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DEPARTMENT OF CIVIL & CONSTRUCTION ENGINEERING

Assessing Deployment of Emerging Innovations and Technologies in Catalysing Sustainable Water Services Provision in Nairobi City County, Kenya: Case of Soweto Kayole Jisomee Mita

MSc Thesis

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F56/34956/2019

A thesis submitted in partial fulfilment of the requirements for the award of the Degree of Master of Science in Civil Engineering (Water Resources Engineering) at the Department of Civil and Construction Engineering, University of Nairobi.

JULY 2023

DECLARATION AND APPROVAL

This thesis is my original work. I also affirm that to the best of my knowledge; this has not been presented for a degree in any other university.

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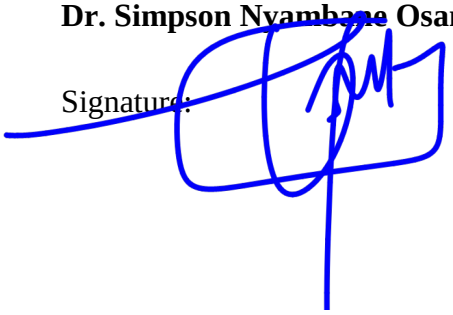
Signature:  Date: 02/Aug/2023

DECLARATION OF ORIGINALITY

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DEDICATION

This thesis is dedicated to my parents Alfred Obunga and Penina Akeyo, my spouse Caroline Anyango Ouma; Our sons Hempstone Opiyo Ouma, Humphrey Odongo Ouma, Mark Okello Ouma (the late) and Teddy Wallace Ouma; and finally to my boss and mentor Prof. Tom P.M. Ogada, the Executive Director of ACTS and the former Chairman of NACOSTI, currently Chairman of KENIA for their unwavering support both emotionally, socially and financially.

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Finally, I am thankful and grateful to God for the precious gift of life, good health and all the provisions. It is through God's grace, mercy and love that I am able to accomplish this work.

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ABBREVIATIONS AND ACRONYMS

4IR	Fourth Industrial Revolution
AfDB	Africa Development Bank
AI	Artificial Intelligence
AMCOW	African Minsters' Council on Water
AWWDA	Athi Water Works Development Agency
CDAs	Community Development Assistants
FGD	Focus Group Discussions
GIS	Geographical Information System
GLL	Grundfos Lifelink
GoK	Government of Kenya
GPOBA	World Bank Global Partnership on Output Based Aids
GRACE	Gravity Recovery and Climate Experiment
GWP	Global Water Partnership
IBT	Integrated Block Tariff
IDA	International Development Association
iMoMo	Innovative Monitoring & Modelling
IoT	Internet of Things
IWMI	Integrated Water Resource Institute
IWRA	International Water Resources Association
IWRM	Integrated Water Resource Management
JM	Jisomee Mita
Kes	Kenyan Shilling
KII	Key Informant Interview
KISIP	Kenya Informal Settlement Improvement Project
MoWSI	Ministry of Water, Sanitation and Irrigation
NACOSTI	National Commission on Science Technology & Innovation
NASA	National Aeronautics and Space Administration
NCWSC	Nairobi City Water and Sewerage Company
NGWMN	National Groundwater Monitoring Network
NRW	Non Revenue Water
NWHSA	National Water Harvesting and Storage Authority
NWIS	National Water Information System
NWMP	National Water Master Plan
OBA	Output Based Aid

PESTEL	Political, Economic, Social, Technological, Environmental and Legal
PPD	Pre-Paid Water Dispenser
SCADA	Supervisory Control & Data Acquisition
SCP	Social Connections Policy
SDGs	Sustainable Development Goals
STI	Science Technology and Innovations
SWM	Smart Water Management
SWOT	Strength Weakness Opportunities and Threats
TFAs	Technology Focus Areas
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNICEF	United Nations International Children's Emergency Fund
USAID	United States Agency for International Development
WASH	Water Sanitation and Hygiene
WaSHMIS	Water Sanitation Hygiene Management Information System
WASREB	Water Services Regulatory Board
WaSSIP	Water & Sanitation Services Improvement Project
WB	World Bank
WIPs	Water Innovation Partnerships
WRA	Water Resources Authority
WRMA	Water Resources Management Authority
WRUAs	Water Resources Users Association
WSBs	Water Service Boards
WSPs	Water Services Providers
WSTF	Water Sector Trust Fund
WWDAs	Water Works Development Authority

ABSTRACT

Water services provision and sanitation challenges are still prominent in the informal settlements such as Soweto Kayole (SK) characterised by poor water distribution networks, high population with low income level while posing high demand for water supply which the water utility cannot manage to meet as evidenced with frequent water supply rationing. Deployment of Jisomee Mita (JM) intervention as an emerging technology and innovation could help residents of Nairobi City County and Nairobi City Water and Sewerage Company (NCWSC) with more efficient, innovative, and profitable water services provision. The study assessed the successes and challenges of deployment of technology and innovation in catalysing sustainable water services provision, in SK slum, Nairobi City, Kenya. A total of 329 interviewed including local residents, landlords, staff from NCWSC and World Bank, apart from local water vendors, operators and community representatives. Descriptive statistics and correlational analysis used to analyse the data and descriptive statistics used to interpret the findings. Inferential statistics used to establish the level of deployment of technology and innovation in catalysing sustainable water services provision. Main finding was that JM as an emerging technology and innovation was not fully aligned to the expectations of the residents of SK as depicted by the numerous misalignments both internally and externally denying the poor residents their intended water tariff benefits instead transferring to the rich property owners. JM initiative however proved feasible for the informal settlement and can be scaled up provided that the existing structures are strengthened, pro-poor and social connection policy promoted by the government and innovative financing and community engagement and participation explored appropriately. Government of Kenya and key stakeholders should prioritize and promote innovative financing for water provision, management of non-revenue water, adoption and uptake of pro poor strategies, social policy and emerging technologies and innovations to help in sustainability and management of the water services provision to the populace. The success of deploying science technology and innovation in the sector is enhanced efficient and effective delivery of critical and essential services while the main challenge is on the initial costs required and adoption and uptake by end users.

CHAPTER ONE

1.0. INTRODUCTION

1.1. Background of the Study

Africa has a combined population of over one billion people and represents about 17% of the global population (UN, 2019). Its water resources are estimated to be nearly 9% of the world's freshwater resources (FAO, 2005 & AQUASTAT, 2020). Water security pose an eminent dynamic and complex challenge for the continent with a growing population, a changing and more volatile climate leading to floods and water shortages in different parts of the continent, demographic changes, urbanization, water quality, diminishing supplies of water from aquifers, and potential for conflict over water resources (AQUASTAT, 2020 and Adelana, S. M. A., & Macdonald, A. M. 2008). In 2017, the United Nations estimated that globally 2.2 billion persons are without safely managed drinking water, including 785 million without even basic drinking water, and 4.2 billion without safely managed sanitation (www.sdgs.un.org).

The Africa Water Vision for 2025 is in tandem with the African Vision for 2063, the United Nations (UN) Sustainable Development Goals (SDGs) and Kenya Vision 2030 and the current president big four agenda. Goal number 6 of the UN's SDGs has the following eight targets including provision of drinking water (6.1), sanitation and hygiene services (6.2), treatment and reuse of wastewater and ambient water quality (6.3), water-use efficiency and scarcity (6.4), transboundary cooperation (6.5), protecting and restoring water-related ecosystems (6.6), international cooperation and capacity building (6.a), and participation in water and sanitation management (6.b) (UNESCO, UN Water, 2020). The targets and their indicators are shown below. The report released by Network of African Science Academies in 2014 purport that the current progress of the implementation of SDG 6 in Africa is unclear whether the SDG 6 water security targets will be achieved by 2030. The Africa Water Vision 2025 also offers a context within which water security and sustainable management of water resources could be achieved.

Science and technology and innovation are the major drivers for Africa and global prosperity and has assisted to realize the ever-increasing demands in the water sector. Africa's Agenda 2063 has recognized STI as a tool and enablers necessary for achieving the development goals (AUC, 2014). Also, the Agenda 2063 has emphasized that, for sustained growth, economic transformation, and competitiveness to be achieved in Africa, there must be continuous investment in new technologies and innovation in several sectors including clean energy, water, health, education, agriculture. Africa is well-placed to leapfrog to new ways of operating when

it comes to technology and innovation. The Science, Technology and Innovation Strategy for Africa (STISA-2024) aimed at achieving the AU vision calls for increasing efficiency while eliminating duplications when designing and implementing STI policies nationally and regionally (African Union Commision, 2014).

Ever increasing rate of urbanisation is exacerbating challenges of water management in Nairobi city and across most of the cities in the regions (UN-Water, 2020). Accounting for urban water, combining data from hydraulic and hydrological modelling, measurements from fields and remote sensing, can improve understanding of the urban water cycle and can help to address complex and dynamic urban water challenges. This includes quantifying the amount of water entering and leaving a city, assessing the impact of green infrastructure, and optimising urban rainfall harvesting techniques.

Jisomee Mita initiative was rolled out in Soweto Kayole in 2014 and employed community sensitization approach where staff and residents/ landlords were trained on the use of the technology and its functionalities. At the project inception, resistance to the unknown new technology was faced. This necessitated establishment of an office dedicated to Soweto Kayole residents by Nairobi City Water and Sewerage Company was prioritized. Under the social connection policy, the office handled water accounts and emerging complaints related to the new technology, besides conducting continuous outreach, training, and communication that was necessary in ensuring the customers are conversant with the new technology and can use it with ease. Moreover, the system went through constant technological improvements to match up with the changing trends (World Bank Group, 2015).

1.2. Problem Statement

Deployment of emerging technologies and innovations, processes and knowledge that can help to make Nairobi City more efficient, innovative, and profitable is foreseen to be vital in the near future. However, lack of coordinated efforts and unpredictable trends, calls for a well thorough thought out strategies by the research and innovation sector players to offer solutions to the highly unique, diverse and interrelated challenges especially similar to the case in Soweto Kayole where JM intervention has been initiated to offer possible solutions. Major innovative investments is required in the current innovation platforms, policy and enterprise to involve/ engage, with a portfolio of long, medium and short-term programmes stimulating and promoting business incubation and investment, and aiding both national and county governments to meet UN's SDG #6 targets besides environmental and climate targets, as well as social objectives.

However, identifying how to invest and maximize the impacts of the emerging innovations and technologies in water services start with understanding the present use of these technologies in the water sector, current institutional and decision-support frameworks and financial mechanisms associated with use in the context of water services provision, assessing science, technology and innovation (STI) actions, and identifying promising future STI initiatives for achieving water services provision in Nairobi City County, Kenya is still lacking and this is the main problem of this study. With STI actions varying from location to location, specific analysis of STI interventions in Soweto Kayole in Nairobi City County, Kenya are crucial for better governance, access to water services, collaborations, effective regulations and enhancement of more proactive and focus interventions and cooperation and partnership and this is what need to be done urgently by the relevant stakeholders.

1.3. Rationale and Justification for the Study

There are gaps and opportunities for the Nairobi City County and the water sector institutions under the ministry of water, sanitation and irrigation, Kenya to explore the emerging technologies and innovations such as artificial intelligence (AI), machine learning (ML) and Internet of Things (IoT) to address the issues in the water sector ranging from unaccounted for water, water losses, reliable data, reliable water supply and distribution, pipeline extension/ distribution network extension, monitoring, revenue collection and financing etc. The study expected to contribute to the development of knowledge on suitable strategies for deployment of STI in the sustainable management of water services provision and water security while ensuring access to the populace. This might enhance the attainment of the Kenyan Vision 2030, NWMP 2030, 2030 Sustainable Development Goal 6 (SDG 6) and 2063 Agenda for Africa.

The findings of this research thesis maybe used to make recommendations to the Ministry of Water, Sanitation and Irrigation (MoWSI) and other relevant water sector institutions such as KEWI, NCWSC, WASREB, WRA, WSTF, AWWDA, NWHSA and policy makers on the appropriate measures that can be instituted to promote adoption and uptake of the emerging STI interventions in the management, framework conceptualization and policy formulation of the water sector. Last but not least, the results are anticipated to supplement the public's access to already published academic and general knowledge papers for use in project planning, design, execution, and management focusing on sustainable development goal number 6 and other related SDGs.

1.4. Objectives of the Study

The overall objective of the study was to assess the level of deployment of Emerging Innovations and Technologies in catalysing sustainable water services provision in Nairobi City County, Kenya: Case of Soweto Kayole Jisomee Mita.

The specific objectives of the study were:

1. To establish the status of water services provision in Soweto Kayole, Nairobi City.
2. To evaluate the current and emerging innovations and technologies applicable in the urban water services provision in Nairobi City.
3. To evaluate the current impacts on adoption and uptake of emerging innovations and technologies in improving sustainable management of water services and access in Nairobi City.
4. To establish the strategies in place for mainstreaming best bet practices in the emerging innovation and technology interventions into national water sector development policies and frameworks.

1.5. Research Questions

The study was guided by the following research questions:

1. What is the status of water services provision in Soweto Kayole, Nairobi City, Kenya?
2. What are some of the current and emerging technology and innovations applicable in the urban water services in Nairobi City, Kenya?
3. What are the current impacts on adoption and uptake of the emerging innovations and technologies in improving sustainable management of water services and access in Nairobi City, Kenya?
4. What are some of the strategies in place for mainstreaming best bet practices in the emerging innovation and technology interventions into national water sector development policies and frameworks?

1.6. Hypothesis of the Study

Application and deployment of STI beyond sectoral perspectives can boost deeper understanding and management of the links between downstream and upstream water services provision. Strengthening water services provision will yield positive benefits surpassing public-private and human health that encompass improved resilience to climate change effects, supporting livelihoods, food security and economic productivity of the citizens. The perceptions that the innovative technologies may ease the burden of high cost of water in the informal settlement may not hold as water services provision strategies that enable integration

of both technological choices and an organizational system. Technological and innovative gadgets can aid facilitating and supporting services provision in the informal settlements localities in Nairobi City County, Kenya. Relevant interventions to support capacity building for utilities is required for sustainable service delivery, improved governance, access to water services, collaboration and partnership.

1.7. Basic postulates of the Study

It was hypothesized that the thesis's variables wouldn't change or fluctuate over the length of the research period, which informed and confirmed the findings' acceptability and ownership. The assumption that the respondents would be truthful, willing, and committed to providing genuine and valid data and other information for further synthesis came next, followed by the premise that the sample size and sample population would be sufficient to help in drawing valid and trustworthy inferences.

1.8. Scope of the Study

The thesis was conducted within Nairobi City County, Kenya focusing on the water services provision. The scope of the study was limited to Soweto Kayole Slums under the jurisdiction of NCWSC, Nairobi City County. The research work focused on the catalysing sustainable water services provision and role of emerging innovations and technologies in the utilization and management of sustainable water services and access.

1.9. Limitations of the Study

The research study collected feedback or responses from respondents from Soweto Kayole Jisomee Mita Project located in Nairobi City, managed and implemented by NCWSC in collaboration and partnership with other institutions which required ample time that was managed by recruiting competent research assistants to assist in the administration of the questionnaires. It's possible that generalizing the conclusions and suggestions won't be useful or repeatable in other localities in Kenya. Finally, another limitation was that the study focussed on a number of water sector institutions involved in the management of water services provision as this might cause biased and inconsistent information being generated. This was managed by giving specific focus and priority to Nairobi City County water services provision as the main study target narrowing down to the specific project sites in Soweto Kayole.

CHAPTER TWO

2.0. LITERATURE REVIEW

2.1. Introduction

This chapter presents a review and or analysis of both theoretical and empirical studies on the deployment of Science, Technology and Innovation (STI) in catalysing sustainable water services and addressing issues of climate change impacts on water services development, utilization and management in Nairobi City County, Kenya. The main focus being on the water services provision to the residents of Nairobi City County and other stakeholders involved directly or indirectly in the management and provision of water services. This entailed NCWSC, WRA, WSTF, AWWDA, NWHSA, WASREB etc. all under Ministry of Water, Sanitation and Irrigation (MoWSI). The specific variables under study were water services and use, institutions, financial sources, threats to water quality, policy and legal instruments, and technologies and innovations.

2.2. Status of Water Services Provision

The deployment and use of the emerging technologies and innovations in the management of water resources in Nairobi city will likely make the services more efficient, effective and reliable especially for real-time monitoring and uses machine learning algorithms to learn various trends of the data to incorporate its learning in the system and aid in decision making.

2.2.1. Groundwater Challenges

The notable and progressive growth in the advancement of technological and innovative infrastructural development in groundwater science has immensely improved the hydraulic and hydrological modeling. Mining of relevant groundwater data from satellites platforms have commenced and enhancing generation of new useful insights even though disseminating how groundwater works to make a well informed deductions, backed up with evidence still remains a big and critical challenge (Olago, 2018). The next impediment is the significant spatial and temporal lags between the occurrence of groundwater pollution and their detection. Aquifer's geologic and characteristics (such as diffusivity, hydraulic conductivity, and transmissivity) of groundwater normally influence both positive and negative impacts of depletion and pollution, hence full comprehension of long-term consequences of contemporary groundwater trends is required (Adelana and Macdonald, 2008).

Proper management of water resources and water services provision can be applied to detect visible impacts years to come, presenting enormous breakthrough in the funding, research &

management practices in the sector. Unless adequately monitored, groundwater is out of sight and gradually spreading negative impacts from depletion resulting from contamination and pollution which may not be detected instantly (UNESCO, 2019). As a result of these perennial challenges, the Kenya government has established a new regulatory structures informed by the increased visible (and litigation) of groundwater impacts to offer or provide possible solutions.

2.2.2. STI Infrastructure in Groundwater

At present the surest method to estimate quality of groundwater is through models that need some deeper comprehension of geology, porosity, boundaries, stream flow depletion, recharge, stream capture amongst others and gathering of baseline data needs adequate financing, which has substituted science, innovation and technology as the limiting factor to comprehending quality of groundwater. Currently, USGS is deployed to monitor and convey both groundwater and surface water data via the National Water Information System and contribute to the design, development and implementation of the national groundwater monitoring network to aid in providing solutions to major data gaps for proper management of water services provision and groundwater resources. Satellite and remote sensing are also increasingly being deployed in comprehending and analyzing changes of volume of groundwater over large areas. For instance, NASA's Gravity Recovery and Climate Experiment (GRACE) which was launched in 2002 is the surest satellite that explicitly measures variation in the water column by measuring variations in mass/ month. Since 1982, remote sensing (RS) data has been providing avenue for assessing changes in groundwater at 30 to 120m spatial resolutions per 16 days.

The challenges of groundwater in terms of the existing data, information and monitoring system for acquisition, processing and storage in Kenya is still a big problem (Olago, 2018). The problem is worsen by lack of adequate knowledge about aquifer systems which is also not new in Kenya as recharge and sustainable yield values, which are vital for assessment and management of resources continue to be approximated based on postulates that may not be actual and verifiable simply because of absence of empirical evidence, unfortunately urgent decisions must be made about the resource (Olago, 2018). For instance, in the NWMP 2030, the sustainable yield of groundwater is estimated to be 10% of its recharge value. Aquifer knowledge is lagging behind aquifer development, instead of the other way around, resulting to development of poor policy decisions since they lack sufficient evidence (Olago, 2018).

2.2.3. STI Infrastructure in Surface Water

The complex and dynamic of the nature of surface water bodies to change their appearance or course of flow with time, expand and even shrink are all as a result of different natural and

human-induced factors (Karpatne et al., 2016). Differentiation in volume of surface water normally results to serious negative consequences and in extreme scenarios rapid increase of surface water causes flooding like recently experienced in Kenya. Remote sensing (RS) technology offers effective ways to observe and analyze surface water dynamics because of its ability to continuously monitor earth's surface at multiple scales hence making it much and more efficient.

The provision of spatial and temporal data sets by RS through frequent observation of data of a number of physical attributes about the earth's surface, appropriately leveraged to map the extent of water bodies at regional or even global scale, and to monitor their dynamics at regular and frequent time intervals is a key achievement of the technology. The dynamic nature of surface water bodies are caused by the shrinking or expanding with time, owing to several natural and human-induced factors. The numerous changes in water bodies have critical consequences on other human assets, natural resources and influence the environment (Karpatne et al., 2016). Spatio-temporal monitoring of water body dynamics is necessary for comprehending availability of regional water and descriptive insights about the natural hydrological processes that shape the storage of water resources. Spatio-temporal monitoring of surface water dynamics is usually achieved by using multi-temporal remote sensing images (Schaffer-Smith et al., 2017).

