



MINISTRY OF WATER, SANITATION & IRRIGATION
KENYA WATER INSTITUTE

PROCEEDINGS OF THE NON-REVENUE WATER MANAGEMENT SYMPOSIUM



THEME "CLOSING THE LAST MILE TO SDG 6"

DATES: 9TH AND 10TH MAY 2022

**VENUE: PRIDEINN FLAMINGO BEACH RESORT, SHANZU -
MOMBASA**



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PREFACE

Kenya Water Institute (KEWI) with the support of partners held the Non-Revenue Water (NRW) Management Symposium on 9th and 10th May 2022 in Mombasa, Kenya. The symposium theme was “*closing the last mile to SDG 6*”. The Symposium showcased cutting edge technologies that address NRW reduction, brought together water service providers (WSPs), Water Works Development Agencies, scholars, technology experts, policy makers, development partners, institutions of higher learning, water associations, civil society, private sector and investors to share experiences on the globally accepted standards for the management of NRW.

The symposium was both physical and virtual through plenary sessions, interactive panels for face to face participants and online sessions for virtual participants. The thematic areas were: 1) Non-Revenue Water Management Strategies; 2) Enabling Environment and Incentives for Non-Revenue Water Reduction at WSP level; 3) The Role of Academic Institutions, in the Management of Non-Revenue Water; 4) The Role of Financial Institutions and Private Sector in the Management of Non-Revenue Water; 5) National Policies, Regulations for Non-Revenue Water Reduction ; and 6) Data Management Analysis in Support of NRW Management. A total of 17 Abstracts were submitted, 8 institutions participate in the exhibitions.

We cordially thank the sponsors, presenters, exhibitors, keynote speakers, panelists and all participants for their contribution to the quality of the Non-Revenue Water (NRW) Management Symposium.

Leonard Makokha
Chairperson of the Organizing Committee of the Symposium



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OPENING REMARKS

Ag. Director KEWI

Kennedy Riaga

The Director welcomed all the participants to the Symposium and appreciated the Ministry of Water, Sanitation and Irrigation for the support in hosting the Symposium. He further acknowledged support from Safaricom PLC, National Bank of Kenya (NBK), DOSHI, and Water Sector Trust Fund (WSTF) who were sponsors of the symposium. He also thanked all participants for honouring the invitation to attend the symposium. On the subject of Non-Revenue Water, the Director mentioned that since access to clean water was still a challenge, the symposium aimed to create a dialogue on the theme of Non-Revenue Water Management.

KEWI Governing Council Session Chair

Eng. Peter Wanday

The session KEWI Governing Council Chairperson welcomed all physical and online participants. He recognized symposium sponsors and stated that the support was the beginning of a journey in line with KEWI's key mandate of training, research and consultancy services as per the Kenya Water Institute Act, 2001. He also recognized the presence of KEWI Governing Council Members who are tasked with providing strategic direction for the Institute.

Ag. CEO Water Services Regulatory Board (WASREB)-

Joseph K Keter

In his remarks, WASREB CEO recognized the Water Service Providers (WSPs) who were present in the symposium. He further mentioned that the National regulator was currently regulating more than 90 WSPs in country while its vision was to regulate more than 200 rural schemes. The regulator's mandate was to protect the interests of the consumers through tariff setting. He confirmed that WASREB was already working with NBK and other non state actors to ensure consumer rights were protected.



Irrigation Secretary

About Moeva

The Irrigation Secretary congratulated KEWI and appreciated her efforts in coordinating the symposium. He also thanked sponsors for partnering to have the symposium take place and looked forward to having more activities together. On the subject of NRW, he stated that issue has been there with us and hoped that the symposium will provide solutions and added that although NRW focused on domestic and industrial water losses, there was significant irrigation water loss which can be equated to NRW. Irrigation as a major water consumer uses 70% of water where about 40% of the water is lost. Water use efficiency including reducing irrigation system water loss, and efficiency can be achieved through partnership.

Chief Guest

Water Secretary

Eng. S.A.O Alima

Eng. S.A.O Alima while speaking on behalf of Cabinet Secretary MWSI, appreciated KEWI for organizing event, sponsors and all participants for making symposium possible. He noted that he had hoped to see more WSPs represented in the symposium. On the subject of NRW, the Chief Guest stated that its management starts at design stage hence the Water Works Development Agencies (WWDAs) should have also been present in large numbers in the symposium. He challenged academic institutions to have NRW to be taught at institutions of higher learning. As according to engineering, design systems allows for 5% loss but now we are losing 47% which was way beyond the design limits or the sector standards of 20%. Proper training of NRW should therefore be done at universities. He urged the symposium organizers to have key players in the 3rd symposium. The WSPs were challenged as to how with 47% loss the institutions were still able to break even/ be in business if they were not overpricing water. What were the utilities running on if not overcharging the consumers? He paused a question to the symposium participants.

He challenged the participants to be able to answer the question “What do we need to do as a country to come out of this challenge. The symposium should



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come up with resolutions on the things that needed to be done with clear implementers.

He wished all participants fruitful discussions.



