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THE DETERMINANTS OF NON-REVENUE WATER IN SHURUGWI TOWN:

A CASE OF MAKUSHA RESIDENTIAL AREA.

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ABSTRACT

Non-revenue water levels are reported to be averaging around 50% in Zimbabwe which is in contrast to the 25% level accepted by the World Bank. This study sought to establish the determinants of non-revenue water in Makusha residential area, Shurugwi. Although non-revenue water studies have been extensively conducted globally, there are somewhat a few empirical studies which focus on smaller towns in developing countries. A questionnaire survey of a 110 randomly selected households, a direct observation exercise, and key informant interviews were employed to collect data. Research findings reflect that the town council's system of estimating water consumption encourages negligent water usage. Moreover, incidences of water theft and leakages are rampant. The study recommends that the town council must conduct regular monitoring to ensure cut-off users do not practice water theft. Furthermore, the town council may need to incentivize residents to ensure that leakages and illegal water usage are reported promptly.

Keywords: Non-Revenue Water, Leakages, Incentives, Estimates, Meters, Shurugwi.

INTRODUCTION

Siyembe (2008) reports that the globe loses an estimated 48 billion cm³ of water as non-revenue water through both commercial and physical means per annum. This loss amounts to an estimated 14 billion USD$ lost annually (Kingdom, Liemberger & Marin, 2006). Non-revenue water levels are not uniformly distributed across the globe. A large portion of non-revenue water averaging to above 50% is lost in developing nations which is 25% more than the approved levels by the World Bank (Kingdom et al, 2006). Non-revenue water losses have been estimated at approximately 40% in South East Asia (Agrawal & Hunter, 2009), 50% across Balkan countries (Murrar, 2017) and 50% in Zimbabwe (Dube, 2014). Non-revenue water loss occurs in the form of physical and commercial water losses.

The International Water Association defines physical losses as ‘the volumes [of water] lost through all types of leaks, bursts and overflows on mains, service reservoirs and service connections, up to the point of customer metering' (Siyembe, 2003, p. 30). Kingdom et al (2006) state that the greatest proportion of non-revenue water loss in developing countries occurs through leakages. They argue that water lost through leakages is sufficient to serve nearly 200 million people annually. Physical losses in developing countries are exacerbated by the poor and aged infrastructure (Makaya & Hensel, 2014a, p. 56). Moreover, such water utilities seldom have adequate leakage detection programmes. A case in point is a study carried out by Makaya and Hensel (2014a) among four selected residential areas in Harare which estimated water leakages at 33% per annum. As a result, one of their recommendations was that the Harare city council had to purchase leakage detection equipment and conduct periodic water audits. Likewise, the study area, Shurugwi continues to grapple with non-revenue water issues despite a revamp of the Manzimudhaka water treatment plant (Musteyekwa, 2012), as a result of dilapidated pipes.

On the other hand, commercial losses refer to treated water consumed but not paid for by the consumer. Agrawal & Hunter (2009) report that inaccurate customer meters, illegal connections and poor billing practices trigger the high commercial losses in South Asia. They maintain that non-revenue water reduction initiatives in the area are now receiving increased attention in India and Bangladesh as a result of the soaring estimated revenue loss. Similarly, commercial water losses are high in African countries. Manzungu & Machiridza (2005) attribute this to poor monitoring systems by water utilities. Consequently, physical and commercial water losses are disastrous due to their cyclic nature.

Physical water losses increase the water utilities operating costs and simultaneously deter municipal water from reaching the consumer (Farley, Ghazali, Istandar, Singh & Wyeth, 2008). Commercial losses, on the other hand, reduce revenue generation thereby undermining the financial viability of the water utility due to illegal connections, data inaccuracies and faulty meters (Demetrio, 2013). Reducing non-revenue water releases sources of ‘new water' and finance for the utility (Agrawal & Hunter, 2009). In fact, Kingdom et al (2006) maintain that if the current global non-revenue water level was able to be reduced, 90 million people would have access to municipal water without extra costs incurred by the water utility. Similarly, a study conducted by the World Bank in 2008 discovered that approximately 80 million cubic meters of water were lost daily in developing nations which was equal to an ample water supply for Cyprus for a full year (Demetrio, 2013). For this reason, he argues that non-revenue water is the worst consumer of water. Siyembe (2008) posits that reducing non-revenue water signifies that less system volume of water is used to supply water which in turn reduces the amount of energy consumed. From a physical loss point of view, Agrawal & Hunter (2009) argue that managing non-revenue water reduces property damage and improves water pressure throughout the water network. Furthermore, reducing non-revenue water loss would improve the service provided by the water utility ensuring consumer satisfaction (Gambe, 2013). With all these perceived benefits developing nations must prioritize reducing non-revenue water so as to strive towards sustainable cities. In fact, the 6^{th} Sustainable development goal (SDG) recognises the need to ensure universal access to safe and affordable drinking water (Stevance, 2015). Therefore, reducing non-revenue water is one of the ways through which this can be achieved.

