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A Comparative Study of Factors Influencing Non-Revenue Water in Mpumalanga, (a Case Study of Perceptions from Emalahleni, Emakhazeni and Steve Tshwete local Municipalities)

T. M. Maloba[1]*, M. D. Matlala[2]

1. MSc. Student, Dept. of Environmental Sciences, College of Agriculture and Environmental Sciences, University of South Africa, Florida Science Campus, 28 Pioneer Ave, Florida Park, Roodepoort, 1709, Johannesburg, South Africa
(Corresponding Author: 41383486@mylife.unisa.ac.za)
2. Senior Lecturer, Dept. of Environmental Sciences, College of Agriculture and Environmental Sciences, University of South Africa, Florida Science Campus, 28 Pioneer Ave, Florida Park, Roodepoort, 1709, Johannesburg, South Africa

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Abstract

Non-revenue water poses a significant challenge to sustainable water management in municipalities worldwide. This study investigates the factors contributing to NRW and assesses the effectiveness of existing management strategies in three municipalities in Mpumalanga, South Africa. Through a survey-based approach, perceptions of municipality workers were collected to gain insights into the drivers of NRW and the efficiency of currently employed NRW management strategies. The findings highlight real losses; broken pipes, pipe bursts, water leakages, and storage overflows are perceived as the most significant contributing factors of NRW across all three municipalities. These results align with previous studies, emphasizing the importance of addressing real losses to mitigate NRW. Additionally, the study reveals management factors and political interference as perceived contributors to increased NRW in the municipalities. In terms of management strategies, modern flow metering is employed in two of the municipalities to control active leakage, while the third municipality relies on active leakage control equipment. Pressure management practices, automatic pressure-reducing valves, and regular asset performance assessments were identified as common practices for managing and mitigating NRW, whereas the use of smart metering technologies, modern leakage detection techniques, zoning (district metered areas), and improved estimation techniques were proposed as mitigation strategies with the potential to further reduce NRW in the three municipalities. The study fills a research gap by providing insights into the specific factors contributing to NRW in the selected municipalities and evaluating the effectiveness of existing strategies. The results of the study can inform decision-makers and water utility managers in developing targeted interventions to reduce NRW and improve water management practices. It is further recommended that future studies explore the implementation and long-term effectiveness of some of the proposed mitigation strategies to effectively address NRW in order to ensure sustainable water supply, efficient resource utilization, and improved service delivery.

Keywords: Active Leakage Control, Ageing Infrastructure, Non-Revenue Water, Pipe Bursts, Real Losses, Apparent Losses.

1. Introduction

Water is an essential resource that is vital for the survival of all living organisms. It is considered a crucial natural asset that requires effective management to ensure its sustainable usage. Only a small fraction, approximately 1% of water resources is available for domestic and commercial consumption, while the rest remains inaccessible to living creatures (Tabesh et al., 2018). Water users are typically divided into three main categories: domestic, agricultural, and industrial (Reddick and Kruger, 2019). However, the demand for this limited water supply is rapidly increasing (Matlala, 2023). The widening gap between water demand and supply is influenced by various factors, including population growth, climate change impacts, urbanization, and ageing infrastructure (Hamilton, 2013; Huyssteen, 2022).

In addition to the factors mentioned earlier, the increased distribution of water to essential economic activities such as farming, industry, and energy exacerbates the situation. Furthermore, the loss of treated drinking water due to ageing infrastructure, leading to leaks and pipe bursts, as well as billing inaccuracies, further intensifies the challenges faced by municipalities worldwide in meeting water demand and supply. Neglecting to address these water challenges on time will exacerbate the problem in the future. It is crucial to emphasize the sustainable use of vital natural resources in light of these circumstances. In developing countries, a significant amount of water designated for drinking purposes is lost worldwide daily, estimated at approximately 45 million m^3 (Bhagat et al., 2019). This accounts for around 30% of the global drinking water being lost before it reaches consumers in rural areas, townships, and urban cities (Bhagat et al., 2019).