SPONSORS AND PARTNERS REMARKS

Safaricom

Jerry Teka stated that Safaricom was delighted to be part of the symposium. NRW cannot be left to the utilities alone to solve. The issue required concerted efforts from different stakeholders and if resolved can lead to access to additional financial resources that are self generated, supplying water to additional people, reducing illegal connection, improved service delivery to customers, and achievement of SDG 6. Safaricom's purpose is to transform life and is currently transitioning from telecommunication to a technology company. Safaricom was committed to working with different stakeholders to reduce NRW from 47% to less than 20% and the Company has invested in smart water technology- including smart meters, and platform that enables customer management, inventory management. Further, Safaricom was currently building relevant technology expertise. He pledged commitment to KEWI towards equipping laboratory with latest water smart technology and collaborate in developing curriculum that will build technical expertise in smart water technology.

National Bank of Kenya

Paul Russo of NBK expressed cordial business relationship that exists between the Bank and KEWI. On the subject of partnerships, the Bank was glad to be a partner and also to bring other partners to the table. Partnerships were key in achieving the goal of improving livelihood for all citizens through improving access to water and sanitation for all. Reducing NRW was also key towards achieving SDG 6. NBK was committed to supporting SDG 6 which espouses Article 43 of the Constitution of Kenya's, right to clean water and adequate sanitation. Partnerships is borne of the realisation that NRW management is important so as to allow utilities expand service. NBK delivers competitive tailor-made solutions including a fund Maji Connect that supports individuals, Communities and entities affected by NRW challenge. This was a financing programme targeting SMEs, Corporate and Individual with the objective to support water sector. The Bank committed to continue working with KEWI and to be part of the next symposium.



DOSHI

Eng. Elisha Omega said DOSHI has been collaborating with KEWI through offering technical trainings to KEWI. Further, DOSHI is a partner and a key player committed to support NRW through DOSHI water division and has worked with most of the WSPs through their practical solutions to reduce NRW. Doshi was open to partnerships in areas of connectivity, financing among others.

Water Sector Trust Fund

Fidelis Tamangani was happy to be part of the symposium and hopes to learn and meet with partners and assist WSPs in NRW Management. The mandate of the Institution involves financing, grants and on-lending to improve WASH projects. The grants main target was underserved and unserved areas. WSTF gives grants to WSPs implementing projects targeting NRW reduction and has financed projects that have components of NRW reduction including– Urban project concepts, output based aid programme, conditional support grant

ESRI Eastern Africa

Clifford Okembo of ESRI-Eastern Africa works closely and partners with KEWI, WSPs, and WWDAs in bringing location intelligence to water sector. In GIS, knowing where each and everything is was the first step in understanding and dealing with that specific thing. He looked forward to engage in conversations during the symposium and look forward towards more collaboration after the symposium.



KEY NOTE SPEAKERS

1. Eng. Mori,
JICA Team Expert
New approaches for reducing NRW in Kenya
2. Aboud Moeva,
Irrigation Secretary, MWSI
Irrigation Water Use efficiency
3. Leonard Mutai
Nakuru Water
(NAWASSCO) Good practices on NRW Reduction
4. Gona Mwembe
Kilifi- Mariakani water and
sewerage Company
5. Margaret Maina
Limuru Water
6. Python Mutiga
National Bank of Kenya
The role of financing in reduction of
NRW
7. Willis Ombai
Water Sector Trust Fund
8. William Oduor
Kenya Water Institute
The Role of Private Sector in Non-
Revenue Water Management
9. Isaac G Kabutha
Safaricom
Digitizing Water Management
Operations



CLOSING REMARKS

KEWI Governing Council Session Chair

Eng. Peter Wanday

The Chairperson thanked all participants on behalf of the KEWI Governing Council and hoped that all present had taken home key lessons on the subject of NRW.

Ag. CEO Water Services Regulatory Board (WASREB)

Joseph K Keter

The CEO thanked KEWI for the bringing all to the symposium and urged that in future, the symposium should be planned in good time and involve more stakeholders. On the subject of symposium resolutions, it should be presented in an action matrix. He also informed the participants that WASREB was about to release Impact Report No. 14.

Chief Guest- Irrigation Secretary

Aboud moeva

The Chief Guest thanked organizers and sponsors for the successful symposium. He further thanked presenters and believed that all learned from the sharing sessions. He urged all to work as a team/ partner with others so as to succeed in NRW management. He guided that the symposium resolutions be 3-pronged having short term, medium term and long term actions. Short term action to include a meeting of all WSPs and partners to share information and chart way forward but more importantly was to have a coordinated engagement with partners.



SYMPOSIUM RESOLUTIONS

The participants were taken through Symposium Resolutions. Summary of the resolutions is as presented below.

Item	Action
1. Data	Billing data analysis to guide management in decision making
2. Financing	Financing institutions now have interests in WASH sector. There is need to tap into this financing.
3. Partnerships	Coordinated engagement with partners. MWSI to lead so that the finances are not lost to other sectors
4. Good Governance	High turnover of MDs in the sector leading to brain drain. Disseminate good governance practices. WASREB and MWSI to continue supporting the sector to ensure that good governance is entrenched.
5. Capacity building and Research	KEWI to ensure there is human development for the sector. Non Revenue Water and Management to be taught in Institutions of Higher Learning. Increase in NRW is associated with devolution- Research in the increase in trajectory of NRW as relates to devolution should be done.
6. Good practices	Good practices relating to NRW management to be shared and documented including e.g. - having independent NRW units/ Directorates in WSPs.



