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Enhancing Formal Access to Water in Kenya: The Non-Revenue Water Management Approach

Beatrice A. I. Olwa

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Beatrice A. I. Olwa

Infrastructure and Economic Services Division
Kenya Institute for Public Policy
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Bishops Garden Towers, Bishops Road
P.O. Box 56445, Nairobi, Kenya
tel: +254 20 2719933/4; fax: +254 20 2719951
email: **admin@kippra.or.ke**
website: http://www.kippra.org

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Abstract

Access to safe water is both a necessity for life and a Constitutional right for all citizens in Kenya, despite there being widespread condemnation of unequal access, management, and waste of water. Additionally, there is growing realization in the 21st century of the need to enhance ecologically friendly water usage and harvesting techniques that rely less on the "hard-path" infrastructure approach. The purpose of this study is to promote "soft path" infrastructure approach through better understanding of the effect of water losses on access to safe water. The study assessed the effect of changes in levels of non-revenue water (NRW) on formal access to water in Kenya, and further approximated the impact of proper management of non-revenue water to the urban population and to the economy. Regression analysis using Ordinary Least Squares method and qualitative method of analysis were used. Data was sourced from Water Services Regulatory Board Annual Report-Impact report, No. 4 of 2011. The study established that the available water treatment capacity (facility) in the country can adequately serve the urban population and the hinterland, if non-revenue water is appropriately managed and kept at the recommended 25 per cent level. The study demonstrated that just one per cent reduction in non-revenue water will enable the water sector collect Ksh 7.3 million more revenue per year, as additional 15 per cent of urban population gain access to safe water at a reasonable consumption per capita level of 42 litres per person per day. However, policy issues of system efficiency, networking, economic viability and public involvement are pertinent to the achievement of the estimated outcome

Abbreviations and Acronyms

ELL	Economic Level of Leakage
GoK	Government of Kenya
IWA	International Water Association
KIWASCO	Kisumu Water and Sewerage Company
LVSWSB	Lake Victoria South Water Services Board
MDGs	Millennium Development Goals
NRW	Non-Revenue Water
ONEA	National Water and Sanitation Office
SONEDE	La Société Nationale d'Exploitation et de Distribution des Eau
SPA	Service Provision Agreement
SWOT	Strengths, Weaknesses, Opportunities, and Threats
UfW	Unaccounted for Water
UNICEF	United Nations Children's Fund
UNESCO	United Nations Educational Scientific and Cultural Organization
WASREB	Water Services Regulatory Board
WHO	World Health Organization
WSB	Water Services Board
WSP	Water Services Provider

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1. Introduction

1.1 Background Information

Water is the most important natural resource, essential for life and a major determinant of growth and wealth creation for mankind. It is also regarded as life in itself because no living being on the planet can survive without it (WHO, 2003). The human body for example, comprises of about 60 per cent to 80 per cent water.[1] Incidentally, utilization of unsafe water and lack of basic sanitation cause 80 per cent of diseases and kills more people annually than all forms of violence, including war. The United Nations predicts that one tenth of the global disease burden can be prevented simply by improving water supply and sanitation.[2] Accordingly, improved access to water in Kenya is valued for economic growth as well as for promoting good health, reducing the cost of living and boosting productivity for global competition. In light of this, the Kenyan Constitution (Government of Kenya, 2010) confers the right to water on every person. The domestication of this law brings about the commitment to scale up efforts to ensure access to safe, clean and adequate water.

In the global scene, Kenya joined 189 nations who reaffirmed their commitment in the year 2000 to free people from extreme poverty and multiple deprivations. The pledge begot the famous eight Millennium Development Goals (MDGs) and of specific interest to this study is goal number seven–target number ten, which aims at reducing by a half the proportion of world's population without sustainable access to safe drinking water and sanitation by 2015. This target has been mainstreamed in the National Water Services Strategy (NWSS) for 2007-2015, whose overall goal is to ensure sustainable access to water and basic sanitation to all Kenyans.

To this far, there is no internationally standardized definition of access to safe water. However, distance, time and water quantity are variously used to formulate country-specific definitions. Borrowing from the Water Services Regulatory Board (WASREB) and World Bank definitions, formal access to water in this study refers to the proportion

[1]Babies are approximately 75% to 80% water, and as we grow older, this percentage decreases until the percentage is reduced to approximately 60% to 65% for men and 50% to 60% for women (http://www.chemcraft.net/wbody.html accessed on 22nd September 2011).

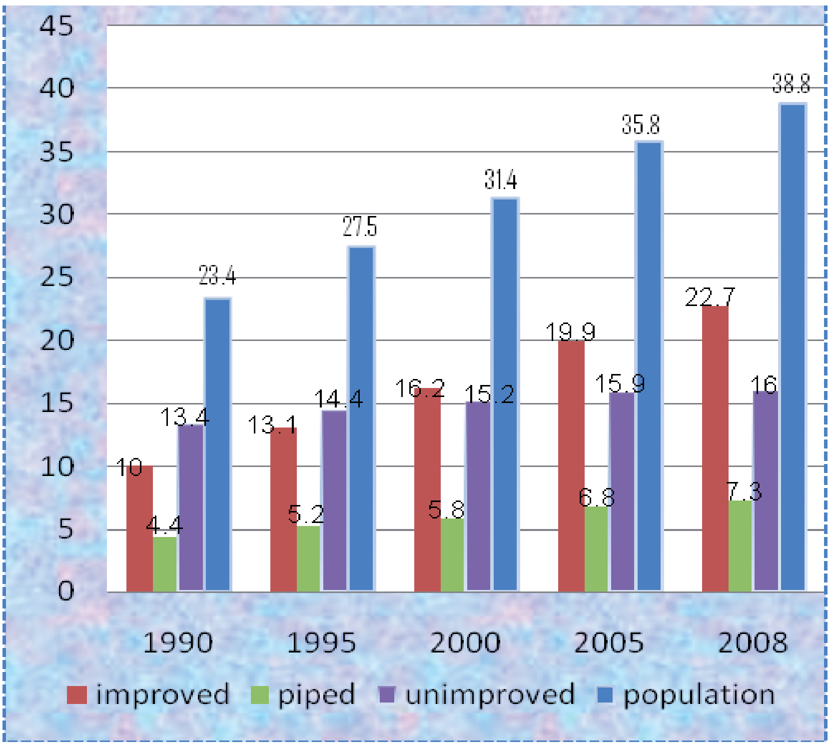
[2] http://www.charitywater.org/whywater, accessed on 22 September, 2011).

of population with the right to use piped water, provided by authorized service providers within their dwellings or at a public fountain/ standpoint located preferably within 200 metres.

To achieve adequate access, the water sector strategies being pursued under the Water Act 2002 target tackling major causes of limited access, which include deteriorating water quality and quantity at sources, dilapidated infrastructure, institutional inefficiencies, and Non-Revenue Water (NRW), also termed as Unaccounted for Water (UfW), which is water that has been produced and "lost" before it reaches the customer.[3]

In 2006, the Ministry of Water and Irrigation–MWI (2007) estimated both NRW and access to water in urban setting at 60 per cent each, and targeted to increase formal access to 80 per cent and reduce NRW to 30 per cent by 2015 as a national

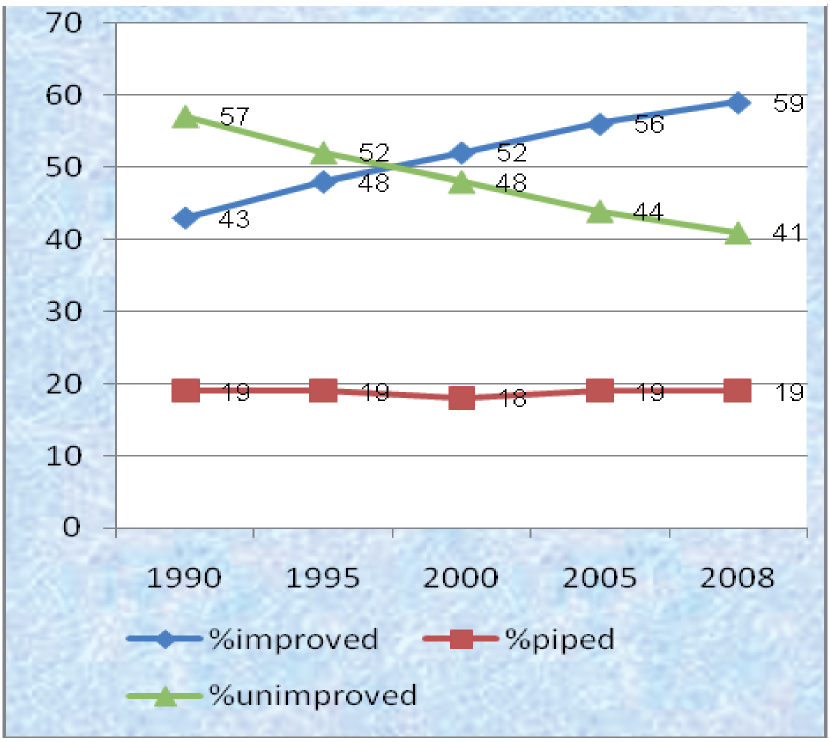
Figure 1.1: Access to water in Kenya ('M)



Source: WHO/UNICEF (2011), Joint Monitoring Programme, available at www.wssinfor.org

[3] http://www.ib-net.org/en/texts.php?folder_id=103&mat id=84&L=1&S=2&ss=3 on 18 July 2011.