Water losses are categorized into two types: apparent losses, which include inaccuracies in meter readings and billing anomalies, as well as real losses, which involve water leakages, spills and pipe bursts (Bozkurt et al., 2022; Firat et al., 2021). The collective term for these water losses is Non-Revenue Water[1]. NRW refers to the disparity between the volume of water entering a drinking water system and the amount of water that is authorized and billed for consumption (Firat et al., 2021). NRW is defined as water distributed in a water network without generating any revenue (United States Agency for International Development, 2018). Thus, NRW encompasses both apparent losses, which include unbilled authorized consumption, as well as real losses, which as previously mentioned, include water leakages, spills as well as pipe bursts.

Apparent losses refer to water consumed by customers without generating revenue, resulting in a loss of potential income (Chabe, 2018). These apparent losses are often caused by meter under-registration, billing errors, as well as water theft through unauthorised use (Chabe, 2018; Yi et al., 2017), which involves the illegal tapping of water supply systems and subsequent revenue loss.

Real losses, on the other hand, are a result of poor maintenance and operations which often results in storage tank overflows, water leakages from broken pipes as well as pipe bursts (Appiah and Du, 2017). Furthermore, the absence of active leakage control measures also exacerbates real losses. Most cities in Africa have old water supply distribution networks that are characterized by high NRW figures (Shushu et al., 2021), and South Africa is no exception.

South Africa faces significant challenges in managing NRW, with an estimated annual loss of 1,580 million cubic meters, equivalent to a financial loss of approximately seven billion rands (Moraka, 2018), which amounts to just over 354 million dollars ($), or around 7 billion rands. This accounts for approximately one-third of the total distributed water. Many municipalities in South Africa struggle with water loss during distribution and unaccounted revenue from water (Dube, 2017), and similarly, the province of Mpumalanga is not exempt from these challenges.

With over 118 million cubic meters of water unaccounted for in 2015 and 2016 (Business Intelligence Support Team, 2017), Mpumalanga has the highest NRW statistics in the country. Furthermore, it is worth noting that within the seventeen municipalities in Mpumalanga, the combined contribution of Emalahleni, Emakhazeni, and Steve Tshwete municipalities accounts for more than 65% of the reported NRW in the province (Mckenzie et al., 2013; Wegelin and Wensley, 2014).

This study, therefore, aims to investigate and analyse factors contributing to the occurrence of NRW within the three municipalities with the highest NRW in Mpumalanga, namely Emalahleni, Emakhazeni, and Steve Tshwete. The primary objectives of this study are first, to assess the relative significance of these factors about NRW within the municipalities; secondly, to evaluate the effectiveness of the currently implemented NRW management strategies; and finally, to propose feasible mitigation measures aimed at effectively addressing the issue of NRW in the three municipalities. Mitigation strategies refer to the risk handling strategies used to ensure that the impact of the risk is minimized (Mamai and Yinghua, 2016), for example, NRW. While there exists a substantial body of literature on the subject of NRW and its associated components including studies by (Abdu Nasara et al., 2021; Farley et al., 2010; Kanakoudis and Muhammetoglu, 2014; Kingdom et al., 2006), there is a dearth of comprehensive studies focusing on the specific factors contributing to NRW in the selected municipalities. Furthermore, there is a noticeable lack of documented information regarding the efficiency of existing NRW management strategies in mitigating the occurrence of NRW, specifically within the three municipalities as well as in the larger region of Mpumalanga.

This study, therefore, aims to address this gap by exploring the perceptions of municipality workers who

[1] Non-Revenue Water (NRW)

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possess first-hand knowledge of the common factors that lead to NRW in their respective municipalities. Additionally, this study seeks to ascertain the effectiveness of the currently employed NRW management strategies, as perceived by these municipal workers. By exploring and analysing these perspectives, the study aims to highlight the multifaceted aspects of NRW and contribute to the existing knowledge base in the field of water supply and demand management, as well as successful water service delivery. Moreover, the findings of this study can potentially inform policymakers and stakeholders in formulating more effective strategies to mitigate NRW and ensure sustainable water management practices not only in the selected municipalities, but in Mpumalanga, South Africa, and beyond.

