Sustainability of Drinking Water and Sanitation Delivery Systems in Rural Communities of the Lepelle Nkumpi Local Municipality, South Africa

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Abstract

Water and sanitation are core for the growth and development of communities. Yet, South African local municipalities are often unable to sustainably deliver safe water and basic sanitation for all. Drawing on perspectives of ecological economics, this study analysed the sustainability of water and sanitation systems in rural communities of the Lepelle Nkumpi Local Municipality. Mixed research approach was used to collect the data from 657 household and institutional respondents. The study found that households used water for multi-purposes including consumptive, productive and domestic, but existing facilities are in deplorable condition. Pollution arising from agrochemicals, waste systems, mining, sewerage, and industrial effluence significantly affected water systems in the communities. Bridging demand-supply gaps require initiatives like bulk water supply and implementation of the free basic water policy in underprivileged areas. Tariffs should either be waived or adjusted for extremely poor households. Waste management initiatives like capacity building, public education, investments, and facility upgrade, could help avert spread of water-borne infections and improve the resident's health.

Keywords: ***Sustainability; Drinking Water; Basic Sanitation; Rural Communities; Lepelle Nkumpi Local Municipality; South Africa.***

Introduction

Water and sanitation are at the heart of development, crucial for the existence of people and the sustenance of their ecological systems. As a result, the 6th Sustainable Development Goal (SDG) lays emphasis on universal access to water, sanitation, and hygiene for all (UN, 2015). In sub-Saharan Africa, countries and civil society actors have made efforts to address water issues related to equity and sustainability (Food and Agriculture Organisation [FAO], 2017). Yet, at the local level, the capacity of local municipalities to sustainably deliver water and basic sanitation services has been grossly ineffective (Hemson, 2015). A worsening situation persists in low-income and informal settlements (WHO, 2022), where the capacity of local municipalities to provide basic services has been problematic (Maake & Holtzhausen, 2015; Hutton & Chase, 2017).

In South Africa, the challenges of sustaining potable water and sanitation delivery in rural municipalities are widespread (Tapela, 2018). Apartheid regulations, policies, and white supremacy led to the skewed provision of social amenities (Madigele, 2017). During the apartheid regime (1948 to 1994), racial discrimination was rampant in the country and led to the segregation of service and infrastructural provision, especially in rural communities (Förster et al., 2017). At the end of apartheid, South Africa's newly elected government inherited huge services backlogs. Thus, for example, basic social amenities *[like education, water, and sanitation]* were offered to black South Africans at substandard levels compared to their white counterparts (Madigele, 2017). An estimated 1.5 million people did not have access to safe drinking water and improved sanitation

(Hutton & Chase, 2017). Improving and sustaining service delivery thus, became the responsibility of the government after independence. Though efforts have been made to bridge gaps pertaining to the provision of basic services, implementation remains ineffective. The South African government considers safe drinking water and basic sanitation as essential preconditions for good health and well-being of its citizens (Hutton & Chase, 2017). Initiatives and policies like the Integrated Water Resource Management (IWRM), the Water Act, the local government system, and free water initiatives were introduced to sustain water and sanitation delivery. However, in most rural communities, people still walk three to four kilometres (approximately 50 minutes or more daily) to rivers and streams to fetch water (Hemson, 2016). Safe drinking water and basic sanitation are interconnected and hence, can make or break a community. A "sustainable water system is the capacity of an improved water source such as boreholes, pipe schemes, dug-out wells to provide continued beneficial potable water supply over a considerable period of time" (Bazaanah, 2022, p. 4). In view of the inadequacy of safe drinking water and basic sanitation, it is common for community members to dig their own wells to access water, which is often not treated and unsafe for human consumption (Edokpayi et al., 2018). They also commonly use pit latrines without ventilation and/or defecate in open spaces, which poses a serious threat to disease outbreaks (Swanepoel & De Beer, 2016). The unreliable provision of drinking water and basic sanitation in provinces such as the Eastern Cape and KwaZulu-Natal has been associated with many cases of waterborne diseases in rural communities (Hemson, 2016). Accessing water from boreholes and shallow wells and the use of pit latrines are common practices in rural communities that lack access to service delivery. This is because inherited apartheid legacies, policies, legislations, and institutional arrangements skewed the provision of water in South Africa (Madigele, 2017).

The municipal census reports [1996 – 2011] consistently revealed a vast inherited backlog in the provision of water and sanitation services in the Limpopo province (Statistics South Africa [StatsSA], 2011). The most affected areas include the Capricorn District Municipality, Greater Sekhukhune District, Mopani District, Vhembe District, Waterberg District, and the Lepelle Nkumpi Local Municipality (LNLM). The topography, logistics, funding, and capacity constraints account for inequity in water and sanitation services in these municipalities (Hemson, 2016). Decades of neglect by duty bearers and low investments in water and sanitation facilities have resulted in a mismatch between facility access and population increase, and thus, outstretched service delivery beyond sustainability levels (Oskam et al., 2021). The adverse impacts account for low water access and facility maintenance by the municipalities. Similarly, sanitation facilities have consistently missed the benchmarks of reliability, acceptability, appropriateness, affordability, and sustainability (South African Government, 2015). These challenges have often triggered service delivery protests in several local governments, especially in the rural communities of the Limpopo Province (Kanyane, et al. 2017). In this article, we assess the factors which affect the sustainability of drinking water and basic sanitation systems in rural communities of the Lepelle Nkumpi Local Municipality.

Theoretical and Empirical Literature

The idea of safe water and improved sanitation are inherently interlinked. This is because water plays an important role in maintaining adequate health, well-being, and livelihoods of rural populations. However, the quality and sustainability of drinking water systems can be

compromised when they become contaminated by waste arising from improper sanitation maintenance (Tapela, 2018). The quality of water is often determined by such elements as odour, taste, and the presence of either organic or inorganic materials. In most developing countries, the sources of water contamination are due to geological, agricultural, and industrial activities (FAO, 2017). These pollutants can adversely affect the quality of drinking water and human health upon drinking, particularly before proper treatment is carried out. Since quality water and improved hygiene can affect human life, and ecological sustainability, access to clean drinking water is now globally recognised as a fundamental human right. Yet, sustainable access to potable water and improved sanitation remains limited in rural settlements of many developing countries. Estimates by the WHO and the United Nations Children's Fund revealed that over 700 million people (WHO & UNICEF, 2014), who mostly live in developing countries, have no reliable access to potable water sources and improved sanitation facilities (WHO, 2019).

In post-apartheid South Africa, studies have shown that inadequate sanitation sometimes leads to water contamination and results in avoidable disease outbreaks, including cholera, dysentery, salmonellosis, and typhoid. Annually, waterborne diseases are attributed to be the cause of preventable deaths in most rural communities (Lange & Hassan, 2006). Safe and readily available water is important for public health, whether it is used for drinking, domestic [cleaning, cooking], food production, or recreational purposes. Improved water supply and sanitation and better management of water resources can boost countries' economic growth and can contribute greatly to poverty reduction (Tropp, 2022).

In 2010, the United Nations General Assembly recognised the human rights to water and sanitation. Everyone has the right to sufficient, continuous, safe, acceptable, physically accessible, and affordable water for personal and domestic use (UN, 2015). Similarly, section 27(1) (b) of the South African Constitution stipulates that every South African has the right to adequate water and basic sanitation (SA Government, 1997). To achieve this, a Free Basic Water (FBW) policy was formulated to address the huge inequalities that existed between rich and poor households after the apartheid system was abolished (Meyer, 2007). Yet, recent studies reveal that geographic, socio-cultural, and economic inequalities persist, not only between rural and urban areas but also in towns and cities (WHO, 2022; Ndimande, 2022). People living in low-income and informal settlements usually have less access to improved sources of drinking water and basic sanitation (Hove et al., 2019). In addition, rural-poor people who constitute more than half of the South African population have inequitable access to water and sanitation (Meyer, 2007) . As Tropp (2022) contends, the overall public and private sector investment needed for improved water and sanitation services are considered by countries to be essential. However, at the local level, meeting such investment challenges is mostly beyond the capacity of rural-poor communities. Drawing from earlier studies, we argue in this article that there is a need to correct historical inequities to water and sanitation access and give impetus to the universal human rights enshrined in the 1996 South African Constitution.

Narratives of water and sanitation: Ecological economics perspective

In this paper, water, and the environment are perceived as essential natural capital useful for advancing the public good. In line with the ecological economics paradigm, water and sanitation

are theorised from the perspectives of basic needs and natural capital (Schultza et al., 2015). Water and hygiene are perceived to be essential human rights, natural capital and basic needs required for survival of every human being (Fourie et al., 2013). For ecological economists, water as a natural capital is linked to the production of other goods and services in every economic system (Schultza et al., 2015). From the perspective of natural capital, water can be seen as an important resource for enabling productive activities and enhancing human well-being and livelihoods (Lant, 2004; Costanza, 1992). Similarly, as a basic need, scholars like Distefano and Kelly (2017) have argued that water and improved sanitation are important catalysts that underpin all aspects of human life. This means that reliable and safe water supply and improved sanitation may go beyond having beneficial effects on ecosystems and the livelihoods of rural people but may also pose a serious danger or threat to growth of rural environments if not well managed at all levels of society. From the rights-based perspective, the United Nations Human Rights Council indicates that all human beings have the right to adequate and clean water that is suitable, physically available, and affordable for personal and domestic use (United Nations Human Rights Council, 2014). Thus, disadvantaged, and marginalised communities must be socially and economically included in the allocation of water and sanitation systems. In South Africa, the FBW, and the Water Service Act (1996) are ambitious steps toward addressing the historical imbalances and injustices of the past through the provision of equal access to services in local communities.

