Journal of Water & Health

Journal of Water and Health Vol 21 No 7, 939 doi: 10.2166/wh.2023.078

Assessing the social and economic implications on water security in the Nelson Mandela Bay Metropolitan Municipality, Eastern Cape of South Africa

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ABSTRACT

Access to water is a universal human right for every individual and a key instrument in meeting the United Nations' sustainable development goal SDG 6, namely, to ensure safe drinking water and sanitation for all by 2030. Water is also intrinsically linked to any society or country's social, economic and political development. Nevertheless, many communities and households, predominantly rural and underprivileged in the Nelson Mandela Metropolitan Municipality, continue to experience persistent water shortages. This means entrenched poverty, ill health, hunger, stress, and social and economic challenges for the population. Using data collection tools inspired by traditional methods of qualitative and quantitative approaches, this paper scrutinised the social and economic factors contributing to severe inequality in water access in the municipality. Our findings established that water shortage is portrayed as a stand-alone issue without linking it to social and economic challenges. Furthermore, both government and municipalities fail to contextualise a multidimensional problem-solving approach to the water provision challenges in the municipality. This paper, therefore, recommends a multidimensional approach to tackling the problem of accessibility, taking into consideration the social and economic needs of the population.

Key words: socioeconomic development and sustainability, water access

HIGHLIGHTS

- This paper highlights the inequalities of water provision in Nelson Mandela Metropolitan Municipality.
- While some households enjoy uninterrupted access to a reliable water supply, other marginalised communities face regular water shortages or lack access altogether.
- The uneven distribution of water resources exacerbates social and economic inequalities within the municipality.

1. INTRODUCTION

Water is a crucial resource for human consumption and other sectors, including agriculture, industries, energy production and recreation. It is also the foundation of every ecosystem on the planet (Durrani 2020). 'Water can be a matter of life and death, depending on how it occurs and how it is managed; when in excess or scarce, it can bring destruction, misery, or death' (Rice 2015: 4). Conversely, it can be a tool for growth and development if correctly managed. It can be a channel for poverty reduction while at the same time improving the well-being of people (Kingsland 2021). On the other hand, insufficient quantity and quality can contribute to poverty and economic stagnation, which often leads to high unemployment and slow growth, food insecurity, poor health, conflicts and migration (Abdu-Raheem & Worth 2011). The connectivity between water accessibility and economic growth is depicted by linking water with poverty (Bhuvan & Rop 2015). Water availability calculations are based on the available water resources per unit (e.g. basin or country) and time (daily, monthly, seasonal, annual or even longer time scales). The mismatch between water availability and demand leads to water scarcity issues and adds stress to societies (Bharti *et al.* 2020). As Mancosu *et al.* (2015) disclosed, water insecurity directly impacts food security; thus, lack of water supplies limits the production of agricultural products, hence resulting in food shortages. The same view is supported by Blignaut & van Heerden (2009), who wrote that the net effect of reduced water reserves has

decreased food production. Water and economic development are mutually inclusive, as interlinkages, synergies and trade-offs exist between them (Adom & Simatele 2021). On the one hand, they can be focal points in the correct sequence, strengthening one another in an accelerated manner. Such interactions generate an ascendant growth in which enhanced social and economic expansion generates the resources required for the progressive evolution of water resources and which, in turn, support and instigate additional economic growth (Manase 2009). On the other hand, they can be pivotal in a malignant sequence that puts communities into a descending curve of feeble economic development and a reduced standard of living (Edokpayi *et al.* 2020).

Like most municipalities in South Africa, Nelson Mandela Metropolitan Municipality (NMMU) is not immune to water accessibility challenges. The municipality is a clear case where water scarcity and accessibility are caused by both physical scarcity and socioeconomic factors (Cole *et al.* 2018; Chitonge 2020). Palmer *et al.* (2017) and Viljoen & van der Walt (2018) disclosed that the municipality's water crisis is fundamentally linked to poor and outdated water infrastructure, lack of investment, infrastructure failures including theft and vandalism, recurrent droughts driven by climatic variation, institutional failures, corruption, lack of skilled and qualified engineers, persistent labour unrest and strikes over salaries and bonuses and high rate of household poverty and unemployment in the population. This crisis has resulted in 70% of the population experiencing impacts on the municipality's social and economic growth and well-being and beyond. The poor and the vulnerable groups who lack the capacity (financial and social capital) to mitigate against water shortfall are hit the hardest (Chitonge 2020). Mulenga (2017) pointed out that there are many challenges in achieving water accessibility in the municipality. These include a lack of data and comprehensive knowledge of water availability in the municipality, sectoral planning (silo mentality) and fragmentation of policies (Bharti *et al.* 2020). Furthermore, poor governance structures and processes in catchment areas have contributed significantly to the problems (Jacobs-Mata *et al.* 2021).

Based on these challenges, some researchers, policymakers and commentators are increasingly engaging in these complex issues and proposing different models of enhancing water accessibility. For instance, Makaya *et al.* (2020) advocated for institutional coordination to improve water provision to communities, while Palmer *et al.* (2017) proposed an adaptive integrated water resource management in South Africa's municipalities to enhance water provision. Park *et al.* (2009) supported the policy of improving free basic water provision to the rural and vulnerable groups in communities. Collectively, these authors stress the importance of improving water provision to the poor and the vulnerable. However, there is less focus in the literature on understanding the extent of socioeconomic factors and the standard of living disparities regarding water provision in the Nelson Mandela Municipality. In light of these gaps, this paper explores the social and economic factors hindering water accessibility in the Nelson Mandela Metropolitan Municipality in the context of basic human rights. The paper strives to achieve specific objectives by use of the following subheadings: (a) demographic and socioeconomic factors on water accessibility in the municipality, (b) levels of satisfaction among the population to water provision, (c) structural and systemic challenges to water provision in the municipality and (d) alternative strategies to improve water supply to rural communities. The rest of this paper is outlined as follows: Section 2 presents literature on water policies governing water provision and factors hindering water provision, Section 3 presents the paper's methodology and Sections 4–6 present the results of the findings, discussions and policy recommendations, respectively.

