ENVIRONMENTAL IMPLICATIONS OF SMALL SCALE WATER SUPPLIERS IN EMBAKASI LOCATION, NAIROBI, KENYA

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DECLARATION

DECLARATION BY THE CANDIDATE

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DEDICATION

This work is a special dedication to my mother, Mrs Beatrice Anyango Sagwa, for her tireless effort and dedication in supporting me realise my dream.

ABSTRACT

Water is a basic human need. It is required for both domestic and industrial use. In Nairobi, the institution charged with provision of water to the residents is Nairobi Water and Sewerage Company (NWSC). However, NWSC serve only 50% of Nairobi with the rest left to find alternative sources of water. Embakasi location in Nairobi County, which is the study area, is one of the areas of Nairobi city that is inadequately served by NWSC. In addition to the low NWSC network coverage in the Embakasi location, there is irregular water supply owing to rationing with most estates getting water on two days of the week. This situation has led to the emergence of small scale water suppliers who get their water from groundwater resources through boreholes. The study set out to identify households' concerns regarding water supply; identify environmental problems occasioned by small scale water suppliers, identify the small scale water suppliers and their distribution in Embakasi location; assess their activities and operations; investigate the factors determining location of small scale water supplier; and, identify the challenges they face. Thus, the broad objective of this study was to establish the environmental implications of small scale water suppliers in Embakasi location. The study employed the use of interview schedules, observation, photography, geographic positioning systems (GPS) and questionnaires to get primary data. Through purposive sampling, key informants in the water supply sector were identified and interviewed. With the help of a key informant, small scale water suppliers were identified and interviewed. Household interviews were also carried out. The location was clustered to ensure that all the estates were covered and questionnaires administered to 300 households served by Nairobi Water and Sewerage Company (NWSC) and the small scale water suppliers. A total of 20 small scale water suppliers were identified out of which 15 were interviewed. Results indicate that Embakasi residents mean daily per capita water consumption was 51.3 litres per day per person and majority of them preferred privately supplied water as opposed to being served by NWSC. Indeed, water access has greatly been improved by the small scale water suppliers especially in Embakasi estate (an estate within Embakasi location) where NWSC coverage is very low and in some places non-existent. Availability of good quality water, presence of competition from other operators and distance to customers were some of the factors that determined the location of a water supply business in the location. High fluoride concentration in groundwater was the biggest challenge facing these operators. The main environmental concern identified related to groundwater abstraction in Embakasi include absence of monitoring by Water Resources Management Authority (WRMA) and complete disregard to the minimum distance of 800 metres between boreholes as recommended by the Water Act, 2002. The study recommends that WRMA should ensure efficiency in data generation so as to have a more complete database of the water resources in Embakasi location. For environmental stability, the minimum distance of 800 meters between boreholes as set by the Water Act, 2002 should be adhered to. Moreover, buffer zones of natural habitat should be created around boreholes to safeguard against contamination with sewerage water and/or boreholes should not be drilled in densely populated areas.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

ACRONYMS

AWSB	-	Athi Water Service Board
CAWMA	-	Comprehensive Assessment of Water Management
CCN	-	City Council of Nairobi
DN	-	Diameter Nominal (Nominal Diameter)
GoK	-	Government of Kenya
KPLC	-	Kenya Power and Lighting Company
MDGs	-	Millennium Development Goals
MoWASCo	-	Mombasa Water and Sewerage Company
MWI	-	Ministry of Water and Irrigation
NWCPC	-	National Water Conservation and Pipeline Corporation
NWSC	-	Nairobi Water and Sewerage Company
UNDP	-	United Nations Development Programme
UNICEF	-	United Nations Children's Fund
WAB	-	Water Appeals Board
WHO	-	World Health Organisation
WRMA	-	Water Resources Management Authority
WSB	-	Water Services Board
WSRB	-	Water Services Regulatory Board
WSTF	-	Water Services Trust Fund
WSS	-	Water Supply and Sanitation

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OPERATIONAL DEFINITIONS

Abstraction – process of taking water from groundwater resources either temporarily or permanently.

Domestic water – water strictly used for cooking, drinking, sanitation and bathing at the household level.

Groundwater - water located beneath the ground surface in soil pore spaces and in the fractures of rock formations. A unit of rock or an unconsolidated deposit is called an aquifer when it can yield a usable quantity of water.

Renewable internal freshwater resource – refers to internal renewable resources (internal river flows and groundwater from rainfall recharge).

Small scale water supply – a private company(ies) that is fully compliant with Water Act, 2002 cap 57, which stipulates that "the water service provider may not supply more than twenty households or supply more than twenty five thousand litres of water a day for domestic purposes; or more than one hundred thousand litres of water a day for any purpose".

CHAPTER 1

INTRODUCTION

1.1 Background Information

The environmental costs of water supply schemes are becoming less acceptable as they become greater, and as they are increasingly measured in economic terms. These costs arise both in supply (i.e. depleting aquifers, damming rivers and destroying wetlands) and in the disposal of wastewater (i.e. run-off, effluent and sewage) [Winpenny, 1991].

According to UNEP report and the Stockholm International Water Institute (SIWI) (2005) on challenges of water scarcity indicates that water withdrawals are so high, relative to supply that surface water supplies are literally shrinking and groundwater reserves are being depleted faster than they can be replenished by precipitation. This can translate into increased costs of water supply for economic activities and for daily human needs.

Naturally, groundwater abstraction results in a decline in aquifer water level. Where such abstraction is limited, groundwater levels stabilise at a new equilibrium such that flow to the area balances groundwater pumping. However, in case of over-abstraction such that it greatly exceeds average rates of recharge, water levels may continue to decline overtime leading to serious decline in well yields, which can provoke an expensive and inefficient cycle of borehole deepening to regain productivity, or even premature loss of investment due to forced abandonment of wells. In some unconsolidated aquifers, groundwater quality may also suffer as an indirect result of pumping induced subsidence. Differential subsidence causes damage not only to individual buildings and roads, but also to piped services routed underground, by increasing water mains leakage and rupturing sewerage systems, oil pipelines and subsurface tanks. This can cause serious contamination of underlying aquifers (Morris et al, 2003).

As highlighted in Sessional Paper No. 1 of 1999, access to adequate and reliable supply of clean water is key to stimulating economic growth and improving public health. There is a strong correlation between availability of water and the level of socio-economic status of the people (Johnstone and Wood, 2001). Income generating activities such as poultry keeping and kitchen gardening which require low capital to operate and are ideal for alleviating poverty in both rural and urban areas, have water as their entry points (ibid).

There exists a great disparity in access to safe drinking water between developed and developing countries with the situation being worse in the latter. According to 2002 data, the World Bank (2007) reported that the annual freshwater withdrawals in sub-Sahara Africa as 119.3 billion cubic metres while that of the high income countries was 899.7 billion cubic metres. It is estimated that 1.1 billion people in developing countries have inadequate access to water and about 700 million people in 43 countries live below the water stress threshold of 1,700 cubic metres per person per year (UNDP, 2006). In contrast to this, the efficiency of water supplies in developed countries in terms of quantity and quality is very high as noted by Lowry, et al (1981). Their per capita domestic water supply is way above the minimum requirement of 38 litres per capita which is recommended by UNICEF. The per capita domestic water supplies in these countries range from a minimum of between 45 litres to 100 litres per day.

Kenya, with 80% of its land classified as arid and semi-arid, is a water-scarce country with less than 1,000 cubic metres per capita of renewable freshwater supplies. Data available indicate that only 60% and 55% of the urban population in Kenya have access to water and sanitation, and 40% and 45% of the rural population respectively (MWI/WSTF, 2009). Interestingly, as urban and other regions' populations increase and livelihoods are threatened by the unsustainable consumption of regional resources, productivity decreases and the potential for conflict over resources increases. It is for this fact that the Kenya government in 1981 set the target year for the provision of clean water for all to be 1990. However, this target was later extended to the year 2000 and later reviewed to 2010 (Hukka et al, 1992; GoK, 1999). This target has now been reviewed to 2030 through the Vision 2030. To achieve this target, there is need to re-examine the country's domestic water supply mechanism.

Water crises in the country is exacerbated by frequent droughts, poor planning and management of the water supply, underinvestment, unfair allocation of water, rampant deforestation, pollution of water supplies by untreated sewage and a huge population explosion (Hukka, 1998).

1.2 Problem Statement

According to NWSC records, only 50% of Nairobi residents have direct access to piped water. The rest obtain water from kiosks, vendors and illegal connections. Of the existing customers about 40% receive water on the 24-hours basis (NWSC, 2012). Access to improved water coverage in urban areas is worryingly declining. Nairobi's daily water demand currently stands at 650,000 cubic metres against a supply capacity of 431,000 cubic metres (NWSC, 2012). Investment in the urban water supply does not reflect a formula that matches with the rapid urban population growth. The high percentage of inactive connections in urban areas, with Nairobi estimated at 56%, may mean that urban coverage could be lower than officially stated. This situation is further worsened for urban residents as volumes of unaccounted for water through leakage, illegal connections, corruption-fed supply disruptions remain unacceptably high with Nairobi estimated to be 40% (WSPA, 2007).

One of the problems facing Embakasi location is water access especially during the dry seasons of the year. NWSC serve only a section of Embakasi location with the rest left to find alternative sources of water. In addition to the low NWSC network coverage in the location, there is irregular water supply owing to rationing with most estates getting water on two days of the week. For instance, in March (2011), Embakasi went for three weeks without a drop of water (Olingo, 2011). This has seen the emergence of small scale water suppliers who get their water from groundwater resources through boreholes. These small scale water suppliers supply water to the unserved areas and meet the water demand on the days the NWSC rations its supply. Important information about the operations of the small scale water suppliers in Embakasi location is not clear. For example: do they follow the laid down procedures as stipulated in the Water Act, 2002 and EMCA, 1999; environmental implications of their activities (groundwater abstraction); their number and distribution in Embakasi location, their activities and operations; the factors determining location of their businesses and challenges they face. Therefore, this study aims to bridge this knowledge gap.

Previous studies in Embakasi location have mostly been on the quality of surface water for instance, a study on ‘Some problems of water quality degradation in the Nairobi River sub-basins in Kenya’, by Kithiia and Ongwenyi (1997) revealed that heavy metal concentrations exceed those recommended by Government of Kenya (1985) and by the WHO (1984) and pointed out on the strong polluting effect of industries located in Industrial Area (Embakasi) discharging into rivers and other open surface waters. Laboratory studies on the quality of the groundwater in the study area also indicate high prevalence of fluoride leading to salinity. Hydro-geological studies indicate the groundwater quality in the study area is generally good and may be slightly mineralised (Njoroge, 2009).

There are also serious concerns regarding groundwater abstraction especially if proper planning and management is ignored. Excessive withdrawals can lead to reduction in river and stream flows; overexploitation of aquifers can cause existing wells to go dry and can lead to deterioration in water quality. Unlike rivers or lakes whose contamination is generally highly visible and rapidly occurring, groundwater is out of sight and undergoes change over an extended period, so that it can be years or decades before contaminants leached from the land surface will adversely affect a groundwater supply (Morris, et al 2003).

This study aimed at investigating the environmental implications of small scale water suppliers in Embakasi location. The findings of the study can be used to determine the right number of small scale water suppliers per square and mitigate environmental concerns occasioned by their activities.

1.3 Objective of the Study

1.3.1 Broad Objective

To establish the environmental implications of small-scale water suppliers in Embakasi location, Nairobi.

1.3.2 Specific Objectives

1. To identify households concerns regarding water supply in Embakasi Location.
2. To assess environmental problems occasioned by small scale water suppliers.
3. To assess distribution of small scale water suppliers in Embakasi location.
4. To assess the activities and operations of the small scale water suppliers.
5. To investigate the factors determining the presence of small scale water suppliers in a particular location.
6. To identify the challenges faced by small scale water suppliers.

1.4 Research Questions

Based on the above objectives, the study formulated the following questions to guide the research:

1. What are the main concerns of households in Embakasi location regarding water supply?
2. What are the environmental implications occasioned by small scale water suppliers in Embakasi Location?
3. How are the small scale water suppliers distributed in Embakasi Location?
4. What activities are small scale water suppliers engaged in?

5. Where does one expect to find a small scale water supplier?
6. What challenges do these small scale water suppliers face while carrying out their activities?

1.5 Justification of the Study

At any one time, almost half the urban population in developing countries is suffering from one or more of the main diseases associated with inadequate water provision (UNICEF/WHO, 1996) such as cholera, diarrhoea and intestinal worms. These diseases arise from consumption of water of inadequate quality and are often aggravated by inadequate sanitation. Consumption of insufficient volume of water also results in significant adverse health effects such as cholera, diarrhoea and intestinal worms. These adverse health effects brought about by inadequate water supply facilities result in household members taking time off work due to illness or nurse sick family members. The emergence of the small scale water suppliers in public water supply has alleviated water access problems especially in peri-urban areas such as Embakasi location.

There was a fall from 31% (1999 census) to 30% of the total population with access to piped water in Kenya according to the 2009 census. This was despite the fact that the national population had grown by approximately 10 million (GoK, 2010). This is further complicated by excessive pollution of urban surface waters thus limiting options for access to clean water. Previous studies on the quality of river water in Embakasi location indicate that heavy metal concentrations exceed those recommended by NEMA, WHO and UNICEF. The Kenya government had set a target to have the entire republic with access to water by the year 2000. Current national statistics indicate that only 60% and 40% of the urban and rural population have access to water respectively (MWI/WSTF, 2009). This calls for a renewed method of improving water access in the country hence the need for this study.

Owing to low network expansion by the NWSC and unreliability of water supply where the network exists, the private sector has been attracted to public water supply. These small scale water suppliers source their water from groundwater sources through boreholes. It is unclear whether the exploitation of groundwater resources is planned and/or monitored by the agencies responsible for their protection and evaluation. The general neglect of groundwater resources in terms of national planning, monitoring and surveillance will only be overcome once effective monitoring is regarded as an investment rather than a drain on resources (Morris et al, 2003).

In 2008, the Government of Kenya produced the Nairobi Metropolitan Development Plan. Under this development plan, the boundaries of the city (Nairobi Metropolitan Area) were expanded to include adjoining towns and municipalities. With only 50% of Nairobi residents connected to the NWSC distribution network, the inclusion of these towns into the City Council of Nairobi (CCN) will further strain the capacity of NWSC. Water supply shortages can only be averted by small scale water suppliers who are already in these peripheral regions supplying water to residents. As long as adequate funding for improving the NWSC water distribution networks, repairs and increasing the capacity of water dams in Nairobi is not met, water access will always be below expectation and the target of supplying water to all will never be met in the near future.

In addition to this, there has been a growing trend of real estate developers coming up with housing innovations such as Tamarind Meadows Estate which will accommodate 87 households. One key common feature with all these developments is that they are integrating private water supply via borehole and all of them are found in the outskirts of the CBD. This means that the small scale water suppliers have a key role to play in urban water supply.

The findings of this study will benefit policymakers, Water Resources Management Authority (WRMA), Water Services Regulatory Board (WSRB), potential entrepreneurs in water supply and common citizenry who are customers of the small scale water suppliers. Firstly, the findings will be used by the WRMA to better manage groundwater resources in Embakasi location. Risks arising from groundwater pollution will be better understood; over abstraction of groundwater resources, which has some serious environmental implications can also be averted. Secondly, policymakers can draw some insights from the findings on how to formulate policies regarding private sector participation in water supply e.g. when and how to introduce subsidies, taxation and water quality issues. Thirdly, the data provides necessary background material for persons willing to venture into public water supply as it gives information on the challenges some of the small scale water suppliers face, amount of investment required to put up the business and the operation costs. Lastly, from this study, consumers can be certain of the quality of the water they get from small scale water suppliers and hence take precautionary measures against contamination.