Figure 1.2: Access to water in Kenya (%)



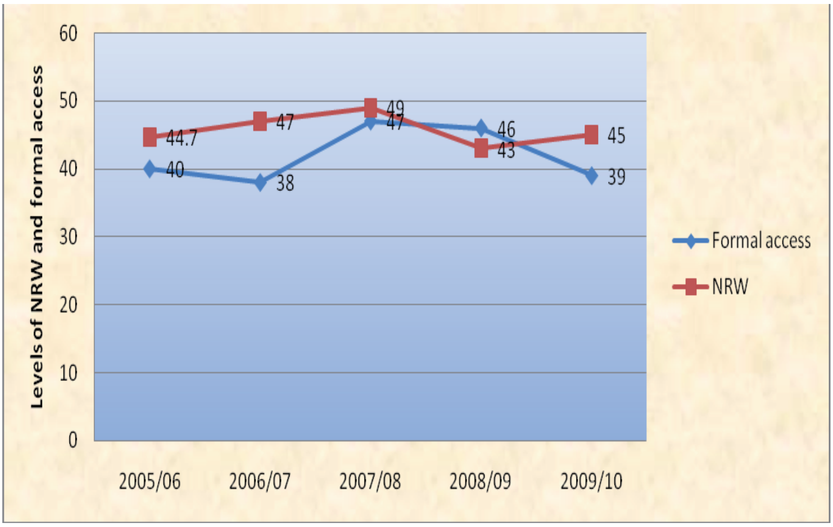
Source: WHO/UNICEF (2011), Joint Monitoring Programme, available at www.wssinfor.org

strategy aimed at achieving MDGs. Post-water sector reform initiatives have tended to concentrate on improving water sources by drilling and equipping boreholes, protecting shallow wells and springs, promoting rain water harvesting, constructing water storage dams and pans, rehabilitating and expanding utilities (Government of Kenya, 2010).

Through these initiatives, the water sector has made some positive progress in enhancing access to water, especially in rural areas where the proportion of population with access to improved[4] water sources increased by 20 per cent (from 32% in 1990 to 52% in 2008). Undesirably, least progress has been made on enhancing formal access to water, which remained sluggish at 19 per cent overall, while urban

[4] An improved drinking-water source is defined as one that, by nature of its construction or through active intervention, is protected from outside contamination, in particular from contamination with faecal matter. But piped water is considered most reliable (WHO/UNICEF-JMP). Available at http://www.wssinfo.org/definitions-methods/introduction, accessed on 30 August 2011.

Figure 1.3: Relationship between formal access to water and non-revenue water



Source: WASREB impact reports (various)

access to piped water on premises declined from 57 per cent to 44 per cent in the same decade (WHO/UNICEF, 2010).

The progress report by WASREB (2011) shows that the relationship between NRW and formal access to water has been inconsistent. The linkage was positive during 2005/06 to 2007/08 and inverse after 2008/09, which is contrary to the empirical literature and the spirit of reforms.

1.2 Problem Statement

The problem addressed by the study is limited access to safe water against the backdrop of high water losses in form of NRW. Precisely, 61 per cent of Kenyans in the urban areas have no access to safe water, while 45 per cent of water produced is lost to NRW (WASREB, 2011). As a coping mechanism, the deprived population has resorted to utilization of water from unimproved/contaminated sources such as unprotected wells, streams and ponds, which put their health and life at risk.

In spite of the ongoing water sector reform initiatives, inadequate access to safe water has been a key challenge in Kenya. The country fell short of realizing its dream of having piped water in every household by 2000, and safe water coverage is increasingly low and is currently estimated at 39 per cent against the national target of achieving water coverage of 80 per cent by 2015 (WASREB, 2011). Population dynamics notwithstanding, formal access to water in urban areas has equally been low at an average of 42 per cent for five years. Following this trend, Kenya might not sustainably achieve its long term vision of universal access to improved water by 2030, considering that Kenya is a relatively water scarce country with only 534m^3 of renewable fresh water per capita, against the WHO's recommended minimum of 1,000m^3 per person per year (World Bank, 2010).

Prior to reforms, the Ministry of Water and Irrigation identified institutional inefficiency characterized by high levels of NRW, water scarcity, and old and dilapidated infrastructure as the main factors contributing to access constraints. Like in most developing countries, Kenya has been addressing the challenge of access to water through investment in new water production plants and storage dams to augment existing infrastructural facility. Although the expansion strategy may be qualified on grounds of deficit capacity and the extended advantage for irrigation and power supply opportunities for purposes of domestic consumption, the strategy may be so costly in the long run, bearing in mind that an increase in water production triggers a responsive increase in NRW as more water is pumped into the leaking[5] networks, and the vicious cycle continues.

To circumvent that trap, worldwide emphasis has been shifting towards managing water demand by efficiently utilizing the water that is already available. Key guiding principles of NWSS (2007) equally accentuate that demand management has priority over supply management. Unfortunately, this does not seem evident from the WSPs operations as presented in WASREB reports.

According to WASREB (2011), increases in NRW have wide implications to the economy. The losses incurred in 2009/2010 arising from increase in NRW to 45 per cent amounted to a fiscal loss of about Ksh 8.6 billion.[6] This represented approximately a third of the annual sector development budget for 2009/10. Had the lost water volume been channelled to paying customers, the water sector could have reduced by 33 per cent the government budgetary allocation to the sector, and enabled additional 4.6 million people gain access to safe water.

[5] Leakage includes both physical and artificial leakages arising from commercial sources such as illegal connection.

[6] Estimated using an average tariff of Ksh 53 per cubic metre given by the Regulator (WASREB) for 2009/10, and 1 m^3 is equivalent to 1,000 litres.

Therefore, there is potential for enhancing formal access to water through proper management of NRW. Increasing levels of NRW against reducing levels of formal access to water is an indication of under-estimation or inadequate understanding of the effect of NRW on formal access to water, which is a cause of concern and a bridge to the underlying question: what is the effect of water losses on access to water?, and to what extent can proper management of water losses help enhance access to safe water in Kenya? Other guiding questions are:

(i) How do changes in levels of NRW impact on formal access to water?

(ii) How does NRW relate with performance indicators such as metering ratio, water quality and revenue collection efficiency,[7] which are linked to access?

(iii) What can be done to enhance formal access to water in Kenya?

1.3 Objectives of the Study

The broad objective of the study is to establish the effect of changes in levels of NRW on formal access to water, and approximate the impact of proper management of NRW on urban population and the Kenyan economy.

The specific objectives are to:

(i) Test the relationship between NRW and formal access to water.

(ii) Estimate the magnitude of the effect of changes in NRW on formal access to water.

(iii) Examine the correlation between NRW and selected performance indicators (thus, metering ratio, water quality and revenue collection efficiency), which are linked to access.

(iii) Propose policy direction for enhancing access to safe water in Kenya using the NRW management path.

[7] Revenue collection efficiency is the total amount collected by WSPs compared to the total billed in a given period. Water quality is measured in terms of number of chlorine tests carried out, and metering ratio is determined by the number of connections with operational metres compared to the total connections (WASREB, 2011).

1.4 Justification and Policy Relevance

In addition to the Millennium Development Goals (MDGs) and the NWSS for 2007-2015, water has formally been recognized under economic and social rights in the Constitution of Kenya. The rights approach can be viewed as a pointer for fast tracking the government's overall goal of ensuring sustainable access to water for all in the right quantity, quality and price. Incidentally, the puzzles caused by NRW tend to shutter not only the national goal for access, but also the dream of being a prosperous and globally competitive economy (Vision 2030). Reducing water losses is thus critical to efficient resource utilization and utility management as well as enhancement of formal access to water and consumer satisfaction. Furthermore, there is growing realization in the 21st century to enhance ecologically friendly water usage and harvesting techniques, which rely less on the "hard-path" infrastructure approach.

The Constitution classifies water catchment and sources, including rivers, lakes and others yet to be identified, under land (Government of Kenya, 2010: Article 62). The Ministry in charge of water, the land commission, county governments and private sector will collectively play a crucial role on catchment protection and delivery of the human right to water. It is important that the above mentioned key players understand the critical aspects of water service delivery to guide their investment decisions. This study, therefore, suggests some pointers for change management and cursors for more sustainable water services delivery that is necessary for realization of the human right to water and Vision 2030.

2. Literature Review

2.1 Institutional Set-Up for Water Sector

Kenya's structure for the management of water and sanitation is rooted in the National Water Master Plan of 1974, which sought to ensure the availability of piped water in every Kenyan household by the year 2000. The plan perceived the government as the main player in the water sector by assuming both financing and management responsibilities. The government later realized that the function of the water service was not very efficient, nor was it cost effective. There was growing discontent among water users in both rural and urban areas, arising from deficiencies in the management of water and sanitation installation; insufficient maintenance, shortage of funds for operation brought to a halt, and the extension of services to new and fast growing settlements. Insufficient cost recovery caused increasing interruption of water supply, dwindling water quality and falling coverage (Government of Kenya, 2007).

