

Challenges in Implementing ICT Tools in Water and Sanitation Services Management in South Africa

Tafadzwa Jaqueline Mukasi and Olabanji Oni (2023)
University of Fort Hare, South Africa

DOI: <https://doi.org/10.14796/JWMM.C506>

ABSTRACT

This article discusses challenges encountered in implementing Information Communication Technology tools in water and sanitation services management in South Africa. This qualitative study used a Human Capital Development framework. The study area has had limited consultation on Information Communication Technology tools, low Information Communication Technology usage, and skills gap. Attention is paid to the effective use of Information Communication Technology tools, for example, mobile phones and their application to address the challenges faced. This promotes proper water and sanitation services management by implementing relevant tools to increase the knowledge and skills of service providers. South Africa needs to address and eliminate challenges experienced in implementing Information Communication Technology tools, inequalities, and human-made challenges to ensure availability of services and sustainable water and sanitation services management.

1. INTRODUCTION

Supplying safe drinking water and sanitation, outlined under Sustainable Development Goal 6, is a vital aspect of the global development agenda. The goal ensures that 'no one is left behind' on sustainable development and sustainability in the management of water and sanitation services (UN Water 2019). However, there is a cause for concern and a need to implement solutions to advance progress and make sure that "no one is left behind". The use of and access to water is one of the leading global challenges in the 21st century, specifically the management of water and sanitation services and the availability of safe and clean drinking water (Rediana and Pharmasetiawan 2017). At least 2 billion individuals worldwide are utilising drinking water sources contaminated with faeces (WHO 2019) Roughly one thousand children under five years

Mukasi, T.J., and O. Oni. 2023. "Challenges in Implementing ICT Tools in Water and Sanitation Services Management in South Africa." *Journal of Water Management Modeling* 31: C506.
<https://doi.org/10.14796/JWMM.C506> www.chijournal.org ISSN: 2292-6062 © Mukasi and Oni 2023



old die every day because of water and sanitation related diseases (UN 2015). According to WHO (2014), unsafe drinking water, inadequate sanitation, and poor hygiene are projected to cause a minimum of 502 000, 280 000, and 297 000 deaths annually, respectively, caused by diarrhoea. Generally, an estimation of 842 000 deaths from diarrhoea are triggered by these risk elements. Poor water quality, water scarcity, as well as insufficient sanitation also have a negative impact on the livelihoods of people. Moreover, mismanagement of water and sanitation services makes it difficult to practice and improve hygiene practices, which has an impact on diseases such as the Coronavirus Disease 2019 (COVID19) which is currently causing the deaths of thousands of people of all ages around the globe.

In South Africa, droughts, which started around 2015, have raised significant concerns on water use patterns (Meissner and Jacobs-Mata 2016). Furthermore, the expansion of urbanisation due to rural-urban migration by people, as well as population growth, is putting a strain on the water and sanitation infrastructure. Thus, clean water supply and wastewater treatment needs amplification. Additionally, the water and sanitation sectors in many countries that have high coverage of water and sanitation services are encountering several problems that are potentially compromising the sustainability of the services because water and sanitation services are utilised unwisely, and valuable resources destroyed and not reverted to the resources cycle. The study was conducted in two district municipalities, Ugu District Municipality (UDM) and Umkhanyakude District Municipality (UKDM) in KwaZulu-Natal (KZN) province, which are experiencing severe drought conditions and water restrictions (Mena Report 2015; Mena Report 2016; States News Service 2016, Independent Online 2017a; Independent Online 2018). Furthermore, there is still a lack of information and communication from service providers on realizing widespread and justifiable access to safe drinking water for everyone, and adequate sanitation and hygiene. Communities face slow service delivery, inaccurate meters, polluted water, inadequate freshwater, damaged pipeline installations, and an increase in non-revenue water (Rediana and Pharmasetiawan 2017). The two district municipalities are still facing the challenges of receiving quality and reliable services; raw sewage runs in streets, broken pipes, and difficulty generating competencies for effective, sustainable management of water and sanitation services (Democratic Alliance KwaZulu-Natal 2017; Independent Online 2017b). The municipalities are struggling to implement Information Communication Technology (ICT) tools such as computers and software programs, to sustain the demands, which are growing fast and are aggravated by population growth, irrigated agricultural productivity, climate change, and deteriorating water quality.

According to Jothirathne and Pushpakumara (2017), ICT refers to the functions of communication and integration of telecommunication, computers, and essential storages and human interaction. ICT includes technologies (for capturing, storage, processing, communication, and display) that enable handling information and promote various forms of communication amongst human actors (water and sanitation service providers and users), between humans and electronic systems, and amongst electronic systems (Madon and Krishna 2018). It is worthwhile for the international community to give ICT crucial attention as a tool that can significantly contribute towards the management of water and sanitation services in different countries and various initiatives that focus on it, such as the SDGs, by 2030. Emerging ICTs can deal with challenges linked to water and sanitation services and assist the government at local, district, provincial, and national levels, and other service providers in addressing vulnerability by understanding the impact of specific challenges on the management of water and sanitation services. Municipalities in the Western Cape and Eastern Cape provinces in South Africa have a 'fault reporting system' that

permits reporting challenges directly to the public service provider via Short Message Service using mobile phones and their applications (Hill 2015; Rivett et al. 2018). Thus, it is crucial to nurture the South African communication and information society by connecting ICT tools and the existing knowledge to support civil society to identify opportunities that will improve sustainability and achieve sustainable water supply, sanitation, and hygiene.

Management practices of water and sanitation services and implementation of ICT tools are critical for the sustainable supply of good water quality and safe and reliable water resources (Ryder 2018). Consequently, this can promote sustainability in the management of water and sanitation services, thus, allowing water and sanitation service providers to act on key challenges such as climate change, and positively contribute to economic growth (Gourbesville 2016). Implementation of ICT in water and sanitation services management can be inaccessible, especially to vulnerable and poor populations and people with limited mobility (Hill 2015). As a result, such users may face significant obstacles in accessing water and sanitation and lack the technological capacity to communicate their problems to service providers. Consequently, this study sought to fill this gap by investigating the challenges encountered in implementing ICT tools in the management of water and sanitation services in municipalities in South Africa. Furthermore, the research empirically explored the influence that the implementation of ICT tools, such as mobile phones and their applications, has on managing water and sanitation services. Thus, the need to identify technological developments in the management of water and sanitation services and identify ICT tools such as mobile phones and their applications stimulating sustainability in water and sanitation management. Moreover, the need for knowledge and suggestions related to water supply and sanitation services management may assist in policymaking and advocacy efforts. Innovative solutions through ICT use are required to enable the integration of water and sanitation management.

ICT use is advancing; affordable and high-performance water treatment, distribution and discharge practices, adequate sanitation, and offering new treatment abilities that can permit economic utilisation of unconventional water sources to increase the water supply (Qu et al. 2013). In developed countries, an estimation of 90% of people own mobile phones (The World Bank 2015, Taylor and Silver 2019) and young people spend approximately five hours per day using their mobile phones (Salesforce 2014). ICT has immensely automated business processes in municipalities in South Africa, and the sound design and implementation of ICT as most important to enhanced service delivery, including water and sanitation services (Sibanda and von Solms 2018). Apart from this, UDM and UKDM are still facing challenges in implementing ICT tools. For instance, mobile phones and their applications offer a platform for affordable and sustainable information dissemination and communication between water and sanitation service providers and users. This study sought to fill this gap by investigating the challenges encountered in implementing ICT tools in the management of water and sanitation services in KwaZulu-Natal province. Accordingly, the study formulated the following research questions:

1. What are the challenges encountered in the implementation of ICT tools in the management of water and sanitation services?
2. How is the municipality applying solutions to these challenges?