1.6 Study Area

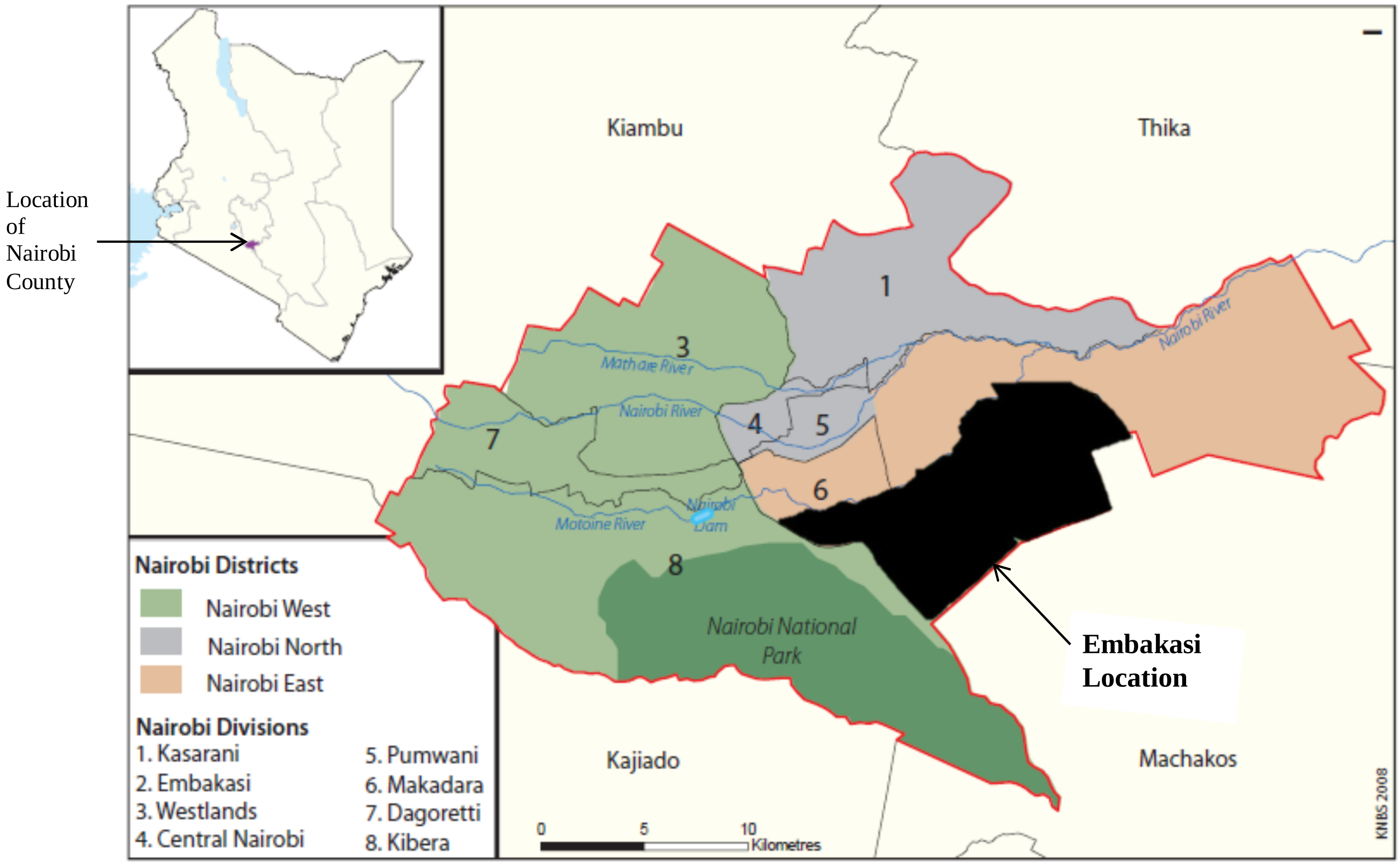
1.6.1 General Information

The study area for this research was Embakasi location in Nairobi County with a total area of 203.6 km^2 and a population of 87,970 with 25,982 households as per the 2009 census. It is located between 01^{0}18^{0}S 36^{0}55E / 1.300^{0}S 36.917^{0}E. Embakasi location lies within the greater Embakasi Division to the east of the central business district [CBD]. This is Embakasi location within Embakasi division (Figure 1).

The area lies within the savannah subtropical climate with about 800mm rainfall per annum. It is underlain by thin layers of Athi Tuffs and Lake Beds which overly Kapiti Phonolites and Basement rocks, mainly gneisses and schists. Previous hydro-geological studies have indicated the groundwater to be saline or hard, or have peak concentrations of chloride, sulphate, fluoride, carbonate, sodium, calcium and potassium ions, especially where groundwater is shallow, groundwater flow is low and the evapo-transpiration rate is high (Njoroge, 2009).

Embakasi location is quite diverse and includes marshland, grassland, residential, communications and industry. With the increase in industrial production and change in government policy in favour of industrial diversification (GoK, 1986), there has been an increase in the number of industrial establishments and consequently attracted a large population to the area in search of employment. This has increased the number of housing units and area of residential land and it has also increased the volume of domestic waste. A greater number of industrial establishments has also increased the effluent load discharged into the rivers passing through the city and has caused a serious deterioration in water quality (Kithiia and Ongwenyi, 1997).

Embakasi location was selected for this research because it lies within the largest constituency (Embakasi) in the republic in terms of registered voters and faces one of the most acute water supply shortages in Nairobi. This situation was made worse by the recent drought (2009) that hit the country leading to drying up of rivers that feed into the Ndakaini and Sasumua dams which are the major sources of the city's water.



Source: KNBS, 2008

Figure 1: Nairobi's three districts and eight divisions.

1.6.2 Drainage

Embakasi location is drained by Athi River and its tributaries which flow to the North-East and East. Athi River has several seasonal tributaries which only have water during the rainy seasons between March-April (long rain season) and November-December (short rain season). The other times of the air the tributaries are usually dry.

The volcanic rocks of the area are not favourable aquifers since they are not particularly permeable. Groundwater, never the less can occur in fractured zones and weathered layers and may also be found in the "Old Land Surfaces" which act as fractured zones (Njoroge, 2009). The weathered layers are normally the erosion layers or Old Land surfaces formed between successive lava flows. The area taps adequate water supply from semi-confined aquifers in the Athi Series, fractured zones of the phonolites and at the contact zone between the phonolites and the basement rocks (ibid).

1.6.3 Geology and Ground Conditions

Embakasi location is covered by Athi tuffs and lake beds, Kapiti phonolites underlain by gneisses and schists of pre-cambrian rocks (Njoroge, 2009). The top black cotton soils overly thin layers of sediments and tuffs of Athi tuffs and lake beds which overly Kapiti phonolites which in turn are underlain by gneisses and schists of pre-cambrian rocks. These rocks are sometimes intercalated with sediments and clayey layers which are evidence of old land surfaces. The Athi tuffs and lake beds forms the best aquifers (water bearing zones) where they are well developed (ibid).

1.6.4 Major Environmental Issues in Embakasi Location

As Embakasi location settlements sprawl outwards, they take over natural savannah grassland fragmenting and degrading remaining natural areas. In addition, rapid population growth has outstripped the location's ability to deliver adequate services such as education, health care, safe water, sanitation, and waste removal. It has also led to an explosion in the number of cars and other vehicles, leading to ubiquitous traffic jams and high levels of air pollution. As it continues to grow, Embakasi location faces the challenge of planning for sustainable urban development that provides adequate housing and services at the same time as it protects air and water quality and the natural environment within and around the city (Tibaijuka, 2007).

Embakasi's physical expansion has come at the expense of the natural environment. Urban sprawl and the construction of roads and other city infrastructure has led to the loss of forests and other natural areas, such as mixed rangeland and bushlands (ibid).

Like in the rest of Nairobi County, Embakasi location rapid growth increased the demand for land and led to land speculation, forcing the poor to settle in fragile and unsavoury areas like in Quarry estate where residents face hardships due to a lack of proper housing and public services and where they are vulnerable to environmental change (ibid).

Ndakaini, Ruiru, and Susumua dams are the principal sources of water that is supplied in Embakasi location. These dams are all on rivers emanating from the Aberdare Forest. Several factors compromise the location's water quality, ranging from natural phenomena such as the high fluoride content in groundwater, to anthropogenic factors such as poor wastewater treatment and environmental degradation both within the greater Nairobi city and the surrounding countryside. Generally, Nairobi's wastewater management has not kept up with increasing demands from the growing population and is inadequate to treat the amount of industrial and municipal effluent entering the Ngong River and other surface waters which flow through Embakasi location (ibid).

1.6.5 Nairobi Water and Sewerage Company Water Supply

Embakasi location is supplied by NWSC which was incorporated on 2nd December 2003 under the Companies Act, Cap 486 of the laws of Kenya as a Private Company limited by shares to give it autonomy and enable it operate commercially. The company is fully owned by CCN. The company was officially launched on 19th August 2004 and it inherited 2,300 staff from the CCN. These staffs were boosted by an additional 30 water experts.

To enhance service delivery to the city residents, the company divided the city into five regions: Northern, Western, Eastern, Southern and Central regions. The study area – Embakasi location lies within the Eastern region. Each of the regions has its own personnel to streamline their activities and address its own unique challenges. Water supply in Nairobi County is sourced through the main pipeline originating from Ndakaini and Sasumua dams. The NWSC has the primary responsibility to provide affordable water and sewerage services through efficient, effective, and sustainable utilisation of the available resources in an environmentally friendly manner, and meet and exceed the expectations of its consumers and other stakeholders.

The working relationship between NWSC (Eastern region) and small scale water suppliers is cordial although some small scale water suppliers have the tendency of engaging in economic sabotage. Some small scale water suppliers have been reported to intentionally burst NWSC supply system creating a water supply crisis forcing consumers to buy water from them. This is particularly prevalent in Kayole, Kariobangi and Dandora. Since the enactment of the Water Act, 2002, there has been tremendous improvement in service delivery as indicated by the General Manager of the Eastern region office. The main drawback of the new legislation is that it has created a lot of supervisors making decision making process very long and cumbersome.

The biggest challenge facing the NWSC Eastern region in its quest to supply Embakasi location with water is inadequate sources of potable water and an old leaking network. Overtime, the NWSC has been using internally generated funds to finance expansion of the network to the unserved areas and upgrading of the sewer lines expecting refund from Athi Water Service Board (AWSB). However, for small lines (less than 100mm for water and DN 225mm for sewer) the company extends and upgrades with the same funds. The company is restricted from laying or repairing lines more than 100mm for water and DN 225mm for sewer lines by the AWSB.

From the NWSC records, the Eastern region has the lowest network coverage with approximately 45,547 active connections to water supply system and 722 connections to the sewer line. These data include both domestic and commercial connections.

1.6.6 Water Quality in Embakasi

A study on water quality degradation in the Nairobi River sub-basins in Kenya by Kithiia and Ongwenyi (1997) reveals that metal concentrations exceed those recommended by the GoK (1985) and by the WHO (1984) (Table 1) clearly show the strong polluting effect of industries discharging untreated wastes into Ngong River.

Table 1: Mean concentrations of chemical parameters vs. WHO and NEMA standards in Ngong' River, Embakasi

Parameter (mg/L)	WHO (upper limit)	NEMA (upper limit)	Ngong' Embakasi
Zinc (Zn)	5.0	1.5	0.1
Fluorine (Fl)	1.5	1.5	1.84
Copper (Cu)	1.0	0.05	0.1
Iron (Fe)	0.3	0.3	1.2
Aluminium (Al)	0.1	-	1.65
Manganese (Mn)	0.1	0.1	1.6
Lead (Pb)	0.05	0.05	0.1
Mercury (Hg)	0.001	-	0.3

Source: WHO, 1984; GoK, 1985; Kithiia and Ongwenyi, 1997

Kithiia and Ongwenyi (1997) contend that trends in water consumption and demand are often a guide to the availability of water in terms of both quantity and quality. In many instances, an increase in water demand and use is directly proportional to deterioration in water quality. The amount of waste discharged tends to increase with rising water demand, although the relationship depends in detail on the amount of water and the specific use involved.

The amount of water in a river depends on the type and number of water abstraction facilities along the course, the number of tributaries, amount of rainfall and distribution, soil type, temperature and the shape of the drainage basin, as well as the population structure. The nature and extent of human activity, be it industrial, agricultural or both, will in turn determine the magnitude and nature of pollution and the water quality status of the water course. This makes abstraction of water from these rivers for domestic purposes unviable.

According to hydro-geological studies, groundwater in Embakasi location may be saline or hard, or have peak concentrations of chloride, sulphate, fluoride, carbonate, sodium, calcium and potassium ions, especially where groundwater is shallow, groundwater flow is low or absent and the evapo-transpiration rate is high (Njoroge, 2009).

1.7 Limitation of the Study

- Technical details on engineering, geology and hydrology was not used in this study.
- Some sections of the study area were avoided due to security concerns.
- The study had sought to find out the efficiency of small scale water suppliers (i.e. water extracted should be equal to water distributed and proportionate revenue collected) unfortunately this information was found missing. This information could have shed some light on effectiveness private sector participation in public water supply *vis-a-vis* central water supply.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

The literature review considered for this study included journal articles, publications, conference papers, magazine and newspaper articles, websites, government Acts, expert interviews and Sessional Papers. This chapter begins with an introduction in section 2.1 and is followed by a close look at the private sector in the water supply in section 2.2. This is then followed by a discussion on global water supply in section 2.3. A comparison of water supply in developed and developing countries is then made in section 2.4 and 2.5 respectively. An environmental implication of groundwater abstraction is covered in section 2.6. This is followed by groundwater planning and management in section 2.7. The Kenyan water supply situation is provided in section 2.8 which is followed by the national legal and institutional framework for the provision of water in section 2.9. The chapter concludes with a theoretical and conceptual framework in sections 2.10 and 2.11 respectively.

2.2 Private Sector and Water Supply

Bakker (2003) asserts that private sector management of water supply systems is not a new phenomenon. The diversity of water supply management systems worldwide - which operate along a continuum between fully public and fully private - bear witness to repeated shifts back and forth between private and public ownership and management of water systems.

Bakker (2003) goes further to explain that water is expensive to transport relative to value per unit volume, requiring large-scale capital investments in infrastructure networks which act as an effective barrier to market entry. Water supply is thus highly susceptible to monopolistic control (a condition termed 'natural monopoly' by economists). In addition to water's 'natural monopoly' characteristics, the symbolic and cultural importance of water as a (partially) non-substitutable resource essential for life, its strategic political and territorial importance, the intense conflicts that arise over the shared use of a flow resource required to fulfil multiple functions, and the need in industrialised, urbanised societies to mobilise large volumes - invariably at a high cost relative to the economic value generated - have been used, particularly in the 20^{th} Century, to justify public sector involvement. Moreover, the health and hygiene effects of lack of access to water, together with the tendency of private companies to fail to extend coverage to the poor (both as a result of the tendency to ‘cherry-pick’ profitable neighbourhoods and classes of consumers, and the high prices and poor services resulting in a situation of natural monopoly), were two of the most important justifications for bringing water supply under the control of the state, whether through strict regulation or public ownership of water supply infrastructure, during the 20^{th} Century.

The above sentiments are further shared by Ngunjiri (2010) who adds that huge capital required upfront, long payback period and low rate of returns are some of the reasons the private sector is not investing in power, transport and water infrastructure in Africa despite the sector being responsible for more than half of the continent’s recent improved growth performance.

A similar study conducted in Honduras, Pearce-Oroz (2006) confirms the viability of decentralised water supply in developing countries. Whether or not decentralised operators can more effectively and efficiently provide these services (water and sanitation services) than their centralised counterparts will depend to a large extent on the management capacity of local operators.

The evident failure of past approaches to WSS services has spurred a number of interdependent shifts in the mainstream/orthodox philosophy of provision in urban areas in recent years as reported by Johnstone and Wood (2001). These have resulted in a trend towards increased private sector participation (PSP), more decentralised management, an emphasis on demand-based provision (and differentiated levels of service) and a greater degree of cost recovery.

The case for PSP in the WSS sector stems in part from a belief that the private sector is better placed to undertake the kinds of investment necessary to expand and rehabilitate the infrastructure. In many cases, it is felt that public authorities in developing countries have been unable to manage urban WSS efficiently and to undertake the investment necessary to provide adequate levels of service provision. Expansion of the service network has not kept up with demand; households which are connected face considerable unreliability in service provision due to inadequate maintenance; cost recovery has been negligible; and large financial transfers from government treasuries have been required. A number of closely related reasons have been frequently cited in the literature as being responsible for these problems (ibid):

Gamekeeper-poacher problems: public water and sewage utilities will tend to be inefficiently managed since governments have multiple objectives but limited financial resources. With the government as both owner and provider, the manager of the utility is subject to a number of conflicting influences, which it may not be able to balance if clear priorities are not established.

Flexibility and autonomy: at the level of operations, public utilities are often constrained by bureaucratic requirements which do not affect private firms to the same extent. For instance, there is often considerable inflexibility in the management of human resources within public utilities.

Absence of competitive discipline: since public utilities are not usually subject to the disciplines of the market they have fewer incentives to minimise costs (and maximise tariff collection rates), and provide services in a manner which customers demand.

Access to capital: with government budgets strained, most public utilities have insufficient financial capital to undertake the necessary investments to maintain (let alone expand or improve) services. It is argued that private companies are better placed to access capital, both domestically and internationally. They may also be better placed to access technical skills (human capital).

2.3 Global Water Supply

Globally, there is more than enough water for domestic purposes, for agriculture and industry. But access to water is very uneven across and within countries. Poor people have limited access, not so much because of physical water scarcity, but because of their lack of purchasing power and because of inappropriate policies that limit their access to infrastructure (World Bank, 2007).

