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Water Supply Infrastructure Resilience in the Wake of Rapid Population Growth in Urban Areas:

A Case Study of Norton Town Council, Zimbabwe

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Abstract

Rapid increase in urban population poses a precarious challenge to the available water supply infrastructure most especially in developing nations including Zimbabwe. The study investigates the resilience of water service delivery Norton Town Council in Zimbabwe. An increasing gap between water demand and supply is witnessed owing to urban expansion, obsolete infrastructure, climate change, financial constraints, personnel incapacity and weak governance frameworks have exacerbated the problem resulting in poor and unsustainable water supply. These challenges undermine socio-economic development and sustainability. The study used qualitative research methodology using key informant interviews and a case study design. The findings highlight that the Town Council is drastically failing to balance demand and supply because of population and the outdated infrastructure system. Critical factors affecting water supply resilience include population growth, urban expansion, dilapidated infrastructure system, financial incapacity, climate change, institutional and governance inefficiency. The study thus proposed strategies for Norton Town Council to implement towards attaining infrastructure resilience emphasizing infrastructure development and maintenance, improved stakeholder engagement and responsive financial reforms. Likewise, climate change adaptability, strengthening institutional capacity and adopting innovative technologies in water management will guarantee water supply infrastructure resilience.

Key words

Infrastructure resilience, Population growth, Sustainable development, Water demand, Water supply

INTRODUCTION AND BACKGROUND

Access to water is fundamental towards sustainable socio-economic development and sustaining life. World Health Organization (WHO) (2017) highlights access to water as an inalienable human right also essential for the realization of other human rights. Integrating resilience thinking provides a holistic approach to improve water access globally faced with rapid growth in population, especially in urban areas, is putting pressure on the available water supply infrastructure couples with climate change. This threatens the ability of the water supply infrastructure to commensurate with ever-growing demand (Bishonge, 2021). This poses a critical challenge towards the provision and access to equitable water. Global urban population has continuously been on the rise with projections of around 2.4 billion people lacking access to adequate water supply by 2050 from 933 million in 2016 according to the United Nations (UN) (2023). Sub-Saharan Africa (SSA) as one of the fastest growing regions globally is also experiencing rapid population increase coupled with poor infrastructure investment worsening developmental prospects by international organizations (Dangul & Style, 2022). In 2014, the population in SSA was approximately 961 million however, by 2023, the population has reached 1.2 billion (United Nations, 2024) posing a significant water access challenge. This increase in water demand continuously puts pressure on water resources which are already failing to cater for the available demand threatening the region's capacity to develop.

The Millennium Development Goals (MDGs) aimed at halving the proportion of people lacking access to water by 2015 were enacted. The initiative was highly ambitious thus drastically failed to meet its intended goal in SSA since water insecurity is still a persistent challenge which can be attributed to population growth as one of the critical issues (Dangui & Jia, 2022). This ultimate failure of the MDGs water targets underscored the need for inclusive and sustainable strategies that meet the unique and context specific needs of the region expressed under the Sustainable Development Goals (SDGs). In response, the SDGs promulgated in 2015 by the UN set to be achieved by 2030 are meant to address the shortfalls of the MDGs substantiating the importance of access to water for all and the need for infrastructure investment to attain the goal. Tortajada (2014) asserts that water supply infrastructure is an integral component to advance socio-economic growth and environmental sustainability. Water supply infrastructure has continued to attract relevant attention from policy makers and the academia as postulated by Dangui and Jia (2022) thus the need to incorporate resilience in water supply infrastructure systems amidst several challenges.

Water supply infrastructure comprises physical facilities and systems that are crucial towards providing access to water, treatment, storage and distribution facilities (Grey & Sadoff, 2007) inclusive of regulations, policies and institutions known as 'soft infrastructure'. To ensure the integrity, quality and functionality of the water supply infrastructure, Lambertini et al (2011) notes the need for several operational and maintenance measures. In developing countries, however, water supply infrastructure is characterized by inadequate financing, obsolete infrastructure, high rates of planning, operational, and maintenance failures (Hoko et al, 2024). The infrastructure failures thus contribute to high non-revenue water, reduced water quality and deteriorating water supply resulting in severe water insecurity, outbreak of waterborne diseases such as cholera, diarrhea and typhoid and persistent poverty (Hoko et al, 2024; Adeoti, Kandasamy & Vigneshwaran, 2023).