The government decentralized the mandate of water services provision in urban areas to local authority/municipal councils, while the Ministry of Water Development continued to provide water services in rural areas, through District Water Officers (DWOs). This did not bear fruit, either as municipal councils diverted revenue generated from water service provision, which was meant for operation, maintenance and improvement of water systems to other council uses. The National Water Conservation and Pipeline Corporation (NWCPC) was later established to take over the management of water schemes in selected urban centres and rural areas on commercial basis. Unfortunately, water services in the country had deteriorated so much to the point that more government support was needed to rehabilitate and expand the systems (Ochien'g, 2008). This necessitated water sector reforms that were initiated through Sessional Paper No. 1 of 1999.

The policy paper emphasized the need for restructuring and clear definition of activities for the Ministry of Water and other participants in water and related functions, such as the ministries of local government, agriculture and livestock. Recommendation was made for gradual liberalization through commercialization of viable water utilities, de-emphasizing government role away from direct service provision to regulatory functions, capacity development and research. These reform initiatives have been translated into law in the Water Act, 2002.

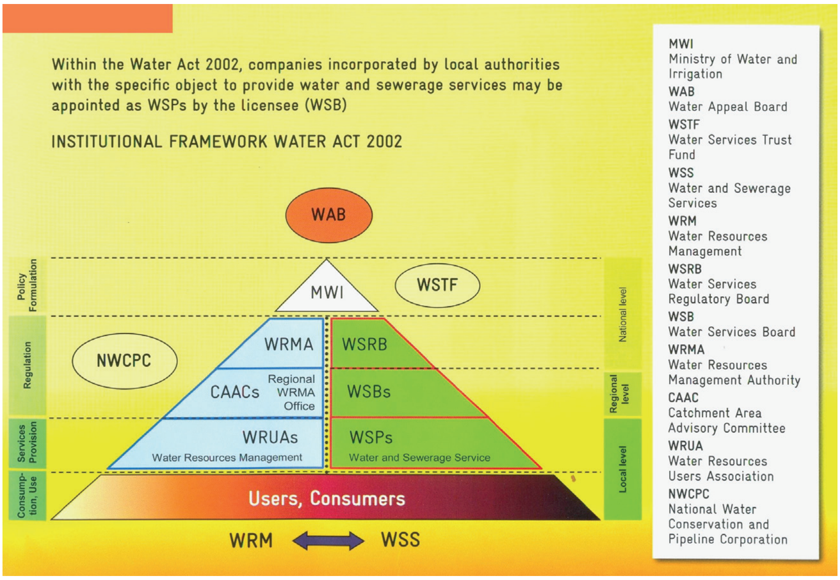
The institutional framework as spelt out in the Water Act (2002) is pyramidal. At the apex is the Ministry of Water and Irrigation (MWI), charged with development of legislation, policy and strategy formulation, and overall sector investment planning and resource mobilization. Other institutions include the Water Appeals Board (WAP) which is responsible for arbitration of disputes and conflicts; Water Resources Management Authority (WRMA) in charge of catchment and source protection; Kenya Water Institute (KEWI), which undertakes training and research in water sector; National Water Conservation and Pipeline Corporation (NWCPC) responsible for construction of dams and drilling of boreholes; Water Services Trust Fund (WSTF) finances pro-poor water services infrastructure; and the Water Services sub sector comprising of the Water Services Regulatory Board (WASREB), Water Services Boards (WSBs), and Water Services Providers (WSPs) for water services delivery (Government of Kenya, 2007).

WASREB is the regulator and its regulatory role includes issuing licences, setting service standards and guidelines for tariffs, as well as providing mechanisms for handling complaints. There are eight (8) Water Service Boards spread regionally across the country namely: Athi, Tana, Coast, Tanathi, Northern, Rift Valley, Lake Victoria South and North. These Boards have been established at the regional level and delineated on the basis of catchments, administrative boundaries and economic viability (Institute of Economic Affairs, 2007).

The WSBs are responsible for efficient and economical provision of water and sewerage services in their areas of jurisdiction. In executing their mandate, the WSBs maintain and acquire assets, and plan, develop and manage the systems in their jurisdictions. The WSBs are, however, prohibited from engaging in direct service provision, but contract WSPs as agents for this purpose through a Service Provision Agreement (SPA). The WSB can only provide water services directly in situations where it has not been able to identify a WSP that is able and willing to provide water services (Water Act, 2002).

WSPs are commercial organizations with the sole mandate of operating and maintaining water and sewerage services as prescribed in the SPA between WSBs and WSPs. Most of the current urban WSPs are owned by local authorities, though set up as independent entities registered under the Companies Act Cap 486 of the Laws of Kenya. Rural WSPs are largely community or faith-based, responsible for managing community water supplies.

Figure 2.1: Schematic representation of the current institutional framework



Source: Lake Victoria South Water Services Board (LVSWSB), 2007

There are also District Water Officers (DWO) reporting directly to the Ministry of Water and Irrigation, which receive direct funding through MWI to undertake some "asset development". Other players include the private sector and very small scale water service providers, who are yet to be mainstreamed into the system.

2.2 Access to Water

As pointed out in Section 1.1, there is no internationally standardized definition of access to safe water. According to UNICEF,[8] each nation sets its own definition of 'access' to water. While in some countries access means piped water in each home, in others it means a well within half an hour's walk. The most frequently used definition is that of the United Nations Development Programme (UNDP)[9], which states that those with access comprise "the proportion of the population using any piped water, public tap, borehole with a pump, protected well and springs or rainwater."

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[8] Available at http://www.unicef.org/pon95/heal0014.html, accessed on 1 November, 2011.

[9] UNDP, available at http://www.thelancet.com/journals/lancet/article/PIIS0140-6736%2803%2913703-8/fulltext.

The World Bank provides various definitions dependent on the type of residential area being assessed; "in urban areas for example, such a source [of safe water] may be a public fountain or standpoint located not more than 200 metres away. At the country level, several governments modify the definitions provided by UNDP and the World Bank to apply to their population. However, three factors of distance, time and water quantity are variously used to formulate country-specific definitions".

Joint Monitoring Programme (JMP) for WHO/UNICEF uses the proportion using an improved drinking water source as the indicator for measuring access to safe drinking water in MDG progress reviews. In Kenya, service coverage has been used to describe access (WASREB, 2011) and the three factors of time, distance and quantity are separately assessed to gauge performance.

2.2.1 Human right to water

The Constitution under the Bill of Rights, Article 43 (1) (d) confers on every person the right to clean and safe water in adequate quantities. This right is in line with the International Covenant on Economic, Social and Cultural Rights (ICESCR). To state parties, it implies a considerable state responsibility and action beyond the provision of water for drinking purposes, and extends to water for environmental hygiene and health, as well as for growing food. It also involves accessibility, affordability and non-discriminatory access to water; protection against contamination by harmful substances and pathogenic microbes; and monitoring and combating aquatic ecosystems that serve as a habitat for disease (World Bank, 2004).

Under ICESCR, the state parties also obligate to Respect (refrain from interfering directly or indirectly with the enjoyment of the right to water), protect (prevent third parties such as individuals, groups, corporations or other entities from interfering in any way with the enjoyment of the rights) and Fulfil (take positive measures to facilitate individuals' enjoyment of their rights through the development of strategies, policies and legislative measures to promote the rights by appropriate education concerning the hygienic use of water, protection of water sources and methods to minimize water wastage).

To attain the right to water, state parties should ensure that water supply for each person is sufficient (adequate) and continuous for personal and domestic uses, which ordinarily include drinking, personal sanitation, washing of clothes, food preparation, personal and household hygiene.[10] According to WHO,[11] the minimum amount of water required for survival is 20 litres per person per day. Based on his analysis, Gleick (1996) recommends to service providers to adopt a basic water requirement standard for human needs of 50 litres per person per day. Therefore, about 50 to 100 litres of water per person per day are needed to ensure that the most basic needs are met and few health concerns arise (WHO, 2003).

Borrowing from the human rights and the Constitution, every Kenyan is therefore entitled to about 50 litres of water per day. CESCR acknowledges that due to the limits of available resources, immediate realization of this right to water may be a constraint. Therefore, the right to water requires government activities to progressively increase the number of people with safe, affordable and convenient access to drinking water.[12] WASREB (2011) estimated water consumption per capita for 2009/2010 in Kenya at 102 litres per person per day (l/p/d), based on total water production, while actual per capita was 36 l/p/d after deducting NRW.

Wagah *et al.* (2010) estimated mean water consumption per capita in Kisumu town at 32.92l/p/d, while a study conducted by the World Bank (2005) estimated daily per capita water use in Kenya at 45.2l. Even with the variations, it is important to note that for Kenya to achieve MDGs and human right to water, the rate of increase in access to water should be higher than the rate of population increase, especially in urban areas.

In tandem with its long term socio-economic aspiration, Kenya has always aimed at attaining universal access to safe water for all. The motive saw government expenditure on water supplies and related services increase from Ksh 3 billion in 2004/2005 to Ksh 31 billion in 2010/2011 (Table 2.1).