Water is needed for most economic activities, but agriculture is the most water intensive sector, using 73% of global water withdrawals. Each year some 7,100 cubic metres of water are consumed by crops to meet global food demand, the equivalent of ninety times the annual run-off of the River Nile, or more than 3,000 litres per person per day. Most of it (78%) comes directly from rainfall, the remainder from irrigation (CAWMA, 2007).

Nuttle (1993) allays his fears that groundwater, the source of municipal water supply for a large number of basin communities, also may be vulnerable to changes in recharge rates brought about by climate change. Sustainable water supply is crucial to meeting the millennium development goals (MDGs).

Adaptation options designed to ensure water supply during average and drought conditions require integrated demand-side as well as supply-side strategies. The former improve water-use efficiency, e.g., by recycling water. An expanded use of economic incentives, including metering and pricing, to encourage water conservation and development of water markets and implementation of virtual water trade, holds considerable promise for water savings and the reallocation of water to highly valued uses. Supply-side strategies generally involve increases in storage capacity, abstraction from water courses, and water transfers. Integrated water resources management provides an important framework to achieve adaptation measures across socio-economic, environmental and administrative systems. To be effective, integrated approaches must occur at the appropriate scales (Bates et al., 2008).

For much of the world, the availability of adequate water poses a significant challenge to development and environmental sustainability (Kniveton and Todd, 2006). The diminishing supply of natural water resources on a global scale has led to serious social crises in a large number of countries (Forrest, 2001). The World Bank (2007) warns that competition between water for food production and other sectors will intensify, but food production will remain the longest consumer of water worldwide.

2.4 Water Supply in the Developed Countries

The efficiency of water supplies in developed countries in terms of quantity and quality is very high as noted by Lowry et al (1981). Their per capita domestic water supply is way above the minimum requirement of 38 litres per capita which is recommended by UNICEF. The per capita domestic (restricted to cooking, drinking, sanitation and bathing) water supplies in these countries range from a minimum of between 45 litres to 100 litres per day. Gleick (1996) clearly points out that water for recreation such as swimming or home gardening is not considered as domestic water.

Planning and management of domestic water supplies in the developed countries differs from country to country but common denominators include: most of these countries have an internal political structure, which gives considerable regional autonomy. This is particularly so in the case of United States of America and Canada, where the federal or national government fulfil national policy role and the provinces and states exercise a strong planning and management control of water supplies. Water resource issues confined within a given region are usually within the jurisdiction of that regional government (McDonald and Kay, 1988).

In most of these countries, the regional or provincial governments have mainly involved the private sector in the planning and management of domestic water supply within a well-established institutional and legal framework. The institutional and legal framework of domestic water supplies is well organised and the responsibilities of the various actors well defined. Through legislation, privatisation is given political legitimacy and sets the platform for the discipline of process, transparency of decision making and the legal security of transactions. Due to sensitivity of the water sector, the enabling legislative framework is crucial. Some of the enabling legislation includes a system to handle and resolve disputes and address consumer complaints and employee grievances, clear designation of decision making authority and the guarantee of property rights whose contracts will hold the test of time and equality before the law (Anwar, 2001).

The legal and institutional framework governing the private sector involvement provides the establishment of a regulatory system, which is designed to be independent of the political influence and pressure groups. The main objective of the regulatory system is to ensure compliance with standards of acceptable service. Other objectives include striking the right balance between protecting workers (in the water provision sector) and consumers while providing adequate incentives to investors, provide a mechanism to access legal recourse for aggrieved stakeholders and promote a business environment that promotes commercial viability.

2.5 Water Supply in the Developing Countries

UNICEF and WHO (2010) report indicate that about 4 billion cases of diarrhoea per year cause 2.2 million deaths, mostly among children under five while intestinal worms infect about 10% of the population of the developing world and, depending upon the severity of the infection, lead to malnutrition, anaemia or retarded growth, and diminished school performance. In addition to this, about 6 million people are blind from trachoma, a disease caused by the lack of water combined with poor hygiene practices. Studies found that providing adequate water supply could reduce the infection rate by 25%. In the case of schistosomiasis, about 200 million people are infected with the disease, of whom 20 million suffer severe consequences. Studies found that adequate water supply and sanitation could reduce infection rate by 77%.

It has also been argued that societies suffer water stress when annual renewable supplies fall below approximately 2,000 cubic metres per person at a time when demands for water are increasing in the process of development (Falkenmark, 1989). Progress to improve access has been significant in the last decade but probably insufficient in Africa to meet the 2015 MDGs target to halving the proportion of people in 1990 without sustainable access to safe drinking water (World Bank, 2007).

The major underlying constraint to increasing coverage of access to safe drinking water in developing countries is the shortage of investment capital for extending the service, and the negligible or partial recovery of operating costs of providing service. The specifics vary according to the level of service, choices of technologies, management systems, and cost recovery practices. The total of the global annual investment in the water and sanitation sector in the developing countries was estimated to be about US$10 billion in the 1990s. On average, 65% of this funding was raised from in-country resources, the rest from bilateral and multi-lateral external funding. There is strong regional variation in the fraction of funding from in-country resources, from a high of 90% in the Middle East to a low of about 25% in Africa (Christmas and Rooy, 1990).

Commonly, the technical performance of the public water systems is poor (e.g. there is much “stolen” or unaccounted-for water: 58% in Manila, 40% in most Latin American cities), leading to huge foregone revenue to the water utility. Organisational performance is poor. The number of employees per 1000 connections is small in a well-run water utility in a developing country for example, 4 in Santiago, Chile and 3 in Hong Kong), but between 10 to 20 in most Latin American utilities and occasionally even higher in Asia (e.g. 33 in Mumbai, India) (Briscoe and Garn, 1993; Asian Development Bank. 1997). Lastly, financial performance is also poor. Hundreds of millions of dollars of annual government subsidies are needed to keep the water utilities solvent.

Gadgil (1998) contends that the justification for the high level of government subsidy for water services is claimed to be the low ability of the poor to pay for services. In practice, it is the rich, not the poor, who almost always benefit disproportionately from subsidised water services in the developing countries.

Another challenge affecting water supply in the developing world is that freshwater supply comes in the form of seasonal rains, such as the monsoons in Asia. Such rains often run off too quickly for efficient use. India, for instance, gets 90% of its rainfall during the summer monsoon season – at other times rainfall over much of the country is very low. Because of the seasonal nature of the water supply (without storage), many developing countries can use no more than 20% of their potentially available freshwater resources.

Furthermore, water supplies can also vary from year to year, depending on variations in the weather. For example, monsoons may fail in some years. Also natural phenomena such as the El Niño Southern Oscillation can lead to significant differences in rainfall in the southern Pacific Ocean, affecting south-east Asia and south and Central America.

According to another source, Parliamentary Office of Science and Technology (2002), issues affecting water supply in developing countries include population growth and urbanisation. As world population and industrial output have increased, the use of water has accelerated, and this is projected to continue. Indeed, it is projected that by 2025 global availability of fresh water will drop to an estimated 5,100 cubic metres per person per year as the world's population increases by 2 billion (Cosgrove and Rijsberman, 2001). One of the main problems facing developing countries is rapid urbanisation. This results in increasing numbers of people living in urban fringe areas of shanty towns where it is extremely difficult to provide an adequate supply of clean water or sanitation.

Another issue affecting water supply in developing countries is the quality of water. As well as the need for an adequate quantity of water for consumption, it also needs to be of an adequate quality that minimises health impacts, such as water-borne diseases. However, WHO estimates that around 4 million deaths each year can be attributed to water related disease, particularly cholera, hepatitis, dengue fever, malaria and other parasitic diseases.

In many developing countries farmers use, on average, twice as much as water per hectare as in industrialised countries, yet their yields can be three times lower – a six-fold difference in the efficiency of irrigation. On top of this, only one-third of all the water withdrawn for agriculture actually contributes to making crops grow – of the remainder some is returned to the system and reused but much is polluted or unusable.

In addition to the inefficiency in use, aquifers are being depleted faster than they are being replenished. This is particularly the case in China, India, Mexico, Thailand, North Africa and the Middle East. Also intensive pumping can deteriorate the quality of groundwater by attracting salt water either from the sea or from naturally saline groundwater (ibid).

According to Comprehensive Assessment of Water Management in Agriculture (CAWMA), globally, one billion people live in areas of economic water scarcity, where human, institutional and financial capital limit access to water even though water is available locally to meet human demands, a situation especially prevalent in much of sub-Sahara Africa and south Asia (CAWMA, 2007).

Unlike water supply in developed countries, the privatisation of domestic water supply services is limited. There are many constraints to environmentally sound planning and management of domestic water supplies in most developing countries.

The sectoral approach to domestic water supplies is a major constraint. This problem has its basis in the sectoral approach to water resource planning and management in most developing countries. It is imperative to note that domestic water supplies provision is a sub-set of water resources management. Therefore, reliable provision of water supplies can only be achieved within the context of overall environmentally sound water resources management. Unfortunately, most developing countries hardly adequately integrate environmental conservation in most of their development strategies. Issues of environment and development are hardly considered simultaneously. Often, in many of these countries, different ministries work in isolation from the ministry of environment. Such separation works against the adoption of a holistic view of water resources planning and management and by extension, domestic water supplies. Planning and management of water resources in these countries has often been an ad hoc response to particular, pressing problems with only limited number of countries promoting water management at the national level. In order to address this challenge, the environment, which includes water resources, should be integrated in the overall economic and social planning (Thanh and Biswas, 1990).

2.6 Groundwater Abstraction and the Environment

The environmental costs of water supply schemes are becoming less acceptable as they become greater, and as they are increasingly measured in economic terms. These costs arise both in supply (e.g. depleting aquifers, damming rivers, destroying wetlands) and in the disposal of wastewater [run-off, effluent, sewage] (Winpenny, 1991).

A report compiled by the United Nations Environment Programme – Finance Initiative (UNEP-FI) and the Stockholm International Water Institute (SIWI) (2005) on challenges of water scarcity indicates that water withdrawals are so high, relative to supply that surface water supplies are literally shrinking and groundwater reserves are being depleted faster than they can be replenished by precipitation. This can translate into increased costs of water supply for economic activities and for daily human needs.

Naturally, groundwater abstraction results in a decline in aquifer water level. Where such abstraction is limited, groundwater levels stabilise at a new equilibrium such that flow to the area balances groundwater pumping. However, in case of over-abstraction such that it greatly exceeds average rates of recharge, water levels may continue to decline overtime leading to serious decline in well yields, which can provoke an expensive and inefficient cycle of borehole deepening to regain productivity, or even premature loss of investment due to forced abandonment of wells. In some unconsolidated aquifers, groundwater quality may also suffer as an indirect result of pumping induced subsidence. Differential subsidence causes damage not only to individual buildings and roads, but also to piped services routed underground, by increasing water mains leakage and rupturing sewerage systems, oil pipelines and subsurface tanks. This can cause serious contamination of underlying aquifers (Morris *et al*, 2003).

Major changes in hydraulic head distribution within aquifers can lead to the reversal of groundwater flow directions, which can in turn induce serious water quality deterioration as a result of ingress of sea water beneath coastal cities or intrusion of other saline groundwater, especially along coastal towns as studies have shown in Kwale County (Tole, 1997).

According to studies done by UNEP (1996); leaking sewers, on-site sanitation systems and on-site disposal/leakage of industrial waste water have shown to lead to water quality deterioration with a heavy influx of nitrogen compounds, boron, chlorides, faecal coliforms, sulphates, hydrocarbon and diverse industrial chemicals. In addition to this, the impact of mining and industry produce a cocktail of heavy metals, organic solvents of various types and hydrocarbons in their effluents and wastes.

The direct contamination of groundwater sources caused by poor sanitary completion has also been linked to both endemic and epidemic disease and in both developed and developing countries. Outbreaks linked to poor sanitary completion have been noted in many countries. The use of poorly protected groundwater sources has been linked to acute diarrhoeal disease (Trivedei *et al.*, 1971; Nasinyama *et al.*, 2000) in the developing countries. Sanitary completion should be addressed in the design and construction stage and continued through effective operation and maintenance. Appropriate sealing of abandoned wells is also noted as essential to protect functioning groundwater sources (Rojas *et al.*, 1995; Robertson and Edberg, 1997). Groundwater supplies can be well designed and constructed, but the measures put in place to prevent contamination will require maintenance to ensure that they remain effective in the longer term.

2.7 Planning and Management of Groundwater

Protecting groundwater quality should be a priority issue when planning urban and/or industrial development or other significant land use changes. Groundwater derives its importance for both potable water supplies and for irrigation worldwide given the limited quantity of fresh water available.

In many countries, including Kenya, ownership of the water is often unclear due to ambiguous legal status and most of the time there exist weak regulation of the resource. Morris, *et al* (2003) argues that agencies responsible for protecting and evaluating groundwater resources, often have limited resources and powers. The production of aquifer vulnerability maps is rarely undertaken while it is a very useful first step in assessing groundwater pollution risk at the planning stage. Thus, agencies responsible for promoting activities that may potentially contaminate groundwater are often unaware of the impact of those activities. One consequence is that regulations to control waste disposal are absent or not enforced. Likewise, economic incentives are usually designed to increase output rather than to treat wastes or to limit the negative environmental impacts.

Unfortunately, groundwater is too often seen as a convenient, and relatively cheap, resource to be exploited rather than as a valuable but potentially fragile resource that needs to be sustained by protection and management. This lack of awareness of the potential threats to groundwater, by those planning development, often results in groundwater issues being absent from discussions at the planning stage. Unlike rivers or lakes whose contamination is generally highly visible and rapidly occurring, groundwater is out of sight and undergoes change over an extended period, so that it can be years or decades before contaminants leached from the land surface will adversely affect a groundwater supply (ibid).

Figure 2 illustrates the vicious cycle that can lead to groundwater quality degradation as lack of resources leads to lack of knowledge, preventing positive involvement in planning by regulatory agencies. This is further coupled by rampant corruption which frustrates adoption of effective measures. In order to redress the balance, the importance of groundwater must be brought to the attention of those involved in planning development and infrastructure, who should be made aware of the fragility of this resource and the need to include its sustainable use as a tenet of the planning process (Morris, et al 2003).

The general neglect of groundwater resources in terms of national planning, monitoring and surveillance will only be overcome once effective monitoring is regarded as an investment rather than a drain on resources. For this reason monitoring systems should be periodically reassessed to make sure that they remain capable of informing management decisions so as to afford early warning of degradation and provide valuable time to devise an effective strategy for sustainable management.

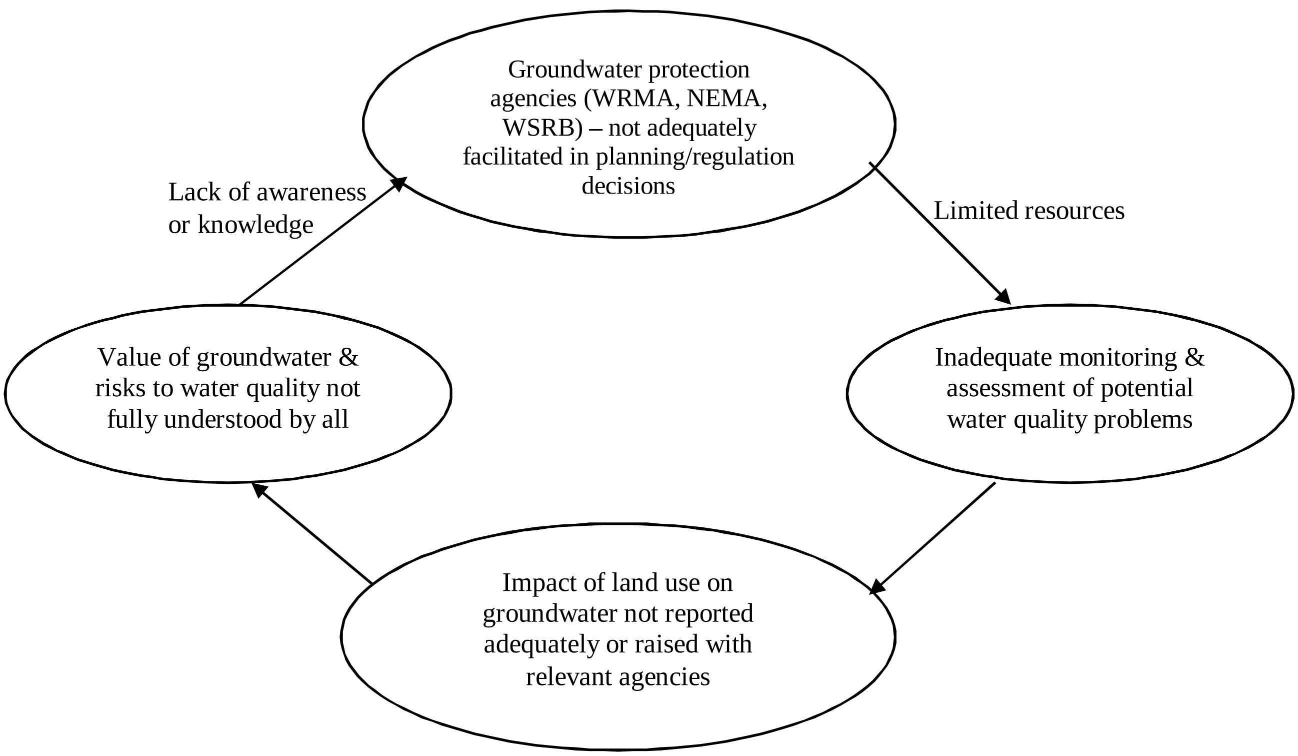


Figure 2: Lack of resources results to lack of knowledge and thus lack of planning. Source: Adapted from Morris et al (2003).

