Assessment of Unaccounted For Water Strategies In Service Delivery: Case Of Nakuru Water And Sanitation Services Company, Kenya

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ABSTRACT
Water is an important natural resource, indispensable for life and also the backbone of growth and prosperity for mankind. Kenya is a water scarce country with renewable fresh water per capita at 647m^3 against the United Nations recommended minimum of 1,000m^3. Despite the efforts made by the Government of Kenya, Unaccounted-for-Water (UFW) is still high, currently standing at 49%.
The overall objective for this study was to assess the strategies for reducing UFW in water supply systems. The scope focused in identifying areas for improving the water supply systems at NAWASSCO. The target population was 296, out of which 42 were employees of RVWSB and 254 were employees of NAWASSCO. Data was collected through interviews and questionnaires and analyzed using Statistical Package for Social Sciences (SPSS). Descriptive statistics such as, bar graphs, percentages and means were used to present the results.
The research findings indicate that majority of employees working in water supply systems are in operations level, considering that majority are diploma holders, their capacity should be enhanced. The research confirmed that on average, the level of Unaccounted-for-Water at NAWASSCO was at 45%, this is in concurrence with the 2010 Impact Report by WASREB. It was further established that implementation of appropriate strategies to reduce UFW enables water supply systems to serve more customers for longer periods and thus WSPs realize high revenue. Therefore, sustainable resource utilization, monitoring and control measures, modern technology and improvement of existing regulatory mechanisms were found to be instrumental in enhancing efficiency of water supply systems.
Key Words: Unaccounted For Water strategies, Nakuru Water & Sanitation Services Company

1.0 Background

Water is an essential resource, vital for sustaining life and fostering economic and social development in a country. When it is too much or too little, it can bring destruction, misery or death (GoK-NWSS, 2007). Irrespective of how it occurs, if appropriately managed, it can be an instrument for economic growth. The WHO/ UN-Water Global Annual Assessment of Sanitation and Drinking Water (WHO, 2010) indicates that diarrhea, a water borne disease is the second leading contributor to the global burden of disease more than heart diseases, HIV/AIDS and military conflicts. Unaccounted-for-Water (UFW) is a major component of the problem; indeed, it is a significant challenge in many developing countries.

Unaccounted-for-water (UFW) is the difference between the total amount of water leaving treatment facilities and the total amount of water measured at customers' meters (Denver water, 2011). The terms Unaccounted-for-Water (UFW) and Non Revenue Water (NRW) has been used interchangeably, the International Water Association (IWA) recommends the use of NRW. The elements that contribute to UFW are; leakages, inaccurate meters, water consumed but not metered, unbilled metered water, improper meter reading and billing errors (Krohne, 2010). Non-revenue water (NRW) includes physical/real losses and commercial losses/non-physical losses (Wyatt, 2010).

Water scarcity is defined by UN-Water as “the point at which the aggregate impact of all users impinges on the supply or quality of water under prevailing institutional arrangements to the extent that the demand by all sectors, including the environment, cannot be satisfied fully”. Though Kenya is a water scarce country, the little that is available is not efficiently managed; a lot of the water goes to waste or is siphoned away and thus Water Service Providers losses huge amounts of money that would otherwise be registered as income. Currently, the level of UFW in Kenya is 49% (GoK-WASREB, 2010) against an apparent acceptable economic level of 10% to 12% (Thornton et al, 2008). To date, the Government of Kenya has made numerous efforts in facilitating access to water since the enactment of the 2002 Water Act which enabled introduction of reforms in the water sector. The reforms were aimed at addressing the policy, regulation and service provision weaknesses in the previous set-up (GoK-NWSS, 2007). However, despite these positive developments millions of Kenyans are still underserved. Vision 2030 recognizes that efficient water management can contribute to long-term economic growth since all the three pillars (social, political and economic) which forms its foundation have water dimensions.