Zimbabwe also faces a significant challenge with regards to failing water supply infrastructure thus lagging towards achieving SDG 6 compromising on development and the health of the citizens (Matsa, Mavugara & Dzawanda, 2021). Urban areas are most affected with some areas going for years without consistent water supply (Nhapi, 2015). Mutandwa and Vyas-Doorgapersad (2023) articulates that population growth and urbanization is suffocating most cities resulting in poor water supply infrastructure development that commensurate with the demand. Much of the population increase in urban areas contributes to the mushrooming of unplanned informal settlement areas that are not covered with water supply services whilst overpopulated areas also contribute to the deteriorating infrastructure system (Dos Santos et al., 2017; Nhapi, 2015). Under such conditions, water supply infrastructure is therefore prone to failure as evidenced by precarious water supply challenges. The current water supply services within the urban areas is characterized by serious waterborne diseases. A massive cholera outbreak caused havoc in the urban areas of Zimbabwe claiming more than 4 000 lives leaving more than 100 000 people infected burdening the already failing health system (Musemwa, 2021). In 2018, there was yet another outbreak of cholera and typhoid reported in the Zimbabwe affecting more than 10 000 people with over 60 deaths reported cases as postulated by (Musemwa, 2021; Unicef, 2018). Water supply thus remains a perennial challenge in the urban areas of Zimbabwe.

Norton, a small town approximately 40km west of Harare in Mashonaland West province, is also grappling with water supply challenges. The town gets its treated water from the Harare City Council together with other towns such as Chitungwiza, Ruwa and Epworth (Chigonda, 2010; Vyas-Doorgapersad & Mutandwa, 2023; Magidi, 2023). The source of treated water for Norton, which is Harare City Council, is already failing to provide equitable water supply services to its residents as mandated by the Urban Council's Act [Chapter 29:15] of 2001. Norton Town Council is the responsible authority running the town responsible for the provision of basic urban governance such as water provision, waste management, housing, education and health in line with the ethos of the Urban Council's Act of 2001.

Nonetheless, the council has failed to provide the essential services to the residents owing to several challenges. Shayamano (2021) notes that Norton has continuously experienced a significant increase in population over the years which has subsequently contributed to increased demand for essential services such as water supply. The population has doubled in size from around 44 000 to approximately 88 000 people over a 10-year period from 2002 and 2022 (Magidi, 2024; Zimstats, 2022). The population increase has put pressure on the existing infrastructure and resources within the town, going for years without access to piped water according to Magidi (2023). Given these challenges, there is urgent need for a paradigm shift to incorporate resistance thinking in water supply governance within the smaller urban areas. Saikia et al (2022) postulated that globally, urban areas are confronted with unpredictable and systematic risks thus the concept of resilience can be a useful framework to address water supply issues and shocks emanating from both climatic conditions and governance risks. The resilience of water supply infrastructure system is therefore compromised and vulnerable to water related stressors. These challenges have prompted the researcher to explore ways to ensure water supply infrastructure resilience in the contexts of a small urban town narrowing the current research gap as most research focused on bigger towns in Zimbabwe. This therefore justifies the use of Norton as a case study attaining research inclusiveness.

LITERATURE REVIEW

This section discusses relevant literature on water supply infrastructure resilience in urban areas and the systems theory which acts as the lens for this study.

Understanding Water Supply Infrastructure Resilience

The term resilience has been defined by various scholars differently based on different concepts and discipline and as such, the concept becomes difficult to define due to varying perspectives and conditions (Sinha et al., 2023). Understanding resilience therefore requires critical understanding of the challenges experienced, resources required and ultimately timeous response to recover (ibid, 2023). United Nations Office for Disaster Risk Reduction (UNODRR) (2017) defines resilience as “the ability of a system, community or society exposed to hazards to resist, absorb, accommodate, adapt to, transform and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions through risk management.” The definition accentuates that resilience as a concept goes beyond risk identification and management, but it also includes recovery mechanisms and adaptation measures for both present and future needs. Resilience in water thus requires a systematic approach which considers complex interconnectedness and interactions that exist within water supply infrastructure system (Sinha et al., 2023). Leigh and Lee (2019) argue that the term ‘*water resilience*’ is relatively a new phenomenon previous studies available in literature links the concept to socio-ecological systems.