In 2008/2009, majority of water works were undertaken on expansion and upgrading of existing water supply systems, maintenance of water purification system points, drilling of boreholes

[10] Definition according to United Nations available at http://base.d-p-h.info/es/fiches/dph/fiche-dph-8111.html, accessed on 1 November, 2011.

[11] WHO Technical Notes for Emergencies: Technical Note No. 9.

[12] World Water Council (WWC), available at http://www.worldwatercouncil.org/index.php?id=1764 (28 December, 2011).

Table 2.1: Development expenditure on water supplies and related services (Ksh.Mn)

FY	2004/05	2005/06	2006/07	2007/08	2008/09	2009/10	2010/11
Water development	760.6	1,895.9	3,368.0	4,448.5	9,989.0	13,822.0	21,703.5
Training of water staff	23.3	50	39.0	40.0	25.0	33.0	26.4
Rural water supplies	373.2	789.8	814.0	80.0	1,056.7	1,044.8	1,308.7
Misc. and special water prog.	342.4	236.5	141.5	1,218.0	178.0	216	176.7
NWCPC	463.4	1,974.3	2,031.5	1,733.5	3,002.2	4,034.2	4,877.0
Total	3,317.1	6,598.7	7,592.1	8,414.3	15,290.6	22,264.0	31,338.9

Source: Economic Surveys, 2006-2011

and construction of dams (Government of Kenya, 2009). In 2009/10 through to 2010/11, the government continued to direct its spending at core priority areas of water infrastructure development. Project activities under the water sub-sector were geared towards expansion of water coverage and sewerage facilities, scaling up of water storage to improve water security, and development of irrigation and drainage infrastructure (Government of Kenya, 2011).

2.3 Non-Revenue Water

Initially, UfW and NRW were used interchangeably, though NRW has currently gained wider acceptance following recommendations by the International Water Association (IWA) task force on water loss that use of the term 'unaccounted for water' be discontinued (Alegre *et al*., 2000) because of widely varying interpretations of the term worldwide. While UfW measures volume of water produced but not reaching consumers, NRW defines the difference between the amount of water produced for distribution in the system and the amount of water billed to consumers (WASREB, 2010). It combines both real/physical losses from leakages and bursts, and apparent/commercial losses through illegal connections, unmetered public use, meter error, unbilled metered use and water for which no payment/revenue is collected.

For clarity, we note that NRW and leakage is not one and the same thing. Leakage is a part and sometimes a large part of NRW, but it is just one piece of the puzzle. NRW also includes unauthorized or unmetered use; unavoidable leakage that costs more to locate and repair than it would to permit it to exist; inaccurate metres (master, industrial, commercial and domestic), which could be worn out, improperly installed or have reading errors; and unusual causes such as non-existent metres and leakage of reservoirs (Johnson, 1996).

NRW is increasingly being considered as one of the major issues affecting water utilities in the developing world, and it has been outlooked as a surrogate for a poorly run water utility that lacks the governance, the autonomy, the accountability, the technical and managerial skills necessary to provide a reliable service to their population (Liemberger *et al.*, 2006). As a result, studies on NRW have tended to concentrate on institutional efficiency. Governments and businesses have concentrated on measuring and comparing institutions, with emphasis being placed on performance and profit as an overriding measure of performance at the expense of growth in formal access.

In the year 2005, after WSBs were operationalized in Kenya. The water sector set a target of reducing the level of NRW from 70 per cent to 25 per cent by 2010, and thereafter maintain it below 25 per cent (Kenya Water Report, 2005). The target for NRW was later revised in NWSS (2007) to be reduced from 60 per cent to 30 per cent by 2015. The proposed interventions for reducing NRW included improving efficiency of the water delivery systems from the water source to the households, reducing leaks throughout the network, and reducing technical, management and social losses through rehabilitation of the dilapidated systems, laying new pipes, standard fittings, detecting and fixing leaks, and installing pressure control valves, zonal and bulk meters at key points in the system. The sector adopted the use of Water Resources Information System (WARIS) software as a national reporting system for collection and consolidation of data on water. For the last five years, NRW has increased from 44.7 per cent to 45 per cent, which remains high relative to global average of 35 per cent and sector benchmark of 25 per cent.

2.4 Relationship between Formal Access to Water and Non-Water Revenue

Globally, the volume of NRW is staggering. More than 32 billion cubic metres of treated water is lost through leakage from distribution networks annually, and an additional 16 billion cubic metres are delivered to customers but not invoiced because of theft, poor metering or corruption. In some low income countries, the loss represents 50 to

60 per cent of water supplied against the global average of 35 per cent. Saving just a half of this amount would supply water to additional 100 million people without further investment (Wyeth *et al.*, 2010).

By reducing water losses, water utilities have additional supply to expand services to underserved areas and can reap several other related benefits summarized by Wyatt (2010) as follows: under capacity deficit, which is the situation in many developing countries where water production is constrained by capacity and demand is not being met due to current water losses. If utilities adopt more stringent policies to control NRW (physical and commercial losses), it will increase its initial cost of managing NRW, but the result will yield increase in volume of water available to consumers, increase in revenue at existing tariff (to the extent that such consumption is correctly metred, billed and fees are collected), and make saving on capital cost of expansion.

Other benefits that accrue from reduction of NRW include enhanced access to safe water, creation of new business opportunity, improved customer service and, above all, reduction in illegal connections and greater fairness between legal and illegal categories of water users. In a nutshell, a reduction in levels of NRW should, among other benefits, help increase formal access to water.

2.5 Theoretical Framework

For over two decades, leakage measurement was not based on any scientific measurement; a process that Liemberger and Farley (2005) termed as guesstimation. Current level of achievement can be associated with the efforts of the United Kingdom and other developed countries whose contributions have culminated into a scientific approach that has since been put forward by the IWA to handle the problem of water balance formats, methods and leakage performance indicators. This approach has been adopted variously with or without amendments by key national associations including the American Water Works Association and the African Water Association.

It is globally appreciated that undertaking a water balance or a water audit is the basis for analysis and/or management of NRW. There is no doubt that the foundation for NRW reduction is laid on understanding how much volume of water is lost and why it is lost. Liemberger *et al.* (2010) affirm that many utilities in the developing world have implemented NRW reduction programmes with donor funding, but the results often failed to match expectations because a comprehensive water balance was neither developed nor calculated. Arising from such practices, the gap between the sophisticated NRW reduction programmes in well managed water utilities and the situation in many of the world's water utilities, especially in utilities in developing countries, has been widening at a fast pace.

Kumar (2010) measured the performance of twenty urban water utilities using data from an Asian Development Bank survey of Indian water utilities in 2005. He applied directional distance function as an analytical tool for measuring performance of water utilities. The results reveal that, at the mean level, Indian water utilities had the potential of increasing water delivery levels and reducing UfW by 20 per cent. About half of that could be realized by changing the scale of operation. Metering of the water delivered and the length of the distribution network were major determinants of performance of water utilities.

Salleh[13] favours Data Envelopment Analysis (DEA) as a powerful tool for the analysis of the magnitude and cause of utilities' inefficiency. He argues that econometric analysis approach addresses the effects of different operating environments by statistically adjusting costs for the influence of factors that affect costs, but are beyond managerial control. DEA, on the other hand, uses linear programming to establish an "efficiency frontier" from the most efficient utilities in the data set. His results show that utilities that form the efficiency frontier use the minimum quantity of inputs to produce the same quantity of outputs as other similar utilities.

Leakage and management practitioners are aware that real losses will always exist even in new and well managed systems. The overriding question is the extent to which these unavoidable losses will be. As a rule of thumb, it is often said that there is no point in reducing NRW below 20 per cent of production, because the costs outweigh the benefits. But Singapore disapproved this theory when it managed to reduce its NRW to 5 per cent in 2000 (Mclntosh, 2003).

The IWA water loss task force developed the Economic Level of Leakage (ELL), which outlines the optimal level of physical losses based

[13] Approaches to measuring performance in water services by Hasnul M. Salleh, BSc (Undated internet source). Available at http://www.jba.gov.my/index.php/en/rujukan/papers/134-kertas-kerja/249-aproaches-to-measuring-performance-in-water-services (accessed on 23 February, 2012).

on engineering inputs. It was premised on the understanding that determining the economic level of NRW is essential to setting the initial NRW target, and it requires a comparison of the cost of water being lost versus the cost of undertaking NRW reduction activities (Wyeth *et al*., 2010). The ELL approach has nonetheless been faulted as being less useful in developing countries than in developed countries because it ignores commercial losses, the annualized cost of water supply capacity expansion, and situations in which production capacity does not meet demand (Wyatt, 2010).

Wyatt *et al*. (2010) have introduced a financial model for optimal NRW management in developing countries. The model computes optimal NRW for a given utility, from a modest commonly known set of site specific data, and uses default values where specific in-country data are not readily available. This model is still being developed though specifically for conditions in Africa.

For various reasons including data limitation, total elimination of NRW in developing countries might not be feasible. However, reducing the current level of water losses by half is a realistic target (Kingdom, Liemberger and Marin, 2006). This target has not been achieved either, probably because reduction of NRW is not just a technical but also a socio-economic issue.