2. FACTORS HINDERING WATER SUPPLY IN THE NELSON MANDELA METROPOLITAN

There is consensus among scholars and commentators that water scarcity in Nelson Mandela Metropolitan Municipality has no single cause (Amoah & Thabisa 2021; Ellis *et al.* 2021). Various factors ranging from population growth to social, economic, political and infrastructural contribute significantly to this dilemma (Mnisi 2015). Chitonge (2020) disclosed that water scarcity in the metro is associated with dry rivers, dams, taps and long queues at water points. Additionally, water scarcity is connected to changing weather patterns and climatic conditions and decreasing freshwater availability. While these factors contribute to physical water scarcity, they are not the sole reasons for water scarcity in many parts of South Africa. Mnisi (2020) opined that water scarcity occurs even in communities or areas where freshwater is available. Given this, Chitonge (2020) argued that a substantial number of people in South Africa could not access water resources due to a lack of income, status, spatial location, gender, political affiliation, level of education and racial background. Currently, the metro has about 2 million people, with 64% of the population living in the urban environment and 36% living in rural settlements (StatsSA 2017). The metro population has sharply increased in the past 25 years (Ngumbela 2021). This has contributed to water shortages in cities with a fixed water supply. Lebeka *et al.* (2021) further attribute the scarcity of water in the metro to

poor water infrastructure, including pumps, pipes, storage facilities and treatment plants that have deteriorated and, in most situations, beyond repair, as stated by Draai & Oshoniyi (2013). As disclosed by Molobela & Singh (2011), without proper infrastructure, it will not be possible to access clean water, transport, store and deliver fresh water to communities that depend on it.

Similarly, Mnisi (2020), Adom & Simatele (2020) and Mulenga (2017) asserted that water accessibility constraints in the municipalities could be summarised and grouped under four dimensions, namely: physical, economic, geospatial and institutional. Physical or first-order scarcity is the inadequacy of water in the natural environment. This is based on issues that water is not enough to meet all demands or that there are inadequate natural water resources to meet the demands of the population (Viljeon & van der Walt 2018). Rosegrant *et al.* (2002) highlight that this scarcity is due to demand-driven water scarcity, population-driven water scarcity, climate-driven water scarcity and pollution-driven water. The economic or second-order scarcity revolves around the lack of economic means to access water resources available to all people (Makaya *et al.* 2020). For instance, the failure to invest in or repair water infrastructure or lack of human capacity can lead to constrained and lack of access to water for a community, even in cases where freshwater is abundantly available (Chitonge 2020). The third-order or geospatial scarcity has much to do with the historical background of South Africa. Apartheid geospatial planning has resulted in many rural areas not having access to basic water supply and sanitation services (Turok 2012). Predominantly, rural provinces and small towns in South Africa are characterised by a high-water infrastructure backlog and low water service dependability. For example, StatsSA (2006) disclosed that the municipalities with the enormous backlog are generally located in the largely rural areas along the Eastern Cape, KwaZulu-Natal and to a lesser extent, Limpopo. The fourth-order scarcity arises from social relations between different people (Chitonge 2020). In Wrisdale *et al.* (2018), the fourth-order scarcity arises not because there is a shortage of water or poor infrastructure but because of the social relations between different groups of people. Most of the Nelson Mandela Metropolitan Municipality (NMMM) population struggle to access water because they have no or low income as they live in poor neighbourhoods; they may be refugees, foreigners, women or a combination of all these factors (Martin 2021). In this sense, the fourth-order scarcity is the most subtle and often operates at a micro level and, as such, tends to be conspicuously invisible to public policy. It was observed that an adequate water allocation monitoring index in South Africa could play a vital role by promoting programs that will ensure all South Africans get access to domestic and drinking water (Hemson 2016).

3. MATERIAL AND METHODOLOGY

This paper investigated the social and economic issues hindering water accessibility in the Nelson Mandela Metropolitan Municipality of South Africa. The study was carried out through a comprehensive study of the relevant literature and an empirical study based on the mixed approach of quantitative and quantitative methodologies.

3.1. Description of the study site

This study was carried out in Nelson Mandela Metropolitan Municipality in the Eastern Cape of South Africa (see Figure 1). This municipality was chosen due to its current challenges of providing water to its population and the massive backlog of water provision to poor households. Furthermore, the municipality is noted for its social and economic inequalities relating to water provision. Economically, the municipality has high suburban areas with high-income households that have water security while the overwhelming majority of the households, primarily of black and coloured racial backgrounds, are poor, depend solely on government social grants as their source of income and are highly water insecure (du Toit 2017). Moreover, the municipality is among the hottest in the country, with high humidity and temperatures, and is prone to prolonged droughts (Nhamo & Agyapong 2019). Currently, with a total water volume of 4.5% left, of which 1.5% is unusable water, the Kouga Dam, which is the main water supply in the municipality, has reached its lowest level since 1957 and 1969 and will run dry by June 2023 (Ellis *et al.* 2021). The dam has a capacity of 125,910 million litres but currently has 5,571 million litres of water left (Martin 2021). As a result, approximately 30% of the population lacks access to safe water, and this figure is projected to double by 2050 (Ellis *et al.* 2021).

3.2. Research design

This paper's data was collected through a concurrent mixed-method approach of positivist (quantitative method in the form of a questionnaire) and interpretivism (qualitative approach in the form of interviews) paradigms. Cameron (2015) posited that mixed-method research combines quantitative and qualitative elements to answer a research question. This approach

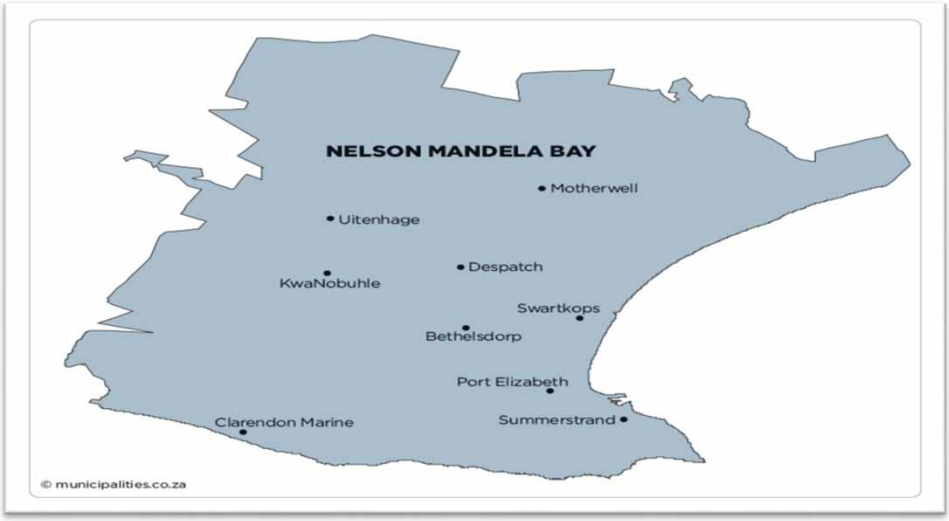

Figure 1 | A map of the study site. *Source*: Department Local Government and Rural Development, Eastern Cape.

gives a more complete picture of a phenomenon than a stand-alone quantitative or qualitative study. Creswell (2011) further alluded that mixed-method research is a philosophical assumption that provides direction for collecting and analysing data from multiple sources in a single study. Considering the nature of the topic in this study, it is prudent to apply the mixed-method strategy so that a holistic understanding of the social and economic challenges of accessing water among the population can be analysed and evaluated. Specifically, the qualitative method was used to unearth the perception of individuals and groups about the influence of social and economic status as well as the historical backgrounds of the population, which affects water accessibility in the study area. The quantitative approach was used to evaluate, compare and ascertain the influence specific demographic and social variables such as gender, age, occupation, income and ethnicity have on water access.