Emanating from the broader definition of resilience and available studies, the notion of water resilience in line with the view presented by Saikia et al. (2022) can be defined as the systems and stakeholder’s ability to persevere, transform and adapt to water-related challenges. Falkenmark, Wang-Erlandson and Rockstrom (2019) postulates that water resilience is relatively a new phenomenon which has continuously gained research attention as fundamental towards the sustainability of water supply. According to Rodina (2019) water supply resilience is defined as the capacity of the water supply system to effectively withstand and recover from several water related stresses without affecting the delivery of water services also adapting new approaches to water supply. Sinha et al. (2023) underscores the importance of promoting infrastructure resilience due to growing need emanating from frequent disruptive events which subsequently affect communities including technical and governance practices. The availability of water supply is dwindling characterized by poor management practices amidst population increase and climate change (Magidi, 2023; Matsa et al., 2021). Bulti and Yutura (2023) argue that water supply infrastructure in towns is inefficient in both operation and maintenance. This poses a serious risk to current and future water supply needs in a volatile environment which calls for the urgent need for resilience of water supply infrastructure (Bulti & Yutura, 2023). Therefore, it is important to include resilience thinking in water supply governance within urban areas as a sustainable way to mitigate the impact of water challenges and also respond to water stresses thereof (Saikia et al, 2022).

Zimbabwean Context

Zimbabwe has continuously witnessed complex water supply challenges especially in urban areas (Vyas-Doorgapersad & Mutandwa, 2023; Magidi, 2023; Musemwa, 2021). A significant number of factors can be attributed to these water supply woes that have crippled the country to a situation of dire crisis. Since the attainment of independence in 1980, water reforms have been enacted to ensure equal access through the Water Act of 1998 and the Zimbabwe National Water Authority (ZINWA) Act (Chapter 20:15) of 1998 (Manzungu, 2024). The local authorities have a prerogative responsibility to supply water in urban areas governed by the Urban Council’s Act (1996). In 2000, an independent parastatal ZINWA was established responsible for water resources planning, management and development (Manzungu, 2024). In 2005, the responsibility to supply water was transferred from the local authorities to ZINWA without proper planning and lack of capacity further crippled water supply in urban areas (Mutandwa & Vyas-Doorgapersad, 2023; Muchadenyika and Williams, 2018). Upon this realization, water supply responsibility was then transferred back to local authorities although there are a handful of areas where ZINWA is responsible for water supply to citizens. To enhance efficiency and operations within the water sector, a new National Water Policy was developed in 2013 calling for the harmonization of water-related legislation (Manzungu, 2024). Nonetheless, the principles of the policy are still to be implemented thus the water supply and governance in Zimbabwe is still guarded by fragmented water related policy frameworks. Gambe and Karakadzai (2023) thus postulate that this fragmentation contributes to tensions, confusion and overlaps which further weakens the water sector.

The country is also plunged in severe decline in water supply services because of poor infrastructure system which is old and dilapidated. Studies show that urban areas in Zimbabwe are faced with precarious water shortages due to poor infrastructure maintenance and infrastructure failure (Magidi, 2023; Matsa et al., 2021; Nhapi, 2015). Cities such as Harare, Masvingo, Gweru and Bulawayo operate with outdated and dysfunctional treatment plants, inadequate storage capacity and poorly maintained distribution systems consequently failing to meet water needs for the ever-growing population. The infrastructure system thus requires urgent need for rehabilitation to also meet with expansion, however, the local authorities do not have adequate finances to maintain as well as rehabilitate the system (Matsa et al., 2021). The lack of financial resources and economic crisis to upgrade and expand the infrastructure system ultimately resulted in consistent breakdowns, contamination risks and severe water rationing in most urban areas posing a severe health risk to the population.

The situation is further complicated by population growth and urbanization in most urban areas as postulated by Brooke and Fenner (2023) in Harare thus widening the demand and supply gap. A study by Vyas-Doorgapersad and Mutandwa (2023) also notes population growth with concern indicating that Harare water supply infrastructure was built in 1953 accommodating a small population but now the system also supplies water to Harare satellite towns including Chitungwiza, Norton and Ruwa thus failing to cope with intense population in all these towns. Disparity in water access is

still evident in the country four decades after attaining independence with the poor population residing in peri-urban and high-density areas mostly affected (Musemwa, 2021; Shayamano, 2021). As the population increases, urban expansion also increases often than not outpacing the capacity of the infrastructure resulting in unreliability and unsustainability in water provision giving pressure to the infrastructure system (Mutandwa & Vyas-Doorgapersad, 2023; Matsa et al., 2021). This pressure thus compromises the resilience of water supply infrastructure as it becomes more vulnerable to disruptions and pipe bursts.