Kingdom, Liemberger and Marin (2006) observed that even progressive reduction of NRW, both physical and commercial water losses, are not popular with key actors such as engineers, politicians, technicians and managers. The politicians, for instance, do not support NRW management because there is no "ribbon cutting" involved, and unpopular decisions such as disconnection of illegal consumers have to be made. Engineers feel it is more "fun" to design treatment plants than to fix pipes buried under the road, while managers feel that managing NRW needs time, constant dedication, staff, and upfront funding. Given the choice, it has been much easier for managers to close any revenue gap by just spending less on asset rehabilitation and letting the system slowly deteriorate, or asking the government for more money.

The World Bank (2009) report on best African utilities brings out a clear linkage between NRW levels and formal access to water. Utilities with low NRW levels progress well on service coverage. Cited cases include Johannesburg water with target population of 3.2 million. About 35 per cent of its water was lost but service coverage stood at 75 per cent. ONEA in Burkina Faso had service coverage of 84 per cent from a target population of 2.8 million, and NRW level was 18.5 per cent. SONEDE in Tunisia achieved 20 per cent level of NRW, with service coverage of 99 per cent in urban areas and 89 per cent in rural areas from a target population of 8.17 million.

2.6 Synthesis

From the theoretical background, it is evident that NRW is still a new concept that is gradually gaining acceptance and better understanding among developing countries such as Kenya. Previous studies on NRW have tended to focus mostly on institutional performance efficiency, developing a suitable methodology for accurate estimation of the water losses, and implementation of the correct methodology to achieve desired results. Major contributions can be attributed to the efforts of Seago (2007) and Kingdom, Liemberger and Marin (2006), among others.

Arising from the literature review, the need for a water audit/balance cannot be over-emphasized as it forms the basis for knowing the volume of water lost, the balance components, and strategy for improving the accuracy of the water balance results. African countries will soon be able to determine the optimal NRW levels for their utilities once the financial model being developed by Wyatt and colleagues is finalized. In the meantime, it is assumed that current levels of NRW in Africa can be reduced by 50 per cent or maintained below 30 per cent as the ELL.

The study's approach underscores the fact that water balance and institutional efficiency are necessary for achieving the desired level of NRW, but that alone may not offer sufficient attestation for best performing utilities in terms of performance outcome or benefit to the target population. The magnitude of change in access arising from changes in NRW under the current level of production should be established. To achieve this, the study focuses on establishing not only the relationship between NRW and formal access to water, but also the effect of proportionate changes on target population, taking cognizance of the constitutional right to water.

A similar approach was pursued by Shafik (1994) in his econometric analysis of the relationship between economic growth and environmental quality. He hypothesized four determinants of environmental quality: endowment, income, technology and policy. Indicators of

Table 2.1: The standard IWA water balance

System Input Volume (corrected for known errors)	Authorized consumption	Billed authorized consumption	Billed metered consumption (including export)	Revenue water
			Billed unmetered consumption	
		Unbilled authorized consumption	Unbilled metered consumption	Non-revenue water (NRW)
			Unbilled unmetered consumption	
	Water losses	Apparent losses	Unauthorized consumption	
			Customer metering inaccuracies	
			Systematic data handling errors	
		Real losses	Leakage on transmission and/or distribution mains	
			Leakage and overflows at utility's storage tanks	
			Leakage on service connections up to point of customer metering	

Adopted from Farley and Trow, 2003 in Wyatt, 2010

environmental quality were used separately as dependent variables in panel regressions based on Ordinary Least Square estimates. Environmental quality indicators analyzed by Shafik were lack of clean water, lack of urban sanitation, ambient levels of Suspended Particulate Matter (SPM), ambient sulphur oxides (SO^2), dissolved oxygen and fecal coliforms in rivers (used to measure quality of stock of natural resources). His regression results indicate that access to clean water and urban sanitation improve with higher per capita incomes. He also tried cross-section regression but the results were less robust. He attributed the findings to data limitation and the wide variations in country coverage across years.

2.7 Conceptual Framework

Until the early 1990s, there was no reliable and standardized method for accounting for water losses. In 2002, the IWA task force on water developed best practice on all aspects of water loss, and has since become the most widely accepted framework for describing NRW.

The IWA water balance has however been faulted for failing to fully incorporate the situation in developing countries. For example, during the assessment of the potential savings from water conservation/ water demand management for the Gauteng area, it was found that the standard IWA water balance lacked some information required by the project team to estimate realistic savings. The problem was particularly significant in South Africa, and it was due in part to the "free basic water allowance" and in part to the high levels of non-payment for "billed authorized" water (McKenzie *et al.*, 2007).

According to WASREB (2011), commercial losses result from poor management accounts for the highest proportion of NRW in Kenya. Most causes of these commercial losses are attributable to unbilled authorized consumption and billed unmetred consumption. This makes the IWA water balance a suitable tool for understanding the balance components/aspects of water losses, and for devising a way forward in Kenya. The IWA water balance therefore formed the premise on which the model was conceptualized by the researcher.

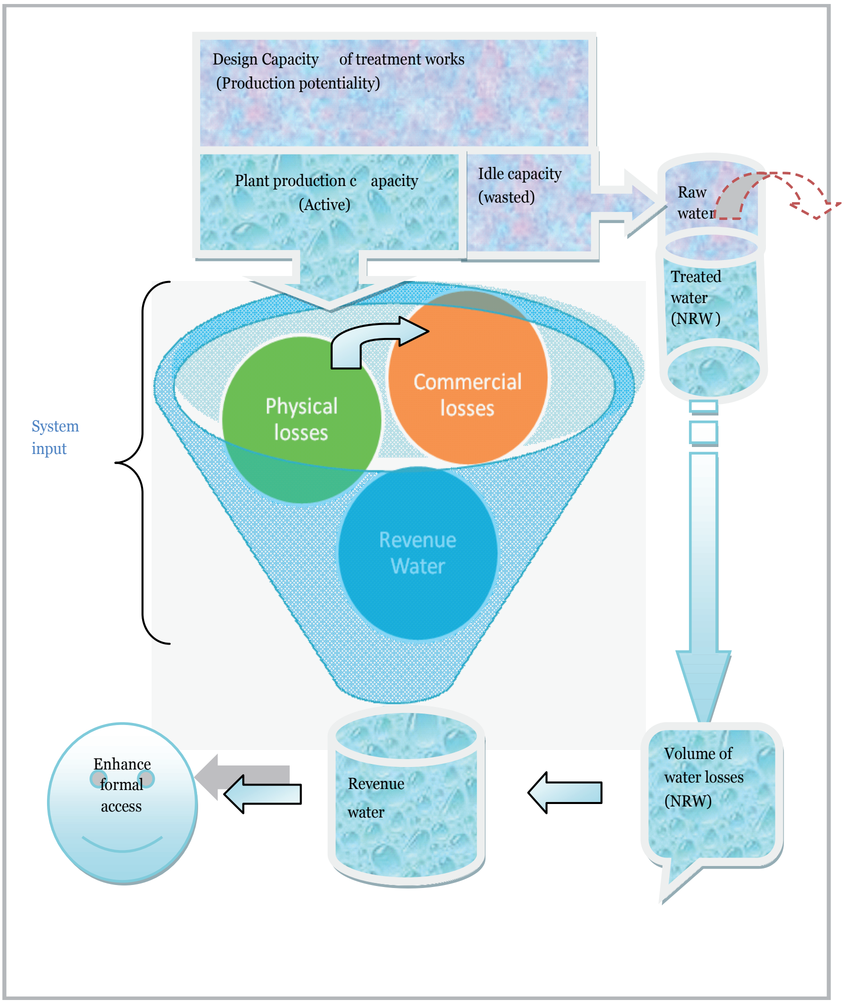
2.8 Conceptual Model

The model is founded on the premise that most utilities in Kenya do not operate at full capacity. The idle capacity marks the initial water losses, though for raw water this is not within the scope of the study. The active plant capacity processes water and channels into the system input. From the IWA model, physical and commercial loses are incurred as the system operates, and only a portion of system input is accounted for as revenue water. The other component constitutes the NRW, which varies with utilities.

The researcher conceptualizes using various strategies, especially those that are aimed at reducing commercial losses; the WSPs will reduce NRW by a certain margin. Through this reduction, some volume of water, which varies with the capacity of the water treatment facility, will be saved. Even at constant level of production, the WSPs will have at their disposal more input in the revenue water reservoir. If there is a proper linkage between NRW and access to water, then the additional volume of water arising from savings made from NRW should positively impact on formal access. The WSPs and the public further stand to gain more from cross effects such as financial sustainability, affordability, increased quantity and quality, improved health and productivity, as long as the additional volume of water is channelled to current and new paying customers.

If the WSPs choose to ignore NRW but increase the production capacity of the treatment facility, then for every additional one unit of water produced an average of 42 per cent or more is likely to be lost to NRW.

Figure 2.1: Conceptual model



3. Methodology

The new institutional framework under Water Act (2002) introduced a separation of responsibilities for sector institutions as elaborated under Section 2.1. In discharging its mandate of monitoring and evaluating the performance of WSBs and WSPs, WASREB uses Water Regulation Information System (WARIS) software to collate data and information from the WSBs and WSPs. The data is then compiled and presented annually through the WASREB's impact reports. The regulator has so far produced four (4) reports since 2008. Currently, there are 93 registered WSPs countrywide, comprising of urban (62) and rural (31) WSPs.