Drawing on the idea of water as a human right, basic need, and natural capital, as theorised by ecological economists, this chapter attempts to understand the complex human-environment relationship in rural worlds and to use the evidence produced to suggest policy strategies that may lead to ecologically sustainable, socially just, and robust rural communities, which have the capacity to sustain water systems and maintain adequate hygiene. Here, we situate the fundamental problem of environment-economy not in market failures, but in humans' inadequate understanding of their role, rights, impacts, and responsibilities they have towards sustaining water and sanitation systems within the larger ecological system. We stress in this article that the sustainability of natural resources (water) and sanitation services in rural spaces are often multifaceted. The narratives on water and sanitation must be reconfigured, focusing on local scales. Using evidence from rural communities in South Africa, we argue that water and sanitation are basic needs that are critical for human survival and well-being. There is a need to understand the territorial conditions prevailing in rural communities and integrate the different elements of sustainability (ie social, economic, political, environmental, etc.) in order to develop better strategies for improving water and sanitation systems in rural worlds. In doing so, we posit that human rights to water must be integrated in national and local efforts towards addressing disparities of access to and sustainability of water and sanitation services confronting South African communities.

Sustainability of drinking water sources in South Africa

The South African government has numerous mechanisms in place for the provision and sustainability of water in rural communities, despite countless communities having no access to clean drinking water. Among the actors working to sustain water supply in the country include the government, private sector, individuals, and community development workers (UNICEF, 2010; WHO, 2012). Of all municipal services, the provision of potable water is perhaps the most vital. Nel et al. (2013) argue that South Africa is currently using 98 % of surface water, which comes

from sources like lakes, rivers, and oceans. Sibiya and Gumbo (2013) reported that in South Africa, it is estimated that over 1.5 million people do not have access to clean drinking water. There are several types of household water sources for a community's daily use, including boreholes, piped water, communal taps, rainwater, irrigation channels, and greywater (Nel et al., 2017). Greywater is usually beneficial for both domestic animals and societies as it is produced from household dishwashers, flush toilets, and municipal wastewater (Mpenyana-Monyatsi et al., 2012). In addition, groundwater constitutes an important natural source of drinking water for household purposes in numerous rural municipalities (UNICEF, 2022). Rural communities often depend on groundwater for their water supply, which is critical to their livelihood, health, and dignity. Improving water services and uses in developing countries is essential for increasing hygiene and sanitation services that affect the productive lives of people and easing the burden and drudgery of those who have to collect water from far and unsafe sources such as rural communities (WHO, 2022).

In South Africa, 93% of the population has access to water supply services and 76% have access to basic sanitation. However, the proportion of the population using improved water sources remains substantially lower in rural than in urban areas (Oskam et al., 2021). This clearly indicates that there is a wide disparity between urban and rural communities with respect to safe drinking water supply. Health, economic, and human rights perspectives on water suggest that water access in urban areas should not be prioritized above rural areas. Like many African societies, the water challenges in South Africa were inherited from the apartheid system. As noted by Nwankwoala (2011), many African governments adopted water distribution practices that were characteristics of former colonial governments; - largely segregatory and doing little for rural and native communities.

Due to "urban bias", the majority of the rural communities in the country have no access to piped water and improved water sources. The primary water sources are mostly developed springs and hand-dug wells, boreholes, shallow and deep-drilled wells. Other unimproved sources include ponds, lakes, rivers, lagoons, and open-dug wells (Lange & Hassan, 2006). Moreover, there are sources of drinking water that are poorly constructed or do not have any engineered facilities such as a spring box, borehole capping and dug-out-wells. Improved sources, including piped water inside dwelling units, piped water inside the yard, communal taps, water vendors, rainwater tanks, and closed-wells are rare and often beyond the affordability of rural populations (van Koppen et al., 2020). Edokapyi (2018) asserts that water availability can reduce the burden of waterborne diseases among community members. Drinking water must thus, be treated in accordance with the South African National Standard (SANS, 241) and World Health Organization drinking water recommendations. Though efforts have been made to extract drinking water from the Olifants River through the establishment of the Olifantspoort Water Treatment System and the Lepelle Northern Water Board, the burden of water collection has not improved. Women and girls in the rural communities still carry water on their heads, whereas others use wheelbarrows and donkey carts to transport water. Apart from the municipal sources, community members resort to illegal connections and buying from illegal water vendors to carry out their household chores. Domestic animals *[such as cattle, goats, sheep, donkeys, cats, and dogs]* drink water from the same source where members of the households access their drinking water. Access to water is vital for health, livelihoods, and economic growth in rural communities (Duncker, 2015). Its vitality has been observed in periods of water scarcity, which compel societies to access unclean drinking water

from unprotected wells, rivers, and dams for household usage. These observations are common in the Lepelle Nkumpi Local Municipality, as the rural dwellers walk long distances to collect contaminated drinking water for their daily household purposes. In addition, infrastructural decay, maintenance, and improvement have been serious challenges in ensuring safe water provision in South Africa. At the municipal level, aging infrastructure, and high demand, compounded by poor operations, pollution, and poor maintenance culture, make a strong case for improvement in the water situation of the country (Nsoba, et al., 2020).

Climate impacts on water resources

Water accessibility depends on prevailing climatic conditions. Climate change brings about the elevation of temperature, unpredictable rainfall patterns, increased droughts, and floods (Rankoana, 2016; Hemson, 2016). Households become vulnerable in accessing domestic water during these unstable climate conditions. These conditions also affect other socio-economic activities including the cultivation of traditional fruits, vegetables, the brewing of traditional beer, the production of traditional food crops and livestock. In the 2010-2011 season, the local communities, experienced destructive floods which caused infrastructural damage estimated at ZAR500 million (Musyoki et al., 2016). Moreover, drought is a common challenge affecting local communities in the Limpopo Province. The occurrence of drought has resulted in the drying-up of surface water and dug-out water sources. This has affected agriculture, drinking water, and sanitation delivery. *Figure 1* depicts the worst annual drought and rainfall patterns between 1921-2013 in the Limpopo Province (Mpandeli et al. 2015). At a threshold of surface rainfall index of SPI 1.5, a total of five drought years were recorded (1926, 1930,1932, 1962 and 2007). The most severe drought year occurred in 1962. On the other hand, the wet years occurred in 1940, 1955, 1967 and 2000. There is a link between water scarcity and climate in the rural communities. When rainfall is reduced, water availability is reduced. Climate events, characterised by seasonal fluctuations, impact water availability for domestic and agricultural uses. Earlier studies found the Limpopo Province as a drought-prone province (Maponya & Mpandili, 2016; Lethoko, 2016).

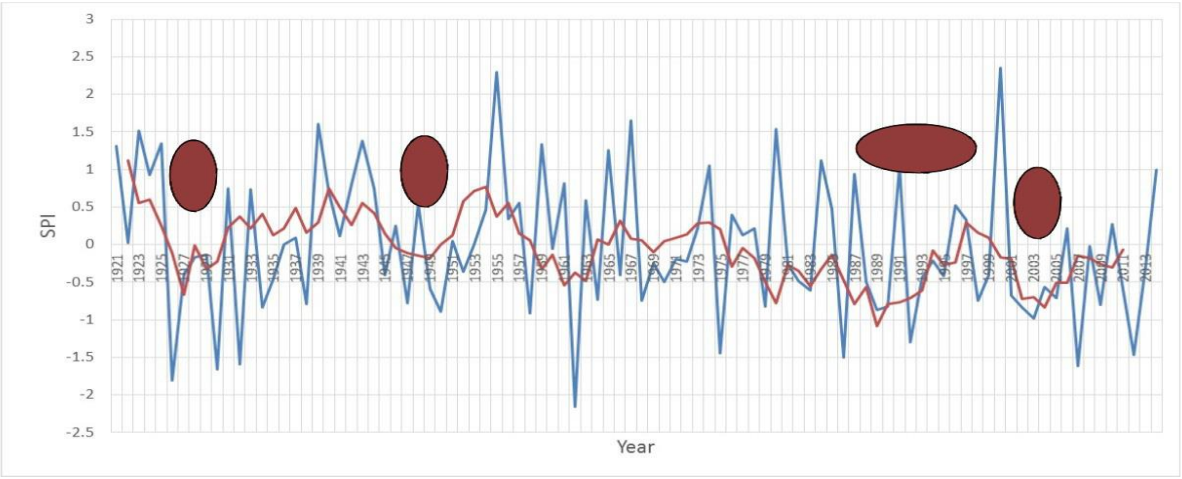

Figure 1: *Surface Rainfall Index (SPI) in the Limpopo Province (1921-2013). Source: Mpandeli et al. (2015)*

Water sources from boreholes, dug-out wells, and surface water, dry up rapidly due to climate variability and uncontrolled human activities. The shortage of water resources impacts both the high - and low-lying areas of the province (Musyoki et al., 2016). Again, floods in the Limpopo

basin resulted in the displacement of people, and caused food and water insecurity, pollution of surface water, and livelihood challenges in the communities. The devastating effects have been more pronounced on the most vulnerable populations, including women, children, and the disabled who have limited adaptive capacities (Alemaw & Kileshye-Onema, 2014).

Sanitation and waste management practices

In terms of hygiene and waste management, there are several types of toilet facilities, including pit latrines without ventilation, flush toilets [with septic tanks], flush toilets [connected to a sewerage system], dry toilet facilities, bucket toilet systems, bush, and open fields. Gedroogte and Ga-Molapo communities depend on pit toilets without ventilation, bush, and open fields as their main places of convenience. Magatle community depends on pit toilets without ventilation, even though other members of the community have access to flush toilets connected to the sewage system, flush toilets connected to septic tanks, and dry toilets. Construction of new toilet facilities in the communities is problematic, as they do not have the resources and technical know-how to comply with the WHO and the South African Standards (WHO, 2014). Consequently, rural communities are vulnerable to waterborne diseases such as diarrhoea and malaria. The sanitation situation is most acute in rural areas, home to most people who defecate in the open and without basic sanitation (WHO, 2022).