To further worsen the situation, institutional weaknesses and poor governance structures in water supply have also affected the water supply infrastructure system within Zimbabwe and particularly in Masvingo (Gambe & Karakadzai, 2024). The governance of water is characterized by a top-down approach with lack of public participation thus significantly undermining the sustainability of urban infrastructure system (Taruvunga, 2024). Shayamano (2021) also opines that this weakness likewise limits transparency and accountability in water management hence the needs of the communities are not taken into consideration during the planning and decision-making processes. As such, communities are often unwilling to cooperate with the water supply authorities, weakening infrastructure adaptability and responsiveness. Due to these challenges, water supply in the country has been going downhill with a huge number of people within the urban areas lacking adequate water supply for both domestic and hygiene uses.

THEORETICAL FRAMEWORK

The study is underpinned by the systems theory by Ludwig in the 1950s. The theory can be utilized in several disciplines to address multi-faceted problems with the major principle centered on understanding relationships between a given phenomenon (Norton, 2017). In understanding water supply infrastructure resilience, this theory is critical as it emphasizes the interconnected components that function as a system. Furthermore, the theory is also fundamental in this study as it conceptualizes the water supply system as a complex system substantiating the importance of interaction between various factors towards guaranteeing functionality and sustainability. The concept of water supply infrastructure resilience can be well explained based on the physical infrastructure system, institutional elements, policy frameworks, environmental conditions and socio-economic aspects that help in shaping and nurturing effective water governance. The researcher thus aims to explore these components and their interconnectedness towards the realization of resilience infrastructure systems identifying key challenges and strategies to enhance resilience.

The theory provides a holistic approach to analyzing and enhancing the resilience of the water supply infrastructure system considering increasing challenges that come into play because of population growth and dilapidated infrastructure system. One of the key components of the theory is the interconnectedness and interdependence of the system which by extension implies that when one element of the system is malfunctioning, the entire system is thus distorted. Contextualizing this argument to water supply, this implies that attaining resilience does not just consider the physical infrastructure system but also the socio-economic, political and environmental factors. Organizations are thus shaped and nurtured by the external environment within which they operate in (von Bertalanffy, 1968) this is because local authorities use an open approach. Understanding the environment thus significantly impacts the understanding of the systems challenges, adaptation and sustainability (von Bertalanffy, 1968). In response, the system must address the challenges that come from the environment which in this case is population increase essential towards enhancing viability and resilience infrastructure system.

To add on, consistent feedback is also critical according to the theory (Kuhn, 1974) which in this case can be realized through constant stakeholder engagement in the water governance system within the urban areas. Through this engagement, the citizens are able to provide their views to enhance the system functionality by fostering active participation. The use of the systems theory provides an all-inclusive approach to the multi-dimensional factors that affect water supply sustainability and resilience in urban areas. As a result, this holistic understanding aids in the development of strategies to address these issues in an effective and robust manner thus realizing water supply infrastructure resilience in urban areas amidst rapid population growth.

METHODOLOGY

Study area

Norton is a small urban town located 40km west of the capital which emerged as a satellite town to alleviate pressure on Harare. The town is located within rich natural water resources strategically positioned near Lake Chivero and Lake Manyame (Vushoma, 2016) which provides abundant water for domestic, agricultural and even industrial uses. Regardless of this strategic location, the town faces perennial water supply challenges, and it sorely relies on buying treated water from the capital city for all its water supply needs (Shayamano, 2021). According to Zimstats (2022), the population of the town grew from 44 000 people in 2002 to 88 000 by 2022 which is a very significant increase. Chigonda and Chazireni (2017) asserts that the water reticulation system was developed more than 50 years ago comprising old and new sections and components now serving more than twice the population it was initially designed to serve. Figure 1.1 shows the geographical location of Norton.

