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Challenges during installation and maintenance of water delivery infrastructure: a citizen perspective

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ABSTRACT

The installation and maintenance of water infrastructure in South African cities poses a challenge to communities, municipalities, and installation contractors, who face problems such as inadequate access to homes, traffic jams, inadequately barricaded trenches, leaking water pipes, water supply cut-offs, vandalism, and theft of water. The research problem, therefore, involves an inadequate understanding of what drives these problems and how to mitigate them through better management. The aim of this study was to investigate the challenges of managing water infrastructure as perceived by the citizens of a South African municipality. The study was a descriptive and cross-sectional survey, with data collected, via a literature derived, emailed questionnaire, from a self-selected non-probability sample of 402 City of Tshwane residents. Analysis, via SPSS Version 27, used descriptive and inferential statistics. The findings revealed that both the municipality and the contractors contributed to the challenges experienced by citizens, with maintenance challenges being more serious than installation challenges. Municipal and political challenges were the main drivers, with political ownership of construction companies and political interference being the biggest problems. The findings contributed to a better understanding of the challenges inhibiting effective installation and maintenance of water infrastructure, and are important to the municipality, and the community at large, because they contribute to a better understanding of service delivery from the citizens' perspectives.

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Introduction

The management of water infrastructure (WI) is a key task of local authorities which must deliver water to the communities they serve. Municipalities in South Africa (SA) are experiencing major problems as far as water services are concerned. South Africa. Department of Water and Sanitation (2018) revealed that municipal water lost through leakages is estimated at 35% and that only 64% of South Africans have a consistent water supply. Furthermore, 56% of wastewater treatment works and 44% of water treatment works are in a poor or critical condition, with 11% of such infrastructure not functional at all.

These problems are exacerbated by vandalism and theft (Mokgobu, 2023), resulting in municipalities losing R9.9 billion every year, and R33 billion is required each year for the next decade to achieve water security for the communities covered by these municipalities (South Africa. Department of Water and Sanitation, 2018). This situation is aggravated by SA's water being underpriced, which means the authorities do not recover their costs. The SA municipalities experience a high rate of urbanization thereby creating pressure on existing infrastructures (Zindi, & Shava, 2022; Ndebele-Murisa et al., 2020; Madonsela, Koop, Van Leeuwen, & Carden et al., 2019; Samkange, Mahabir, & Dikgang, 2019). These metropolitan areas have diverse social systems, differing interests, special

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characteristics, and are separate spatial entities (Turok, 2016), which, in addition to the usual problems of urbanization, lead to particular social, economic, and environmental implications (Turok, & Borel-Saladin, 2014).

One such metropolitan community is the City of Tshwane (CoT) in Gauteng province, South Africa, which manages a vast range of water infrastructure (WI) networks that are spread across its seven regions. These networks are managed daily to ensure a reliable and uninterrupted supply of water to communities. However, acceptable service delivery is often not achieved, resulting in communities staging protests, which sometimes last for days, to obtain basic services such as shelter, water, sanitation, and electricity (Mamokhere, 2023). Wall (2021) points out that, for communities to enjoy water supply, 'delivery' of clean water should be supplied directly to households, be fresh and without impurities, all day throughout the year, and with adequate pressure for at least five decades. It is not sufficient to have the water supplied to the communities by water tankers, and this method of supply should not be considered a standardized supply. The lack of water connections and lack of continuous supply within households aggravates social costs and has a negative health impact on communities and justifies the community protests. According to Damoah (2023) the lack of service delivery is perpetuated by lack of technical capabilities.

Ariyan (2020) reported that CoT has historically experienced an average of 3.4% annual population growth, twice that of the national average of 1.7%. The city has experienced even higher growth of 4.4% per annum since 2005. As a result, the city started experiencing pressure on roads, housing, water, electricity, and transport infrastructures. The demand for water is aggravated by population increase, urbanization and other factors (Donnenveld, Crookes, & Hedden, 2018), with the CoT failing to sustain the existing, and to provide new, infrastructure, due to a lack of adequate finances, even after the collection of rates and taxes and the sale of water and electricity utilities (Ariyan, 2020). According to Leburu (2017), the CoT's water and sanitation division is ineffective in tracking the water management system (WMS) usage, so this failure consequently leads to accumulation of debts by clients.

The aspects of lack of adequate capacity and finance, inappropriate installation and maintenance, and lack of provision of new infrastructure may trigger backlogs leading to monetary challenges that prevent municipalities from providing the required service delivery (Leburu, 2017). Mamokhere (2023) recommends public participation for effective service delivery and better communication flow to stakeholders. In terms of engagement, South African municipalities experience a diminishing public participation in matters that involve community development processes, which creates a breakdown of communication (Zindi, & Shava, 2022). For these reasons, many municipalities lack functional and performing infrastructure and proper service delivery.

As will be discussed in more detail in the literature review, CoT has a problem with the delivery of water services to their citizens and with the management of the water infrastructure. Although service delivery protests and negative media reports suggest a dissatisfied citizenry, sound planning cannot be based on such subjective and selective information. Furthermore, most literature focuses on technical aspects of water infrastructure and very little on the management of such infrastructures (Mokgobu, & Mason, 2022). Therefore, this study aims to provide an objective basis for the assessment of citizens' opinions about water service delivery and their perceptions about the challenges they face due to poor service delivery. A descriptive and cross-sectional email survey method was selected to collect perceptions from a sample of City of Tshwane residents.