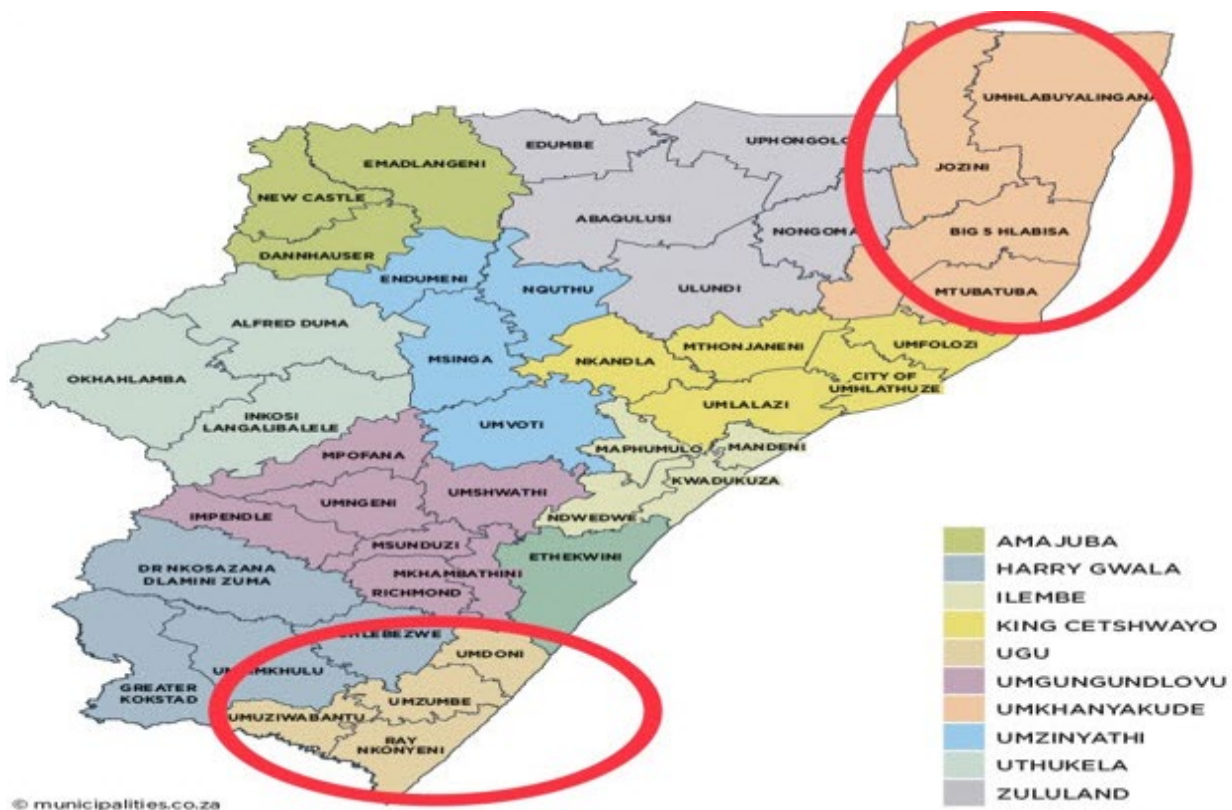
This paper discusses the literature supporting the implementation of ICT tools in managing water and sanitation services in municipalities in the following section. Thereafter, the article discusses the research method employed for data collection, the analysis, discussion of findings, and conclusion.

2. LITERATURE REVIEW

2.1 Management of water and sanitation services in South African municipalities

The Constitution of the Republic of South Africa, Act 108 (1996), assigns the management of water and sanitation services for the citizens to municipalities whose role is to focus on quality, quantity, continuity, and connectivity. The South African municipalities are responsible for transforming the delivery and management of water and sanitation services to reach the people's needs; hence, implementing ICT tools is a significant enabler of service delivery and management practices. Each South African municipality is subjected to national and provincial legislation and has a right to govern its initiatives and community's local government affairs, as required by the Constitution. The South African Constitution (RSA 1996) provides three municipality levels (provincial, district and local municipality), focusing on expanding the local economy and affording infrastructure and services.

The KwaZulu-Natal province consists of one metropolitan municipality and ten district municipalities (including the study areas, UDM and UKDM) subdivided into forty-three local municipalities as shown in Figure 1 (Municipalities South Africa 2021). The Ugu District Municipality comprises two distinct areas: the coastal belt, which is mostly urban, and the rural inland vastness, and the district contains six local municipalities (UDM 2019). According to



Source: Municipalities South Africa 2021

Figure 1 Map of KwaZulu-Natal Province showing locations of UDM and UKDM

UKDM (2019), UKDM is the second largest district municipality in the KZN province, and it consists of four local municipalities. UDM and UKDM are responsible for delivering water and sanitation services in line with the constitution and national standards. Furthermore, they are responsible for addressing financial viability, enhancing access levels, operational efficiency, and water quality.

The Strategic Framework for Water Services (SFWS) by the Department of Water Affairs (2013), states that the district municipality, as a water services authority, has a duty to ensure that the inhabitants of its area of jurisdiction receive at least a basic level of water and sanitation services. The Department of Water and Sanitation Services (DWS) in South Africa controls the country's majority of water systems. These water systems consist of several large dams, inter-basin transfer schemes, irrigation schemes, and water pipelines. The DWS developed a strategic document called the National Water Resource Management Strategy, which aims to ensure water resources management towards attaining national sustainable development over a period of five to ten years (Department of Water Affairs 2013). The legislation on water and sanitation services offers fundamental reform of the law regarding water resources, regulations, and matters concerning water and sanitation services.

According to the South African Water Services Act (WSA) 108 of 1997, water services refer to the supply of water services, whereby the minimum standard for essential water supply services is to provide suitable education regarding operational water use. A minimum quantity of potable water of twenty-five litres for each person daily, or six kilolitres for each household monthly, with the water flow rate of at least 10 litres per minute, within 200 metres of a household, and having an efficiency that allows every service user to receive a supply for more than seven full days in any year (WSA 1997). The WSA (1997) refers to sanitation services as providing a suitable health and hygiene education, a lavatory that is safe, reliable, environmentally sound, easy to clean, offers protection against the weather and privacy, well ventilated, and keeps away smells. These services are basic human rights, passed by the General Assembly of the United Nations, which then called upon countries and international organisations to offer financial resources, assist human capacitation, and technology transfer. Thus, assisting nations, especially developing nations, to deliver accessible, clean, affordable, and safe potable water and sanitation for everyone. In South Africa, the implementation of these principles at the national level was done in 2002, when the international agreement was signed (Muller 2014).

South Africa has several regulations, policies, and legislation that directly associate with and inform the delivery of water and sanitation services to South Africans. Water and sanitation services legislation is relevant and essential for managing and protecting water resources and ensuring strictly evidence-based decisions. These are related mostly to the South African national and provincial spheres. Brown et al. (2006) argue that regulations have two main features: regulatory substance governance, and regulatory governance. Regulatory governance consists of notions such as the association between regulators and policymakers, and the accountability of the regulator, whereas the regulatory substance focuses on controlling tariffs, and the quality of service by the service providers. According to the National Water Resource Strategy (NWRS2 2013), regulations are aimed at improving the capability of the Department of Water and Sanitation (DWS) to regulate the water and sanitation sector to achieve the governmental objectives, protect resources and water users, as well as ensure the sustainability of water and sanitation facilities.

In the South African context, Chemisto and Rivett (2018), Rivett et al. (2018), and Ntuli and Abu-Mahfouz (2016) investigated factors influencing water management and focused on the use of ICT solutions for the management of water. Abade and Alex (2015) extended the focus on the applicability of smart water metering technologies in alignment with mobile banking and employed a business model that ensured water supply sustainability. Researchers such as Murthy et al. (2018), and Mukhtarov et al. (2018) have indicated that ICT is essential in supporting the sustainability of water supply and sanitation services, improving access to, effectiveness, and sustainability of the management of water and sanitation services. Abade and Alex (2015) applied smart water metering technologies incorporated with mobile banking to deliver effective utilisation of water resources and employed a business model that ensured water supply sustainability.

Mobile phones and their applications offer instantaneous access to social networks and communication with one another. Emerging mobile phone applications are available to deal with challenges, including optimizing water and sanitation resources, climate change, lack of expertise of municipal workers, and service users' trust. Furthermore, they assist the government at the local, district, provincial, and national level, and any other service providers in addressing vulnerability by understanding the impact of specific challenges on the management of water and sanitation services. Implementing ICT to water management in municipalities enables data collection to better understand how municipalities operate and enhance it to benefit the environment and the community (Mukhtarov et al. 2018).