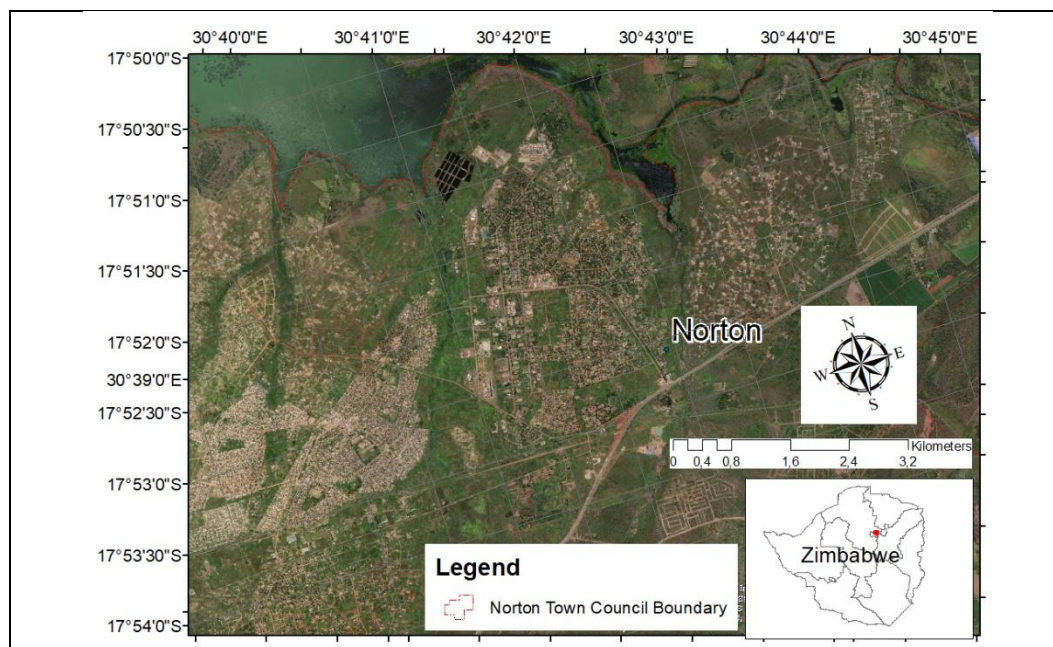


Fig. 1 Location of Norton
Source: Shayamano (2021)

Methods

The study utilized a qualitative research methodology which was appropriate to gather in depth and comprehensive understanding of water supply challenges in Norton town. Data for the study was collected using key informant interviews (experts) with Norton Town Council officials who were selected using purposive sampling technique. The interviews were recorded and transcribed with the consent of the participants. Thematic analysis was used to analyze the data collected. Themes and subthemes emerged in the data are essential to address the objective of the study. The names of the participants were not disclosed during the data presentation stage. The key findings which emanated from the research are presented and discussed in the following section.

RESULTS AND DISCUSSIONS

Significant increase in population

Rapid population growth emerged as a critical challenge, putting significant strain on water supply infrastructure system in Norton. The increase in population within this small urban town exacerbates the demand for water supply services exponentially making it difficult for the council to provide reliable and adequate water supply. The findings suggest that the water supply infrastructure system was designed for relatively smaller population as compared to the vast population it now must cater for. One of the interviewed participants alluded that *“population increase is putting pressure on our existing water supply infrastructure as such we are failing to keep up with the ever-increasing demand [...] initially, the system was developed to manage less population than that it serves now”* the implication of this statement shows that the town council is failing to keep up with growing trends with regards to population growth which is outpacing the capacity of the council to effectively provide equitable water supply to all its residents. The challenge of population growth is also emphasized by Brooke and Fenner (2023) and Vyas-Doorgapersad and Mutandwa (2023) alluding that increasing population is straining the water supply system in urban areas.

The population of the town doubled in size within the last decade whilst the water supply infrastructure system did not expand to commensurate with the new demand for water as such demand continues to rise with dwindling supply capacity. The influx of new and emerging residents in the town has subsequently contributed to frequent shortages of water characterized by low pressure and more often dry taps. High density areas are most affected as compared to the low-density residential areas, yet demand is higher in the high-density areas. The 50-100 liters proposed by WHO to meet personal hygiene needs ensuring few health concerns is drastically being ignored thus preventing the human rights to water. Increase in population against deteriorating water supply drastically affects sanitation and hygiene practices thus increasing the risk of waterborne diseases such as cholera, typhoid and dysentery. This health risk is disastrous in highly populated areas within the town as it can spread rapidly while the healthcare system is already severely under constraint. Hoko et al. (2024) also observed the same conclusions thus cementing the findings in this study showing how water challenges pose a significant health related risk to the citizens.

Furthermore, the population increase results in rapid urban expansion to accommodate new urban dwellers like in the case of Norton which has witnessed spatial changes due to this expansion. The expansion of the town has led to the mushrooming of new settlement areas and informal settlements that are not connected to the council's water supply infrastructure system. Another interviewed participant emphasized this challenge articulating that;

“our town is expanding in terms of residential locations but we are unable to cater for their water supply needs since our infrastructure is not developed enough to cover the areas.”

This quotation implies that there is lack of equilibrium in terms of urban planning against essential service needs. Therefore, this mirrors how urban expansion is impacting negatively on access to water or the Norton residents as some areas lack equitable piped water connections whilst others have gone for a prolonged period without running water.