To reduce non-revenue water Kingdom et al (2006) propose that water utilities should adopt a diagnostic approach before implementing any strategy. Diagnosis ensures that the magnitude of the problem is identified enabling the most practical and achievable solutions to be adopted by the water utility (Farley, 2003). Makaya & Hensel (2014b) maintain that the water utility must understand its network and operating practices. Typical information to be gathered during this process includes determining how much water is being lost, pinpointing where losses are occurring, identifying strategies to improve performance and determining how the strategies can be maintained for continuous improvements (Farley, 2003). As a result, obtaining such baseline information on non-revenue water is invaluable for effective strategy formulation and implementation. Simply addressing one aspect will not yield desired results instead; a holistic approach is required in dealing with the phenomena. For instance, Gumbo & Van der Zaag (2002) report that despite Mutare (Zimbabwe) completing a US$ 100 million water scheme it continued experiencing high non-revenue water levels (50%) due to inadequate water monitoring and auditing. Similarly, Shurugwi rehabilitated the Manzimudhaka treatment plant (Musteyekwa, 2012), but the water supply system has not improved per se. Water utilities in Zimbabwe continue struggling to supply adequate water to its consumers (Kusena & Beckedahl, 2016).

The literature on the non-revenue water in Zimbabwe is scanty and a lack of substantial studies on non-revenue water in Zimbabwe impedes policymakers in implementing appropriate measures to deal with the phenomenon. Although there is a general consensus that non-revenue water levels are high, averaging about 50% (Dube, 2014), a few empirical studies have been carried out to identify the determinants of non-revenue water in smaller towns across the country. Makaya & Hensel (2014a) carried out a study in the city of Harare where they estimated non-revenue water losses at 36% on a monthly basis which cost the city an estimated 1 million US$ per annum. Ncube (2011) estimated non-revenue water levels in Bulawayo at 35 % whilst Gumbo & Van der Zaag (2002) estimated non-revenue water in Mutare at 50% of the total system input volume. What these studies have in common is that they were all carried out in major towns of the country. Demetri (2013, p. 11) argues that non-revenue water varies from city to city, consequently, response programmes may differ from place to place. Furthermore, Farley et al (2008) contend that gaining a better understanding of non-revenue water, why and how it occurs helps improve the basic understanding of the issue and aids policymakers in making informed decisions on the matter. In this regard, this study seeks to contribute to the literature by providing a baseline review of the determinants of non-revenue water in Makusha residential area in the smaller town of Shurugwi. It is hoped that this study will aid policymakers in making informed decisions when formulating policies and strategies to solve the problem. Moreover, the findings may not necessarily be peculiar to Shurugwi, Makusha; and may have resonance cutting across smaller town residential areas in Zimbabwe and developing nations at large. Despite receiving a 1.2 million USD$ fund in 2012 to restore the water and reticulation system from the United Nations Children's Fund, Shurugwi continues facing water supply problems (Shoko, 2012). In 2015 the high-density suburbs in Shurugwi experienced water shortages attributed to the cutting of water supply by the Zimbabwe National Water Authority due to the town's council outstanding debts (Shoko, 2015). For over three years of erratic water supply residents in the mining town have responded by refusing to pay their water bills (Mutseyekwa, 2012) which further affects service delivery. Makusha residential area is one of the oldest residential compounds in Shurugwi characterized by dilapidated facilities which contribute to the non-revenue water challenges experienced in the area leading to water supply and sanitation-related hazards. Against this backcloth, the aim of this paper is to explore the determinants of non-revenue water in the high-density suburb of Makusha. The paper unfolds through four sections. First, the study area is explored, second, the materials and methods employed are highlighted. Third, the results and discussion are presented. Finally, an overall picture is presented in the conclusion.