The benefits of reducing UFW include; Need for less water to be produced, treated, and pumped, translating into cost savings on operations and maintenance, as a result of savings in energy and treatment overheads. In order to resolve the UFW puzzle, institutions need to review what UFW is in their system, identify areas of UFW and purge the system to remove as much UFW as possible. Veerabhadra & Vignewwar (2009) argues that the reduction of UFW is a crucial step to improvement of the water supply and financial soundness of water utilities. Indeed, no water supply can be kept at a reasonable and affordable level if the income from the customers does not cover the costs of providing a good service (Biswas & Tortajala, 2010).

1.1 Water Sector in Kenya

Kenya is located in the equatorial region where water availability should be more reliable than other countries in Africa; however, it is ironical that access to water in Kenya is way below the accepted levels and thus worse off in comparison to other countries with more harsh climatic conditions such as Namibia, Egypt and Botswana. Currently, it is estimated that nationally piped water coverage in Kenya is between 42% and 59%, which leaves millions of citizens without easily accessible water (World Bank, 2009).

The renewable freshwater resources of Kenya are at 20.2 km^3 per year, which corresponds to 647 m^3 per capita annually, this compares unfavorably with the neighboring countries of Uganda and Tanzania, which have per capital levels of 2,940m^3 and 2,696m^3 respectively (GoK-Vision 2030, 2007). Kenya's water per capita decreased from 1,853 cubic metres in 1969 to 704 cubic metres in 2000, to the current estimate of 647 cubic metres thus going below the global benchmark of 1,000 cubic metres per person a year. With the current trend, by 2025, Kenya's per capita water availability will be in the danger zone of 235 cubic metres (GoK-NWSS, 2007).

The Government of Kenya recognizes the central role that water and sanitation plays in poverty alleviation, this is in concurrence with the Millennium Declaration by the UN General Assembly of September 2000 which underscored that fighting poverty and sustainable development cannot be achieved without substantial improvements in water and sanitation. This is addressed by goal number seven of the United Nation's MDGs; it requires the reduction, "by half the proportion of people without sustainable access to safe drinking water and sanitation". This goal was underlined further at the World Summit on Sustainable Development. The Constitution of Kenya, 2010 also recognizes that water and sanitation are not only a basic human right but a prerequisite for social human and economic development.

The responsibility of water supply management in Kenya is vested on the Ministry of Water and Irrigation (MoWI) which provides policy & strategy direction. The Ministry's services are complemented by seven other water sector institutions that play the role of regulation, training, research, mobilization of funds, coordination and monitoring; these are WSTF, WASREB, WRMA, WAB, NWCPC, NIB and KeWI (GoK-Water Act, 2002). Additionally, within the MoWI, there are eight Water Service Boards (WSBs) i.e. TWSB, TAWSB, CWSB, AWSB, RVWSB, LVSWSB, LVNWSB and NWSB (GoK-Water Act, 2002). These WSBs are in charge of assets and contracting Water Service Providers (WSPs) for water and sewerage services. RVWSB which is the focus of the research covers 36 districts, with 12 WSPs, 24 CBOs and serves more than 5.5 million people.

In order for Kenya to achieve the MDGs, it is imperative that water must be made available, accessible and affordable. This underscores the need for increased coverage; reduction of the high water losses; rehabilitation and expansion of existing schemes; sustainable demand management; construction of new water supply schemes; transparency, accountability and good water governance; efficiency; clear institutional framework; and encouraging pro-poor focus, strategies and programmes.

Kenya's Vision 2030 acknowledges the fact that Kenya is a 'water scarce' country and it underscores the central role that water plays in the performance of key sectors of the economy and the livelihoods of Kenyans. Under the economic and social pillars of the Vision, improved access to safe water and sanitation has been given prominence with the rehabilitation and expansion of water supply and sanitation services in urban centres and construction of water storage dams identified as some of the flagship projects (GoK-Vision 2030, 2007).

1.2 Statement of the Problem

The water supply systems lose considerable amount of water on daily basis, both from the main and the distribution lines through real and apparent water losses. Globally, the acceptable level of UFW is 10% to 12%

(Thornton et al, 2008). UFW can be reduced by developing and systematically implementing appropriate strategies to resolve the problem and thereafter sustain the desirable level. The savings realized from UFW reduction can be re-invested in the supply systems and thus ensure continual improvements in water access and infrastructure upgrade.