Similarly, the expanding spatial area served by the council drastically overwhelms the ability of the council to meet up with its constitutional mandate and urban council's proclamations. The issue of urban expansion affecting water supply infrastructure is also substantiated by the findings presented by Mutandwa & Vyas-Doorgapersad (2023) giving pressure to the available infrastructure system. As the demand for water keeps growing, the water supply infrastructure is strained and overburdened as witnessed with water supply disruptions and worst water rationing experienced by the residents. This has forced residents to rely on unsafe and unreliable water sources such as shallow wells and boreholes that are mostly polluted and contaminated as a result of dense population. The situation in Norton is further exacerbated by lack of sustainable financial investments to expand the water supply infrastructure to keep with demand and growing urban expansion.

Dilapidated water supply infrastructure systems

The study findings highlighted the aging and dilapidated water supply infrastructure in Norton Town as another critical challenge negatively impacting on equitable access to water and water supply sustainability. Following influx in population over the years, water supply infrastructure is not growing to meet with the rising demand. The town lacks an independent water treatment plant to cater for the demand for water, rather, the council relies on buying treated water from Harare City Council which is costly and inadequate. One of the interviewed participants highlighted that;

'we do not have a water treatment plant, we depend on water from the City of Harare and the water is not enough they give us 5 to 6 mega liters per day and it is not enough. Even when we distribute the water, it is not for more than 6 hours,'

The town is located in a rich water resource, located between lakes such as Lake Chivero and Lake Manyame. The town nonetheless has a dependency syndrome on Harare failing to treat its own water to meet with growing demand. With a current population of 88 000 residents, the town requires more than 10 megaliters of water per day but the current capacity only manages to cater for 5-6 megaliters of water per day, meaning that the council is not adequately distributing water to the residents. This translates to less than 50% of their daily water requirements without any other safe and reliable source of water that puts the town in a conundrum, a ticking timebomb for waterborne disease outbreak. These findings are also consistent with the findings presented by Nhapi (2015) asserting that the water provided is not adequate to supply the town resulting in citizen's vulnerability to diseases.

All the interviewed participants concurred that the infrastructure system is old and dilapidated, lacking regular maintenance. The state of water supply infrastructure within Norton is in serious despair characterized by aging infrastructure system, illegal connections and high levels of non-revenue water as a result of burst pipes and leaks. This concurs with the assertions made by Chigonda and Chazireni (2017) that the infrastructure has outlived its capacity hence becomes more vulnerable to leaks and high non-revenue water in Norton. The current water supply infrastructure system was built over three decades back characterized by lack of regular maintenance which consequently contributes to frequent infrastructure failures hence failing to adequately meet the demand for water. Aging pipes, storage facilities and pumps are more prone to leaks and bursts resulting in water loss and higher maintenance costs that the council cannot afford. Old high-density suburbs such as Katanga and Ngoni have the oldest infrastructure system that was developed during the inception of the town and no substantial maintenance or rehabilitation have been witnessed yet the system is overburdened due to increase in population. Mutandwa and Vyas-Doorgapersad (2023) also highlights this challenge in their study hence supporting the findings of this study.

To further support the findings Shayamano (2021) also noted with concern that other suburbs in Norton were not entirely connected to water supply as the infrastructure system which is highly unsustainable. Suburbs like Kalfa, Johannesburg and Maridale were found not completely connected to water supply meaning that the infrastructure system within these areas has corroded due to prolonged periods amounting to years without tap water. The residents have since resorted to alternative water sources to cater for their water needs. This significantly undermines water supply infrastructure resilience, weakening the integrity of distribution pipes leaving them more vulnerable to leaks and bursts. Norton also faces significant water shortages as a result of the aging infrastructure system which has contributed to severe water rationing in the town. Sustainability of water supply is thus compromised.

Ineffective financial capacity

The study findings show that the council is faced with inadequate financial capacity which severely impacts on the resilience of the water supply system in Norton. As a result of this challenge, the council fails to effectively manage as well as expand their infrastructure system, leaving the town vulnerable to supply disruptions undermining water supply sustainability. These findings are additionally reinforced by Hoko et al, (2024) and Matsa et al. (2021) The participants cited inadequate funding as a major limitation which undermines the efforts of the council to effectively meet the demand for water within their area of jurisdiction. One of the interviewed participants said that;

"Norton town council struggles to pay for the right amount of water. We are supposed to do regular water quality monitoring, regular upgrading of the water reticulation system but we find ourselves being strained financially so we won't be able to provide the water."