2.8 Kenyan Situation

According to World Bank (2007), Kenya's renewable internal freshwater resource – refers to internal renewable resources (internal river flows and groundwater from rainfall recharge) in the country was 21 billion cubic metres which implied a per capita of 604 cubic metres. The report goes further to highlight that the annual freshwater withdrawal (2002 data) was 1.6 billion cubic metres of which 7.6%, 64%, 6% and 30% was for internal resources, agriculture, industry and domestic respectively. The Ministry of Water and Irrigation (2009) indicate that 60% and 40% of urban and rural population have access to improved water source - access to improved water source includes piped water, public tap, borehole, protected well or spring and rainwater harvesting/collection.

The estimated surface water potential (lakes, rivers, wetlands) in Kenya is 19,590 million cubic metres which represent about 18% of the national annual rainfall. The estimated annual groundwater potential is 619 million cubic metres. 31% of which is deep seated aquifers, exploitable through boreholes and 69% is located in shallow aquifers exploitable through shallow wells (GoK, 1999).

As a follow up to the International Drinking Water Supply and Sanitation (WSS) decade from 1981 to 1990, the Kenya government in 1981 set the target for the provision of clean water for all to be 1990. However, this target was later extended to the year 2000 and later postponed to the year 2010 (Hukka et al, 1992; GoK, 1999). Since the enactment of Water Act, 2002, there has been considerable improvement in facilitating access to water. Spending by the MWI increased from KShs. 6.9 billion in 2004/05 fiscal year to KShs. 18.6

billion in 2008/09. With the increased spending, the development budget increased from KShs. 140 per capita to KShs. 391 (GoK, 2009).

Despite these positive developments, a lot remains to be done. Millions of Kenyans are currently underserved and too many citizens continue to drink unsafe water, or are forced to use minimal quantities of water as distance, waiting times, and cost make water inaccessible. Inequities in access to water are glaring and the struggle for water by the excluded sections of Kenya's population contrasts sharply with the privileged, who benefit from water delivered to their homes, often at very low prices.

Unfortunately, duplication of efforts, competition, conflicts and misallocation of resources has been noticed due to inadequacies in the monitoring process put in place by the government. This is evidenced by the fact that in 1999, there were a total of about 600 water supply projects operated by the Ministry of Water Resources, 200 by the National Water Conservation and Pipeline Cooperation (NWCPC), 400 by the communities, 300 by self-help groups, 200 by local authorities and 300 by non-governmental organisations (GoK, 1999). Despite all these initiatives, most Kenyans still depend on unreliable water sources for their domestic water supplies. Table 2 shows the national percentage household by main source of water from the latest two censuses i.e. 1999 and 2009.

Table 2: National Households Main Source of Water (%)

Source of water	1999	2009
Piped	31	30
Springs / streams	27	21.6
Dams / lakes / Rain / harvest / Boreholes/ Others	42	48
Population (million)	28.7	38.6

Source: GoK, 1999, GoK, 2009

From table 2, despite the 9.9 million increase in population, there was a drop of 1% and 5.4% in the number of households with piped water and those that source their water from springs and streams respectively. There was a marginal increase of 6% of households who source their water from reservoirs, lakes, boreholes, rain and other sources.

2.9 Kenyan Legal and Institutional Framework on Water Management

Since independence, Kenya has had two legal frameworks on water management in the country i.e. the Water Act Cap 372 that was replaced by the current Water Act, 2002. The current Act is discussed as follows:

2.9.1 The Water Act, 2002

The Water Act, 2002 became operational in March 2003 and created a number of institutional reforms which were intended to improve the management of water resources in the country and in the process, domestic water supply. The institutions created include: the Water Resources Management Authority (WRMA), Water Services Regulatory Board (WSRB), the Water Trust Fund (WTF), the Water Services Boards (WSB) and the Water Appeals Board (WAB). Their roles and mandates are highlighted in Figure 3.

WRMA is expected to spearhead the restoration of the degraded water catchments and depleted groundwater aquifers. The WSRB is expected to licence, regulate and supervise service boards, thus ensuring access and expansion of water supply service and affordability (GoK, 2003).

The WTF is mandated with the financing instrument for expanding water supply services especially to the poor. The WSB are expected to hold the licence and legal responsibility for water provision in their areas of jurisdiction. The licence will be acquired from WSRB on submission of satisfactory business and strategic plans. By law, the water services boards will not by themselves be permitted to provide directly to the consumers but through competitively contracted providers. These providers can be private companies, NGOs, consumer organisations or autonomous companies owned by local authorities but exclusively engaged in water services.

The WAB is mandated to act as an arbitrator of disputes that may arise from time to time between the regulator, the water services boards, services providers and service consumers. The Ministry's role is water policy formulation and direction (GoK, 2003).

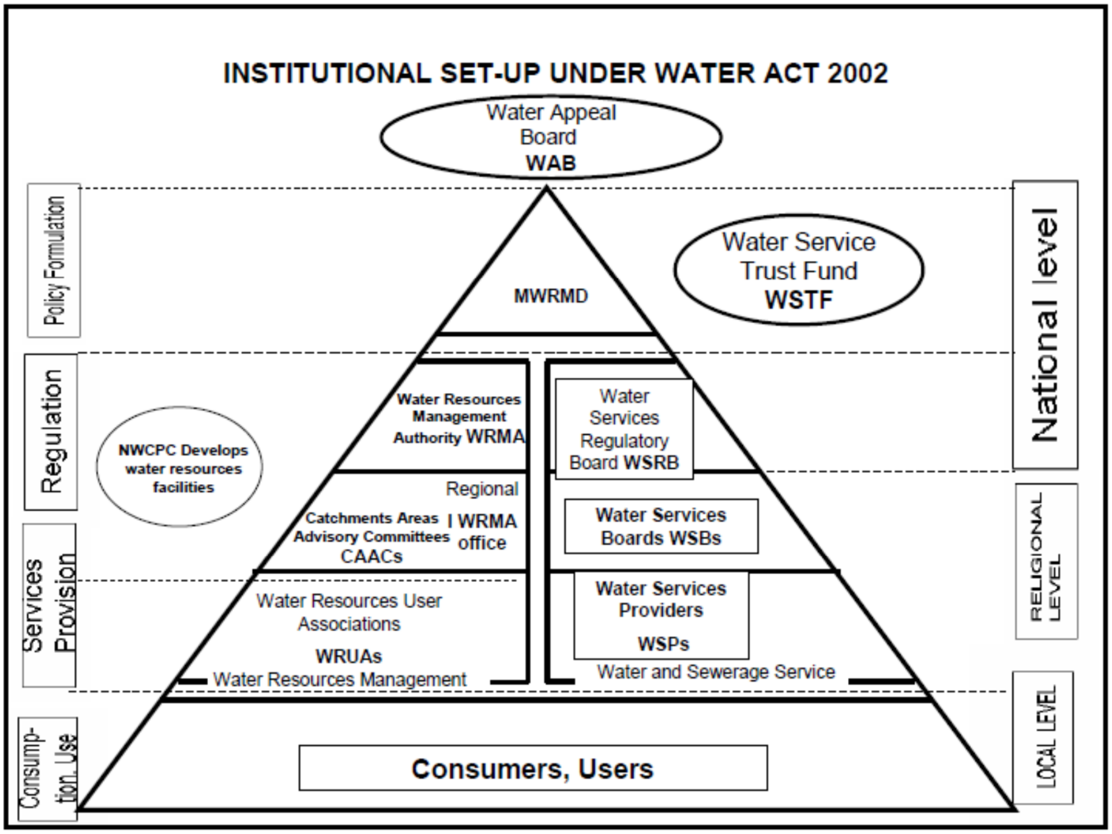


Figure 3: Institutional set-up under the Water Act, 2002.

Source: GoK, 2003

2.10 Theoretical Framework

This study utilised two theories: systems theory of planning and water as a basic human need approach to serve as an underlying reference point to understanding the challenges of water supply in Embakasi location and indeed the entire country.

2.10.1 Systems Theory of Planning

As has been noted, the biggest challenge facing most institutions in Kenya is the sectoral approach to issues. In order to address this issue of sectoral approach, the systems theory of planning was incorporated in this study. This theory postulated by Faludi (1973) appreciates the fact that for there to be harmony in any planning process, every institution(s) or sector(s) involved in planning must act in a coordinated and harmonious way. The planning process in itself is a system whose varied components – all the stakeholders and institutions involved, must work in close collaboration with each other in order to achieve their objectives or mandates.

The systems theory advocates for a systematic approach to planning. It is from this hindsight that this study advocates for a closer collaboration amongst the many institutions and stakeholders involved in water supply, not only in Embakasi location but also the entire republic. For the purposes of this study, the institutions concerned include: the NWSC, WRMA, small scale water suppliers, MWI, Ministry of Local Government, Ministry of Public Health, Ministry of Planning and National Development, international partners and the common citizenry.

To meet the desired outcomes as proposed by Faludi (1973), the various stakeholders engaged in planning and management of water resources in Kenya need to be engaged from the onset and collaborate in a harmonised and integrated framework. It is well documented that lack of capacity at the national or regional level to provide effective water governance; mismanagement of watershed, waterways; fragmentation of responsibilities and ineffective enforcement of water regulations and allocation rights – all these situations create uncertainty for long term planning (UNEP-FI/SIWI, 2005; Morris et al, 2003). Working in harmony and as an integral unit ensures successful planning and management of water resources which will go a long way to improve access to water especially for domestic use in a rapidly changing environment.

One shortcoming of this theory is the inter-relationships among the various parts of the system which have to be recognised and understood by all players. The theory demands a shared vision by all stakeholders in the water supply sector to have an idea of what they are trying to accomplish as a team. It also requires a cohesive effort from all participants which is a big challenge bearing in mind the many players involved in public water supply in the country.

2.10.2 Water: Basic Need Approach

Water is one of the prime elements responsible for life on earth - two thirds of the earth's surface is covered by water and 75% of the human body is made up of it. Water circulates through the land in a similar fashion as it does through the human body, transporting, dissolving, replenishing nutrients and organic matter, while carrying away waste material. Further in the body, it regulates the activities of fluids, tissues, cells, lymph, blood and glandular secretions. The very importance of water is captured in the following extracts from the international consensus and action agenda on water:

- That water is an economic as well as a social good that should be treated as a valuable and finite resource, and be equitably and sustainably allocated (Dublin Principles & Bonn Recommendations for Action);

- That access to water supply and sanitation should increase by 2015, such that the proportion of the world's population lacking access to safe water supply and basic sanitation be halved (Millennium Declaration / MDG 7);
- That all stakeholders to water sources should recognise their responsibility for the common good, and that management or ownership of water assets carries the obligation to conduct business in a socially, environmentally, and ethically acceptable manner (Bonn Recommendations for Action);
- That the international community should forge a global partnership for development, which can act as a catalyst for reform and capacity development to mobilise knowledge and financial and other resources to reduce poverty and create more sustainable forms of water resources management (MDG #8 / Bonn Recommendation for Action).

It is from this fact that access to water is so important that the UNICEF and WHO have recommended a minimum daily amount of water per person at 38 litres and 27 litres respectively (Lowry et al., 1981). Figure 4 illustrates the theoretical framework for this study.

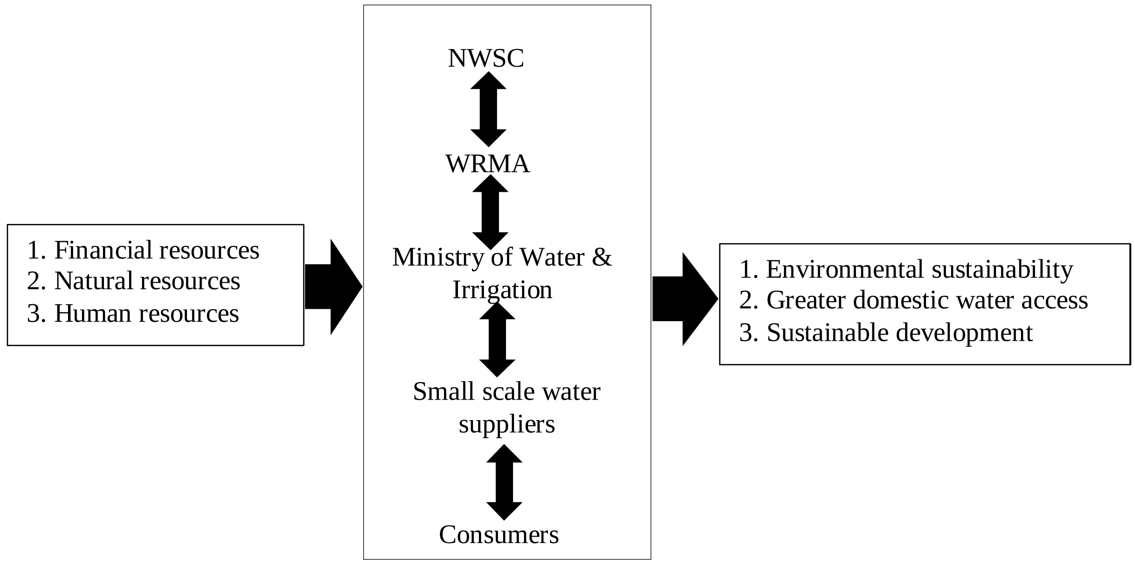


Figure 4: Theoretical framework

Source: Author, 2013

2.11 Conceptual Framework

As highlighted in the theoretical framework illustration, adequate financial, human and natural resources are the main inputs for an organisation or institution to carry out its mandate (see theoretical framework in previous page). These inputs are ingredients for institutional arrangement, leadership, knowledge and accountability to be actualised.

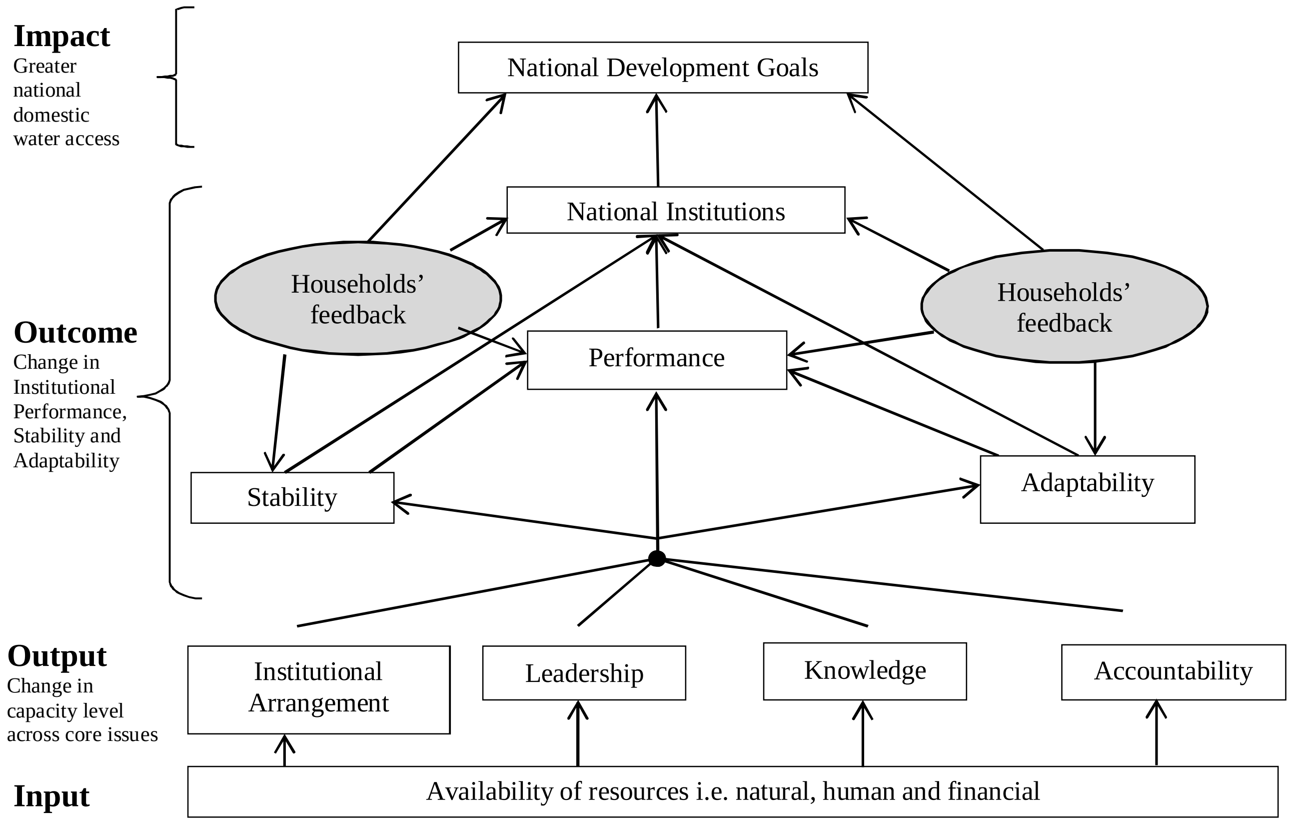
Institutional capacity assessment frequently reveals that organisations work inefficiently because the policies, procedures and processes to guide their work are not well designed. The way the institutions are organised within the public sector architecture, their respective roles and coordination arrangements, how they manage human, natural and financial resources are all key determinants of organisational effectiveness and ultimately of developmental effectiveness – proper environmental planning and management, service delivery, response mechanism etc. Some of the most common challenges plaguing institutions in Kenya include lack of coordination amongst ministries, the absence of common monitoring and evaluation framework across government, lack of clarity and demarcation of mandate and lack of consolidated human resource management framework and guidelines (UNDP, 2010).