2.2 Challenges encountered in implementing ICT in the management of water and sanitation services in municipalities.

Several challenges are inhibiting the implementation of ICT tools on sustainable management of water and sanitation services in developing countries, which include a lack of technical skills and capabilities, insufficient intellectual property protection, and financing instruments (Ferreira et al. 2020, Chipidza and Leidner (2019), Butler et al. (2017), Organisation for Economic Co-operation and Development (OECD) (2016). In South Africa, according to Sibanda and von Solms (2018), there is insufficient external and management support offered, limited ICT budgets, inadequate oversight activities, poor ICT control environment and poor integrated planning. There is lack of integration between ICT tool and the existing systems. There is a view that the decision-makers and the municipalities who are the water and sanitation services provider hesitate to make decisions on untested and/or new systems. Tsokota et al. (2017) identified challenges of insufficient collaboration amongst stakeholders, poor e-service user relationship management, limited infrastructure and enabling services, a lack of integration of systems as well as poor human capacity development in the ICT implementation. Reliable electricity as a source of energy is problematic throughout South Africa, thus, contributing to the unavailability of ICT infrastructure (Etoundi et al. 2016). Mow (2014) highlighted challenges encounters in the implementation of ICT which includes, lack of management at provincial and national levels poor monitoring and evaluation of projects, and ineffective management of national ICT projects and initiatives. Limited financial resources and corruption by service providers abusing few available financial resources meant for ICT projects, is a huge obstacle in managing services. Elkadi (2013) argues that corruption in relation to finances is a huge constraint, however, this can be overcome by appropriate organizational and management structures.

Different effective methods can be implemented to address these challenges, for instance, implementing compliance and quality assurance programmes and designing vital systems which are easy to use, to deal with ICT challenges. Thus, affording acquisition of useful and quality data which enhances success in implementing ICT in the management of water and sanitation services. It is essential to establish realistic and clear goals as well as restrictive policies and regulations for or successful ICT initiatives (Etoundi et al. 2016).

In the study areas, even though ICT use is subject to the implementation of sound ICT government practices and ICT legislation, its implementation is challenging because ICT initiatives collapsed because of these municipalities' inability to absorb ICT tools into their culture and infrastructure. Furthermore, ICT tools (such as computers and software) are not aligned with social and political priorities, and there is a lack of ICT infrastructure, financing and economic instruments, and capacity development. The World Bank and various other international organisations have advocated that ICT should be regulated to enhance the benefits of utilising ICT. According to the International Telecommunications Union (ITU 2014), efficient regulations have been demonstrated to produce better quality service, improved sustainable development, economic growth, rapid growth, and advanced penetration of ICT innovations. The OECD (2016) and ITU (2014) argue that innovative technology requires specialised skills and knowledge, often lacking in developing countries. To deal with the challenges faced, it is essential to implement ICT initiatives with the gradual convergence and integration of ICT solutions applied to managing water and sanitation services (Gourbesville 2016, and Choi et al. 2016).

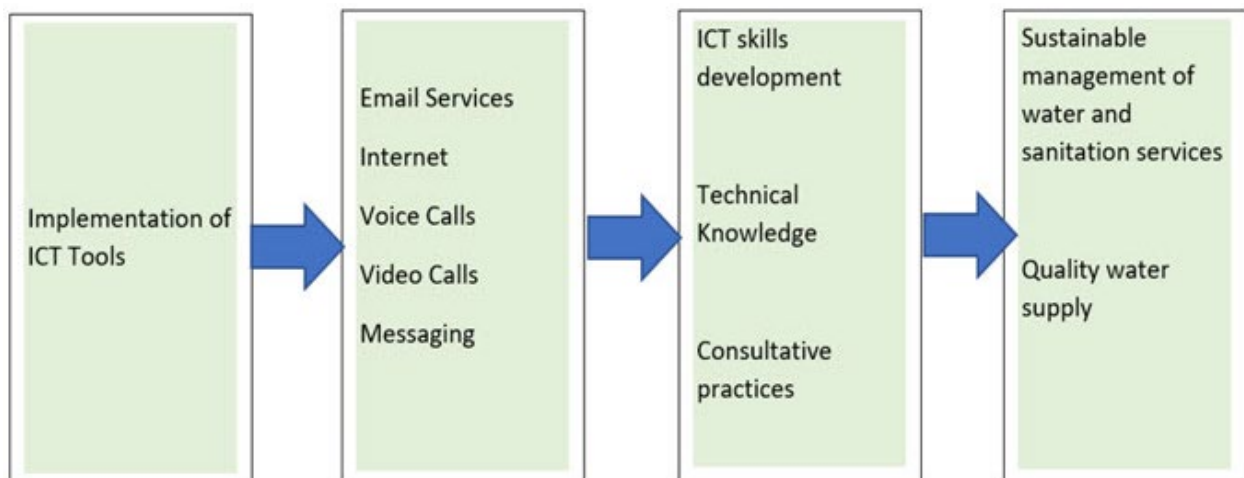
Present and future water and sanitation crises require speedy action, which involves implementing ICT tools for the management of services, improved efficiency provision and treatment, reduction of demand, and development of resources. For this reason, the current study aimed to contribute to the literature on the challenges encountered in the implementation of ICT tools, thus, revealing the contribution of ICT tools to sustainable solutions, collaborative partnership, and resource productivity in the management of water and sanitation services in the KwaZulu-Natal province. Mere access to water and sanitation is not sufficient; it should be accompanied by access to clean and safe drinking water and access to safe and adequate sanitation. In Sub-Saharan Africa and other African countries, there is a rise in open defecation, insufficient water supply and sanitation services, inadequate water and sanitation resources, and management attributable to population growth. Consequently, this leaves many children and families living in impoverished communities at risk of being left behind. Hence, this study advances the understandings of implementing ICT tools in the management of water and sanitation services in South African municipalities by examining the challenges faced.

2.3 Human Capital Development framework

For the past few decades, the Human Capital Development (HCD) framework has been acknowledged as vital to water and sanitation services management, thus promoting sustainability and development of policies (WHO 1982; Carefoot et al. 1984). Skare (2011) and Blair (2011), refer to human capital as knowledge, skills, national or organisational workforce capabilities and elements that build assumptions or opportunities for people to produce innovations or make every effort to achieve higher outputs. It is crucial to understand human development by considering the extensive ecological system within which growth transpires.

The association between humans, ICT, and the environment is significant for assessing whether results are fruitful or stressed. This framework examined how the implementation of ICT tools and HCD can transform the management of water and sanitation services in UDM and UKDM. The implementation of ICT tools, highly skilled labour, and capacity building contributes to improved management of water and sanitation services (Liao et al. 2016). It boosts ICT skills development and improves usage of ICT tools, hence, the contribution towards input and output of human production knowledge in the water and sanitation sector. Moreover, treating the use of ICT tools as a harmonizing element in water and sanitation services management limits the challenges faced in the implementation of ICT tools. Intensifying capacity-building support in the water and sanitation sector in developing states is one of the Sustainable Development Goals' targets. The current study advances understanding of the challenges encountered in implementing ICT tools in the management of water and sanitation services by employing the HDC framework that is based on the assumption that ICT tools can be instrumental and essential in enhancing municipal officials' production capacity.

Figure 2 outlines the association between ICT implementation, HCD, and the management of water and sanitation services. Human capital that can be established through ICT skills development, technical knowledge, and consultative practices leads to communication and distribution of information. This occurs through mobile phones and their applications, computers, and software platforms that permit email services, voice calls, video calls, and messaging services between the service provider and civil society to enhance water and sanitation services management sustainability.



Source: Primary Data

Figure 2 A link between the implementation of ICT tools, HCD, and water and sanitation services management.

Evidence suggests that technology is useful in building capacities of communities and stakeholders from the public and/or private organisations and is crucial to successful knowledge transfer and communication methods (Murphy et al. 2009). Literature suggests that capacity building effectively enhances service providers and service users' ability to conduct their evaluation for cultivating the improvement and accomplishment of services rendered (Fetterman and Wandersman 2017). In this manner, the service users and service providers can be capacitated and achieve sustainable management of water and sanitation services through

the implementation of ICT use, sustaining their livelihoods. Capacity building is not automatically achieved, except when supplemented with proper inputs and appropriate ICT implementation. These views are echoed in the study by Murphy et al. (2009), which claims that for the implementation of ICT tools to be effective, they have to be readily available to users and meet the needs of users (safe water supply and adequate sanitation services). Moreover, they must be more sustainable than using imported tools from the developed world, which might not be easily fixed locally.