Despite the fact that Kenya is considered as a 'water-scarce' country, a significant amount of the available water goes to waste. The 2006-2015 Strategic Plan for RVWSB identifies UFW reduction for NAWASSCO as a major challenge to expansion of service provision in the area; indeed 50% of the potential customers are not reached. The Strategic Plan further recognizes that NAWASSCO's Unaccounted-for-Water is at 43%. In addition, the WASREB Impact Report (2010) indicates that at the national level, UFW in Kenya stands at 49%. The water losses contribute extensively to inadequacy in water and sanitation coverage, resulting to escalation of water borne diseases, poverty and water related conflicts.

With an economy that is struggling to thrive amidst a myriad of challenges; the water sector should facilitate efficient water management to foster accelerated growth and development. The major sectors in the economy as stipulated in the Vision 2030 blue print cannot flourish without adequate access to water and sanitation i.e. infrastructure development, housing, agriculture and health. Consequently, for Kenya to be a globally competitive and prosperous nation as per the Vision 2030, the existing level of UFW has to be reduced significantly. The study therefore addresses issues on; sustainable resource utilization, technological advancement, improvement of the existing regulations as well as the monitoring and control measures that can be employed to facilitate reduction of UFW.

2.0 LITERATURE REVIEW

2.1 An Overview of Unaccounted-for-Water

Information on water resources, their availability and use is fundamental considering the emergence of water shortages and the need to efficiently improve water use (Mohd et al, 2009). The technical capacity of a water supply system is determined by the physical infrastructure of the system that enables access, availability, and adequacy of water to the users. Management of the water system depends on proper operation and maintenance of the infrastructure. Consequently, this ensures uninterrupted delivery of safe water (Ramesh, & Narayanasamy, 2010). Since water is considered as a free gift of nature, the tendency to use it lavishly is widely evident, according to an empirical study in Tamil Nadu, India, the amount of water wasted in the study villages was found to be 35% (Ramesh, & Narayanasamy, 2010).

A country is categorized as 'water stressed' if its annual renewable freshwater coverage are between 1,000 and 1,700 cubic metres per capita, and 'water scarce' if its renewable freshwater supplies are less than 1,000 cubic metres per capita (United Nations Environment Program, 2002). Kenya is in the 'water scarce' category and thus concerted efforts are required to alleviate the situation. In addition to conserving water catchment areas to increase availability of water resources, the already available water must be utilized sustainably with special emphasis on UFW reduction.

2.2 UFW Reduction and the Millennium Development Goals

The importance of improved water supply, sanitation and hygiene has been recognized by their inclusion as specific targets in the framework of the MDGs. It is among the 2015 targets set for these goals i.e. a commitment to "reduce by half the proportion of people without sustainable access to safe water and sanitation". Indeed; equitable access to water supply is a common thread to achieving all the MDGs and poverty reduction. Therefore UFW reduction is a major component in mitigating the prevailing water scarcity condition in Kenya.

2.3 Linkages with Poverty Reduction

Water supply is a key driver for development, a condition for productive and healthy lives, and therefore contributes towards poverty reduction. Water is multi-functional and the various functions are complementary and synergistic. All these functions, including productive uses, should be taken into account when reducing UFW to support sustainable livelihoods and local economic development. (GoK-Vision 2030, 2007).

2.4 Sustainable resource utilization

The management of water resources presents numerous challenges to decision makers in developing countries and it requires a comprehensive approach for any meaningful results to be achieved (Weng, 2009). A sustainable water supply system requires responsible management of resources where the public demand is met, without undesirable consequences. Though resources are limited, optimal utilization would yield remarkable improvements and thus contribute significantly to reduction of UFW. The available resources should be examined and optimally allocated to the various areas as per the planned activities. Kumar (2008) argues that in some Indian cities UFW is more than half of the water produced and thus benchmarking is necessary where utilities with reduced UFW and improvements in service delivery are credited. A strong and proactive management team to motivate and supervise the work force in order to reduce the large volumes of water lost annually is necessary (Kuma, 2010). Plessis Du argues that, with water supply systems under pressure due to staff shortages, there is need for benchmarks to assist in the planning process of their water infrastructure (Du Plessis, 2007).