Study area

Shurugwi is a mining town harbouring a population of 21 905 citizens (ZimStats, 2014). The town lies at 30°00′E' longitude and 19°40′S latitude and is located in the Midlands province of Zimbabwe, which lies 350 km south of Harare (Figure 1). Shurugwi falls under agroecological region three receiving rainfall ranging from 500mm to 700mm annually (Chenje, Paleczny & Sola, 1998). These rainfall amounts enable significant recharge of underground water sources and water supply dams namely Gwenoro and Amapongwe. Gwenhoro dam is the major supplier of water to the town, however, due to climatic variations, there has been limited water storage in the dam straining water supply not only for Shurugwi town but the city of Gweru as well (Matendere, 2014). Occasionally the town obtains its water from the small-scale Amapongogwe dam (Financial Gazette, 2013). This water is pumped and treated at the town's Mhanzimdaka water treatment plant before it reaches the consumer where it is distributed to various neighbourhoods in Shurugwi including townships such as Makusha. Makusha is one of the oldest residential areas in the town of Shurugwi. The residential area harbours approximately 2066 residents (ZimStats, 2014). Shurugwi experiences three discernible seasons as the year progresses although these are now being affected by climatic variations and climate change (Chenje et al, 1998). Traditionally from September to January a generally hot-dry season is experienced followed by, the rainy season characterized by thunderstorms and high temperatures which last until late March. The winter season experience from April to September is exhibited by cool temperatures and little rainfall. The area is located at an altitude of between 600 to 900 meters above sea level (Chenje et al, 1998). This altitude allows it to experience relatively cool mean temperatures ranging from 17 to 20ºC throughout the year. The relief of the area comprises of steep slopes and a generally rugged terrain. This has an influence on water pressure particularly on households located on steep slopes such as those in Makusha. Shurugwi is located on the great dyke which harbours a number of minerals deposits. The town is dominated by brown and sandy loam soil derived from the dominant granite underlying rock structure. The soils in the area are not uniform but vary with respect to underlying geology and gradient. The dominant soil types are luvisols, cambisols which although acidic offer good water holding capacity (Chenje et al, 1998).

A significant proportion of the economically active urban dwellers survive through informal means as a result of the economic malaise nationwide. Due to the poor economic status of the country, a limited number of economically active individuals from the Makusha residential area are actively employed in the formal sector. The informal sector is quite diversified as the economically active engage in various activities such as vending and selling of clothes to generate an income. Particularly the female counterparts survive by the selling of fresh produce at the towns' marketplace and various convenient spots across the central business district of the town.

The development of the town is largely attributed to the presence of mineral deposits. The town is located on the great dyke which is rich in minerals such as chrome and gold deposits (Chenje et al, 1998). Most able-bodied men engage in mining as a basic livelihood option. Such citizens are formally employed in the mining sector at mining companies such as the Anglo-America based Unki Mine and Russian owned Todal mine which are in the vicinity of the town's boundaries. However, a significant number of individuals practice illegal mining activities such as gold panning and artesian mining to sustain themselves and their families. The residents of Makusha also practice urban agriculture to supplement household food security. Since the area receives a sustainable amount of rainfall during the rainy season the residents of Makusha plant crops such as maize during the rainy season which is harvested and used to sustain household food security. The residential area is located within close range of a number of public facilities such as hospitals as well as schools, for example, Selukwe Primary, Charles Wraith School, and Shurugwi Secondary among others.