Furthermore, the HCD approach helped offer essential support in increasing existing information on water and sanitation services and promoting service providers' accountability. The study contributes knowledge on challenges encountered in implementing ICT tools in the water and sanitation services in developing countries' municipalities by employing the HCD framework. In contrast, several studies explored the use of ICTs in water and sanitation management (Skoulikaris et al. 2018; Rojek and Studzinski 2019; Cavazza et al. 2018). The current study emphasizes the challenges encountered and how these challenges can be counteracted to achieve sustainable management of water and sanitation services in municipalities.

This study advances understanding of the challenges faced in implementing ICT tools to manage water and sanitation services in KZN municipalities and other developing countries by applying the HCD framework. Several studies cited explored emerging water management challenges (Butler et al. 2017; Makropoulos et al. 2018; Juan-Garcia et al. 2017). Simultaneously, the current study emphasises the support of implementing ICT tools in water and sanitation services management through its ability to raise the current workforce's production in several ways, including increasing the knowledge, skills, and capability of municipal officials. Furthermore, it influences organizations' human capital and leads to higher outputs for communities and improved water and sanitation services by different service providers. As a result, investing in human capital has a positive influence on implementing a municipality's activities and technological advancements. By adopting HCD, this study contributes to the literature by paying attention to an approach that understands experts' expertise and competencies in using ICT tools, which is essential for efficient and effective management of water and sanitation services in South African municipalities and other developing countries. Furthermore, it assists in solving crucial policy questions, helping municipalities and service users construct critical and practical judgments, and permits municipalities to address challenges faced in the implementation of ICT tools in the management of water and sanitation services.

3. RESEARCH METHODOLOGY

A qualitative research approach was employed as a plan and procedure that spans the steps from vast assumptions to comprehensive techniques of collecting, analysing, and interpreting data (Creswell and Creswell 2017; Naderifar et al. 2017). The qualitative approach helped researchers better understand the challenges faced in implementing ICT tools to manage water and sanitation services through in-depth interviews, key informant interviews, observations, and available documents. In this manner, this research considered the value of the perceptions of the participants, recognizing their experience and world view, and it holistically focused on the settings and people involved (Hennink et al. 2020). The study applied in-depth interviews,

key informant interviews, observations, and available documents, which helped to better understand the challenges faced in implementing ICT tools in managing water and sanitation services. The interviews allowed discussion of innovative ideas that were crucial in the study (Doody and Noonan 2013). Morgan et al. (2017) states that observation offers an opportunity to record behaviour, activities, and physical traits without relying on the willingness and ability of individuals to respond to questions.

The study was carried out in UDM and UKDM of KwaZulu-Natal province, South Africa because the two district municipalities have been experiencing water woes. Twelve key informant interviewees (municipal officials) and eighteen in-depth interviewees (community members/residents) were selected from the study areas using snowball sampling. This sample size was sufficient, and the study reached data saturation. The sample size was enough to guarantee that significant perceptions were uncovered. Moreover, if the study had more samples, data would have been tedious and, ultimately, superfluous (Babbie 2015). The snowball sampling afforded a chance to acquire rich qualitative data (Marcus et al. 2017). Attention was given to ethical considerations during the study, and it was conducted responsibly and honestly. The study reflected on key ethical concerns, which include consent, confidentiality, honesty, and respect.

The qualitative data was analysed using thematic analysis, which supported an assessment and evaluation of the challenges encountered in implementing ICT tools in the management of water and sanitation in KZN province. Thematic analysis was employed to identify, analyse, and report patterns (themes) within the interviewees' data and document review. It increased the accuracy of data analysis and yielded empirical findings. Moreover, it sought to establish a recursive and fluid frame that varies from the structured and rigid frame used in the traditional codebook method (Braun and Clarke 2006). The study started by transcribing evidence, understanding the study record, categorising transcripts and other data, and discovering key themes, ideas, and concepts. Moreover, the study altered and structured the themes until each evolving theme was acknowledged through each data collection technique. The key thematic categories for analysis were formed from the topics covered in the interview questions, which are the challenges encountered in the implementation of ICT tools for water and sanitation services management. A descriptive approach was applied to focus on lived experiences obtained from the interviews and observation.

By discussing challenges faced in the implementation of ICT tools in the management of water and sanitation services, data was arranged according to the types of challenges encountered by the two municipalities and how these challenges can be counteracted. The fundamental themes provided a structure for empirical analysis. The research applied the use of ATLAS.ti version 8 software in coding data collected, making the analysis of data easier. ATLAS.ti permitted the study to analyse the modeling of themes within the collected data, as well as a universal pathway across the data.

3.1 Research respondents

In this study, the number of key informant interviewees from UDM and UKDM were six from each area, as shown in Table 1. The number of sampled in-depth interviewees from UDM and UKDM consisted of nine from each district municipality. The study's response rate was 100%, which is considered very good, as posited by Martella et al. (2013), who recommend that a response rate be at least 75% and above. Thus, the higher the response rate from a sample, the more reliable the results will be.

Table 1 Key informants and service users interviewed.

Interviewees by Area	Key Informants	No. of Key Informants	In-depth Interviewees	No. of In-depth Interviewees
UDM	Municipal water and sanitation specialists	6	Residents (service users)	9
UKDM	Municipal water and sanitation specialists	6	Residents (service users)	9

Source: Primary Data

The eighteen in-depth participants were the residents of the respective district municipalities. Moreover, the twelve key informants from the two district municipalities are water and sanitation specialists. In terms of human resources, the two district municipalities have appropriately qualified employees with the adequate capacity to implement services in their respective water and sanitation department. The interviews provided insight into the successes and/or failures of the water and sanitation department based on the capability and experience of the municipal officials who render the necessary services.

4. RESULTS

4.1 Challenges encountered in the implementation of ICT tools in the management of water and sanitation services in municipalities

This study analysed qualitative data by classifying themes from data and identifying different relationships between themes. The study identifies primary themes associated with the challenges encountered in the implementation of ICT tools in the management of water and sanitation services. Data collected was coded and organised in accordance with the identified themes. Table 2 shows the identified themes of the study.

Table 2 Primary themes from data.

Themes	Meaning	Evidence from the Data
Lack of consultations on relevant ICT use	Lack of collective decision-making and service user engagement for sustainable water and sanitation services management whereby ICT use is a prerequisite for participation in consultations.	“The service provider does not interact with us as a community on issues pertaining to the management of water and sanitation services. There are no participation opportunities through the internet or social networks to discuss water issues” (In-depth Interviewee 7, 2020)
ICT skills gap (inadequate skills)	Lack of the ability to apply ICTs such as telemetry systems and understanding the information supplied.	“The municipality launched the water leak detector rig, the mobile app, but we were never trained on how to use these ICTs. We just do trial and error” (Key Informant 9, 2020)
Low usage of ICT tools	Lack of ICT tools and ICT community centres to access ICTs for the management of water and sanitation services.	“The municipality is not giving the residents opportunities to learn and apply ICT use in water and sanitation issues. Also, municipalities must provide the residents with free WiFi to access the internet for water and sanitation services management even build community centres with free internet and computers for the residents to use” (In-depth Interviewee 2, 2021)

Source: Primary Data

Lack of consultations on relevant ICT use

Several participants interviewed revealed the challenges encountered in the implementation of ICT tools in the management of water and sanitation services. These include limited consultation on the implementation of ICT tools for communication between the service providers and service users. These ICT tools include mobile phones and their applications, computers, and software platforms such as meter reading, leak detection, pressure sensors, and valve malfunction software platforms. Even though the implementation of ICT tools is crucial for managing water and sanitation services, in UDM and UKDM, there is no dialogue or consultation between service providers and service users on the use of relevant ICT tools, specifically software platforms and mobile phone applications. Subsequently, the study areas lack innovative consultative practices that can afford central ICT use, such as internet use, which is significant in managing water and sanitation sustainability issues. Implementation of mobile phones and their applications and software platforms is vital in collecting accurate data for better planning and efficient monitoring for adequate water and sanitation services management. ICT tools are significant in developing innovative ways of citizen engagement. Planning and establishing knowledge for involvement is progressively collaborative, whereby social networks are widely utilised to broaden consultations and distribute information. Therefore, giving residents and municipal officials the ability to build and strengthen skills and knowledge promotes sustainability.

