort to alternative water supply sources to serve the high population in their properties.

5.2.2.3 Changes in Water Supply Reliability over the Study Period

The study objective addressed is the effect of the increased density development on water supply reliability in Upper Hill over the study period; the null hypothesis states that 'there is no significant effect of increased density development on water supply reliability in Upper Hill'.

The rapid rate of development of high rise office buildings in Upper Hill has seen an upsurge in population in the area, albeit more so during the day than during the night, due to the fact that most office workers leave the buildings for residential estates at the end of the day. The study found that during peak hours, most offices house over 251 people, this is compared to the old set up in which a single bungalow in a compound would house a maximum of ten to twelve people. This calls for supply of water that is commensurate with the high number of people in the offices.

Plate 5.2: *Concentration of high rise commercial developments in Upper Hill; Source: Field Data, 2014*

The study found that current NCWSC water supply to properties in Upper Hill is not adequate. Only 41% of the respondents described the water supply adequacy as being excellent or good. 59% expressed reservations with water supply to their premises – 27% said water supply is poor while 32% said the supply is fair. It can be concluded therefore, that most people are dissatisfied with the NCWSC water supply in Upper Hill. This has seen property owners resort to alternative water supply sources to serve the high population in their properties, for example, 55% of the respondents have alternative water supply sources, while 45% depend purely on NCWSC supply that is supplied two days a week.

The study also found that water supply to Upper Hill area is rationed and supplied on two days in a week – Mondays and Thursdays from 6 am to 9 pm; further, most buildings now store water in underground or outside overhead tanks to cope with the water rationing regime.

Water rationing is not restricted to Upper Hill area alone, as a matter of fact, water to most city estates is rationed. This finding is collaborated by a study conducted in 2012 by Macharia, who noted that there is unreliable supply of water in Upper Hill area which may be attributed to the pressure being exerted on the city's water supply in general, by the growing population and also due to the high density developments that are coming up in the area. Private water suppliers using bowsers are complimenting the supply of water to premises in the area; this private supply of water has led to higher business costs, putting into question the economic sustainability of the businesses (Macharia, 2012).

5.2.2.4 Recommendations on possible approaches to development densification with a view to sustainable water supply in growing suburbs such as Upper Hill

Kenya anticipates continued economic growth, and Nairobi, which contributes over 50% of the country's GDP is expected to be the centre of this growth, this is expected to come with increased population numbers, attracted to the city by better jobs and other means of livelihoods. This growth will require commensurate growth in supply of service and physical infrastructure (roads, water, electricity, sewerage, medical and education facilities, among others), to serve this anticipated higher population. It is therefore imperative that the concerned authorities come up with a well-coordinated policy guideline, to ensure holistic provision of services and corresponding infrastructure in Nairobi in general, and areas such as Upper Hill which have experienced increased development, including provision of adequate water supply.

The main source of water supply for Nairobi is the Eastern Aberdare Rivers within the protected Aberdare Conservation Area (ACA) which includes the Aberdare National Park and the gazetted Forest Reserves that surround the National Park. The total water supplied to Nairobi City and Satellite Towns in 2012 was 580,000 M^3/day against a demand of 750,000 M^3/day. This demand is projected to increase to 860,000 M^3/day by 2017 and 1,200,000 M^3/day by 2035, requiring large and sustained investments in expanding water supply to meet the growing water needs (AWSB, 2012).