Thus, this study set out to meet the following objectives:

i. To identify citizens' perceptions of the challenges experienced in the maintenance and installation of water infrastructure by the CoT municipality
ii. To rank the importance of the identified challenges from the citizens' perspective
iii. 3 To identify the drivers of these challenges from the citizens' perspective

Literature Review

Challenges Faced by Municipalities

Donnenveld et al. (2018) explained that water is scarce in SA, which is a major problem resulting in inadequate provision of sufficient water for the citizens. The individual, fragmented systems of local authorities each operate as single standalone departments, with independent management, which results in poor communication and disintegration of services. Makole, Ntshangase and Msosa (2022) criticized the silos system of operation of the CoT with advice to streamline their Integrated Development Plan with the National Development Plan with a strategy to align service delivery and socio-economic development pathways. Snyman and Vorster (2011) maintained that CoT had been immune to service delivery protests, but this has since changed with the city being ravaged by protests with 20% of the service delivery protests in Gauteng province occurring in the CoT (Ndlovu, 2015) and in the City of Johannesburg (Ragolane, 2022). According to Damoah (2023), service delivery protests are caused by inequality, poor service, corruption, joblessness, poverty and lack of good governance in SA. In addition, poor quality service is exacerbated by inadequate staffing and overworked and demotivated staff which is prevalent in SA public service departments (Modise and Roberson, 2023).

Several problematic issues can affect communities, towns and cities when water pipes are being installed and maintained (Kruger, 2018). These issues can negatively affect the daily routines of communities and businesses. Because of the failure of infrastructure, communities experience hardships such as intermittent water supply, undrinkable water, and results in sicknesses (Wall, 2021). In addition, the effects of climate change result in damage to valuable infrastructure, which leads to traffic disturbances and road

accidents (Mashamaite, 2021). Water leaks flowing on the roads cause hazards to road users, damage paving, and form potholes. These aspects become a safety risk to motorists and pedestrians using the roads (Chauke, 2017). Hazardous trenches are left open, which become dangerous, especially to children who play in their vicinity. Vehicles are often involved in accidents because of these trenches, heaps of materials, and damaged kerbs. Maintenance, or lack thereof, becomes an issue when pipes are left leaking for a long time (Alvisi et al., 2019), with children playing in flowing and dammed water in the streets and nearby bushes. This exposes children to the risk of drowning or water-related diseases. Thus, installation and maintenance of water infrastructure requires strategic management so that businesses and communities are not left without water for long periods or subjected to physical dangers.

The Dissatisfaction Expressed by the CoT Residents

In addition to the above types of service delivery problems, CoT residents have expressed their dissatisfaction with other aspects of water service delivery, for example, the supply of contaminated water (Portfolio Committee on Human Settlement, Water and Sanitation, 2019). Table 1 provides a brief outline of the residents' dissatisfactions.

Table 1: CoT Residents' Dissatisfaction

Dissatisfactions expressed by the CoT residents
Contaminated water supplied by the CoT to the residents of Hammanskraal.
CoT's rejection of assertions from the residents regarding contaminated water.
Request by CoT to the residents to provide scientific proof of contaminated water.
Non-adherence of CoT to the master plan from 2004 for the upgrade of the infrastructure.
Of 15 wastewater treatment works for CoT, 2 were functional and 4 in serious condition.
Lack of future planning by management.
Human rights violations by CoT for substandard quality water supplied to the residents.
Estimated and inconsistent water billing system.
Ignorance in reply to the residents' (Hammanskraal Residents Forum) memo of demand.
Response by the CoT after Hammanskraal experienced a total shutdown by the residents.

Source: Portfolio Committee on Human Settlement, Water and Sanitation (2019).

The issues mentioned mostly arise from the lack of management interventions when the problems are still easy to control. Community dissatisfaction was prompted by the city management's lack of diligence and their ignorance of the city master plan, which led to the failure to provide the planned service delivery to the community. According to the Portfolio Committee Human Settlement, Water and Sanitation (2019), the CoT management acknowledged that the city is facing problems regarding water infrastructure, with underinvestment in the upgrading and maintenance of water reticulation over the past ten years. Furthermore, CoT management is committed to addressing the poor planning situation, agreeing to form forums with communities to address the issues around planning.

The National Council of Provinces select committee on finance identified several management gaps at the CoT. These management shortfalls included unlawful awarding of contracts, individualizing the matters which needed the attention of other stakeholders for success, unattended loopholes in the organizational structure, slow pace to report matters to the law enforcement agencies, disregard for the water and sanitation standards, politically motivated protests with demands of sub-contracting, and misalignment with other departments (National Council of Provinces, Finance, 2017).

Strategies to Educate Residents to Conserve Water

Armitage et al. (2014) suggest that SA must work more efficiently with limited human and financial resources to manage the transition towards water-sensitive settlements. Local legislation and regulations need to be strengthened and municipalities must use what they have more effectively and efficiently, specifically regarding the following aspects of management, such as policy improvement, organizational structures, community involvement, construction of the infrastructure, and operation and maintenance. For example, Weaver, O'Keeffe, Hamer, & Palmer (2019) suggests that education about water-related issues should be provided for citizens, with face-to-face water knowledge sessions and informal conversations being facilitated with citizens. The issues discussed should cover, amongst other things, how to preserve water, the best method to safely conserve water, individual water rights, and the responsibilities of a citizen concerning water. Such sessions will encourage behavior change which could be measured by performance indicators of change such as the implementation of water-saving practices and the number of notifications of water leaks to the municipality.

Service Delivery and Payment of Services

According to South Africa. Department of Cooperative Governance (2018), municipalities must deliver basic services, make sure that the infrastructure is maintained, maintain openness, be accountable, and engage with communities regularly. The Ministry of Cooperative Governance and Traditional Affairs, with the Municipal Infrastructure Support Agent, intervenes where there is underperformance in a municipality concerning the improvement and maintenance of infrastructure projects. Currently, there is inadequate expertise to manage infrastructure projects, examine tender documents, and consult with stakeholders, resulting in a slow

pace of scheduled maintenance of the infrastructure. Consequently, there has been under expenditure of the infrastructure improvement grant from the national government.

Non-payment of the services rendered, especially water and electricity, has far-reaching negative consequences in SA. The issue of repairs and maintenance is hampered if those contractors who provide the services are not paid. The situation becomes worse when political interference (Masuku, & Jili, 2019) plays a role, by connecting the payment for services to politics (Maphela, & Cloete, 2019), rather than to the reality which is about usage. It is also about how residents understand and value the whole value chain of the infrastructure system. Maphela (2015) outlines the relationship between poverty and inequality, pointing out that willingness and capability to pay plays a pivotal role in water demand management (WDM).