Leadership is a catalyst for achieving, improving and sustaining sound development objectives. Mirroring the systems theory, leadership is the ability to influence people and systems to achieve and go beyond the set goals. Good leadership requires visioning, systems thinking, priority setting, communication and advocacy and strategic planning.

Knowledge is the foundation of capacity which can be developed through education, training and learning or experience sharing. Great investments should be made in tertiary education and technical training. Access to environmental data and knowledge is fundamental to capacity development and should be incorporated with sufficient resources, into national development strategies and organisational plans.

Accountability and open feedback mechanism can lead to better performance and effectiveness. Households, who are the ultimate clients of water institutions in Kenya can provide feedback on the water supply system. Their feedback helps individual institutions and systems to monitor, guide and adjust their service delivery and to learn and self-regulate. Accountability and feedback mechanisms often fail to have an impact because of corruption, manipulation and lack of capacity to use them effectively. In other circumstances, public institutions are captured by those with power and resources. Accountability between state-run institutions and communities promotes mutual engagement for development and should be accorded priority. Sustained participation of civil society in national policy and budget dialogue is critical for national development and poverty reduction strategies.

These (institutional arrangement, leadership, knowledge and accountability) feed into the national institutions that increase their performance, stability and adaptability. The overall impact of these is a change in people's well-being i.e. greater national domestic water access levels. Figure 5 provides the conceptual framework adopted for this study.



Source: Adapted from: UNDP, 2010

Figure 5: Conceptual framework

CHAPTER 3

RESEARCH METHODOLOGY

3.1 Introduction

This chapter will focus on the methods and procedures that were used in this study. It is organised under the following subheadings; the research design, the study population, the sample size and sampling procedure, data collection instrumentation, validity and reliability of research instruments, data collection procedures, data analysis and presentation and ethical considerations.

3.2 Research Design

This study was conducted through a survey. The study was mainly to investigate the environmental implications of small scale water suppliers in Embakasi location. The survey research design generally entails investigating populations by selecting samples to analyse and discover occurrences. For the purposes of this study, mixed methods procedures were used. Mixed methods research employs the combination of qualitative and quantitative approaches. The study employed this method because it best utilises the strength of both qualitative and quantitative research. Moreover, problems addressed by the social and health sciences researchers are complex and the use of either qualitative or quantitative approaches by themselves is inadequate to address these complexities. In addition, there was more insight to be gained from the combination of qualitative and quantitative research than either form by itself. Their combined use provides a wide understanding of research problem (Creswell, 2009).

The qualitative enquiry procedure was applied. According Creswell (2009) qualitative research is a means for exploring and understanding the meaning individuals or groups ascribe to social or human problems. One of the key characteristics of qualitative research is the commitment to view events, actions, norms and values through the eye of the people being studied (Orodho, 2009). This kind of design allowed data to be collected within the setting of the respondents and data analysis inductively building from particular to general themes with the researcher interpreting the meanings of the data.

The environmental problems occasioned by small scale water suppliers were accomplished through observation. Descriptive statistics was adopted for this study.

3.3 Target Population

The target population for this study consisted of households in Embakasi location, all small scale water suppliers licenced by the WRMA to supply domestic water, the NWSC and key informants in the national water supply i.e. MWI, NWSC, WRMA and private water suppliers.

3.4 Sampling Technique

To investigate the households concerns on water supplied by NWSC and the small scale water suppliers, a total of 300 households were identified and interviewed with each contributing 150 households. The section below presents how these 300 households were selected.

There are a total of 15 estates in Embakasi location i.e. New Donholm, Old Donholm, Savannah, Sunrise, Greenfields, Fedha, Tassia, Embakasi, Avenue Park, Tumaini, Tena, Pipeline, Honeysuckle, Imara Daima and Quarry. The estates were clustered according to their sizes (area coverage) and number of houses where the housing units was uniform such as Old Donholm, Savannah, Greenfields, Fedha, Avenue Park, Tumaini, Honeysuckle and Imara Daima. This resulted to 10 different clusters. Quarry estate was avoided because of security concerns. From these 10 clusters; 15 households were randomly selected and a questionnaire administered to the household head. The 150 household heads interviewed were all served by NWSC. This is illustrated in table 3.

Table 3: Cluster Sampling of Estates in Embakasi

New Donholm	Greenfields	Avenue Park	Tumaini
Old Donholm	Tena	Pipeline	Fedha
Sunrise	Honeysuckle	Tassia	
Savannah	Imara Daima	Embakasi	N = 14 estates

A total of 20 small scale water suppliers were physically identified in the various estates. Contact details provided by WRMA were sketchy and did not have a telephone contact through which the researcher could make an appointment and get directions to the small scale water supplier. Methods of identifying the small scale water suppliers were thus formulated within the course of carrying out the research with the help of a key informant from NWSC. Majority of the small scale water suppliers had installed big overhead reservoir tanks and their identification was easy. *Mkokoteni* water vendors also helped to identify those that had installed underground reservoir tanks. There were a total of 20 small scale water suppliers in Embakasi location. Of the identified small scale water suppliers, 15 were interviewed while access to the rest was denied with owners/tenants raising security concerns. A sample of 10 households served by these small scale water suppliers was randomly selected and a questionnaire administered. The geographical locations of these small scale water suppliers were taken using a geographic positioning system (GPS).

The key informants were identified through purposive sampling.

3.5 Data Collection

3.5.1 Instrumentation

The study used observation, interview schedules (Appendix 1), questionnaires (Appendix 2 and 3), GPS and photography as the main tools for collecting primary data. The selection of these tools was guided by the nature of data to be collected, the time available and the objectives of the study. The questionnaires and interview schedules were self-made and in cases where the respondent did not understand the question, the researcher explained. A pilot study was conducted to verify the questions to be asked, sample size and observations to be made. A pilot study provided an opportunity for improving the research instruments. Secondary data was got from Government of Kenya reports, NWSC website and annual reports, World Bank databases, UNICEF and WHO websites, journals, publications and newspaper articles.

3.5.2 Research Procedure

As mentioned, the study adopted a mixed methods procedure where combination of qualitative and quantitative approaches. The data was collected through interview schedules (Appendix 1), questionnaires (Appendix 2 and 3), observations and photography. Amongst the issues captured in Appendix 1 included the number of years the small scale water supplier has been in the business, staffs employed, number of households supplied and the challenges they face. Insights on NWSC were captured in Appendix 2. Issues captured included the number of households they supply with water, number of household connections per month and year. Key issues captured in the household survey (Appendix 3) included: employer of the household head, education level, income range, size of the household, approximate quantity of water used per day and their perception towards water supply matters. All the data collection process was carried out by the researcher between September and December 2010 in Embakasi Location. The number, distribution, factors determining location and challenges faced by small scale water suppliers and observed environmental aspects of groundwater observations was collected from 15 small scale water suppliers (the researcher was able to identify 20 but 5 of them declined to be interviewed). A further 300 questionnaires were administered to households served by the NWSC and small scale water suppliers.

3.6 Validity and Reliability of Research Instruments

Validity of research instruments is demonstrated when the instrument is seen to be asking the right questions framed in least ambiguous way. It therefore answers the question “are the findings true” (Kathuri and Pals, 1993). To test the validity and reliability of the research instruments used in this study, the instruments were circulated to selected researchers at Moi University who commented and advised accordingly as regards the quality of the instrument. A pilot study was also conducted before the actual data collection which served to test the validity of the research instruments.

The questionnaires and interview schedules were pre-tested using an identical sample of households who were not featured in the main study. They were pre-tested using ten (10) households, 5 from the NWSC and 5 from SSWC. This enabled the researcher to establish the validity and reliability of the research instrument by ensuring that the instrument were clear to the subjects and that they tested what they are meant to test.

3.7 Data Analysis and Presentation

The data obtained was both quantitative and qualitative; where quantitative was guided by numerals while the qualitative was statements mostly from the key informants. The study findings were collated and analysed using Microsoft Excel and results drawn. Total daily household water consumption was fed into the SPSS software and the daily per capita household consumption rate determined. The variance and standard deviation of per capita household water consumption was also determined through the software. In addition to this, the cost of water per 1000 litres was fed into the software and graphs generated. Findings were presented using bar charts, line graphs, tables and photographs.

3.8 Social and Ethical Considerations

Carrying out a social research where people are involved in the study population may trigger suspicion and subsequently withdrawal of responses. To prove authenticity, ethical considerations were taken into account. To this end, identification material was sort from the relevant authorities. The purpose and significance of the study was explained to every respondent from whom information was sort. All the respondents were assured that the information availed was to be used for the purpose of the study. All published and unpublished literature made reference to was duly cited in the bibliography section. All the support obtained either morally or in kind was acknowledged.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Introduction

This chapter provides the findings of the study. It is divided into two major sections: results (section 4.2) and discussion (section 4.3). Subsection 4.2.1 begins with the findings from household concerns regarding water supply; it is followed by environmental problems occasioned by small scale water suppliers in section 4.2.2. This is followed by identified small scale water suppliers and their distribution (section 4.2.3); assessment of the activities and operations of the small scale water suppliers (section 4.2.4); assessment factors determining location of small scale water suppliers in a particular location (section 4.2.5); identification of the challenges faced by these operators (section 4.2.6). The data provided in this section is all field data unless stated.

4.2 Results

4.2.1Objective 1: Households Concerns Regarding Water Supply in Embakasi Location

4.2.1.1 Households socio-economic status

Most of the households are headed by men – 78%, with women heading 22%. Majority of the household heads are employed in the private sector (43%). This was followed by civil servants, non-governmental organisations and self-employed at 25%, 22% and 10% respectively. In terms of educational level, 52% are post-secondary while 48% are university level. The mean household size was 3.95 (4).

The household income ranged from KShs. 25,000 to above 80,000. Of the surveyed sample, 15% earned from KShs. 20,000 - 40,000; 11% from KShs. 40,000 - 65,000; 57% from KShs. 65,000 - 80,000 and 17% earned KShs. 80,000 and above. The total number of households interviewed in this study was 300 (Table 4).

Table 4: Number of Households Interviewed

Range of household size	Median	Frequency number of households	(%)	Number of people in respective household range
1 – 3	2	117	39	234
4 – 6	5	162	54	810
7 – 9	8	21	7	168
Total		300	100	1,212

4.2.1.2 Quantity of water consumed

The quantity of water consumed per day was based on metre reading data and/or approximate number of 20 litre containers used in a day where metre reading data was missing.

With regard to the preferred water supplier, 55% expressed preference to private supply while 41% would rather be supplied by the NWSC (Figure 6). Majority (80%) of the respondents did not care much about the quality of the water supplied as long as their taps do not go dry. For those who expressed preference to NWSC, their main concern was the quality of water. It is also important to note that all of the privately supplied respondents were at one time supplied by NWSC. Of the 41% who showed preference to NWSC, some had two metres (one for NWSC and the other from a private water supplier) with most of the time water supplied by the private supplier used when NWSC taps go dry.

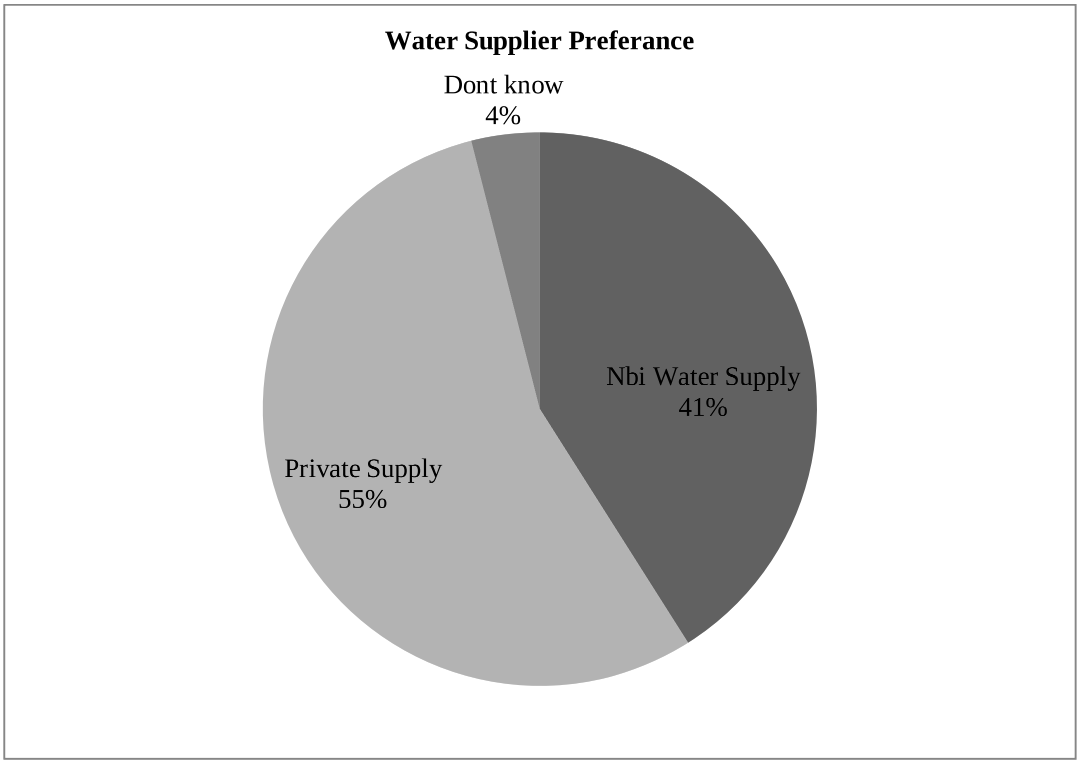


Figure 6: Water supplier preference in Embakasi location

4.2.1.3 Households served by NWSC

Most of the households (86%) served by NWSC do not harvest rainwater to supplement their water needs. The main reason given for this is that they do not have the right to modify the house without prior permission from the landlord. In addition, they were not willing to incur any additional cost (purchasing gutters, tanks and the associated accessories) and yet there was an overwhelming uncertainty that they will be staying in the same house the following day. The 14% who harvest rainwater are the bona fide owners of their homes and therefore had the incentive of boosting their water supply options.

As earlier mentioned, NWSC water supply is preferred to private supply due to its quality. Majority (80%) of the households do not perceive any problem with the quality of the water supplied with 20% raising quality concerns. Most of the households (76%) interviewed have a water metre while 24% indicated that they lacked one. Less than half (44%) of the respondents were sure the metre was read every month with the rest not knowing if the metre was read at all. More than half (52%) mentioned that the water bill came within a specific week of the month, 44% mentioned that the bill varied while 4% had never seen a water bill.

In the case where the bills are not paid for in good time, 18% of the respondents mentioned that the water supply was disconnected on the 3rd week, 24% on the 4th week and 58% had never been disconnected. This was because they had never been late in paying for their water bills; some did not own water metres while others had not been paying for their water services for some time (5 months).

4.2.1.4 Households served by small scale water suppliers

Unlike the households served by NWSC, 74% of households served by private water supplier harvest rain water. The high percentage can be attributed to the advice given while entering into agreement with the water supplier. At the time of getting connected to the small scale water supplier, they are encouraged to adopt rain water harvesting. Only 26% of the households interviewed do not harvest rain water reason being they live in an apartment that gets supplied with borehole water and/or they are still constructing their homes and the stage for installing the gutters has not reached.