3.3. Sampling techniques and the study population

Purposive and random probability sampling techniques were used to select 500 respondents for this study. Illiyasu & Etikan (2021) defined purposive sampling as a non-probability sampling technique that focuses on a non-random group selected due to specific characteristics. The choices of the individuals were based on specific traits such as skills, expertise, experience and willingness to participate. Intrinsically, this technique also involves distributing questionnaires based on the total population in a particular set-up (Noor *et al.* 2022). This implies that the larger the number in a group, the more questionnaires are distributed or more interviews are conducted. These principles guided the selection of the ten participants for the semi-structured interviews and open discussions conducted with the management and leadership of Nelson Mandela Metropolitan Municipality, Non-Governmental Organisations (NGOs) and some community leaders in the municipality.

Alternatively, a random probability sampling approach was used to select participants for the quantitative data. Random probability sampling is a technique in which every population member has an equal chance of participating in the study (Berndt 2020). This technique was considered because it assisted the researchers in sampling a large pool of household respondents for the survey. A total of 500 respondents were selected from five communities, namely, Betheldorp, Bloemendal, KwaNobuhle, Motherwell and Summerstrand, in the municipality. In order to achieve the proportional representation of the population based on socioeconomics, a proportional sampling technique was employed. The probability of selecting each unit in the sample was determined in accordance with the social, economic and demographic factors of the population. The approach ensured that a population with a larger population had a higher representation, yet maintained a representative sample from the entire population. In the study, we employed a probability proportional to size (PPS) sampling formula of $P = (C/T) * S$ to calculate the sampling population in each community: In this formula: *P is the proportion of the community in the sampled population, C is the population of the community, T is the total population and S is the sample size*. Using this equation, we calculated the sampling population of the identified communities: Betheldorp 182,012 with a population distribution of 87,366 males and 94,646 females; Bloemendal 11,942 has 5,408 males and 6,534 females; KwaNobuhle 107,474 has

51,229 males and 56,245 females; Motherwell 140,352 has 66,701 males and 73,651 females and Summerstrand with a total population of 12,614 has 5,928 males and 6,686 females (StatsSA 2020) The computation is as follows:

Betheldorp (182,012/453,394) * 500 = **200**; *Bloemendal* (11,942/453,394) * 500 = **12**; *KwaNobuhle* (107,474/453,394) * 500 = **117**; *Motherwell* (140,352/453,394) * 500 = **154**; *Summerstrand* (12,614/453,394) * 500 = **17**.

However, it is important to note that the selection of the respondents was conducted via a systematic sampling method in which a respondent must be 18 years or older and must reside in the area for at least a year. The questionnaires were self-administered with the help of two field assistants who were conversant with the area.

3.4. Data collection procedure

Data for this paper were collected through an extensive review of the literature and primary surveys based on interviews and questionnaires after obtaining ethical clearance from the Ethics Committee from the University of Witwatersrand on 12 March 2021 and permission from the leadership from NMMM. The interviews were conducted face-to-face and telephonically. They were structured to first acquire information on the individuals' and groups' daily challenges of accessing water, the perceptions and the influence that variables such as age, gender, income and other socioeconomic factors have on water access in communities and households. This approach was also used to obtain information on the municipality's challenges in providing water to the communities, the impact of drought and climate change on water availability, infrastructure deterioration and overall systemic and structural challenges to water provision.

Quantitative data were obtained from households and community leaders, specifically on respondents' demographic, employment status and income ranges. A statistical significance was then applied to measure the levels of connectivity between demographic and socioeconomic variables on the water accessibility of households. Imbens (2021) defined statistical significance as a measurement of the likelihood that the difference between two groups, models or statistics occurred by chance or because two variables are related to each other. Therefore, we applied this concept to test the relationship between age, gender, income and ethnicity as variables of water accessibility. The data were aggregated using central tendencies of mode, median and arithmetic means to measure internal consistency, standard deviation and standard errors of the data obtained. This formula operates such that a *Null Hypothesis* (H_0) signifies: No true relationship between the variables and water access; a *Positive Hypothesis* (H_1) signifies: A strong connection between the stated variables and accessibility of water. Consistent with this formula, a significance value of an average mean was computed as: ($x = 0.05$ or 5%) and was set to test the levels of significance among the population. This suggests that an outcome of 5% or lower is considered a null hypothesis, whereas a result of more than 5% is a positive hypothesis, thus, a positive correlation. The literature from book chapters, journals, government gazettes and journals were used to obtain data involving policies and regulations enacted since post-independence in 1994 on water provision and to evaluate the strengths and weaknesses of the policies in meeting water security in the municipality.

3.5. Data analysis

Both the qualitative and quantitative data obtained from the field were analysed concurrently. The quantitative data were analysed using descriptive statistics of SPSS Windows Version 21. This technique was used to analyse Household Water Insecurity Experience (HWISE) and Individual Water Insecurity Experience (IWISE). This provided a better understanding of how water insecurity shapes household well-being. Additionally, this analysis enabled data to be captured and analysed and produced frequency tables, graphs and diagrams that ensured quick interpretations and easy data comprehension. The qualitative data acquired from the interviews and the literature contents were analysed using the thematic analysis technique. Thematic analysis is a method for analysing qualitative data that entails searching across a data set to identify, analyse and report repeated patterns (Kiger & Vanpio 2020). This analysis technique was used to classify data into themes for interpretation and discussion.

4. EMPIRICAL EVIDENCE AND ANALYSIS OF RESULTS

The analysis of this paper was done based on the objectives set out at the beginning, which include demographic and socioeconomic influences on water accessibility, the levels of satisfaction among the population on water access, structural and systemic challenges to water accessibility and alternative strategies of enhancing water provision in the NMMM.

4.1. Demographic and socioeconomic characteristics of respondents

The analysis of demographic and socioeconomic factors on water accessibility was done using household coordinates information. The computation was done using the formula:

$$(\sigma) = \sqrt{(\Sigma(x - \mu)^2/N)}$$

where σ (sigma) represents the standard deviation; Σ (capital sigma) indicates the sum of the values; X represents each individual data point; μ (mu) denotes the mean (average) of the data set and N represents the total number of data points.