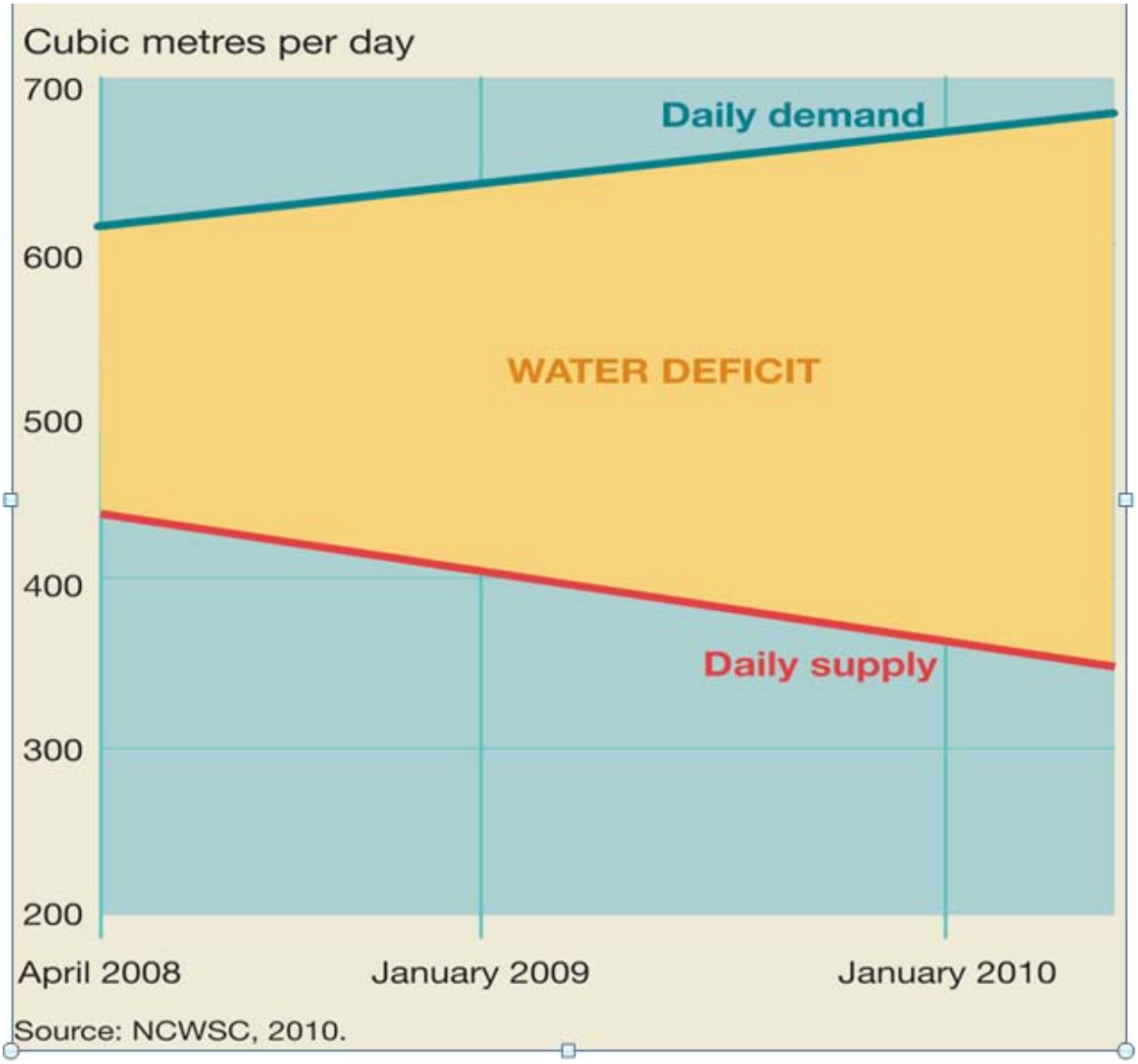

Table 5.1: *Water supply and demand in Nairobi (2008 – 2010); NCWSC.*

Study recommendations are outlined in the recommendations section of the study.

5.3 Conclusion

Upper Hill, as noted in this study, has changed over the last twenty five years, from a low density residential neighbourhood, to one developed with multi-storeyed commercial and residential buildings. The area is one of the fastest growing office locations in the city, with resultant increased day time population of office workers in the high rise buildings that have come up, and continue to come up in the area.