While 74% of the households served by NWSC experience a problem with water supply, 90% of the households served by private water supplier do not perceive any problem with access to water. In regard to the quality of the water supplied, 72% of the households have a problem with the quality of the water supplied. They are fine with the water supplied for domestic purposes only that they have to buy bottled mineral water for drinking purposes. As mentioned earlier, the groundwater in Embakasi location has a high proportion of fluoride concentration and thus unpleasant for drinking and excessive exposure can lead to skeletal and/or teeth fluorosis.

Nearly all (96%) of the households interviewed have a water metre while a very small proportion (4%) reported to have none. When it comes to the metre reading, 84% of the households reported that the reading took place on monthly basis while 16% did not have an idea whether the metre reading was taken at all. The main concern of the households was that metre reading would be taken the first month after installation and in the subsequent months, water consumption would be estimated on the basis of the first reading.

After taking the metre reading, 28% of the households reported that the bill would come on a specific day of the month, 46% on a specific week of the month; 18% mentioned it varied while 8% reported that the bill did not come at all. As a consequence of this, 74% of the households interviewed have never had their water supply disconnected while 16% and

10% had their water disconnected in the 1^{st} and 2^{nd} week respectively. Table 5 summarises the findings on households connected to both the NWSC and the private water supply.

Table 5: Summary of Concerns on Water Supply (%)

	Harvest rain water		Access problem		Quality problem		Metre		Metre reading		Receiving water bill				Disconnections		
	Y	N	Y	N	Y	N	Y	N	Monthly	Don't know	Specific day of month	Specific week of month	Varies	Don't come at all	1st Wk	2nd Wk	Never
NWSC supply	14	86	74	26	20	80	76	24	44	56	52	44	0	4	18	24	58
Private supply	74	26	10	90	72	28	96	4	84	16	28	46	18	8	16	10	74

Key:

Y – Yes

N - No

4.2.2 Objective 2: To Identify Environmental Problems Occasioned by Small Scale Water Suppliers

By law (Water Act, 2002), the borehole drilling agent is supposed to keep a borehole log. Unfortunately, there was no evidence of borehole logging data. The borehole logging data is used by WRMA in its evaluation of the borehole. In addition to this, WRMA is mandated to perform regular inspections on the wells/boreholes in the country. Unfortunately, all the 15 interviewed small scale water suppliers indicated that they had never seen an official from WRMA since they started operating their water supply businesses. This creates a loophole for unscrupulous businesspersons to supply contaminated water to unsuspecting consumers or over abstract risking the location's groundwater resource.

According to the Water Act, 2002, a minimum distance of 800 metres should be maintained between any two adjacent boreholes. This regulation is not followed in Embakasi location as some of the boreholes were found to be as close as 200 metres and one of the owners complained of declining water levels.

There is an on-going alteration of the land use (Plate 1) as Embakasi location continues to urbanise with most open surface being developed and streets being paved. With the high shortage of urban housing in Kenya, Embakasi location has seen its natural landscape transformed into a concrete jungle. Open spaces that used to exist in Donholm, *Imara Daima* and *Fedha* estates now have housing apartments on them. This has the potential to lead to reduced infiltration and thereby causing a reduction of groundwater recharge. When the land is paved in urban areas, there is a likelihood of reduction of groundwater recharge.

Plate 1: Rapid urbanisation of Embakasi location has seen natural environment replaced by housing complexes (Source: Author, 2013)

Due to the low NWSC sewerage coverage in Embakasi estate, households are forced to use septic tanks. As more people buy plots (usually quarter acre plots) and settle in the area, there is a risk of polluting groundwater resources through seepage thus creating a serious environmental health problem. In addition to this, the aging NWSC sewer lines pose serious risk on groundwater resources through leakage. The most susceptible areas in Embakasi location are: Donholm, Greenfields, Savannah, Tassia, *Fedha* and *Imara Daima* estates. Table 6 summarises the environmental observation made at the boreholes identified in Embakasi location.

Table 6: Environmental Concerns Observed around the Identified Boreholes

Name of Supplier	Yield (M^3/Day)	Depth (m)	Households supplied	Environmental observations
Jam Bush	18	152	250	- The water has high fluoride concentration (Njoroge, 2009). - The borehole is protected by a100m radius of open space surrounding it. - The borehole is approximately less than 200m from a neighbouring borehole.
Joyce	20	116	1	- The water contains high fluoride concentration. - The borehole stands on undeveloped 5 acre piece of land thus ensuring no contamination.
Mwea Investments	20	200	20	- The water has high fluoride concentration (Njoroge, 2009). - The borehole is located in a developed area where households use septic tanks as a means of disposing solid waste. This makes it susceptible to contamination. - There was no clearly defined dumping site for household waste thus it was spread all over.
SAFCOR Investments	50	190	37	- The borehole water was of very good quality (no high Fluoride concentration). - The borehole is located in a high population density area. - The environment around the borehole was clean with no garbage or open/burst sewers within the vicinity.
Exotic Springs	13.8	182	180	- The water has high fluoride concentration (Njoroge, 2009). - The environment around the borehole was kept clean and heavily grassed. - All domestic waste was deposited at designated points around the estate.
Pipeline Water Services	20	200	20	- The borehole water was of very good quality (no high Fluoride concentration). - The borehole is located in a high population density area. - There was unlined drainage 20m from the borehole. - Approximately 30m away, there was a burst sewer which was emptying into the open drainage. This exposes the borehole to high risk of contamination. - There was no clearly defined dumping site for household waste thus it was spread all over.
Mt. Sinai CMI	18	200	40	- The water has high fluoride concentration (Njoroge, 2009). - The borehole protected by a 50m radius of trees and located away from settlements. - The operator of the borehole reported that the yield significantly fell when a second borehole was drilled less than 200m away.
Sky Investments	50	204	90	- The water has high fluoride concentration (Njoroge, 2009). - There was intensive irrigation around the borehole site. This makes it susceptible to

Name of Supplier	Yield (M^3/Day)	Depth (m)	Households supplied	Environmental observations
				nitrates and chemical contamination.
Betty Multipurpose	50	137	210	- The borehole water has high fluoride concentration (Njoroge, 2009). - The borehole is located in a developed area where households use septic tanks as a means of disposing solid waste. This makes it susceptible to contamination. - The operator has a strict regime of ensuring domestic wastes is properly handled.
Magkinyua Water	30	105	30	- The water has high fluoride concentration (Njoroge, 2009). - The borehole is sandwiched between two-5 acre undeveloped plots.
Mwuma Solutions	22.5	140	200	- The water has high fluoride concentration (Njoroge, 2009). - The borehole is located in a developed area where households use septic tanks as a means of disposing solid waste. This makes it susceptible to contamination. - There was no clearly defined dumping site for household waste thus it was spread all over.
Taj Village	30	125	50	- The water contains high fluoride concentration (Njoroge, 2009). - Borehole protected (100m radius of open space surrounding it)
Realtors Properties	20	210	24	- The borehole water was of very good quality (no high Fluoride concentration). - The borehole is located in a high population density area. - The site of the borehole was susceptible to contamination through burst sewers especially during the rainy season. - The operator had maintained high level of cleanliness around the borehole site.
Honey Suckle	20	205	54	- The borehole water was of very good quality (no high Fluoride concentration). - The borehole is located in a high population density area. - Garbage could be found all over the area around the borehole.
Tamarind Valley Estate	30	215	50	- The water has high fluoride concentration (Njoroge, 2009). - The environment around the borehole was kept clean and heavily grassed. - All domestic waste was deposited at designated points around the estate.

4.2.3 Objective 3: Identified Small Scale Water Suppliers and their Distribution

As indicated earlier, a small scale water supplier(s) or provider(s) is a private company that is fully compliant with Water Act, 2002 cap 57, which stipulates that *"the water service provider may not supply more than twenty households or supply more than twenty five thousand litres of water a day for domestic purposes; or more than one hundred thousand litres of water a day for any purpose"*.

WRMA is charged with maintaining a database of all the boreholes in the country which are then forwarded to the MWI for mapping. Unfortunately, WRMA did not keep the telephone contacts of the owners and therefore the researcher relied on an official of the NWSC who helped with the identification of small scale water suppliers in the location. An additional feature of a small scale water supplier which helped with identification was the overhead tank (see Plate 5 and 6). The study focused on boreholes licenced to supply domestic water and ignored boreholes licenced for agricultural and/or industrial purposes. The geographical locations of the identified boreholes were taken using a GPS. A total of 20 (Figure 8) boreholes (indicated by the red spots) were identified in Embakasi location. The numbers next to the spots indicate the borehole number as assigned by WRMA. The study observed a large data gap especially between years 2005 to 2007 in the WRMA records. This can be attributed to the transitional period when the MWI and WRMA were streamlining their functions.

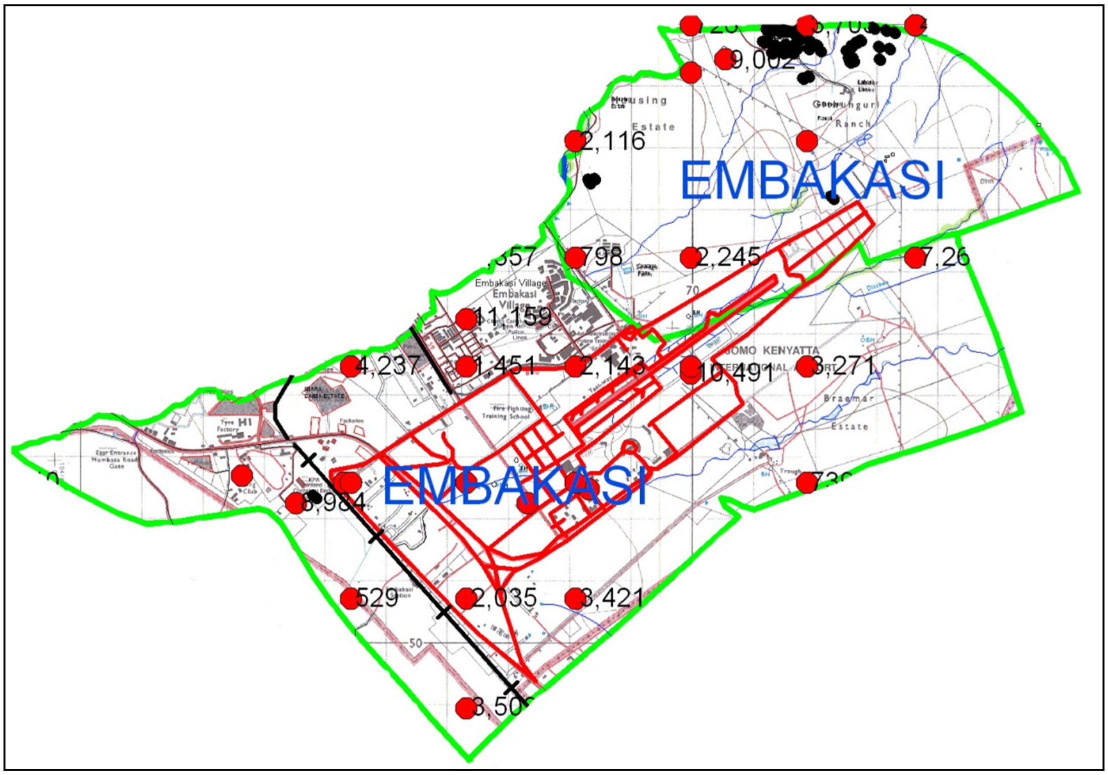


Figure 7: Identified boreholes used by small scale water suppliers in Embakasi Location

(Source: Author, 2013)

According to requests launched for borehole licence at the WRMA, there have been a total of 118 applications for domestic water boreholes between 2007 and 2010 in Embakasi location alone. The status of their development could not be verified due to budgetary constraints in the WRMA. Table 7 shows the breakdown of the borehole applications.

Table 7: Domestic Water Supply Borehole Applications in Embakasi Location

Month	Year	Applications
September – December	2007	5
January – December	2008	43
January – December	2009	60
January – September	2010	10
Total		**118**

The high number of borehole applications in 2008 and 2009 is attributed to the drought that affected the entire country. Of the possible 118 boreholes in Embakasi location, the study was able to identify 20. The study interviewed the operators of the 15 boreholes while access to the rest was denied. The 15 boreholes identified are used as source of domestic water for the small scale water suppliers (Table 8). In total, they offer employment to 58 people and supply 1,256 households with domestic water.

Table 8: Distribution of Boreholes Identified in Embakasi Location

Name of Estate	Boreholes Identified
Donholm & Savannah	2
Greenfields	1
Fedha	2
Tassia	1
Embakasi	5
Avenue Park & *Tumaini*	0
Tena	1
Pipeline	1
Honeysuckle	1
Imara Daima	1

The occurrence of water vendors using *mkokotenis* (handcarts) (Plate 2) was a sign that the estate had water supply challenges. Interrogation of these vendors led to the source of their water which most of the time was from a private borehole licenced to provide domestic water.

Plate 2: Occurrence of water vendors in an estate such as this in Greenfields indicates a water supply challenge (Source: Author, 2013).

NWSC water supply shortcomings have prompted many real estate developers to incorporate private water supply sources in their units to attract tenants or home buyers as shown in plate 3.

Plate 3: A real estate developer promising potential tenants reliable water supply through borehole water in Tassia Estate (Source: Author, 2013)

4.2.4 Objective 4: Activities and Operations of the Small Scale Water Suppliers

All the identified small scale water suppliers are engaged in domestic water supply only. They have invested and installed a distribution network from their premises (site of the borehole) to the customers' homes. Some of these suppliers have put the customer's metre at their premises while others have set it up at the customer's homes. In case of a supply challenge resulting from burst pipe or clogged system, the location of the metre determines who is responsible for the repairs. It was noted that most of the suppliers located in high density estates such as Donholm estates had their customer's metres installed at the borehole site, which meant that the client had to address supply challenges (as soon as possible) brought about by burst pipe.

The small scale water suppliers also offer ‘water kiosk’ services. *Mkokoteni* water vendors buy their water from them to resale it in estates that have supply shortage but mostly they sell it to informal settlements in the location i.e. *Matopeni* village and Kayole Soweto. Institutional water boozers also get their water from the small scale water suppliers. This water is used in slaughterhouses, hotels, schools, ranches or sold to individuals with voluminous storage capacities.

The small scale water suppliers have a workforce which does the metre reading on monthly basis and thereafter produce water bills with most of them sending out the bills on a specific week of the month. In case of non-payment of the water bill, 16%, 10% and 74% disconnect the supply in first week, second and never have had their supply disconnected respectively. To keep the operation and maintenance costs low, the small scale water suppliers hire casual labourers who do the laying of pipes to customers and do the repairs, if any. On average, each water supplier has a workforce of four people hired on permanent basis.

The small scale water suppliers, as a group, have not organised themselves in terms of area of operation. Some of their supply networks crisscross each other posing a big risk of sabotage from a competitor as was noted under objective six (challenges faced by small scale water suppliers). The supply network was only 10-15cm deep making it susceptible to damage as vehicles would burst the pipes. In addition to this, some households would liaise with unscrupulous workers to be illegally connected at night.

Of the interviewed water suppliers, only one (7%) treated his water by chlorination before it was distributed. The rest (93%) supplied the water without any form of treatment. None of the small scale water suppliers was involved in sanitation services. As has been mentioned in the household surveys, the small scale water suppliers have been encouraging their customers to adopt rainwater harvesting technologies to boost their water supply and to install large capacity reservoirs in their homes.

4.2.5 Objective 5: Factors determining location of Small Scale Water Supplier

The study found out that the quality of the water, presence of competition from other operators and NWSC, distance to customers and the security of the business as some of the factors determining the presence of a small scale water supplier in an area. These are discussed in more detail below.

4.2.5.1 Quality of water

This was reported by all 15 small scale water suppliers. Surface water sources in the entire Nairobi County are heavily polluted. This is attributed to the major human activities: upstream agricultural practices, rapid urbanisation in and around Nairobi where the rivers pass and industry effluents being discharged into the rivers without pre-treatment (Plate 3 and 4). This pollution has increased rapidly in recent times.

Plate 4: An accidental burst sewer in Tassia estate where wastewater finds its way into Ngong River (Source: Author, 2013).

Plate 5: Brackish Ngong River at the Embakasi bridge which marks the end of the Industrial Area (Source: Author, 2013).

Water supply by the NWSC has not kept to speed with the growth of Nairobi City due to shortage of potable water amongst other challenges. With most of surface water heavily polluted with heavy metals from industry effluents, raw sewer contamination and household wastes, all small scale water suppliers interviewed source their water from boreholes.

According to WRMA laboratory tests, generally, Embakasi location has a high fluoride concentration with some parts of Embakasi estate recording as much as 9mg/L (Ngaruiya, pers.comm). Despite this, Embakasi estate had the highest number of boreholes identified compared with other estates. This is attributed to low water supply coverage by the NWSC. Borehole water in the other estates is of good quality for domestic purposes.