The Council for Scientific and Industrial Research (CSIR) (2010) has presented some of the facts about the shortfall of payment for services rendered:

i. Only a few customers pay for the services.

ii. Consumers who qualify to pay are reluctant to do so.

iii. Consumers who qualify for the free basic services exceed their allocated limit and refuse to pay for the extra usage.

These shortfalls relating to the non-payment of services have been a problem for many years, being identified originally in the seminal report by Muller (1999) and in a more recent study conducted by Maphela and Cloete (2019).

According to Muller (2019), SA has experienced supply failures resulting from heat waves and late rains in some areas, while in urban areas there was generally satisfactory water supply from dams. Wafer (2019) and Madonsela et al. (2019), however, recall the experiences of the City of Cape Town (CoCT) in 2017 and 2018 when the city nearly ran out of water. Water managers encouraged residents to use less water to extend the life of the infrastructure, but this was not sufficient to counter the failure to build new WI. Simpson, Simpson, Shearing, & Cirolia (2019) envisioned that because of the aftermath of the drought, the CoCT would have to consider a tariff structure that would require the underprivileged to pay for water in future.

In Gauteng province, the reservoirs ran dry because of residents excessively watering gardens (Muller, 2019), while in Eastern Cape Province, the dam at Adelaide ran down, unnoticed, to 1% full and resulted in supply failure with no funding to resuscitate the situation. Local authorities distributed water before confirmation of adequate supply and before setting controls to regulate unnecessary usage. These same issues of poor planning and poor management during periods of drought, or failing to plan, are persistent and occur in towns and villages countrywide (Muller, 2019). There is increasing water scarcity in Eastern Cape, water shutdowns in KwaZulu-Natal, water-shedding in Polokwane, Free State water riots, and water cuts in Tshwane and Mpumalanga.

Comparing the state of water scarcity between SA (third world country) and first world countries, South Africa's average water consumption of 237 liters per person per day is significantly higher than the 173 liters per day world average. This is clearly a problem that is exacerbated by existing water resources being under pressure, with a need for better management and planning and a need for new water infrastructure to be built to cope with the increasing demand and other eventualities (such as droughts) (3SMedia, 2020).

Research & Methodology

Research Design

This study used a quantitative methodology following a deductive approach with a cross-sectional survey design to collect data (Watson, 2015).

Respondents

The target population for the survey was all citizens of the CoT, as they would have had personal experience or perceptions about the performance of the CoT WI and how it is being managed. Since this was a self-selected sample (i.e., members of the database decided whether to participate or not), the sampling was non-probability.

For the CoT population of 3.1 million (Ariyan, 2020; City of Tshwane, 2019), and based on an assumed standard deviation of 1, an allowed error of 0,1 and a significance level of 95%, the required sample size was 384 (Raosoft, 2004; Sekaran, & Bougie, 2016). To cater for unusable or incomplete responses, a sample of 400 was aimed for.

Data Collection

Development of Data Collection Instrument

The data collection instrument was a structured questionnaire with five-point closed-ended Likert-type scale questions. The five-point Likert-type scale responses were, strongly disagree (1), disagree (2), neither disagree nor agree (3), agree (4), and strongly agree (5). Simpler questions came first, and the more demanding or sensitive questions followed, the whole taking about 10 minutes to complete. The questions were derived from previous research studies - the authors and the focus of the papers are as follows:

i. Kloosterman and van der Hoek (2020) - personnel who understand WI

ii. Mello (2020) - endemic political factional battles
iii. Bello et al. (2019) - improved delivery standards and client satisfaction
iv. City of Tshwane (2019) - poor supply and quality of water, vandalism and theft of cables
v. Soppe, Janson, & Piantini (2018) - political interference
vi. Urich et al. (2013) - improved water management strategies
vii. Masolane (2019) - the CoT budget strain that led to poor service delivery
viii. Dludla (2020) - the CoT experienced revenue collection difficulties
ix. Hamer et al. (2018); Alexander et al. (2018); Pooe, Worku, & Van Rooyen et al. (2016);Mofolo (2016) - protests in SA municipalities due to poor quality of service
x. Mofolo (2016) - elimination of communities from decision-making processes

A pretest study was conducted to identify and remove any ambiguities or weaknesses from the instrument (O'Sullivan, Rassel, Berner, & Taliaferro, 2017). The pretest questionnaire was administered to a snowball sample of ten CoT respondents obtained through referrals by respondents to a previous qualitative study (Mokgobu, 2023). Recruitment was done through Google Forms with a link to connect the sample respondents to the test questionnaire. The pretest study did not identify any weakness or ambiguities in the questionnaire.

Administration of the Instrument

An online survey lasting 14 days was administered by a professional research firm who had access to a database of CoT citizens. Recruitment of respondents was administered through emails sent to the respondents, and which contained the aim of the study, an informed consent letter and a link to connect to the questionnaire. Multiple emails were sent until the target sample size of at least 400 acceptable responses were received. The survey received 693 responses, but after data cleaning and capture, 402 responses were completely answered and therefore eligible for analysis (58% useable response rate). The remaining 291 questionnaires were spoilt or incomplete and were excluded from analysis.

Data Analysis

Data Capture and Cleaning

Data were checked to ensure no information corruption or errors such as missing values, nonresponses and incomplete questionnaires (De Waal, Pannekoek, & Scholtus, 2011) had occurred during the recording and migration process.

Quantitative Analysis Techniques

Using Statistical Package for the Social Sciences (SPSS Version 27), descriptive statistics (frequencies, means and standard deviations) and inferential statistics (t-tests and regression analysis) were used to measure respondents' perceptions of the various challenges and to rank the importance of these challenges.

Validity and Reliability

Face and content validity were assessed first by a subject matter expert and a statistician, and then checked via the pretest as discussed previously. The pre-test yielded positive results without any complaints**.** Exploratory factor analysis was used to check the factor structure of the four research constructs measured in the questionnaire.

Ethical Issues

Ethics approval was obtained from the Durban University of Technology's Faculty Research Ethics Committee (FREC), and gatekeepers' approval was obtained from CoT before any data collection. Furthermore, the questionnaire explained the following principles: voluntary participation, confidentiality of information, anonymity, and voluntary withdrawal from the study at any time without giving reasons.