Table 1 | Profile of respondents

Variables	Frequency	Per. (%)	Mean (SD)	Mean per. (%)	Standard deviation	Standard error
Gender						
Male	150	30	250	12	0.67	0.04
Female	350	70	250	28	0.28	0.02
Age						
18–30 years	120	24	100	24	0.17	0.12
31–40 years	170	34	100	24	0.41	0.01
41–50 years	85	17	100	17	0.18	0.08
51–60 years	72	14	100	14	0.39	0.05
60^{+} years	53	11	100	11	0.90	0.22
Marital status						
Single	105	21	125	17	0.19	0.01
Married	280	56	125	45	0.55	0.03
Divorced	75	15	125	12	0.67	0.29
Not disclosed	40	08	125	6	1.02	0.16
Household size						
1–2 people	25	5	125	4	4.16	0.83
3–5 people	120	24	125	19	0.46	0.04
6–8 people	240	48	125	38	0.47	0.03
More than 10 people	115	23	125	18	0.93	0.09
Employment status						
Employed	107	24	125	19	0.17	0.12
Self-employed	168	34	125	27	0.26	0.02
Unemployed	210	42	125	24	0.49	0.03
Seasonally employed	05	01	125	0.8	1.25	0.56
Annual income of households per annum						
No stable income	155	31	71 (84)	44	0.54	0.04
R5000–R10,000	126	25	71 (55)	35	0.44	0.04
R10,000–R50,000	96	19	71 (25)	27	0.26	0.02
R50,000–R100,000	52	10	71 (−19)	14	0.37	0.05
R100,000–R300,000	31	06	71 (−40)	08	1.33	0.24
R300,000–R500,000	27	05	71 (−44)	07	1.69	0.33
R500,000–R700,000	13	03	71 (−58)	04	4.83	1.34

Source: Adom & Simatele (2021). Fieldwork in Nelson Mandela Metropolitan Municipality.

As shown in Table 1, the majority of the respondents are females (60%). A large proportion (34%) of the respondents was between 31 and 40. Most of the respondents were unemployed (42%), while 44% have no stable income or depend on government grants. Only 7% are in the income bracket of between R300,000 and R700,000. Table 1 also revealed that the majority of the respondents (56%) are married, with the majority having household sizes of six and more.

Table 1 suggests that demographic characteristics significantly impact water accessibility in the municipality. Socioeconomic and demographic factors such as age, gender and income determine whether a household can afford basic water of quantity and quality. The table revealed that out of 500 respondents engaged, 350 of them, representing 70%, are women compared to 150 (30%) who are male. These numbers are not surprising because women are worst hit by water scarcity across the municipality; hence, they have more interest in the survey than men. In many communities in the municipality, women are traditionally responsible for water-related tasks such as fetching water, cooking and cleaning. These responsibilities are time-consuming and physically demanding, limiting women's opportunities for education, employment and personal development. A respondent from one of the communities re-echoed this during an interview:

Women bear a significant burden in providing water for their households and also suffer unique consequences for water shortages. Due to the societal burden of water collection, women are disadvantaged in nutrition and food security, disease risks, reproductive health, personal safety and access to education. Women mostly from rural communities spend hours, multiple times per day, waiting in long lines at community kiosks carrying buckets full of water over long distances.

Another community member was engaged in an interview. She posited that:

The income of households directly affects water access, households with higher income are able to afford to pay required fees, which ensure uninterrupted access. Centrally, lower-income households are struggling to meet the costs leading to limited access and unsafe water access which have led to contraction of diseases such as cholera, typhoid fever and hepatitis.

The majority of the respondents felt that a safe water source at home empowers women and their families to explore their income-generating potential; instead of walking to find water, children have the time to do their schoolwork, and mothers (women) have the time to earn money to support their families by engaging in activities like farming, sewing and teaching.

4.1.1. Descriptive analysis and correlation

Based on statistical information from Table 2 and focusing solely on household incomes as the main variable, we explore the impact of household incomes on the affordability, accessibility, acceptability, availability and quality and safety of water

Table 2 | Global water security index (GWSI)

Water security criteria	Indicators	Spatial, temporal and mean error	Definition, notion and measurement
Availability	Water scarcity index (WSI)	0.5 spatial resolution: Monthly mean/ standard error measurement	WSI define as the ratio of total water withdrawal to the water availability. Water availability must be 70% and drought index 15% (> = 70%/ > = 15% in drought)
Accessibility	Water Scarcity index	Country scale data	Maximum distance/time to water source. Maximum of 200m or 20minutes to water source (= < 200m/ = < 20 minutes
Safety and quality	Water quality index	Country scale data	Nephelometric turbidity unit (NTU). (NTU < 5) per litre of water and 95% of samples should have more than 0.2 mg and less than 2 mg/l of free residual chlorine per litre of water
Affordability	Households income	Country scale data	The costs for water services should not exceed 5% of a household's income (= < 5% of household income)

Source: Gain *et al.* (2016).

Table 3 | Descriptive analysis and correlation

Variable assessed	Standard unit/Requirements	Observation	No. of pop. below standard unit	Per. %	No. of pop. above standard unit	Per. %	Min. standard	IWISE/HWISE assessment
Affordability	R8,035.50 per month	500	281	75	123	25	R8,035.50 per month	75% insecure in affordability
Acceptability	Water must be interrupted once in 50 years	500	500	100	0.00	0	Once in 50 years	100% insecure in acceptability
Quality and safety	Basic health standard, taste good, no smell and purified	500	400	80	100	20	100 ml coliform free	80% insecure in quality
Availability	25 litres per person	500	280	56	220	44	20 litres	56% insecure in availability
Accessibility	Max. distance to water source is 200 mm/ 15 min to water	500	350	70	150	30	120 m/ 10 min	70% insecure in acceptability

Source: Adom & Simatele (2021). Fieldwork in Nelson Mandela Metropolitan Municipality.

among the residents in the municipality. Our correlation was done using the mean score (SD) and mean percentage from Table 2. This was done by comparing the mean to some global and national statistics to test the municipality's residents' IWISE and HWISE. Table 2 shows the global water security index.