4.2.5.2 Distance to customers

This was reported by 13 small scale water suppliers. The widely dispersed the customers, the greater the cost of laying the pipes as this will translate to more casuals labourers being hired. Therefore, most of the small scale water suppliers have set up their businesses close to their customers. This is particularly the case in all the estates surveyed except Embakasi. Water suppliers in these estates on average supply water to more than twenty households accommodated in apartments.

In the case of Embakasi estate where development and population concentration per unit area is low and sparse, the water suppliers have no option but to put up their business anywhere and hope that customers will come and settle in and around the neighbourhood.

4.2.5.3. Competition

This was reported by 13 operators. NWSC is the biggest competitor of the small scale water supplies in most of the estates. Fortunately for the small scale water suppliers, the NWSC cannot meet the demand for water in the location and therefore has instituted water rationing regime with most of the estates getting water on two-days-a-week programme. This is particularly the case in Donholm, Savannah, Greenfields, Tassia and *Fedha* estates. When there is a supply shortfall by the NWSC, the small scale water suppliers bridge the deficit.

Private sector participation in small scale water supply in Embakasi estate is very crucial. Owing to the very low coverage by NWSC, the residents rely solely on small scale water suppliers for their water. In this estate, the competition amongst the small scale water suppliers is very stiff. Most of the small scale water suppliers manipulate the initial connection fee which on average is KShs. 25,000 to attract customers. It was mentioned that when the customers are few (where people have not yet constructed their homes and started living in them), they can charge as low as KShs. 20,000. When the customer numbers have increased to the required number, which is dictated by the yield of the borehole, the water suppliers can increase the connection fee to KShs. 35,000 or simply turn them down.

4.2.5.4. Security of the business

This was reported by 10 small scale water suppliers. Another factor determining the siting of a small scale water supplier in a place is the security of the business. All the identified boreholes were to be found far from informal and semi-formal settlements such as *Matopeni* village and Kayole Soweto. Cases of vandalism, non-payment of water and harassment of operators of these boreholes in and around informal settlement had been reported by some of the small scale water suppliers. In addition, majority of the residents in low income areas cannot afford the water.

4.2.6 Objective 6: Challenges Faced by Small Scale Water Suppliers

This subsection summarises the most acute challenges facing the small scale water suppliers. It begins with the most to the least reported challenge. Table 9 provides the challenges facing the small scale water suppliers in Embakasi location.

Table 9: Challenges Faced by Small Scale Water Suppliers

Challenge	Number of times reported
High Fluorine concentration	15
High electricity costs and blackouts	15
Pump breakdown	9
Interference to distribution network	8
Very expensive venture	6
Theft of water / illegal connections	5
Regular leaks	4
Non-payment of bills	3
Competition	3
Too close to one another	2
Sabotage	2
Long licence application process	2

4.2.6.1 High fluoride concentration (water quality)

Fluorides are commonly added to dental products and sometimes to tap water to prevent cavities. The amount of fluoride present naturally in drinking water is highly variable depending on the specific geological environment from which the water is obtained. Unfortunately, according to WRMA laboratory tests, Embakasi estate has a very high fluoride concentration - 9mg/L (Ngaruiya, pers. comm.) while the WHO, NEMA, and Kenya Bureau of Standards recommended level is 1.5mg/L. Excessive exposure to fluorides can lead to skeletal and/or teeth fluorosis and damage to bone structure (IPCS, undated).

4.2.6.2 High electricity costs and frequent power outages

All the interviewed water suppliers complained of very high electricity bills. This was occasioned by the high pumping frequencies. Some reported the pump was always on while others it was automatic. It was particularly serious for suppliers with small capacity reservoirs and a fairly large number of households served by them (Figure 9). The storage capacity ranged from 10,000 to 100,000 litres. Another challenge related to electricity is the frequent power surges that damage the pump whose repair is very expensive. One respondent mentioned that to have the pump diagnosed, one has to be ready to make a down payment of KShs. 50,000 while repairing could cost twice as much.

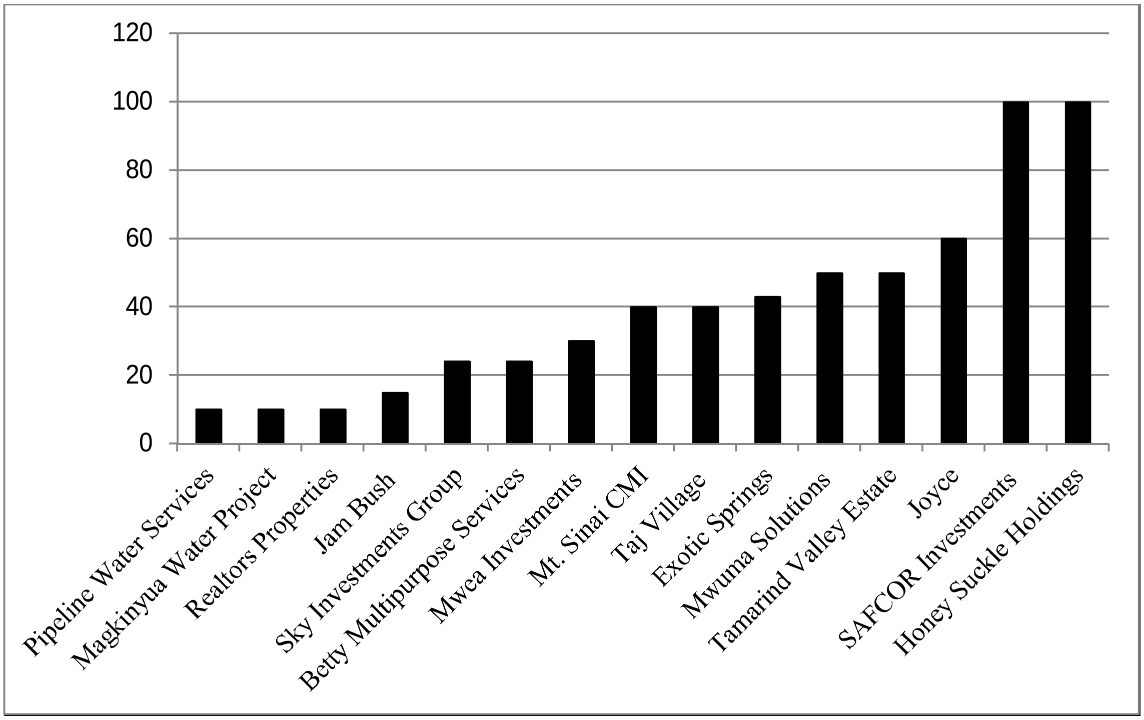


Figure 8: Reservoir capacities ('000 L) of the small scale water suppliers.

4.2.6.3 Disruption of distribution lines

This was a common challenge in Embakasi estate where rapid development of homes and apartments is on-going. The laying of water pipes is shallow and, therefore, heavy construction trucks have been reported to burst water supply pipes leading to disruption of water supply to homes thus increasing the operation and maintenance costs.

4.2.6.4 Theft of water / Illegal connections

Theft of water was very prevalent in Embakasi estate where there are no fences securing the homes and due to sparse population, individuals would connect themselves at night. Cases of illegal connections running into years are commonplace.

4.2.6.5 Cost of drilling

Drilling boreholes is very expensive. From getting the prerequisite licences, geological and hydrological surveys to hiring a contractor to do the actual drilling one needs to have a minimum of KShs. 2.8 million. A further KShs. 1.7 million can be spent to have the overhead storage tanks installed as shown in the plates (Plates 5 and 6).

Plate 6: A borehole with this kind of storage tank goes for a total of KShs. 4.5 million (Source: Author, 2013).

Plate 7: A modified storage tank like this one goes for KShs 3 million (Source: Author, 2013).

4.2.6.6 Regular leaks leading to enormous losses

All the surveyed water suppliers had installed plastic water distribution pipes. In addition, the pipes are only about 10 – 15cm deep and with the frequent vehicular operations coupled with poor workmanship, these pipes eventually start leaking.

4.2.6.7 Delayed or non-payment of water bills

Some clients take unnecessarily long to settle their water bills. Before one gets connected to a water supplier, there is a contract that is signed by both parties. The contract normally specifies the date the metre reading will be taken, the day the bill will be out and when it is supposed to have been cleared; failure to which the water supply will be disconnected. Despite this being clearly stated, some clients can fail to pay for water supplied with some having 5 – 6 months arrears. On enquiring why they have not been disconnected, it was reported that disconnecting a customer was expensive. Extra labourers had to be hired. Then some clients would come and explain why they have not paid their water bills and the supplier would sympathise with them.

4.2.6.8 Competition from NWSC

Small scale water suppliers operating in the same locality as the NWSC complained of stiff competition. All, except one, of the small scale water suppliers charged so much more than NWSC. Given a choice, customers would prefer NWSC and only use privately supplied water when they did not have an alternative. Business was good for small scale water suppliers in estates that experienced prolonged water rationing such as Donholm, Greenfields, Honeysuckle and *Imara Daima*. Figure 10 shows the price (per 1,000 litres) variation amongst the water suppliers and how they compare with NWSC and MWI recommended price.

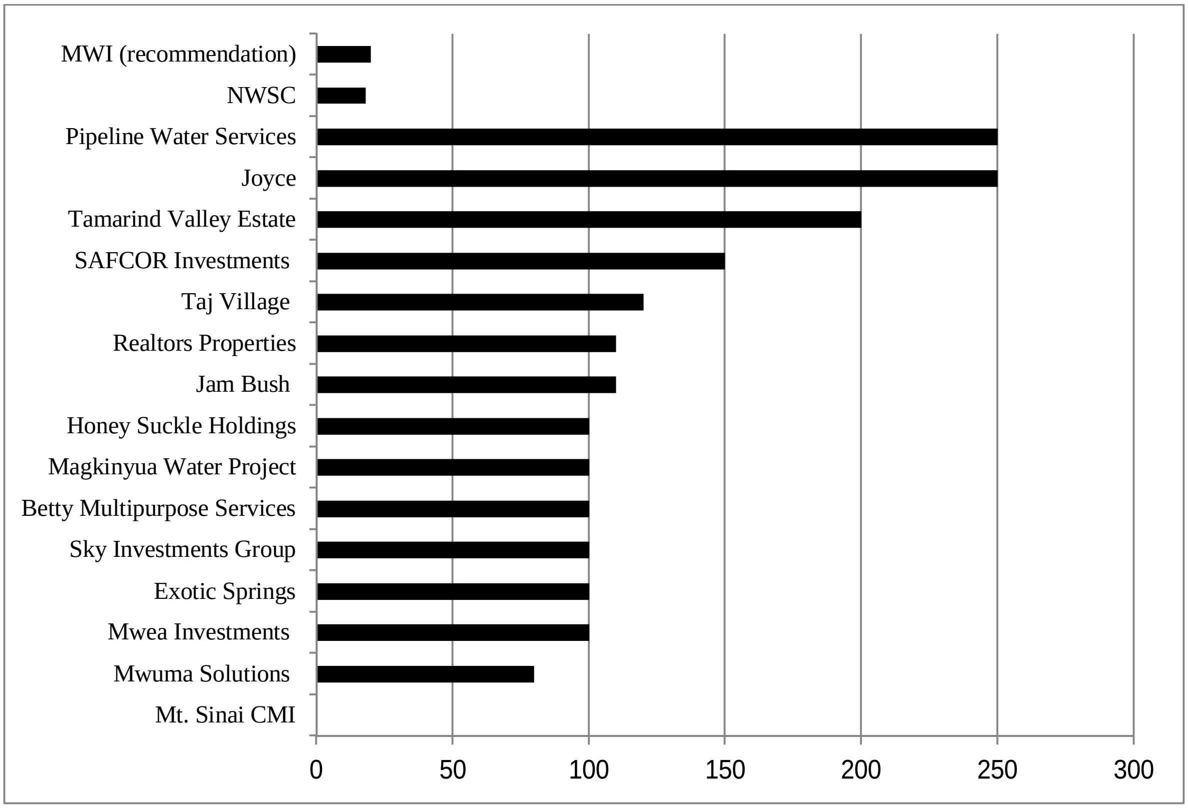


Figure 9: Comparison of the price per 1000 litre (KShs) of water supplied.

4.2.6.9 Sabotage from competitors

Stiff competition from other water suppliers has led to some using underhand methods to stay in business. The water suppliers have not agreed on their specific territories to conduct their businesses, thus, water supply pipes more often than not end up crisscrossing the competitors. It is during the laying or repair of burst pipes that a competitor intentionally damages the other's pipes. This challenge was very prevalent in Embakasi estate which had the highest number of identified small scale water suppliers.

4.2.6.10 Long licence application process

Normally, it takes between 2 weeks – 6 months for one to get a borehole licence but some water suppliers complained that the process takes too long with one supplier complaining it had taken 18 months. According to WRMA, this could have been a case where one did not have the required documentation hence the long application process. If one has the correct documentation, the process should take a minimum of 2 weeks.

4.3 Discussion

This discussion is structured around the five objectives of the study; i.e. (i) to identify households concerns regarding water supplier in Embakasi location; (ii) to identify environmental problems occasioned by small scale water suppliers; (iii) to identify the small scale water suppliers and their distribution; (iv) assess the activities and operations of the small scale water suppliers; (v) to investigate the factors determining their presence in a particular location; (vi) to identify the challenges faced by these operators.

The first objective of this study was to identify households concerns regarding water supply in Embakasi location. The daily per capita domestic water consumption in Embakasi location is above both the UNICEF and WHO standard, i.e. 38 and 27 litres respectively (Lowry et al., 1981). The daily intake established by this study was 51.3 litres per day per person. This can be attributed to an increased expenditure on water supply and related services from KShs. 8.4 billion in 2007/2008 to KShs. 10.6 billion in 2008/2009 (GoK, 2009).

Majority of the households (55%) prefer small scale water supply while 41% would rather be served by NWSC. Majority of the households did not care much about the quality of the water supplied as long as their taps do not go dry. For the households served by NWSC, majority (86%) did not harvest rainwater to supplement their water needs. This was in complete contrast to households who are served by small scale water supplies where 74% of them indicated they harvest rain water. An overwhelming number (90%) of households served by small scale water suppliers expressed no problem with access to water while households (74%) served by NWSC indicated it was a big issue. There is great concern regarding the quality of water supplied by small scale water suppliers with 72% of the responds indicating they were not satisfied with it. In the case of NWSC supplied water, 80% indicated that they had no problem with its quality.

Embakasi location residents would rather have poor quality water supplied than go without water. This water was used for other domestic purposes while drinking water was bought from shopping malls and supermarkets.

The second objective was to identify the environmental problems occasioned by small scale water suppliers. The Water Act, 2002 provides a minimum distance of 800 metres be maintained between adjacent boreholes. Unfortunately, WRMA uses the ‘richness or poverty’ of the aquifer to determine the number of boreholes that can be drilled in a given area. This strategy was found defective as some suppliers indicated that the level of water in their boreholes had fallen drastically after another borehole was drilled nearby. This is a risk to the environment as it can lead to excessive abstraction which can lead to land subsidence – resulting in disruption of canals, drains, structural damage to civil engineering structures and potential loss of life. Excessive abstraction can also lead to lowering of the water table exposing groundwater resources to risk of pollution through entry of polluted water from rivers and lakes. This leads to drying up and/or depletion of rivers, small lakes and marshes, causing eradication of important wetland habitats.

In addition to this, WRMA is charged with the restoration of the degraded water catchments and depleted groundwater aquifers. Unfortunately, this mandate is not executed to the latter. WRMA is supposed to regularly keep checking on the amount of water abstracted from the boreholes as stipulated in the respective licences but owing to budgetary constraints, it lacks the capacity to do so. This has the potential to destroying our national groundwater resources.

EMCA, 1999 empowers NEMA to establish and review in consultation with the relevant lead agencies, land use guidelines. These land use plans should take into account the rapid urbanisation around Embakasi location. In collaboration with WRMA, major zones of aquifer recharge should be mapped and preserved in some use (parks, orchards, open space, etc.) which will not restrict infiltration or contaminate groundwater recharge.

Owing to low NWSC sewerage coverage in Embakasi estate, use of septic tanks is common. As the population continues to grow, there is a risk of polluting groundwater resources through seepage. According to the ARGOSS (2001) risk assessment guidelines for on-site sanitation, the safest separation distance should be 25 to 50 days travel time. This is based on survival times of faecal indicator bacteria and viruses from laboratory and field experiments. In addition to this, the aging NWSC sewer lines pose serious risk on groundwater resources through leakage with the most susceptible estates being Donholm, Greenfields, Savannah, Tassia, *Fedha* and *Imara Daima*.

Morris et al (2003) observed that agencies responsible for protecting and evaluating groundwater resources often have limited resources and powers. This is the case with WRMA. The Authority lacks sufficient funds to carry out its mandate. It also lacks personnel to monitor groundwater abstraction owing to limited funding from the government and inadequate revenue generation. Limited resources lead to inadequate monitoring and assessment of water quality problems. Budgetary constraints also lead to lack of knowledge and thus lack of planning.