Participants have revealed that there are no consultations on how to utilise the available municipal mobile phone application to enable successful interactions between the service provider and service users and enable meaningful decision-making regarding the management of water and sanitation services in UDM and UKDM. Furthermore, the in-depth interviews from UDM indicated that the UDM mobile application has discouraged service users from interacting with the service provider on the UDM mobile app platform due to inaccurate information (billing, water interruption notifications) received from the app. One interviewee revealed the following:

“The UDM mobile application is always giving me false information. Whenever I report on the app that there is no water, after a few minutes, the app always says that the problem has been resolved, but my water taps will still be dry. I have stopped using the app because it is unreliable” (In-depth Interviewee 1, 2020).

In South Africa, it is the responsibility of the municipalities to maintain, treat, and potentially advance the water and sanitation management systems, and monitor the quality of water through the implementation of ICT tools, as failure to do so increases health risks through exposure to water-related diseases. Moreover, it is the municipalities' responsibility to invest in the communities, put more effort into access to water and sanitation, and deliver water and sanitation services, which are fundamental human rights.

The information obtained from the key informant interviews, in-depth interviews, observation, and document review showed that UDM and UKDM municipalities have encountered numerous challenges. UDM and UKDM have limited interaction with the implementation of ICT tools with existing programs for provision and management of water and sanitation services. The research question, 'What are the challenges encountered in the implementation of ICT tools in the management of water and sanitation services?' produced the following data:

“In our municipality, we are facing so many water challenges. Ugu District Municipality is always facing water cuts for a long period of time. For example, in 2019, we had no water in our taps for thirteen days in a row with no communication from the municipality. Ugu does not respond to our queries and complaints via email, call centre, Facebook page, and Twitter account, even on their Ugu App” (In-depth Interviewee 2, 2020).

Accordingly, municipalities are responsible for giving service users feedback to improve water and sanitation services management to meet current and future environmental, social, and economic needs. While data collected via SMS is viewed as vital for the delivery and management of water and sanitation services, the study revealed that the municipalities lack effective implementation of ICT tools. Implementing ICT tools that include mobile phones and their applications can avoid water scarcity through integrated management of water and sanitation services and promote efficient and effective decision-making by the municipalities and relevant stakeholders. Furthermore, it promotes accomplishing goals, which includes providing adequate water supply and sanitation services to all. ICT tools such as SMS can help UDM and UKDM connect with and support civil society to boost water and sanitation services management's sustainability. Additionally, mobile phones and their applications can permit service users to fill a knowledge gap and support decision-making, thus presenting the users with options regarding challenges.

ICT skills gap (Inadequate ICT skills)

Data collected using document review and key informant interviews have shown that the two district municipalities have inadequate knowledge of how ICT use can be implemented and the barriers to limiting service users' access to ICT tools. The challenge encountered in implementing ICT tools on water and sanitation services management is that less attention is given to the role of ICT use by municipal officials in the water and sanitation services.

“We have software installed on our computers that aims to share real-time information by networking with every water and wastewater treatment plant under our district municipality. Sometimes we use emails to send information, but the problem is that we were never trained and capacitated on how to use the software; as a result, some plants struggle to use our system and never capture data” (Key Informant 4, 2020).

Results have shown that municipal officials are not putting forth an adequate effort to utilise computers and relevant software to manage water and sanitation services due to limited human capacitation. Thus, leading to insufficient technical skills by officials to implement ICTs for the management of services. Moreover, there is a lack of funding to promote ICT skills, ICT knowledge, and human capacitation for municipal officials to effectively transfer information, and for communication systems (Key Informant 4, 2020; UDM Integrated Development Plan (UDM 2019), and UKDM Integrated Development (UKDM 2019)). Municipal officials' technical skills, particularly, are not balanced with the general lack of ICT skills in these areas due to underfunding and skills migration to metropolitan areas. Key informants have indicated that it is significant to promote workforce capabilities and elements that create opportunities for municipalities to produce innovations or make every effort to achieve higher outputs. Human capacitation and other elements are essential in building opportunities for municipalities to produce innovations and make every effort to achieve higher outputs in the management of

water and sanitation services. ICT integration of the water supply network, sharing real-time information by smart networking and measurement, and healthful water supply management have proven to be significant in managing water and sanitation services. As a result, this can help these two district municipalities, which are struggling to sustain the fast-growing demands, and are aggravated by population growth, irrigated agricultural productivity, climate change, and deteriorating water quality. Moreover, capacity development for the municipal workforce should involve strengthening skills to operate and maintain ICT tools.

Low usage of ICT Tools

Results indicated that the municipalities have limited computers and mobile phones, which are shared amongst the municipal officials; this makes it challenging to store specific information to manage water and sanitation services. Thus, the service providers' low usage of ICT tools is due to the limited availability of ICT tools. Key Informants from both UDM and UKDM have revealed that the municipalities are experiencing a lack of proper management of essential data on water and sanitation services because of the low usage of ICT tools. As a result, the two district municipalities lack updated details of service users to send information (such as bill and water cut notifications) to the users. Consequently, there are inadequate computers and mobile phones for sending, receiving, and storing data. According to Key Informant 3 (2020):

“UKDM municipality do not have updated contact details of their customers; not all residents receive updates on their billing information unless if they physically visit the municipality for their monthly bills”. Inadequate computers, software packages, and mobile applications impact the management of water and sanitation services.

Moreover, the municipalities do not have an effective communication system to send information to service users on the water and sanitation services interruptions. In-depth interviewees from both UDM and UKDM have shown that the two municipalities are not significantly active on the available social network platforms, proving to be a common means of communication. Because of the continually growing and endless evolution of social networks and other ICT innovations, the municipality should address water and sanitation-related queries on social network platforms and encourage service users to join official social networking platforms. Hill (2015); Abade and Alex (2015) have observed the effectiveness of the implementation of ICT tools in boosting the management of water and sanitation services, especially the use of mobile phones and their applications, by making available information concerning provision, management, and development of water and sanitation services. This is evident in the use of the City of Cape Town Municipality's 'fault reporting system' (Hill 2015) and the Kenyan's money transfer services (Abade and Alex 2015) thus, the need to address the challenges faced in the implementation of ICT tools to boost the management of water and sanitation services.

UDM and UKDM lack innovative ways of ICT use that continuously address issues related to the management of water and sanitation services in their areas of jurisdiction. For instance, community-based ICT initiatives such as community ICT centres for data management are non-existent in the two district municipalities. Moreover, the municipalities do not regularly update their websites and/or social media platforms to update service users on interruptions, thus, offering potential technology users a chance to contribute and actively expand and adopt sustainable use. An in-depth participant from UKDM revealed the following:

“Umkhanyakude is very frustrating; as residents, we cannot use any social networks to report water problems in our community. It is cheaper to use Whatsapp or Facebook messages than their call centre where one waits for a long time before answering the call. Most of the time, we always struggle to go through to them via telephone because they rarely pick up calls” (In-depth Interviewee 5, 2020).

In the case of UKDM, there are no official municipal social media platforms to allow the residents to have easy communication and information access on water and sanitation services. In dealing with the challenges of water pipe leaks and burst pipelines, the UDM has launched a leak detection testing rig and a control room for pressure management, which equips UDM with the necessary resources to detect and respond to leaks speedily. Key Informants revealed that this initiative is meant to detect visible and invisible underground leakages, consequently eradicating prolonged water interruptions. According to key informant and in-depth interviews conducted in the UDM, the participants argued that there had not been many changes since the launch of this initiative due to lack of municipal officials' skills and capabilities to implement the initiative. ICT innovations require specialised skills and knowledge to deal with the challenges encountered. The observation and interviews indicated that the municipality is constantly experiencing water leaks; even when reported through an SMS and/or the online form, the municipality does not take immediate action to fix the reported problems. As a result, it is important for South African municipalities to put in place codes of practices that can afford relevant solutions to challenges encountered in the implementation of ICT tools in managing water and sanitation services. Hence, it is vital to advocate for the regulation of ICT implementation to enhance its benefits and advance penetration of ICT innovations.

The two municipalities have inadequate knowledge and pay little attention to utilising ICT tools to manage water and sanitation services and their initiative. The two municipalities have been experiencing poorly organised wastewater management and a lack of wastewater management plans and frameworks due to the lack of implementation of ICT tools, specifically mobile phones, and their applications. Moreover, the municipalities also experience inadequate funding, which negatively impacts the implementation of ICT initiatives/projects and operations and maintenance in managing water and sanitation services. Data collected in this study has also revealed that corruption in the municipalities affects ICT implementation for water and sanitation initiatives or projects and the provision, delivery, and management of water and sanitation services; therefore, impacting the sustainability and equitability of service delivery. Consequently, the challenges of implementing ICT tools and the management of water and sanitation services are draining the existing infrastructure and non-compliance with the norms and standards of the municipality's water and sanitation services.