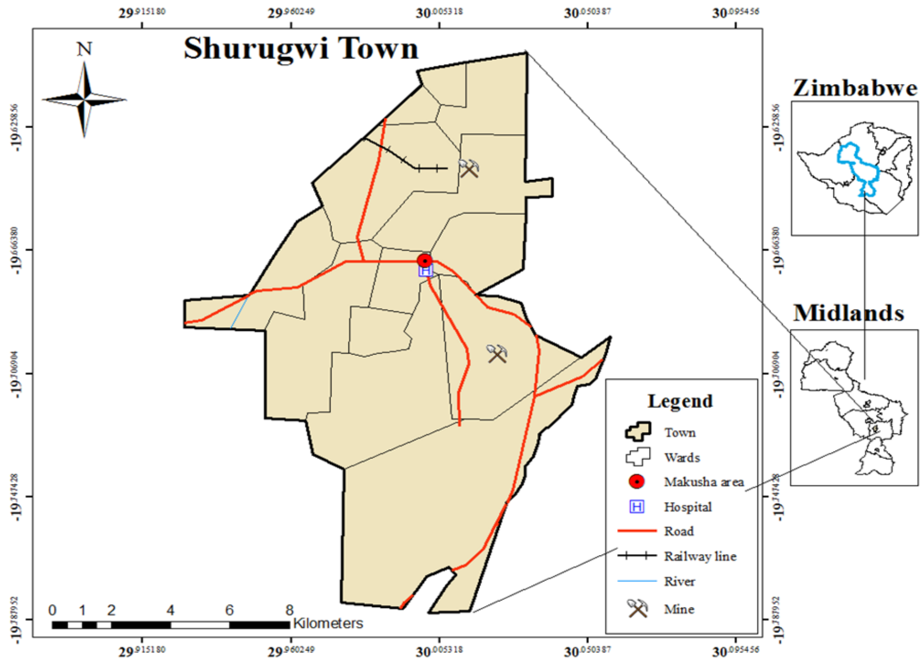

Figure 1: Location of Makusha residential area in Shurugwi Town

METHODOLOGY

The study employed both quantitative and qualitative designs to fulfil its objectives. The overarching reason for adopting a mixed approach was to minimize the flaws of each design (Creswell, 2003). Makusha residents were the target population for the questionnaire survey. Questionnaires were originally supposed to be administered to 88 randomly selected households but eventually, 110 questionnaires were administered for reliability and validity purposes. The sample size (n=88) was calculated through the use of the Yamane equation (equation 1) with an error percentage margin set at 10% for a 95% confidence level. Masuku & Singh (2014) note that employing this equation is justified when calculating sample size provided the finite populace is known. Resultantly, the equation was employed since the number of households (785) was available from the town council. A household register obtained from the town council was utilised as the sampling frame from which the 110 households were randomly selected. In this case, households were assigned numbers on the register, and 110 numbers were selected following the rules of random number tables.

$$\mathbf{N} = \frac{\pi}{1 + n\ e^2}$$

Where $\boldsymbol{\pi}$ is the total population size,

e is the error percentage margin set at 10% for a 95% confidence level,

N is the desired population size

(1) Yamane equation (Kasiulevičius, Šapoka & Filipavičiūtė, 2006)

Questionnaire respondents had to be at least 18 years or older and if no one was available in the house a replacement household was randomly selected. The questionnaire was structured to solicit the socio-demographic characteristics of the respondents. Other sections of the questionnaire captured information on the condition of the meter, witnessing and reporting leakages and reporting water theft among others. The questionnaires were personally administered to ensure a high response rate. Moreover, this form of questionnaire administration ensured the conduction of an observation exercise to monitor the conditions of water meters of the respondents. Purposive sampling was conducted in the selection of key informants. Key informants for this study included the town council Administration Officer, the town council Meter reader, the Local Initiatives Developmental (LID) Agency Project Officer the Care International Monitoring and Evaluation Officer. These informants were selected for interviews on the premise that they had direct involvement in the water and sanitation issues in the town hence were knowledgeable on non-revenue water issues in the study area. Face to face in-depth interviews were conducted with the key informants using semi-structured questions aimed at identifying why non-revenue water prevailed in the study area. Collected data was analysed using different procedures and analytic tools. The Statistical Package for Social Sciences Version 16.0 was used to present and analyse nominal and ordinal data obtained from the questionnaires. A Chi-Square test was used at 95% confidence interval to show the strength of association between meter replacement and status of household occupancy. Thematic analysis was employed to analyse qualitative data. Ethical protocols were observed during the course of the study.