SUBMITTED ABSTRACTS

NON-REVENUE WATER MANAGEMENT STRATEGIES SUB-THEME

1. HELIUM GAS LEAK DETECTION TECHNIQUE -*Nicholas M Mangelu, Nairobi City Water and Sewerage Company*

Water loss is known as a part of Non-Revenue Water (NRW), Nevertheless, it has been a great challenge for the water operators since identification of the leakage locations is not a simple task as the pipe networks are buried under the ground in certain depth. Low pressures problems and increase of rigid pavements create emergence of new undetected leakage issues. The undetected leakages do not appear at the surfaces (pavements) and so, they become water losses under the ground for longer period. To reduce leakages, it is essential that the water operators select appropriate leak detection methods for their water distribution networks. There are several leak detection methods and most water operators, use either acoustic methods, tracer gas technique, IR camera thermography or ground penetrating radar (GPR). The use of helium gas to detect water networks leakage is an alternative technique to acoustic leak detection methods and its extremely efficient. It can be used on all pipe materials and requires a minimum pressure of only one bar.

2. Methodology The process involves three main procedures a) Flow measurement. b) Helium Injection c) Helium Detection

3. Results Leak detection is a part of leakage management systems, which comprises several actions such as; quantification of the total water loss, monitoring of leakage, locating and repairing leaks, and pipe pressure management.

4. Conclusions The leak detection using helium gas is accurate (more than 80%) to detect all leakages, both small and big leakages, as well leakages due to high or low pressurized network. The method detects leakages precisely on various pipe materials and on various pipe diameters. Besides, high noise backgrounds do not affect its detection accuracy in identifying water leaks

5. Helium equipment cost The approximate cost of the Helium leak detection equipment is approximately 3-5 million Kenya shillings



2. APPLICATION OF SMART METERS IN THE MANAGEMENT OF NRW THE PREPAID REVOLUTION IS ROLLING ON- *Kenneth Wendo, Maji Milele Marcel Schreurs, Maji Milele*

Prepaid water meters are not a golden bullet, but the advantages are too many to be ignored: commercial NRW is always zero; WSPs improve cash flows as payments are upfront; operational costs are reduced substantially (no meter reading and billing required for meters and no operators required for prepaid ATMs). For ATMs, this mostly leads to a yearly cost reduction of Kes 100,000-150,000. Over 100 Maji Milele clients reap the above benefits in more than 35 Kenyan counties including the national water companies in Rwanda and Uganda: WASAC and NWSC respectively. Prepaid meters are now also available in smart versions realizing prepayment, reduced operational costs together with daily data collection. These new generation meters respond to local technical requirements like longevity (up to 10 years); compliance with KEBS standards like OIML-49 and the ability to customize requirements by WSPs. Further, prices are getting lower! **Methodology** We compared the uptake of prepaid smart meters and ATMs by Kenyan public (regularized) WSPs and private (non-regularized) WSPs. Public WSPs have a strong preference for smart meters, while private ones, prepaid meters. The latter appeared to have a strong financial perspective, while the former, focus on the data collection aspect. This seems different in Tanzania where public WSPs focus on prepaid rather than on smart meters. For ATMs, we observe public WSPs, mostly, charging pro-poor tariffs (Kes 0.5-3), while private WSPs mostly charge Kes 3-5. Public WSPs purchasing ATMs seem focused on avoiding operator costs and providing water to customers 24-7, while private providers mainly seek revenue aspects and a quick return on investment. **Conclusion** WSPs looking for quick returns in investments mostly use prepaid meters, while those primarily interested in data collection and improved services to customers show interest primarily in smart meters. New meters coming to market now have both the smart and prepaid aspects, but the costs are prohibitive. WSPs are recommended carefully assess what is needed and then make a decision for prepaid, smart or a combination of both.



3. MANAGING NON-REVENUE WATER IN KENYA USING GIS (APPLICATION OF EARTH OBSERVATION AND GIS IN NON-REVENUE WATER MANAGEMENT) *Simon Ndeweni, Kenya Water Institute*

Rapid population growth and urbanisation in Kenya make Kenya consume more water than is available from renewable sources. Renewable water supply currently only meets about half of total water consumption. Shortages are caused by unsustainable groundwater extraction, including thousands of illegal private wells. As a result, many communities in Kenya have long experienced tensions over water scarcity which is worsened by the prolonged droughts. With this rapid influx in population, the gap between available water and demand, particularly in the North-Eastern region, has widened significantly. In response, there is a need to adopt more robust and efficient technologies such as GIS and Remote Sensing to strengthen water management and governance and reduce water losses, especially by focusing on Non-Revenue Water (NRW). Kenya is estimated to have NRW levels of more than 50% in many areas. This is quite alarming given that Kenya has 23 ASAL counties, which constitute 88% of the country's landmass. The condition of the Kenya water distribution system poses a great number of problems like: 1. A very high percentage of water losses, more than 50%. 2. Strong pressure variations within the system lead to frequent new pipe breaks. 3. A large number of illegal connections. 4. Old water network. It is important to reduce the NRW to improve the efficiency of the water sector and financial sustainability and conserve Kenya's limited water resources. Revenues will be increased by the reduction of NRW and will generate more returns for water utilities as a result of accurate metering, billing, and revenue collection. In addition, the cost of the operation and maintenance required will be reduced. Using geographic information systems in this study is contributed to achieving most of the field survey, evaluating the subscribers' meters and limiting the illegal uses. The density of the subscribers' consumption per 100m*100m was determined to illustrate the most locations of water consumption. The water balance is the best practice to assess the amount of lost water. It aims to track and account



for every component of the water that is added to and subtracted from a water supply system within a study period.