Despite this growth however, there has been no integrated policy to enhance the service infrastructure to cater for the growth; roads in the area are currently being widened to cater for the increased volume of vehicular traffic, while KPLC has taken measures to increase electricity supply to the area through a new substation on Ragati Road (Upper Hill Sub-Station), to reduce the length of distribution lines and consequently, the number of line breakdowns and poor voltages previously experienced by customers. In particular, this study found that water supply has not changed in terms of storage capacity or pipe network, and continues to be supplied under a rationing programme. This has resulted in use of alternative water supply sources by building owners in Upper Hill.

5.4 Recommendations

5.4.1 General

According to the Nairobi City Environment Outlook (UNEP, NCC, 2007), Kenya's leading development challenge today is environmental management in the context of rapid population growth and urbanization (UNEP, NCC, 2007). Kenya's population stood at 38.6 million people in 2009 and is expected to reach 48 million in the year 2020; an addition of one million people yearly, to its already high population. This high rate of population growth coupled with rural-urban migration driven by the search for better livelihoods in urban areas, exerts pressure on existing infrastructure and facilities including health, education, environment, roads, power supply, water, sewerage and other social and economic amenities (KNBS, 2010)

To come up with sustainably developed and planned urban areas, supportive facilities like water, electricity, drainage, water hydrants, and roads among others are planned and provided in advance, to support the expected population and commercial activities. This was not the scenario in the case of Upper Hill where the service infrastructure is trying to catch up with enhanced development in the area (Macharia, 2012). An ambitious Master Plan handed over by JICA to the County of Nairobi is set to transform Nairobi into a world-class city, and will, if well implemented correct such planning anomalies in the future.

The character of the developments in Upper Hill indicates a demand-led instead of an infrastructure-led type of development. The implementation of plans for development of infrastructure has been inadequate and ineffective. The new developments are now exerting undue pressure on the existing level of infrastructure. Water supply to the area is inadequate necessitating water rationing.

Property owners have adopted the coping strategy of sinking boreholes or purchasing water from water bowsers; the use of underground and reservoir tanks and booster pumps to raise the water to the roof storage tanks has also become mandatory.

5.4.2 Study Recommendations

Upper Hill area in Nairobi has experienced rapid development of high-rise buildings in the past two and a half decades, which has resulted in increased population (largely daytime) in the area. Services such as water, electricity, roads and drainage have been over stretched and this calls for the upgrading of basic infrastructure in the area, as is happening with the roads which are being widened to cater for higher traffic flows. Development densification has a direct impact on efficiency of operation of the service infrastructure of an area. The supply of utilities such as water should be integrated in the development plan of any given area, Upper Hill area, (the subject study area), and any other urban areas, included. This study established a serious shortage and unreliability of water supply in Upper Hill. Despite the fact that buildings put up in Upper Hill reflect international building standards, water supply unreliability presents a continuous challenge to building owners/management and users.

The researcher therefore recommends that the central Government of Kenya and the Nairobi City County Government come up with the following measures, in a bid to sustainably marry development enhancement through higher densities, and service infrastructure;

- An integrated plan for the continued development of Nairobi County and especially prime office locations such as Upper Hill, Westlands and Parklands among others.

  This will ensure that requisite service infrastructure (water, electricity, roads etc) are put in place prior to development enhancement and resultant higher populations, putting the development and service infrastructure in tandem. To this end, it is expected that the draft Master Plan upon completion will give, together with the legal framework under the national constitution, the legal and policy framework necessary for future development.
- NCWSC should increase the volume of water available for the area; with an additional storage facility to supplement the ‘Hill Tank’, assessment of adequacy of existing pipe network is also recommended.

- Property owners in Upper Hill should ensure they have adequate water storage facilities on their properties, to ensure adequate storage to cater for periods of non-supply or water shortages.
- A policy guideline on alternative water sources including rain and storm water harvesting and grey water recycling should be developed and implemented by the National Government in liason with County Governments, as a way of boosting existing NCWSC supply.
- NCWSC should have continuous and updated records on water supply and consumption for regular review and assessment by stakeholders.