2.2.4. Water Services Management

Internet of Things, Artificial Intelligence, Machine Learning and Deep Learning techniques have contributed immensely in development of wireless sensor networks. These advancements in technology and innovation have given rise to detection ability of capturing data about the physical condition and remote correspondence that empowers impromptu systems administration with no preset physical framework. IoT in particular has direct influence on water licensing and monitoring of water permit. For ground water sustainability and reliability, there should be permit and or license system to enforce the exploitation and management (GWP, 2015a & GWP, 2015b). License and permits are normally issued to grant and control quality of groundwater resources and monitor duration of groundwater abstractions (Pandey VP et al. 2011).

The basic importance of permits regarding groundwater sustainability is economic instruments, demarcating groundwater rights and groundwater licensing. AI, ML, DL and IoT can support monitoring of groundwater abstraction. Figure 2.1 shows institutional arrangement of the water sector in Kenya as per the water act of 2016.

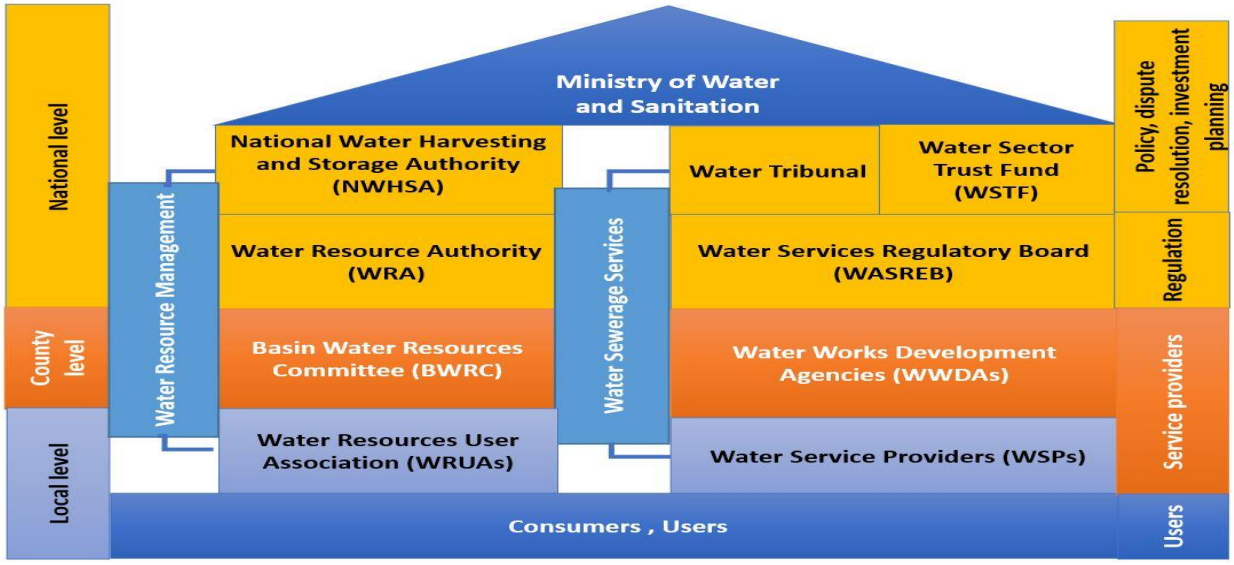

Figure 2.1: Institutional Framework for the Water Sector in Kenya under Water Act 2016
Source: WASREB, 2018

2.3. Emerging Innovations and Technologies in the Water Sector

There are a number of initiatives which are currently being pursued and some already on implementation at different levels. This review considered global, regional and national level initiatives. Despite having high drinking water quality in Korea, the rate of direct drinking of tap water in Korea is about 5% and is lower than other advanced countries such as japan (52%) and the United States (56%). Most Koreans do not trust the quality of tap water due to concerns with taste, smell, and aging pipes (SIWW, 2016).

CityTaps which is a social enterprise solution has been developed to bridge the gap between the urban poor and water utilities in France. The tool has a prepayment service that employs smart, prepaid water meters connected to an ICT platform and billing software and allows users to prepay any water amount. The data from the smart meters is transmitted to keep track of usage in real-time providing information on leakages and thefts (GSMA, 2020). By using smart mobile solutions such as mobile app and mobile money for logistical operations and collection of payments, Loowatt has reduced the operational costs by up to 25% and serviced over 100 toilets in Antananarivo (GSMA, 2020).

Loowatt has also partnered with Airtel Madagascar for provision of the mobile technology that is used to support the servicing and maintenance of the waterless toilets. Customers can use Airtels' mobile money and SMS platforms to make payments for waste collection and schedule for the collections and toilet maintenance. To overcome the mobile money challenges and

increase its adoption, the Loowatt Customer Service Management supported the customers with the use of mobile money, reduced the number of key strokes during mobile payments, minimized likelihood of a timeout, and printed out easier instruction manuals (GSMA, 2020).

Innovative Monitoring and Modelling (iMoMo) systems have been created by a group of Swiss, GWP, and international partners to help create new data sources in Tanzania. In order to observe the water resource networks supervised and preserved by national/regional hydro-meteorological services, the new data sources are employed to supplement the currently available sources. Through the method, the persistent holes in handling data and sources are addressed with creative fixes. The project has helped the stakeholders and local communities through the integration of software and hardware components and better analytical decision-support. According to the World Meteorological Organization (WMO), some of the results include the iMoMo Service Center, which supports institution strengthening and building, outreach, and project advocacy; site instrumentation by providing the catchment with river gauges so that local communities are able to track every day's irrigation metrics using smartphone apps to operate; specific information provided through SMS for end-users such as weather forecast updates and market prices; gather data to inform management, oversight, and other decision-making processes; and project advocacy. Several lessons were learnt from the iMoMo project including: The importance of a usable technology since a successful technology uptake is dependent on the local context and needs. Community involvement is important from the onset and communicating the benefits of timely and precise information on water resource use and availability (WMO, 2017).

In Nairobi, Kenya, Jisomee Mita (JM) is an infrastructural initiative designed to improve access to piped water system in Soweto Kayole (SK). SK is an informal settlement (slum) in the outskirts of Nairobi, Kenya and is inhabited by about 89,000 residents. SK is one of the informal settlements in Nairobi and has sparse piped water connections (WSP, 2015). Water is only accessed from about 35 stand posts owned by private vendors selling water at Kenya shillings 2 for a 20-litre container, with the price rising during scarcity. The Nairobi City Water and Sewerage Company (NCWSC), the utility provider has pursued several innovations aimed at providing affordable water and sanitation services to the slum dwellers. Through the Social Connections Policy (SCP), NCWSC has piloted an innovative approach for affordable clean water provision in SK under JM project. The SCP as adopted by the NCWSC promotes the right of non-discriminative access to affordable water and sanitation services particularly for marginalised and disadvantaged groups (Guma, et al., 2019).

The SCP subsidizes new connections in the slum areas thus addressing barriers such as non-existent primary infrastructure networks and high costs for materials and connections. The SCP was informed by the understanding that the best way for improving water provision in the slums is by providing the residents with accessible reliable water supply through a piped network. Increasing water access by increasing connection affordability and the customer and revenue base is key to the approach (Guma, et al., 2019). Additional benefits to the utilities and users include weakened water cartels and adoption of recommended construction and piping materials such as pipes, potable water, improved pricing, increased affordability of new connections, reduced water related diseases, and improved sanitation and hygiene. The vision 2030 Kenya blue print aims to provide access to water and sanitation by all by the year 2030 in line with the UN's SDG6 targets 6.1, 6.2, and 6.3.

The objective of JM (self-meter reading) is to empower and facilitate the low-income dwellers of SK to read their own water meters and make water bill payments through mobile money platforms. The project employs an advanced technological linked ICT with water network expansion. The technology enables the users to interact with the service provider linearly in enabling self-meter reading functionality and send the readings through short message service (SMS) for billing (World Bank Group, 2015). Other technology firms dealing with mobile money payment then provide the platform for users to make payments to the utility provider. JM thus provides users with a mobile-based model for communication and financial transactions. The system allows for self-meter reading, invoice acquisition, related inquiries, billing, and making payments (Guma, Monstadt, and Schramm, 2019). Figure 2.2 shows the architecture of the JM system (Guma et al., 2019).

With JM, SK residents get their water bills and make payments on via phones, while NCWSC no longer must print paper bills thus making the whole process less costly and very convenient (World Bank Group, 2015). The mobile payment platforms provide the users, mainly working in the informal sector with an advantageous flexible payment arrangement given their irregular incomes. Since the launch of JM in 2014, more than 2217 customers have been migrated from the old to the new metering system with about 1300 regularly sending their meter readings and making payment, resulting in an increased revenue collection by more than 50%. The roll-out of JM had some challenges such as the need for community sensitization and outreach. For efficient service provision, community development assistants were recruited from Soweto Kayole's youth to provide the residents with mobile phone use support by going door-to-door distributing flyers and training residents.

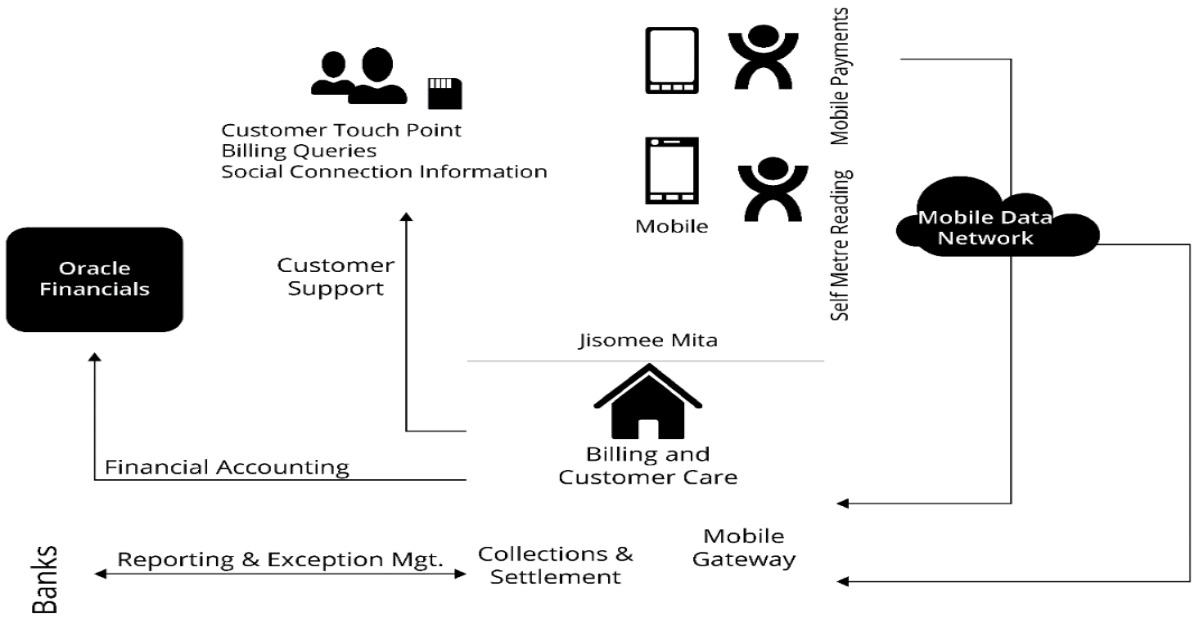

Figure 2.2: Architecture of the Jisomee Mita System.

Source: Guma, et al., 2019

Another case in Mathare Valley, NCC - 2015, Grundfos Lifelink and NCWSC launched a partnership to enhance water supply to the informal settlement populace in Nairobi with affordable water and reliable access to a clean drinking water. The establishment of the partnership was to test an innovative Grundfos Lifelink solution, the AQtap water dispenser a part from incentivising and empowering NCWSC to expand its water distribution networks to the undeserving slum dwellers and to curtail undesirable water cartels (Cheong et al., 2016). The AQtap which is a single product combining three elements essential to smarter water management ranging from smart cards to store water credits; a dispenser unit to tap water and manage credits; and a water management system where data from transactions and operations are processed and published is the viable solution to the perennial problems.

Four Grundfos Lifelink AQtaps were installed in 2015 by NCWSC in existing water kiosks in Mathare Valley Slums. The current water supply system were integrated with automatic water dispensers together with water grid and an overhead water storage tank hence giving water kiosks with twenty four hours water availability and automatic revenue generation and collection. Deployment of these technologies and innovations will help in the management of water supply and access in Kenya.

Finally, M-Maji which is a “mobile-for-development” initiative in Kibera intends to deploy widely accessible mobile phones to empower residents of the informal settlements with better

information on availability, price and quality of water (Umande, 2020). Water vendors use the M-Maji Unstructured Supplementary Service Data (USSD) short code to show their price, purification method and location (Boakye, et al., 2020). M-Maji initiative in Kibera is designed to enhance access to portable water by the residents through providing better information about where water is available, price, and quality through coordinated and centralized water information.

2.4. STI Infrastructure for Water Services Development, Utilization and Management

The rural areas of Kenya are most affected by lack of access to clean drinking water. In the rural areas, residents must walk long distances for water, which in some instances is contaminated thus presenting serious health challenges (water.org, 2020)(UNICEF, 2020). The challenges have significantly contributed to the water crisis in the region and it can be assumed that each part is affected. Despite the challenges, alternative mechanisms are available.

STI (science, technology, and innovation) can contribute significantly to the development of long-lasting water security alternatives. For STI to be implemented successfully, it needs be paired with collaborations, funding, and commercial models. Figure 2.3 displays the eight possible key areas or drivers for innovations in the water sector (World Bank Group, 2015) while Figure 2.4 illustrates the interlinks of key components of water security and some of the roles of science technology and innovation addressing specific gaps in water services and sustainable development (World Economic Forum, 2018).

Figure 2.3: Key drivers for innovation in the water sector.
Source: World Bank Group, 2015.

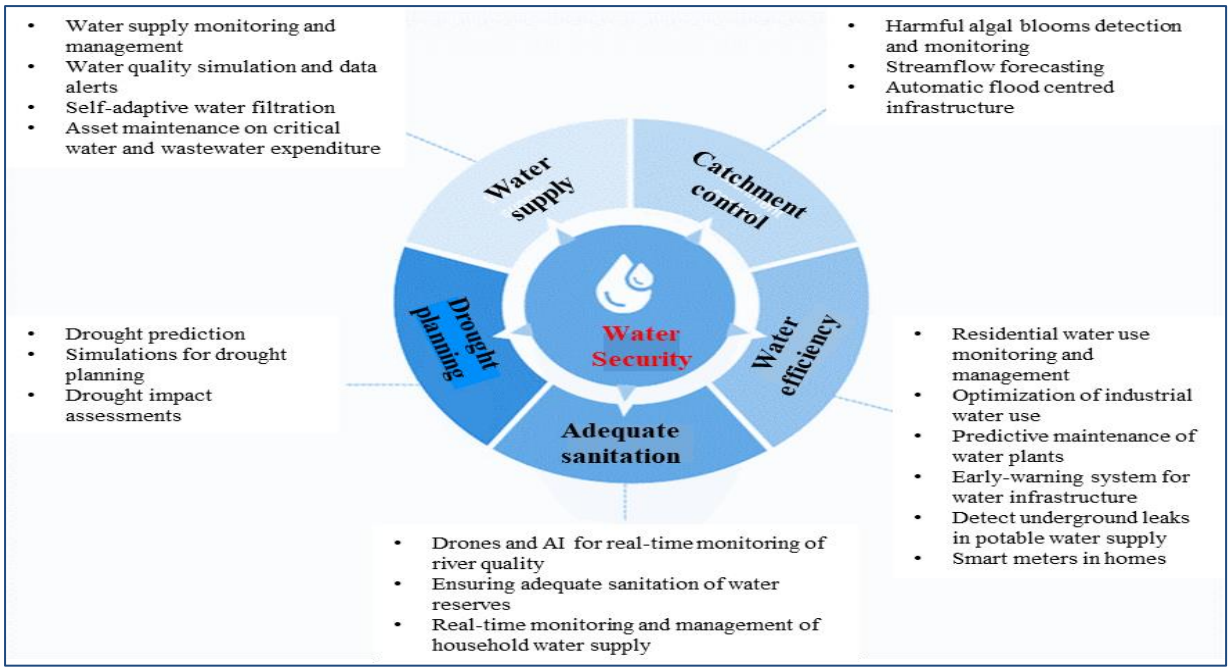

Figure 2.4: Role of STI in promoting water services and sustainable management
Source: World Economic Forum, 2018.

Figure 2.5 was conceived during the 2016 Singapore International Water Week where a feasible roadmap was drafted by the stakeholders to depict specific levels of priorities of three major focus areas thus on joint technology, clean water technology and wastewater technology (SIWW, 2016).

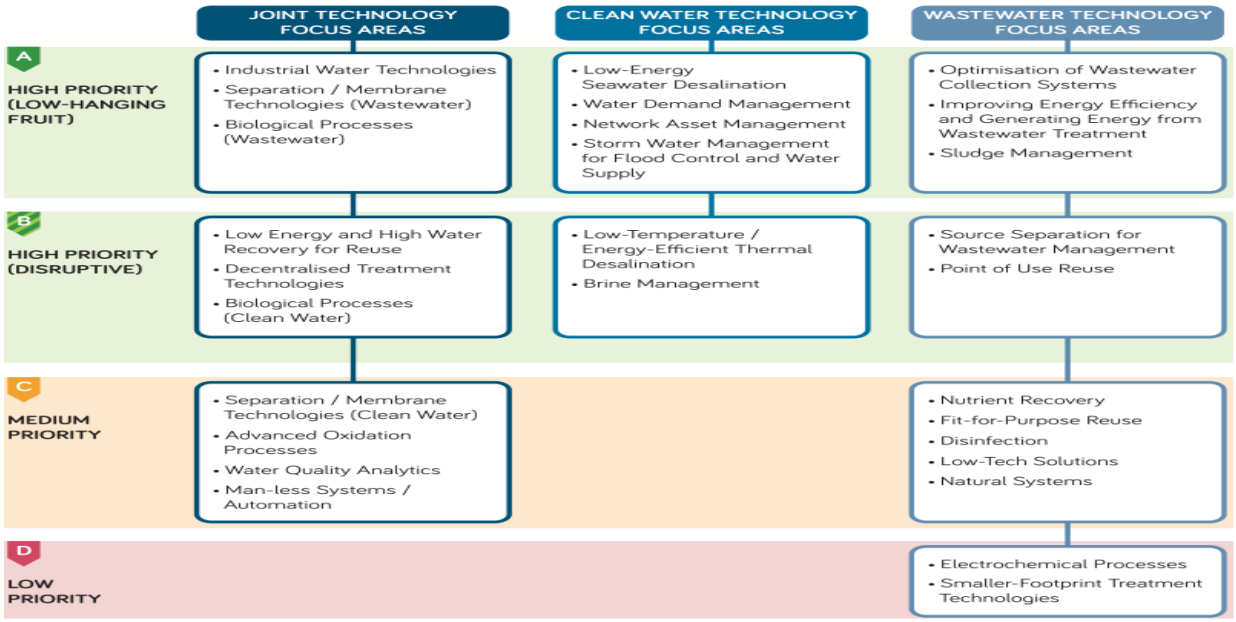

Figure 2.5: Global technology roadmap.
Source: SIWW, 2016.

Water technology solutions related to the Fourth Industrial Revolution (4IR) will enhance the uptake of more off-grid and localized solutions for the treatment and management of water and wastewater as indicated in Figure 2.6 (World Economic Forum, 2018). The water-related 4IR technologies will also offer methods for creating hybrid centralized-decentralized water systems. There are currently a number of developments in place, such as the use of micro-grid methods in the power sector for water systems. The adoption of off-grid water systems will also expand dramatically as a result of the real-time monitoring of water quality, quantity, and system performance (World Economic Forum, 2018).

Through actual time techniques for water quantity tracking, transforming water systems will strengthen the link between utility suppliers and customers. Table 2.1 shows some of the aspects of water management where the application of 4IR and ICTs tools can improve water resource management in developing countries (Mvulirwenande and Wehn, 2019).