2. Materials and methods

2.1. Study area

Mpumalanga is among the nine provinces in South Africa with an estimated populace of four million people. It is known to be the province of the rising sun. It is located in the North-eastern part of the country, with a coverage of 76,495 km^2 (Stats SA, 2019). The province is the second largest after Gauteng. Mpumalanga is bordered by eSwatini on the eastern part of the province, and by Mozambique to the north-east. Additionally, four provinces in South Africa border the province of Mpumalanga, with Limpopo to the north, Gauteng on the south-western part of the province, Free-State Province to the south and Kwa-Zulu Natal to the south-eastern parts of the province (Fig. 1).

Mpumalanga is divided into three major districts that are further subdivided into seventeen municipalities (Stats SA, 2019). This study assesses the perceived drivers of NRW in three of the seventeen municipalities in Mpumalanga, namely, Emalahleni, Emakhazeni, and Steve Tshwete (Fig. 1).

In 2016, Emalahleni had a population of 455,228, Emakhazeni had 48,149 and Steve Tshwete had 278 749 residents (Stats SA, 2016). Emalahleni Municipality forms part of the region referred to as the Energy Mecca of South Africa, due to its rich coal deposits and power stations such as Kendal, Matla, Duvha, Ga-Nala, and Kusile (Emalahleni, 2021). Steve Tshwete is a municipality located in the Nkangala District of the Mpumalanga Province. Emakhazeni is also a municipality situated within the Nkangala District of Mpumalanga Province and it is the largest of the six municipalities in the district.

2.2. Data collection

To achieve the stipulated objectives a quantitative methodology was employed. The data was collected using a questionnaire survey. With a total population interest of 245 respondents (Emakhazeni (84), (across all three municipalities), a target sample size of Emalahleni with a total of 50 questionnaires were distributed to each municipality. Fig. 2 shows the flow diagram of the

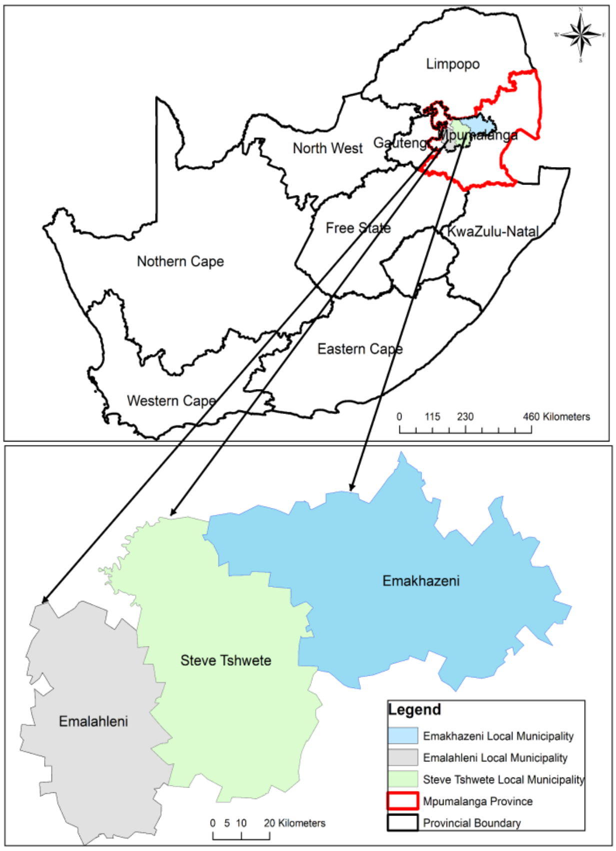

Fig. 1. Study area map

study. A confidence level of 95% and a margin of error of 5%. A 150 (equation 1) was considered appropriate at a (80), and Steve Tshwete municipality (81), from a total population of approximately 853 employees