Table 3 suggests that the majority of the respondents are below the standard units assessed, which include affordability, acceptability, quality and safety, availability and accessibility. Compared with the minimum requirements in Table 2 against the information obtained from the national income survey of South Africa (NISSA), cross-subsidisation (between high- and low-income groups and between commercial and residential land uses), the white paper on local government (Government Gazette, 13 March 1998. No. 18739: 113), the Water Poverty Index (WPI) and international benchmarks from the United Nations Social and Economic Development (UNSED 2018), it was found that a minimum income of $400 (equivalent to (7291.74) ZAR) a month is required by a household with a maximum of six members to meet their water needs. Judging from Table 3, 377 out of 500, representing 75%, earned income below the standard minimum, implying that they cannot meet the minimum water requirement of 25 litres per person. Similarly, regarding acceptability or reliability, the international standard stipulates that water supply should not be interrupted more than an average of once in 50 years due to drought. However, data from Table 3 revealed that all 500 (100%) are below the stipulated requirement, while 80% of the respondents rated their quality as below both the international and national standards. Nonetheless, the majority of the respondents (70%) disclosed that they travelled shorter distances (less than the recognised distance of 200 m) and spent less time (less than 15 min) accessing water. These statistical breakdowns were validated by a community leader who was engaged in an interview. This interviewee disclosed that:

The income inequalities significantly impact water accessibility in the municipality. Households with employment and higher income have more resources to ensure safe water, mostly piped taps on their property. She mentioned that the municipality's dualistic nature of water provision is displayed nowadays. Most higher-income households buy their drinking water from shops and other water outlets that are purified and well-treated. While households, mostly informal with lower income, often have limited access to safe water and often resort to using water of poor contaminated and unhygienic and lower standards that is supplied by the municipality.

This view was reinforced by a community leader who was interviewed. This interviewee posited that:

Poverty is a major hindrance to water insecurity in our communities. Households are struggling to afford safe, sufficient and reliable water services. Most of the low-income households pay an average 10% of their monthly household income for water services, more than double the government estimate of 4.5% of income as an affordable rate.

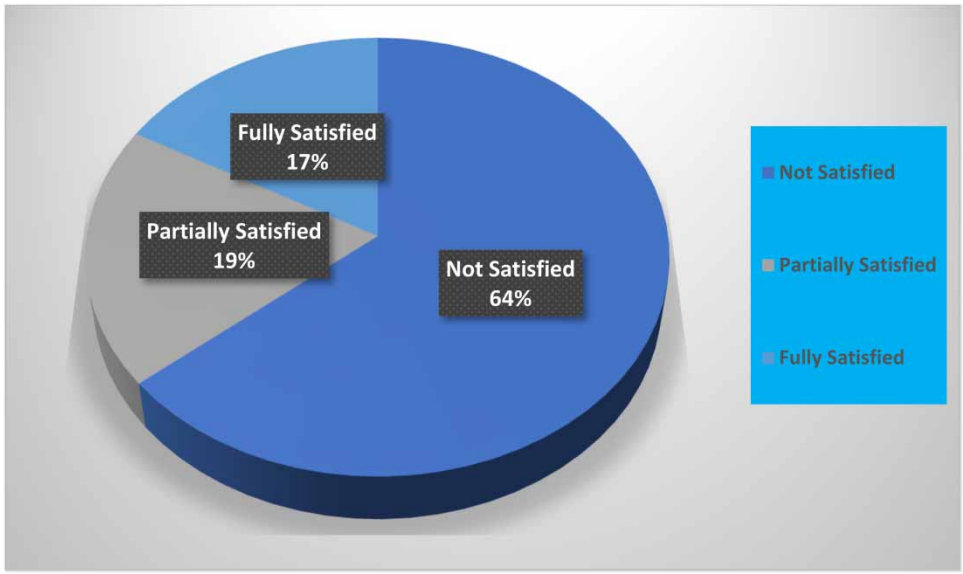

Figure 2 | Levels of satisfaction among respondents. *Source*: Adom & Simatele (2021). Fieldwork in Nelson Mandela Metropolitan Municipality.

The statistical and empirical evidence proved that income is the driving force behind striking water disparities. Households with higher incomes have better and more regular water provision than poor households relying on poor-quality surface water.

4.2. Levels of satisfaction among respondents

During the survey, respondents were asked to indicate their satisfaction and the emotional toll that accompanies water inaccessibility. Figure 2 reflects the perspectives of respondents.

Of the 500 respondents surveyed, 320, representing 64%, are not content and despondent with the quantity and quality of the water provided by the municipality compared to 17% of the exclusively satisfied respondents. Moreover, 19% of the households were partially satisfied with the municipality's provision of water to their homes. The unsatisfied respondents are primarily from lower-income and poor households. The general assumption among these respondents is based on the fact that the municipality's leadership has little or no regard for their well-being, which means that there is a gap between what the Constitution states and the services they are receiving in terms of water provision. Conversely, respondents who indicated satisfaction mentioned reliability and quality of water supply. Based on the respondents' perspectives of satisfaction and dissatisfaction, the study went on to assess the variables that inform their choices.

As shown in Figure 3, the majority (119 or 24%) of the respondents regarded poor water quality as their main concern. An average of 15% of the respondents mentioned lack of water availability, constant interruptions and high cost of water services as their frustrations. For instance, a community member who was engaged in an interview stated that:

The municipality's water supply services are extremely poor; the services provided can simply be defined as unreliable, the water supply is of poor quality, unjustified bills that are not delivered on time and poor communication. The municipality generally responds late and slow leakage; this reflects a poorly maintained water system that mirrors poor service provision.

Another community leader disclosed similar sentiments during an interview:

There is inadequate information regarding water distribution among households, coercion, lack of consultation, corruption and feeling of discrimination based on education and income status and geographical locations are other factors contributing to discontentment among residents.

The general findings picked up in the survey are that services provided are unreliable, leading to the lack of trust between the population and the municipality, lack of transparency, accountability and general mismanagement in the whole system.

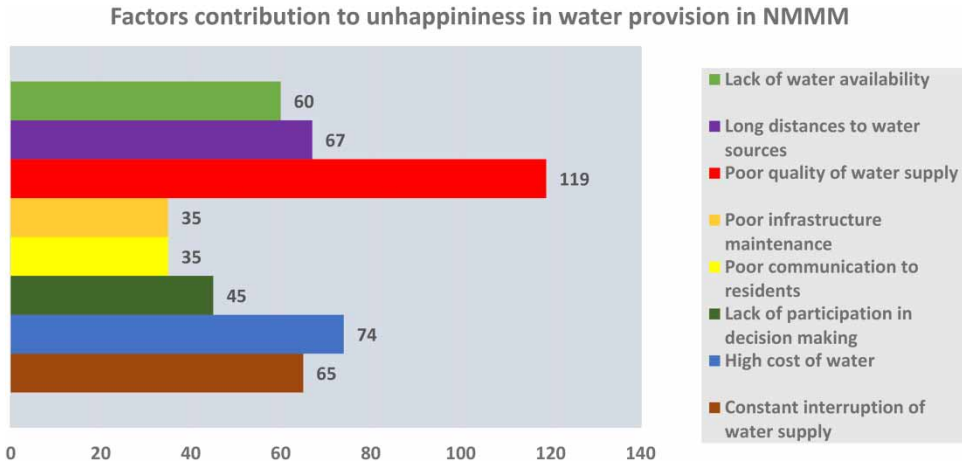

Figure 3 | Factors contributing to the satisfaction of water provision. *Source*: Adom & Simatele (2021). Fieldwork in Nelson Mandela Metropolitan Municipality.