3.1 Empirical Model

Adequate access globally takes into consideration the three factors of time taken to fetch water, including time on queue, distance to the nearest source-estimated at 150-200m in urban setting, and quantity. This can be expressed functionally as:

A=F(Qtty, dist, time).. 1.1

Where A=Access, Qtty=Quantity, dist=distance, time=time taken.

Formal access, which is the focus of the study, takes into consideration piped water that is within the premises or public standpoints within 200m. Due to data inadequacy, it is assumed that all urban customers that are served by urban WSPs have piped water in their premises or at public standpoints within the recommended distance. Similarly, data on hours of supply was found to provide a better estimate for formal access to water as opposed to time taken to fetch water, which seemed rural oriented. However, services provided by small scale and very small scale WSPs such as water vendors are not considered in this study, because they have not been mainstreamed in water service provision. This is in line with Section 56 (1) (a) of the Water Act (2002), which states that no person shall.... provide water services to more than 20 households... except under the license, unless the supply is made to employees or otherwise as specified in section 56(3) of the Act. In this regard, water service provision without a license is regarded as illegal.

The study adopted the model used by Shafik (1994) to analyze the relationship between economic growth and environmental quality. It borrows from Shafik's model; the choice of variables was determined by indicators and data availability, and the choice of cross-section regression was based on observations. Unlike Shafik's model, the study did not use regress indicators separately, but combined them to capture the combined effects.

Using service coverage as synonymously used in Kenya to define access to water (WASREB, 2008), then from equation 1.1, formal access to water in urban areas can be expressed as follows, assuming distance condition is always met:

$$A=f(hrs, prod) \qquad 1.2$$

Where hrs=hours of supply and prod=water quantity produced

Therefore,

$$A=\beta_0+\beta_1 Prod+\beta_2 Hrs+\varepsilon \qquad 1.3$$

But part of system input is lost to NRW, which we target to recover.

Therefore,

$$A_i=\beta_0+\beta_1 Prodi+\beta_2 Hrs+\varepsilon_r \qquad 1.4$$

3.2 Data Sources and Analysis

Cross-sectional data for 2009/2010 was used because: (i) the short duration of time over which the reformed water institutions have been in operation could not favour time series method; (ii) cross-sectional data gives better coefficients for estimating relationships, even though it cannot be used to predict outcome on the basis of time; and (iii) in the previous WASREB reports, there was a mix of urban and rural WSPs. Only Issue No. 4 captured accurately the sector performance with clear separation between urban and rural WSPs (WASREB, 2011).

The cross-sectional data was obtained from 62 urban WSPs (giving summary report for all urban centres in Kenya) as provided in the WASREB report. Additional data and information was obtained from secondary and tertiary sources.

Regression analysis using Ordinary Least Squares method of estimation and correlation analysis was used to establish the relationships. This was supported by use of EViews and SPSS software.

4. Findings and Discussion

4.1 Relationship between NRW and Formal Access to Water

Regression analysis results (Appendix Table 1) show an inverse linear relationship between NRW and formal access to water, meaning that as NRW increases, formal access to water tends to decrease and vice versa. This initial finding is consistent with the World Bank (2009) report, which indicates that low NRW corresponds to high service coverage/ access.

The findings also illustrate that 42 per cent of the formal access is explained by hours of supply, NRW and quantity of water produced. Access is significantly explained by the coefficients of hours of supply and production at 5 per cent level, while the coefficient of NRW is significant at 10 per cent level. This shows that access is most affected by production and distribution, without which NRW will not be there either.

Table 3.1: Relationship between NRW and formal acces to water

Dependent variable: Access		
Variables	**Coefficient**	**Std. Error**
Hours of supply	9.764041	3.828569
Non-revenue water	-14.90616	8.803493
Water produced	22.81274	9.631313
C	-107.7742	26.04445
R-squared	0.420035	
Adjusted R-squared	0.390037	

Source: Author's analysis

$A = 107.7742 + 22.81274prod - 14.90616nrw + 0.976404hrs$

(se) (26.04) (9.63) (8.80) (3.23)

Regression test results (white heteroskedasticity, histogram-normality, breusch-godfrey serial correlation LM and ramsey RESET tests) demonstrate that the variance of residuals is constant (homoskedastic); they follow a normal distribution with no serial correlation, and that the model is linear (Appendix Tables 2, 3, 4 and 5). Therefore, the model above is a well specified and reliable estimate.

Therefore, it can be construed that a one percent reduction in NRW can yield up to 15 per cent increase in formal access to water. However, the statistical significance of the error term shows that the combined effect of omitted variables is equally significant. These variables, according to Stewart and Edoardo (2011) include water demand, chemical and energy use, capital and operating costs per unit of water supply that collectively influence system efficiency and economic viability. Due to lack of data, these variables were not included in the model.

4.2 Magnitude of Effects

Effect on urban population

Supposing production is held constant at the current level of 303,177,000m^3 in a year. From the estimate, a reduction in NRW by one per cent yields a proportionate increase in formal access to water by 15 per cent. This translates into an increase in access from the current 39 per cent to 54 per cent, resulting from respective increase in volume of revenue water from 166,747,350m^3 to 168,111,647m^3. As a result, a total of 11,130,221 people out of the estimated urban population of 20,261,520 (WASREB, 2011) will have adequate access to safe water.

Consumption per capita for the new urban population served will be 42 l/p/d, which is slightly below the recommended adequate access of 50 l/p/d, but twice more than the WHO required minimum of 20 l/p/d, which was adopted by MWI (MWI Handbook, 2007). 42l/p/d is also above WASREB estimate of 36l/c/d for 2009/2010 (WASREB, 2011) and consistent with findings by Gulyani *et al.* (2005), which average per capita water use in urban households in Kenya, including provision by small scale providers (water vendors), at 40 to 45 litres per capita per day.

[14] The conventional dictum that "correlation does not imply causation" means that correlation cannot be used to infer a causal relationship between the variables, but should not be taken to mean that correlations cannot indicate the potential existence of causal relations (John, 1995). "Correlations Genuine and Spurious in Pearson and Yule". Statistical Science 10 (4): 364–376. doi:10.1214/ss/1177009870 in http://en.wikipedia.org/wiki/Correlation_and_dependence#cite_note-10 (accessed on 23 February, 2012).

Effects on economy in monetary terms

Using average tariff of Ksh 53.00 per m^3 given by WASREB (2011), it is estimated that the water sector has potential for increasing revenue collection by Ksh 72,307,714 owing to one per cent reduction in NRW. Using the public rate of Ksh 2.00 per 20 litres charged at water kiosks, then the rise in revenue doubles to Ksh 136,429,650.

It is evident that the urban population who are dependent on water kiosks are paying more than those with service connections at the premises. Using the average tariff of Ksh 53 per 1,000 litres against the authorized Ksh 2.00 per 20 litres charged at the water kiosks, a consumer with service connection within the premises pays Ksh 1.06 per 20 litres, which is about half of what the public pays at the regulated water kiosks but 20 times less than what the water vendors charge. The additional cost of water service is thus an avoidable burden on households' budget.

4.2 Correlation between NRW and Other Performance Indicators

Correlation results (Table 4.1) yield inverse relationships between NRW and other performance indicators that are linked to access. Thus, as NRW increases, access to water and other performance indicators linked to access, namely water quality, metering ratio, and revenue collection efficiency, will possibly[14] reduce and vice versa. This is because NRW reduces the volume of water supplied to customers, increases operating costs, and reduces revenue stream (Frauendorfer and Liemberger, 2010).

NRW and metering ratio

From the table, the statistically significant negative coefficient of correlation between NRW and metering ratio indicates that NRW will tend to reduce the ratio increases. All other variables (access, water quality, hours of supply and revenue collection efficiency) have statistically significant positive correlation coefficient with metering ratio. This underscores the importance of metering on water service provision. UNESCO (2003) reports that Singapore achieved an impressive six per cent level of NRW through consistent monitoring programme that was based on metering, audit of commercial water use and leak detection.