Women and girls are disproportionately impacted by lack of access to water and sanitation. Poor drainage systems create spaces for breeding mosquitoes while littering and indiscriminate waste disposal cause pollution of surface water systems. An alarming situation occurs regarding washing of hands after using pit toilets (UNICEF, 2011). This is because water is not readily available for maintaining adequate personal hygiene. Since 1994, South Africa's Constitution has committed to achieving everyone's rights to water and improved sanitation. Although efforts have been made by the government in terms of investment in public resources, establishment, and capacitation of water boards and in the local municipalities to address the pre-1994 infrastructural gaps, backlogs in low-income, informal settlements and rural areas continue to prevail. Nationally, "over 3 million people still do not have access to a basic water supply service and 14.1 million people do not have access to safe sanitation" (van Koppen, 2020, p. 1). Studies have shown that the reliability of services that have been provided since 1994 is declining, with only 64 % of households having access to improved sanitation services (Balzer, 2019, p. 4). In rural Limpopo Province, Ramugondo et al. (2013) found that only 14 % of water infrastructure implemented is fully functional, while 15 % is sub-functional and 71 % is dysfunctional.

We argue that a better understanding of rural communities' systems, practices, experiences, and priorities related to water and sanitation may provide baseline information for duty bearers to develop public water and sanitation infrastructure in low-and middle-income settings more cost-effectively and sustainably. Among the measures to improve water and sanitation facilities include the protection of water sources, water treatment [*at distribution points, collection, or consumption]*, and ensuring that treated water is safely stored at home in regularly cleaned and covered containers (WHO, 2020). In the context of the Covid-19 pandemic, the government of South Africa needs to do things differently to reverse the existing condition. A *business-as-usual approach* to water and sanitation maintenance will further expose already vulnerable people to infections. The pathways

to achieving sustainability include moving away from centralised and one-size-fits-all solutions to more decentralised and community-based approaches, with the involvement of all stakeholders.

Design and Methods

Design and setting the scene

The study employed the post-positivism design. Post-positivism supports quantitative methods and adherents view knowledge construction through observable and measurable evidence rather than words (Glesne & Peshkin, 1992). Post-positivism allowed the researchers to remain detached from the respondents in order to gather reliable and valid data through the administration of questionnaires. The research design made it possible to assess the drinking water and sanitation situation in the municipality in a clear, logical, and objective manner. This allowed the researchers to further analyse the data holistically in relation to the aim of the study. The study scenes cover the Lepelle Nkumpi Local Municipality (LNLM) and Capricorn District Municipality (CDM), located in the Limpopo Province. The areas cover 24°15'0"S and 29°40'0"E, situated to the northern part of South Africa *(see Figure 2)*. Although water and sanitation service delivery are the responsibilities of the LNLM, through agreement, the CDM serves as the water service provider for the township and rural communities of the LNLM area. The CDM was selected because it serves as the water service authority of the LNLM. According to the Water Services Act (Act 108 of 1997), a water service authority is considered to be "any municipality responsible for ensuring access to water services in the Act which may perform the functions of a Water Service Provider and may also form a joint venture with another water services institution to provide water services" (South African Government, 1997, p. 4). With a household population of 233,925, the LNLM is the second-largest rural municipality in the Limpopo province. About 95 % of the municipality falls under the jurisdiction of tribal authorities. The study areas covered the Gedroogte, Ga-Molapo, and Magatle communities of the LNLM *(see Figure 2*).

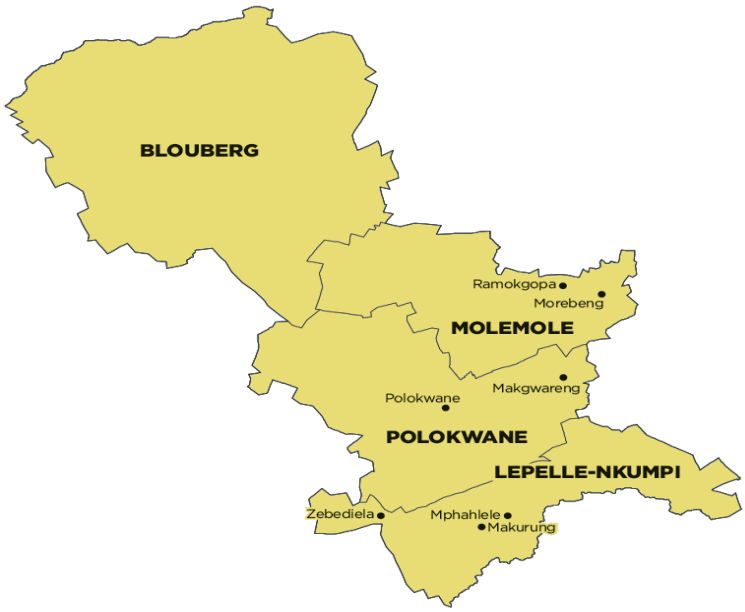

Figure 2: *Map of the Lepelle Nkumpi Local Municipality*
Source: ArcGIS version 10.1.

These settings are relevant and selected by the study because access to water is vital for life, livelihoods, and economic growth of the rural settlements. However, these communities are disadvantaged as their livelihoods are being impacted by water scarcity and ill health, arising from poor sanitation. Water scarcity and inaccessibility challenges result in competition and conflict among residents in the area. The climate at the LNLM can be described as a humid subtropical type, with hot and humid summers and mild to chilly winters. Rainfall pattern is erratic and unevenly spread to only 12 % of the land area, causing 50 % of stream flows. The maximum rainfall is observed in summer and the minimum in winter, while spring records the lowest or no rainfall. The name '*Gedroogte'* (meaning *drought*) defines the condition, which indicates that a level of poverty is expected due to climate change and water scarcity, that are typical of its landscape. The communities depend on boreholes for water supplies to meet domestic, consumptive, and agricultural purposes. There is a heightened demand for clean water which is needed for drinking, cooking, washing and sanitation, involving safe disposal of human waste and proper usage of greywater. In Figure 3, we depict the water and sanitation cycle of the three rural communities.

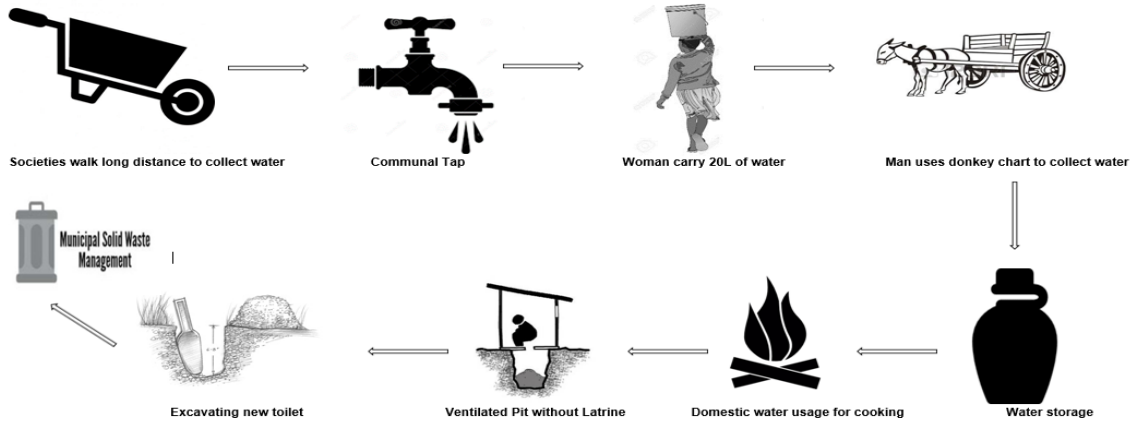

Figure 3: Water and sanitation cycle (Source: Authors' construct)

Figure 3 shows that in the Gedroogte, Ga-Molapo and Magnate communities, both men and women collect water daily from community taps either through head-portership or using wheelbarrows and donkey carts. Water is typically stored in containers of 25 litres and commonly used for cooking. Ventilated pits are the main toiletry systems used by households, complemented by new communal toilets constructed by the municipality. Human waste disposal is challenging for most households in terms of its appropriate excavation as per international and national standards.

Sample design, instrumentation, and data analysis

The study adopted a mix of approaches in sampling and collection of the data. The total sample size for the study constitutes ten key informants and 647 household respondents from the three communities. The sample size for the households was calculated based on the formula: $n = \frac{N}{1+N(\alpha)^2}$, where n = sample size, N = total household population of the communities (233,925), α = margin of error (0.05) (Raosoft, 2004). A confidence level of 95 %, representing a 5 % error margin was used in estimating the sample size for the households. Having determined the sample

size, a sample proportion formula *(P*n/N)* was applied in determining the units of household members selected from each community. Table 1 presents the sample distribution by community and by household, based on the population size.