4. LEAK DETECTION TECHNIQUES ON NON –REVENUE WATER MANAGEMENT- *Aristopher Karisa, Kenya Water Institute*

Water service providers (WSPS) were created under the provision of Water Act 2002 to supply the clients with water and as a result the services of water provision have improved. However one of the major issues affecting urban water and sanitation providers is the considerable difference between the amount of water put into the distribution system and the amount of water billed to consumers commonly referred to as non-revenue water (NRW). In general many of the Kenyan towns have 40-60 percent non revenue water. It seriously affects the financial viability of water utilities through lost revenues and increased operational costs. A high NRW level is normally a surrogate for poorly run water utility that lacks the governance, accountability, and the technical and managerial skills, to provide reliable service to their population. Revenue collection and cost recovery are as low as 20-30 percent of operational and maintenance (O&M) costs. This leads to limited funds for routine maintenance, infrastructure coverage and poor quality of services. The purpose of the study was to understand the strategies of non revenue water management, in consideration of the leak detection techniques. This calls for an understanding of the goals to reduce leakage, the concept of how to identify leak location and the type of leak detectors. The survey leakage methodology was applied in this study. In conclusion utilities need to consider establishment of non revenue water management teams, develop strategies and ensure all components of non revenue water are addressed.

5. USE OF GIS IN NON-REVENUE WATER MANAGEMENT- *Martin I. Kareithi, Nairobi City Water and Sewerage Company*

Commercial losses sometimes called “apparent losses” include water that is consumed but not paid for by the users. In most cases, water has passed through the meter but is not recorded accurately. Various intervention



strategies are implemented to reduce this figure, key among them being undertaking a household survey dubbed Customer Identification Survey (CIS). It involves mapping various premise types, their source of water (NCWSC, others) such that consumption analysis will be carried out to check on the usage. Focus will be in those areas that the Meter-Reading team attains 100% Meter-reading and Billing efficiency. Onsite meter testing will be carried out upon flagging of suspected cases once data analysis is carried out. Collecting such massive data and to be able to make meaning out of it calls for the deployment of smart tools that would ensure accurate locating. Use of Online ArcGIS field data collection apps – SURVEY 123 and COLLECTOR App for ArcGIS in developing field data collection form and online dynamic digital maps are being used in Nairobi City Water and Sewerage Company to implement this strategy. These intuitive apps are both form-centric and map-centric field data gathering solutions that makes creating, sharing and analyzing surveys possible. Simple to sophisticated surveys are custom-designed according to user's interest and then shared in ArcGIS where the field team get to capture survey results with their smart phones, tablets or handheld GNSS devices. Data captured is submitted via web-browser and is immediately available for analysis thereby helping in decision making. This paper demonstrates how these field mapping tools have been used in designing customized forms and their effectiveness in collecting NRW related data.

Keywords: CIS, ArcGIS, Survey 123, Collector App

6. MAPPING OF NON-REVENUE WATER POINTS USING GIS AND REMOTE SENSING IN KITUI TOWN, KITUI COUNTY, KENYA- *Margaret Mbinja Kasuki Kenya Water Institute*

Non revenue water (NRW) is the difference between water put in the distribution system and water billed to the consumers. Water Service Providers were created under the provision of Water Act 2016 to supply the clients with water and as a result the services of water provision have improved, however high non revenue rate is one of the major issues affecting Water Service Providers (WSPs) in Kenya. A research conducted by Water Service Provider Association (WASPA) in November 2019, on the rates of NRW in Kenya recorded up to 41% which accounts to Ksh.7.8 billion lost



annually. Kitui Water and Sanitation Company (KITWASCO) is a major water service provider in Kitui County which is facing a problem of non-revenue water recording up to 58%. This presentation therefore focuses on mapping ways in which this water is lost through physical and commercial losses in Kitui town. The Mapping involved the use of Geographical Information System (GIS) technology. Global Positioning System (GPS) data for water meters, gate valves, leaks, bursts which are primary and secondary data were collected. Kitui Town shape file maps were obtained using QGIS software to facilitate the mapping procedure. Data was obtained from KITWASCO for the period between January 2019 – January 2020 to help in mapping of commercial losses. Results showed that the highest mean monthly water produced was $390,000\text{m}^3$ in January 2020 and lowest was $285,000\text{m}^3$ in May 2019. Highest mean monthly water billed was recorded as $290,000\text{m}^3$ in December 2019 and lowest as $205,000\text{m}^3$ in August 2019. Highest mean monthly water was recorded as $145,000\text{m}^3$ in January 2019 and lowest as $45,000\text{m}^3$ in may 2019. It was noted that bursts and leakages were the main causes of NRW, followed by illegal connections, and lastly, accounting errors where some staff read meters erroneously and some didn't go to the field thus guessing bills. The presentation recommends that KITWASCO should adopt mapping as one of their ways to control NRW so as to achieve the target of 25% that is recommended by Water Service Regulatory Board WASREB.