4.2.1. Structural and systemic constraints in accessing water in households

Certain factors remained significant and impeded most households and communities in the Nelson Metropolitan Municipality from accessing water. Respondents were asked to mention the factors that hinder their water accessibility. The answers obtained from respondents are displayed in Figure 4.

The study results revealed that out of 500 respondents, 90, representing 17%, identified inadequate funding as the most significant constraint to water accessibility. Lack of skilled and qualified workforce in the municipality immediately follows as a factor hindering access to water provision, as attested by 87 (17%) respondents. In total, 72 and 60 respondents mentioned corruption, political interference and broken infrastructure as structural and systemic constraints to water provision in the municipality. Edifying to these responses, a municipality manager mentioned during an interview mentioned that:

> *Inadequate investment due to insufficient funding has been identified as a major contributor to poor operations and maintenance performance. The lack of investment hampers the operation and maintenance of water supply facilities as money is not available to buy spare parts, properly train staff and provide competitive salaries to attract highly qualified personnel.*

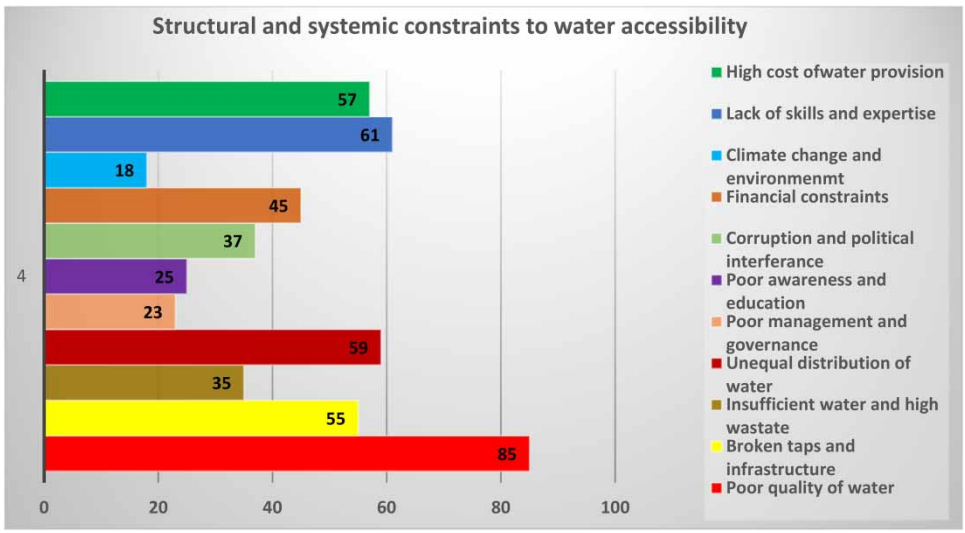

Figure 4 | Water access challenges to households and communities *Source*: Adom & Simatele (2021). Fieldwork in Nelson Mandela Metropolitan Municipality.

This view was supported by a water consultant who is affiliated with the municipality. He disclosed during an interview that:

The municipality's water infrastructure is at risk of failure. The consistently poor performance of water and sanitation infrastructure is attributed to poor governance by both the provincial and local departments, poor asset management and insufficient maintenance, lack of technical skills within key planning and operational divisions within the municipality, poor enforcement of policies, theft and vandalism of infrastructure, financial mismanagement, corruption and funding shortfalls have contributed greatly to infrastructure decayed impacting negatively on water supply.

A community leader in one of the communities who was engaged in an interview stated:

The water crisis in the municipality cannot be blamed solely on lack of water; this region received one of the highest rainfall in the whole province; furthermore, when it rains, the rivers are full and overflow their banks, while some rivers flow from the highest landscapes to this area leading to sufficient water. The problem is how to clean the water and pipe it to residents. The root cause of the problem is that a significant number of infrastructure is very old and broken. The collapsed infrastructure has resulted in millions of litres of water being wasted.

A climate change expert working for an NGO in Port Elizabeth stated in an interview:

Climate change is disrupting weather patterns leading to extensive weather events, unpredictable water availability, exacerbating water scarcity and contaminating water supplies. Climate change exacerbates water stress in communities extremely linked to water scarcity leading to increased competition for water and even conflicts.

Besides the challenges mentioned, a common perspective that runs through the respondents is incoherent policies and weak coordination are significant barriers to water provision.

4.2.2. Strategies for enhancing water provision in the municipality

The findings of this paper unearth that the challenges in providing water are directly linked to issues of governance, planning, accountability and infrastructure breakdown. In light of this, we sought strategies to address the challenges. A set of strategies were presented to respondents to classify under one of these; 'Not relevant, Fairly Relevant, Relevant and Absolute Relevant'. Table 4 shows the responses of the respondents.

Table 4 shows that of the 13 variables assessed, all were regarded as either Relevant or Highly Relevant strategies required to improve water accessibility in the municipality. Only two of the variables were seen as Not Relevant. For instance, a Director for an NGO based in Port Elizabeth disclosed that:

For Nelson Mandela Metropolitan Municipality in particular, and South Africa in general, to enhance water accessibility, then it needs to catch up with other countries regarding recycling wastewater. Less than 1% of treated water in the municipality is recycled or reused. That is the opposite in some countries, such as 8% in Italy and 14% in Spain. This is a long way from the situation in some countries where much wastewater is recycled back into the system; notably, the Gulf States such as the United Arab Emirates, Kuwait and Qatar recycled more than 60%, while Israel recycled over 80% of its wastewater.

This view was buttressed by another interviewee from NMMM. This respondent stated that:

To secure and improve water accessibility, especially among the poor and the vulnerable population. There must be effective accountability mechanisms; service providers must be punished when they fail to provide services to the population. There should be cross-subsidies between the rich and the poor in this municipality. Nevertheless, cross-subsidies that work against sound financial sustainability must be avoided.