RESULTS AND DISCUSSION

Commercial losses

Makusha being one of the oldest residential areas in Shurugwi town possesses the oldest infrastructure in terms of water pipes and meters. Rightfully so the town council Administration Officer revealed that most meters in Makusha were on average above 20 years old. As a water meter gets older, its efficiency is reduced hence old water meters are susceptible to under registration (Siyembe, 2008). Consequently, the town council possibly lost significant amounts of revenue as meters become inefficient with age. This situation was intensified by intermittent water supply in the area which further damages meters due to pressure variations. The town council did not retain any records of the conditions of meters of Makusha residents. Similarly, Zeraebruk, Mayabi, Gathenya, & Tsige (2014) learned that Asmara Water Supply Department in Eritrea did not possess a database of information regarding the type and condition of meters in their water supply area. Such a situation affects the capacity of the water utility in formulating non-revenue water management strategies (Kingdom et al, 2006). Questionnaire results corroborated by field observations enabled the researcher to assess the condition of the water meters among the surveyed households. Only 60 respondents reported their meters to be functional. This indicates the prevalence of commercial losses as a result of meter inaccuracies. The town council Administration Officer indicated that houses with vandalized water meters were slapped with estimated water charges based on ‘expected water consumption patterns' at the end of each month. Similarly, Manzungu & Machiridza (2005, p. 929) report that some residents across high-density areas in Harare intentionally vandalized meters which prompted the town council to resort to estimating the amount of water consumed. A total of 22 meters were not working at all and respondents maintained that they received similar water charges which barely fluctuated at the end each month. Unfortunately, this does not reflect the actual water consumed by that particular household hence the likelihood of commercial losses. Moreover, it can be assumed that if residents are aware that they receive the same unaltered water charge monthly they may use water more negligently. The Care International Monitoring and Evaluation Officer maintained that most water charges were estimated in the Makusha area as the majority of meters were visibly vandalized. The influence of the uneven terrain coupled with vandalized meters intensified commercial losses in the area. This is because, during times of low water pressure, water is only accessible to households located at lower altitudes. This observation is compatible with findings by Gumbo & Van der Zaag (2002) which confirm that the uneven terrain of Mutare affected water pressure such that residents on higher ground had difficulty accessing water from their taps. In the case of Makusha, this scenario caused commercial losses since residents from higher ground fetched water from households located at a lower ground with vandalized meters. This suggests that residents are mindful of the fact that they will not be additionally charged. One of the respondents deliberated that residents at lower altitude at times generated money from this predicament. The respondent maintained that such residents were mindful of the fact that they receive fixed water charges, consequently, they were able to sell water at exorbitant prices. A total of 3% of meters among the surveyed households in Makusha residential area had readings which were not accessible. These households consisted of meters with readings facing the ground or the wall and those with a stained glass. Siyembe (2008) attributes such problems to improper installation of the meter and this creates difficulties in attempting to get a proper reading. This may lead to faulty readings and loss of revenue by the water utility if readings of water used are below the actual water consumed. Furthermore, 30 water meters were buried just below the surface of the ground. As the Meter Reader pointed out during an interview, he could not start digging out buried water meters as he had to meet a target hence engaging in such activities would thwart this. The logical thing to do in such a scenario would be to make estimations risking commercial water losses in the process if consumers exceed the estimate (Farley, 2003).

The questionnaire survey revealed that 75 (68%) respondents had witnessed illegal water usage in the community within the previous six months. Most respondents had witnessed meter by-passing and illegal connections as the most dominant mode of illegal water usage. However, meter by-passing could not be identified through the observation exercise as Farley (2008) notes that, it is difficult to detect as the by-passing pipe is usually installed underground to prevent detection. Illegal fire hydrant usage was the least dominant mode of water theft witnessed by respondents in the area. Direct observations discovered at least 2 households practising water theft in the form of illegal connections (Plate 1). Similarly, Ainuson (2010, p. 68) conducted a study in Ghana, which reported a prevalence of illegal water connections in the communities of Ashalley Botwe, Nima, and Ashaiman. The LID Agency Project Officer maintained that water theft was quite prominent in the area because of illegal miners who interfered with the water system to access water from main pipes. Moreover, he corroborated that the uneven terrain prevented water from reaching households located on higher ground hence residents obtained water from households with vandalized meters at lower gradients. This exacerbated the levels of water theft in the community.

Plate 1: Illegal connections identified in Makusha residential area

The town council Administration Officer revealed that they attempted to reduce instances of corrupt meter readers by regularly rotating them on different routes. Although this suggests that corrupt meter reading can be ruled out, inaccurate or false readings were conspicuous due to the prominence of buried, stained and inaccessible meters readings across the surveyed households. At the time of this study, Shurugwi town council was in the process of installing prepaid water meters in an attempt to reduce corruption and data errors. However, this plan was impeded by a lack of funds hence the prioritization of commercial water users as pointed out by the town council Administration Officer. At the time, the town council was practising the traditional form of operation, therefore, could have been experiencing data handling and accounting errors at different stages. Such errors include the meter readers recording incorrect data, the billing department entering inaccurate data into the system or simply delivering the water bill to an improper address. Siyembe (2003) argues that this obsolete form of record keeping and billing operation based on human capital has a high risk of error as it is based on human efficiency.

Two sampled households were connected to a bulk meter. The bulk water meter was not working and the respondents claimed they received fixed water charges. The households were, in fact, government property and the respondents maintained that the government paid the water charges. The town council Administrations Officer mentioned that such houses received fixed charges due to the damaged bulk meter but the government barely cleared the bills. This corroborates Chinyama (2007) who discovered that institutions in Bulawayo such as police camps had bulk meters and barely paid their bills on the premise that the government would settle the debt. Such a scenario is unsustainable and negatively affects the water utility as revenue is not collected for the service provided. Consequently, the water utility is bound to fail to supply adequate water to the consumer in the long run.