The population of the study comprised 150 employees from the three municipalities (50 respondents from each municipality), based on Equation 1 (Stockemer, 2018)

$$\text{Sample size} = \frac{Z^2 \times P(1-P)}{1+\left(\frac{Z^2 \times P(1-P)}{e^2 N}\right)} \qquad (1)$$

Where
N = Population Size
Z = z-score (predefined as 1.96 at 95% confidence interval)
e = margin of error (0.05 at 95% confidence interval)
P = proportion of the population usually predetermined as 0.5.

The questionnaire was divided into four sections; where Section A focused on the demographic characteristics of the respondents from the three municipalities, Section B focused on the identification of common drivers of NRW in the three municipalities,

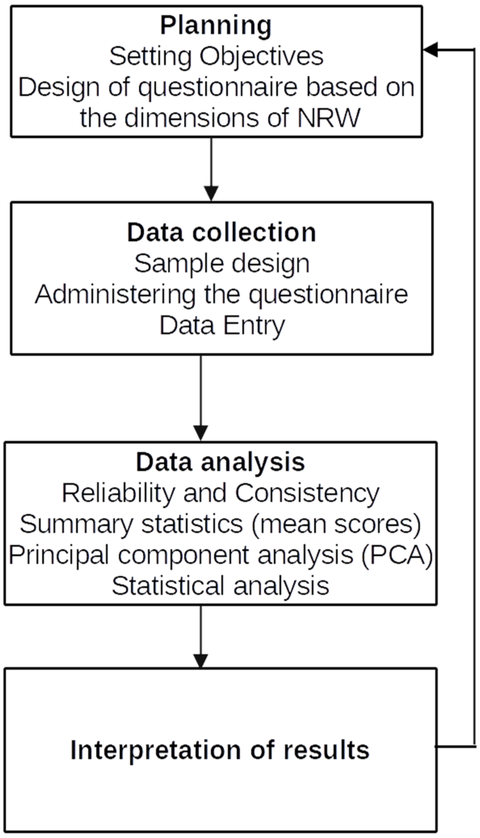

Fig. 2. Flow diagram of the study

Section C focused on the identification and assessment of the efficiency of NRW management strategies, whereas section D focused on the identification of the mitigation measures employed by the three municipalities to reduce NRW (Appendix 1).

The questionnaire made use of the 5-point Likert scale. The questionnaire was grounded in the perception and self-knowledge concerning the management and mitigation strategies being utilized by municipalities to reduce NRW.

2.3. Data analysis

The data were analysed using descriptive methods. Cronbach's alpha measure of internal consistency was used to test for reliability and internal consistency on all questions, whereas the Kaiser-Meyer-Olkim of Sampling and Adequacy as well as the Bartlett's Test of Sphericity were used to test for validity on all questions.

The validity test was carried out to corroborate the appropriateness of the factors used in this research study. Additionally, Principal Component Analysis[1] was used to identify themes which were measured in the questionnaire based on the loading of variables on the retained principal components. PCA is a mathematical technique that reduces the dimensionality of the data while retaining most of the variation in the data set (Ringnér, 2008). PCA accomplishes reduction by identifying directions, called principal components, along which the variation in the data is maximal (Ringnér, 2008). Thus, PCA was used to identify themes for further analysis. The IBM Statistical Package for Social Sciences[2] version 25 was used to conduct all the above-mentioned analyses of the data.

3. Results and discussion

Out of the 150 distributed questionnaires, 130 questionnaires were completed and returned, giving a response rate of 86.6%. However, during data entry, ten questionnaires were discarded due to missing information, which led to 120 questionnaires being used for data analysis giving a final response rate of 80%.

The study interpreted and analysed responses which were sufficiently completed by a total of 120 (55 males and 65 females) respondents made up of 44 employees from Emakhazeni, 41 from Steve Tshwete and 35 employees from Emalahleni, all between the ages of 18 and 65, with the highest qualifications ranging from matric (high school certificate) to a PhD, and years of working experience in the water sector/municipality ranging between less than a year to over 20 years (Table 1).