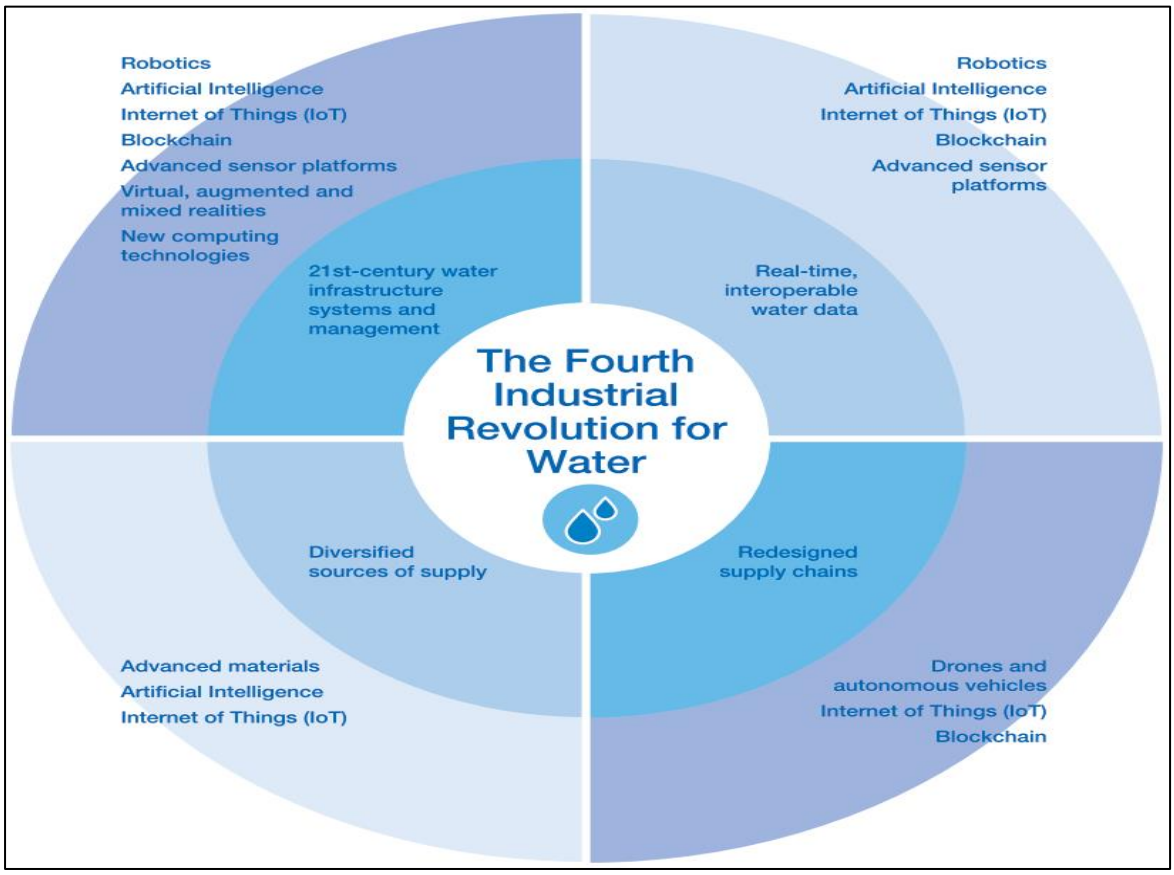

Figure 2.6: 4IR innovations for water and sanitation.
Source: World Economic Forum, 2018.

Table 2.1: Key areas of water management for application of 4IR and ICT tools.
Source: Obunga, et al., 2021

Areas for ICTs in Water Management	ICT tools	Benefits for Water Management
Weather Forecasting	wireless sensor networks, geographical information systems (GIS), Remote sensing (RS) satellite systems; in situ terrestrial sensing systems	superior, systematic investigations of the outermost layers of the ocean and atmospheric conditions; real-time exchange of meteorological data and information
Mapping of Water Resources	GIS; satellite mapping; water portal; supervisory control and data acquisition (SCADA)	Increased knowledge of the water resource base, present levels of water abstraction and usage, and enhanced supply and demand predictions for water resources
Asset Management	GIS, buried asset identification and electronic tagging; smart pipes, hand pumps and meters; supervisory control and data acquisition (SCADA)	Improved management of distribution networks; reduced water losses; reduced network damage and reduction in degradation, lowered maintenance costs, faster reaction times, and decreased danger of infection in the water system
Early Warning Systems	GGIS; sensor networks; early warning websites; mobile phone applications; digital delta	Enhanced handling of data (rapid data collecting, collection, analysis, and sharing to alert the public) enhanced reservoir oversight enhanced mapping of floods
Water Demand Forecasting	GIS, ground penetrating radars; optical and pressure sensors; cloud computing; SCADA	Rain/storm water harvesting; managed aquifer recharge; improvements in water resource management
Service Delivery	e-payment systems: GIS, call centres	Access to timely water information, operational efficiency of water sector organizations - shorter reaction time, enhanced financial management, and higher revenue collection are all examples of improved service delivery.
Governance and Visualization	Smart mobile phone applications: websites	greater public engagement, transparency, and integrity; better relationships with consumers

2.5. Challenges Militating against Adoption of STI in Water Services Management

2.5.1. General Barriers and Risks

Several smart technologies have been adopted for the management of water resources including water quality, supply, and treatment, water resource management, wastewater treatment and reuse, and water harvesting and storage. Despite the progress made, there are existing infrastructural and related challenges in adoption and scaling up. These are funding, adoption of smart technologies and innovations and cyber-security (World Economic Forum, 2018).

2.5.2. Barriers to Smart Water Metering

High costs are involved in installing, updating, and maintaining smart meters thus hindering their uptake by small water utilities, particularly in the rural and peri-urban areas. Water service providers including retailers must secure the meters, pay for the installation, and other related project costs. Transmission issues including the reliability of the network, electricity and power supply damage by users and cross connections can hinder the uptake of smart meters especially for developing countries like Kenya. Network and power problems are more acute in the rural areas and especially in developing countries. Several water utilities have identified the lack of a clear, user-friendly integrated smart technology solution as a major perceived deficiency in smart water metering. The lack of standard water meters that are internationally recognised pose additional challenges since systems do not mix easily, because of lack of attainment of international standards which are needed (Sensus, 2012) and (Cheong, Choi, & Lee, 2016).

2.5.3. Challenges to Integrated Water Resource Management

According to a 2018 status report on the implementation of Integrated Water Resources Management (IWRM) in Africa, several countries including Kenya face obstacles leading to low levels of IWRM implementation. Some of the barriers faced include constrains to (AMCOW, 2018);

a. effective water management plans, laws, and policies formulation and implementation,
b. institutional establishment for stakeholders engagement,
c. application of instruments of management for the implementation of IWRM, and
d. Water resource management financing.

Some of the challenges that are infrastructural related are lack of inclusive public participation in the management of water processes thus some key stakeholders like users need to be supported in accessing information and capacity development, while in some there is unwillingness by the government to engage non-state actors; low engagement of the private sector in water resource management processes due to lack of incentives to promote the involvement of the private sector; lack of water management instruments are lacking, particularly for ground and surface water monitoring and disaster mitigation. Also, where the instruments exist, they are sometimes broken, non-functional, or ageing and with limited; mobilizing funding for the implementation of water resource instruments at the local level is more challenging than at the national level; and over reliance on external funding (technical and financial partners) for the implementation of water resource management (AMCOW, 2018).

2.5.4. Infrastructural Challenges to Groundwater Development

Improving electrification in the rural areas of Kenya would allow for higher usage of groundwater and adoption of smart technologies for water resource management. Presently, in most rural areas have scarce electrical connections and those with grid connection with frequent blackouts while the prohibitive high energy costs are hindering groundwater development (World Bank, 2018).

2.5.5. Inadequate Information Systems

The inadequate valid information on the status of water resource and services provision across the region is a major hindrance to the adoption of STI in water resource management, particularly in the rural areas. For instance, in Kenya the data on water resource management and coverage that is published by the relevant ministry are sometimes not reliable since they are not based on extensive review (Jiménez & Pérez-Foguet, 2010).

2.5.6. Enabling Political, Institutional, and Financial Environment.

Focusing on the favorable political, institutional, and economic climate for the promotion and scaling up of some of the best bet practices in the STI in the water sector, most of the government agencies entrusted with driving STI policy making have operated in isolation from the rest of other policy agencies and continue to have weak links to academic institutions and private sector. Initiatives are being undertaken in Kenya whereby three agencies NACOSTI, KENIA and NRF were established with the principal purpose of coordinating various activities in the STI sector (Republic of Kenya, 2013).

However, poor coordination in the activities has been one of the foremost capacity building initiatives have sought to address. Kenya was highlighted as a case study where private sector engagement with the Science Granting Council (SGC) seems to be visibly present; however, this was also noted to be restricted just to presence of these stakeholders in the funding panels. National Science Granting Councils and STI agencies are always granted the mandate of and are autonomous entities managing the STI sector. However, in most cases with limited financing the capacity of the Science Granting Councils to effectively spearhead the mandate has been questioned (Hanlin, R. & Khaemba, 2017). Kenya has devolved units and there is need for the STI agencies to be strengthened to further the coordination of STI activities to these devolved units (Hanlin, R. & Khaemba, 2017); since Kenyan stakeholders are yet to fully explore the opportunities created in the STI sector by devolution.

2.5.7. Challenges to ICT Focused Water Innovative Partnerships

A study by Mvulirwenande and Wehn (2019) analyzing about 24 water innovation partnerships with an emphasis on ICT that have been executed in Africa found that despite having in place relevant governance and structural mechanisms, some of the ICT-WIPs experienced significant challenges.

The key challenges included: Low levels of commitment by partners-this challenge results in poor delivery of inputs from stakeholders and can sometime lead to early termination of the collaboration; Dissemination of implicit knowledge is challenging - translating expert's knowledge into a digital handbook that can be easily used the operators and other users with zero experience and low educational background has been challenging. This is not surprising since most of the knowledge held by water experts is tacit in nature thus making it difficult to communicate and formalize; Asymmetries in resource exchange - challenges in data acquisition and sharing between the collaborating partners leading to delays in technology implementations (Mvulirwenande and Wehn 2019).

This challenge could be due to confidentiality concerns or management style; and Ambiguity of partnership objectives - inadequate consultation among partnering organisations can lead to the implementation of technologies that are not applicable to the local conditions.

2.6. Strategies in Mainstreaming Best Bet STI Interventions into National Water Sector Development Policies and Frameworks

Several smart water resource management projects and services are driven by regulatory requirements including water quality, efficiency targets, and prevention of the depletion of groundwater resources. While sometimes the regulations do not prescribe the real-time technologies that are needed to meet the set standards, having them in place forces the water service providers and users to innovate practices and technologies for water management. It is thus important for policies and regulations to be introduced to enhance the implementation of smart water management. It is worth noting that Kenya has prioritized smart water management for instance putting in place strong policy support that has made the implementation of smart technologies being noticed. Strong policies also act as drivers for relevant stakeholders such as technology developers to participate in the adoption of smart technologies. Localised plans and policies applicable to the rural setting can be a major driver for the implementation of STI in the rural areas. In contrast, the lack of adequate government support in terms of plans, policies, or funding can significantly affect the adoption of smart technologies (MoWSI, 2018 and MoWSI, 2019).

2.6.1. Policy, Planning, and Governance

The Korea Water Resources Corporation (K Water) in collaboration with the International Water Resources Association (IWRA) and over 40 contributing organizations spread across the world carried out a major study on Smart Water Management (SWM). The study which was based in developed and developing countries focused on exemplary SWM projects addressing the use of STI to tackle water challenges across several scales from household to transboundary. The study identified the factors outlined below as being key to the successful uptake of SWM as per the Korea International Water Week, 2018: long-term investment from the government and institutions since it will allow for continued research, testing, and development of new smart water technologies; funders should value short-term benefits that are non-financial including governance, technical, environmental, and social benefits of SWM. Financial-benefits are only realizable in the medium to long term: first by internal and external engagements for the implementation of collaborative projects, data sharing, and improving outputs; second by top-down support and multi-stakeholder engagement to enable the continued development and implementation of smart water projects; third by promoting SWM potentials for reduced additional infrastructural needs; forth by engaging and collaborating with the stakeholders from the initial stages particularly local agencies to ensure a good understanding of project complexities and having all stakeholders on board with decision making and implementation; fifth through policies and regulations, and government support to drive the SMW projects; sixth by a clear understanding of the varying approaches for successful implementation of SWM technology dependent on the implementation tools and the required additional support such as governance, engagement, or business models; seventh by building trust in the community through engagement with reliable real-time data increasing water conditions awareness, positive behavioural changes, and informed decision-making; eighth by developing strong business models leading to the creation of new sustainable jobs and opportunities the community and water users (Mvulirwenande and Wehn, 2019).

Two-pronged approach by including governance networks, business models, and engagement tools for strengthening the potential for successfully implementing SWM technologies that are long-term; training and capacity development for community members to ensure successful monitoring and management of installed technologies and systems; and lastly by achieving short-term results such as increased water quality, reduced consumption, efficient water management, and reduce water conflicts.

2.6.2. Smart Metering in Soweto Kayole: Successes and Challenges

Jisomee Mita (a smart metering technology) rolled out in Soweto Kayole, Nairobi Kenya, and employed community sensitization through provision of mobile phone use assistance to the members of the community. Residents including landlords were trained on the use of the smart technology. The staffs at the utility level were also trained on the functionalities of the new technology. At the beginning of the project, some resistance to the unknown new technology was faced while doubt on the ability of low-income earners to pay their bills existed.

The establishment of an office dedicated to Soweto Kayole residents by the service provider was important for the successful project implementation. Under the social connection policy, the office handled water accounts and emerging complaints related to the new technology. The good relationship between the utility staff and the community members equally contributed to the technology acceptance by the users (Boakye-Ansah, et al., 2019).

Continuous outreach, training, and communication have been necessary in ensuring the customers are conversant with the new technology and can use it with ease. Moreover, the system undergoes constant technological improvements to match up with the changing trends (World Bank Group, 2015). Considering the factors outlined as being key to the successful uptake of SWM, gives a policy framework that would promote successful implementation of smart water technologies

2.6.3. AQTAP Water Dispenser in Mathare Slums

NCWSC and Grundfos Lifelink (GLL), collaborated to pilot a new technology for portable and cheap water services provision to the slums such as Mathare Slums. The AQtap water dispenser has been installed in Mathare slum and other selected slums in Nairobi. The system uses smart cards with self-service kiosks that dispense water for as low as fifty cents for a twenty litre jerrican.

The connected water consumers swipe digital cards, loaded with funds at the water kiosk, top up using the mobile handsets and pay for the amount of water they want to fetch and one can top up any amount of money as there isn’t maximum nor minimum cash. The water ATM dispenser is foreseen to help in curbing incidences of waterborne diseases spreading normally experienced by pollution of water sold by the vendors (Boakye, A. et al., 2020).

The water automatic teller machine project provides the residents in the informal settlement affordable and predictable access to water any time and prevent them from cartels. The main objective of the technology is to enable NCWSC design, develop and implement water service

provision that matches consumer behavior as well as Non-Revenue Water (NRW) identification for corrective measures and mitigation to avoid further loses. The fixed tariff-payment either through mobile payment or with digital money transfer also enabled by the new technology (Guma, et al. 2019).

The new technology for water services provision is focused on enhancing increased access to affordable and sustainability is supply via dependable services provision and regular repair and servicing; water delivered at fixed but low prices; accountability and the administration of revenues is transparent; friendly payment through use of mobile-money transactions, which also raises customer awareness of smartphone tech; safe transactions through a mobile device as instead of a bank account, which the majority of people living in slums do not have access to and engagement and involvement in the management of water for communities which eventually increase their ownership of the water points or kiosks. Figure 2.7 on innovative financing and microcredit scheme for the Soweto Kayole JM project displays the key stakeholders and their roles in the project and also explains how the OBA subsidy works or integrated into the project implementation (World Bank Group, 2015).

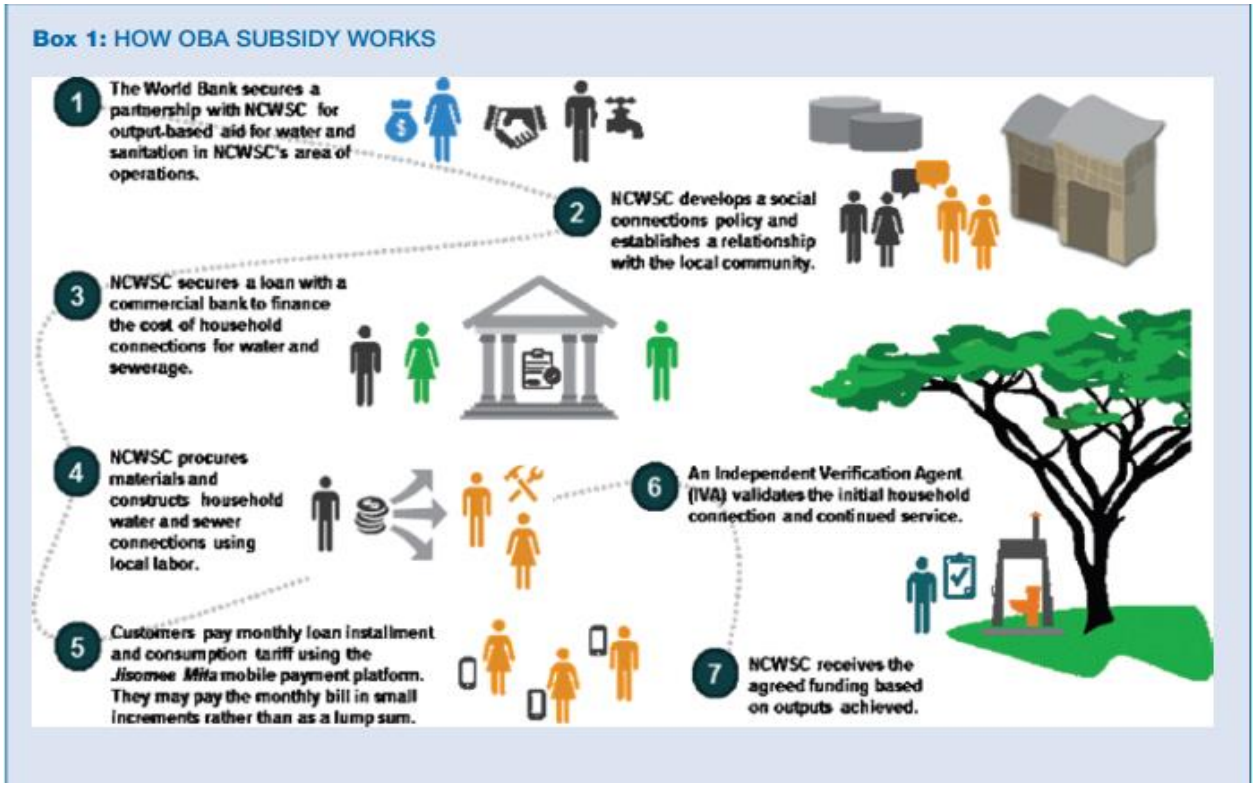

Figure 2.7: Innovative Financing and Microcredit Scheme in Nairobi.
Source: World Bank Group, 2015.

Table 2.2 briefly explains and or explores on policy recommendations for the adoption and uptake of SWM technologies mainly focusing on strategies around the society, environment, economy, technology and governance and their possible policy entry directions (Korea International Water Week, 2018).

Table 2.2: Policy recommendations for the adoption of smart water management technologies Source: KIWW, 2018.

Strategies	Policy direction
SWM for an improved quality of life (Society)	1. Facilitate adoption of SWM tools, especially in developing countries, to support access to basic services, and to support equality for poverty reduction, public health, and quality of life. Include capacity development, technology sharing, collaborative business models and community governance and decision-making opportunities
	2. Build trust and community engagement using SWM tools in areas where the community feel unsafe using the local water sources
	3. Empower people in developing countries with smart tools to reduce the time spent on water management and increase farm income and time available for other activities (e.g. further schooling, and additional work opportunities)
Investment in SWM for improved resilience and sustainability development (Economy)	4. Strengthen collaboration across and within sectors to provide opportunities for networks improved resilience and to share information and data to assist with effective and efficient water management
	5. Value non-financial benefits (e.g. environmental, social, governance and technical benefits) as equally important as financial benefits for SWM implementation, as they contribute to building resilience to the effects of climate change and increasing populations
	6. Support long-term investments for SWM implementation to enable adequate research, development, and testing SWM
SWM for conserving and protecting water resources (Environment)	7. Introduce policies, regulations, and incentives to drive environmental and ecosystem protection through use of SWM.
	8. Encourage SWM solutions to increase water quality, manage demand and use, water reuse, reducing groundwater depletion and increase energy efficiency, etc.
	9. Introduce SWM solutions for climate adaptation plans for flood and drought planning and management and major storm events
Support evolving smart technology development and adoption (Technology)	10. Develop standards to ensure all SWM technologies are compatible (can communicate) with each other to enable tools to be purchased across various suppliers to enable those implementing SWM to create the right set of tools for each context.
	11. Support on-going research, testing and development of SWM tools to advance them to a point where they are robust and require minimum maintenance and are ready to be commercialized (Government policies that support taking SWM tools from R&D to market)
	12. Support technology to assist in regions without built infrastructure or the adequate resources (e.g. electricity), as currently SWM infrastructure is (almost always) reliant on built infrastructure Building
Building capacity and networks for increased resilience and collaboration (Governance)	13. Empower people, especially those in developing countries, by providing them with SWM tools, data and capacity development and education to enhance/support local decision making.
	14. Strengthen the capacity to adapt to climate change by adopting SWM planning and operational technology 15.
	15. Plan for water disasters in advance by creating proactive policies instead of reactive policies

2.6.4. M-Maji Project in Kibera Slums

In the slums of Kibera, Water is scarce, costly, and contaminated even though they have mobile phones. M-Maji is a "mobile-for-development" initiative that intends to deploy widely accessible mobile phones to empower residents of the informal settlements with better information on availability, price and quality of water. Water vendors use the M-Maji Unstructured Supplementary Service Data (USSD) short code to show their price, purification method and location.