Physical water losses

The town council had already revamped the water treatment plant hence leakages at the reservoir and overflowing tanks were halted. This is commended as Stevance (2015) notes that Sustainable development goal (SDG) number 6 recognises that ensuring universal access to safe and affordable drinking water by 2030 will require investment in adequate infrastructure. Therefore, this indicates a positive investment by the town council. Nonetheless, a total of 81 respondents reported witnessing leakages on water pipes and service connections over the past six months in Makusha. This prevalence of leakages was not alarming considering that the infrastructure is severely old and dilapidated hence burst pipes and leakages were expected. Most respondents indicated that leakages occurred along service connections before the meter (Plate 2). Observations assisted in identifying the leakages which occurred just before the meter. These could be identified despite the absence of water as there was evidence of attempts at sealing the leaking pipes by residents (Plate 2). This form of leakage is usually visible and costs the water utility as the water leaks before it is charged for consumption hence consumers might not even take heed of it as it does not affect their water bill (Farley, 2003). Although some residents attempted to seal the leakages it was with minor success as observations revealed that most residents used an elastic and plastic material to seal leakages which were not suitable, as a result, leakages continued.

Plate 2: Two sealed leakages identified on meters in Makusha residential suburb

Only two leakages were identified along visible service connections during the observation exercise (Plate 3). Just 3.7% of the respondents had witnessed bursts on main pipes which are not very difficult to detect due to high pressure in the main pipes. Identifying leaking and burst pipes was difficult since there was no water at the time of the investigation as a result of the intermittent water supply. A total of 81 respondents had come across leakages on pipes during the course of the previous six months. Only 36 of these respondents reported the identified burst pipes to the town council. Failure to report burst pipes by the remaining 55 witnesses implies that a significant portion of revenue was lost through leakages. On the other hand, Manzungu & Machiridza (2005) in their study in Harare discovered that the majority of sampled residents (81%) reported leakages to the Harare City Council. Their findings indicated that this was good practice as it enabled the water utility to repair leakages in a timely manner preventing physical water losses. The town council

Administration Officer acknowledged that the town council was relatively quick in attending to leakages particularly on main water pipes but response rates also lay in the ability of consumers reporting leakages promptly.

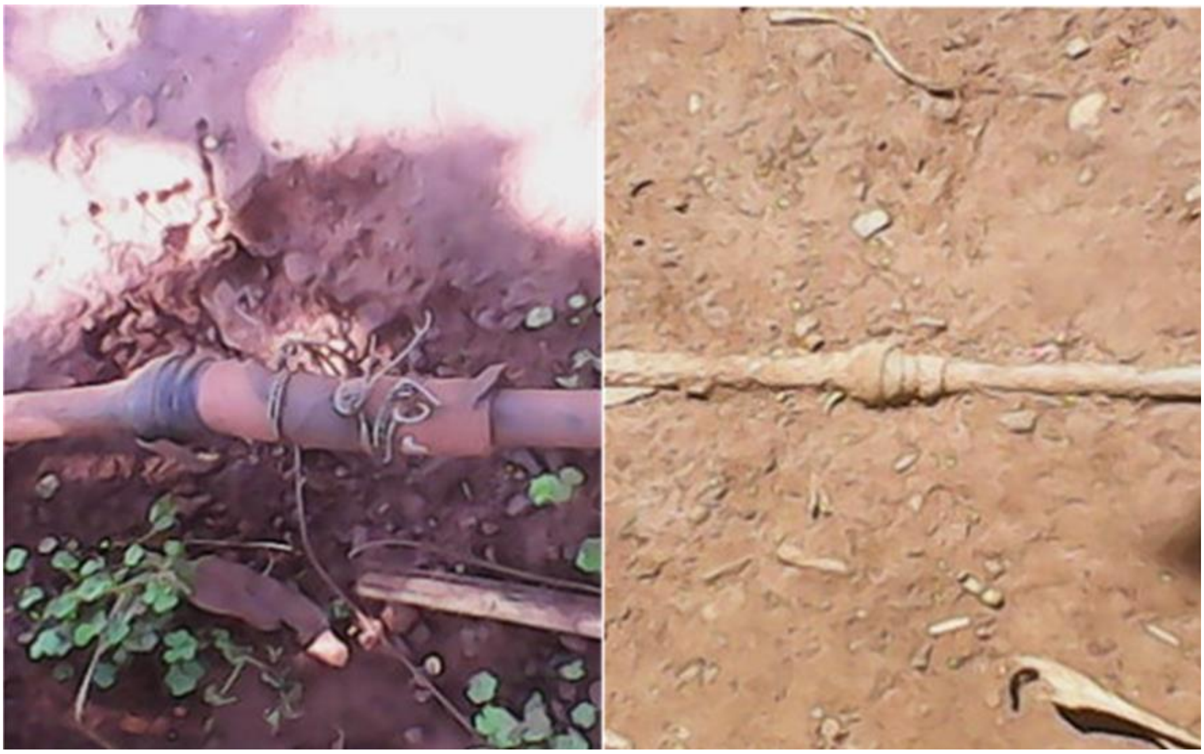

Plate 3: Two leaking pipes identified along service connections in Makusha residential area