4.2 How the municipality is applying solutions to these challenges

Dialogues on ICT use for the management of water and sanitation services

The implementation of ICT tools, specifically mobile phones and their applications, can help address various challenges in the management of water and sanitation services such as limited interaction on ICT tools implementation, inadequate technical skills, and limited ICT tools and initiatives. The study's findings have revealed that it is crucial to address the challenges linked

to the implementation of ICT tools and the management of water and sanitation services. Participants claim that implementing ICT tools can curb challenges in the water and sanitation sector by adding value to the management of services through technical consultations and the implementation of water and sanitation systems. Thus, it supports the facilitation of efficient and effective accountability and decision-making in the management of water and sanitation services. Human capacitation is essential in dealing with challenges linked to the implementation of ICT tools and the management of services. A key informant participant revealed the following on the solutions implemented by the municipalities based on the challenges faced:

“The KZN province is in the process of conducting provincial dialogues known as ‘the Water Indabas’ to address challenges faced in the water and sanitation services. These Indabas are addressing all the issues concerning the province, although the government has not touched more on the ICT issues related to water and sanitation.” (Key Informant Interviewee 8, 2020).

Establishment of ICT initiatives

Key informant interviews and observation have shown that there is a need for the service providers to develop a plan on ICT initiatives and infrastructure development that helps the municipalities with information on the maintenance of the current infrastructure and disruption of services. Key informants have highlighted that UDM and UKDM should efficiently and effectively implement ICT tools to revamp the water and wastewater treatment plants, the raw water system, the water pumps, pipework, reservoirs flow, level control, energy supply, and telemetries. Furthermore, monitoring reservoir levels, flowmeter, wastewater management, and other output instruments can facilitate the water stability audit in actual time, thus enabling sustainable management of water and sanitation services.

The study has revealed that it is essential to encourage residents to report incidents related to service interruption and for service providers to analyse faults in service delivery using ICT tools such as mobile phones and their applications, as promoted in the study by Hill (2015). Furthermore, there is a need to enhance communication and distribution of information between the service provider and the service users. Participants from the study suggested that the district municipalities can use proven innovative ICT tools such as mobile phones and computers through sustainable designs with reliable treatment systems for greywater and wastewater, which can meet the primary performance standards for water treatment.

Even though UDM implements some ICT tools to provide better services to the residents, such as ICT tools that monitor the reservoir, flowmeter, and additional output instruments to enable the water stability audit in real-time, the implementation is always a problem because of the load shedding of electricity, and the municipality does not have power backup (*Key Informant Interviewee 1, 2020*).

For such ICT tools to function uninterruptedly and counteract the challenges faced in implementing ICT tools during power outages, there is a need to have power backup plans, such as generators and solar energy. UDM and UKDM should ensure equal and adequate service delivery and distribution of water and sanitation resources and promote the capacity for engagement between the service providers and service users through electronic platforms.

5. DISCUSSION

This study advances the understandings of the implementation of ICT tools in the management of water and sanitation services in municipalities in the KZN province, South Africa, by examining the challenges linked to implementing ICT and managing water and sanitation services.

Accordingly, several challenges faced in the study areas are triggered by the municipal authorities' incapability to sustain services through the implementation of ICT tools, specifically mobile phones and their applications. In accordance with the HCD framework, Fetterman and Wandersman (2017), and Liao (2016), human capacitation in the implementation of ICT tools is crucial to transfer knowledge successfully, and as a communication method. Moreover, it affords service providers and relevant stakeholders the ability to conduct evaluations for cultivating the improvement and accomplishment of management of services. Most participants in this study find human capacitation and skills development important in building opportunities for municipalities to implement ICT tools and produce innovative initiatives to achieve higher outputs. The study areas continue to face poor water and sanitation services management, which limits the availability of quality drinking water and adequate sanitation for all societal classes. These have been mostly caused by the inadequate implementation of ICT tools that have permitted infrastructure degradation. The two municipalities have insufficient knowledge and pay less attention to implementing ICT tools and ICT projects to manage water and sanitation services. This study supports the view that implementing ICT tools is vital in building civil society capacities for effective knowledge transfer and communication.

KZN municipalities experience inadequate funding for implementing ICT tools and ICT initiatives, which can help address water and sanitation services management challenges. By considering the implementation of ICT tools, specifically mobile phones and their applications, through the HCD framework, it is significant and draws attention to how ICT tools can help to report incidents related to service interruption and analyse faults in service delivery. This, in turn, helps promote sustainable management of service. Implementing ICT tools in the management of services expands the efficiency of water systems and decreases demand. The findings of the study suggest that these improvements in the ICT implementation and management of water and sanitation services are significant in sustainability, and a crucial empowering feature for enhanced resilience of operations in water-scarce situations.

The current study supports existing literature by Abade and Alex (2015), Ssozi-Mugarura et al. (2015), Hill (2015), Rediana and Pharmasetiawan (2017), and Chemisto and Rivett (2018) in demonstrating the relationship between the implementation of ICT tools and management of water and sanitation services. Additionally, it supports the view that ICT solutions and involved restriction measures increase service delivery and management intervention of ICT in water and sanitation services management. Moreover, studies by Chemisto and Rivett (2018), Kedia (2015), Hill (2015), and Chisholm et al. (2013) indicates that ICT tools can improve water and sanitation management and ensure effective ways of communicating on related challenges as a key to the maintenance and enhancement of service delivery systems. Addressing challenges related to implementation of ICT tools and the management of water and sanitation services will permit water and sanitation service providers to reach community needs by sharing information needed on water and sanitation services at various municipal levels.

From the data collected, there appeared to be a small variation between solutions to the challenges linked to how to implement ICT tools in the management of water and sanitation services. ICT emerges as an essential factor in supporting the sustainability, improving access to, and the effectiveness of water and sanitation services. Municipalities as service providers have not addressed the challenges of deploying ICT tools in water and sanitation services management. In this regard, this study supports the observations by Ferreira et al. (2020), Chipidza and Leidner (2019), Butler et al. (2017), and OECD (2016) about the importance of examining the challenges linked to the implementation of ICT tools in the management of water and sanitation services.

The study focused on the challenges encountered in the implementation of ICT tools on water and sanitation services management and solutions that can be applied to help municipalities diagnose challenges. Furthermore, solutions to monitor water resources, protect and control water and sanitation management, and solve water-related challenges, thus increase the effectiveness of water and sanitation services management. Implementation of ICT tools on water and sanitation services management should be carried out to support and promote the development and eliminate inequality. Addressing efficiency, sustainability, and equity in access to water and sanitation services and water resources in the management of water and sanitation services is significant in promoting fairness and giving attention to all community members' needs. Furthermore, software platforms, mobile phones, and their applications relevant to water and sanitation services management can support and/or educate water and sanitation management decision-making processes. Moreover, acknowledging the dynamic role of using ICT tools, addresses the complex challenges encountered in the sector and establishes interdisciplinary and practical resolutions to the crisis with meaningful impacts on the service users and the nation at large.

From this study, it is clear that improvement on capacitation development for municipal officials and the civil society is essential for the sustainable development of water and sanitation services management. Thus, it is significant that ongoing research on the use of ICT tools in the management of water and sanitation services continues; to embrace the skills, capacity, and knowledge empowerment of municipal officials together with service users and relevant stakeholders.

6. CONCLUSION

This study investigated the challenges faced in implementing ICT tools in managing water and sanitation services in the KwaZulu-Natal province, South Africa. The study revealed challenges faced in applying ICT tools in the management of water and sanitation services in municipalities. UDM and UKDM have been experiencing water shortages due to challenges linked to water and sanitation services management and implementing ICT innovations, making the district municipalities struggle to sustain the increasing water demands, security, and availability in the jurisdiction. The planning of and associations amongst ICT tools, water and sanitation service providers, water and sanitation services users, and management of water and sanitation services, linking them to delivering services is essential. Thus, holistically addressing

problems to stimulate the management of water and sanitation services and enhance multiple interdependences. The implications of this research are to embrace the need for ICT tools in enabling the integrated management of water and sanitation services in South Africa and other developing countries. Mobile phones and applications are essential for enhancing information flow in the management of water and sanitation services by tracking water and sanitation systems' performance and reporting operational data.