Table 1: Sample size distribution for household and official respondents

Communities	****Household population**	**Sample fraction/ proportion *(P*n/N)***
Gedroogte	96500	267
Ga-Molapo	76980	213
Magatle	60445	167
Sub-total	233925	647
Municipal officials	20	10 (Officials were purposively selected)
Grand Total	233945	657

Source: ***Stats SA (2011)*

Following Bazaanah (2022) and Ndimande (2022), a proportional formula [P x n/N] was used to determine the units from the households, where P = households in the community officials, n = total sample size and N = total number of household population. Thus, in applying the above formula, the total sample for Gedroogte was determined as *[96,500 x 647/233925=267]*; Ga-Molapo *[76,980 x 647/233925=213]* and Magatle *[60,445 x 647/233925=167]*. Having achieved homogeneity of the sample, the simple random sampling technique (Babbie, 2016) was used to select the units of analysis from the households. This technique enabled the respondents in each of the communities to have equal and fair chances of being represented in the study (Hacker, 2014). The key informants were composed of the Senior Superintendent for Operations and Maintenance at the LNLM, three tribal authorities, and six community ward councillors (i.e., two from each of the three communities). These participants were purposively selected by the study because they had expert knowledge and experience on matters related to water and basic sanitation in the communities. The instruments included questionnaires and interview guides (Crano et al., 2014) which were used to gather data. The instruments covered the respondents' demographics, socio-economic, and environmental concerns, water, and sanitation service provision in the three communities. The instruments were piloted in a trial study to confirm their reliability and validity and to refine the logistics for the actual field data collection (Babbie, 2016). In this small-scale study, Mugenda (2003) prescribes that the instruments be pretested on 10 % of the sampled respondents. Thus, in this study, a total of 66 (10 %) respondents were selected for the pre-test phase. The Cronbach Alpha value of the reliability statistics was α = 085, an indication that the instruments were consistent and reliable for a large-scale study. However, the test for normality using the probability plot test showed that the data did not follow a normal distribution. The test outcome informed the decisions related to the choice of statistical techniques used by the main study. The pre-test informed decisions for modifications/adjustments which ensured clarity, validity, reliability, and quality control in the instruments (Creswell, 2014). In the actual field exercise, the questionnaires were administered to officials and key informants from the municipality while face-to-face interviews were conducted with the household respondents. The officials were literate and could read, understand, and independently answer the questionnaires without the physical presence of the researchers. A face-to-face interview was considered appropriate for the households considering the literacy level of residents in the communities. The household respondents were made to answer the same questions in all three rural communities.

This made it possible to combine the responses in the data analysis phase. The key informant interviews were conducted to firm-up the views from the household respondents. Stata (Version 13) was used to analyse the qualitative data. The framework for quantitative data analysis included descriptive statistics such as the mean, standard deviation, and percentages. The Fisher's exact test (Mehta et al., 1984), i.e, the Chi-square test, was used to check whether there were frequencies lower than five on the tables and determine the association between the variables. The variables used include household income, water sources used, duration at the settlement, type of toilet facility used, household size, and water shortages. At a 95 % confidence level and with a tolerated error margin of 5 % (e) = 0.05, a probability level of $p \leq 0.05$ was taken to indicate statistical significance whereas $p \geq 0.05$ was taken to indicate there was no statistically significant association between the variables.

Results and Discussion

Demographic characteristics of the respondents

Figure 4 depicts the gender of the respondents who participated in the study: 44 % of them were males, and 56 % were females. The result on gender is consistent with the population characteristics of the study area, based on the data published by Stats SA which showed that women accounted for approximately 55 % of the total population in 1996, about 56 % in 2001, and 54 % in 2011 as per the census report (Integrated Development Plan (IDP) 2016 - 2021).

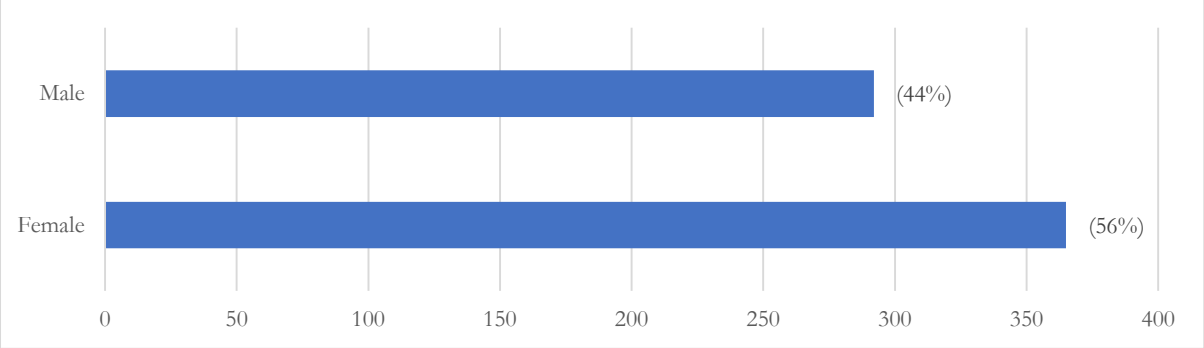

Figure 4: *Gender of the respondents*

As illustrated by Table 2, the sizes of the households ranged from one to three (8 %), four to six (51 %), seven to ten (36 %), and ten and above (5 %). The communities have a relatively youthful population, with almost two-thirds (59 %) accounting for the ages between 18 and 49 years. The adult populations ranged from 18-29 (30%), 30-49 (30%), 50-64 (32%), and a few retirees of 65 years (8%) and above. The population growth trends, and household membership composition indicate that the demand for water and basic sanitation is likely to increase in the future. An increase in per capita water consumption driven by local economic activities and development conditions in the communities will likely intensify freshwater demand. Therefore, deliberate efforts to address possible shortfalls in service provision cannot be overemphasised. We caution that erratic service delivery could affect young people's future growth and development prospects.

Populations resident in dry and high-lying areas of the communities are likely to receive the brunt as more projects will be needed to transport fresh water to them. In terms of education status,

Table 2 reveals the level of education of the respondents in the communities. About 64% of the respondents have no formal education while 31% have national certificates, 3% have degrees and 2% have diplomas. The findings highlight that educating the people about water and sanitation matters could be an important strategy for improved health, water quality and sustainability, especially in developing communities of the municipality. It can have implications on the people's health, water conservation, socio-economic and development prospects of communities. Poor hygiene practice which is linked to the pollution of freshwater sources could probably be due to the low education levels of the people. Similarly, low education levels can affect compliance to water and sanitation regulations and standards. This is also highlighted by SDG6 of the United Nations (2015).

Table 2: Household size, age and education of household respondents

***Household size**	**Percent**
1-3	8
4-6	51
7-6	36
10 and above	5
Total	100
Age category	**Percent**
18-29 years	30
30-49 years	30
50-64 years	32
65 years and above	8
Total	100
Education category	**Percent**
Degree	3
Diploma	2
Certificate	31
Non-formal	64
Total	100

**Note: Total household heads was 647. A household was considered to be a social unit composed of individuals who live together under the same roof and share housekeeping arrangements. A household head is a person recognized as representative of a household with the capacity to make decisions on water and sanitation matters.*

Table 3 shows that more than a fifth (22 %) of the respondents are employed while those who were unemployed constituted 43 %. About 16 % were students, 1% were housewives, domestic workers or seasonal workers (employed on municipal programmes) unable to work or chose not to work, 5 % were pensioners and thus dependent on government social grants, 7 % were labourers, and 2 % were teachers. Without tenure employment, residents would have no sustainable source of income to pay for critical services like water and sanitation. Thus, unemployment can affect the livelihoods of the residents and access to essential services like water and sanitation. If unattended, then it can have future implications for the people's health, mental well-being, productivity, and maintenance of the physical environment. With the relatively youthful population (60 % between 18 and 49yrs), the water and sanitation sector could provide employment prospects for the unemployed in areas including sanitation inspection, water distribution, revenue collection and water management. It has been established that household income is linked to clean water access, decent sanitation and improved hygiene in rural settlements. This is because household income is not only important for reducing poverty, but it can also help drive local economic growth, save lives and maintain habitable environment. In this study, we

found that a little above half of the respondents earned no income (57 %), 13 % received incomes between R100 and R500, 21 % earned R501 to R1000, less than a tenth earned R1001 to R3000 (6 %), R3001 to R5000 (1 %), R5000 and above (2 %) per month (Table 3).

Table 3: Employment and income levels of the household members

Employment status	**Percent**
Employed	22
Unemployed	43
Student	16
Full-time housewife	1
Pensioner	5
Seasonal worker	1
Unable to work	1
Chose not to work	1
Labourers	7
Domestic worker	1
Teacher	2
Total	100
Household income level	**Percent**
None	57
R100-R500	13
R501-R1000	21
R1001-R3000	6
R3001-R5000	1
Over R5000	2
Total	100

With little to no disposable income, it means that the residents will not be able to afford the cost of freshwater and improved sanitation services. This means they will likely live in an unclean environment without improved drinking water and proper waste disposal systems. In such squalid conditions, diseases are able to spread easily among the most vulnerable, including women and children.

Local economic activities/ livelihoods and social conditions

In Table 4, among the respondents who earned an income, half (53 %) were engaged in subsistence farming, and 20 % survived on a monthly income. The economically active population in the municipality mainly does subsistence agriculture and has small/medium-scale businesses. The key agricultural sub-sectors in the municipality include crop farming, livestock rearing, fish farming (at homes), and tree planting. The elderly community members were found to be living on allowances (10 %), and pension fund (7%). The other income sources included trading, assistance from either NGOs or relatives, rental income and poverty funds/ state grant schemes. The study shows that these rural communities are currently trapped in poverty as the majority rely on subsistence farming to sustain their households. The results highlight that bridging poverty gaps among the rural residents without incomes and those living on remittances and humanitarian grants may likely improve access to potable water and sanitation. The municipality may struggle to achieve Goal 6 of the SDGs on universal access to basic services, especially water and sanitation (WHO 2022), where citizens continue to live on humanitarian grants which are unsustainable.

Table 4: Economic activities and livelihood support systems

Income sources	**Percentage**
Agriculture	53
Allowance	10
Monthly income	20
Poverty fund/ State grant	1
Pension fund	7
Trade	5
Support from NGOs	1
Depend on relatives	1
Rental income	1
Total	100

With respect to duration or period of stay in the communities, most of the respondents (85 %) settled in the communities for over 15 years (see Table 5 below). A little above a tenth (11 %) of the respondents lived at the study location for a period between 6 to 15 years. A key informant said that: *"a sense of belonging and having a share in a supportive, caring, and welcoming communities is important for us as the residents" (Participant 2).* The findings highlight that the power of united, strong, and supportive communities where residents pitch in and support each other socially, economically, and emotionally, can create enabling environments for vulnerable individuals to receive support from neighbours. Thus, vulnerable residents are better able to adapt and share common facilities when they live together in a community setting.