In Mauritius, the labour force for water supply is structured grade-wise where each unit performs specific task. This thwarts the optimum utilization of the human capital and the whole system of work gets intertwined where the work of one is an offshoot of another. Human capital can be more proficiently utilized if workers in the Operations Section could become skillful in doing a reasonable variety of tasks than becoming proficient in only one particular area. A scheme of multifunctional operatives was implemented to address this problem; however, what was initially intended was not achieved. A more comprehensive re-organization of the trades could bring substantial savings in terms of cost and time to the Authority (Republic of Mauritius, 2010).

According to the International Journal of water resources development, 2010, the level of UFW in Phnom Penha Water Supply Authority, in Cambodia was well over 70% in 1993. The staffs were demoralized due to poor governance, miserable pay, indiscipline, lack of motivation, and persistent corruption. A strict regime with interrelated components were designed and implemented. The work culture was fundamentally changed by enforcing strict discipline. This was an uphill task since the rest of the public sector employees in Cambodia were in a similar situation. During the 15-year timeframe of transformational change management, Phnom Penh Water Supply Authority experienced a transmutation with enlightened management, dedicated and competent staff. This resulted to reduction of UFW from 72% to 6.19% (Biswas & Tortajada, 2010).

In most developing countries, many existing systems are operating intermittently and at a fraction of their capacity. According to the WHO/UNICEF Joint Monitoring Programme (JMP), in 2008, more than 2.6 billion people were living without access to improved sanitation, and nearly 900 million people lacked improved drinking water supplies (WHO/UNICEF, 2010). Omer (2010) argues that the communities should be fully utilized in any attempts to promote the local management of water supply and sanitation systems because a change in water and sanitation sector approach from supply-driven approach to demand-responsive approach call for full community participation.

2.5 Monitoring Measures

Monitoring involves supervising activities in progress to ensure they are on-course and on-schedule in meeting the objectives and performance targets (Business Dictionary.com, 2011). Monitoring helps stakeholders to track the progress in the achievement of the water and sanitation targets, reduction in water leakages in the supply systems contributes significantly to achievements of the targets. Leak detection techniques for pipelines include secondary containment with interstitial monitoring, vapor monitoring, groundwater monitoring, statistical inventory reconciliation, and tightness testing. Pressurized piping should also have an automatic line leak detector. Advancement in metering expertise has shifted the focus to monitoring and systems management. Monitoring of water flow in the supply systems, leakage reduction and apt billing are important aspects of UFW reduction. According to Alexander Krohne, (2010), using telemetry data offers a distinct advantage especially when monitoring night flow and leak detection. This is because the readings are taken at the same time, making comparisons and trends easier to comprehend.

Krone (2010) argues that since mechanical bulk meters are the most widely used metering devices by local authorities, water providers and water boards, monitoring of leakages should be done on a continuous basis using the bulk meters. The meters should be installed at strategic points in the supply system and the readings compared with the sum of domestic water meters in that specific area. Leakage occurs in all water supply systems, as noted by William Hope (1892), "there is no water supply in which some unnecessary waste does not exist and there are few supplies, if any, in which the saving of a substantial proportion of that waste would not bring pecuniary advantage to the Water Authority". The amount of water leaked in water supply systems varies widely between different countries, regions and systems, from as low as 3-7% of distribution input in the well maintained systems in The Netherlands (Beuken *et al*. 2006) to 50 plus % in some undeveloped countries and less well maintained systems.

Leakages cause inefficient energy distribution through the network and also may affect water quality by introducing infection into water distribution networks in low pressure conditions (Puust *et al*, 2010). It is crucial that monitoring of water system leakages is done efficiently to ensure that timely remedial measures are taken. The monitoring devices particularly leak detectors guide the repair and maintenance teams to exact problem areas making their work easier and efficient.