Occupancy status of households had a significant bearing on the management of non-revenue water. A total of 40 households were occupied by temporary tenants (lodgers) hence there was a high reluctance for occupants to replace damaged service connection pipes and malfunctioning water meters. Temporary occupants reported that they could not repair such pipes and meters since they were not permanent residents of the household. According to one tenant, 'that is the responsibility of the landlord to whom I pay rent which is supposed to cater for such repairs and maintenance [of the property]'. Of the sampled units, only 5 tenants had replaced their water meters in Makusha residential area. These findings corroborated the Care International Monitoring and Evaluation Officer's statement who maintained that tenants had no incentive to replace or repair damaged service connection pipes. A chi-square test (.001) conclusively revealed that there was a relationship between meter replacement and status of occupancy which reflects significant dependence between the variables.

CONCLUSION

The study set out to highlight the determinants of non-revenue water in Makusha residential area. The research findings present some significant insights. Firstly, the condition of the meters is potentially causing commercial losses for the town council. Vandalised meters prompt a response of estimating water bills by the town council which is 'standard procedure'; however, this presents the following problems. The estimated values may be below the actual water utilised during that month. Moreover, the resident's knowledge of this procedure encourages negligent water use as they are certain they will receive more or less the same bill at the end of the month. This situation is exacerbated by residents residing in lower areas that do not face pressure problems hence welcome residents from higher ground to fetch water from their property. As such, a single service connection could be providing water sustaining more than a single family but charged as one which is unsustainable for the water utility. Meters with inaccessible readings present a challenge for the council. If a meter is facing the wall, buried or facing the ground meter readers have a difficult time accessing the reading, in fact, they do not bother reading such meters. This encourages erroneous recordings offsetting data errors throughout the system. If the town council is to ensure that all residents have access to safe and clean water (SDG 6) by the stipulated deadline of 2030 it may need to take urgent measures in addressing non-revenue water. Firstly, in response to inaccessible meter reading, reinstallation of meters facing the ground/wall must be conducted and residents must be encouraged to ensure that meters are visible to meter readers. The council must conduct water audits and identify all damaged meters and replace them on a periodic basis. Ad-hoc monitoring exercises could be conducted regularly to curb the dominance of illegal connections in the area. Secondly, the resident's low rates of reporting leakages and water theft reflects limited knowledge of non-revenue water and how it affects them as consumers. In this regard, the town council may need to collaborate with stakeholders such as non-governmental organizations and schools in raising awareness on such pertinent issues in the community. The town council may need to incentivize residents to ensure that they report leakages in a timely manner, especially leakages which occur on the main pipes. Incentives may also prove to be helpful in ensuring that illegal water usage is reported promptly. Finally, failure of government institutions to pay their water bills significantly affects revenue generation for the town council. Additionally, it presents a poor image to the residents in Makusha who may adopt the same attitude (or have already done so). The council and relevant authorities need to devise ways through which payment arrangements can be made to ensure that the service provided is paid for.

REFERENCES

Agrawal, P. & Hunter, R. (2009, February). *Non-revenue Water Management in South Asia: Issues and Challenges*, Paper presented at the 7th Meeting of the Urban Think Tank, New Delhi, India.

Ainuson, K. (2010).Urban water politics and water security in disadvantaged urban communities in Ghana. *African Studies Quarterly, 11*: 59-82.

Chenje, M. Paleczny, D. & Sola, L. (1998). *The State of Zimbabwe's Environment.* Harare: Government Printers.

Chinyama, A. (2007). *Assessment of Metering and Billing as Water Demand Management Measures: A Case Study of the City of Bulawayo*. (Unpublished master's thesis). University of Zimbabwe, Harare.

Creswell, J.W. (2003). Research design: Quantitative, qualitative and mixed methods approaches, Thousand Oaks: Sage publications.

Demetriou, G. (2013, June). *Cyprus Council of Civil Engineers Water Management Non-Revenue Water Reduction Management - (Drought climates and the case of Nicosia, Cyprus).* Paper presented at the 57th ECCE General Meeting – SC Environment and Sustainability, Lisbon, Portugal.