The respondents were made up of 28-meter readers (collecting readings on water meters for billing purposes), 27 finance officers (financial management of the municipality and maintaining financial systems); 25 administrators (monitoring the activities of the municipality and evaluating progress towards attaining the municipality goals as well as ensuring the efficient running of the municipality), 20 technicians (planning, maintenance, assessment and analysis of infrastructure and coordinating the development of technical skills to support the delivery of services), as well as 20 management personnel (Managing the financial, human and technical resources needs of the Municipality as well ensuring the efficient running of the Municipality). The results of the study are presented in two subsections with the first section focusing on the identification of common drivers of NRW as perceived by employees in the three municipalities, and the second subsection presents the existing mitigation measures implemented by the municipalities.

3.1. Drivers of NRW

Previous studies (Chabe, 2018; Güngör-Demirci et al., 2018; Yi et al., 2017) classified drivers of NRW were due to apparent losses (metering errors, theft, billing anomalies, non-compliance of community members), real losses (broken pipes, pipe bursts, water leakages, and storage overflow), management-related factors (mismanagement, bad organizational culture, staff shortages, and absence of an integrated plan), as well as political interference.

[1] Principal Component Analysis (PCA)

[2] Statistical Package for Social Sciences (SPSS)

Table 1. The biographical information of the respondents

		Experience									
		1 to 5 years		6 to 10 years		11 to 20 years		Above 20 years		Total	
Education	Matric	3	10	4	13	8	3	2	1	17	27
	Diploma/Degree (including honors)	5	12	17	14	4	4	3	1	29	31
	Masters		2	3	2	4	2	0		7	6
	PhD	0		0		0		2	1	2	1
Total		**8**	**24**	**24**	**29**	**16**	**9**	**7**	**3**	**55**	**65**

The results (Table 2) show that out of the fourteen identified factors; poor infrastructure (4.83); mismanagement (4.83) and political interference (4.80) were identified by over 93% of the respondents as the top three factors leading to NRW in Emalahleni municipality. In the municipality of Emakhazeni; the results show that pipe bursts (4.68), water leakages (4.64), and non-compliance of community members (4.64) were the top three factors identified by approximately 97% of the respondents, whereas over 90% of the respondents from Steve Tshwete identified poor infrastructure (4.68); as well as mismanagement (4.68) as the leading factors of NRW in their municipality. The results show that employees in all three municipalities identified poor /aging infrastructure as the main driver of NRW, and this is similar to previous studies by (Farley et al., 2010; Gorzoni et al., 2019; Güngör-Demirci et al., 2018; Shushu et al., 2021), who independently concluded that old infrastructure propagates leakages within the distribution network. In addition to poor infrastructure, over 90% of respondents from all three municipalities also identified non-compliance of community members as one of the common factors leading to increased NRW; and similar claims were made (Gorzoni et al., 2019; Shushu et al., 2021), that respectively identified unaffordable water services well as consumer dissatisfaction as the reasons for non-compliance. Thus, in all three municipalities, the respondents identified real losses (such as broken pipes, pipe bursts, water leakages, and storage overflow), as the primary factors contributing to NRW. These findings align with previous studies (Bozkurt et al., 2022; Leauber, 2020; Shushu et al., 2021; Yi et al., 2017) that also emphasized the significant impact of real losses on NRW.

MR = Meter Readers, ADM = Administrators, TECH = Technicians, FO = Finance Officer, MP = Management Personnel.

The findings of the study also indicate that, apart from issues related to inadequate/poor and aging infrastructure as well as non-compliance among community members, the respondents in each municipality (with a percentage exceeding 80%) also perceived management factors and political interference as contributing to the increasing NRW in the three municipalities. It is therefore important to acknowledge that ineffective management often leads to poor service delivery and an escalation in NRW. In a similar study, political interference, corruption, and insufficient public involvement were identified as the primary factors affecting water utilities (Firat et al., 2021). Enhancing financial management by implementing revenue collection strategies and allocating sufficient funds to improve governance within water utilities was emphasised (Jang and Choi, 2017).