Table 5: Duration in settlement and conditions of water and sanitation amenities

Duration in settlement	**Percent**
15years+	85
6 -15 years	11
1 - 5 years	3
< 1 year	1
Total	100
Condition of water and sanitation facilities	Percent
Excellent	4
Good	5
Average	6
Poor	15
Very poor	70
Total	100

Most of the household respondents perceived the water and sanitation conditions to be very poor (70%). This is perhaps due to neglect, lack of maintenance or that state-of-the-art facilities are yet to be installed. Water scarcity and ill health loom if this trend continues in the communities. A key informant confirmed that *"humans share surface water sources;- rivers, streams, and open wells) with animals" (Participant 1).* In such conditions, the residents become vulnerable to contracting waterborne diseases and health-related complications. The findings agree with Sinyolo et al. (2014) who point out that conditions for food security should be assessed similarly to water and sanitation conditions at national, provincial, and rural levels. Similarly, Rankoana's (2017) study found that rural communities have perceptions which are impacted by some challenges not limited to climate change and drought, but also conditions of social amenities including water and sanitation. In Figure 5 electricity, torch/flashlights, kerosene lamps, gas, solar energy, power from private

generators, candles and fuel wood constitute important energy sources for the people in the communities. The residents generally depend on the national grid for electricity supply (60 %). Fuel wood and charcoal (29 %) are the widely used energy sources for cooking and heating. Modern energy sources like gas and electricity (for cooking) are rare (10 %), possibly because the people are unable to afford the tariffs. This was confirmed by an informant who said that*; "due to poverty, the local people are unable to afford the cost of improved energy sources…" (Participant 18).* Meanwhile, energy from gas and solar (0.2 %), is a privilege for the middle and upper-class people.

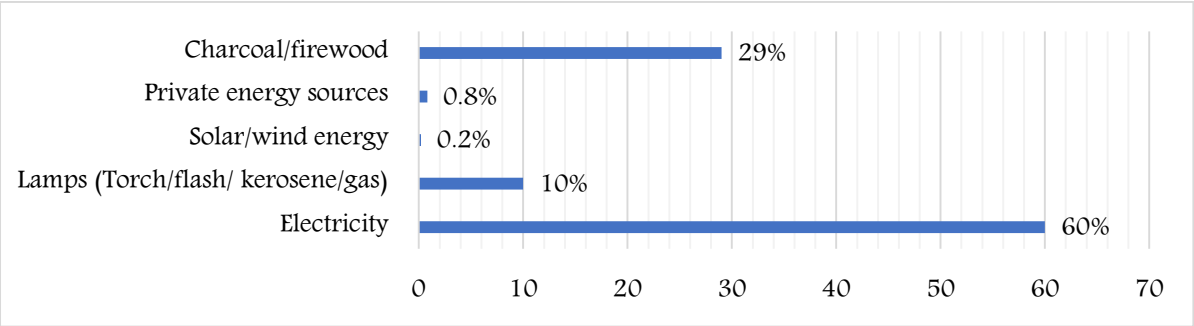

Figure 5: *Energy use and depletion of environmental resources*

Since deforestation is often associated with fuel wood and charcoal production, environmentally friendly energy sources could be important strategies to safeguard the environment. This view was highlighted by a key informant who suggested that; *"…if the cost of gas and electricity from Eskom can be reduced, it will reduce charcoal use and indiscriminate cutting down of trees which affect our water sources…" (Participant 11*). In the long to medium term, if deforestation and depletion of environmental resources are not mitigated, it can induce climate hazards like floods and droughts (Musyoki et al., 2016) which can affect the availability of surface water (rivers and lakes etc.) and groundwater sources in the communities. South African municipalities, including the LNLM, are confronted with countless challenges in terms of upgrading infrastructure and social amenities. To improve the quality of life (QOL) of citizens, it is essential to not only capture what is required quantitatively in terms of infrastructure but also to understand the perspective of the public on service levels and the demand for improved social amenities. Madigele (2017) reports that a great number of rural communities lack access to infrastructure, which escalates to poor societies in local municipalities.

Household water collection, conservation, and hygiene maintenance in the communities

In rural communities of South Africa, previous studies have established that the lack of clean water and sanitation in dwelling units compel residents to either collect drinking water and/or use dumping sites outside homes (Duncker, 2015; Hemson, 2016; Edokpayi et al., 2018, Asoba et al., 2020). The findings of this study confirmed that almost all residents of the communities fetch drinking water and access hygiene facilities (ie, toilet and waste sites) outside dwelling units. In Figure 6, although the communities differ in terms of the distances they cover to water sources, it emerged that access to quality water and sanitation remains a daily struggle. On average, 85% of the respondents walked more than 4kms, 11% walked 3kms, 3% walked 2kms and 1% walked either 1km or less to either fetch water or access a dumping facility. Similarly, in revealing the burdens associated with water collection, a key informant stressed that *"…after water has been collected from a remote water point, women then face a long walk home, sometimes in the dark, exposing themselves to snake bites, attacks, violence and even sometimes rape…" (Participant 7).* The results give credence to Hemson's

(2016) study which found that in rural settlements, people walk 3 to 4kms (approximately 50 minutes or more daily) to rivers and streams to fetch water and dispose of waste. This is due to the grossly inadequate provision of safe drinking water and hygiene services for their households.

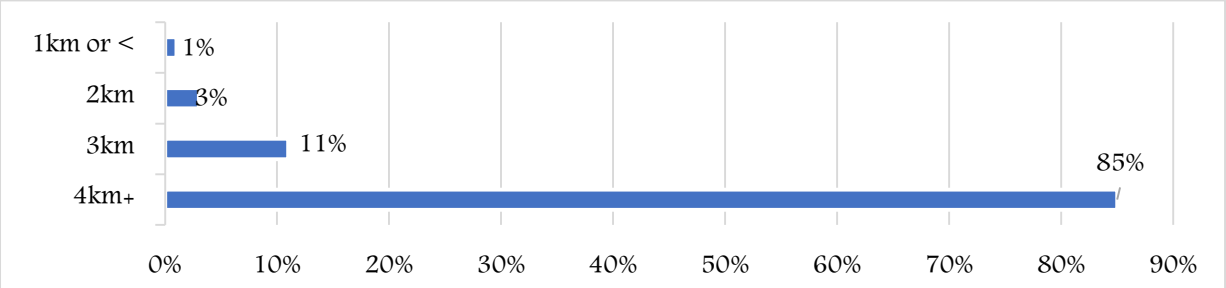

Figure 6: *Distance covered by households to access drinking water*

The results confirm Mudau et al. (2016) who found that people who access tap water at the Vhembe District Municipality complained of problems related to back pain, resulting from the distances they had to travel to either dispose of waste or fetch water from different sources like taps, rivers, springs or boreholes. The gender perspective of the problem was revealed (Figure 7), with many women having to face most of the water and sanitation challenges. This was not surprising since women are mainly involved in the cleaning and water-based chores of households in African communities. At the Gedroogte, Ga-Molapo and Magatle rural communities, the burden of water collecting is heavily borne by women (50 %), boys (16 %), girls (19 %), men (9 %) and donkeys as means of transporting water (6 %).

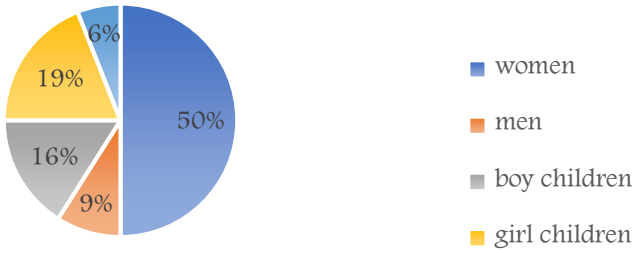

Figure 7: *Responsibilities for household water and hygiene maintenance*

Women are primary providers, users, and managers of water in the households, and they are often directly affected by lack of sanitation facilities. A key participant corroborated this view by saying that *"women are the ones who shoulder the problem of carrying water for up to four hours per day when the water system (borehole/pipes) malfunctions" (Participant 6).* In the communities, water is used for drinking, food production, cooking, personal and family hygiene, washing, cleaning, and caring for domestic livestock. The lack of fairness in the distribution of water and sanitation responsibilities can seriously affect young girls, especially during puberty when they need regular access to water and proper sanitation for personal hygiene. Similar studies found that the overall burden of water collection and sanitation maintenance among populations in rural communities is more heavily dependent on women and girls than on men and boys (Greere et al., 2010; UNICEF, 2011). It is very common to see children spending much time collecting and carrying water and rubbish to the dumping sites in rural communities. Such practices can have physical, emotional and mental consequences on children's educational outcomes. Statistics show that women outnumber men in

these communities, which clearly identifies the burden and stress they are experiencing daily with regard to fetching water and using sanitation facilities. The findings are not surprising because in traditional societies, cultural and social norms have designated gender roles for men and women. Girls and women have been confined to the domestic roles of fetching water, cooking, washing and cleaning (Bazaanah, 2022). Where these burdens fall heavily on girls, they could be adversely affected in their school attendance and academic performance. This challenge can lead to road casualties, risks, assault, attacks on unaccompanied girls and health-related problems such as injuries to the back and neck while carrying water. The findings are similar to the results of Geere et al. (2010), who found that carrying water can cause damage to the body regarding musculo-skeletal illnesses linked to the spinal cord and other joint problems. In Table 6, due to scarcity of water, the communities employ different water collection and conservation strategies. Water containers are often made of lightweight metals or plastics, and they are often used by the residents to collect, transport, treat, store or consume water. The range of domestic water containers commonly found in the communities includes buckets, jerrycans, storage drums and gallons. In Table 6, the study found that a little above half of the respondents (56 %) used 20-litre buckets to fetch water for their households. About 20% of the respondents used water drums/jerricans, 25-litre gallons (15 %) and 10 % used barrels to fetch water.