Dube, M. (2014). *US fund 35m to ward off water losses.* The Standard, September 28, 2014. Retrieved from..https://www.thestandard.co.zw/?s=US+fund+35m+to+ward+off+water+losses&submit.x=8&submit.y=9

Farley, M. (2003, October). *Non-revenue water - international best practice for assessment, monitoring and control*. Paper presented at the 12th Annual CWWA Water, Wastewater and Solid Waste Conference, Paradise Island, Bahamas.

Farley, M. Ghazali, Z. Istandar, A. Singh, S. & Wyeth, G. (2008). *The Manager's Non-Revenue Water Handbook a Guide to Understanding Water Losses*. United Kingdom: USAID.

Financial Gazette. (2013). *Gweru faces water crisis*. April 11, 2013. Retrieved from http://www.financialgazette.co.zw/gweru-faces-water-crisis/

Gambe, T. (2013). Stakeholder involvement in water service provision: lessons from Msasa Park, Harare, Zimbabwe. *International Journal of Politics and Good Governance, 4*: 1-21.

Gumbo, B. & Van der Zaag, P. (2002). Water losses and the political constraints to demand management: the case of the City of Mutare, Zimbabwe. *Physics and Chemistry of the Earth 27*: 805–814.

Kasiulevičius, V. Šapoka, V. & Filipavičiūtė, R. (2006). Sample size calculation in epidemiological studies. *Gerontologija, 7*(4): 225–231.

Kingdom, B. Liemberger, R. & Marin, P. (2006). *The Challenge of Reducing Non-Revenue Water in Developing Countries. How the Private Sector Can Help: A Look at Performance-Based Service Contracting, World Bank.* Water Supply and Sanitation Sector Board Discussion Paper Series paper no.8, Washington DC: The World Bank.

Kusena, W. & Beckedahl, H. (2016). An overview of the city of Gweru, Zimbabwe's water supply chain capacity: towards a demand-oriented approach in domestic water service delivery. *GeoJournal* 81: 231–242.

Makaya, E. & Hensel, O. (2014a). Water Distribution Systems Efficiency Assessment Indicators – Concepts and Application. *International Journal of Science and Research, 3*: 219-228.

Makaya, E. & Hensel, O. (2014b). The Contribution of leakage water to total water loss in Harare, Zimbabwe. *International Researchers Journal 3*: 55-63.

Manzungu, E, & Machiridza, R. (2005). An analysis of water consumption and prospects for implementing water demand management at household level in the City of Harare, Zimbabwe. *Physics and Chemistry of the Earth 30*: 925–934.

Masuku, B, & Singh, A. (2004). Sampling techniques and determination of sample size in applied statistics research: an overview. *International Journal of Economics, Commerce and Management,2*:1-22.

Matendere, B. (2014). *Gwenhoro Dam fails to take in enough water*. The Zimbabwean, 29 January 2014. Retrieved from http://www.thezimbabwean.co/2014/01/gwenhoro-dam-fails-to-take

Moshkovitz, A. (June, 2012). *Performance-Based Non-Revenue-Water Contracts in South Africa*. Paper presented at the Public-Private Partnerships Conference, Dakar, Senegal.

Murrar, A. (2017). The Determinants of Non-Revenue Water in Balkan Countries. *American Journal of Water Science and Engineering 3*:18-27.

Musteyekwa, L.(2012). *In Zimbabwe, improving water systems to safeguard children's health*. UNICEF-Zimbabwe, 16 February 2012. Retrieved from https://www.unicef.org/zimbabwe/media_12660.html

Ncube, B. (2011). *Assessment of Performance of Urban Water Supply in the City Of Bulawayo*. (Unpublished Master Thesis), University of Zimbabwe, Harare.

Shoko, P. (2015). *Shurugwi taps run dry*. Southern Eye, 16 May 2015. Retrieved from http//www.southerneye.co.zw/2015/05/16/shurugwi-taps-run-dry/

Simbeye, I. (2008). *Managing Non-Revenue Water, Non-Revenue Water Sourcebook for Trainers WAVE Programme*, Germany: WAVE.

Stevance, A. (2015). *Review of Targets for the Sustainable Development Goals: The Science Perspective*, International Council for Science (ICSU) & International Social Science Council (ISSC) publishers.

Zeraebruk, N. Mayabi, O. Gathenya, J. & Tsige, Z. (2014). Assessment of Water Supply Services and Operational Performance of Asmara Water Supply Department (AWSD) for Development of Decision Support Tools. *Environment and Natural Resources Research 4*: 208-222.

ZIMSTAT. (2014). *Zimbabwe 2012 Population Census Results: Shurugwi Town*. Harare: Population Census Office.

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