The main source of revenue for the council is through user fees however, the residents have resorted to a culture of non-payment due to poor services being rendered. As such, the council operates under limited financial resources thus they struggle to pay for adequate amount of water from Harare City Council and struggle to cater for their operational costs hence the council is unable to provide reliable supply. This challenge also affects the quality of the water provided susceptible to contamination in the distribution network. The contamination further exposes the residents to both long- and short-term illnesses amidst economic crises. Economic hardships that have continuously plundered the country over the years have also worsened the situation. The council fails to maintain the current water supply network further weakening water supply infrastructure resilience.

The study also discovered mismanagement of financial resources as another crimping challenge in the town which has left the water supply system ill-equipped to serve the growing population and also respond to infrastructure failures. Another respondent highlighted that financial mismanagement is hindering the council's effort to upgrade the outdated water supply system and the availability of a water treatment plant for the town. The infrastructure thus fails to adapt to the growing demand resulting in unsustainable water supply prone to adverse failures also costing the council as it becomes non-revenue water. The water is lost in the distribution network which the council would have paid for when purchasing treated water from Harare.

Climate change

The findings also suggest that climate change is also a serious challenge within Norton which has subsequently affected the sustainability of water supply infrastructure. Rising temperatures have continuously threatened the reliability and dependability of the water supply system. The interviewed participant highlighted high temperatures cause the water supply infrastructure system to degrade at a faster pace as compared to normal weather conditions. Droughts and reduced precipitation have also exacerbated the problem resulting in prolonged dry seasons thus affecting the availability and sustainability of water for the residents. The town has limited and dilapidated water storage facilities to curb the impact of climate change thus forcing the residents to depend on unsafe water sources which are also dwindling due to climate change. Alternative water sources such as shallow wells and boreholes end up drying leaving the residents with worsened water access challenges. These findings are also validated by the findings presented by Matsa et al. (2021) implying that climate change poses a serious challenge to water supply.

On the other hand, the participants also reported flash floods due to heavy rain as another challenge caused by climate change resulting in water supply inefficiency. The flash floods cause water contamination as the water frequently contains harmful chemicals and sewage negatively impacting on the council's capability to supply water services and other water sources for the residents. This implies that in the event of flash floods occurrence, the damage weakens the already dilapidated water supply infrastructure systems increasing repair and maintenance costs which the council does not afford. Underground pipes are more frequently exposed due to excessive erosion, cross contamination also occurs due to burst potable water and wastewater pipes and storage facilities are also impacted. This is clear evidence that Norton Town council does not have climate resilient infrastructure negatively impacting the water supply.

Institutional and governance weaknesses

Resilient water supply infrastructure in Norton is also compromised by weak institutional and governance systems that are currently in place in line with the study findings. The following subsections articulate these challenges in line with the study findings.

Inadequate public participation

Inadequate public participation emerged as another weakness impacting infrastructure resilience in Norton Town Council hence affecting the water supply for the residents. Decision making ideally rests upon the council as a result, the unique water supply needs within different suburbs are not effectively addressed. In the long run, the lack of public participation translates to poor infrastructure planning, poor water conservation practices and lack of public awareness on ways to enhance water supply resilience. Taruvinga (2024) and Gambe and Karakadzai (2024) also concur with the findings indicating that the governance of water in Zimbabwe is centralized with limited involvement of citizens hindering decentralization which is critical for effective water governance. Poor infrastructure planning in Norton continues to weaken the resilience of water supply infrastructure as the system is not designed properly to commensurate with current and future demand. As a result, the infrastructure is prone to failure characterized with inadequate coverage as some old and new suburbs are not connected to the water supply system. This not only overburdens the pipelines but also contributes to low water pressure and worsened water rationing. Upgrades of the water supply system are minimal coupled with lack of coordination between water management and urban planning further compromising access to water for all. This calls for strategic planning in Norton for water supply infrastructure to support demand and urban development.

Similarly, water conservation according to the study findings plays a fundamental role towards guaranteeing water supply sustainability considering increasing population as well as dilapidated water supply infrastructure. One of the participants alluded that;

“water conservation strategies are our first call to action towards achieving water sustainability since the Council is financially unstable to maintain the current infrastructure system. Our revenue base does not allow us the independence to do that.”