Nevertheless, little has been done in the implementation of ICT tools in the management of water and sanitation services during this digital era. Moreover, municipalities have limited efforts to implement ICT tools in the water and sanitation services management primarily due to limited knowledge by municipal officials and service users. The government at all levels and relevant stakeholders ought to offer a more standardised and comprehensive method for the implementation of ICT tools and management of services, which may aid to curb the challenges encountered, and add value to the management of water and sanitation services through technological developments in the water and sanitation sector.

ACKNOWLEDGEMENTS

The authors hereby acknowledge the participants from Ugu and Umkhanyakude District Municipalities for taking part in this study.

REFERENCES

- Abade, O.E., and O.G. Alex. 2015. "Mobile phone supported water dispensing system for the "un-watered" population." In *AFRICON 2015* (pp. 1–4). IEEE.
- Babbie, E.R. 2015. "The basics of social research." Nelson Education. Boston, USA.
- Blair, M.M. 2011. "An Economic Perspective on the Notion of 'Human Capital'". In *The Oxford Handbook of Human Capital*, eds. A. Burton-Jones and J.C. Spender. Oxford Handbooks Online. <https://doi.org/10.1093/oxfordhb/9780199532162.003.0002>.
- Braun, V., and V. Clarke. 2006. "Using thematic analysis in psychology." *Qualitative Research in Psychology* 3 (2): 77–101.
- Brown, A.C., J. Stern, B. Tenenbaum, and D. Gencer. 2006. "Handbook for evaluating infrastructure regulatory systems." *The World Bank Publications*.
- Butler, D., S. Ward, C. Sweetapple, M. Astaraie-Imani, K. Diao, R. Farmani, and G. Fu. 2017. "Reliable, resilient and sustainable water management: the Safe & SuRe approach." *Global Challenges* 1 (1): 63–77.
- Carefoot, N., H. Gibson, and World Health Organization. 1984. "Human resources development handbook: guidelines for ministries & agencies responsible for water supply and sanitation (No. WHO/CWS/ETS 84.3. Unpublished)." World Health Organization.
- Cavazza, F., F. Galioto, M. Raggi, and D. Viaggi, D. 2018. "The role of ICT in improving sequential decisions for water management in agriculture." *Water* 10 (9): 1141.

- Chemisto, M., and U. Rivett. 2018. "Examining the adoption and usage of an e-government system in rural South Africa: Examining e-government system adoption." In *2018 Conference on Information Communications Technology and Society (ICTAS)*, pp. 1–6. IEEE.
- Chipidza, W., and D. Leidner. 2019. "A review of the ICT-enabled development literature: towards a power parity theory of ICT4D." *The Journal of Strategic Information Systems* 28 (2): 145–174.
- Chisholm, A.A., C.L. Genda, S.Pailla, J.L. Martin, A.M. Thrash, K.J. Sheehy, and G.E. Louis. 2013. "Devclear: An information-sharing platform for rural development." In *Proc. IEEE Systems and Information Engineering Design Symp. (SIEDS)*, Apr. 2013, pp. 201–206. IEEE, Charlottesville.
- Choi, G.W., K.Y. Chong, S.J. Kim, and T.S. Ryu. 2016. "SWMI: new paradigm of water resources management for SDGs." *Smart Water* 1 (1): 1–12.
- Creswell, J.W., and J.D. Creswell. 2017. *Research design: Qualitative, quantitative, and mixed methods approaches*, Fifth Edition. Sage Publications.
- Democratic Alliance KwaZulu-Natal. 2017. "MEC Dube-Ncube must focus on resolving Ugu water crisis." Available at: <http://www.dakzn.org.za/mec-dube-ncube-must-focus-on-resolving-ugu-water-crisis/>. Accessed 16 March 2020.
- Department of Water Affairs. 2013. "National Water Resource Strategy." South Africa.
- Doody, O., and M. Noonan. 2013. "Preparing and conducting interviews to collect data." *Nurse Researcher* 20 (5).
- Elkadi, H. 2013. "Success and failure factors for e-government projects: A case from Egypt." *Egyptian Informatics Journal* 14 (2): 165–173.
- Etoundi, R.A., S.F.M. Onana, A.A. Eteme, and M.L.F Ndjodo. 2016. "Special issue on ICT for Africa development: An introduction and framework for research." *The Electronic Journal of Information Systems in Developing Countries* 76 (1): 1–11.
- Ferreira, J.J., C.I. Fernandes, and F.A. Ferreira. 2020. "Technology transfer, climate change mitigation, and environmental patent impact on sustainability and economic growth: A comparison of European countries." *Technological Forecasting and Social Change* 150, 119770.
- Fetterman, D., and A. Wandersman. 2017. "Celebrating the 21st anniversary of empowerment evaluation with our critical friends." *Evaluation and Program Planning* 63: 132–135.
- Gourbesville, P. 2016. "Key challenges for smart water." *Procedia Engineering* 154: 11–18.
- Hennink, M., I. Hutter, and A. Bailey. 2020. *Qualitative research methods*. Sage Publications.
- Hill, W.C. 2015. "E-Governance: Silencing vulnerable populations." *Procedia Engineering* 107: 181–185.
- Independent Online. 2017a. "Hardship and heroes in Ugu water crisis." Available at: <https://www.iol.co.za/news/south-africa/kwazulu-natal/hardship-and-heroes-in-ugu-water-crisis-11897968>. Accessed 25 January 2020.
- Independent Online. 2017b. "Ugu district without water for 2 weeks." Available at: <https://www.iol.co.za/sunday-tribune/news/ugu-district-without-water-for-2-weeks-11381276>. Accessed 25 January 2020.
- Independent Online. 2018. "Ugu municipality water sabotage won't affect tourism." Accessed 25 January 2020.

- International Telecommunications Union (ITU). 2014. "Trends and development in the telecommunications environment." *International Telecommunications Union*. Available at <https://www.itu.int/pub/D-PREF-TTR>. Accessed 12 March 2020.
- Jothirathne, P.A.A.U., and C. Pushpakumara. 2017. "Review the Sri Lankan Information and Communication Technology Industry." *International Journal of Management, Accounting and Economics* 4 (2), 31, 178–187.
- Juan-Garcia, P., D. Butler, J. Comas, G. Darch, C. Sweetapple, A. Thornton, and L. Corominas. 2017. "Resilience theory incorporated into urban wastewater systems management. State of the art." *Water Research* 115: 149–161. <https://doi.org/10.1016/j.watres.2017.02.047>
- Kedia, N. 2015. "Water quality monitoring for rural areas-a sensor cloud based economical project." In *2015 1st International Conference on Next Generation Computing Technologies (NGCT)*, 50–54. IEEE.
- Liao, H., B. Wang, B. Li, and T. Weyman-Jones. 2016. "ICT as a general-purpose technology: The productivity of ICT in the United States revisited." *Information Economics and Policy* 36: 10–25.
- Madon, S., S. Krishna (Eds.). 2018. *The Digital Challenge: Information technology in the development context*. Routledge, New York.
- Makropoulos, C., D. Nikolopoulos, L. Palmen, S. Kools, A. Segrave, D. Vries, S. Koop, H.J. van Alphen, et al. 2018. "A resilience assessment method for urban water systems." *Urban Water Journal* 15, 4: 316–328. <https://doi.org/10.1080/1573062X.2018.1457166>
- Marcus, B., O. Weigelt, J. Hergert, J. Gurt, and P. Gelléri. 2017. "The use of snowball sampling for multi-source organizational research: Some cause for concern." *Personnel Psychology* 70 (3): 635–673.
- Martella, R.C., J.R. Nelson, R.L. Morgan, and N.E. Marchand-Martella. 2013. *Understanding and interpreting educational research*. Guilford Press, New York.
- Meissner, R., and I. Jacobs-Mata. 2016. "South Africa's Drought Preparedness in the Water Sector: Too Little Too Late." SAIIA, Policy Briefing 155.
- Mena Report. 2015. "South Africa: Water and Sanitation sets aside R352, 4 million to help drought-stricken areas in KwaZulu Natal." Mena Report, 24 Jan 2015. Academic OneFile. Available at: <http://link.galegroup.com/apps/doc/A398657950/AONE?u=27uos&sid=AONE&xid=639e54d2>. Accessed 22 Mar 2020.
- Mena Report. 2016. "South Africa: Water and Sanitation on KwaZulu Natal dam levels." Mena Report, 11 Aug 2016. Academic OneFile. Available at: <http://link.galegroup.com/apps/doc/A462411658/AONE?u=27uos&sid=AONE&xid=aba620dc>. Accessed 22 March 2020.
- Morgan, S.J., S.R. Pullon, L.M. Macdonald, E.M. McKinlay, and B.V. Gray. 2017. "Case study observational research: A framework for conducting case study research where observation data are the focus." *Qualitative Health Research* 27 (7): 1060–1068.
- Mow, I.T.V.C. 2014. "Issues and Challenges, Strategies and Recommendations, in the development of ICT in a small island developing state: The case of Samoa." *The Electronic Journal of Information Systems in Developing Countries* 63 (1): 1–24.
- Mukhtarov, F., C. Dieperink, and P. Driessen. 2018. "The Influence of Information and Communication Technologies on Public Participation in Urban Water Governance: A Review of Place-Based Research." *Environmental Science and Policy* 89: 430–438.