7. DIGITAL MANAGEMENT OF NON-REVENUE WATER- *Murathi Erastus, Kenya Water Institute*

Digitalization is transforming the way water and wastewater utilities plan and manage their infrastructure and interact with their customers and their staffs. Digital technologies have been playing a role in resource-efficient water management for some time, including in the management of water losses and the energy efficiency of utilities. Digital applications have been developed for customer engagement, leak detection, pressure management, energy efficient pumping, energy management and wastewater treatment. The digital transformation of resource-efficient water management brings new challenges. But it also provides opportunities for the digitalization of utilities in emerging markets and developing economies (EMDEs), which, due to economic,



technical, social and legal differences, are often quite different from those in high-income economies. This document addresses these differences, from tariff structures to levels of water losses, and identifies opportunities for digitalization in resource-efficient water management that can work especially well in EMDEs. It also discusses some digital applications that are already in widespread use in high-income countries, but due to economic, technical or other factors are not currently suited to the needs of EMDEs. The fields of opportunity identified are considered in three categories – those related to reducing commercial (or apparent) losses; those related to reducing physical (or real) losses; and finally those related specifically to increasing the energy efficiency of water and wastewater utilities. Factors that are common in EMDEs, such as high levels of unauthorized consumption and low water tariffs, mean that, overall, the requirements for digital applications in EMDEs are very different from those in high-income economies. This is particularly in regard to mitigating commercial losses, but also for reducing physical losses. These differences are significantly less marked when examining energy efficiency, where local and regional differences, particularly electricity tariffs and actual use of electricity, are much more important.

8. PROSPECTING LASER BASED ADDITIVE MANUFACTURING TO REDUCE NON-REVENUE WATER - *Virginia Nanetia, Kenya Water Institute*

Advanced technology and research are seen as critical elements in addressing some of these challenges to deliver cost-competitive approaches to mitigating non-revenue and related losses in water sector; especially for the water service providers and other stakeholders to remain profitable in business. Laser technology is a current technology that is changing the dynamics of manufacturing and product development. Though relatively new, it offers a myriad of openings suitable for infinite applicable across engineering field the water sector being one of them. This technology can potentially aid in managing if not mitigating non-revenue water. Laser based additive manufacturing can potentially be applied in repairing of pipe leaks and bursts instantaneously or even onsite, by application of 3D concept to seal them.



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Manufacturing intricate water fittings like impellers and shafts plus many equipment parts that are susceptible to wear and tear will not only reduce non-revenue water but also increase profits by reducing the cost of operation and maintenance.

This presentation thus is meant to trigger and essentially align stakeholders to explore the prospects and potential that laser based additive manufacturing has in and ensuring we have efficient an effective systems geared towards improved profits and exemplary service delivery in the water sector.



ENABLING ENVIRONMENT AND INCENTIVES FOR NON-REVENUE WATER REDUCTION AT WSP LEVEL SUB-THEME.

9. THE ROLE OF WATER QUALITY MONITORING IN NON REVENUE WATER REDUCTION - A CASE STUDY OF NAIROBI CITY WATER AND SEWERAGE COMPANY- *Michael Alexander Onyango, Nairobi City Water and Sewerage Company*

The Drinking Water Distribution Network (DWDN) is one of the most important infrastructure within a city. They are designed in ways that ensures they deliver safe potable water with adequate pressure and continuous flows, 24 hours a day to meet the demand of the population. On the contrary many water utilities are today faced with the challenge of non-revenue water (NRW) resulting in not only loss of revenue but increased operational cost. The current NRW for Nairobi City Water and Sewerage Company (NCWSC) stands at 42.83% with physical losses accounting for 12.85% and apparent losses, 29.98%, which is above the sector benchmark of under 20% set by WASREB. This has remained a major concern to the management of the company and other stakeholders requiring urgent attention. Overtime concerns arising from burst and particularly background leakages have internally prompted NCWSC operational team to seek more support from the water quality team to address leakages and intrusion of contaminants linked to the leakages. This has been viewed from the prism that fundamentally water loss due to leakages makes the work of pinpointing the specific location of the leaks more complicated necessitating the need to use methods such as regular sampling and testing. Indeed, it has been documented that for intrusion to occur, three conditions must be present; an adverse pressure gradient (the driving force), intrusion pathway (leakage points), and contaminant source. This paper therefore looks into how NCWSC applies water quality monitoring not only to control water loss and subsequently minimize NRW but also to address water quality issues. The paper will present secondary water quality data collected during self-monitoring, and demand monitoring covering the period between 2017 to 2022. The paper will also put forth the strategies employed during these exercises and the lessons learnt.