The M-Maji project works in 3 steps as follow: First step is that water vendors prompt the M-Maji USSD short code to display water adverts confirming the purification method, location and price at which they selling water. All adverts are gathered and secured in a central database which expires at midnight. The second step is that the end water consumers dial the M-Maji USSD short code to get locations of listed water vendors with water, water qualities, water prices and vendor ratings. Potential buyers can access information by texting with the estate name they need water, then get a text message listing of all available water vendors in that estate or if not available in the identified estate the closest estate with water. The third and final step is that if end water consumers subsequently discover misreporting of information by the water vendor on water availability, price, or quality then the buyer lodge a complaint with M-Maji via USSD. The history of misreported information is stored in database for future references to buyers through the use of water vendor ratings (Umande Trust, 2020).

Figure 2.8 and 2.9 shows the process on how M-Maji works and the steps involved respectively (Umande Trust, 2020).

Figure 2.8: Illustration of how M-Maji works in Kibera Slums. Source: Umande Trust, 2020

Figure 2.9: Illustration of the steps involved M-Maji. Source: Umande Trust, 2020.

The justification and rationale of the M-Maji initiative is designed to enhance access to portable water by empowering informal settlements with better information about where water is available, price, and quality through coordinated and centralized water information.

2.6.5. Action Areas for Integrated Water Services Management

There is need for a shift from policy, strategies, and laws to practical implementations. For effective water services management at the national, county, and rural levels, integrated approaches are necessary. Recommended action areas include enabling environments for IWRM, financing IWRM, applying management tools, developing infrastructure, and establishing institutional and governance frameworks as shown in Table 2.3 (AMCOW, 2018).

Table 2.3: Action areas for integrated water resource management.

Source: AMCOW, 2018.

Action area	Targets
Enabling environment for IWRM	• Target and provide priority support to countries that are falling behind with IWRM implementation, including by creating enabling environments, especially in countries recovering from conflicts, political crises, and disasters. • Enhance political will for water reforms by conceiving and implementing specific programmes on information and awareness-raising and targeting advocacy towards policymakers.
Establishing governance and institutional frameworks	• Promote the establishment of effective governance and institutional frameworks (based on IWRM) at the transboundary, national, and local levels (basin commissions, agencies, local water committees). • Enhance capacity-building at all levels to obtain the necessary human resources for IWRM implementation.
Applying management instruments	• Improve the monitoring of water quantity, quality, and use. • Develop appropriate water allocation models. • Promote forecasting and early warning systems through peer learning from existing good experiences.
Infrastructure development and financing	• Promote preparation of basin plans for IWRM, including comprehensive investment programmes. • Strengthen and sustain the African Water Facility
Financing IWRM	• Build the knowledge base on best practices regarding the implementation of the user pays and polluter pays principles. • Increase government financing of water resources management, to help increase national contributions for water resources development. • Support countries in creating an environment suitable for private sector financing.

2.7. Sustainability of Deployment of STI in Catalysing Water Services Provision

The success of these innovative approaches will be possible with strong governance and leadership and goodwill by NCWSC and MoWSI. The JM initiative established a well thought out directions and strategies to secure active participation of Soweto Kayole communities in all aspects of the projects and therefore build ownership and sustainability. NCWSC and WB are working closely with community and other stakeholders and also created a position for the Sociologists and Community Development Assistants (CDAs) to create awareness and sensitize and train the community on the initiative (Nilsson, 2017). The CDAs have helped in conducting door-to-door awareness creation and sensitization of the community and capacity building on Jisomee Mita accurate reading, inquiring for bill through mobile phones, and settling of bill for water through M-Pesa mobile money platform.

The institutions involved in the implementation of JM project in Soweto Kayole are NCWSC, AWWDA, WASREB, Local leaders/ community, IDA, World Bank Water and Sanitation Program, KISIP, WASSIP, K-Rep Bank, Safaricom, JamboPay, and GBOBA.

World Bank's WSP team normally plans for field visits to engage with and involve the community and address their concerns about the initiative and status progress while on the other hand, NCWSC operationalized a fully functional office in Soweto Kayole to offer real time solution to the customers and the utility. The Soweto Kayole residents have been engaged/ involved from the inception stage of the project to ensure that they own the project and identify with the initiative which is very important for sustainability after the closure of the project period (World Bank Group, 2015).

Right from the conceptualization stage of the project, WSP together with NCWSC, carried out an elaborate need assessment of the socio-economic analysis to aid in buy-in and ability and willingness of the Soweto Kayole community to subscribe for the connections and subsequent water consumption. Out of the exercise, a detailed income profiles of the residents was mapped or generated which informed the WB - NCWSC partnership in the designing and developing a model for payment appropriate and fits daily and weekly income patterns of the residents. Besides all these efforts, there is also in-kind contribution by the community through participating in community labor which strengthens the residents' ownership of the project and partially promises project sustainability (Guma, 2019).

Embracing innovative financing model combining technical assistance, output-based aid and micro-credit to bring forth services to the underserved is another key strategy employed to guarantee sustainability. Deployment of advanced technological innovations such as use of

digital innovation like AI, ML and IoT, has reduced the cost normally incurred on paper for printing receipts and bills besides empowering the water users in reading their water meter and remitting payments to settle the bills through mobile money platforms (Boakye, 2020).

Documented lessons learnt in the process of execution of the project will form very vital sustainability plan that will be looped back to the project to enhance on continuous and constant improvements at the subsequent stages of the project implementation. Looping in the NCWSC in the implementation will really strengthen the project execution and effectiveness. This will ensure that even when World Bank and Grundfos pull out of the project, there still will be continuity in running of the water affairs in Soweto Kayole similarly to other part of the city under its jurisdiction. There is also the aspect of impact evaluation that will be conducted to better inform the government the value of subsidy and hygiene that will inform future strategic plans and policies in the water and sanitation sector (UNESCO, UN Water, 2020).

2.8. Strategic Plans Relevant to the Study

More than 40% of Kenya's population depend on unimproved water sources including shallow wells, rivers, and ponds, while about 70% cannot access basic sanitation (water.org, 2020). The water and sanitation challenges are prominent in urban slums and rural where there is poor infrastructure of piped water. Table 2.4 and Table 2.5 documents the UN sustainable development goals number 6 targets and their indicators to gauge on their realization.

Table 2.4: Snapshot of SDG 6 in Sub-Saharan Africa

Drinking water	Twenty seven percent of the population in Sub-Saharan Africa (SSA) use a safely managed drinking water service (SDG indicator 6.1.1, 2017)
Sanitation	Eighteen percent of the population in SSA use a safely managed sanitation service (SDG indicator 6.2.1a,2017)
Hygiene	Twenty five percent of the population in SSA has access to a basic handwashing facility (SDG indicator 6.2.1b, 2017)
Water stress	Six percent of the renewable water resources in SSA are being withdrawn, after taking into account environmental flow requirements (SDG indicator 6.4.2 on level of water stress, 2017)

Source: https://www.sdg6data.org

Table 2.5: United Nations SDG 6 targets and indicators

Targets	Indicators
6.1. By 2030, achieve universal & equitable access to safe, affordable drinking water for all	6.1.1. Proportion of population using safely managed drinking water services
6.2. By 2030, achieve access to adequate and equitable sanitation and hygiene for all and end open defecation, paying special attention to the needs of women and girls and those in vulnerable situations	6.2.1. Proportion of population using safely managed sanitation services, including a hand-washing facility with soap and water
6.3. By 2030, improve water quality by reducing pollution, eliminating dumping, and minimizing release of hazardous chemicals and materials, halving the proportion of untreated wastewater, and substantially increasing recycling and safe reuse globally	6.3.1. Proportion of wastewater safely treated 6.3.2. Proportion of bodies of water with good ambient water quality
6.4. By 2030, substantially increase water-use efficiency across all sectors and ensure sustainable withdrawals and supply of freshwater to address water scarcity and substantially reduce the number of people suffering from water scarcity	6.4.1. Change in water-use efficiency over time 6.4.2. Level of water stress: freshwater withdrawal as a proportion of available freshwater resources
6.5. By 2030, implement integrated water resources management at all levels, including through transboundary cooperation as appropriate	6.5.1. Degree of integrated water resources management implementation (0–100)
	6.5.2. Proportion of transboundary basin area with an operational arrangement for water cooperation
6.6. By 2020, protect and restore water-related ecosystems, including mountains, forests, wetlands, rivers, aquifers, and lakes	6.6.1. Change in the extent of water-related ecosystems over time
6. A. By 2030, expand international cooperation and capacity-building support to developing countries in water- and sanitation-related activities and programmes, including water harvesting, desalination, water efficiency, wastewater treatment, recycling, and reuse technologies	6. A.1. Amount of water- and sanitation-related official development assistance that is part of a government-coordinated spending plan
6.B. Support and strengthen the participation of local communities in improving water and sanitation management	6. B.1. Proportion of local administrative units with established and operational policies and procedures for participation of local communities in water and sanitation management

Informed by the current WASREB Strategic Plan, and a number of empirical studies, there are numerous emerging technologies in smart water management and information systems which require water services institutions not only to adopt the emerging technologies and innovations and subsequently increase uptake rate in order to yield efficiency for the sector. Water services

provision play a key role in ensuring the success of the president's Big Four Agenda on affordable housing, affordable healthcare, manufacturing and food security. Further synthesis by WASREB of both internal and external environment using the PESTEL and SWOT analytical tools of the operating environment specifically under technological environment and environmental factors revealed the critical need for deployment of STI in the management of water resources in Kenya (WASREB, 2018).

Technology related with gaps such as inadequate resources to leverage on innovation and technology to address challenges in the water sector; technology and innovation adoption and uptake is slow; automation of processes within the systems is lacking; complex and dynamic technological and innovative changes; lack of proper and effective capacity building of staff in the water sector; lack of intelligence water network management infrastructure such as SMART meters; staff managing/ operating water infrastructure not able to handle technology and innovative gadgets in the sector; and insufficient investment in research to innovate on new technologies (UNESCO, 2019) while environmental related gaps such as lack of better strategies in managing water demand and supply by the water utilities resulting to over-exploitation of water resources & consumption and worsen by rapid climate changes; pollution of water sources leading to high cost of water treatment; and finally, degradation of environment leading to siltation of dams has diminished the quantity of water available (UNICEF, 2020). Figure 2.10 depicts the priority of the African Union Commission in the role of emerging technologies and innovation in catalyzing development initiatives in the region.

The Ministry of Water, Sanitation and Irrigation (MoWSI) is putting policy objectives in addressing water losses through development and implementation of Non-Revenue Water (NRW) reduction strategies for all categories of Water Service Providers (WSPs) across the country. The intention is to gradually bring NRW levels to the globally acceptable levels. Since Kenya is still recording high NRW levels of above 40%, the Ministry is focusing on NRW reduction to justify the capital outlay on water infrastructure. The estimated Kenya's average of NRW ratio was 41%. The challenges remain to achieve the national NRW target ratio of 25% by 2030. A high level of water losses is due to leaks and thefts from the system; as well as losses due to inaccurate or non-meter readings and billings because of poor management of customer records (MoWSI, 2018 and MoWSI, 2019).

The NRW Unit is established to monitor NRW levels, promote and coordinate NRW reduction activities, develop and promote NRW standards, and implement ministry policies and strategies on NRW reduction. WASREB promotes the observance of NRW reduction by WSPs, while

KEWI develops and rolls out curriculum for strengthening NRW reduction capacity amongst staff in the main institutions dealing with NRW reduction (MoWSI, 2018 and MoWSI, 2019).

Sessional Paper No. 1 of 2021 on National Water Policy, whose overall objective is to provide a framework that is evolving, innovative, and effective for re-engineering the water sector. The policy's overall goal is to guide the achievement of sustainable management, development, and use of water resources in Kenya. It was created to fill in any gaps in the management of water resources and to build on the achievements, difficulties, and experiences learned from earlier policies from 1999, 2012, and the requirements of the Kenya Vision 2030 on water use and protection. By ensuring that collaboration and expedited partnerships are mainstreamed in the management and provision of water resources, the national water strategy seeks to alleviate the issues and dangers facing the water sector. It also aims to improve the country's watershed and other catchment area preservation. (Republic of Kenya, 2021).

The national water policy of 2021 specific objectives related to water provision (which was the main focus of this thesis) are: to promote the development of water harvesting and storage infrastructure, to strengthen sustainable water resource management in the nation, to mainstream climate change considerations and disaster risk reduction through the water sector, and to accelerate the delivery of water supply services through progressive realization of the human right to water towards universal access. (Republic of Kenya, 2021).

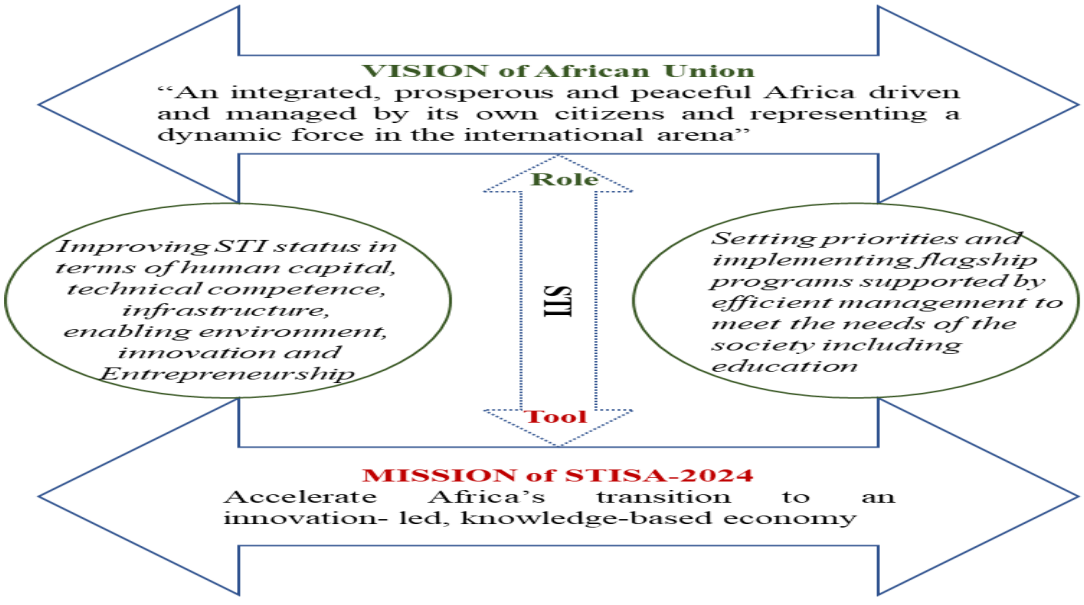

Figure 2.10: Role of STI in achieving the AU vision.

Source: African Union Commission.

2.9. Knowledge Gaps

Some of the knowledge gaps the study identified were lack of workable water provision strategies in the informal settlements, inadequate or total lack of data, limited management skills of the utility staff, and unreliability of supply of water to the urban informal settlement segments especially for the Soweto Kayole residents.

The study context was centred around assessment of the level and extent of deployment of Science, Technology & Innovation (STI) in catalysing sustainable water services provision, water services infrastructure development, utilization and management in Nairobi City County, Kenya, case of the Soweto Kayole Jisomee Mita Project. Such kind of study has never been done to help in proper decision making and this was also a major gap. Another gap was lack of feasible and appropriate recommendations for effective adoption and uptake of the emerging innovations and technologies for improved and efficient management of water services provision in the urban informal segments of the city.

Another critical knowledge gap was on possible mechanisms of innovative financing models applicable in the water services provision especially tailored to fit the low income segments of the urban and peri-urban population.

Water services provision at the water utility – Nairobi City Water and Sewerage Company Limited is shrouded by numerous inefficiencies hampering effective services delivery, high unreliability of services and consequently promoting overexploitation of the residents from expensive water vendors or walk long distances to fetch water. This study was focused on unearthing these gaps and made appropriate recommendations.

CHAPTER THREE

3.0. RESEARCH METHODOLOGY

3.1. Overview of Methods

The research methodology are plans and procedures that justify the rationale on the choice of approaches to be adopted in order to respond to the research questions posed in a study. The chapter outlines the project's study area, research design, target population, sample size and sampling procedures, research instruments used in data collection, data collection procedures, data analysis techniques, ethical considerations and lastly research approach framework.

3.2. Description of the Study Area

Soweto Kayole is an informal settlement situated at Embakasi in Nairobi's Eastlands area, where women and children often walk long distances to get water on daily basis. The average monthly income of the residents is about $200. The area has land tenure in the form of allotment letters and approximately half a million people living in Kayole continue to suffer due to lack of adequate clean and safe drinking water. This inadequacy has been caused by the growing population which has stretched the facilities and infrastructure to their limits. Neglect from state agencies in charge of water and sewerage, rogue politicians and cartels interfering with water supply for their own personal gains are the myriad causes of shortage. The map of where the field work was conducted is presented in Figure 3.1.

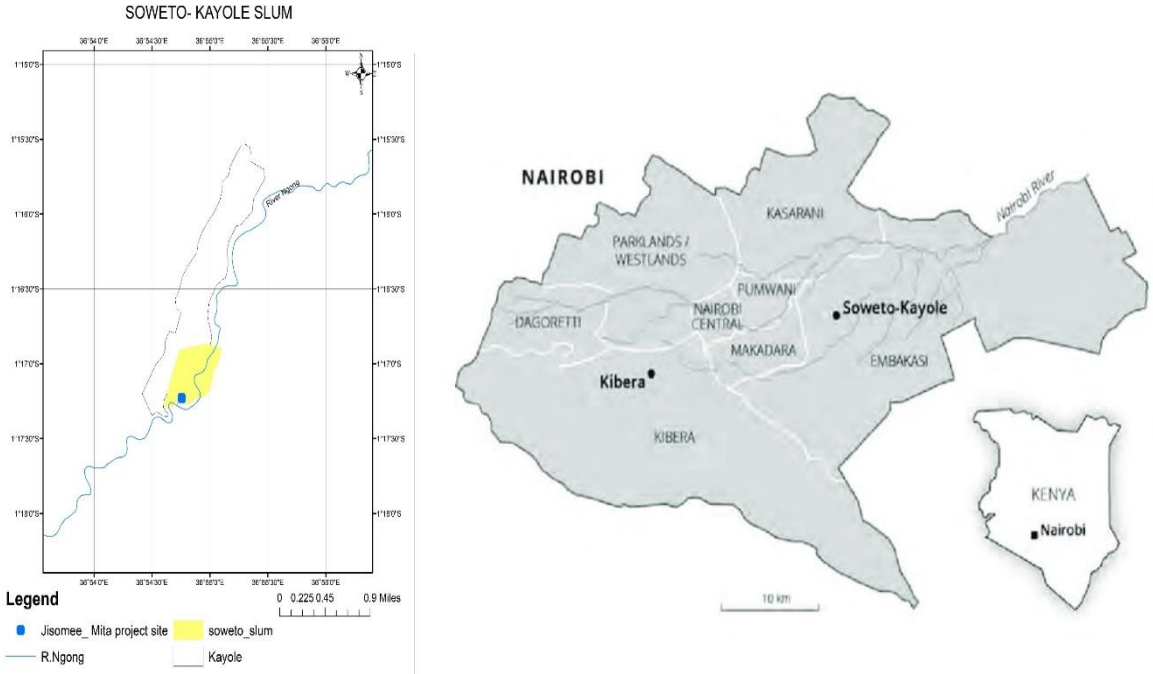

Figure 3.1: Map of Soweto Kayole

3.3. Research Design

The study used a descriptive survey design, where questionnaires were administered to gather data. The design relied on a qualitative approach by seeking to capture factual and detailed information about the views and perceptions and the dominant narratives on the role and impact of deployment of STI for instance impacts of IoT, AI &ML tools and techniques has radically changed the way the local residents receive water services, living standards and work, and even helped to accelerate progress toward meeting the UN's SDG#6.