Table 4.1: Correlation matrix

		Access	Qlty	Hrp	Metr	Colef	NRWp
Access	Pearson Correlation	1	0.279(*)	0.541(**)	0.422(**)	0.138	0-.126
	Sig. (2-tailed)	.	0.037	0.000	0.001	0.283	0.328
	N	62	56	62	62	62	62
Qlty	Pearson Correlation	0.279(*)	1	0.475(**)	0.297(*)	0.187	-0.172
	Sig. (2-tailed)	0.037	.	0.000	0.026	0.168	0.206
	N	56	56	56	56	56	56
Hrp	Pearson Correlation	0.541(**)	0.475(**)	1	0.431(**)	0.358(**)	-0.143
	Sig. (2-tailed)	0.000	0.000	.	0.000	0.004	0.268
	N	62	56	62	62	62	62
Metr	Pearson Correlation	0.422(**)	0.297(*)	0.431(**)	1	0.483(**)	-0.269(*)
	Sig. (2-tailed)	0.001	0.026	0.000	.	0.000	0.034
	N	62	56	62	62	62	62
Colef	Pearson Correlation	0.138	0.187	0.358(**)	0.483(**)	1	-0.082
	Sig. (2-tailed)	0.283	0.168	0.004	0.000	.	0.526
	N	62	56	62	62	62	62
NRWp	Pearson Correlation	-0.126	-0.172	-0.143	-0.269(*)	-0.082	1
	Sig. (2-tailed)	0.328	0.206	0.268	0.034	0.526	.
	N	62	56	62	62	62	62

* Correlation is significant at the 0.05 level (2-tailed).
** Correlation is significant at the 0.01 level (2-tailed).
Source: Author's analysis

A further assessment of individual WSPs data on performances depict a wide statistical range of 100 per cent metering ratio that vary from zero per cent (in Rumuruti, Sibo, Mandera, Olkejuado, Nol Turesh and Gulf WSPs) to 100 per cent (in Eldoret, Nyeri, Nanyuki, Embu, Kericho, Kisumu, Muranga, Kiambu, Tarda Kiambere, Wote, Karuri and Kitui WSPs) (WASREB, 2011). The average ratio from 2009/2010 data was 69 per cent, and only 17 WSPs out of the 62 attained the acceptable sector benchmark of above 95 per cent. It means that most customers in Kenya are on flat rate connections. This contributes to the increasing levels of NRW against reducing levels of access. Liemberger and Farley (undated) also established that flat rate connections do not encourage sensible water use and mending of customer leaks by companies due to insufficient revenue generated.

NRW and hours of supply

The negative correlation between NRW and hours of supply shows that hours of supply will tend to increase as NRW reduces, though this is not statistically significant in Kenya because increases in hours of supply have tended to result from rehabilitation/expansion of facilities. For example, most Kisumu town residents currently enjoy 24 hours of water supply after LVSWSB augmented the capacity of Dunga treatment works by 24,000m^3 per day, and not from reduction in NRW. Unfortunately, without extension of distribution system, benefits from expansion work does not accrue to customers without service connections.

In the Citizen report card (2007), it was observed that water companies are relying heavily on access to mains through water kiosks to achieve their benchmarks for coverage, despite the fact that kiosks offer much lower level of service than connections within premises. Those in support of water kiosks argue that kiosks provide a flexible, desirable and good service to the poor, by allowing them to purchase in small quantities as and when they have money. Nonetheless, Gulyani *et al.* (2005) found out that kiosks are the least preferred "improvement" option among unconnected urban households in Kenya.

Liemberger (2011) also established that a utility reporting 30 per cent NRW and supplying water for only six hours per day will have its NRW jump to 60 per cent, if it moves to constant supply without fixing the network. Accordingly, stating NRW in percentage terms is also a problem in itself. Consider for instance, the case of Nyeri and Gulf, which were respectively the best and worst performing WSPs in 2009/2010. Using percentages, the NRW levels for Nyeri and Gulf were 31 per cent and 59 per cent, respectively, portraying worst performance by Gulf. However, in actual terms, Nyeri WSP lost more water amounting to 1,467,540,000 litres relative to Gulf WSP's water loss of 391,170,000 litres.

NRW and revenue collection efficiency

As NRW reduces, formal access to water will tend to increase and vice versa. However, revenue collection efficiency will remain the same. The statistical insignificance of the coefficient of correlation between access and revenue collection efficiency can be explained by weak commercial orientation in management of WSPs and reliance on government subsidies in form of staff deployment, provision of water treatment chemicals, and payment of electricity bills, which largely remain unaccounted for (WASREB, 2011).

Businesses are of great concern as no business can survive for long if it losses as much as 80 per cent of its product as witnessed among some WSPs such as Eldama Ravine during 2009/2010. WASREB (2011) equally admits that information submission on investments is poor, and there is no correlation between the number of approved regular tariff adjustments, and the coverage of operational costs contrary to the objective of the tariff process. Wambua (2004) also observed that the Water Act broadly sets out the policy implementation framework, but is weak on clearly elaborating and outlining government policy on privatization in the water sector.

NRW and water quality

As NRW increases, water quality is expected to reduce and vice versa. However, the coefficient of correlation is not statistically significant because most water losses are through commercial sources such as unmetered use, meter error and unbilled metered use, which ideally does not contaminate water in the system.

As access increases, water quality will equally tend to increase and vice versa. The coefficient of correlation is not statistically significant due to the component of physical losses. If WSPs have a proper system maintenance programme in place, leakages and bursts that contaminate water would be minimized.

5. Conclusion and Policy Implications

5.1 Conclusion

It is globally acknowledged that non-revenue water is a key indicator of operational utilities and financial performance which manifests in the level of access to safe water for the population. The study was premised on assessing the effect of non-revenue water on access to water and on other performance indicators that are linked to access. From the results and discussion, we can conclude that water treatment or production capacity in the country can adequately serve the urban population, but subject to system efficiency and economic viability. Precisely, if one per cent reduction in non-revenue water can trigger a proportionate increase in formal access by 15 per cent and enable 54 per cent of urban population to gain access to water at a reasonable consumption per capita of 42 l/p/d, then reducing the current level of non-revenue water by a half will justifiably enable the attainment of the constitutional right to water. Therefore, proper management of non-revenue water presents a sustainable "soft path" for enhancing formal access to water in Kenya.

5.2 Policy Implications

Water sector reforms were intended to enhance access to safe water for all. To achieve this, the Water Act (2002) attempted to address weaknesses in policy regulation and service provision characteristic in the previous Act, Cap 327. The expected output from service provision included increased coverage, improved management, ability to attract and retain manpower, efficient provision of services leading to self sustainability, and ability to attract investments and improve infrastructure (Government of Kenya, 2007). Progress reports show a sluggish improvement in access to water against the backdrop of increasing water losses. The study findings indicate that there is adequate water production capacity that can support daily water requirement for all urban population. To realize this, the following policy issues should be addressed:

System efficiency and economic viability

The inverse relationship between non-revenue water and access to water, together with other performance variables that are linked to access, calls for aggressive reduction in non-revenue water. Reduction in non-revenue water is better achieved when utility systems are viable and efficient. But system viability and efficiency require financial sustainability. Therefore, the water services sub-sector should enhance collection efficiency and practise strict financial management so that a portion of revenue collected is ploughed back to maintain the distribution network.

Due to regional imbalances, it is advisable that the expansion of distribution networks permits regional linkage to promote bulk purchase across WSBs or counties. The current licences issued by WASREB already have provisions for bulk purchase between WSPs and WSBs. Moreover, the Delegated Management Model (DMM) which has been piloted by some WSPs such as Kisumu Water and Sewerage Company (KIWASCO) also borrows from the concept of bulk sales.

The water sector institutions should collectively help the public to understand that water is a right but not a free commodity, and all rights come with responsibilities attached. The public has to pay the water tariff and refrain from wasting water. The attainment of financial sustainability also calls for a culture change; a change from over-reliance on government subsidies to commercial re-orientation.

Estimation and understanding of the magnitude of losses

Analysis of magnitude of effects shows that losses can largely be underestimated if not ignored. The significance of the omitted variables is an indication of data gaps, which should be addressed by WASREB. An accurate estimation requires undertaking a water balance. WSBs/WSPs should adopt the use of supportive tools such as World Bank's EasyCalc for accurate estimation and clear separation of physical and commercial losses. WASREB should also ensure that data submitted by WSBs and WSPs is adequate, accurate and verifiable. It might be necessary for the sector to undertake periodic household surveys to obtain household response data for comparison.

For the water services sub-sector to better understand the magnitude of water losses, it should also consider adopting indexing method in its monitoring and evaluation system to better estimate access directly using the universal factors of time distance and quality. Indexing will also help in reducing errors in use of percentages, as was in the case of Nyeri and Gulf WSPs. Targets for reducing NRW should be prioritized and adjusted accordingly through strict monitoring and analysis. The 15 per cent estimate from study findings can be adopted as a gauge, but without losing track of WSPs unique conditions of operation. The Ministry of Water and Irrigation should also incorporate a reward/ penalty system so that WSPs incurring losses above the maximum permissible level assume the cost of losses, so as to gradually reduce direct subsidies extended to WSPs.

Metering and system maintenance

The statistical significance of the correlation coefficient between metering ratio and all other variables underscores the importance of metering. The WSPs should learn from Singapore and other providers, and have in place a sustainable metering programme for domestic, industrial, commercial as well as zonal and bulk flow meters, aside with meter replacement policy to achieve efficient operations.

Economic evaluation of water demand management measures is important to ensure that cost effective measures are implemented in the right sequence. It might even be appropriate for the sub-sector players to ensure that all customers are metered, before establishing the right tariff system to ensure fairness and gain public support in water services provision.

Public awareness raising and involvement

The public can benefit from increases in hours of supply arising from reduction in NRW, only if they have direct service connections. The WSPs should therefore sensitize the public to realize the benefits that accrue from efficient water utilization, and due from having legal service connections within premises. Through public awareness raising and involvement, the public will also realize savings on costs associated with purchasing water from unregulated vendors and/or of using water that is sourced from unsafe alternative sources.

Policies that are aimed at dissuading users not to commit fraud should be introduced. This includes giving incentives to honest users, and providing payment options to give disconnected users opportunities to have their services back because disconnections attract illegal reconnections and increase non-revenue water.