Results and Discussion

The various challenges exposed by this study, for example maintenance difficulties, lack of trust in the municipality, and political interference may lead to more challenges. For example, these challenges may develop negative implications like more dilapidated infrastructure, substandard maintenance work, children falling into unbarricaded trenches when playing, and health problems caused by denying the community access to clean potable water.

Exploratory Factor Analysis

Exploratory factor analysis using principal components analysis was performed to check the factor structure of all research constructs. To determine the factorability of the data, a Kaiser-Meyer-Olkin measure of sampling adequacy (KMO) and Bartlett's test of sphericity were computed. The KMO values were all above the minimum cut-off value of 0.5 and all results for Bartlett's test were significant at 0.000 (p value sig < 0.05). These results confirmed that the sample size was sufficient for EFA, and that the data were factorable. Therefore, no items were discarded from any of the four scales as all recommended thresholds were met (factor loadings

> 0.5; eigenvalues > 1.0; communalities > 0.4). The values therefore warranted further analysis of the data (Madanchian, Hussein, Noordin, & Taherdoost, 2018; Yap, Komalasari, & Hadiansah, 2018). The EFA procedure revealed that each of the 14 items had a one-dimensional structure. In terms of the cumulative percentage of variance explained, all four constructs scored less than the recommended minimum of 60% (Hair, Black, Babin, & Anderson, 2014). The range for the overall mean scores for the scales (2.46 to 4.00) signified an inclination towards the 'agree' and 'strongly agree' positions on the Likert scale, demonstrating that respondents agreed with the questions on each measurement scale and that all four constructs were valid measurements for the perceived challenges of managing water infrastructure. Data from these tests is illustrated in Table 2.

Table 2: Exploratory factor analysis

Con-struct	Item code	Factor loading	Commu-nalities	Eigen-values	% of variance
Community challenges	There are challenges during installation of WI in your township or suburb	.743	.713	5.090	36.358
	There are challenges during maintenance of WI in your township or suburb	.783	.795	1.747	12.478
	Unbarricaded open trenches, inaccessible streets due to installation and maintenance, materials lying around, unnoticed water cut-offs are challenges experienced	.721	.536	.716	5.117
Contractor challenges	There are challenges arising from contractors in installations of WI.	.827	.798	1.332	9.516
	Striking contractors affect the smooth running of installation and maintenance	.639	.527	.622	4.444
	There are delays arising from the contractors	.686	.525	.445	3.176
	Public is disturbs smooth running of contractor's work by vandalizing projects	.198	.390	.323	2.309
	Contractors adhere to minimum health/safety standards	.322	.376	.474	3.389
& Municipal political challenges	There are challenges arising from municipality in WI installations	.839	.838	.989	7.063
	Political interferences play major role in awarding jobs to contractors by municipality	.623	.549	.764	5.456
	Politicians own construction companies doing the installation and maintenance of WI	.498	.557	.574	4.102
& Managerial political support	CoT managers have enough technical/management capacity to oversee contractor's work	.384	.404	5.29	3.776
	CoT managers have a better strategy of managing project initiation until project close out by contractors	.327	.619	.232	1.654
	Politicians enhance projects and work closely with municipality, citizens, contractors for project success	.325	.542	.163	1.161

Kaiser-Meyer-Olkin Measure of Sampling Adequacy and Bartlett's Test of Sphericity

Constructs	KMO	Bartlett's test
Community challenges	.663	Approx. Chi Sq. 371.798; df 3; sig .000
Contractors' challenges	.718	Approx. Chi Sq. 283.977; df 10; sig .000
Municipal & political challenges	.621	Approx. Chi Sq. 182.514; df 3; sig .000
Managerial & political support	.616	Approx. Chi Sq. 132.294; df 3; sig .000

Reliability Analysis

Although usually a score above 0.7 for "acceptable" reliability is required, Khare and Rakesh (2010) suggest a reliability score above 0.6 for a newly developed construct, which applies in this research. Table 3 shows that scores for all constructs are above or very close to the suggested criteria of 0.6, indicating acceptable and consistent scoring.

Table 3: Reliability Statistics

Constructs	No. of items	Sample size (n)	Cronbach's α
Community challenges	3	402	.782
Contractor's challenges	5	402	.656
Municipal and Political challenges	3	402	.650
Managerial and political support	3	402	.596
Overall	14	402	.730

Overview of Installation and Maintenance Challenges

First, the challenges perceived by citizens of both installation and maintenance of WI were analyzed via t-tests, with responses being as per the scale of 1 = strongly disagree to 3 = neutral and 5 = strongly agree. These results are shown in Table 4.

Table 4: Perceived Challenges of Installation and Maintenance

Construct	N	Mean	SD	t	sig	95% conf	
						Lower	Upper
Q1: challenges during *installation* of WI in your township or suburb.	397	3,12	1,142	54.465	.000	3.01	3.23
Q2: challenges during *maintenance* of WI in your township or suburb.	397	3,39	1,200	56.283	.000	3.27	3.51

The perception of challenges during *installation* reflects a slightly more than neutral value of 3.12, meaning that most citizens neither agree nor disagree that there are challenges with installation of WI. The perception of challenges during *maintenance* is significantly higher, but the value of 3.39 is still in the neutral area but coming closer to agreement. So, although having a statistically significant difference, there is neither much agreement nor disagreement about the challenges faced during installation and maintenance of WI. This could also imply that citizens do not have strong trust or distrust in the installation and maintenance of water infrastructure.

Since there is little difference in perceptions about installation versus maintenance, it is necessary to examine the role of the two parties in installation and maintenance, i.e., contractors and municipality. First we look at their role in installation, with the findings being presented in Table 5.