Another water expert from SafeWaterSA, an NGO based in Port Elizabeth, said during an interview:

Table 4 | Perspectives of strategies for improving water accessibility

{∑ fx/n)} where ∑fx represent the sum total of sample population; (n) equate to the number of sample population		Not Relevant	Fairly Relevant	Relevant	Highly Relevant	Total
Improve infrastructure facilities to minimise leakages.	Count	0	20	55	75	150
	Row N %	0%	13%	37%	50%	100%
Construct boreholes and pumps in local communities	Count	15	10	80	45	150
	Row N %	10%	7%	53%	30%	100%
Implement rainwater harvesting to collect and store rainwater	Count	0	14	50	86	150
	Row N %	0%	9%	34%	57%	100%
Promote low-cost solutions such as chlorine tablets	Count	5	20	75	50	150
	Row N %	3%	14%	50%	33%	100%
Promote home-based water treatment and water recycling	Count	2	30	68	50	150
	Row N %	1%	20%	46%	33%	100%
The centralised water distribution system in each community	Count	0	25	55	70	150
	Row N %	0%	16%	37%	47%	100%
Involve private organisations to assist in water provision	Count	0	3	60	87	150
	Row N %	0%	2%	40%	58%	100%
Use technology to increase water availability, e.g. desalinisation	Count	0	5	37	108	150
	Row N %	0%	3%	25%	72%	100%
Enhance water monitoring and regulation.	Count	10	5	70	65	150
	Row N %	7%	3%	46%	44%	100%
Improve accountability in the water sector.	Count	15	8	37	90	150
	Row N %	10%	5%	25%	60%	100%
Invest in simple, efficient irrigation technologies.	Count	20	13	75	42	150
	Row N %	13%	9%	50%	28%	100%
Invest in staff skills and capacity.	Count	4	13	55	78	150
	Row N%	2%	9%	37%	52%	100%
Increase financial investment in the water sector	Count	3	7	35	105	150
	Row N%	2%	5%	23%	70%	100%

Source: Adom & Simatele (2021). Fieldwork in Nelson Mandela Metropolitan Municipality.

> *The population must treat water as a precious resource, not a free good, thus must minimise wastage practices. People must be more selective about the use of potable water. For instance, using treated water to wash cars or water lawns and gardens makes no sense. People need to know where water comes from. The population must understand that anytime one turns on a tap, water emerges from a river, a dam or a lake. That means that the more we abuse water at home, we put stress on these sources.*

Though many views and suggestions, such as an increase of financial support to households to assist them in purchasing safe water, the introduction of simple and affordable technologies to purify water for consumption, and many intervention strategies emanated from the field survey, nevertheless, the common sentiment shared by most of the respondents, as the critical solution, is having the residents taking ownership of their water solutions.

5. DISCUSSION

The discussion of this paper is structured and sequenced to build a collective understanding of the municipality's social and economic challenges to water accessibility.

5.1. Socioeconomic and demographic factors to water accessibility

The findings of this paper confirmed the views of some scholars and commentators, such as Adams *et al.* (2016), Rhodes & McKenzie (2018) and Gomez *et al.* (2019), that socioeconomic factors such as household incomes and the social status of people are essential prognosticators in accessing water in the Nelson Mandela Metropolitan Municipality and South

Africa as a whole. It was established that while water accessibility is a general challenge in the entire municipality, lower-income households are acutely impacted and severally prone to water insecurity. We uncovered that most poor households could not afford the cost of safe and clean water, compelling them to depend on contaminated and lower-quality water, while wealthy households have access to regular, clean and treated water. These findings validated the perspectives of Wrisdale *et al.* (2018), namely that poorer households in South Africa and NMMM are incapable of spending over 10% of their household incomes on in-house and yard tap connections that provide treated water, thereby compelling them to depend on poor quality and unsafe water. Furthermore, Adams *et al.* (2016) stated that living in a low-class socioeconomic household is associated with less access to safe and quality water. Interestingly, our findings uncovered that lower and middle levels households in this municipality spend over 15% of their household incomes on water services, which is far above the government-stated maximum expenditure of 4% on water provision. It was uncovered that higher-income households, though they spend less on water services, have access to safe and quality water because they can acquire private and alternative water sources. The results inveterate the assertion that the disparities in access to and control over water resources could be attributed significantly to ineffective water policies and inefficient institutional arrangements for managing water resources.

In terms of demographic characteristics, our findings established that human factors such as age, education and gender are intrinsically linked to the accessibility and affordability of water resources. The findings established that households headed by educated individuals are more likely to have access to safe and quality water than households with less-educated heads. A common explanation given by most respondents is that a higher education achievement of an individual means more prospects of getting a well-paid job and enough income to afford greater access to safe and quality water. Our findings also proved a strong interlink between water accessibility and gender. It was established that women are responsible for managing and maintaining communal water supplies. It is common practice in rural communities that women regulate and control the use and maintenance of water resources. These are also similar views by Gondo *et al.* (2020) and Wynne & Mia (2018) that water consumption varies between people of different sexes and gender. Gender is a critical variable in household water management and decision-making. Women are perceived as high-water consumers – more than men – because they carry out more water-related activities than their male counterparts. In most communities, especially the informal settlement in the municipality, women's responsibilities include fetching water, cooking, washing and providing safe drinking water at home (Pouramin *et al.* 2020). The findings, therefore, established that water insecurity disproportionately affects women and girls, as they are responsible for household chores and taking care of children. They face the worst ramifications of living in water-scarce areas. Water scarcity increases their food insecurity, personal safety concerns, risks of diseases and education setbacks. Each of these challenges underscores women's vulnerability to water insecurity as they are the most affected. This view is elaborated by Graham *et al.* (2016) that women do not have enough time for a job due to the length of travel often needed to access the closest clean water supply. The safety and health of women are also compromised when they fetch water as there is an increased risk of exposure to transmission and contracting of diseases and social ills such as rapes (Gondo *et al.* 2020). Poor sanitation particularly keeps girls from going to school. Wynne & Mia (2018) pointed out that in many countries, including South Africa, when girls reach the age of puberty and start menstruating, they leave school, as there is a lack of water in restrooms, and they have no other facilities and accessible water to address their sanitary needs. Collectively the findings expose gender inequities that exist and are experienced by women associated with the municipality's inability to supply water to communities.