10. DETERMINANTS OF NON-REVENUE WATER AMONG URBAN WATER SERVICE PROVIDERS IN KENYA - *Seth Muthusi, Kenya Water Institute, EddahTerer, Kenya Water Institute*

In developing countries, about 45 million cubic meters of water are lost daily through water leakages, all in all some countries have managed to reduce NRW to very low levels. Kenya is classified as a water scarce country, however it losses about 47% of its piped clean water. If this water that goes to loss can be saved then almost an equal population to that already connected to piped water would be connected this can also be a cheaper way to realize more connections unlike other ways like dam constructions, borehole and funding new water system that the government has invested in year after year. **The study therefore sought to establish the determinants of non-revenue water among water service providers in Kenya.** The study specifically focused on state of water meter, unauthorized consumption of water, water infrastructure and leakages. The current study was anchored on the economic crime theory, Utility theory; Resource based theory and the New Public Management theory. The study focused on urban water service providers. A descriptive research design was used for this study. The urban water service providers face the problem of non-revenue water and since the urban centers suffer the most from water shortage, this unit of analysis forms the basis for this study. The study focused on 65 WSP in the urban centers. A census approach was used hence the size was 65. Each company had one operation manager participate in the study. The study used SPSS version 21 to establish the descriptive and inferential results regarding the mean, frequencies, standard deviation, regression and correlation. The results were presented in form of charts, graphs and Table. Correlation results revealed that that State of Water Meter, Unauthorized Consumption of Water, Water Infrastructure, Leakages have a positive and significant effect on non-revenue among urban water service providers in Kenya. Regression results also indicated that State of Water Meter, Unauthorized Consumption of Water, Water Infrastructure, Leakages have a positive and significant effect on non-revenue among urban water service providers in Kenya. The study concluded that the state of water meters, unauthorized consumption of water, water infrastructure and leakages



positively and significantly affect non-revenue water. There is also need for urban WSPs to replace of faulty water meters in the company to enhance accuracy in meter reading. The study further recommends urban WSPs to ensure there are master meters in their system so as to enhance rationing of meter connection. The study also recommends urban WSPs to ensure that there are no cases of illegal connection of water meters by penalizing customers who have illegal connections. There is also need for urban water service providers to ensure there are no manipulations of water meter reading. Moreover, urban WSPs should ensure that all their customers have registered water meters. In addition, urban WSPs to ensure there are high quality water system assets in their company so as to minimize non-revenue water. Urban WSPs should also ensure they have adequate sources of water so as to sustain their customers. The study further recommends the WSPs to replace old meter and water systems (aged). There is also need for WSPs to ensure that their old main service lines are in good status. Moreover, the study recommends urban WSPs to completely shut down their systems so as to repair their entire water system. There is also need to minimize the cost of repairing leakages. The study further recommends urban WSPs to reduce the percentage of their pipe leakages as it determines the NRW.

11. GLOBALLY ACCEPTED STANDARDS FOR THE MANAGEMENT OF NRW- Otieno Frederick Onyango

Non-revenue Water (NRW) is a critical constituent of municipal water supply networks. Essentially, NRW is the proportion of output from the production unit of Water Supply providers (WSPs) that does not reach the consumer, leading to revenue losses for the affected companies. The purpose of this paper is to outline universally recognized standards for the management of NRW. The objectives of this analysis are: (1) to delineate the main causes of NRW, (2) to outline the benefits of NRW reduction, and (3) to highlight cost-effective, sustainable standards for the reduction, and control of NRW. To realize the objectives, secondary data collection methodology was used. The research established universally acknowledged standards for the management of non-revenue water as(i) mitigation of risks from leaks, causing technical



and commercial losses (ii) reduction of inadequate, unlawful connections, pipe bursts, and unmetered water, (iii) Effective Customer Metering, (iv) Pressure Management, (v) Effective NRW Reporting, and, (vi) Adoption of Geographic Information Systems (GIS). The findings further suggest that sound NRW management standards could save water utility companies some \$ 15 billion annually. In Kenya, revenue losses totaling some \$ 100 million could potentially be avoided. Findings from this research will aid governments and water sector stakeholders to supply water to a larger number of people through reinvestment of funds that would otherwise be channeled to maintenance, and repair of broken supply systems.

Keywords: non-revenue water, technical losses, commercial losses, GIS.

12. NON REVENUE WATER REDUCTION IN WATER SERVICE PROVIDERS, A CASE STUDY OF MURANG'A WATER AND SANITATION COMPANY LIMITED- *Josephine Wambui Kinuthia.*

The study sought to find out the effectiveness of water service provision in reducing NRW. The Data used is the billing analysis of Murang'a water and Sanitation Company limited and analyzed using descriptive statistics and thereafter presented by use of statistical means of tables, pie charts and bar graphs. The methodology used in the study is by use of the billing data, daily big consumer readings master meter daily readings, daily complaints and observation. The study had the following findings: The most NRW in the company i.e 47% is due to high rate of burst which is caused by their old dilapidated water supply pipes, human activities and also the poor quality of pipe materials. 23% of the NRW is due to commercial losses which include error in meter readings, data handling errors and estimated consumptions. 8% is due to the water losses due to the meter aged and meter inaccuracies and the remaining 22% was due to unauthorized consumption and by passes. To reduce NRW in the company, the company should try to replace the old dilapidated pipes bit by bit until they change it 100%. It should have an effective billing system to give reports on NRW analysis; they should also



identify a very strong team in the non revenue section for effective NRW reduction.