Table 2. Factors leading to NRW as identified by the different sectors of the municipalities

Factor	Emalahleni	Emakhazeni	Steve tshwete
Absence of an integrated strategic plan to avoid NRW	4.74	4.57	4.56
Bad organizational culture	4.66	4.45	4.56
Billing anomalies	4.44	3.91	4.00
Broken pipes	4.57	4.34	4.46
Metering errors	4.29	3.59	3.83
Mismanagement	**4.83**	4.45	**4.68**
Non-compliance of community members	4.77	**4.64**	4.66
Pipe burst	4.66	**4.68**	4.56
Political interference	**4.80**	4.52	4.59
Poor infrastructure	**4.83**	4.61	**4.68**
Staff shortages	4.26	4.57	4.54
Storage overflow	4.46	4.11	4.10
Theft	4.77	4.45	4.29
Water leakages	4.63	**4.64**	4.62

Table 3. Identification of the current NRW management strategies used by the three municipalities

	EMalahleni	EMakhazeni	Steve tshwete
Management strategies		**Mean**	
Active leakage control			
Our municipality has a detailed active leakage control	3.03	3.11	3.00
Our municipality uses modern flow metering	**3.29**	**3.43**	3.20
Our municipality uses digital methods to detect leakages	2.40	2.70	2.41
Our municipality uses ALC equipment such as noise loggers, ground microphones, leak noise correlators and sound sticks	2.74	2.61	3.32
Pressure management			
Our municipality uses automatic pressure-reducing valves to manage pressure	**3.46**	**3.61**	**3.49**
Our municipality uses break pressure tanks to manage pressure Our municipality uses speed dump controllers to manage pressure	3.20	3.36	3.22
Asset management	**3.20**	**3.25**	**3.02**
Our municipality uses information systems to manage assets	3.11	**3.23**	**3.37**
Our municipality regularly assesses the performance of all assets	**3.23**	**3.23**	**3.37**
Our municipality engages all stakeholders before deciding to replace or rehabilitate any asset	3.00	2.95	3.32
Other management strategies			
Our municipality uses the Burst and Background Estimates[1]	2.89	3.00	2.94
Our municipality uses the Infrastructure Leakage Index[2]	2.94	3.02	2.98
Our municipality uses the Apparent Loss Index[3]	**3.03**	**3.09**	**3.15**

3.2. Efficiency of existing management strategies

In addition to identifying the drivers of NRW in the three municipalities, this study also assessed the effectiveness of the current management strategies implemented by the municipalities in reducing NRW. The evaluation was based on the perspectives and insights provided by municipality employees involved in the water management processes.

The results (Table 3) indicate that both Emalahleni and Emakhazeni municipalities employ modern flow metering as a strategy to control active leakage, while in order to detect and control active leakages in Steve Tshwete, the municipality relies on the use of active leakage control[4] equipment, (such as noise loggers, ground microphones, leak noise correlators, and sound sticks) which have been recognized as effective approaches to detecting and preventing leakages (AL-Washali et al., 2016; Ayad et al., 2021; Berardi et al., 2016; Boztaş et al., 2019).

In terms of pressure management, respondents across all three municipalities confirmed the use of automatic pressure-reducing valves, and when it comes to asset management, respondents across the three municipalities all indicated that their respective municipalities regularly assess the performance of all assets, with the majority of respondents from Emakhazeni and Steve Tshwete municipalities confirming the utilization of information systems for asset management within their municipalities. Furthermore, all three municipalities identified the use of the ALI as an additional management strategy to reduce NRW.