5.2. Levels of satisfaction

Regarding the level of satisfaction, the findings of this paper established that a significant majority of the population are dissatisfied and frustrated with both the quality and quantity of water supply by the municipality and have no confidence and trust in the municipality's water provision. Our findings established that the dissatisfaction of the majority of the population in the municipality is due to reduced or compromised water quality, frequent water supply disruption, a poor billing system, poor communication and general unreliability of provision. The outcomes suggest that in most communities, the tap water and boreholes installed by the municipality could not fully satisfy the population's drinking water requirements. There are constant interruptions in the systems due to technical problems, which often degrade the quality of supplied water. These findings validate the views of Mahlasela *et al.* (2020) that several challenges affect the population's satisfaction with water accessibility; these include severe deterioration of water quality, unscheduled supply and inequitable pressure in water supply, which is inherent to the intermittent supply system across various cities, towns and the rural communities in the municipality. Furthermore, Mahlasela *et al.* (2020) opined that the Water Service Act (WSA) guarantees households 6,000 litres of

free water monthly. Nevertheless, only 22% of respondents have access to this service, while the majority, 78%, have no access to free water provision prompting significant unhappiness among a larger population. The findings further recognise the lack of communication between the municipality and water service providers as a source of dissatisfaction among the population. Most households disclosed that they barely received any notification from the municipality prior to water interruptions. These are similar outcomes shared by Weaver *et al.* (2017), namely that there are challenges around services offered by NMMM and the level of engagement in the process of supplying water. Kalanda (2021) also reiterates similar views that most residents in NMMM are convinced that the municipality does not care about their well-being; this means that there is a gap between services received and their expectations.

5.3. Structural and systemic challenges to water provision

Our findings confirm the South African Institute of Engineers (SAIE 2020) finding that most municipalities, including NMMM, lack the technical knowledge, skill and expertise necessary to perform core operational and financial functions. These deficits include planning, engineering and project management. Other constraints identified by the findings include the high cost of water services, broken infrastructure, insufficient water and political interference in water administration (Molobela & Singh 2011). These are significant barriers to water accessibility in the municipality and South Africa. We established that the deterioration of old pipes, for instance, contributes to increases in water loss, which in turn leads to decreases in water availability the further one goes from the main treatment facilities. These findings coincide with the perspectives of Makaya *et al.* (2020) and Mothetha *et al.* (2013), namely that many water infrastructures in the NMMM were designed for intermittent water flow, not a continuous or constant flow. As a result, less water can flow through the pipes further away from main water distribution centres, decreasing the number of people having access to potable water. Further findings uncovered that lack of investment in ageing infrastructure, either as a policy choice or due to insufficient funding, has led to significant barriers to accessibility. These findings correspond with the views of Adom & Simatele (2020), namely that lack of funding, expertise and poor infrastructure increase the cost of providing water to households. The result of the study also identified that political interference at the administrative and operational levels of water accessibility contributed to this challenge. It was established that the interference comes in the form of manipulations in infrastructure development and municipal operational issues. This interference has negatively affected the municipality's performance and institutional capacity for water provision. These observations were also shared by Molobela & Singh (2011), namely that political interference affects the decision on how public funds are applied to investments, staff appointments and awarding of contracts and tenders.

5.4. Strategies to enhance water accessibility

Strategies to improve water accessibility were discussed in this paper. The findings recognised that interventions are critical if communities are to improve their water accessibility. It was established that helping community leaders take ownership of their water solutions and transferring their responsibilities to their communities should be part of the strategies to ensure that the residents place value on water resources and minimise wastage. These findings are similar to views shared by Omarova *et al.* (2019), namely that to create long-term, sustainable access to water, it is prudent to educate the population to understand the value of water. Our findings recognised that strengthening the participation of local communities to see the value of water in an economic context will propel the government, companies and individuals to set limits on water consumption and minimise pollution. We further uncovered that enhancing water accessibility in the municipality cannot be achieved if the stakeholders (government, communities, NGOs and private organisations) work in silos. A multisectoral collaboration is critical to improving access through collective and coordinated efforts to understand the demand, supply and equity issues and promote innovation in the face of climate change and rising population. It was established that an integrated funding strategy of public–private partnership (PPP) should be promoted to build infrastructure to support water provision. These partnerships should collaborate in planning, building, maintaining and monitoring existing infrastructure. These findings are collaborated by Grigg *et al.* (2018) that PPPs offer possible solutions for governments seeking to achieve better value for money and fund the investments needed to provide infrastructure for sustainable water provision. Despite these overall strategies identified above, our perspectives on improving water accessibility in this municipality must be based on an integrated and coordinated approach. To achieve this, the provincial and national governments must support the municipality with adequate human capital and financial resources. Local government should build capacity to engage communities on water-saving strategies, mobilise funds for system expansion and maintenance of existing infrastructure, and oversight of

public and private sector service providers. Additionally, the municipality must increase support to private small-scale water suppliers to increase access, especially in small towns, peri-urban neighbourhoods and rural communities. Finally, the municipality must promote simple, efficient and smart technologies such as rainwater harvesting, water recycling and resourceful irrigation systems that are based on water conservation.

6. CONCLUSION

The conclusion drawn from this study revealed that despite numerous reports by the national government, such as Water Supply and Sanitation Policy, National Water Resource Strategy and National Water Policy Review, that access to water has improved, communities and households have different experiences. Access to water in this municipality is an everyday struggle for most residents especially vulnerable, lower and even middle-income households. Water accessibility is severely constrained by interwoven systemic, structural and institutional challenges. Besides these constraints, the provision of water is exceedingly skewed in favour of high-income and affluent groups. Considering these abnormal conditions, this paper recommends a social innovation model (SIM) as a policy reform to improve water provision in the municipality. This model addresses the entire value chain of water provision, from tapping natural sources such as rainwater harvesting to household connections using small-scale technologies such as recycling and reuse and social interventions that optimise water supply systems; these must be integrated with active communities involvement in water management through effective capacity building programmes, public education and awareness, as well as people-centred and bottom-up solution-driven strategies to water provision. Under this model, community leaders must take ownership of their water governance and solutions and transfer that to the whole community. Additionally, the municipality should concentrate on water demand management (WDM) by devoting resources to maintain and improve the infrastructure that minimises water loss. This can be achieved by fixing leakages as soon as they are detected, promote maintenance culture and encourage water conservation (WC) strategies that include water storage upgrades, pipes replacement and construction of water points at community centres to serve as water sources for households.

ACKNOWLEDGEMENTS

The authors are grateful to the NRF's Global Change Grand Challenges, under the funding instrument, 'Global Change Social Sciences Research Programme, Grant No. 129481, for providing financial resources which gave us the data on which this paper is based. The authors are also equally grateful to the Federation for Sustainable Environment for their contributions to writing this paper.

DATA AVAILABILITY STATEMENT

Data cannot be made publicly available; readers should contact the corresponding author for details.

CONFLICT OF INTEREST

The authors declare there is no conflict.

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First received 12 April 2023; accepted in revised form 13 June 2023. Available online 28 June 2023