Table 6: Facilities for fetching and conserving drinking water

Water storage strategies	**Percent**
Buckets	56
Water drums/ jerricans	20
Barrels	10
Gallon containers	14
Total	100
Water conservation strategies	**Percent**
Water drums	86
Underground tanks	7
Buckets	6
Overhead Polytanks	1
Total	100

Similarly, to the prevailing conditions at the Gedroogte, Ga-Molapo and Magatle rural communities, a study by Greere et al. (2010) found that numerous rural communities in Venda, Limpopo Province also collect water using 20 to 25-litre plastic buckets. In terms of water conservation/ storage, a large majority (86%) of the respondents store their water in water drums. Others also stored water in underground tanks (inside their houses) (7%), in 25 litre buckets (6%), and in overhead polytanks (1%) (see Table 6). The results are also similar to Edokpayi et al. (2018), who found that the households at Thulamela Municipality in the Limpopo Province normally store their drinking water in large water drums, plastic buckets and jerrycans. Although, the Gedroogte, Ga-Molapo and Magatle rural communities depend on boreholes which pump three (3) litres of water per second as indicated by 80 % respondents, 7 % of the respondents depended on piped water inside the yard, 5 % on piped water from an access point outside the yard, and 4 % depending on water vendors. The others depend on rain-harvesting polytanks (4 %), communal taps (3 %) and neighbours' support (0.2 %). Maake and Holtzhausen (2015) show that in the Mopani District of the Limpopo Province, the main water sources include streams, wells,

boreholes and rivers. These results are similar to those of Edopayi et al. (2018) which show that in the Thulamela Municipality of the Limpopo Province, the rural communities depend on boreholes as their water sources. Table 7 reveals that most of the households (89 %) do not have toilet facilities in their homes. A few of the respondents depended on toilets in their dwelling units (10 %) or community toilets (1 %). These results are similar to Beyers (2016) who found that in the Fetakgomo Local Municipality, Limpopo Province, sanitation issues are a major challenge impacting the localities. Moreover, Hemson (2015) reported that in the Amathole District Municipality in the Eastern Cape Province, communities do not have toilets in their households. Again, in Table 7, nearly half (42 %) of the respondents showed that they depend on pit toilets without ventilation, 16 % depend on dry toilets and 12 % use bucket toilet systems, 10 % use the bush and open fields, while 5 % depend on flush toilets connected to a sewage system.

Table 7: Waste management and community hygiene practices

Households' toiletry systems and practices	**Percent**
No toilet in dwelling unit	89
Commonly used toilet in dwelling units	10
Community toilets	1
Total	100
Main type of toilet facility used by the household	**Percent**
Pit latrine (Without ventilation)	42
Dry toilets	16
Buckets toilet system	12
KVIP	10
Bush & open fields	10
Flush connected to sewage system	5
Flush system with septic tank	5
Total	100

A few respondents (5%) depend on flush toilets with septic tanks for their households. Adopting modern and hygienic waste disposal systems and strategies for pollution abatement (solid and liquid waste) should be of high priority to the people. The solid waste generated in the area is either disposed of in public dumps (open space or container) or is indiscriminately dumped on the streets, gutters or sewerage systems. The households have a combination of closet flush toilet facilities (WC), pit latrines, KVIPs or bucket/pan latrines. Public toilet facilities (KVIPs) are for communal or public use (paid or free use). Water closet toilet facilities are symbols of prestige and associated with middle-class and upper-class status. In terms of locality, improper solid waste disposal is generally higher among rural households. Open defecation is more pronounced in the rural areas where access to improved toilet facilities remains a challenge.

Acceptable waste management helps to prevent the spread of some types of infections and improves the quality and general hygiene of the environment. These results are dissimilar to those of Edokpayi et al. (2018) which shows that in the Thulamela Municipality in the Limpopo Province, few people practised open defecation. The findings, however, confirm Hemson's (2015) study which shows that communities at the Amathole District Municipality in the Eastern Cape depend on the bush as their alternative to a household toilet. This inadequate number of toilets and the dependency on open defecation (bush) could contaminate surface water and groundwater systems. Similarly, Stats SA (2016) reported that 2,683,048 households in the country still lack

access to basic drinking water. The three rural communities studied still depend on boreholes as the primary source of water, apart from private dug-out-wells, which are unprotected and unsafe for drinking. Waterborne diseases such as diarrhoea, malaria and cholera are likely to rise in the communities if stringent measures are not put in place. In rural communities of the Limpopo Province, 10% of children aged four to five years have been found to have dental caries due to the consumption of unsafe drinking water, which has led to fluorosis (Edokpayi et al., 2018). The outbreak of a cholera epidemic which originated in Kwa-Zulu Natal did not only affect the people's health, but also raised questions about the quality of water they consumed in the area (Hemson, 2016). The consumption of water from unimproved sources without treatment constitutes a major public health risk. In South Africa, diarrhoea is found to be one of the leading causes of death among young children, and this problem is worse in children infected with HIV (Edokpayi et al., 2015). To avert events of the past, particularly in the era of COVID-19, this study cautions the need for awareness creation, public education, and advocacy programmes, and effective waste management practices to be implemented by civil society organisations and municipalities.

Ecological economics and policy nexus of water and sanitation service delivery

The use of contaminated water and inadequate sanitation maintenance is frequently connected to people's income and capacity to afford service delivery. This is because poor individuals cannot afford basic necessities such as water and sanitation (WHO, 2022). Due to poverty, about 98% of respondents stated that they were unable to afford adequate water and sanitary facilities. This might imply that household water consumption and sanitation habits are connected to larger socio-economic variables. Sinyolo et al. (2014) point out the need to investigate water security at the national and rural levels. In Table 8, water scarcity appears to be an endemic problem in the communities. Almost all the participants (93%) revealed that water supply in the communities is erratic and insufficient. The supply gap has implications for food security and sustainability of livelihoods. Meanwhile, 6 % of the respondents indicated that water shortages occurred for several months and 1 % responded they went "day-zero" without water. This is a clear violation of human rights to water as contained in the 1994 Constitution and the Water Service Act 108 of 1997. Both regulations specify that it is unlawful for South African communities to be deprived of drinking water, irrespective of their geographic location or economic status (South African Government, 1994).

Table 8 further reveals that the respondents perceive water shortages in the communities to be drought-induced (78%), or caused by allocation inequalities (8%), water scarcity (1%) and broken infrastructure (12%) in the communities. Mpandeli et al. (2015) report that the drought which occurred in the Limpopo Province from 1926 to 2012 affected farm products and water supplies to the Gedroogte, Ga-Molapo and Magatle rural communities. An informant testified that "*since 1958, these three rural communities have been characterised by harmful drought, poverty, and unemployment" (Participant 16).* For some of the residents, water shortages in the communities could be resolved through bulk distribution. This was stressed by an informant who indicated that *"the state should implement the FBW policy and steps for bulk water distribution to address water stress" (Participant 9*). Among the households, a little above half (53%) were of the view that their water needs could be addressed by bulk water distribution, 35% suggested implementation of the Free Basic Water policy (FBW) and 10% preferred the state/government while 2% viewed privatisation to be an effective pathway

to resolve water scarcity problems in the communities. An informant indicated that *" we need all stakeholders including the private sector, government, civil society groups and individuals to address the perennial water shortages in the communities" (Participant 7*).

Table 8: Water shortages and the White Paper addressing water scarcity in the communities

Duration of water shortages	**Percent**
Day-zero/ no water	1
Months	6
Years	93
Total	100
Water shortages	**Percent**
Inequality in water allocation	8
Broken infrastructure	12
Water scarcity	1
Drought	78
Total	100
Strategies to address water shortage	**Percent**
Bulk water distribution	53
Implement FBW policy	35
State-led approach	10
Privatise water distribution	2
Total	100
White Paper 1994	**Percent**
2 litres per/person per/day	2
20 litres per/person per/day	12
25 litres per/person per/day	16
200 litres per/person per/day	61
More than 200 litres per/person per/day	9
No litres but a sustainable provision of water	1
Total	100

From the perspective of ecological economics, this study argues that the most basic needs of human beings are air, water, food, clothing, and decent shelter. From the findings, water and sanitation can be considered to be: i) social goods: - providing core security and welfare benefits for households, neighbourhoods, societies and communities; and ii) economic good: - that stimulates growth and the development of municipalities. For instance, a key informant said *"…We are basically subsistence farmers. Water shortages affect our everyday life and well-being, be it our social, politcal or economic livelihoods, but due to drought, poverty, and increase in population, we barely have enough water…" (Participant 10).* The findings highlight that improved water and sanitation remains a challenge considering the rate of urbanisation and climate events like drought impacting on the municipality. Yet, despite decades of independence, post-apartheid regulations and policies in South Africa have not closed gaps of access to facilities, especially water and sanitation facilities and services in the country (Madigele, 2017). Water is an essential resource for human survival, a catalyst to revitalise rural economy, promote growth, and productive activities at the local level (Fourie et al., 2013; Lant, 2004). In expanding this narrative, this study highlights that water defines every aspect of human life; socially, economically, politically, and geographically. Access to improved water and hygienic environments creates social prestige, positive image building, and healthy, productive, prosperous individuals and societies. As basic needs, water and sanitation are core to poverty alleviation in rural environments (Schultza et al., 2015). From the perspective of 'natural capital', water and sanitation is linked to productive and service sectors of the rural economy of the municipality. Water is a vital ecological resource which creates possibilities for the productive and

extractive sectors of the rural economy (i.e., enabling agriculture, livestock raising and boosting mining industries). It revitalises ecological systems and service delivery sectors in ways that can enable development to take place naturally in the municipality. From the economic and the human rights standpoint, about 61 % of the households agreed they have unmet needs of approximately 200 litres of clean water per person per day, 15 % have unmet water demand of about 25 litres, about 12% of the households require 20 litres of water per person/per day, 9 % need more than 200 litres, 2 % need 2 litres and 1 % require no litres but a sustainable provision of water for their households (see Table 8).