Apart from active leakage control measures, the three municipalities also rely on the use of automatic pressure-reducing valves as a management strategy to reduce NRW. Pressure management has been identified as the most important, beneficial, and cost-effective way of managing leaks (Bozkurt et al., 2022; Tsitsifli et al., 2017), indicating that the NRW management strategies employed in the three municipalities are in line with current trends. In addition to automatic pressure-reducing valves, Emalahleni and Emakhazeni also use modern flow metering, whereas Steve Tshwete relied more on asset management, which is believed to assist municipalities increase efficiency by decreasing water losses (Tsitsifli et al., 2017). Besides identifying management strategies employed by their municipalities, respondents also identified mitigation strategies which can be introduced to further reduce NRW (Table 4).

[1] Burst and Background Estimates (BABE)
[2] Infrastructure Leakage Index (ILI)
[3] Apparent Loss Index (ALI)
[4] Active Leakage Control (ALC)

Table 4. Proposed mitigation measures to reduce NRW

	Emalahleni	Emakhazeni	Steve Tshwete	Overall	
Mitigation Measures		**Mean**		**Mean**	**SD**
Investing in infrastructure and technology	4.03	4.27	4.39	4.23	0.18
Using zoning (district-metered areas)	4.46	**4.45**	4.54	**4.48**	0.05
Implementing smart metering technologies and modern leakage detection techniques	**4.60**	4.36	**4.59**	**4.51**	**0.14**
Devising a repair policy	4.14	4.39	4.51	4.35	0.19
The use of data-driven solutions	4.26	4.39	4.44	4.36	0.09
Ensuring good pressure management practices	**4.57**	**4.48**	**4.66**	**4.56**	**0.09**
Improving recording procedures	**4.51**	**4.48**	**4.63**	**4.54**	**0.08**
Improving estimation techniques	4.46	4.41	**4.59**	4.49	0.09

The respondents in all three municipalities, identified additional mitigation strategies that they believed would be effective in further reducing NRW within their utilities. These strategies include good pressure management practices and improved recording procedures. Additionally, respondents in Emalahleni and Steve Tshwete municipalities proposed the implementation of smart metering technologies and modern leakage detection techniques. On the other hand, respondents in Emakhazeni municipality suggested the use of zoning, specifically district metered areas, as well as the improvement of estimation techniques to mitigate against NRW.

In addition to the proposed mitigation strategies, other researchers have shown that the installation of modern leakage detection techniques (including the use of GIS, acoustic listening devices, hydraulic pressure control valves, thermal imaging cameras, as well as smart metering technologies and leak correlations (Di Nardo et al., 2013; Roozbahani et al., 2018), can help municipalities to detect leaks that have been difficult to detect in the past, thus significantly reducing NRW.

4. Conclusions and recommendations

Municipalities worldwide are responsible for the distribution of water resources to communities, industries, and organizations; however, this becomes extremely challenging in water-scarce areas such as South Africa, particularly in the province of Mpumalanga where water resources are extremely limited. This study has highlighted the issue of NRW in the municipalities of Emalahleni, Emakhazeni, and Steve Tshwete. The findings of the study reveal that NRW poses a significant challenge in these areas, with a substantial volume of water being unaccounted for, with the identified drivers of NRW encompassing poor infrastructure, non-compliance of community members, management factors, and political interference. Notably, real losses, including broken pipes, pipe bursts, water leakages, and storage overflow, emerged as the primary contributors to NRW in the three municipalities. Furthermore, the study demonstrates that the municipalities employ diverse management strategies to mitigate NRW. Emalahleni and Emakhazeni municipalities have implemented modern flow metering, while Steve Tshwete relies on ALC equipment for leak detection. Additionally, all three municipalities emphasize pressure management practices, regular asset performance assessment, and the use of the ALI as common approaches to address NRW.

In addition to the findings of the study, there is a need to quantify factors leading to NRW such as the number of metering errors, billing anomalies, and frequency of pipe bursts. Furthermore, the study recommends that the municipalities address the underlying issues related to infrastructure deficiencies and non-compliance of community members. Implementing infrastructure improvements and raising awareness among residents about the importance of responsible water usage could significantly contribute to reducing NRW. Moreover, proactive measures should be taken to enhance management practices and minimize political interference in water utility operations.