2.6 Control measures

Control measures are the physical efforts (hardware) aimed at improving information flow and network visibility that will enhance control of the water supply systems. The success or lack thereof is identified; risk prone areas are also mapped and targeted for improvement. UFW is not only due to the status of the infrastructure but also as a result of poor approaches in management and monitoring. Administrative causes range from illegal connections, lack of measuring devices, inaccurate meters, mistakes in billing, laxity in meter reading and poor record keeping. Usually, improvement of UFW of infrastructural nature would require investment levels that may not be available to a typical WSP within the required time frame. On the other hand, collection efficiency depend largely on how well a water utility has put measures towards ensuring that as much revenue as possible is collected during each billing event (GoK-WASREB, 2010). The current inefficiencies in the water supply systems resulting to high UFW emanate from poor control systems. With the new tools of detecting water loss, the water industry underwent a paradigm shift toward sounder water loss management. Water utilities provided accountability operations by auditing their operations and then implemented controls to keep system losses to reasonable minimal levels (Deborah, 2009).

According to the empirical study conducted in Tamil Nadu, India, there is a cost in feeding the piped water supply system with water and thus UFW adds on to operations and maintenance costs (Ramesh, Narayanasamy, 2010). This is in addition to the serious issue of water sources becoming increasingly exhausted. Consumers should be unacquainted with the cost of water wasted unnecessarily without anybody benefiting. Applying appropriate control measures to reduce water loss can contribute significantly in improving efficiency of the water supply systems. Bahrain, a Gulf State reduced its levels of unaccounted-for-water (UFW) from nearly 32% in 1993 to just over 23% in 2001. The reduction was made possible due to a leakage detection and control programme involving the replacement of old pipeline systems. (Global Water Intelligence, 2003)

A number of past studies exist in the field of leakage modeling and management. One of the earliest studies by Morris (1967) which provided an overview of potential causal factors leading to water pipe breaks. A report summarizing different leakage control policies can be found in Goodwin (1980). Comparisons of the key attributes of different leak detection methods are given by Cist and Schutz (2001). Another review and classification of leakage detection methods is reported by Liou *et al* (2003). A review of calibration methods in water pipelines (including leaks) can also be found in Kapelan (2002) and Savic *et al* (2009). Controlling water losses in the water supply systems is crucial for the sustainable management of this scarce resource. The WSPs must embrace appropriate preventive maintenance measures that ensure minimal water loss and thus improving on water accessibility to consumers as well as revenue maximization.

2.7 Technology advancement

Embracing new technology and innovations would result to remarkable improvements in reduction of UFW. Good provision of services is not merely about infrastructure; it includes the local capacity to innovate and/or make appropriate choices with regard to technology and the institutional frameworks for building and managing it (Osinde Rose, 2007). The main areas of modern ICT where water systems management can be improved may include; metering, leakage detection and billing. In addition, calibration testing on installed meters and use of Automatic Meter Reading where meters are enabled with transmitters (Pickard *et al*, 2008) is potential for reducing UFW. The system is able to detect apparent losses and immediate remedial measures taken. Technology can also be exploited in leak detection as well as customer billing. Pusst *et al* (2010) in the Urban Water Journal argues that leakage pinpointing methods include methodologies that are the most accurate in today’s leak detection surveys.

The World Bank estimates that in developing countries, leakage is about 45 million cubic meters per day (Kingdom, et al, 2006). Also, roughly 30Million m^3/day are not paid for. With a basic allocation of 100 liters per person per day , the 45 million m^3/day of leakage could serve roughly half the total population not currently covered. The same report estimates the total financial losses in developing countries to be about $5.8 billion per year.

2.8 Regulatory framework

This refers to a set of interrelated conditions such as legal, organizational, fiscal, informational, political as well as cultural factors that impact on development and sustenance of water systems. According to the Baltimore Charter for Sustainable Water Systems (2007), regulations have been written set standards for large, centralized systems in separate parts of the water cycle. Although governance assessments in most Water Supply and Sanitation (WSS) generally focus on the relationships between the agencies responsible for WSS services and those who receive the services, consideration is given to individuals, households and settlements that have no relationship with these formal agencies. Rose Osinde, (2007) argues that enhancing water governance goes beyond ensuring that policies and institutions are in place, and captures issues of water access to water resources and information.