Table 5: Perceptions of Role of Contractors and Municipality in Installation

Construct	N	Mean	SD	t	sig	95% conf	
						Lower	Upper
Q3: challenges arising from contractors in installations of WI.	400	3,26	1,122	58,055	0,000	3,15	3,37
Q4: challenges arising from municipality in WI installations.	397	3,46	1,162	59,387	0,000	3,35	3,58

As far as the perception of challenges during the installation of water infrastructure is concerned, there is no significant difference between those arising from contractors and those arising from the municipality, although the perception of challenges arising from the municipality is a little higher (3.46) than that arising from contractors (3.26). Looking at the 95% significance intervals, the challenges arising from the municipality only just extend outside the 'neutral' area (2.5 to 3.5) indicating that there is some agreement with the municipality being responsible for installation challenges. However, we still see little explanation of the challenges during installation, neither by studying installation versus maintenance, nor contractors versus municipality. Therefore, we progress to examining installation in more detail.

Challenges in Installation

The results of the two prior analyses raise the question of how to interpret the neutral values observed, which have a slight tendency to "agree". Although there is a tendency to 'agree', there are also definitely citizens who 'disagree' that problems occur in the area of installing and maintaining water infrastructure and with both municipalities and contractors. Considering 'installation' it can be asked if citizens have a lack of trust in the municipality or the contractors, and, if so, which has a higher influence on the perception of WI installation challenges?

The influence of the municipality and contractors on the perceived challenges experienced by citizens during the installation of water infrastructure was analyzed using regression analysis, with the experienced challenges during installation as a depended variable (Q

1) and the perception of the challenges caused by contractors (Q 3) and the municipality (Q 4) as independent variables. The regression model produced an r^2 of 0.528, showing that 52.8% of the variance in the perception of WI installation challenges experienced arise from the municipality and the contractors. Other factors, not included in this study accounted for 47.2% of the variance in the perceived challenges.

Furthermore, as shown in Table 6, there is a significant difference between the influence of the challenges arising from contractors and the challenges arising from the municipality, and that the influence on challenges caused by the municipality (0.521) is more than twice as great as the influence on challenges caused by the contractors (0.236).

Table 6: Regression Analysis – Municipality or Contractor Influence of Challenges

Model	Std Beta	t	Sig.	95% conf	
				Lower	Upper
(Constant)		4,312	0,000	0,304	0,813
Q3: challenges arising from contractors doing installation of WI	0,236	3,949	0,000	0,120	0,359
Q4: challenges arising from municipality regarding WI installation.	0,521	8,710	0,000	0,397	0,628

All requirements for satisfactory regression analysis were fulfilled - Durban Watson around 2 (1,956), tolerance value > 0.1 (0.339), plots showing no sign of homoscedasticity or no normally distributed residuals. So, it can be stated that the observed neutral attitude, i.e., a lack of trust, towards challenges during the installation of water infrastructure is, in the citizens' opinion, mainly caused by their lack of trust in the municipality and not a lack of trust in the contractors.

Ranking of Perceived Importance of Installation Constructs

Based on the literature and the EFA, four constructs were identified, namely *community challenges*, *contractors' challenges*, *municipal & political challenges* and *managerial & political support*. Using t-tests the perceived importance of these constructs to the installation challenges were identified. The scales for the questions ranged from 1 = low challenge/low support to 5 = high challenge/high support, with 3 being neutral and the range between 2.5 and 3.5 being interpreted as the area of mainly neutral opinion. While *managerial and political support* (2.60), *contractors challenges* (3.30) and *community challenges* (3.42) are in the neutral area, *municipal and political challenges* (3.65) clearly fall within the high challenge area. Thus, *municipal and political challenges* are perceived by the respondents as the highest ranking, or most important, issue influencing WI installation challenges. These analyses are presented in Table 7.

Table 7: Ranking of Constructs

Constructs	t	Sig	Mean Diff	95% conf	
				Lower	Upper
Municipal and political challenge (mean Q 4, Q 5, Q 8)	94,748	0,000	3,645	3,569	3,721
Community challenges (mean Q1, Q2, Q 6)	70,298	0,000	3,423	3,328	3,519
Contractors' challenges (mean Q3, Q 7, Q 10, Q 11, Q 12)	109,918	0,000	3,299	3,240	3,358
Managerial and political support (Q9, Q 13, Q 14)	69,137	0,000	2,603	2,529	2,677

The constructs *community challenges* and *contractor challenges* show high similarity to the single items regarding challenges arising from the municipality and contractors doing the installations of water infrastructure. They are also both in the neutral area with a slight tendency towards agreement and do not show a significant difference. *Municipal and political challenges* score significantly higher than all other constructs and it can be concluded that this construct is clearly perceived by the respondents as having a negative influence on WI installation. The opposite applies to *managerial and political support*, which is perceived significantly lower than all other construct values and is on the border between neutral and low perception.

Drivers of Contractors' Challenges

To better understand what leads to the challenges experienced by contractors, the drivers of the perceived challenges arising from the contractors were analyzed. Items identified by the EFA as being part of the construct *contractors' challenges* are included in a regression analysis, with *contractors' challenges* being the dependent variable and *strikes, health and safety standards, contractor delays* and *public disturbance/vandalism* being the independent variables. The results of this analysis are provided in Table 8.

Table 8: Regression Analysis of Criteria Driving Contractors' Challenges

Model	Std Beta	t	Sig.	95% conf	
				Lower	Upper
(Constant)		3,715	0,000	0,506	1,642
Q7: Striking contractors affect the smooth running of installation and maintenance	0,236	4,848	0,000	0,145	0,344
Q10: Contractors adhere to minimum health and safety standards.	-0,097	-2,252	0,025	-0,222	-0,015
Q11: There are delays arising from the contractors	0,364	7,548	0,000	0,302	0,515
Q12: Public disturbs the smooth running of contractor's work by vandalizing projects.	0,045	1,032	0,303	-0,040	0,130

Overall, the independent variables explain 31% of the challenges arising when contractors install water infrastructure. Based on the respondents' answers, the criterion *The public is disturbing the smooth running of contractor's work by vandalizing the projects* has no significant influence on contractor's challenges when installing water infrastructure ($p = 0.303$). The weakest but negative significant influence ($p = 0.025$) is *contractors doing the installation and maintenance adhere to the minimum health and safety standards* ($\beta = -0.097$). That means, although rather weak, that the more the contractors adhere to health and safety rules, the fewer problems occur. The criteria with the strongest and most significant influences are *striking contractors affect the smooth running of installation and maintenance of water pipes* ($\beta = 0.236$) and, even stronger, *there are delays arising from the contractors doing the installations and maintenance of water infrastructure* ($\beta = 0.364$), both with $p < 0.000$.