The inability of the LNLM to meet the daily needs of water for consumption, productive and domestic activities is contrary to the Bill of Rights enshrined in Section 27 (1) (b) of the South African Constitution. Little to no access of water and sanitation by the residents has implications on human rights at the municipality. The residents of Gedroogte, Ga-Molapo and Magatle need to be enlightened about government policies and regulations and be empowered to hold the municipality more accountable for their water and hygiene needs. In a related study, Marume et al. (2016) found that public policy is a complex, dynamic and diverse process that includes different methods and procedures to achieve governmental aims and objective for its constituencies. We highlight here that the water and sanitation conditions at the municipality are not an exception. Throughout the world, water and sanitation have become symbols of power and control, carrying with them ideas of "baptism, refreshment and new life," with properties for cleansing, healing, and stimulating growth and development (WHO, 2022). Thus, we caution that in municipalities like LNLM, with a youthful population and growing demands on a limited resource like water, shortage or scarcity of improved water can result in devastating conflicts, civil unrest and irreparable catastrophic effects in the communities.

Gaps in water and sanitation service delivery among the households

As illustrated by Table 9, the cost of freshwater resources can have implications on water demand, affordability and choice of water sources used by the people. Almost all residents (99 %) usually buy water for their household when there is no supply from the municipality, with as few as 1 % who claim they do not buy water. On average, a 200 litre water drum costs approximately R40.00 (R1= $0.05) (Lepelle Local Municipality, 2017), which normally does not last for a month, depending on the number of people in the household. It is safe, based on the above, to infer that pricing water affordably could encourage the residents to either waste less or pollute less water and rather invest more in water infrastructure. Table 9 depicts the annual cost estimates of household's water consumption pattern from 2017, with an annual adjusted increment of 5 %.

Container size (large drum) 200L = R40.00 ($2.4)

R40.00 X 1 Month = R160 ($9.4)

R160 X 12 Months = R1920 ($112.9)

The findings show that water tariffs are likely to increase from R2016.00 in 2017 to R3652.00 by 2030 if the current conditions are not mitigated. Considering the rate of urbanisation, poverty

(income levels) and composition of the household membership, the residents with high household membership are likely to have increased water demand and incur more costs on water (IDP, 2016-2021). Higher water tariffs could compel impoverished residents to fall on unimproved water sources. To ensure equity in water allocation and bring demand and supply into balance, water tariffs should either be waived or adjusted for extremely poor rural residents. In addition, riparian allocation systems, where the right to use water is linked to land ownership along rivers, needs to be abolished.

Table 9: Annual estimates of drinking water tariffs in the communities (2017 - 2030)

2017	2018	2019	2020	2021
R1920 X 5% **R2016.00**	R2016 X 5% R2111.00	R2111 X 5% R2217.00	R2217 X 5% R2328.00	R2328 X 5% R2444.00
2022	**2023**	**2024**	**2025**	**2026**
R2444 X 5% **R2566.00%**	R2566 X 5% R2594.00	R2594 X 5% R2724.00	R2724 X 5% R2860.00	R2860 X5% R3003.00
2027	**2028**	**2029**	**2030**	
R3003 X 5% **R3154.00**	R3154 X 5% R3312.00	R3312 X 5% R3478.00	R3478 X 5% R3652.00	**(R1= $0.05**

The practice of using rivers and other water sources as channels for waste disposal (industrial effluence) could affect the health of users located along upstream and downstream areas. Effective catchment management and participatory efforts are needed to improve water allocation and sanitation conditions in the communities. In Table 10, the inability of the municipality to sustain water systems is caused by broken facilities (taps or hand pumps) (78 %), insufficient water (12 %) and unsafe drinking water (10 %). Similarly, the sanitary conditions and waste management systems are undesirable due to the unavailability of waste disposal facilities (50 %), repairs/maintenance culture (30 %), high waste disposal tariffs (10 %) and unavailability of dumping sites (10 %). Education and sensitisation campaigns are important to increase residents' awareness and knowledge on hygiene maintenance. These findings are similar to Maake et al. (2015), who found rural communities of the Mopani District are constrained by high water losses, leaking infrastructure, and poor waste management systems.

Table 10: Constraints of water and sanitation systems in the communities

Water systems	**Percent**
Broken down	78
Insufficient water	12
Unsafe water	10
Total	100
Waste management systems	**Percent**
Unavailability of waste disposal facilities	50
Repairs/maintenance	30
Waste disposal tariffs	10
Unavailability of dumping sites	10
Total	100
Structures for reporting water and sanitation complaints	**Percent**
Water and sanitation committees	78
Tribal administration	13

Water boards	9
Total	100
Municipality's responsiveness to complaints by residents about water and sanitation conditions	**Percent**
30 days (one month)	71
14 days (two weeks)	18
More than 365 days (one year)	7
7 days (one week)	
1 day	1
48 hours	1
Total	100

About 78 % of the respondents indicated that they reported defects on their water system facilities and sanitation constraints to the water/sanitation committees, 13 % to the tribal administration offices and 9 % reported to the local water boards. Moreover, consultation with residents is important for decision-making, obtaining information, sharing experiences and knowledge on local affairs in the municipality. In Figure 10, the channels for consultation and feedback/complaints with the municipal authorities include telephone/ cell phone conversations (60 %), online (5 %) and use of representatives/ third party engagement (35 %, i.e., neighbours reported on their behalf). The findings highlight that the residents have more trust in their water and sanitation committees than tribal authorities on matters related to water and sanitation conditions in the communities. Perhaps, they consider the committees as experts with the capacity and knowledge to address their concerns rapidly and more sustainably.

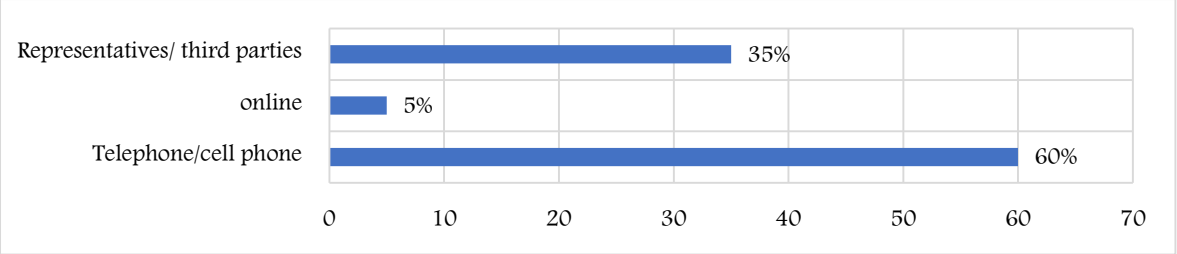

Figure 8: *Community consultative strategies and feedback on water and sanitation*

Although different strategies are employed for consultation and engagement with the residents, the feedback /complaints have not been prioritised and addressed by the municipality. On averagely, 71 % of the respondents indicated that the municipality took 30 days (one month) to respond to reported faults regarding their water and sanitation systems, 18 % mentioned 14 days, 7 % of the respondents mentioned more than a year, 2 % said it took 7 days, 1 % said it took 1 day and 1 % mentioned that it took 48 hours for the municipality to respond to their complaints (see Table 10). The delays in mitigating reported complaints could result in water losses and environmental pollution, thus, adversely affecting the health, livelihoods, and well-being of the residents. The findings corroborate reports from the LNLM (2021), which showed that about 95 % of the land falls under the Tribal Authorities' jurisdiction. However, the authorities lack capacities to manage waste and water systems in the municipality. According to the LNLM (2021), the available channels for reporting service delivery, fraud, and corruption-related water and sanitation complaints has not been well managed by the CDM. The failure of the CDM to timely address concerns of the residents are blamed on lack of capacities, funding, and erratic power supply to its pumping stations. In addition, *"coordination between stakeholders like the CDM, LNLM,*

civil society organisations, private institutions and the residents in finding common grounds for pooling resources together have not been effective" (Participant 9). In a related study, Beyers (2015) discovered that the CDM do not have measures in place to engage the communities and receive feedback related to incidents on water and sanitation. Similarly, access to toilets and waste dumping sites at the LNLM is beset with diverse constraints. According to the WHO (2020), sanitation behaviour changes at scale by whole communities, and the sustainability of that change, has become a global imperative. Irrefutable research evidence is emerging from different countries that demonstrate that poor sanitation, particularly open defecation (OD) occasioned by the lack of public toilets and littering by community members, is causally linked to ill-health and mortality (Hemson, 2015; Edokpayi et al., 2018; Sibiya & Gumbo, 2013).

In Table 11, a little above half of the respondents (53%) find themselves with either no decent toilets or with facilities in deplorable conditions. Nearly a third (27%) of the respondents indicated that they are unable to use public toilet facilities due to cracks in them, 16% perceived the facilities to be very dirty and 2% indicated that the facilities had flies inside them with strong smells. Air pollution emanating from human waste can be contagious to the residents. For the poor households, the cost of constructing and managing private toilets and domestic waste is simply out of reach. Consequently, for residents who either lack proper toilet facilities or are unaccustomed to the use of improved toilets, OD and littering around neighbourhoods are traditionally considered to be the easiest and most economic options.