  This information should be made available to relevant decision makers including urban physical planners to guide in better urban planning thus merging environmental policy with urban planning policy for sustainable development.
- As most of the water for Nairobi is sourced from outside the County, NCC should enter into collaborative partnerships with source Counties for the protection and management of water towers.
- There is need, as part of Policy, Plan and Programme formulation and initiation, to conduct SEA in a deliberate move to marry development and environmental issues /concerns. The National Environment Action Plan (NEAP) enacted through NEMA in consultation with other stakeholders should systematically cover various plans and progammes with relevant policy to support it.

  If the above are effectively implemented coupled with proper implementation of policy and legal frameworks, Upper Hill will become a true commercial hub and choice location for office premises.

5.4.3 Recommendations for Areas of Further Research

The benefits and costs of providing a safe, convenient and reliable water supply to households in the developing world have been the subject of vast and wide-ranging research efforts for at least four decades. According to Thompson et al, most of this research has focused on the relationship between water and disease, the efficacy of water supply projects in improving health, the causes and consequences of differential access and control of water resources (particularly with regard to gender and wealth), and on the financing of water supply infrastructure. Despite this wide array of research, relatively little is known about a number of key aspects of domestic water use.

In particular, knowledge is scarce about the long-term trends and changes in household water use in any part of the world. This is as a result of lack of quality baseline information and cost and complexity of undertaking longitudinal and repeat studies, with most research on household water use being limited to short periods of one season or year. Where studies have attempted to examine changes over time, they have tended to be limited in scope, frequently concentrating on a single locality. Consequently, the dynamics and determinants of domestic water use remain only partly understood. Among the regions of the world, these research gaps are most acute for sub-Saharan Africa, the region whose population has the least access to improved water supply (Thompson et al, 1997). There is therefore need for further research in this line, to show changes in water use taking place over time, which information would be very useful to decision makers in the water sector.

One of the major constraints experienced during this study was inadequate data on water consumption in the study area over the years; the data which was previously in the custody of Nairobi City Council (before the formation of NCWSC in 2003); seems to have been lost or destroyed at the time of transition and was thus unavailable. Another constraint experienced was in obtaining historical pictorial records of the study area.

Although this study has explored the effect of development densification in Upper Hill area on water, there are areas that still need to be further researched, to ensure Upper Hill area is sustainably developed. These include;

- Implications on service infrastructure, of rapid development of high-rise commercial and office buildings in Upper Hill area, Nairobi. This will establish the effects of this development on the current infrastructure and make recommendations for planning.
- Adherence to Planning and Zoning Regulations in Upper Hill area, to establish if ongoing development is compliant with current Regulations.
- Assessment of the effectiveness of water supply policies and institutional framework in Kenya.
- Status of water harvesting as an alternative water supply in Nairobi.

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APPENDICES & ANNEXES

APPENDIX I

KEY RESPONDENTS INTERVIEW GUIDE 1 –USED FOR THE KEY INFORMATIONS (NCWSC)

1. What is the water demand and consumption in Upper Hill area presently?.....
   .....

2. How does this compare to the situation in 1990? .....
   .....

   2. Does the supply adequately meet the demand?..... .....
   .....

3. What was the status of the demand and supply relationship in 1990?
   ....
   .....

4. What are the details of the water supply system/network currently serving Upper Hill area?.....
   .....
5. What changes have been effected in the water supply system and infrastructure in the last 20 years?.....
   .....

6. What has been the effect of the change in development density in Upper Hill area on water demand and consumption?
   …….....
   .....