The requirements for a satisfactory regression analysis were fulfilled - Durban Watson shows a value of 2.034 (which is surprising since a statistical correlation between the perceived delays and the perception of strikes could be expected). Tolerance values were all higher than 0.075 and plots showed no sign of homoscedasticity or no normally distributed residuals.

Drivers of Challenges Arising from the Municipality

Since it was identified above that *municipal and political challenges* are perceived by respondents to have the greatest negative influence on the WI challenges, it is necessary to examine these in more detail and identify what drives these municipality related challenges.

To analyze the criteria that influence the perceived challenges arising from the municipality regarding WI installations the criteria from the positive municipal factor *managerial and political support* as well as from the negative *municipal and political challenges* were included in regression analysis as independent variables. This aimed to identify if the positively intended actions really have a positive influence on the *perceived challenges arising from municipalities.* The results of this regression analysis are presented in Table 9.

Table 9: Regression Analysis of Criteria Driving Municipality Challenges

Model	Std beta	t	Sig.	95% conf	
				Lower	Upper
(Constant)		4,502	0,000	0,971	2,477
Q5: Political interferences play major role in awarding jobs to contractors by municipality.	0,344	6,356	0,000	0,277	0,525
Q8: Politicians own construction companies doing the installation and maintenance of WI	0,114	2,197	0,029	0,017	0,304
Q9: Managers of CoT have enough technical/ management capacity to oversee contractor's installation and maintenance work.	-0,141	-2,892	0,004	-0,252	-0,048
Q13: CoT managers have a better strategy of managing project initiation until project close out by contractors.	-0,048	-0,928	0,354	-0,194	0,069
Q14: Politicians enhance projects and work closely with municipality, citizens and contractors for project success.	0,052	1,007	0,315	-0,056	0,174

Table 9 shows that the criteria *CoT managers have a better strategy of managing project initiation until project close out by contractors* ($\beta = -0.048$, $p = 0.354$) and *politicians enhance the projects and work closely with municipality, citizens and contractors for project success* ($\beta = 0.052$, $p = 0.315$) have no significant influence on challenges arising from the municipality regarding WI

installations. The weakest significant influence is from *politicians' own construction companies doing installation and maintenance of water infrastructure* (β = 0.114, p = 0.029). The second strongest and highly significant influence is *managers of the CoT have enough technical/management capacity to oversee installation and maintenance of contractor's work* (β = -0.141, p = 0.004). The negative directionality shows that the greater the technical and managerial capacity of CoT is perceived, the fewer challenges are perceived. By far the strongest influence on the perceived challenges comes from *political interferences play a major role in awarding of jobs to contractors by municipality* (β = 0.344, p < 0.000). Summing up these findings, it can be clearly concluded that *political interference* and *ownership by politicians* are seen as the driving factors leading to the challenges experienced in the water infrastructure, whereas the abilities of the CoT managers are seen as factors which help to reduce or mitigate these problems.

With an r^2 of 21.3% this regression analysis has the weakest, but still sufficient, explanatory power, explaining that about a fifth of the challenges perceived as being due to the municipality arise from these five issues. Durban Watson shows a value of 2.081, which is again surprising since one could have assumed a correlation between, for example, the *political interference* and *politicians owning construction companies*. The tolerance values were a minimum of .698, so also satisfactory values, and plots showed no sign of homoscedasticity or no normally distributed residuals.

The analyses related to installation challenges are summarized in Figure 1.

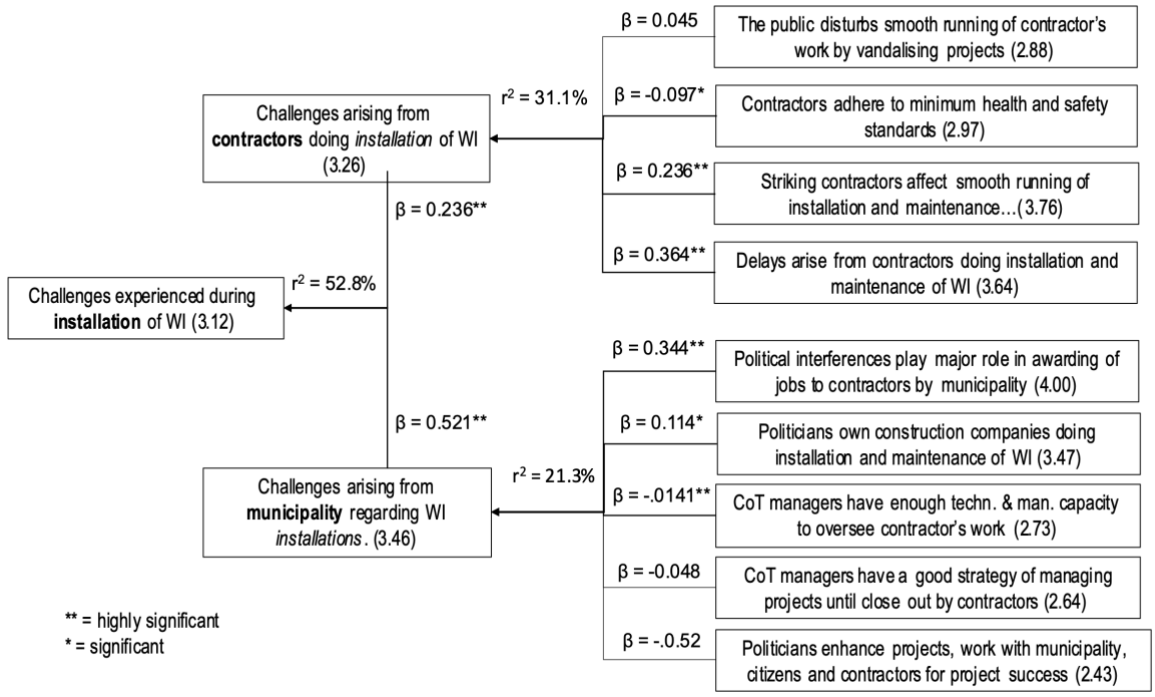

Figure 1: Analyses of WI Installation Challenges

Challenges in Maintenance

Since respondents were more in agreement with the experience of maintenance challenges than with installation challenges (as shown in Table 4), it is now essential, having first analyzed the challenges experienced regarding installation, to now investigate the perceived problems experienced during the maintenance of water infrastructure. For this analysis, the independent variable is '*there are challenges experienced during the maintenance of water infrastructure in your township or suburb'*. Table 4 shows that this had a mean value of 3.39 and a 95% confidence interval from 3.27 to 3.51. The perception, therefore, is in the neutral area with a slight tendency to agreement, which justifies further analysis of the maintenance issues.