13. SUPPORTING COMMUNITY WATER SUPPLY SYSTEMS TO MAP WATER INFRASTRUCTURE AND REDUCE NON-REVENUE WATER USING GIS OPEN TOOLS (WSPS IN MIGORI COUNTY)- *Enock Ayacko, Kenya Water Institute*

Community Water Supply Schemes are crucial entities for ensuring safe and continuous drinking water supply to millions of households in every corner of the country. In Kenya there are about 174 WSPs and numerous community water supply schemes scattered in the rural areas and urban peripheries. Even though the issue of non-revenue water is increasingly becoming a major challenge for WSP, there are few WSPs that have Implemented GIS systems to map their water Infrastructure and manage Non-revenue water. Nonetheless, the existing WSP in Kenya have small budget and are still dependent on outdated CAD maps that are not georeferenced. This paper seeks to develop a cheaper GIS system for easier use by rural community water supply schemes.

A simple geographic information system (GIS) created and implemented by rural community water supply schemes can be done using open source GIS softwares/tools. The outdated Data sources or CAD files can be scanned, georeferenced and digitized accordingly. This will include determination of location of pipes, fittings and other water appurtenance using high accuracy GPS and digitizing feature in the water supply system using open-street map. Dataset can then be added in QGIS and displayed over aerial photographs and other background data. An output/Map Atlas is then generated with features and potential areas for water leaks for non-revenue water management. Notably a SMART workflow taking into considering user needs assessment, source data evaluation, field data collection, implementing a GIS, and map production can be used to solve the geospatial needs of small water supply systems. This workflow can help support water management professionals for peri-urban and rural water supply systems/schemes



14. SMART/PREPAID METERING- EXPANDING POSSIBILITIES FOR SUSTAINABLE WATER SERVICES- *Kenneth Wendo, Maji Milele, Marcel Schreurs, MajiMilele*

From 2019 to 2021 Kenyan NRW figures increased from 43% to 47%, well below the target of 30% or the acceptable sector benchmark of 20% (Issue 13 Report, wasreb). NRW is the least performed KPI for Kenyan utilities. Smart and prepaid metering is not the silver bullet to dealing with NRW, but the evidence is available that with judicious use of these systems it is possible to reduce commercial losses entirely to 100% and aid in the reduction of technical losses via tactical and strategic use of data from these systems. By extension, total NRW can indeed reduce to 20% or below. Data (2019/2020) is compared between general utility performance in the WASREB Impact report 13 to specific performance data of a utility managed by Maji Milele Ltd under Publicly Owned Privately Managed (POPM) in Siaya County. Milele is managing 3 water schemes serving 90,000 people with the plan to assimilate the fourth scheme shortly. NRW in these schemes has dropped from by average 80%+ to an average of 45-50% in 3.5 years. Collection efficiencies are at 102% compared to 89% by public utilities. The 102% is attributed to the ability to collect historical debts using prepaid and smart metering systems. While NRW reduction is attributed to a combination of interventions (among which smart/prepaid metering was one) revenue collection efficiency is solely buttressed by the rollout of prepaid metering approaches. Maji Milele records a positive rate of return now. With a protracted plan to implement a 100% smart/prepaid model over the next few years of the POPM contract, Maji Milele intends to further reduce NRW to below 25%, which we consider acceptable because the schemes are very old (from the seventies) and the piped kilometres are very high in comparison to the population served. NRW is a big problem in the water supply. Smart approaches that leverage technology can go a long way to aid cost reduction and improve utilities cash flows while offering improved services.



THE ROLE OF ACADEMIC INSTITUTIONS, IN THE MANAGEMENT OF NON-REVENUE WATER SUB-THEME

15. DEVELOPING CAPACITY IN THE APPLICATION OF GIS AND ODK FOR DATA MANAGEMENT IN SUPPORT OF NRW REDUCTION *Patrick Murunga Wakhungu, Tharaka University College, John Kiplagat ,Tharaka University College*

Gathering geographical information system (GIS) data has been a challenge for most water organisations due to lack of tools for data collection and technical officers working in water supply companies lack the necessary skills and tools to capture GIS data. Apart from this, time variation of events requires that data is collected on regular basis for organisations to get insight on temporal trends of variables in their operations. Mobile spatial data collection and transmission using Open Data Kits (ODK) comes in handy to enable gathering of these data. Online platforms also exist for storing the data after which organisations can download for analysis and for overlays with other existing spatial data. We have been developing and training users on ODK tools that promote regular updating of infrastructure and service level maps. These capacity development initiatives at KEWI have been undertaken in more than 6 counties in partnership with WSTF and WASPA. More than 32 water utilities have been introduced to these simplified and cost-effective mapping tools with commendable outcomes in areas like non-revenue water. KEWI's trainings on ODK have enabled many utilities to utilize their GIS-unskilled staff produce good and useful maps quickly. Results from using ODK and GIS in supporting rural water utilities in assessing their systems and in determining their service level coverage allows them to better appreciate their service provision beyond simply reflecting on operational performance. And this can go a long way in closing the last Mile to SDG 6. There is need therefore to scale up the adoption and use of these simplified



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mapping tools through enhanced training that targets more utilities in the country. University education should also embrace these technologies for related technical personnel. Line patrollers, meter readers and plumbers can become very reliable map makers when trained to use their mobile phones to collect GIS information