Table 11: Condition of toilet facilities and strategies for enabling hygienic communities

Condition of toilet facilities in the communities	**Percent**
No decent toilets/ practice OPD	53
Cracks on toilet facilities	27
Very dirty with faeces everywhere	16
Many flies inside toilet with strong smell	2
Total	100
Enabling sustainable and hygienic communities	Percent
Public education	80
Investment in water and sanitation	78
Build institutional and community capacities	86
Community empowerment & sensitisation	70
Support from government	80
Support by Civil Society Organisations (NGOs)	60
Community initiatives and actions (communal labour)	84

*Note: *sustainability initiatives are in multiple response categories*

This study cautions that with urbanisation, such unhygienic practices and attitudes are likely to adversely impact on the environment and health of the people. There is a need then, to strengthen local institutions, and introduce initiatives that can support collective behavioural change in relation to water and sanitation. Perhaps, community-based processes like Community-Led Total Sanitation (CLTS) could be applied on a community-wide scale, along with fostering the growth of local markets offering improved water and sanitation services that are affordable for all. Similar studies established that the quality and sustainability of drinking water systems can be compromised when they become contaminated by waste arising from improper sanitation maintenance (Tapela, 2018; WHO & UNICEF, 2014; WHO, 2019). In Table 11, the pathways for building resilience and sustainability are multifaceted. They include interventions such as public education (80 %), investments (78 %), building institutional and community-level capacities (86

%), and community forums (70 %) meant to empower, create awareness, and change attitudes toward water and hygiene maintenance. Beyond support received from government (80 %) and civil society organisations like NGOs (60 %), respondents indicated there is a need to develop a communal and institutional culture (84 %) that strives towards more resilient and safe rural environments. Such efforts should include offering communal labour in activities like regular cleaning (clearing of bush and gutters), building affordable toilets and waste dumping sites, and improved public-private engagements. The findings put into perspective the SDG6 which lays emphasis on universal access to water, sanitation, and hygiene for all societies (UN, 2015).

Effects of water pollution on the well-being of the household members

Water promotes the wealth and health of societies, and thus, poor water quality arising from pollution can reduce the life expectancy of residents in the communities. Water and sanitation are critical elements that can contribute to economic growth and development. The well-being of people encompasses different elements, including social, economic, and environmental dimensions. Pollution can affect water sources and human well-being if such sources are consumed without proper treatment. This study found that 62 % of the household respondents confirmed they had been diagnosed with fluorosis, 21% indicated they are infected with diarrhoea, 11% reported cholera infection, 3% malaria, and 3% complained of fever and fatigue after drinking unsafe water. As an arid area, the freshwater resources of the municipality are likely to diminish. Thus, drinking water is likely to be even scarcer by 2030, if existing conditions should continue to persist. Scarier is the fact that treatable water resources (either surface or groundwater) would be unavailable if water pollution continues unabated. The study cautions that water pollution from agriculture, and mining – besides posing threats to the availability of drinking water – could have serious health implications for residents in the communities. Earlier studies established that contaminated water with algae and agrochemicals could result in kidney, nervous system, and heart diseases (FAO, 2017; WHO, 2019). If unabated, water pollution could cause residents to lose trust in tap, surface and groundwater sources, increase the cost of water treatment and further push the cost of drinking water beyond the reach of the most vulnerable and poor households. In Table 12, we used the odd ratio of 95 % confidence, assumed the risk of $\alpha = 0.05$, and the chi-square (χ^2) test of independence to predict a null hypothesis (H_o) which state that *there is no significant relationship between pollution and drinking water supply*. This was measured against an alternate hypothesis *(H_A)* which assumed that *there is a significant relationship between pollution and drinking water supply*.

In Table 12, the main pollutants used in determining the association with water supply are agrochemicals, mining, refuse disposal systems, toilet systems, sewerage systems, and industrial effluence. None of the cells recorded expected frequencies below the 5% threshold, an indication that the rules of the chi-square test were not violated by the study. The association between these pollutants and water supply was found to be statistically significant. If this situation is not mitigated, water pollution and its cascading effects on ill-health are likely to increase among the households in the LNLM. In testing for the null hypothesis *(H_o),* the corresponding *p-values* (Table 12) were compared with the confidence interval (0.05) in order to determine whether the existing relationships are statistically significant. The decision rule applied was "*do not accept the null hypothesis, if p-value ≤ 0.05 and accept the null hypothesis, if "p-value" > 0.05]*. Thus, where the p-values are smaller than the significant level, it is assumed that the result is statistically significant.

Table 12: Effects of pollution on drinking water in the communities

Drinking water pollutants						
Chi-Square Statistics	Agrochemicals	Mining activities	Refuse disposal systems	Toilet systems	Poor sewage systems	Industrial effluence
χ^2	481.449a	155.179a	754.988b	642.978a	687.673b	456.731a
Df	2	2	2	2	2	2
p-value	0.001	0.020	0.041	0.021	0.000	0.000
N	647	647	647	647	647	647
a. 0 cells (0.0%) have expected frequencies less than five. The minimum expected cell frequency is 91.9.						
b. χ^2=chi-square statistic; p-value = significance level; n = sample size and df = degrees of freedom						

In Table 12, since the corresponding *p-values* of the χ^2 statistics are lower than the 0.05 threshold, the null hypothesis (H_o) is rejected, and the alternative hypothesis (H_A) is accepted. We therefore conclude, based on the test results, that within the Gedroogte, Ga-Molapo and Magatle communities, agrochemicals, mining activities, refuse disposal systems, toilets, sewage, and industrial effluence are the most significant pollutants affecting drinking water sources used by households and residents of the area. A key informant confirmed that "…*the main sources of pollution are agrochemicals, miners, and improper waste disposal. These wastes find their way into our water bodies which causes sickness like cholera when we drink from them" (Participant 20).* In related studies, Hemson (2016) found that in South Africa, the occurrence of the cholera epidemic from 2000 to 2001 is linked to waterborne diseases arising from the consumption of unsafe water. Similarly, Edokpayi et al. (2018) discovered that in rural communities of the Limpopo Province, children aged four to five years have been detected to have dental caries due to the consumption of unsafe drinking water, which has led to fluorosis. The outbreak of a cholera epidemic in Kwa-Zulu Natal was linked to the quality of water used by households. Poor water quality makes many communities vulnerable to high mortality rates in South Africa (Hemson, 2016). In addition to this, the outbreak of the COVID-19 pandemic has demonstrated the critical importance of sanitation, hygiene, and adequate access to clean water for preventing and containing the spread of diseases. Hand hygiene can save lives and water availability is important for ensuring proper hand washing. According to the WHO, handwashing is one of the most effective actions to reduce the spread of pathogens and prevent infections. Yet, evidence across the globe shows that billions of people still lack access to safe water and sanitation, South African municipalities are not exception (WHO, 2020).

Conclusion

The basic needs of every human society include water and improved sanitation. From the perspectives of ecological economics, we argued in this paper that water and sanitation affect every aspect of rural life [*socially, economically, politically, and environmentally]*. We found that gender, population growth trends, and household composition affects water and sanitation delivery in the studied communities. The existing facilities are in a deplorable condition due to overuse without rehabilitation – pushing the cost of services beyond affordability by poor residents. This is a signal that future demands for water and basic sanitation are likely to increase if the existing conditions of facilities are not improved. With the relatively youthful population, high unemployment, and poverty rates, the residents will not be able to afford the cost of freshwater and improved sanitation services. Typical of most patriarchal and traditional societies, the burden of domestic water collection and hygiene maintenance, unfairly rests on women who trek long distances to either fetch water or dispose of waste. This highlights decades of neglect and under-investment by duty

bearers as state-of-the-art facilities are yet to be installed in most of the dwelling units. The rural settlers used water for diversified purposes *[like consumptive, productive, and domestic purposes],* a signpost that water scarcity will likely impact on livelihoods and well-being of residents in the communities. Ensuring allocation equity requires that demand-supply gaps be bridged through initiatives like bulk water supply, investment in facilities, the removal of tariffs and riparian systems in underprivileged and poor areas. Water insecurity and ill-health could arise if efforts are not made to address water pollution arising from agrochemicals, toilets and waste systems, mining, sewerage, and industrial effluence in the communities. Acceptable waste management practices could help prevent the spread of waterborne infections. Such initiatives like capacity building, public education/awareness raising, investments, and facility upgrade, are not only critical but could help avert the spread of water-borne infections and significantly improve the resident's health.

Recommendations

In view of the hardships being experienced by the rural communities, it is essential for the LNLM to improve water facilities, including boreholes, in compliance with government regulations. The municipality must implement strategies that incorporate water for productive use in the water distribution plan, as this will foster community development. Handwashing and personal hygiene are important considerations for curtailing the spread of diseases in the municipality. The Department of Social Development, aligned with the Limpopo Province should educate rural communities about the construction, use and maintenance of public pit latrines in line with the environmental health regulations of the country. The Limpopo Department of Water Affairs should implement suitable WASH programmes within LNLM for health education and awareness in the communities, to promote the well-being of the communities at large. To ensure equity in water allocation and bring demand and supply into balance, water tariffs should either be waived or adjusted for extremely poor rural residents. The government of South Africa should be committed to water and sanitation improvements at all levels. Increased funding and capacities should be made available for improvement, particularly in rural water and sanitation facilities, to make them accessible and safe for human use. Moreover, social mobilisation, dialogue and stakeholder involvement should be strengthened for effective water and sanitation service delivery in rural communities. We call on civil society organisations to intensify efforts of educating the residents on the relevance of clean water, basic sanitation, and health hazards. The water and sanitation agencies and departments of the municipality should ensure the provision of environmentally friendly energy sources, and enforce bylaws to curtail the pollution of water sources and the environment.

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