Additionally, exploring the potential of smart metering technologies and modern leakage detection techniques, as suggested by respondents, could provide valuable tools for the efficient management of NRW. Overall, the study emphasises the need for comprehensive and integrated strategies to address the challenges of NRW. The findings of the study contribute to the existing body of knowledge on NRW management and provide insights that can guide policymakers, water utility professionals, and researchers in developing effective measures to reduce NRW and ensure sustainable water resource management in the studied municipalities as well as in other areas with similar challenges. Moreover, further research and implementation of innovative approaches are warranted to address the persistent challenge of NRW and to optimize water supply systems in the studied areas and beyond.

5. Acknowledgements

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Conflict of Interest

The authors report no conflict of interest.

Author Contribution

MTM: conducted the study, conceptualised the paper; interpreted and analysed the data.

MDM: supervised the study; contributed to the methods, results and conclusions; conceptualised and revised the paper.

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Appendix 1: Questionnaire

Section A: Demographic Characteristics

1. Demographics

Which Municipality are you representing?	☐	☐	☐	☐	☐
What is your role in the Municipality	Meter reader ☐	Technical ☐	Administration ☐	Finance ☐	Management ☐
Years of working in the municipality	1-5 years ☐	6 -10 years ☐	11 -15 years ☐	15-20 years ☐	Over 20years ☐
Years of experience in the water sector.	1-5 years ☐	6-10 years ☐	11-15 years ☐	15-20 years ☐	Over 20years ☐
What is the highest level of education you have attained?	Primary ☐	Matric ☐	Degree/Diploma ☐	Masters ☐	PhD ☐

Section B: Factors leading to NRW in Mpumalanga

2. What are (in your opinion) the most common factors leading to NRW in your Municipality?
1: **Not common**-reported once in two years, 2: **Least common**-reported once a year, 3: **Common**-reported every six months (twice a year), 4: **Most common**-reported every quarter (4 times a year), and 5: **Extremely common**-reported every month.

	1	2	3	4	5
Broken pipes					
Pipe burst					
Water leakages					
Storage overflow					
Theft					
Metering errors					
Billing anomalies.					
Poor infrastructure and materials					
Mismanagement					
Political factors					
Bad organizational culture					
Staff shortages					
Absence of an integrated strategic plan to avoid NRW.					
Non-compliance of community members					

Section C: Identification and assessment of the efficiency of NRW management strategies

4. Does your municipality use any of these NRW management strategies?

SD = Strongly Agree, D = Disagree, N = Neutral, A = Agree, SA = Strongly Agree.

	SD	D	N	A	SA
Active leakage control					
Our municipality has a detailed active leakage control					
Our municipality uses modern flow metering					
Our municipality uses digital methods to detect leakages					

Cont. Section C: Identification and assessment of the efficiency of NRW management strategies

	SD	D	N	A	SA
Our municipality uses ALC equipment such as noise loggers, ground microphones, leak noise correlators and sound sticks					
Pressure management					
Our municipality uses automatic pressure-reducing valves to manage pressure					
Our municipality uses break pressure tanks to manage pressure					
Our municipality uses speed dump controllers to manage pressure					
Asset management					
Our municipality uses information systems to manage assets					
Our municipality regularly assesses the performance of all assets					
Our municipality engages all stakeholders before deciding to replace or rehabilitate any asset					
Management by community engagement					
Our municipality has an open telephone and cell number that allows community members to report NRW issues.					
Our municipality has an online platform that allows community members to report NRW issues.					
Our municipality uses social media platforms such as WhatsApp that allow community members to report NRW issues.					
Other management strategies					
Our municipality uses the Burst and Background Estimates (BABE)					
Our municipality uses the Infrastructure Leakage Index (ILI)					
Our municipality uses the Apparent Loss Index (ALI)					

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