Mugenda and Mugenda (1999) states that a descriptive survey design determines and reports the actual scenario and respond to concerned questions on the current status of the subjects under the study. Descriptive surveys are fact-finding enquiries that involves probing questions (often in the form of a questionnaire) of a large group of individuals and alluding that the main purpose is description of the state of affairs as it exists at present and represent the findings/ information statistically, Kothari (2004). This approach is important for mining/ acquiring statistical knowledge of individual, organizational, social and real-life occurrences hence offering retention of the holistic and meaningful attributes of the actual events.

The study employed descriptive analysis to establish opinions and knowledge about the deployment of Science, Technology and Innovation (STI) in catalysing sustainable water services provision and addressing issues on water services development, utilization and management in Nairobi City County, Kenya. This was enhanced by the development and population of a minimum datasets that comprised of six variables i.e. water services and use, institutions, policy and legal instruments, threats to water quality, financial sources and science, technologies and innovations that were all assessed by populating the minimum datasets.

3.4. Target Population

The target population was 2217 connected Jisomee Mita beneficiaries comprising of local water vendors, users, operators and community representatives in Soweto Kayole Jisomee Mita project site. Others were NCWSC, WASREB, WSTF, AWWDA, Safaricom (M-PESA) who are a mobile service provider, Water and Sanitation Services Improvement Project (WASSIP), Kenya Informal Settlements Improvement Project (KISIP). The second category of respondents from the focus group discussion comprising of the NCWSC staff (4), WB staff (2), Assistant chief (1), private investor (1 landlord) and other community representatives were also all reached out for their opinion (Appendix 3.3). Thus focus group discussion members (Appendix 3.3). According to Mugenda and Mugenda (1999), target population is the entire group a researcher is interested in or the group about which the researcher wishes to draw

conclusion. Mugenda and Mugenda (2003) further postulates that a population is any set of persons or objects that possesses at least a common characteristic.

3.5. Sample Size and Sampling Procedures

Sampling techniques offer a wide range of methods and ways that normally assures researcher to reduce the amount of data required to gather by collecting data from a sub-group rather than all possible cases or elements (Kish, 2011). Simple random sampling was considered for this research.

3.5.1. Sample Size

The definition of a sample is that it is part of the entire target population that was procedurally selected to represent it (Oso & Onen, 2009). As per Mugenda and Mugenda (2003), he states that a descriptive study of 10% or above of the accessible population is sufficient to proceed with the study which complied to this study which was 14.75%, while Cochran (1977) assumes that a sample of 30% is adequate for a research work to proceed.

At the project site, actors directly interacting with the Jisomee Mita such as local water vendors, users, operators and community representatives were interviewed (Appendix 3.1 on demographic/ household characteristics, Appendices 3.2 on focus group discussion and 3.3 on mapped out members of focused group discussion, Appendix 3.4 on the water utility – NCWSC and Appendix 3.5 on water point operators). Quantitative data on water supply, distribution of the Jisomee Mita gadgets, and issuance of tokens as well as cost recovery were obtained. Thus, both quantitative and qualitative methods were explored but it is good to indicate that this was mainly a qualitative study hence not offering very good grounds for statistical analysis even though the study provided an array of clear indications of how deployment of STI in the water sector helps in catalyzing sustainable water services provision in Soweto Kayole.

In computing the sample size of the study, Fisher et al. (1991) formula was adopted and applied as shown below.

$$n = \frac{Z^2pq}{d^2}$$

$$nf = \frac{n}{1+n/N}$$

Key

n = desired total sample size [population greater than 10,000]

Z = standard normal deviation = 1.96 [which corresponds to 95% confidence level]

p = prevalence proportion = 0.50 [in accordance with Fisher et al. (1991) guidance]

q = 1.0 – p = 1.0 – 0.5 = 0.5

d = degree of accuracy desired = 0.05 [which corresponds to 1.96, z-statistic]

nf = sample size desired for population less than 10,000 in which n = 384 and N = 2217

$$n = \frac{1.96^2 \times 0.5(1.0 - 0.5)}{0.05^2} = 384 \text{ respondents}$$

The total population of Jisomee Mita was 2217 thus N = 2217 and since N is less than 10,000, then the second formulae applies

$$nf = \frac{384}{1+384/2217} = 327 \text{ respondents}$$

From the calculation, a sample size of 327 respondents was arrived at and considered feasible and adequate for the study at Soweto Kayole JM project site.

3.5.2. Sampling Procedure

Sampling procedure involves simple random sampling of a number of water services providers in Nairobi City County, Kenya operating within the project localities in Soweto Kayole in such a way that the population selected represented the entire population of the study area.

The researcher used a qualitative case study approach by considering empirical studies / investigations. The empirical studies was mainly focused on the processes of implementing the Jisomee Mita Project in Soweto Kayole informal settlements of Nairobi City County, Kenya to assess the level of deployment of STI in catalyzing sustainable water services provision in the area. In this thesis the researcher searched/ investigated for indications of correlation / relation in three broad categories: Science Technology and Innovations functionality; entrepreneurial model related functionality; and Socio-political functionality by means of administration of questionnaires and interviews to the key actors or stakeholders in the water services provision.

3.6. Research Instruments

In this research thesis, the researcher used primary data gathered with the aid of a questionnaire and interview guide, which were administered to the sampled population from Soweto Kayole

Jisomee Mita project site and also from NCWSC (Appendices 3.1: households demographic characteristics, 3.2: Focus group discussion (NCWSC, WB, Chief, Water point operator, and community members), 3.3: Focus group discussion members, 3.4: Water utility and 3.5: Water point operators). The researcher used open and close ended techniques whereby open-ended questionnaire aided to elicit and generate sufficient information from the interviewee with no restriction to their responses. One on one interview was deployed as well as giving clarity on any ambiguous response or information gathered using the instruments. Kothari (2004), states that data collection is the means the study uses to collect the required data/ information. Finally, the questionnaire, FGD and interview guide were prepared and administered to the respondents by the help of research assistants. The research assistants were trained for two days by taking them through the project background and objectives then intensively examine the questions in order to gain deeper understanding of the anticipated results.

3.7. Data Collection Procedure

Data collection is a process of gathering factual materials as a basis of analysis and this necessary for the achievement of the research objectives. Primary data was gathered with the aid of a closed and open-ended structured questionnaire. Secondary data collected from various empirical study reports, government documents, journals, books, manuals and other online sources. The researcher developed a research proposal over a period of two to three months under the supervision and guidance of the research supervisors. The researcher obtained permission to collect data from the National Commission for Science, Technology and Innovation (NACOSTI) (Appendix 3.6) and also from the Nairobi City Water and Sewerage Company (Appendix 3.7). The research instrument was pilot tested to ensure its validity and reliability. Thereafter raw data gathered with the help of competitively recruited research assistants after which the raw data was processed or analysed, interpreted and presented.

3.8. Data analysis Techniques

The raw data was gathered from the study area was cleaned up through thorough and careful scrutiny of the dully completed questionnaires to ensure that the data is valid and accurate and uniformly consistent. Editing of the data was done in order to correct errors and omissions where possible. There was appropriate categorization and coding of information into frequency distribution tables in order to allow further analysis. The closed ended questions were designed to obtain data on the characteristics of respondents, their access to water, water use, and sanitation. Descriptive statistics and correlational analysis used to analyse the data. The researcher used STATA version 14 and Microsoft Excel for analysis.

The open-ended questions were used to explore key themes relating to how participants perceive risks and choose between different water services providers and management strategies. Descriptive statistics such as mean, standard deviation, frequency distribution and percentages used to interpret the findings. Inferential statistics such as regression and correlation analysis was considered to establish the level of deployment of Science, Technology and Innovation (STI) in catalysing sustainable water services provision and addressing issues on water services development, utilization and management at Soweto Kayole in Nairobi City County, Kenya.

3.9. Ethical Consideration

Prior arrangements and or appointments was made with the respondents on the day/ date and time the questionnaires and surveys were administered and conducted. The respondents were briefed prior to the execution of the exercise of the main purpose of the research and as per the requirement not coerced or forced to give their responses but a friendly and conducive environment to participate and contribute voluntarily to the study. More importantly, the objectives of the study explained before and after undertaking the research to aid in attaining an informed consent from the respondents. As per the law, the researcher is obliged to maintain high level confidentiality about the respondents' feedbacks and or responses private and secured and only using them specifically for academic purposes.

As also earlier stated that before embarking on any research, permission must be sought from the National Commission for Science, Technology and Innovation (NACOSTI – Appendix 3.6) and Nairobi City Water and Sewerage Company (NCWSC – Appendix 3.7) and these are mandatory regulations/ requirement by the government of Kenya.

The survey was voluntary and do not contain information that would personally identify the respondents. Informed consent was given prior to the interview, and respondents who were willing to participate had the right to withdraw at any time during the interview.

3.10. Research Approach Framework

The research thesis framework provided an introductory context to deployment of science, technology and innovation in catalysing sustainable water services provision specifying the research objectives, research questions, brief methodological approaches and the research tools and instruments used in conducting the research work. Finally, a synthesis of the research and interlinks of findings from the five specific objectives of the study, available on Table 3.1.

Table 3.1: Research Approach Framework

Specific Objectives	Research Questions	Approach Deployed to Realize the Objectives	Research Tools and Instruments
To establish the status of water services provision in Soweto Kayole, Nairobi City	What is the status of water services provision in Soweto Kayole, Nairobi City?	Empirical studies; Data Collection and Analysis aided by Appendices 3.1, 3.2, 3.3, 3.4 and 3.5	Survey Questionnaire, FGD guide, Field Observations, Field Photography, IBM STATA
To evaluate the current and emerging innovations and technologies applicable in the urban water services provision in Nairobi City	What are some of the current and emerging technologies and innovations applicable in the urban water services in Nairobi City?	Empirical studies; Data Collection and Analysis aided by Appendices 3.2, 3.3, 3.4 and 3.5	Survey Questionnaire, FGD guide, Field Observations, Field Photography, IBM STATA
To evaluate the current impacts on adoption and uptake of emerging innovations and technologies in improving sustainable management of water services and access in Nairobi City	What are the current impacts on adoption and uptake of the emerging innovations and technologies in improving sustainable management of water services and access in Nairobi City?	Empirical studies; Data Collection and Analysis aided by Appendices 3.1, 3.2, 3.3, 3.4 and 3.5	Survey Questionnaire, FGD guide, Field Observations, Field Photography, IBM STATA
To establish the strategies in place for mainstreaming best bet practices in the emerging innovation and technology interventions into national water sector development policies and frameworks	What are some of the strategies in place for mainstreaming best bet practices in the emerging innovation and technology interventions into national water sector development policies and frameworks?	Empirical studies; Data Collection and Analysis aided by Appendices 3.2, 3.3, 3.4 and 3.5	Survey Questionnaire, FGD guide, Field Observations, Field Photography, IBM STATA

CHAPTER FOUR

4.0. DATA PRESENTATION, ANALYSIS AND INTERPRETATION

4.1. Introduction

Chapter four of this thesis focused on data and information analysis, presentation and interpretation of the findings of the study.

4.2. Questionnaire Return Rate

Structured questionnaire (Appendix 3.1) both open and close-ended questions was administered to a sample size of 327 of which 327 were issued, 319 were duly filled and returned. This constituted a response rate of 97.55% which was possible since the questionnaires were administered by the four research assistants. This return rate was in line with Nachmias and Nachmias, (2005) and Coopers & Shiendler, (2000) who asserts that questionnaire return of 75% and above is adequate for a research study to proceed. Given that the response rate was over and above the minimum threshold required, the study proceeded. Table 4.1 represent the actual rate of return for questionnaire that were administered.

Table 4.1: Questionnaire Return Rate

Research Instrument - Questionnaire	Sample Size	Percent
Questionnaires issued	327	100
Questionnaires returned	319	97.55
Questionnaires not returned	08	2.45
Total	327	100
Research Instrument – Interview Guide for FGD (Appendix 3.2 and Appendix 3.3)		
No. of participants invited	10	100
No. of participants attended	10	100
No. of participants not attended	00	0
Total	10	100
Total – (Residents and FGD)	330	98.78

4.3. Demographic Characteristics of Respondents

Demographic characteristics of the respondents for the research study were gathered from Soweto Kayole residents and focus group discussion and presented below.

4.3.1. Distribution of Respondents

During the raw data gathering exercise, respondents were asked to state their demographic characteristics guided by the research assistants and the responses are presented in Table 4.2.

Table 4.2: Demographic Characteristics

Gender	**Frequency**	**Percent**
Male	101	31.66
Female	218	68.34
Total	**319**	**100**
Age		
18 - 30	107	33.54
31 - 40	146	45.77
41 - 50	52	16.30
Over 51	14	4.4
Total	**319**	**100**
Academic qualifications		
Primary	36	11.29
Secondary	104	32.6
Certificate	120	37.62
Diploma	56	17.55
Bachelors	03	0.94
Masters	0	0
Others	0	0
Total	**319**	**100**
Marital status		
Married	198	62.07
Single	74	23.20
Divorced	06	1.9
Others (Widowed)	41	12.9
Total	**319**	**100**
Average monthly household income (Kes)		
0 - 6000	43	13.48
6,001 – 9,000	102	31.97
9,001 – 15,000	143	44.83
15,001 – 24,000	22	6.9
Above 24,001	09	2.8
Total	**319**	**100**
Number of dependents		
1 - 2	42	13.17
3 - 4	226	70.85
5 - 6	40	12.54
7 - 8	11	3.45
Total	**319**	**100**

The analysis on gender participation in the study shows that out of the 319 respondents, 218 (68.34%) were female while 101 (31.66%) were male. The results show that the majority of the respondents were female. The implication of this data confirms the dominance of the female

gender in the water services provision especially for domestic purposes. Figure 4.1 displays gender representation in the study both in terms of frequency / numbers and percentage.

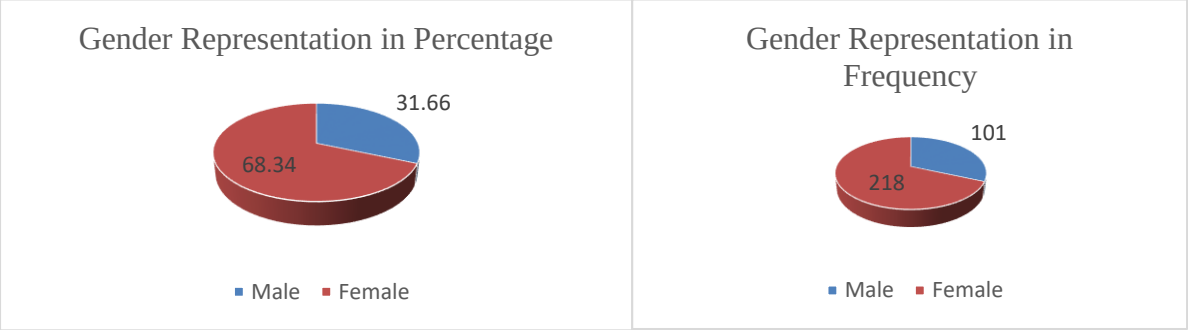

Figure 4.1: Gender representation of the respondents in the study

Figure 4.2 shows that out of 319 respondents who participated in the research study 107 (33.54%) fell in the age bracket of 18-30 years, 146 (45.77%) were in the age bracket of 31-40 years, 52 (16.3%) were in bracket of 41-50 years, while 14 (4.4%) fell in the age bracket of 51 years and above. The implication of this results indicate that the majority of the respondents involved were youthful thus 79.31% of respondents are 40 years and below of age.

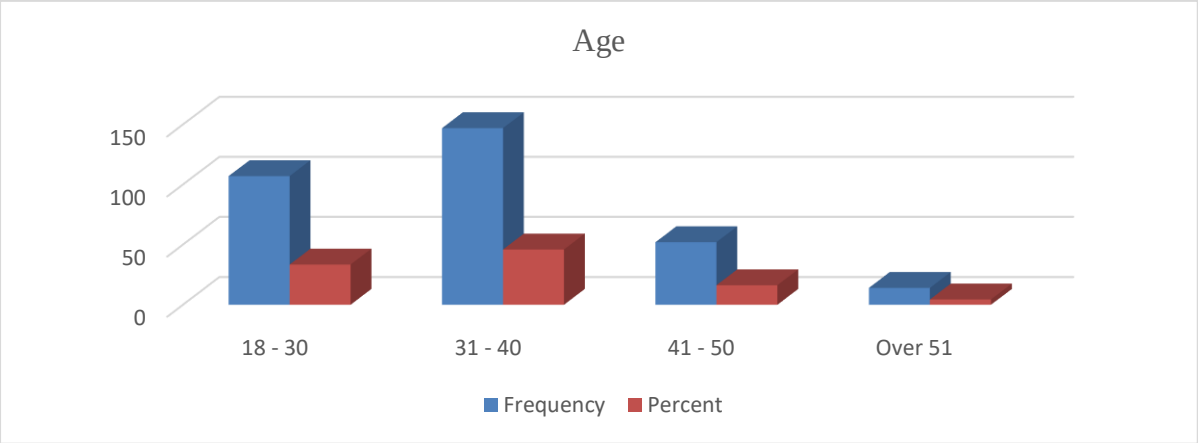

Figure 4.2: Age distribution of the respondents in the study

The analysis and findings on academic qualification as represented in Figure 4.3 portrays that out of 319 respondents, 36 (11.29%) had in primary level, 104 (32.6%) had secondary level, 120 (37.62%) had post-secondary certificate level, 56 (17.55%) had diploma level and 3 (0.94%) had bachelor degree as the highest qualification level of education. The implication of this on the focus of the study is that most of the residents (81.51%) are certificate holders/ graduates and below and hence justify their level of income and their choice to reside in low informal settlement.

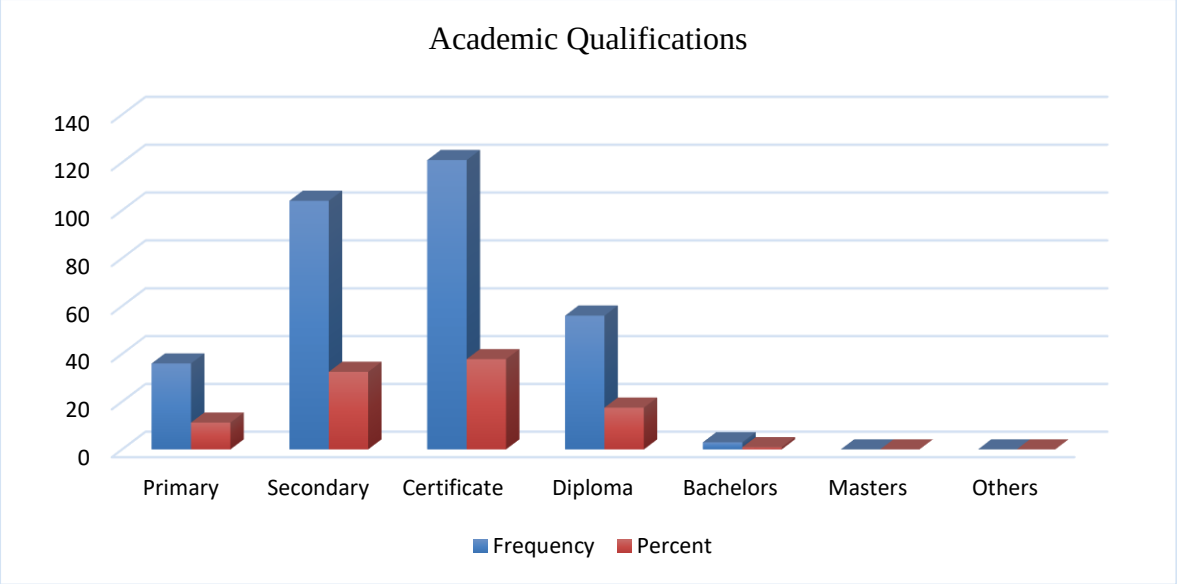

Figure 4.3: Academic qualifications of the respondents in the study

The results on marital status as displayed in Figure 4.4 portrays that out of 319 respondents, majority are married with 198 (62.07%), followed by single 74 (23.20%), then widowed 41 (12.9%) and the least was divorced with 6 (1.9%) of the total sample size. The implication is that the focus of the study was right and gender and inclusivity was considered and met.