The third objective of this study was to identify the small scale water suppliers and their distribution in Embakasi location. Water Act, 2002 created WSRB which is charged with issuance of licences for the provision of water services and determination of standards for the provision of water services to consumers. Despite the fact the small scale water suppliers are engaged in water provision, they get their permits from WRMA and the quality of the water supplied is tested once at the drilling stage. This is duplication (WSRB and WRMA charged with testing quality) of roles and goes against the systems theory of planning as postulated by Faludi (1973) who stresses the importance of all parts of the system be engaged in every step of the process from planning to execution of their mandates. Where this balance is not maintained, it leads to what is bedevilling the various agencies engaged in the country’s water sector - duplication of roles, inappropriate planning and monitoring, inefficiencies, etc.

Data analysis and interpretation of responses from the small scale water suppliers revealed that there has been a rapid entry of small scale water suppliers in Embakasi location with majority of them located in Embakasi estate where NWSC water supply coverage is the lowest in the city. Small scale water suppliers also co-exist with NWSC as observed in the other nine estates in the study area. Considering the large number of borehole licence applications at WRMA, the NWSC cannot meet the water demand of Embakasi location. This is exemplified by the fact that when the country was experiencing one of its acute droughts in 2008-2009, a lot of taps went dry in many homes. This prompted many private investors to venture into water supply business to bridge the shortfall. Of the 118 applications for a water supply licence, 82% came between the period 2008 and 2009. The study identified a total of 20 small scale water suppliers of which 15 were interviewed. Their distribution in the location was as follows: Embakasi estate – 5; Donholm and Savannah estates - 2; *Fedha* estate – 2; Greenfields estate – 1; Tassia estate – 1; Tena estate – 1; Pipeline estate – 1; Honeysuckle estate – 1; *Imara Daima* estate – 1 and Avenue Park and *Tumaini* estate – 0.

Setting up of small scale water supplier businesses in congested estates has its own environmental risks. Due to inadequate domestic waste handling by the CCN, these can contaminate the water. Burst sewers that are not repaired on time can also contaminate the water leading to outbreak of waterborne diseases such as diarrhoea, typhoid, cholera and dysentery. The small scale water supply within the estates has brought unnecessary traffic flows as heavy vehicles come to collect water and in the process block the narrow streets within the estates. In case of an emergency, e.g. fire, rescue operations will be impaired.

These lorries are also a source of residential noise pollution through hooting. To avert these environmental challenges, small scale water supply businesses should be set up where there is enough space for vehicular movement and away from heavy residential occupation.

Bakker (2003) mentioned that the tendency of private companies engaged in water supply to fail to extend coverage to the poor as a result of ‘cherry-picking’ profitable neighbourhoods and classes of consumers was one of the most important justifications for bringing water supply under the control of the state either through strict regulation or public ownership of water supply infrastructure in the 20th century. The findings of this study indicate that the private companies still have the tendency of picking profitable neighbourhoods.

The fourth objective was to assess the activities and operations of the small scale water suppliers in Embakasi location. The study revealed that most of the small scale water suppliers are only engaged in domestic water supply. These entrepreneurs have set up a water distribution network with a metre in place. Some suppliers have the water metres within their business premises while others have installed the metres in the customers’ compound. In case of supply disruptions, this will be rectified by either the consumer or the water supplier depending on the location of the metre. To minimise their operation costs, some suppliers have installed the metre within their premises which makes the consumer attend to supply disruptions.

None of the interviewed small scale water suppliers are engaged in sanitation services. While entering into contract with a customer, they advise them to install big capacity reservoir tanks and encourage them to harvest rain water to supplement their supply. Only one of the water suppliers interviewed treated their water before distribution. The rest supplied untreated water. Groundwater, if unpolluted, requires little or no treatment before use. Water treatment is an additional expense and some consumers are not comfortable with a particular type of treatment. Thus, water treatment is the prerogative of the consumer.

The MWI recommends KShs. 20 per 1000 litres of water (figure 4.4). Despite this guideline, findings from the study indicate that 40% (six suppliers) of the small scale water suppliers charge 5 times more, 27% (four suppliers) charge 7.5 times more, 13% (two suppliers) charge 12.5 times more and 7% (one supplier) charge 10 times more. Only 13% (two suppliers; NWSC and one private supplier) of the water suppliers charge below the recommended rate. NWSC are strictly supervised by the WSRB while the small scale water suppliers are supposed to be supervised by WRMA. Although the Water Act, 2002 exclusively mandates the WSRB to develop guidelines for the fixing of tariffs for the provision of water services but the Act is vague on the agency responsible for enforcing this.

Water being a basic need, households have very limited options. First option is to buy it at exaggerated price and the second option is to find a NWSC operated water kiosk which most of the time is another estate within the location. Unfortunately for the second option, there is additional cost of transport making it more or less the same price as the private water supply. Thus, the households have had to do with the high cost of privately supplied water.

The fifth objective was to investigate the factors determining location of small scale water suppliers. The main factors established by the study include: quality of water; distance to customers; competition and security of the business. Owing to upstream agricultural activities, rapid urbanisation in and around Nairobi where the rivers' tributaries pass, and industrial effluents being discharged into the rivers without pre-treatment has made surface water unusable for domestic purposes. EMCA 1999 gives NEMA and WRMA full mandate in the protection and conservation of the environment including monitoring of wastes discharged into the rivers, lakes and other water bodies. It has been more than 10 years since the Act became operational and heavy metal contamination of the rivers in Embakasi has been on the rise owing to industries discharging into Ngong River. The biggest challenge facing the NWSC, and indeed the small scale water suppliers, is a source of potable water. NEMA and WRMA should closely work together to ensure industries treat their effluents before being discharged into rivers. This will go a long way in guaranteeing residents of Embakasi location have clean potable water for domestic use.

Water scarcity or insufficiency is a critical challenge to residents of Embakasi location. Despite borehole water being relatively salty (presence of fluoride), residents would rather have it than none at all. Another challenge that could make this water even more unusable is the risk of contamination from septic tanks. Embakasi estate and the surrounding areas do not have access to CCN sewerage system and therefore home developers rely on septic tanks. In cases where small scale water suppliers are located in densely populated areas similar risk of contamination is very high. An aging sewerage system is prone to leaks and bursts thus exposing the residents to health problems in cases where the leachates get into the water supply system or the borehole.

The sixth objective was to identify the challenges faced by small scale water suppliers. The biggest challenge facing the small scale water suppliers in Embakasi location is the very high fluoride concentration. Although the recommended level is supposed to range between 0.6 - 1.5mg/L (WHO, 1995), groundwater in Embakasi estate record as much as 9.0mg/L. Fluoride in groundwater originates from fluoride bearing rocks such as fluorspar, fluorite, cryolite, fluorapatite and hydroxylapatite. It is also influenced by the availability and solubility of fluoride minerals, velocity of flowing water, pH and temperature, concentrations of calcium and bicarbonate ions in water. Too much fluoride in water can lead to major health problems - dental fluorosis, teeth mottling, skeletal fluorosis and deformation of bones in children and adults. This calls for remedial measures such as defluoridation techniques and rain water harvesting which can be used to dilute the fluoride concentration thus making it fit for human consumption.

The second and third most reported challenge is related to electricity. It was reported that electricity cost is lowering the small scale water suppliers' profits. Coincidentally, the period 2009/2010 was the same period when the country was experiencing one of its worst droughts. This made hydro-electric generation futile due to the low water levels in the dams. As a result, the national electricity distributor (Kenya Power and Lighting Company, KPLC) was forced to source alternative sources of energy. This alternative electricity was sourced from independent power producers who use the expensive fossil fuels to generate electricity. This cost was passed down to the consumer, thus the high electricity cost. Although the drought situation has since subsided, KPLC cannot meet the demand for electricity and therefore it still purchases electricity from independent power producers.

The other challenge related to electricity is its unreliability in supply. Blackouts are commonplace and there are instances when pumps have been damaged by the high voltage.

Windpumps have been used to pump water all over Africa for irrigation and domestic water supply purposes. This can be a viable option for the small scale water suppliers in Embakasi location. Other challenges noted include disruption to the distribution network, very expensive venture, theft or illegal connections and regular leaks.

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

This chapter presents the study conclusions in section 5.1. The conclusion is based on broad objectives of the study i.e. environmental implications of small scale water suppliers in Embakasi location. Section 5.2 provides recommendations to some of the challenges identified. The chapter concludes by providing further areas of research.

5.1 Conclusions

The study identified several environmental implications of small scale water suppliers in Embakasi location. As highlighted in this study, environmental considerations are well articulated in the Water Act, 2002 and EMCA, 1999. The results of this study indicate lack of regular checks on quality of water supplied by the small scale water suppliers which pose a serious risk of contaminated water being supplied to households. In addition to this, the study found that the small scale water suppliers were found within the estates where burst sewers were common place and therefore could find its way into the water supply. Another observation is that the minimum distance of 800 metres between boreholes set by the Water Act, 2002 is not being kept as some boreholes were observed to be 200 metres apart. This can lead to over abstraction of the same aquifer leading to deleterious consequences to the environment such as land subsidence.

Quality of surface water in Embakasi location and indeed the entire Nairobi County is heavily polluted owing to major human activities in the upstream and industrial effluents finding their way into the river systems thus leaving groundwater as the only viable source.

Hydro-geological studies of the area have also indicated that there is high fluoride concentration in groundwater.

5.2 Recommendations

- WRMA should ensure efficiency in data generation and dissemination. This will alleviate the current data gaps in the number of operating boreholes.
- WRMA should endeavour to do regular checks on the existing small scale water suppliers to ensure good quality water is supplied to households. Incidences of contamination can be flagged and remedies instituted in good time.
- The minimum distance of 800 meters between boreholes as set by the Water Act, 2002 should be adhered to.
- Buffer zones of natural environment should be created around boreholes to safeguard against contamination with sewerage water and/or boreholes should not be drilled in densely populated areas as in the case of Donholm, *Fedha*, Greenfields, Tassia, Tena and Savanna estates.
- NEMA and WRMA should improve their surveillance on industries to ensure they do not discharge untreated wastes into rivers and other water bodies. This will in turn reduce on the reliance on groundwater resources for domestic water supply.
- Small scale water suppliers need to install bigger reservoir tanks. Big capacity reservoirs guarantee ample water to meet the demand eliminating the need for extensive pumping.
- Large capacity reservoir tanks should also be elevated to take advantage of gravitational flow as opposed to pumping.

Areas of further research

1. Household purification of water with high fluoride concentration;
2. Appropriate sustainable minimum distance between boreholes in Embakasi location;

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APPENDIX 1

SMALL-SCALE WATER SUPPLIERS INTERVIEW SCHEDULE

1. Name of the company/supplier:
2. How many years have you been in the business?
3. How many staff are employed?
4. How many households do you supply with water?
5. Do you pre-treat your water before distribution? Y / N   If Y, what kind of treatment?
6. Any limitation to the quantity of water supplied to a household?
7. How much do you charge per unit of water (1,000 litres)?
8. Are there different tariff regimes for various consumers?
9. Kindly fill in the following tables:

Number of household connection per month (or year)

Year / Month									
No. HH connections									

Water Supply Efficiency per Month Sept 2009 – Sept 2010

Index	**S**	**O**	**N**	**D**	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**Mean**
Vol generated (M^3)														
Unaccounted water (M^3)														
Vol of water billed (M^3)														
Revenue (Kshs)														
Electricity cost (Kshs)														
Fuel cost (generator)														

Access to Sanitation (in case the small scale water supplier provides sanitation services)

Year / Month									
No. HH connections									

10. What is the capacity of your pump? ....How many hours do you pump? ....
11. What is the yield of the borehole?
12. Do you emphasise to your customers on rainwater harvesting?
13. What factors did you consider when locating your business here?

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14. Any major challenges you could mention?

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15. Environmental concerns observed?

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APPENDIX 2

NAIROBI WATER & SEWERAGE COMPANY QUESTIONNAIRE

1. How many years have you been in the business?
2. Approximately how many people work for the company?
3. Kindly provide the organisation structure of the company.
4. How many households are supplied with your water in Embakasi Division?
5. Do you pre-treat your water before distribution?
6. Kindly fill in the following tables:

Number of household connections per month in Sept 2009 – Sept 2010

Month	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
HH connections												

Number of Household Connections per Year since the Water Act, 2002 came into force

Year	2003	2004	2005	2006	2007	2008	2009
HH connections							

Water supply efficiency per month Sept 2009 – Sept 2010

Index	**Sep**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Mean**
Vol generated (M^3)													
Vol distributed (M^3)													
Unaccounted water (M^3)													
Vol of water billed (M^3)													
Revenue (Kshs)													
Electricity cost (Kshs)													
Fuel cost (generator)													

Access to urban domestic sanitation

Year / Month									
No. HH connections									

7. Are there different tariff regimes for various domestic consumers? (Can you provide the tariffs?)
8. Do you check on the rate of water extraction from the various sources?
9. When considering connection of new applicant, do you consider if rainwater harvesting is practiced?
10. Any major challenges you could mention?

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APPENDIX 3

HOUSEHOLD QUESTIONNAIRE: EMBAKASI DIVISION

PART A - SOCIO-ECONOMIC CHARACTERISTICS (tick where appropriate)

1. Is the household head a man or woman:
2. What is the occupation of the household head:
3. Employer:
   a. Private sector
   b. Civil servant
   c. NGO
   d. Self employed
4. What is the education level of the household head?
   a. No formal education
   b. Adult education
   c. Primary level education
   d. Secondary level education
   e. Post-secondary level education
   f. University level
5. What is your income (KShs) range:
   a. 10,000 – 25,000
   b. 25,001 – 40,000
   c. 40,001 – 65,000
   d. 65,001 – 80,000
   e. Above 80,001
6. What is the size of the household?
7. What quantity of water do you use per day as a household?
8. (i) Do you harvest rainwater?

   (ii) If you harvest rainwater do you have a rain water tank? Y/N

   (iii) If yes, what is the capacity in litres (approximate if not sure)

   (iv) If you don't have rainwater tank, what do you use to tap rainwater?

   (v) Kind of roofing materials (a) Clay tiles (b) Iron sheets (c) Galsheet
9. If you don't tap rainwater, give reason (can give more than one reason)
   a. Rainwater tastes bad
   b. Rainwater causes diseases
   c. No rainwater tank
   d. Lives in a flat

e. Lives close to a reliable source

f. Others (specify)...

10. Do you perceive any problem in regard to accessibility to water: Y/N - If yes, please give more details

a. Rationed b. Unreliable

11. Do you perceive any problem with quality of water? Y/N - If yes, how do you purify your water?

a. Boiling

b. Waterguard

c. Pur

d. Others (specify).............................

12. Do you recycle or reuse water? Y/N - If yes, how?

a. Flushing the toilet

b. Irrigating the kitchen garden

c. Washing other things/equipment

d. Others (specify)...

13. Are you supplied by the Nairobi City Water supply or by a private supply? Nairobi / Private

100% N.W.S.C. 100% Private Supply 50% Mix

PART B – PRIVATELY SUPPLIED

14. Ever been supplied water by Nairobi Water & Sewerage Company? : Y/N

15. Between Nairobi Water Supply and Private Supply, which of the two systems would you prefer?

a. Nairobi Water supply b. Private supply

Why the preference?

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16. Do you have a water meter? Y / N? If yes, how frequently is meter reading taken?

a. Weekly
b. Monthly
c. Never
d. Don't know

17. When does the water bill come?

a. Specific day of the month
b. Specific week of the month
c. Varies
d. Don't come at all

18. How soon do they disconnect the supply if bill is not paid?

a. Following working day
b. After expiry of 1st week
c. After expiry of 2nd week
d. After expiry of 3rd week
e. After expiry of 4th week
f. Never been disconnected

19. How long do they respond to supply problems (faulty metre, burst pipe, etc.)?

a. On same working day
b. The following working day
c. Within the week
d. Monthly basis
e. Never

20. Any problems? ....

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PART C – NAIROBI CTY WATER & SEWERAGE COMPANY SUPPLIED

21. Ever been supplied water by private supplier: Y/N

22. Between Nairobi Water Supply and Private Supply, which of the two systems would you prefer?

a. Nairobi Water supply
b. Private supply

Why the preference?

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23. Do you have a water metre? Y / N? If yes, how frequently is meter reading taken?

a. Weekly
b. Monthly
c. Never
d. Don't know

24. When does the water bill come?

a. Specific day of the month
b. Specific week of the month
c. Varies
d. Don't come at all

25. How soon do they disconnect the supply if bill is not paid?

a. Following day
b. After expiry of 1st week
c. After expiry of 2nd week
d. After expiry of 3rd week
e. After expiry of 4th week
f. Never been disconnected

26. How long do they respond to supply problems (faulty metre, burst pipe, etc.)?

a. On same working day
b. The following working day
c. Within the week
d. Monthly basis
e. Never

27. Any problems? ....

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