- Muller, H. 2014. "The South African experience on legal, institutional and operational aspects of the rights to water and sanitation." *Aquatic Procedia* 2: 35–41.
- Municipalities South Africa. 2021. *KwaZulu-Natal Province Municipalities*. Available at: <https://municipalities.co.za/provinces/view/4/kwazulunatal#:~:text=KwaZulu%20Natal%20is%20divided%20into,subdivided%20into%2043%20local%20municipalities>. Accessed 16 March 2021.
- Murphy, H.M., E.A. McBean, and K. Farahbakhsh. 2009. "Appropriate technology—A comprehensive approach for water and sanitation in the developing world." *Technology in Society* 31 (2): 158–167.
- Murthy, S., D. Shemie, and F. Bichai. 2018. "The Role of Adaptation in Mobile Technology Innovation for the Water, Sanitation and Hygiene." *Water Practice and Technology* 13 (1).
- Naderifar, M., H. Goli, and F. Ghaljaie. 2017. "Snowball sampling: A purposeful method of sampling in qualitative research." *Strides in Development of Medical Education* 14 (3): 1–6.
- Ntuli, N., and A. Abu-Mahfouz. 2016. "A simple security architecture for smart water management system." *Procedia Computer Science* 83: 1164–1169.
- National Water Resource Strategy (NWRS2). 2013. *National Water Resource Strategy: Water for an Equitable and Sustainable Future*. June 2013 Second Edition, Dept. of Water Affairs, Republic of South Africa. Available at: [https://www.dws.gov.za/documents/Other/Strategic%20 Plan/NWRS2-Final-email-version.pdf](https://www.dws.gov.za/documents/Other/Strategic%20Plan/NWRS2-Final-email-version.pdf)
- Organisation for Economic Co-operation and Development (OECD). 2016. *OECD Science, Technology, and Innovation Outlook, 2016 Country Profile*. OECD Publishing, Paris.
- Qu, X., P.J. Alvarez, and Q. Li. 2013. "Applications of nanotechnology in water and wastewater treatment." *Water Research* 47 (12): 3931–3946.
- Rediana, R., and B. Pharmasetiawan. 2017. "Designing a business model for smart water management system with the smart metering system as a core technology: Case study: Indonesian drinking water utilities." In *2017 International Conference on ICT For Smart Society (ICISS)*, 1–6, IEEE.
- Rivett, U., M. McLaren, H. Arito, T. Pashapa, R. Solomon, and C. Jacobs. 2018. "Assessing the impact of a mobile application in promoting responsible household water use: a Cape Town case study." *Water Research Commission*, South Africa.
- Rojek, I., and J. Studzinski. 2019. "Detection and localization of water leaks in water nets supported by an ICT system with artificial intelligence methods as a way forward for smart cities." *Sustainability* 11 (2): 518.
- RSA (Republic of South Africa). 1996. *Constitution of the Republic of South Africa (Act 108 of 1996)*. Government Gazette No. 25799.
- Ryder, G. 2018. "How ICTs can ensure the sustainable management of water and sanitation." *ITU News*. Geneva: International Telecommunication Union.
- Salesforce. 2014. "Mobile behavior report." Salesforce Marketing Cloud. <https://brandcdn.exacttarget.com/sites/exacttarget/files/deliverables/etmc-2014mobilebehaviorreport.pdf>
- Sibanda, M., and R. von Solms. 2018. "Devising a strategy for IT governance implementation in municipalities. A case study of South Africa." *The Electronic Journal of Information Systems in Developing Countries* 85 (2): e12067. <https://doi.org/10.1002/isd2.12067>
- Skare, M., 2011. "How important is Human Capital for Growth in Reforming Economies?." *Technological and Economic Development of Economy* 17 (4), 667–687. Routledge, London.

- Skoulikaris, C., Y. Filali-Meknassi, A. Aureli, A. Amani, and B.E. Jiménez-Cisneros. 2018. *Information-communication technologies as an Integrated Water Resources Management (IWRM) tool for sustainable development. Integrated River Basin Management for Sustainable Development of Regions*. InTech Publications, London, UK, pp.179-200.
- Ssozi-Mugarura, F., E. Blake, and U. Rivett. 2015. "Designing for sustainability: Involving communities in developing ICT interventions to support water resource management." In *2015 IST-Africa Conference* , pp. 1-8. IEEE.
- States News Service. 2016. "President Zuma Commits Government to Provide Extra Support to Drought Hard-Hit Areas." States News Service, 3 Apr. 2016. Academic OneFile. Available at <https://go.gale.com/ps/i.do?p=AONE&u=27uos&id=GALE|A448334859&v=2.1&it=r&sid=AONE&asid=40c59f74>. Accessed 22 Aug 2020.
- Taylor, K., and L. Silver. 2019. "Smartphone ownership is growing rapidly around the world, but not always equally." Pew Research Center, Washington, DC, USA.
- The World Bank. 2015. "Mobile cellular subscriptions (per 100 people) – Lower middle income." International Telecommunication Union (ITU) World Telecommunication/ICT Indicators Database. Available at <https://data.worldbank.org/indicator/IT.CEL.SETS.P2?locations=XX>.
- Tsokota, T., R. Von Solms, and D. van Greunen. 2017. "An ICT strategy for the sustainable development of the tourism sector in a developing country: a case study of Zimbabwe." *The Electronic Journal of Information Systems in Developing Countries* 78, 1: 1-20.
- Ugu District Municipality (UDM). 2019. Ugu District Municipality – Home. Available at: <http://www.ugu.gov.za/Pages/About-Us.aspx>. Accessed 6 September 2019. Port Shepstone, South Africa.
- Umkhanyakude District Municipality (UKDM). 2019. Umkhanyakude District Municipality. Available at: <https://www.ukdm.gov.za/index.php/municipality/background>. Accessed 6 September 2019. Mkuze, South Africa.
- United Nations (UN). 2015. "UN-Water Releases Publication on Eliminating Discrimination and Inequalities in Access to Water and Sanitation." United States. Available at: <http://www.unwater.org/news-events/news-details/en/c/340338/>. Accessed 25 July 2020.
- United Nations Water (UN Water). 2019. World Water Development Report 2019: 'Leaving no one behind'. United States. Available at: <https://www.unwater.org/publications/un-world-water-development-report>. Accessed 14 July 2019.
- Water Services Act (WSA). 1997. "The Water Services Act (WSA) 108 of 1997". South Africa.
- World Health Organisation (WHO). 1982. "Basic Strategy Document on Human Resources Development: Recommendations of the Task Force on Human Resources Development of the IDWSSD." Geneva, Switzerland. Available at: <http://www.who.int/iris/handle/10665/58550>. Accessed 16 March 2018.
- World Health Organisation (WHO). 2014. "Preventing Diarrhoea through Better Water, Sanitation and Hygiene: Exposures and Impacts in Low- And Middle Income Countries." WHO Press, Geneva, Switzerland. Available at https://apps.who.int/iris/bitstream/handle/10665/150112/9789241564823_eng.pdf;jsessionid=FB83FD05CECE6C08E1F0C85BFA476C88?sequence=1. Accessed 16 March 2020.
- World Health Organisation (WHO). 2019. "Drinking-water." Geneva, Switzerland. Accessed 18 September 2019.