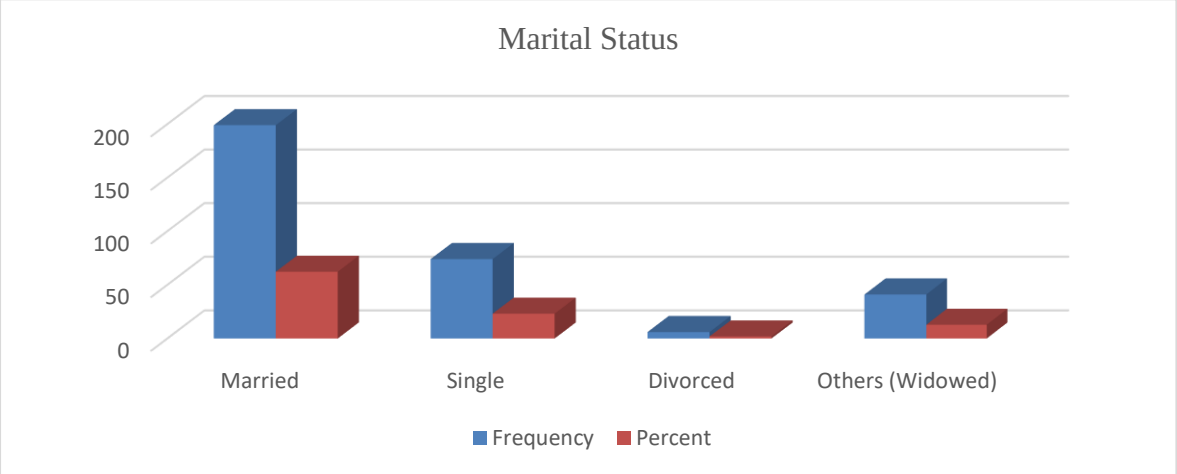

Figure 4.4: Marital status of the respondents

The statistics of monthly average income in Figure 4.5 indicates that households with an average monthly income of below Kes. 6,000 were 43 (13.48%), 102 (31.97%) were getting income between Kes. 6,001- 9,000, 144 (44.83%) were falling between Kes.9, 001- 15,000 which constituted the majority, 22 (6.9%) were getting between Kes. 15,001 – 24,000 and 09 (2.8%) had an average monthly income above Kes.24, 001. The implication of these results confirmed that the focus group or respondents are of low income level hence justifying the slum or low income settlement locality.

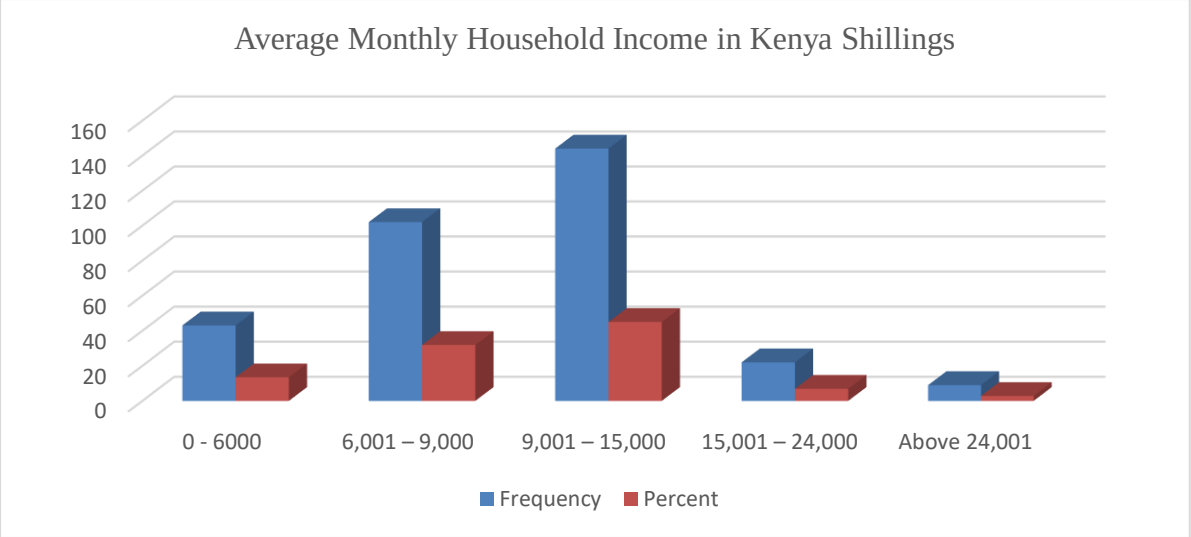

Figure 4.5: Average monthly household income of the respondents

Respondents from the study with 1-2 dependents in their households were 42 (13.17%), 3-4 dependents in their households had 227 (70.85%), 5-6 dependents had 40 (12.54%) and 11 (3.45%) had 7-8 dependents in their households. Figure 4.6 shows the statistics.

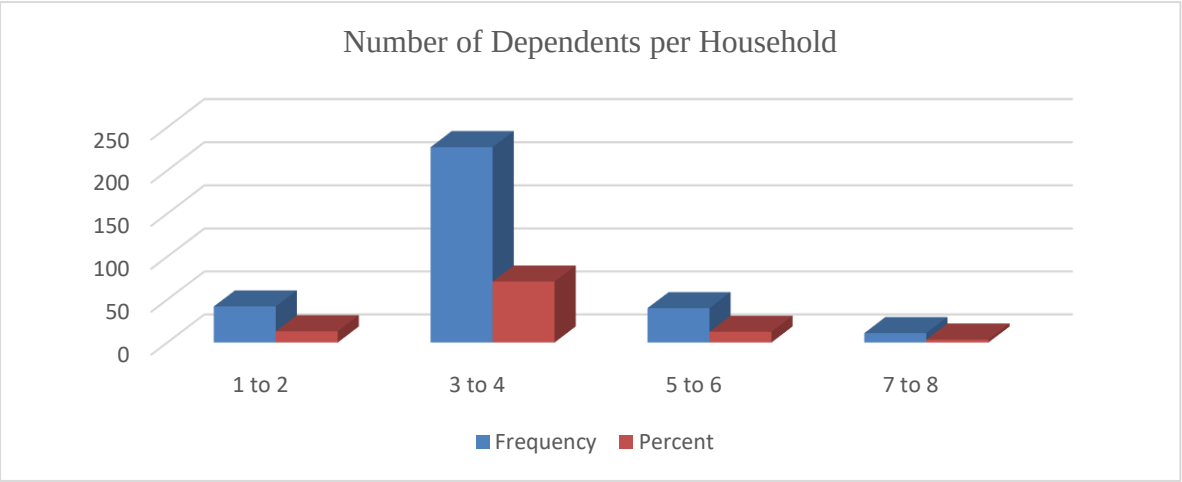

Figure 4.6: Number of dependents per household of the respondents

4.4. Status of Water Services Provision in Soweto Kayole

In this section, the researcher sought to establish respondents' perception on the status of water services provision in Soweto Kayole both before the JM intervention and after the intervention. Soweto Kayole informal settlement residents by large extent relies mostly on other sources of water such as boreholes within their locality for their domestic use as in most instances the institution charged with the mandate of water services provision becomes unpredictable and unreliable on when quality and quantity of piped water will be available and worse of, water vendors sourcing water from the nearby estates sell at exorbitant prices ranging as high as Kes 15 to Kes 20 for a 20 litres jerrican. This portrayed a great mismatch as from the socio-

economic analysis of the average income of the residents shows that majority earn a monthly income of Kes 12000 [9001 to 15000]. Assuming that each household spends Kes 20 i.e. 20 litres jerrican per day which translates to 5% water expenditure on monthly basis.

A study on willingness to pay indicated that about 81% of the end users noted preference on improved levels of services of water connection to individual households. This is also supported by the JMP findings, even though, NCWSC's connection pre-requisite entails a connection fee payment which has proved to be the main hindrance to access of improved quality water services whereby the average cost for a standard water connection is about thirteen thousand three hundreds and fifteen shillings. This amount of money caters for piping and fittings, domestic connection fees and a refundable meter rent. Before the World Bank chipped in to support the community to construct an 18 km pipe water network within the 9 zones with a loan through NCWSC who received the funding to support these activities.

In the initial arrangement, household connections weren't part of the credit facility and therefore it is worth noting that NCWSC requested for a loan facility of about Kes. 10M from K-rep Bank to pre-finance the 2,217 household water connections. It was anticipated that on the completion of the project with the 40% OBA subsidy that covered 50% of the credit facility received from K-Rep Bank by NCWSC, the residents will repay part of the loan through affordable staggered amounts whenever they subscribe to their monthly bills. The residents of Soweto Kayole being an informal settlement segment and with the pro-poor strategy, the households were to make a commitment fee of about Kes 1650 as an equity requirement under the project. So far NCWSC have managed to connect slightly over 2,217 mapped households with metered water enhanced with JM gadget connection and provided quality, affordable and reliable water. Table 4.3 present processed / analyzed results for the intervention before and after (Appendix 4.1).

Table 4.3: Comparison of the situation before and after the intervention

Category	Before	After
Frequency in payment of water bill	81.25% indicated that they pay water bill on a daily basis	78.25% indicated that they still pay water bill on daily basis
Amount paid for water	For those paying on daily basis, the average amount per day is kes.50 while those paying monthly basis, average amount is kes. 550.	For those paying on daily basis, the average amount per day is kes.40 while those paying monthly basis, average amount is kes. 430.
Comparing the amount of money spent on water and that spent on electricity	Most of the respondents [62.13%] indicated they pay higher on water as compared to electricity	Most of the respondents [62.13%] indicated they pay higher on water as compared to electricity
Source of water for the household	Majority of the residents [76.88%] get their water from water kiosks, followed by yard tap [16.56%] while 6.56% indicated they get their water from other sources.	There were slight variations as majority of the residents [74.5%] get their water from water kiosks, followed by yard tap [21.33%] while 4.2% indicated they get their water from other sources.
Quantity of water fetched from the water source on daily basis	Most residents indicated an average of 150L [120L – 180L] per day i.e. 8 jerricans each holds 20L of water	Most residents indicated an average of 150L [120L – 180L] per day i.e. 8 jerricans each holds 20L of water
Adequacy of water for household activities	88.4% of the respondents said water was not adequate for household chores while 11.6% were satisfied	91.75 % of the respondents said water was not adequate for household chores while 8.25% were satisfied
Other water sources or providers depended on in order to meet daily water use and requirement	Majority of the residents [89.13%] indicated they had no other sources a part from rain water and buying from water hawkers.	Majority of the residents [89.13%] indicated they had no other sources a part from rain water and buying from water hawkers.
Average distance walked to collect water and average time taken to fetch water	Respondents mentioned that they walk averagely 100m to collect water, taking an average of 5 minutes at the water point to fetch water.	Respondents mentioned that they walk averagely 100m to collect water, taking an average of 5 minutes at the water point to fetch water.
Average number of hours in a day water is received/ supplied	The residents indicated whenever water is supplied; it flows for an average of 8 hours a day.	The residents indicated whenever water is supplied; it flows for an average of 8-10 hours a day.
Water supply interruptions at water point and the frequency	Majority of the residents [71%] noted that there are water supply interruption which occur most often	Majority of the residents [63.86%] noted that there are water supply interruption which occur often
Level of response to maintenance whenever there is interruption	66.37% of the respondents showed there is delayed response while 33.63% noted prompt response whenever there is interruption	59.6% of the respondents showed there is delayed response while 40.04% noted prompt response whenever there is interruption
Aspects of water supply that require urgent and priority improvement	53% of the residents indicated that cost aspect need to be addressed, 39% indicated need for improved reliability while 8% require need for maintenance improvement	51% of the residents indicated that cost aspect need to be addressed, 43% indicated need for improved reliability while 6% require need for maintenance improvement
How would you rate the existing water supply services at Soweto Kayole	The residents of Soweto indicated that water services are poor with 76.25%, while 17.19% showed average services while 6.6% indicated the services are good.	The residents of Soweto indicated that water services are poor with 65.95%, while 24.65% showed average services while 9.4% indicated the services are good.

The study established that there are some improvements in water services provision such as reliability, quality, quantity, and affordability comparing the two scenarios even though in some aspect the changes were very insignificant. Figure 4.7 is a pie chart showing reduction in payment for water bills after the introduction of the JM intervention.

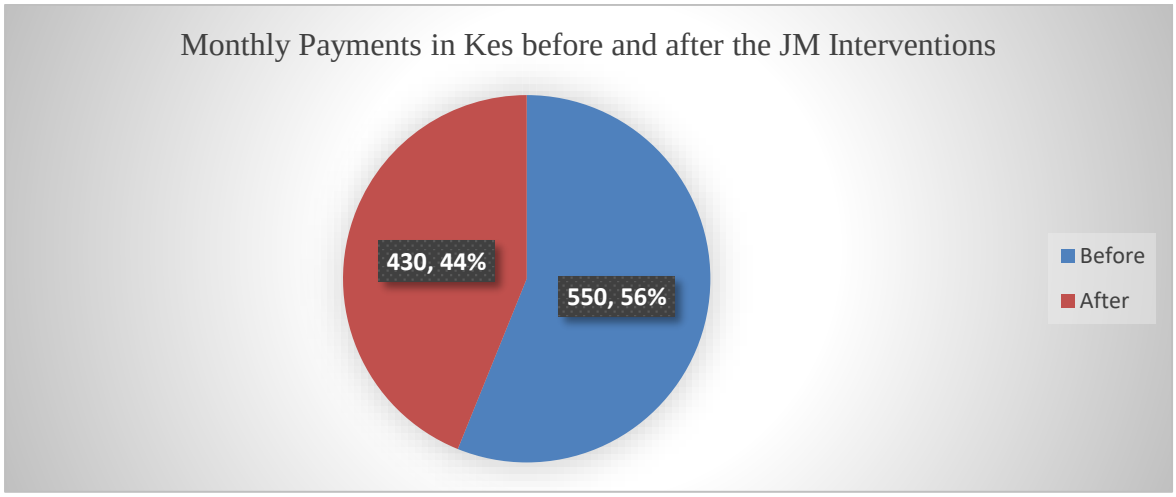

Figure 4.7: Monthly payments before and after the JM interventions.

Figure 4.8 and Figure 4.9 illustrates the rating by the respondents of the existing water provision services and priority components that needs urgent attention and improvement.

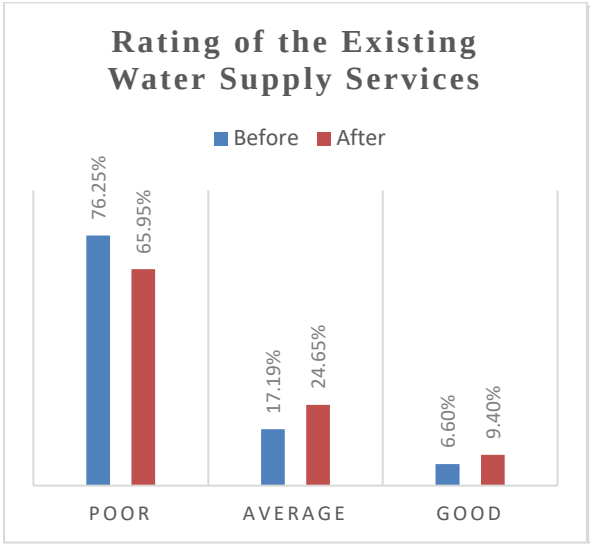

Figure 4.8: Existing water provision services

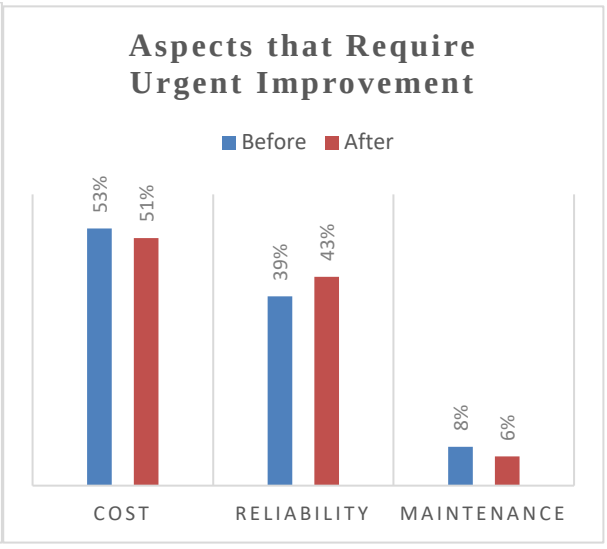

Figure 4.9: Aspects that require improvement

Figure 4.10 and Figure 4.11 displays the level of response to maintenance and repair of water pipes with leakages or bursts and the frequency of water supply provision interruptions before and after the JM intervention respectively.

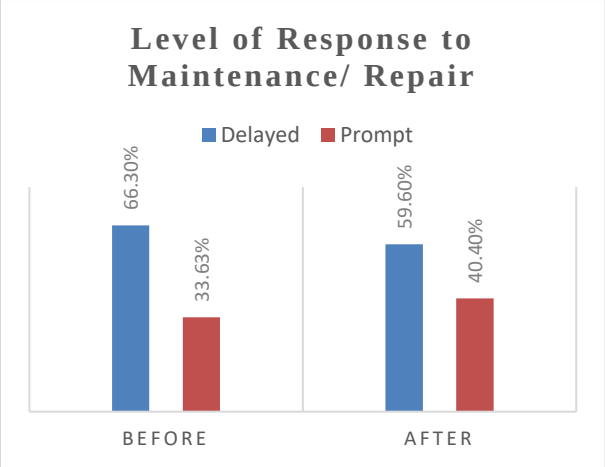

Figure 4.10: Response to maintenance / repair

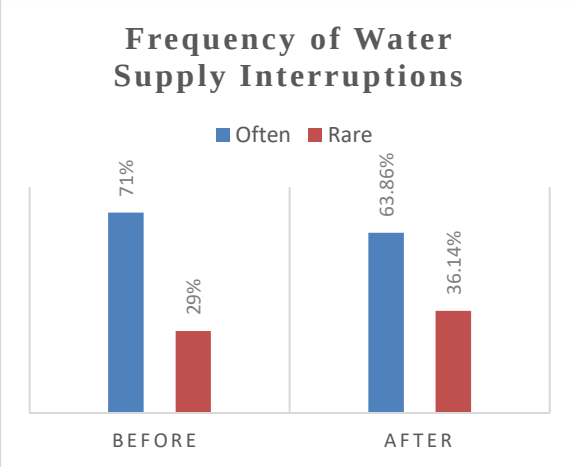

Figure 4.11: Water supply interruptions

Figure 4.12 and Figure 4.13 shows the level of adequacy of water for households' chores and the available sources of water for households use before and after the intervention in the area.

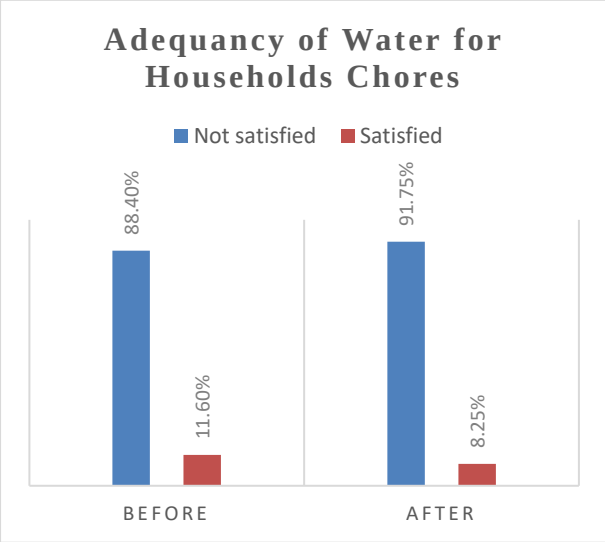

Figure 4.12: Water for household's chores

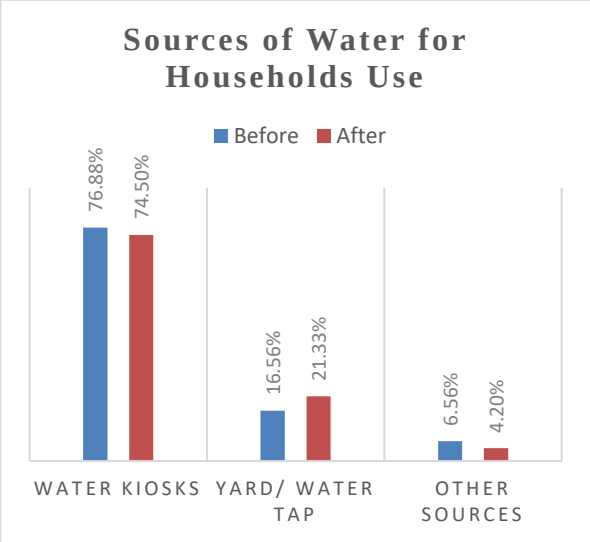

Figure 4.13: Sources of water for households use.