In Kenya, the MoWI is mandated to provide an enabling working environment to WSBs and the WSPs; this is done in collaboration with various autonomous institutions in the water sector. Inadequate enforcement of the stipulated regulations and ambiguity/overlap of mandate of the various water sector institutions results to challenges in management of water supply systems. WSBs do not enforce regulations as required and thus some WSPs do not comply fully particularly on reporting and thus an impediment to development of a sector investment plan (GoK-WASREB, 2010). The WASREB (2010) performance report further states that WSBs submits limited information on water supply and sanitation, investments undertaken and subsidies received in the sector. In order to fulfill the criteria for the human right to water and sanitation, the sector need to enforce the provisions of the Water Act 2002 that oblige all water service provision to be regulated.

2.9 Critique of the Existing Literature

The existing literature indicates that emphasis in most of the studies is mainly on components of UFW and the implications of water wastage; the aspect of strategies to reduce UFW is missing. An example is the poverty reduction strategy paper which indicates that the deterioration in the water supply situation has been as a result of poor management of water supply schemes and rampant destruction of water catchment areas, however there are no strategies identified to surmount the challenge. The information is not conclusive and where available it is scanty.

2.10 Summary and Research Gaps

The literature reviewed from journals publications and research materials address issues on components of water loss, governance, water resource management, the cost and percentages of UFW, deficiencies in water distribution systems, challenges of reducing UFW, and political constraints to water demand management, water loss determination and causes of UFW. However, it failed to address substantively the strategies to reduce UFW. There was little information regarding solutions to UFW in Kenya particularly in the area this study was targeting. Therefore it was necessary to undertake a comprehensive study on strategies for reduction of UFW. Considering that the percentage of UFW in NAWASSCO was high, a significant reduction would improve access to available water and cost savings made would be utilized to improve the existing water supply systems.

3.0 RESEARCH DESIGN AND METHODOLOGY

3.1 Research Design

This is a descriptive case study design. The stratified random sampling technique was used to aid data collection in this study. The study population was divided into homogeneous, mutually exclusive groups called strata, and then independent samples were selected from each stratum. This made the sampling strategy more efficient than simple random sampling. Each stratum became an independent population. Two main strata were developed; one on RVWSB and the other on NAWASSCO. Within each stratum, three sub-strata were developed on the categories; top management staff, middle management staff and operations staff. The sub-strata were divided into portions of seven and every person in the 3rd place in each portion in the sub-strata was selected to form the sample. The target population was 296 which comprised of; 254 employees of NAWASSCO and 42 employees of RVWSB. The sample is 15% of the target population i.e. 38 representatives of NAWASSCO and six representatives of RVWSB. Therefore, the targeted sample size (n) was 44. Stratified random sampling technique was used; strata were developed based on level of operation i.e. either WSB level or WSP level. The source information for this study comprises of all employees of RVWSB as well as employees of NAWASSCO which is one of the 12 WSPs operating within RVWSB region. Data collected was analyzed using simple descriptive statistics. These include central measures of central tendency, mode, mean and measures of dispersion such as percentages and ranks. Qualitative data was arranged into themes using codes after which it was analyzed and interpreted the same way as quantitative data. Quantitative analysis was deductive; the researcher used statistical methods to analyze collected data. This was in terms of tables, pie charts and bar charts. Data was also analyzed qualitatively wherein data analysis was inductive.

4.0 FINDINGS AND DISCUSSION

4.1 Response Rate

In the study, 44 questionnaires were administered to employees of RVWSB and NAWASSCO. 40 questionnaires were successfully filled, returned and taken as a sample, which gave a response rate of 90.9 percent. This response rate was favourable, Mugenda and Mugenda (2003) asserts that a 50% response rate is adequate, 60% good and above 70% rated very good. This implies that the respondents were adequate representation of the entire population.

4.2 Reliability Analysis

The reliability analysis involved questionnaires from ten respondents, for each respondent; there were 20 main items that required their responses. Based on the responses, Cronbach's alpha was calculated by application of SPSS. The following is a table representing the results of the reliability analysis.