7. Has NCWSC faced any challenges out of the said densification?
   …….....
   .....

8. What are some of the challenges that NCWSC faces in the course of water provision?.....
   .....

9. What are the NCWSC' future plans regarding water supply in Upper Hill?
   .....
   .....

10. What other sources of water are available in Upper Hill area, other than NCWSC supply?
    .....

APPENDIX 2

KEY RESPONDENTS INTERVIEW GUIDE 2 –USED FOR THE KEY INFORMATIONS (NCC)

1. What is the current zoning policy in Upper Hill area and for how long has it been in place?.....
   .....
   .....

2. Is the current policy as a result of change in the last twenty years and if yes, what was the reason for the change?
   ……
   ……

3. What is the effect of the current development policy on the service infrastructure in general?.....
   .....

4. How has the development trend in Upper Hill area affected the areas' population?.....
   .....

5. How has this population change affected the general service infrastructure?
   .....
   .....

6. Has NCC had to come up with any intervention measures as a result of 2 above?.....
   .....
   .....

APPENDIX 3

QUESTIONNAIRE ADMINISTERED TO LANDLORDS / BUILDING MANAGERS/CARETAKERS (COMMERCIAL BUILDINGS)

1. What is the name of your building and when was it occupied? …….
   …….

2. How long has this building been occupied?
   Less than 1 year
- 2 – 3 years
- 4 – 7 years
- 8 – 12 years
- Over 12 years

3. How big a piece of land does the building sit on?
- 0.5 – 1.0 Acre
- 1.0 – 1.5 Acre
- 1.5 – 2.0 Acre
- 2.5 – 3.0 Acre
- Over 3 Acre

4. What was on the plot before the building was put up?
- Bungalow
- Maisonette
- Other (Specify)……..

5. How many floors does the building have?.....
   ……

6. Roughly how many people are in the building at peak working periods?

- 50 – 100
- 100 – 150
- 150 – 200
- 200 – 250
- Over 250

7. What is the source of water used in the building / houses?

- NCWSC water
- Borehole
- Other (specify)…….

8. What is the total water storage capacity (in litres) of the building?

   …….....

9. How can you describe the sufficiency/adequacy of your current water supply?

- Excellent
- Good
- Fair
- Poor
- No opinion

10. Do you ever have to seek alternative water supply? (please explain your response)

- Yes: …….
  ……..
- No: ……...
  ……..

11. How would you rate water supply to your building?

- Excellent
- Good
- Fair
- Poor
- No opinion

12. What is your view on water supply in Upper Hill area in light of the types of developments prevalent in the area?

- Very dissatisfied
- Dissatisfied
- Neither satisfied nor dissatisfied
- Satisfied
- Very satisfied
- Not sure / not applicable

13. Do you have any suggestions on the same?

.....

.....

APPENDIX 4

QUESTIONNAIRE ADMINISTERED TO LANDLORDS / BUILDING MANAGERS/CARETAKERS (RESIDENTIAL HOUSES / COMPOUNDS)

1. What is the name of your house / compound? ……
   …….

2. How long has your house / compound been occupied?
   Less than 1 year
- 2 – 3 years
- 4 – 7 years
- 8 – 12 years
- Over 12 years

3. How big a piece of land does the building sit on?
- 0.5 – 1.0 Acre
- 1.0 – 1.5 Acre
- 1.5 – 2.0 Acre
- 2.5 – 3.0 Acre
- Over 3 Acre

4. What was on the plot before the development was put up?
- Bungalow
- Maisonette
- Other (Specify)……..

5. How many houses are within the compound?.....
   ……

6. Roughly how many people are in the compound?

- 0 – 50
- 50 – 100
- 100 – 150
- 150 – 200
- 200 – 250
- Over 250

7. What is the source of water used in the houses?

- NCWSC water
- Borehole
- Other (specify)…….

8. What is the total water storage capacity (in litres) of the compound complex?

   …….....

9. How can you describe the sufficiency/adequacy of your current water supply?

- Excellent
- Good
- Fair
- Poor
- No opinion

10. Do you ever have to seek alternative water supply? (please explain your response)

- Yes: …….
  ……..
- No: ……...
  ……..

11. How would you rate water supply to your building?

- Excellent
- Good
- Fair
- Poor
- No opinion

12. What is your view on water supply in Upper Hill area in light of the types of developments prevalent in the area?

- Very dissatisfied
- Dissatisfied
- Neither satisfied nor dissatisfied
- Satisfied
- Very satisfied
- Not sure / not applicable

14. Do you have any suggestions on the same?

.....

.....