4.5. Adoption Mechanism with the Scarce Water Services Provision

Presently the water production of NCWSC levels are estimated to be slightly over 525 000 m^3/day as compared to the daily demand of 830 000 m^3/day leaving a huge deficit for the Nairobi residents. As a result of the scarcity, water provision to the lately connected residents of Soweto Kayole is controlled to ensure there are senses of equity in distribution to the nine zones whereby each of the nine zones receives water averagely once a week.

Coping mechanism to bear with the limited water supply, the residents adopted various approaches of obtaining water for their day to day use. These include but not limited to water storage where residents keep their water in various sizes of containers, usually 20 liter jerricans and superdrums and pales and since majority stay in a single house, and therefore limited on

the number of containers that can be kept hence worsen their situation when water not available for a long period of time. A few landladies or landlords managed to install between 1000 litres to 4000 litres of water tanks to cushion tenants during water supply rationing. Another hindrance is the high costs of water storage tanks. Second strategy is roof or rain water harvesting in which landladies/ landowners have fixed gutters to the iron sheet roofs to help in water harvesting during rainy seasons. Harvested rainwater is commonly used for cleaning and its quality is compromised. The third strategy is exploitation of borehole water as the residents use borehole water mainly for cleaning and even to some extent for drinking and cooking when they don't any other option. These sources of water are to some extent highly contaminated and polluted hence making them less preferred for consumption.

4.6. Innovative Self-Meter Reading and Billing System

The residents of Soweto Kayole indicated their gratitude of the innovations being rolled out to remedy the water supply and sanitation problems they have been facing for decades. From the initial noble objective of the project which was to enhance on self-meter reading and billing system by the end consumers by empowering customers of low-income levels to read their meters and pay their water bills via M-Pesa/ Airtel money. As a result of this endeavor, NCWSC developed JM innovation, which is a mobile - web platform that gives the residents to submit their meter readings via text, check account number, water consumption balance, and then pay for the water bill. For effective and efficient management of the credit facility, this gadget has the functionality to remit alerts to the consumer on the outstanding credit due for payment. This approach is in line with the socio connection policy for water connection or service provision to the informal settlements in Kenya using mobile money.

It is worth noting the significant and tremendous improvement in services provision in the area as initially before the introduction of JM, the residents were purely depending on the meter reading by the NCWSC staff, then send to customers. This was tedious and ineffective as customers were forced to trek for long kilometers away to NCWSC offices and queues for hours to settle their water bills of which this has been cured by the introduction of the JM. This is both less costly at the same time convenient and reliable since it offers 360 degree functionality of reading and remitting payment as most residents in informal settlements do not have access to postal addresses which is also outdated channel. Finally, the mobile platforms provide customers with low and irregular income a great advantage of a flexible paying arrangement. In contrast, water adequacy for household chores reduced as noted by the

respondents in figure 4.12. This was because of the introduction of JM which to some extent managed reduce non-revenue water or unaccounted for water.

The residents reiterated their confidence with the JM, since they have full mandate to ration their daily water usage and repayment of credit advanced. The platform is versatile and fit the socio-economic attributes of the lives of low income earners, with the flexible credit repayment arrangement. NCWSC already reaping benefits of reduced operations and maintenance costs as they can easily recover loan installments and provide more accurate water bills to the clients. At the same time, launch of JM has seen the utility collects more revenue in Soweto Kayole than ever before and even in other informal settlement locations.

4.7. Challenges Experienced at Soweto Kayole

In comparison with other utilities such as electricity, it is worth noting and emphasizing the problem of access to water and energy in the informal localities is critical and require holistic approaches to remedy them. The informal settlement residents have improvised various innovative channels of access to water outside the realm of the long established centralized, huge complicated system that was borrowed from the colonial era. NCWSC has faced a number of setbacks in trying to meet the ever increasing demand of water by the residents of the city and at the same time confrontations with hybrid constellations of water supply systems operating outside of the City's formalized institutions and regulatory frameworks. Operators of unlicensed water kiosks, boreholes and water cartels and slum gangs who terrorize and frequently involved in bypassing pipes and re-channeling water to strategic locations, creating illegal branches and collection points outside the purview of NCWSC. Consequently, in order for the utility to survive, reverse strategies have been deployed to contend with 'inverse infrastructures' (Egyedi et al., 2012), which are easily accessible to low-income earners and are less expensive to build and operate, and provides more incremental services such as small bottom-up, user-driven, and self-organizing infrastructures.

The residents in Soweto-Kayole sometimes opt for options such as distant yard taps and standpipes, unlicensed public or private water kiosks in the neighbouring high end estates; non-piped networks such as tanks, community-based boreholes, rainwater, and a highly contaminated river on the settlement's periphery. Majority of the population walk kilometers away with 20-litre jerry cans on their backs or cycle or push a cart, to access water in neighbouring satellite estates. Kariuki et al., 2003 cites that there are a numbers of hindrances that reflect the well-documented inadequacies and setbacks of the conventional centralized grid in providing reliable and accessible services to the city population.

Soweto Kayole status has attracted a number of investors, donors, other development agencies and even the government of Kenya to come up with some possible strategies to address the historical and social problems. From historical background, wealthier sections of the City's population enjoy largely unrestricted access to piped water at a fairly low rates.

Different agencies have tried to liberate residents from exploitation by gangs and water cartels who normally ride on the absence of formal water provision channels to sell water at exorbitant rates. Triggered by these concerns, the World Bank considers Soweto-Kayole "an excellent ground for mass formal solutions such as reticulated sewer and water on a demand-driven and affordability basis" (World Bank Group, 2015). From this context, Soweto-Kayole became an ideal space for both local and international agencies and the water utility to deploy JM as an Emerging Technologies and Innovations, which they promote as a tool for promoting water access in the informal settlements.

4.8. Social Connections Implementation in Soweto Kayole

WASSIP and KISIP are the two IDA-funded projects, offering financing to Athi Water Works Development Agency (AWWDA) among other water works development agencies for WSS infrastructure investment in their areas of jurisdiction. The WSP is supporting water service providers in Nairobi to implement policies of social connection which will provide and enhance water access to WSS services to the poor segment of the city informal settlements' populations. The implementation of the policy on social connection in the city in which NCWSC adopted the policy with the assistance of the Water and Sanitation Program (WSP) in 2011.This policy is in line with the AWWDA's informal segments strategic guidelines and policy for improving hygiene/ sanitation and water services in Nairobi's informal segments, this ensures there is improved access to safe and clean water in adequate quantities at the household level in city's informal settlements and other low-income localities.

Execution of this regulatory framework provides subsidized connections for the first time for sewer and domestic water for people living in Soweto Kayole's informal settlements and other low income localities. It is in the general public knowledge of the major hurdles for Nairobi City Water and Sewerage Company to connect the poor directly to the company's network due to the pre-requisite connection fees, and this policy has assisted to some extent in reducing the need for households to rely on water cartels and vendors who sell water at rates which are exploitative under unhygienic conditions. The policy offers guidance on related to the social connection fund, responsibilities and roles, utilization, eligibility of the funds, connection and tariffs fee required.

4.9. Resource Implications and Social Connection Policy Implementation

The uptake and adoption of the policy on social connection in Nairobi began with the development of the Athi Water Works Development Agency (AWWDA) pro-poor policy back in 2007. The guidance developed and steered the AWWDA, NCWSC and other stakeholders in the water sector towards designing, planning and implementation of a more systematic approach to improve water and sanitation services in the informal settlements. The proposed approaches within the guidelines involved capacity building on technical skills to the staff of NCWSC especially the ones working in the informal areas and then social connection program development and implementation.

The establishment of the unit/ department of informal settlement within the NCWSC in the year 2008 with the main role of executing projects in informal localities and staffed at the head office and in the regional offices. NCWSC management placed adequate and sustainable financial and human resources in the units and departments with performance/ appraisal contracts and operational budget. The capacity of the team from the department of informal settlement was considered to make sure that a proper skill mix is attained from engineer, surveyor, sociologists, technicians, community development assistants and meter readers. Structured training and knowledge exchanges were conducted through carrying out of benchmarking activities with other regional utilities and blended with specialized skills training courses. Key staff from AWWDA were very instrumental in mobilization of funds and in partnership with NCWSC, designed, planned and executed improvements of the WSS.

The Social Connection Policy (SSP) was developed and adopted by NCWSC in the year 2011. Mapping of existing infrastructure, social economic assessments and baseline surveys were carried out to facilitate the execution of the policy. The essence of this work was to get data on household incomes and expenditure, willingness and ability to pay and costs of trunk extension required. These data gathered were pre-requisite to aid in the design of utility that best fits the fluctuating incomes of informal sector earners and self-employed. Informed by the findings from baseline survey and existing knowledge from the literature reviewed, technical design was developed and planned infrastructure, hardware interventions and detailed cost estimates were prepared to enhance the execution of the program on social connections in Soweto Kayole which literally commenced in July 2011.

Prior to the roll out of the policy on social connection, establishment of a local NCWSC office was considered in informal settlement in Soweto Kayole. The key mandate of the office was to mobilize and sensitize the residents about the benefits and implications of signing up for a

social connection, applications from customers for connections, provision of customer care, design, development and communication on the rationing schedule, and water pressure adjustment in the network to ensure households receive water. Criteria for executing policy on social connection require steps preceded the execution of the policy (Guma, et al 2019). These included but not limited to the following six criteria:

a. Financial and socio-economic analysis conducted to assess beneficiaries of the project, their willingness and ability to pay as well as possible constraints to full execution. The analysis presented vital information for planning and execution of the project. Informed by the findings, NCWSC estimated the costs of implementing the policy in Soweto.
b. Lack of proper and adequate infrastructure hinders sustainable access to WSS in low income localities. Evaluation of levels of access, status of WSS networks and availability, network expansion and cost of connection was required by WSPs which eventually aided in the assessment of level of investments required by the utility.
c. The government and other agencies have given less priority on investing on the water sector hence increase in water scarcity in the region. One of the determinant of policy on social connection is the availability of water which is a contrast to what most of WSPs do by carrying out water rationing programs in place in order to attempt to meet the ever increasing demand for water. Beneficiaries were skeptical of committing and signing up the policy if water availability and provision could not be assured.
d. Financial and socio-economic analysis results as well as the assessment of adequate WSS infrastructure and availability of water, well informed decision on the selection criteria for target settlements, beneficiaries and modes of payment was made by the water services providers which allowed WSPs to come up with the policy on social connection.
e. Local NCWSC office established in Soweto Kayole. The office helped in the drafting of the rationing schedule, water pressure adjustment in the network for the households applying for a social connection to receive water. The office in Soweto was vital in rolling out the policy on social connection as it receives applications to provides customer care and social connections. It also works closely with the leaders from the community to sensitize and mobilize local residents about the implications and benefits of signing up for the policy. The lessons learnt from executing the policy on social connection in Soweto Kayole confirmed the necessity of office amenities to boost staff morale to work and offer conducive environment for productivity. Consequently, the resources allocation for Soweto Kayole office increased and more human resources

were deployed constituting CDOs and sociologists to support engagement with the locals hence primordial for the success of policy.

f. Harmonization of the technical designs with survey plans and land ownership required coordination with planning authority to help in avoiding disputes. Creation of the NGO coordination secretariat by the NCWSC for projects to share work plans and to aid in harmonizing work plans was equally critical.

The connection rates/ prices for the residents of Soweto Kayole were very high despite the fact that they were willing to pay for improved water and sewerage services. Averagely the costs of connecting to piped water connection from the water utility is estimated at Kes 8,215.00 (after the 40% OBA subsidy) covering non-refundable fee, meter installation deposit, fittings and piping, contrary to mean household monthly income which is about Kes12000, distributed amongst various other priorities in the house. Normally water demand is very high in the informal areas and majority of the resident rely largely on water from boreholes and water hawked by vendors fetched from the neighboring estates at Kes 15-20 per 20 liter jerrican.

Through the policy on social connection, 89,000 people (2,217 plots) existing in the water network were connected in Soweto Kayole slums. The policy has significantly benefited the community as well as NCWSC. As a result of this policy, residents in the slum now have access to affordable, and clean water and considerably shortened the distances trekked to fetch water. Consequently, the water utility has increased her revenues collected from the connected clients and expanded the customer base considerably and this is because of the policy on social connection. Besides Soweto Kayole Slum, other areas with low income are earmarked to benefit from the policy where WSS infrastructure extensions are being supported by KISIP and WASSIP. There are already plans of replication the same policy in Matopeni Spring Valley and Riverbank settlements by the water utility company. 30km of sewer networks are currently under construction in Soweto Kayole locality besides the 25 kilometers of water network. Once the construction is completed, the community will be connected to the sewer network through the policy on social connection.

4.10. Current and Potential STI Applicable in the Urban Water Services

NCWSC commissioned the Jisomee Mita project back in 2014 May which is an STI based infrastructural development project designed and implemented to provide access to networked water services to the undeserved residents. Based on the hybrid techniques constellation combining Science Technology and Innovation tools with an expansion of piped water networks in the locality. JM portrays an emerging technologies and innovations centered

pathway for access to water, designed to facilitate seamless interaction between NCWSC and Soweto Kayole residents which enables the service provider to aid in self-meter reading.

The STI infrastructure and conceptualization of JM was initially designed to enable residents of Soweto Kayole read their meters and remit readings via text to NCWSC. The process was designed as an improvement on the conventional system whereby the locals who were connected to the centralized network waited for monthly paper bills from NCWSC for water consumed. Mobile money payment platform is provided by the Safaricom and Airtel Kenya through M-Pesa and Airtel money respectively. JamboPay which is an innovation and technology firm provides the payment gateway at the interface of mobile communications companies, water utility and water customers.

The residents are anticipated to convey their texts with meter readings to the water utility - NCWSC, either in written form or with graphics and visuals. The 'Query Invoice' option is used through the short code '20618'. There is toll-free texts for Safaricom mobile network operators, where the water utility (through funding from the World Bank Global Partnership on Output-Based Aid – GPOBA) meets the Kes 0.80 charges on behalf of water consumers. Other mobile operators like Airtel Kenya pay this fee themselves. JM is deployed in Soweto-Kayole as an emerging Science Technology and Innovation (STI) enhanced solution to address the previously experienced complications of NRW, billing, and payment and also access to water. It is therefore constituting broad range of the emerging STI enhanced program prioritized and deployed by the water utility as 'quick fixes' for the persistent challenges of water service provision. NCWSC cites that JM is a key driver of the company’s endeavour to improve delivery of services via the integration of STI, and is an approach towards achieving automation of services and accelerated bill payments, curbing NRW as well as improved urban planning, metering, financing, and supply operational efficiency and effectiveness.

The staff at NCWSC, Soweto Kayole office and headquarters at Dunga reported that JM was primarily designed to address spatial and temporal hindrances via the principle of accessibility of 'anywhere-anytime' payments. It was intended to support the routines related to the water provision in the informal settlements of the city. The flat rate billing and payment platforms were initially conceived to offer for anywhere-anytime payments, perceived as critical for reconfiguring daily rituals and routines for billing consumers and improve on the revenue collection for the company.

The architecture of JM therefore provides a mobile-based communication cum financial transaction model that provides an avenue for self-meter reading, mobile-based acquisition of invoices, querying of system, billing of water, and making payment. JM incorporates prepaid crediting mechanisms, self-meter reading taps, and mobile payment. A part from the mentioned services, the platform's initial conception recognized other subsidiary services such as providing consumers to remove or add another mobile operator from the account, and enables consumers the opportunity to effect prepayment without the requirement to upgrade to a new prepayment infrastructure system. The other science technology and innovations being promoted at Soweto Kayole and the neighborhood apart from JM are PPD, Maji Voice, WARIS and WASPA MIS tools.

4.11. STI Infrastructure for Water Services Development, Utilization and Management

Jisomee Mita (JM) initiative is an infrastructural development project configured to perform several functions and or operations in the water service provision especially to the undeserved informal settlements. The system was engineered as a 'do-it-yourself' emerging technologies and innovations meant to drive an 'individualistic' management of concerns that pertains to access to water and billing by water consumers. The main focus is to offer digital application via functionalities and operationalities ranging from self-operation, self-repair, self-meter reading, and self-maintenance.

JM offers a holistic range of self-accountability, self-regulation of self-control by the Soweto Kayole (SK) residents who are the current beneficiaries of the science technology and innovation initiative. Similarly, sociotechnical system mechanism normally reflects the urge of system architects to offer the outsourcing of activities that were hitherto part of the water utility's responsibility, and yet to continue to direct water consumers' attributes. This is in line with the bills payment, which is generally for the water utility as pertains to international circulating ideals of science technology and innovation thus digitized service provision set as one of its goals that is to enhance recovery of costs of investments based on adequate tariffs.

Facilitation of the outsourcing services of functions to the locals of SK while at the same time directing their attributes, JM was conceived and birthed as a frugal and an integrated emerging science technologies and innovations to allows "multiple billing on one cycle" through incremental configurations. When the technology was launched, the residents of SK were convinced and persuaded to subscribe and pay for access to water in small installments and increments, with 0 to 6 units each costing twenty-five Kenya Shillings (Kes 25); 7 to 60 units each costing fifty four Kenya Shillings (Kes 54); and 70 unit and above each costing sixty

Kenya Shillings (Kes 60). Unfortunately, these block tariff structures were not applied to the intended targets as the property owners were charging flat rates for the end users. The tariff block structures were only meant for the informal settlements as a pro-poor strategy and to enhance revenue collection by the NCWSC.

The connected and potential water users of Soweto Kayole were sensitized that failure to remit their monthly bills then units they used would be billed according to the next higher bracket which were never taken positively by consumers considering their irregular sources of income. Some of the respondents were categorical indicating that the logic of the structure is basically conceived to exploit the local slum's kadogo economy and survival-driven. This concept that the water consumers should have the option of remitting their water bills any day of the month and in installments is perceived by the NCWSC as 'an asset' for the sustainability of project. It is justifiable to make small payments other than waiting for the monthly billing cycles, when the bills would have accumulated to bigger figures or amount of money.

However, the arrangement resulted to contingent of misunderstandings between the residents of Soweto Kayole and the NCWSC who realized that their water bills have accumulated due to delayed payment and non-payment. This is due to the fact that the connected residents were anticipated to make a monthly connection fee which automatically accumulated over time. In instances where the connected residents were not able to remit their payments in time and in subsequent months, they are anticipated to contribute more, hence contradicting the whole principle of JM as a small-scale, survivalist and an incremental emerging science technology and innovation infrastructure designed for undeserved segment of the informal settlement and to promote the pro-poor strategy.

It is worth deducing that the infrastructural logic and design of JM gives a clear reflection of the Nairobi City's sparsely populated with fragmentation and segregation. Deployment of the emerging science technology and innovation with the basic principle of prioritizing the poor informal settlements or slums which would otherwise not have been accessible and served by the NCWSC.

These slums localities are well known for being unsecured mostly dominated by gangs and cartels and who exploit the residents from the absence of the NCWSC water networks or the state, or in locations that will require labour intensive because of the deployment of modern infrastructure networks and grids, in localities that have spontaneous population growth trends. This was reiterated during the data collection exercise where NCWSC staff at the pro-poor

department, quoted that JM was conceived with the main objective of reorganizing and upgrading of slum localities in the city of which the initiative was first piloted at Soweto and will eventually be rolled out to other areas for water service provision improvement, empowerment and development of the informal settlements in the city.

JM therefore mirrors a much wider interest, vision and mission of NCWSC determined to create and expand water supply and sanitation networks and possible markets for water supply and sanitation by the government, hence market expansion portion, returns gained from investment, generation and expansion of revenue streams bases. The initiative is line with the global agencies' agendas of achieving advancement of specific emerging science, technology and innovation, access to public services, and empowerment of residents of urban slum dwellers with low irregular income.