Ranking of Perceived Importance of Maintenance Constructs

To conduct this analysis, those elements that refer to maintenance, namely *contractors' challenges*, *municipal and political challenges* and *managerial and political support* were included. This means that the statement *there are challenges arising from the contractors doing the installations of water infrastructure* is excluded from the factor contractor challenges, and the statement *there are challenges arising from the municipality regarding water infrastructure installations* is excluded from the factor *municipal and political challenges*. The factor managerial and political support remains unchanged.

In the first step of this analysis, the mean values of the maintenance factors are analyzed and presented in Table 10. The factor *managerial and political support* remains unchanged since this is a general factor showing a neutral value with a tendency towards disagreement (2.60, with 95% confidence interval of 2.53 – 2.68). *Contractor maintenance challenges* also reflects a neutral value but with a tendency towards agree that such challenges exist (3.31, 95% confidence interval 3.25 - 3.37). Finally, *municipal and*

political challenges scores outside the neutral area, show a level of agreement by the respondents that such challenges exist (3.73, 95% confidence interval 3.66. - 3.81). The confidence intervals show that all 3 factors are significantly different from each other.

Table 10: Ranking of Maintenance Constructs

Construct	t	Sig	Mean diff	95% conf	
				Lower	Upper
Managerial and political support (mean Q 9, Q 13, Q 14)	69,137	0,000	2,603	2,5288	2,6768
Contractors' challenges - maintenance only (mean Q 7, Q 10, Q 11, Q 12)	111,852	0,000	3,309	3,2505	3,3668
Municipal and political challenges - maintenance only (mean Q 5, Q 8)	95,067	0,000	3,733	3,6554	3,8098

In the second step, the influence of these three factors on the perceived *maintenance challenges* is analyzed based on a regression analysis, the results of which are shown in Table 11. The dependent variable is *there are challenges experienced during the maintenance of water infrastructure in your township or suburb*. Together the three independent variables explain 25.4% of the perceived challenges relating to maintenance of water infrastructure. Overall, the requirements for regression analysis are fulfilled, with tolerance >0.7 and the Durban-Watson (2.08) value good.

Table 11: Regression Analysis of Influence of Factors on Maintenance Challenges

Model	Std Beta	t	Sig.	95,0% conf	
				Lower	Upper
(Constant)		3,594	0,000	0,720	2,460
Managerial and political support (mean Q 9, Q 13, Q 14)	-0,151	-3,026	0,003	-0,395	-0,084
Contractors' challenges - maintenance only (mean Q 7, Q 10, Q 11, Q 12)	0,202	3,882	0,000	0,203	0,620
Municipal and political challenges - maintenance only (mean Q 5, Q 8)	0,187	3,376	0,001	0,119	0,451

All three factors have a highly significant influence. As expected *managerial and political support* has a negative influence (β = -0.151, p = 0,003) (the greater the support the fewer the maintenance problems), whereas *contractors maintenance challenges* (β = 0.202, p <0.000) and *municipal and political maintenance challenges* (β = 0.187, p= 0.001) have a positive influence, meaning the more municipal and political challenges there are, the greater are the maintenance challenges. There is no significant difference between the strength of the influence of the *contractors' challenges* and the *municipal and political challenges*. However, there is a clear difference from the installation of water infrastructure where the influence of the *municipal challenges* is twice as high as the *contractors' challenges*. This means that *municipal and political challenges* cause, in the eyes of the citizens, more problems with installation of WI than with maintenance of WI.

The final step in the maintenance analysis is to investigate the influence of the single variables with the constructs. Figure 2 summarizes the results of this analysis. Since the constructs were exactly generated by the selected variables, the r^2 is always 100%. This also explains to a certain extent why the β coefficients are quite similar - the biggest difference of the β coefficients within a construct is 0.089. The only exception is the difference in the influence of *politicians own the construction companies* (β = 0.526) and *political interferences in the awarding of jobs by the municipality* (β = 0.634) on the construct *municipal and political maintenance challenges*. This indicates that, in the perception of the citizens, *political interference* is a bigger problem than *politicians owning maintenance companies* in the maintenance of the water infrastructure.