Table 1 Reliability Results

Variable	Cronbach alpha	No of items
Sustainable Resource Utilization	0.737	4
Monitoring Measures	0.854	4
Control Measures	0.965	4
Technological Advancements	0.729	4
Regulatory Framework	0.687	4
Overall	**0.758**	**20**

Reliability of the scale for the constructs describing the variables was 0.758; this is a reliable coefficient since Cooper & Schindler (2008) argues that; scales of 0.7 have an acceptable reliability coefficient. From the researcher's perspective, the instruments had an acceptable reliability coefficient and were appropriate for the study. This implies that the results of the study were reliable and can be generalized on the entire population.

4.3 Respondent's Knowledge on Level of Unaccounted-for-Water (UFW)

The question sought to establish the respondents' knowledge on level of UFW; below is a table representing the level of UFW according to the respondents;

Table 2 Level of Unaccounted Water (UFW)

	N	Minimum	Maximum	Mean	Std. Deviation
What is the level of Unaccounted-for-water (UFW)?	40	0.200	0.560	0.450	0.063

The study implies that the minimum level of unaccounted-for-water was 20% and the maximum was 56%. This suggests that on average, the level of UFW in the study area was at 45%. The findings are in tandem with the WASREB impact report, 2010 which indicates that the prevailing level of UFW was 49% at the national level whereas the 2006/2012 Strategic Plan for RVWSB indicates that the UFW at the board level was 43%. According to the findings, the level of UFW is quite high and thus it is imperative that a synchronized approach in UFW reduction should be implemented. High levels of UFW erodes the WSPs' revenue, hence limiting opportunities for expansion of the water supply systems, at the same time, the system does not meet the demand of its customers.

4.4 Inferential Analysis

The researcher carried out correlation analysis to determine the strength of the relationship between the UFW and the independent variables i.e. sustainable resource utilization, monitoring measures, control measures, technological advancement and regulatory framework. The following is a table representing correlation analysis of the dependent and independent variables;

Table 3 Correlation Analysis

	UFW	Sustainable resource utilization	Monitoring Measures	Control measures	Technological advancement	Regulatory Framework
UFW	1					
Sustainable resource utilization	-.041	1				
Monitoring Measures	-.457	0.135	1			
Control measures	0.038	0.084	0.048	1		
Technological advancement	-.417	.508	.585	-0.015	1	
Regulatory Framework	-.332	0.031	.649	-0.183	.438	1

Table 3 above shows that there is a weak negative correlation (-0.041) between UFW and sustainable resource utilization, this suggests that an increase in sustainable resource utilization leads to decreased UFW. At the same time, there is a medium negative correlation (-.457) between UFW and monitoring measures, this suggests that an increase in monitoring measures decreases the amount of UFW.

The researcher further carried out a regression analysis on the independent variables (predictors) and the dependent variable. The following is a table representing the regression analysis of the variables;

Table 4 Regression Analysis

	B	**Std. Error**	**t**	**Sig.**
(Constant)	59.005	12.67	4.657	0.000
Sustainable resource utilization	0.412	0.452	1.912	0.008
Monitoring Measures	-0.595	0.461	-2.29	0.006
Control measures	0.113	0.529	3.213	0.000
Technological advancement	-0.754	0.497	-1.518	0.138
Regulatory Framework	0.002	0.674	0.004	0.997
R	.513a			
R Square	0.264			
Adjusted R Square	0.155			
F	21.434			.000

a. Predictors: (Constant), Regulatory Framework, Sustainable resource utilization, Control measures, Technological advancement, Monitoring Measures

b. Dependent Variable: UFW

The coefficient of determination R^2 = 26.4%, this suggests that the independent variables sustainable resource utilization, monitoring measures, control measures, technological advancement and regulatory framework explains 26.4% variations of UFW. The f value of 21.434 indicates that the overall regression model is significant hence it has some explanatory value. This indicates that there is a significant relationship between the predictor variables sustainable resource utilization, monitoring measures, control measures, technology advancement and regulatory framework. At 95% confidence interval i.e. P–value ($p=0.00<0.05$) it implies that all the independent variables combined do influence the levels of UFW. Further, from the Table 4 control measures has the most statistically significant coefficient as indicated by a t-ratio of 3.213. This suggests that a unit change in control measures will change UFW by .113 units. Monitoring measures has a statistically significant coefficient as indicated by a t-ratio of -2.29. This implies a negative linear relationship with the level of UFW.