Nonetheless, the implementation of the water conservation strategies in Norton is still a challenge thus putting immense pressure on the available water supply, making the system more susceptible to failure. The findings also suggest that the lack of awareness on the importance of infrastructure maintenance and resilience results in the citizen's reluctance towards reporting water leaks in the distribution network and illegal connections. As such, the Council loses a substantial amount of money due to non-revenue water loss as repairs take relatively longer and increase system failure vulnerability. The participants noted this challenge with great concern as it is costing the council as it continuously weakens the ability of the municipality to supply reliable and sufficient water. Tawonameso et al. (2022) also echo the same sentiments postulating that public participation is critical towards attaining successful designing and implementation of water policies but in practical terms participation is not prioritized resulting in institutional weaknesses. This therefore implies that if the communities are not made aware of how water supply resilience impacts both short and long-term security on water supply, there will still be consistent and perennial water supply challenges in Norton. Enhancing community engagement and awareness is thus important towards strengthening the resilience of water supply infrastructure system amidst population growth.

Lack of adequate technical expertise

The study also established that Norton Town Council lacks adequate skilled personnel to maintain the water supply infrastructure system affecting its resilience. This challenge has subsequently contributed to inadequate maintenance practices which have also attributed to the dire condition of the water supply infrastructure in Norton. Specialized expertise for planning, designing and maintaining the water supply infrastructure is critical towards effective operation and functionality of the system as concluded by Gambe & Karakadzai (2024). Yet, in the case of Norton, the participants highlighted that the skilled personnel within the council are not enough to enhance water supply infrastructure resilience. One of the participants said that;

“We do not have enough skills capacity at the moment to effectively manage the water supply infrastructure system more effectively. As a result, the system is prone to frequent failures leaving the citizens without running water on their taps daily.”

This implies that lack of adequate skills within Norton Town Council is also affecting the water supply sustainability and resilience. The council is understaffed, lacking the required skills and expertise to effectively maintain the available water supply infrastructure system. Taonameso et al. (2022) and Shayamano (2021) also argue that lack of skills impact negatively on water supply within urban areas in Zimbabwe affecting water sustainability. This contributes to delays in infrastructure maintenance which further deteriorates the infrastructure system compromising both quality and quantity of water supplied. Access to water thus becomes a critical challenge in the town. The town thus lacks adaptive strategies in line with changing population trends and climatic conditions leaving the infrastructure vulnerable to various challenges and unreliable supply of clean water. The absence of adequate expert knowledge and skills to also manage potential infrastructure risks further aggravating the challenge as resilience factors are not taken into consideration when planning and maintaining the water supply system. The town is therefore unprepared for emergency situations leading to continued water supply disruptions impacting both the present and future needs.

CONCLUSIONS

To ensure resilience of water supply in Norton, it is essential that the Norton Town Council strengthen its urban planning mechanisms. Robust urban planning helps in improving participatory governance and effective coordination amongst critical stakeholders. Likewise, urban planning helps towards ensuring that the town expands in a sustainable and equitable manner susceptible to shocks that come from population growth. As such, the expansion of the town will be in line with infrastructure development to cater for an effective supply of water. Equally important is also incorporate climate change into the planning and management process since climate change poses a substantial risk to an effective and sustainable water supply. If this is achieved, it does not only guarantee water supply sustainability but also addresses negative impacts of climate change thus meeting the growing water supply needs of urban population at the same time responding to infrastructure needs to achieve resilience in Norton town.

Investing in the water supply infrastructure system is also a vital component for the town to eliminate overdependence on water from Harare City Council. The investment must begin with completing the construction of an independent water treatment plant as a matter of urgency then expand the existing infrastructure system, including storage facilities, to meet growing demand. The distribution infrastructure system also needs revamping as it reduces non-revenue water due to pipe bursts, eliminates contamination and enhancing system reliability. This in turn boosts resilience as smart technologies will be utilized with designs that are more adaptable to climatic shocks and population increase.

Furthermore, the study also concludes that engagement of the urban communities as well as enhancing community participation is vital towards building and nurturing water supply infrastructure resilience. To ensure effective implementation of this strategy, the urban communities must take initiatives to effectively manage water supply systems in Norton and also take part in the decision-making processes. The council must therefore prioritize engaging the communities through educating the communities on water conservation techniques that promote sustainable water use practices that reduce the demand for water and ensure long-term availability through optimizing water usage. This in turn prevents overuse of water resources thus helping towards maintaining stable supply of water thus minimizing chances of infrastructure failures caused by high demand pressure. The study thus recommends a multi-faceted approach to

effectively address the critical challenges being faced by the Norton Town Council amidst the growth in population. By implementing these strategies, the town can withstand the pressures of increasing population which can be scaled up to attain resilient water supply infrastructure in Norton.

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DECLARATION OF CONFLICT

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