Keywords: GIS, ODK, Training, Infrastructure, Service Level



NATIONAL POLICIES, REGULATIONS FOR NON-REVENUE WATER REDUCTION SUB-THEME

16. ROLE OF NATIONAL GOVERNMENT IN NON REVENUE WATER MANAGEMENT- *John Thiga Waweru, Kenya Water Institute*

There is need for water service providers to adhere to established policies, laws and regulations in providing water services to consumers. The WSPs should obtain necessary permits and licenses from relevant authorities like NEMA, WRA and WASREB. Non-revenue water management is an integrated component that calls for coordination and commitment of all water and environmental stakeholders to achieve a desired goal and a common objective of clean water and sanitation by the year 2030. There is need for water service providers to conduct Environment and social impact assessments before the proponent establishes his water supply venture. This affirms the commitment of the proponent to safeguard water and environmental resources. NEMA has been established as a government watchdog with a mandate to supervise and coordinate environmental matters within the country. ESIA as a planning and management tool presents methodologies and techniques for identifying, predicting and evaluating potential environmental impacts of projects, policies, plans and programmes in the project cycle (planning, implementation and decommissioning phases). The EIA process will present decision-makers with the information necessary to determine whether or not Water supply project should be implemented. It is also important for water service providers to obtain permits from water Resources authority to abstract water from a water resource. WRA has been mandated through delegated authority on behalf of the national government to safeguard the right to clean water by ensuring that there is proper regulation of the management and use of water resources, in order to ensure sufficient water for everyone and in the future. Water service provision is now a devolved function as per the water act 2016. This means that county government will be responsible for establishing water service providers or alternative provision arrangements for both the development and management of water services. According to the year 2019 census the population of Kenya was recorded as 47,564, 296 and is projected



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to reach 66, 959,993 million people by the year 2030 as per the latest United Nations data. The UN classifies Kenya as a chronically water scarce country with the lowest natural water replenishment rates at 647 meters cubes per capita per annum which is way far below the recommended rate of 1000 meters cube per capita per annum. With the projected population increase, the current destruction of water towers, the lowest natural water replenishment it means that as a country we cannot afford to account even a single drop of water. Non-revenue water management should therefore be an integrated component that demands coordinated efforts by all stakeholders. In most cases the terminology has been synonymous to Water Service Providers as they reap direct loses from non-revenue water. This calls for a necessity by the water service providers to abstract more volumes of water from the water resources to meet the demand of the growing population and recover for the unaccounted for water. Every stakeholder and every consumer will therefore be a loser if the current huge figures (42%) of non-revenue water is let to prevail. As per the master plan the sector needs to increase water production to two and a half times the current levels in order to meet future water demand. WRA will lose more revenue from illegal water abstraction. NEMA as a government watchdog will lose revenue from Environment and social impact assessments for water abstraction as only pools of murky, foul, and filthy water will constitute our surface water. The County government will be forced to explore ground water resources to meet the demand of an increased population and the citizens will experience huge water tariffs. Non-revenue water management is therefore not a responsibility of WSPs but an integrated effort where all stakeholders should work in harmony to eradicate this loses. Community should be educated on the need to use water sparingly and the need to report illegal abstraction even if this will call for an incentive by a kitty established by both water and environment stakeholders.



DATA MANAGEMENT ANALYSIS IN SUPPORT OF NRW MANAGEMENT SUB-THEME

17. IDEAL MAPPING WORKFLOW FOR SPATIAL DATA PREPARATION IN SUPPORT OF NON-REVENUE WATER MANAGEMENT- *Eric K Wamiti – Kenya Water Institute (KEWI)*

Preparation of spatial dataset can pose challenges especially where data collection is at the onset. Spatial scientists are in most cases at loss when deciding where to start, how to capture accurate and reliable information and how to fill gaps of missing information. This could pose a challenge of time, financial and resources constraints.

Official organisations’ documents, resource persons, publications, non-spatial tables and sketches have information that spatial data developers tend to skip in the process of building up spatial datasets. This amounts to failure to consider data “within the neighborhood”, that is gradually developed over time and which is data at the time of event and consequently accurate data. We develop a data collection (mapping) workflow which guides the spatial scientists on where to look data in the “neighborhood” or in existing data, what to do with it and considerations in case of its absence. The workflow is designed to speed up spatial data collection activities, help generate rich and informative spatial datasets and reliable and accurate data. By applying the workflow, we considerably reduced the time required to develop large datasets and subsequent maps for twenty-seven projects in five counties in a project funded by Water Sector Trust Fund. We also developed accurate spatial datasets for thirty-five thousand and sixteen connections for Malindi Water and Sewerage Company Limited in six months and we were able to develop infrastructure and households’ spatial datasets for four sub-counties of Baringo County under the project “Pilot baseline Survey and mapping for Monitoring and evaluation” for Central Rift Valley Works Development Agency (CRVWDA).



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EXHIBITION

During the symposium, a total of 8 exhibitors indicated below exhibited in line with the symposium theme.

1. Safaricom PLC
2. National Bank of Kenya (NBK)
3. DOSHI
4. Water Sector Research Fund (WSTF)
5. ESRI –EA
6. Kenya Bureau of Standards (KEBS)
7. Kenya Forestry Research Institute (KEFRI)
8. Kenya Water Institute (KEWI)