Incorporating lessons learnt in reviewing regulatory instruments

Constitutionally, the mandate of water service provision has shifted from the Central government through the Ministry of Water and Irrigation to the county governments. The transition therefore provides a window through which next level water service institutions can learn from past weakness and strengthen future service provision. The re-alignment of Water Act (2002) to the Constitution should therefore take cognizance of the past undoing in the structure, especially with regard to government policy on privatization/commercialization *vis a vis* the institutions mandate. The general public good should dominate public policy for counties to deliver water service as a constitutional mandate.

Owing to governance issues in the water sector - though not directly analyzed in the study, innovative measures replicating DMM or introducing outsourcing of NRW management activities through Performance Based Contracts (PBC) are worth considering. Fanner (2004) details the benefits of using PBCs to reduce NRW and provides several examples of successful contracts undertaken over recent years. Liemberger *et al*. (2006) confirm that activities aimed at reducing commercial losses are technically easy to carryout but politically difficult because it often requires taking a strong stance against fraudulent practises of utility staff and a portion of the population that benefit from status quo. The strong stance against fraudulent practises can better be taken by a contracted party. There is also need to mainstream other feasible options such as computerized billing, rolling out prepaid water meters, and mobile banking alongside institutional capacity development in change management for improved sector performance.

In the words of Johnson (1996), NRW is born from poor maintenance and can die of effective maintenance. In order to put "RIP" to NRW, utilities must choose to review the amount of NRW in the system, identify areas of NRW and purge the system to remove as much NRW as possible. By reducing NRW, unmet demand would possiblly be met, revenues enhanced and future capital expenditure would then go to development of additional supply (Karanja, 2011). Therefore, addressing NRW is a cheaper way of enhancing formal access to water.

5.3 Suggestions for Further Research

The scope of this study was limited to formal access to water due to inadequacy of data and time. However, a similar research can be undertaken to assess the effect of non-revenue water management on sustainability of water sources in Kenya.

Secondly, a citizens' report on urban water, sanitation and solid waste services carried out in Nairobi, Mombasa and Kisumu in 2007 provides information about customers' perception of water quality, which is a component of access; about 70 per cent of households using water from connections to the mains found the taste and smell of water acceptable, and that the water was clear. Even so, the vast majority of respondents treat water prior to consumption, arguably oblivious of the long term effects of this action on human health. Therefore, research could be undertaken on the impact of home-based domestic water treatment on human health and proper management of non-revenue water as a remedy.

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Annex

Annex Table 1: Relationship between non-revenue water and formal access to water

Dependent Variable: ACCESS				
Method: Least Squares				
Included observations: 62				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LHRS	9.764041	3.828569	2.550311	0.0134
LNRW	-14.90616	8.803493	-1.693210	0.0958
LPROD	22.81274	9.631313	2.368601	0.0212
C	-107.7742	26.04445	-4.138085	0.0001
R-squared	0.420035	Mean dependent var		39.09677
Adjusted R-squared	0.390037	S.D. dependent var		24.18014
S.E. of regression	18.88472	Akaike info criterion		8.776924
Sum squared resid	20684.70	Schwarz criterion		8.914159
Log likelihood	-268.0847	F-statistic		14.00201
Durbin-Watson stat	2.038427	Prob(F-statistic)		0.000001

Annex Table 2: Test for homoscedasticity: White heteroskedasticity test

F-statistic	0.665144	Probability		0.736141
Obs*R-squared	6.400660	Probability		0.699245
Test Equation:				
Dependent Variable: RESID^2				
Method: Least Squares				
Sample: 1 62				
Included observations: 62				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-394.2073	5540.812	-0.071146	0.9436
LHRS	-1222.446	1412.176	-0.865647	0.3907
LHRS^2	11.83625	110.8410	0.106786	0.9154
LHRS*LNRW	-1077.939	600.1699	-1.796057	0.0783
LHRS*LPROD	1114.718	631.2555	1.765875	0.0833
LNRW	-1897.440	3160.657	-0.600331	0.5509
LNRW^2	-605.9966	684.5131	-0.885296	0.3801
LNRW*LPROD	1481.629	1496.990	0.989739	0.3269
LPROD	2083.868	3623.170	0.575151	0.5677
LPROD^2	-878.0984	829.8177	-1.058182	0.2949
R-squared	0.103236	Mean dependent var		333.6241
Adjusted R-squared	-0.051973	S.D. dependent var		466.1534
S.E. of regression	478.1135	Akaike info criterion		15.32426
Sum squared resid	11886813	Schwarz criterion		15.66735
Log likelihood	-465.0522	F-statistic		0.665144
Durbin-Watson stat	1.673803	Prob(F-statistic)		0.736141

Annex Table 3: Test for serial correlation in the residuals: Breusch-Godfrey Serial Correlation LM test

F-statistic	0.391647	Probability		0.677780
Obs*R-squared	0.855255	Probability		0.652054
Test Equation:				
Dependent Variable: RESID				
Method: Least Squares				
Presample missing value lagged residuals set to zero.				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LHRS	0.758301	3.963142	0.191338	0.8490
LNRW	0.250417	9.077752	0.027586	0.9781
LPROD	-0.038946	9.923681	-0.003925	0.9969
C	-4.729456	27.08951	-0.174586	0.8620
RESID(-1)	-0.085312	0.144122	-0.591942	0.5563
RESID(-2)	-0.101060	0.143133	-0.706055	0.4831
R-squared	0.013794	Mean dependent var		1.12E-14
Adjusted R-squared	-0.074260	S.D. dependent var		18.41449
S.E. of regression	19.08597	Akaike info criterion		8.827550
Sum squared resid	20399.36	Schwarz criterion		9.033402
Log likelihood	-267.6540	F-statistic		0.156659
Durbin-Watson stat	1.930994	Prob (F-statistic)		0.977131

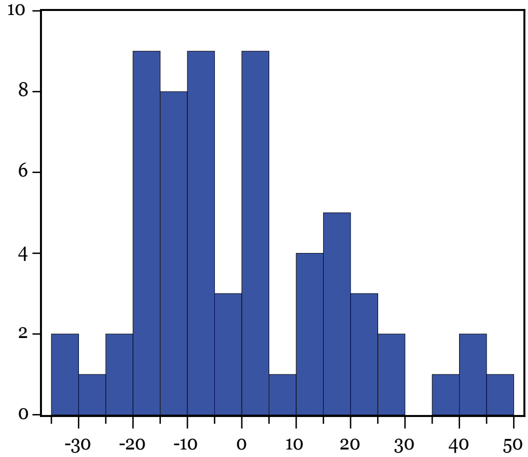
Annex Table 4: Test for linearity: Ramsey RESET test

F-statistic	4.190570	Probability		0.020138
Log likelihood ratio	8.647082	Probability		0.013253
Test Equation:				
Dependent Variable: COVG				
Method: Least Squares				
Sample: 1 62				
Included observations: 62				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LHRS	-29.96576	14.69387	-2.039337	0.0461
LNRW	48.47014	23.48241	2.064104	0.0437
LPROD	-73.66243	34.56372	-2.131207	0.0375
C	382.9823	171.5554	2.232411	0.0296
FITTED^2	0.112107	0.041563	2.697271	0.0092
FITTED^3	-0.000870	0.000356	-2.444017	0.0177
R-squared	0.495535	Mean dependent var		39.09677
Adjusted R-squared	0.450493	S.D. dependent var		24.18014
S.E. of regression	17.92442	Akaike info criterion		8.701971
Sum squared resid	17991.96	Schwarz criterion		8.907823
Log likelihood	-263.7611	F-statistic		11.00173
Durbin-Watson stat	2.051182	Prob(F-statistic)		0.000000

Table 5: Regression

Dependent Variable: NRWP				
Method: Least Squares				
Sample: 1 62				
Included observations: 56				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
COLEF	0.062006	0.109275	0.567426	0.5729
METR	-0.174622	0.063164	-2.764583	0.0079
QLTY	-0.030432	0.061961	-0.491145	0.6254
C	56.99344	8.957098	6.362935	0.0000
R-squared	0.160501	Mean dependent var		48.05357
Adjusted R-squared	0.112069	S.D. dependent var		13.48996
S.E. of regression	12.71160	Akaike info criterion		7.991656
Sum squared resid	8402.408	Schwarz criterion		8.136324
Log likelihood	219.7664	F-statistic		3.313908
Durbin-Watson stat	2.358053	Prob(F-statistic)		0.026955

Annex Figure 1: Test for normal distribution: Histogram-normality test



Series: Residuals	
Sample 1 62	
Observations 62	
Mean	1.12e-14
Median	-4.572470
Maximum	45.82438
Minimum	-33.21063
Std. Dev.	18.41449
Skewness	0.653918
Kurtosis	2.920795
Jarque-Bera	4.434835
Probability	0.108890

Kenya Institute for Public Policy Research and Analysis
Bishops Garden Towers, Bishops Road
PO Box 56445, Nairobi, Kenya
tel: +254 20 2719933/4, 2714714/5, 2721654, 2721110
fax: +254 20 2719951
email: admin@kippra.or.ke
website: http://www.kippra.org

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