5.0 SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Summary of Findings

The study established that mechanical damages and vandalism as the main cause of pipeline leakages in the water supply systems. Consequently, non-reading of meters and lack of access to customer meters were identified as key factors contributing to billing errors. Further, a probe on illegal connections established that individual households and commercial entities were the main culprits. Finally, inclusion of cultural dimensions in water governance emerged as a major factor that should be considered while developing regulatory mechanisms as expressed by majority of the staff.

5.2 Sustainable Resource Utilization

The study findings showed that sustainable water supply systems and subsequent UFW reduction require responsible resource management. A robust management system ensures optimality in resource utilization and consequent achievement of desired results.

5.3 Appropriate Monitoring Measures

Continuous monitoring of leakages in the water systems emerged as an essential aspect in UFW reduction (table 4.11). It was further noted that, monitoring reports is an input to the control level, therefore, it is crucial that accurate monitoring and timely reporting of leakages is done to facilitate on time repairs.

5.4Appropriate Control Measures

The study findings indicate that water utilities should provide accountability by auditing their operations (table 4.12). Transparency and accountability of operations helps in creating confidence to the public, development partners and the employees of the institution. It is an indication that the basic tenets of corporate governance are practiced.

5.5Technological Advancements

The study established that use of new tools of detecting water loss such as leak detectors for pipelines results to sounder water loss. Indeed, water leakages, especially those occurring in the sub-surface are difficult to detect without specialized tools. Therefore, the leak detectors would assist to a great extent on accurate identification of leaks and subsequent repairs.

5.6 Regulatory Framework

The study findings showed that lenient penalties for illegal water connections and lack of cultural dimensions in water governance contributes significantly to high levels of UFW, this was supported by majority of the staff . It emerged that, in order to enhance water governance, it is vital to include cultural dimensions. This is in agreement with the theory of structuration which holds that all human action is performed within the context of a pre-existing social structure which is governed by a set of norms or laws which are distinct from those of other social structures. Therefore, the behavior of water consumers is partly predetermined based on the varying contextual rules under which it occurs.

5.7 Conclusion

The study indicated that illegal water connections, mechanical damages and vandalism are responsible for the high levels of UFW. The situation is exacerbated by the fact that consumption and billing are not synchronized whereas bureaucracies in the regulatory mechanisms and lenient penalties for offenders encourage illegal practices. The essential factors identified as contributing in efficient performance and consequently reductions of UFW are monitoring and control of water leakages as well as inclusion of cultural dimensions in water governance.

Therefore, for UFW to be reduced in water supply systems, it is necessary to employ requisite resource management that controls water loss as well as respecting the cultural values for the people being served. Modern technology cannot be ignored where speed and accuracy is of essence in provision of services to customers. Appropriate regulatory mechanisms are also important to see to it that the rights of all parties are respected and punitive measures are put in place to deter non-compliance.

5.8 Recommendations

In view of the findings of the study, the researcher recommends that; WSPs should put in place measures to reduce levels of illegal water connections, vandalism and customer billing errors as well as ensure inclusion of cultural dimensions in water governance. There is also need for optimal resource utilization complimented by sound management systems and consequently minimizing the levels UFW.

Further, the study recommends that in order for WSPs to improve on monitoring and location of sources of UFW they should ensure accurate measurement of water production and consumption and conduct pipeline mapping to identify legal, illegal, and potential connections. The WSPS should also undertake installation of macro metering of all major supply zones and territories to measure and micro metering for consumers to monitor flows in the distribution network.

Further recommendations from the study are that WSPs should increase consumer awareness on water wastage reduction and reporting of pipeline leakages to the appropriate authorities, this could reduce real/physical water loss significantly. In addition they should undertake detection and control of leaks, building up leak history patterns as well as training personnel on modern technology of leak detection.

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