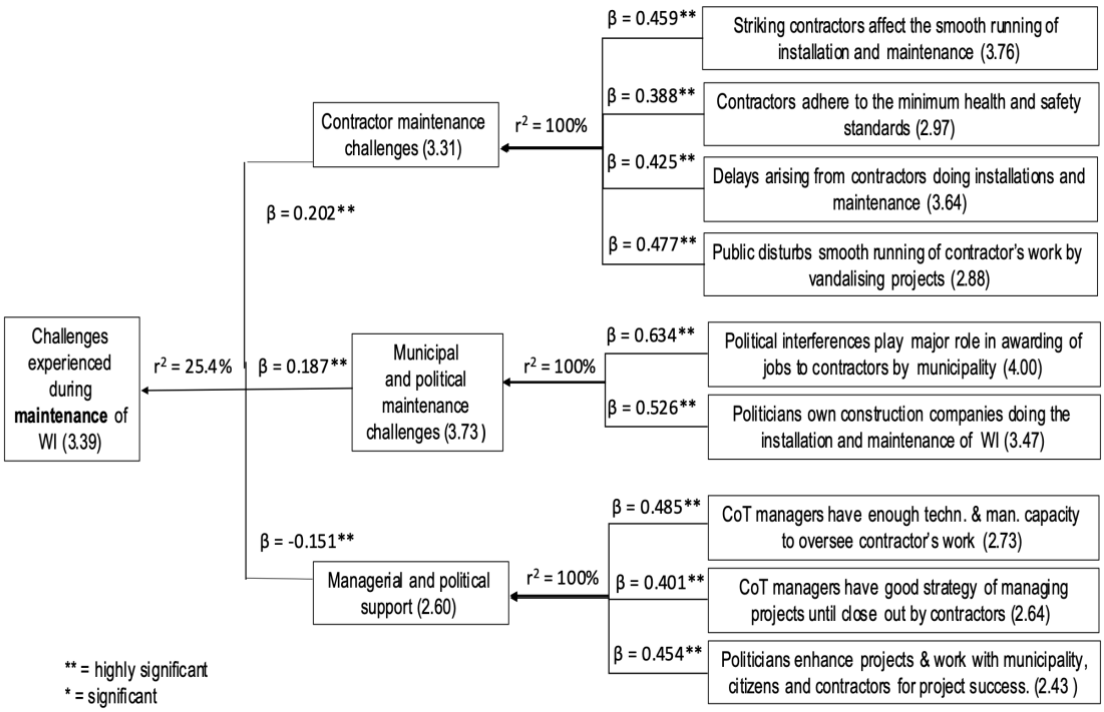

Figure 2: Analyses of WI Maintenance Challenges

Broader implications of the study

The implications of poor leadership, corrupt practices, dysfunctional governance systems, misappropriation of government funds, and non-adherence to recruitment policies lead to poor service delivery and poor governance (Selepe, 2023). These aspects do not only apply to the study area of CoT, but also to other municipalities in SA and probably even globally. If not curbed before they accumulate further, the aspects that played out in the findings may cause detrimental effects to all municipalities. For example, political interference may cause a petty maintenance issue to get out of control due to politicians wanting to award jobs to themselves or friends or relations. These malpractices may have serious implications to the performance, development, and sustainability of some municipalities across the globe. These implications are a red flag to other municipalities facing the same challenges.

Conclusions

The first finding was that the municipality and contractors account for about half the challenges experienced in installation and maintenance of WI, but that the majority influence is from the municipality. Clearly there is a high level of dissatisfaction with, and probably therefore a lack of trust in, the municipality.

The second finding supported the first finding, namely that respondents also agreed with the statement that installation challenges were mainly due to the *municipality and political issues*, especially *political interference in the awarding of jobs* and, to a lesser extent, *the ownership by politicians of construction companies*. This negative perception may be partially offset by the positive perception of *managerial and political support.*

The third finding was that maintenance challenges were perceived as more serious than installation challenges, with *municipal and political challenges* being the main drivers.

The fourth finding was that the *municipal and political challenges* were influenced strongly by both *politicians own the construction companies* and *political interferences in the awarding of jobs,* but with the latter being perceived as the bigger problem.

Recommendations for CoT

To cater for the perception that political issues (political interference and politician owned companies) are the most serious negative influencers of installation and maintenance challenges, the following recommendations are made:

i. Procurement practices and regulations should be revised to provide for a clear separation between the political and administrative duties in the municipality. This should include the appointment of independent witnesses (non-governmental organizations, selected citizens, media) in the tender opening, evaluation and allocation process, to maximize transparency and compliance with rules and integrity.

ii. To further increase openness and transparency in the procurement process, a large range of stakeholders should be involved in the procurement process, including anti-corruption officers, private sector organizations, end-users, civil society organizations, the media and the general public.

iii. To support these suggested actions in improving efficiency and integrity, training and development of municipal officials involved in the procurement processes should be conducted, especially regarding integrity, transparency, reporting and compliance requirements, and the consequences of inefficient or corrupt appointments. Such training should strengthen municipal officials' ability and willingness to withstand political interference.

iv. To reduce citizen dissatisfaction and increase trust in the municipality, regular communications with all stakeholders (especially with affected citizens) are needed in connection with actions being taken to overcome WI problems. Such communications could include dissemination of minutes of procurement meetings, notification of stakeholder involvements, notification of appointment of service providers and feedback on progress of maintenance actions, through the use of newsletters, social media posts, letters accompanying bills, and posters where maintenance is being conducted.

Limitations of the Research

The main limitation of this study is that the sample was effectively self-selected, i.e., citizens decided whether to respond or not. Such a sample could be biased as it is not known whether those responding differed in any way to non-responding citizens. It could be, for example, that non-responding citizens had no complaints about WI and so did not respond, whereas those who did respond had experienced unsatisfactory service levels.

Furthermore, the study was conducted during the Covid-19 pandemic, which may have limited the response as some potential respondents may have only had internet access via their places of work, which they may not have visited due to the pandemic.

The study of a single municipality (CoT) is a limitation – other municipalities may experience different challenges, or none at all and, as a result, any attempt to extrapolate these results to other municipalities should be done extremely carefully.

The regression analyses show that the analyzed constructs only account for a portion of the variances identified. Thus, the findings of this study may not present a complete picture of the challenges faced in the installation and maintenance of WI in CoT.

Recommendations for Further Research

Since this study was rather superficial, only considering the citizens perceptions, follow-up research to delve deeper into the specific challenges, and the suggested recommendations, should be conducted in the context of the CoT.

Since there may be further, yet unidentified challenges influencing installation and maintenance of WI in CoT, further research, probably qualitative, is required to identify what other issues could influence the dependent variables so that these new variables can be investigated in more depth.

It is suggested that similar research be conducted in other large municipalities to identify if the problems identified are unique to CoT or if they are more widespread. If such problems are more widely applicable, a national approach, rather than a regional approach, may be needed to address them.

Further research, also possibly qualitative, is needed with the municipality and the contractors, to better understand the apparent political involvement and influence over the installation and maintenance processes of WI and to identify how such problems could be addressed.

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Conflicts of Interest: The authors declare no conflict of interest.

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