Another contrast is that instead of self-organized infrastructure commencing from the end users and user driven, JM is a bottom-up approach, and market-based intervention. Regulated and approved by the NCWSC, WASREB, AWWDA and other state-level actors, financed heavily and externally supported by the development organizations and donors. The following are the development agencies and international governmental that dominate its promotion and deployment are the Water and Sanitation Services Improvement Project (WaSSIP), GPOBA, World Bank Water and Sanitation Program (WSP), and International Development Association (IDA).

JM is symbolic of the partnerships between global agencies and NCWSC, in which global agencies providing the financial support upon which its deployment and sustainability rest on. The approach of this noble system is to replicate best practices and experiment with new and emerging science, technology and innovation interventions, and to digitize water supply, access and sanitation improvement via interventions aimed at urban slums upgrading, empowerment and development. From the findings both through empirical literature reviews and interviews with the relevant stakeholders, JM is perceived as an integral global STI infrastructure, depicted and characterized by notions of hegemonic water supply and sanitation digitization initiative and urban slum empowerment and development.

The NCWSC has also strategically employed locally anchored approaches and methodologies in promoting the JM initiative as it is part of their decentralized arrangement of water supply and sanitation delivery services for the underprivileged people in the slum segments normally referred as Maji Mashinani Initiative. This initiative was created within the slums and its main

intention is to achieve NCWSC's policy on social connection (Wamuchiru, E.K. 2017), which was construed purposely to enhance initiatives and interventions targeting the city's slum settlements and marginalized households in the slum areas. The project compensates GPOBA for each meter installation successfully completed, only after verification by the World Bank's Water and Sanitation Project. In that structure, loans advanced to first-time connection are awarded via subsidized micro credit facilities and mechanisms which are in tandem with the Kenya's ICT sector and the World Bank through K-Rep Bank which offers microfinance facility. For example, the initial cost of meter installation was Kes 8215 but this has been subsidized to 50% by the World Bank, which paid Kes 4000 for each household connected with JM gadget and remaining balance of the reimbursement distributed over a period of three years through microcredits.

The same concept is applied by the World Bank initiatives in electrifying low income areas in Nairobi (Bercegol and Monstadt, 2018), as they are ostensibly configured to promote inclusivity and equitable connection and supply for the undeserved people who cannot afford the costs for meter installation given their survivalist and precarious economy they are embedded in. The policy on social connections was achieved via creation of task forces and household-based committees amongst various residential plots in SK slums and through this approach, some responsibilities and roles to village elders and area chiefs were delegated by the project's proprietors (World Bank, 2018 and Guma et al., 2019).

An officer at the water utility reiterated that the conception of idea behind the noble practice was that the local representatives of the slum area would automatically become co-regulators in aiding the NCWSC to minimize overheads, operational and transaction costs associated with periodic monitoring. Oversight tasks, functions, and responsibilities, such as securing meters and administering the project are anticipated to be carried out by the locals. The integration of locals into the management and operation of the project was assumed on the idea that socio-spatial justice could be reached by delegating regulatory tasks to the residents. The approach was premised or pegged on the ideal of a 'collective' that exists in SK, and that it could be mobilized to convince locals to assume mandates of the NCWSC and one of the key role that World Bank and NCWSC designated the urban residents with the task of 'peer-to-peer policing', which is the regulation of the infrastructure project.

4.12. Current Impacts on Adoption and Uptake of JM

Jisomee Mita (JM) has not only connected at least over 2217 by 2020 residential plots in Soweto Kayole (SK), but has also turn out to be a ubiquitous innovative technology oriented

infrastructural network in the informal areas. Its remote functionality to do-it-yourself options like self-meter reading and digital transactions and querying, has indeed established and instilled ownership sense amongst many locals who are owning meters. The locals of SK for example are able to appreciate and recognize the real impacts that JM is offering to the undeserved and low income segment of the community. This reality is encapsulated from some of the interview respondents "I feel empowered because of the control I have over my meter", or "It offers the long yearned for functionality of water customers having express freedom to have total control of their water consumption and meter readings".

In spite of the fact that JM's infrastructure-based logic promoted self-management and self-regulation, it also created ambivalences because some beneficiaries were reluctant to regulate, read, and control their own meters. The end consumers felt deprived by realizing that NCWSC outsourced repair and services costs, operations and transaction to them. The residents strongly felt that they are left out technically with no alternative but to be engaged and involved with the operation of the meters. The expectations of the residents range from reading their own meters, repairing them, and making payments remotely for their bills. In contrast, there are residents who due to language barriers, advancement in age and illiteracy are lacking the ability to interpret their personal meters and through SMS text, submit the readings or check their balance. This also informed the setting up of the NCWSC office in SK with full human and financial resources to respond to specific concerns and inquiries and confirmed by respondents who indicated that they have visited the facility for queries and assistance.

Further simultaneous and contradictory feelings the researcher experienced is arrangement that had served to resurface of the existing dynamics in power and demerits as the final consumers do not form homogenous actor category. The so-called peer-to-peer policing and regulation had unsurprisingly brought back the pre-existing power relations in Soweto SK and therefore contradicting JM’s basic principal goals of self-accountability, self-control, and empowerment. The local representatives also presented new version of challenges to the growth and development of the JM project as they provoked futile hierarchies, power struggles and conflicts between themselves and final users. It is therefore ignited power related struggles in the deployment of JM in SK through more powerful people from within and outside the informal settlement perpetuating exclusionary and not just sharing of resources in the locality consequently resulting to residents’ dissatisfaction with the system. The roles and responsibilities of the local operators seemed not crystal clear and even those of area chief and elders. The team from the World Bank and NCWSC delegated policing on peer-to-peer, by

maintaining measures that eventually became responsive to meter reading, invoicing, and payment is unavoidable (World Bank, 2018). This initiative considerably was seen as a noble strategy to reduce both operational and maintenance costs for NCWSC and hence guaranteeing sustainability and viability of the project in Soweto Kayole.

Another aspect of attraction and repulsion emerged as the locals felt that they had been provided with wrong information about the project in terms of the laid down plans for making contribution and loans which they felt were exorbitant. More and more concerns raised ranging from normal water supply costs and charges, along with a statement that the water service set them and that the poor locals were responsible for paying them. Morale of residents diminished registering their low confidence in the project at the same time lamenting on the high costs they are associated with in the project. Consumers and beneficiaries of the project felt the project was indebting them via help for instance the loans which majority were anticipated to get. Even though from the study, some residents managed to clear the credit facility they were advanced, while a number of them were not in a position to afford to repay (anonymity).

The reflection of these ambivalences gives conceptual gap between Soweto Kayole's distinctive socio-spatial condition and JM's initial plans and designs, but the disparities as a result of new development of the infrastructure project. As a result, there seems to be an unequal donor recipient relationship. The findings also show that human and finance resources rights activists emerged and advocating against such approaches, partly arguing that access to critical services such as water service provision should be free or at least affordable, and not disempowering the end users. The SK inhabitants felt duped in the project as their anticipation, optimism and hope they had about the JM initiative as had earlier been explained by the NCWSC, was not being fulfilled as the feeling of desperation and despair at the pledges of the project's architects and engineers at the project rollout stage. Informed by these findings, it is imperative that the limits of the science technology and innovation of the application of JM portrayed proposed deployments as technological and innovative fixed by development agencies and service providers do not always work as planned. At times the complementary and trade-offs, and normally unfaithful to their initial design and purpose.
The interpretation of the ambivalences of the JM portrays its unaffordability, a tool meant for exclusion, control mechanism and exploitation by the water utility.

Two facts emerged thus bottom-up, self-organizing networks, or 'inverse infrastructures' began increasingly to emerge, co-existing alongside JM. Most of the residents resorted to various sources of access to water, including informal, private, and unregistered water delivery

systems: kiosks, standpipes, distant yard taps, as well as non-piped networks such as tanks, rainwater, community-based boreholes. As JM is pictorial representation of a central government characterized by huge-scale systems conceptualized to take tiny, bottom-up diverse infrastructural facilities for service provision in SK (GSMA, 2020), this infrastructural development is comprising of one of the variations from the initial strategy of JM system. Second, tentative investigative results indicate a delicate state, and realizing that the goal project are currently changing hence short changed, some inhabitants commenced to take concerns personally by attempting to regain agency by shifting the technology and innovation.

The researcher discovered that the neighbourhood of the locals, instead of just adapting their routines and behavior to JM, there were multiple instances when distinct users have completely changed how it was used. Some of the residents had started to falsify and interfere/ tamper with meter readings, making wrong illegal connections, and pilferage of water supply via pipes diverted. The re-engineering and reassembling of the workings of JM systems. Consequently, JM became basically pliable to the settlement's place-based demands and realities while being initially established as a top-down infrastructure development project. The locals' imaginations and initial versions of the emerging concepts of technologies and innovations in improving access to water acted to reinvent the project beyond its original models, visions & plans at inception. JM primarily became more susceptible to the SK intricacies, providing an avenue for people a leeway to regain power by changing the technology and innovation leaving them in a highly precarious situation.

The infrastructural configurations displayed in SK portrayed the embedded and institutionalized nature as a situated urban sphere at the same time depicting a well-planned project development infrastructure opening up a new modern constellations and hybrid dynamics. The water utility purely relies on the projects emerging STI mechanism and operation that have been put in place. The initial methodological approach inscribed in the slum informal settlement and emerging technologies and innovations application of JM system proved unsustainable and difficult to enforce and replicate.

Laid down processes and best practices of bypassing, carrying out repairing, tampering with the gadget, and demonstrated improvisation of how the postulate surrounding JM system that would instill some professionalism amongst dwellers in terms of bills payment and metering, unfortunately this proved be inaccurate. Infrastructural project development considering the concept of emerging technologies and innovations which are presenting best processes and practices in addressing water access challenges remain highly place-bound, in spite of

integration of digital and remote-based options which are aimed at relaxing distance, space and time constraints.

4.13. Strategies in place for Mainstreaming Best Practices in STI Interventions

The original idea of deploying STI design to bring solutions to everyday billing, payment, crediting, and meter reading processes, JM's fit for purpose seen in several aspects. The gadget was conceived with in-grid functionality of remotely and digitally enhanced payment and billing, self-meter reading for the poor, designed and marketed as one that offers consumers option to read their own meters. The design of the project was pegged on its remote-based and digital control and order which turned out to be flawed. Trusted, dependable, and disciplined water customers are willing and able, and relied-upon to read their own meter, remit correct meter readings, and then make timely payment via the digital platform, proved futile. NCWSC was not in a position to implement and enforce such attributes and it became difficult for staff to confirm whether water consumers submitted accurate and correct readings. Regular system failures and incidences of missing and incorrect meter readings resulted to distrust between the water utility and water consumers.

Consequently, NCWSC established a regional utility office in SK specifically to supplement the digital operation of the JM project. The operations of the JM commenced via physical interface whereby the water utility personnel were retained within the community personally administering the JM project. A team of community development assistants were recruited by NCWSC to work on behalf of the company as brokers, facilitators, and occasionally mediators, between service providers and customers.

The recruited staff commenced their operations as part of doorstep checks of water meters and operations. The team were mandated with responsibilities and roles of enforcing Unscheduled checks and surveillance at the home level, sensitization, dealing with residents' queries and imposing timely payment, normally in person rather than remotely. The inspections and operations conducted involved asking landlords or tenants to show them their water meter which to some extent eliminated/ reduced the human intermediary that JM initially wanted to replace.

Community development assistants (CDAs) were subjected to harassment and harsh treatment from tenants and landlords because of unwillingness of the residents to be interrogated and even to open their doors for inspection. The locals argued that there is no need of them being inspected since they had been briefed that JM would work remotely and digitally. The research

assistants claimed in some instances they were harassed by the residents during the process of data collection and interviews and this was confirmed by the CDAs as they are also facing the same challenges during their routine inspection of non-payment or illicit practices by the consumers and water supply disconnection.

Worse are instances water consumers adamantly decline to give information necessary for the NCWSC agents to help in monitoring revenues and payments. Some of the other vital observations made by the researcher is that the residents considered steps, such as gating the water taps, to protect their meters from any outside infiltration and meters with the excuse to avoid both ongoing CDA oversight and surveillance, as well as theft. To encapsulate deployment of JM's evolvement, two conclusions were made, first the appropriateness and piping network of the JM did not satisfy its main design function of reliable provision of water to end users as in some instances the gadget was found to be inefficient, with sporadic and increasingly limited water supplies.

The residents received water only for some few hours, about two days a week as most of the taps were dry. To cope with this challenge, the locals devised ways of maneuvering by involving in sourcing for their own services. This was an indication that the water clients were actively in infrastructural appropriation and hybridizing hence maximizing its limited benefits and passing over its inadequacies and hindrances. Secondly, this innovation successfully built a hybrid notion of users displaying a proactive self-regulation of services, however lack of preparedness to address the additional ways that residents become active beyond their previously imagined position as engaged citizens, as described by the movement's proponents. The behavior of the clients turned difficult to be managed by the NCWSC and other relevant regulatory agencies hence call for commencement of innovative and technical infrastructure beyond its functionality renegotiation and reengineering.

Earlier perception of consumers sticking strictly to their initially described role active only in ways that had been inscribed into it by its designers turned out not to be realistic. The idea of stakeholders' involvement, engagement and inclusive participation in the project execution in SK by delegating specific tasks failed, not due to locals remaining passive consumers but their deliberate acquisition of projects through routine behavior and coping mechanisms. However, active appropriation normally plays out through ways not intended, in which technologies and innovations scripts are remade to undermine the intended innovative and technological infrastructure functionality.

The researcher critically investigated and analyzed the water policy on pro-poor infrastructure design innovation, in which science technology and innovation aspects of organizational, at the same time combination of innovative business model. The reason behind the study was to comprehend if the innovation really qualifies as a pro-poor innovation especially with the focus on informal settlement locality.

Many cities in Sub-Saharan African, just like Nairobi City's SK shares a number of "underserved neighbourhoods" (European Union, 2020 & Mulligan et al., 2019). In this locality, inhabitants normally depend on water vendors rarely managed by powerful cartels. The 2010 constitution of Kenya, article 43 (1) guarantees every citizen the right to access to water and sanitation as a basic service (Boakye-Ansah et al., 2019). NCWSC is a licensed water service provider by the state and it is required to devise the most appropriate and cost-effective technologies and innovations which are sustainable and to meet the requirements of the law and supply water to all the inhabitants, including slum localities. This can only be realized by critically reviewing the current existing water policies and frameworks to suit the exact situations on the ground.

Proper strategies should be put in place for better data acquisition on the existing STI initiatives promoting water services provision that requires adequate resources for well-informed planning. Most of the STI applications currently are sourced from outside and financed by development partners who have also differing interests. Public institutions that are recipients of these supports thus need to develop sufficient capacity to facilitate dialogue and levelling of expectations so that common objectives are mutually agreed upon and sector needs are put at the forefront. Development partners have a great influence on the sustainability of STI initiatives and deployment as their support is time bound and continuity is dependent on institutionalization of the interventions.

Support of STI initiatives is critical right from the top government officials in order catalyst successful introduction of STI in the water sector as it involves organizational change. It was clear that the residents are willing to pay for good service, based on the high rate of mobile phone penetration and experience with MJ and other initiatives where residents incur the cost of the SMS. This opportunity can be capitalized upon when up scaling on these new STI applications in the water services provision sector. The local private sector is the perceived leader in terms of capacity and should be adequately engaged.

4.14. Dimensions of Water Services Provision

Assessment of the dimensions of water service provision such as perceptions of water users, convenience, affordability, availability, accessibility, quality and quantity amongst other in the study location revealed some interesting findings. From the sample of respondents interviewed on the above mentioned aspects or dimensions, majority indicated or expressed their lack of confidence on the quality of the water in the pipes reiterating that they have to further boil the water for drinking as the quality is doubtful. Many residents suspected that inadequate design, piping material and pipe networks for both water and sewerage could be the real cause for contaminating drinking water as there are chances it mixes with drainage or sewerage water. Respondents registered their worries as they reported that the water comes when it is very dirty, forcing them to first allow the water flows out before commencing to fetch for storage. "Just next to us here, I will show you where a broken pipe is passing through the sewage". The study discovered that most consumers perceived piped water as not safe hence use it strictly for cooking and laundry preferring buying borehole which is even salty.

As was elaborated in the literature reviewed, the local community were skeptical about piped water quality and some opted to use it only for washing or boil it first. Some of the stakeholders in Nairobi County City pointed accusing figures on the cartels of spreading rumours that could easily ignite and cause confusion that the piped water is not portable. Introduction of an innovation/ technology normally face resistance and threat from the already existing service providers in the area, who in this case of SK are private water vendors mainly depending on water from borehole. To make it more worrying, some residents were more confident with the quality of borehole water to that of piped water as they believe that water from borehole was safer compared to piped water, with the notion that "the pipes are going through the sewer lines". This was simply a mere propaganda used by the vendors to paint imageries and narratives amongst the residents so that they could gain preference in a competitive market. NCWSC categorically stated that vendors have interfered in a number of ways to reduce the popularity of water from the JM pipe networks, and other related policies on pro-poor initiatives. The water vendors and cartels have a history of vandalizing / destroying and interfering with the installation of water pipelines in Soweto Kayole. Figure 4.14 displays some pictorial views of vandalized and disconnected meters in Soweto Kayole at the time of study.

Figure. 4.14: Vandalized JM and Disconnected JM respectively at Soweto Kayole (SK)

4.15. Science, Technology and Innovations (STI) Functionality

Science, Technology and Innovations are emerging as the savior to some of the challenges the society has been facing for decades. Tying the technology and innovation to some basic conventional piped networks and systems, the part of sharing service of JM system is non-radical technology and innovation. JM is an emerging innovations and technologies embodying "hybridity" in the combining of simple piping technology with the digitized enhanced customer interface for payment and meter reading (Guma et al., 2019).

The physical installation involving connecting pipes and meter constitute the main technology and innovation otherwise JM approach would not be able to fulfill its intended functions and operations as one of the key salient observation made was that the functionality of the JM installations was fairly low. At some of the sites visited where the JM was installed, some were found malfunctioning, faulty meters, vandalized and disconnected. From the 80 JM system visited, 10 (12.5%) were found to be malfunctioning, faulty meters, vandalized and disconnected. Proportionally, this can translates to 277 JM systems not working properly from the total sample of 2217 connected assuming all other factors considered remain constant. The explanation provided by some of the respondents included "these meters are delicate", "meters are broken and getting spare parts is a problem", "water used to come initially, but we have not received water for the whole of this year", "some of the houses appear to have been connected but without ever being in operation", "we have not received water through this system since it was installed".

Some respondents were also dissatisfied with the water supply frequency i.e. “water comes after two weeks,” while others cited non-payment of property owners as the problem: “I have lived in this plot for two years and I’ve only seen water come through this system twice or so. The information I have is that water supply was disconnected due to huge accumulation of water bill.” The rationing of water in the city slum areas confirmed the dry state of the JM installations.

The response from the utility company indicates that water is supplied throughout the week to the resident which is in contradiction to the information gathered from the ground confirming that water supply to SK is limited to receiving water on Wednesdays normally once per week. Majority of the residents confirmed that water rarely flows through their pipes and when it comes, not for more than 8–10 h on that day, and residents keep containers for reserve for keeping water for any eventuality. Individual household is capable of filling up between 8 and 12 containers of 20 liters each when the piped water is available to the residents.

Science, Technology and Innovations (STI) give golden chance of modernizing and improving sanitation and water supply access by the slums informal settlement of the urban areas. The STI for catalyzing sustainable water services provision covered in this thesis present clear and robust entry points of services provision due to their applicability, up-scaling and replicability to the informal settlements with low and irregular sources of income situation. This is further solidified by the social connection policy that offers some conducive guidelines for better and equitable access, availability, affordability that suits the low income earners. In SK, this has been realized by deploying innovative financing model and technology oriented – JM that provides a digital platform empowering water clients through self-meter reading and subsequent bill which taps into commercial financing and OBA.

4.16. Entrepreneurial Concept Functionality

JM entrepreneurial concept was developed based on the principle of post-paid pegged on consumption volumes, and a tariff blocked progressively. The entrepreneurial model is in line with the water utility conventional operations which is the same as the electricity one, with the added components of mobile payment and e-billing. NCWSC coined the idea of JM principally to aid low-income water consumers to avoid accumulation of water bill which eventually present a burden to them considering their irregular and low levels of incomes making them more exposed. A low volumetric tariff of Kes 25 per m^3 is billed in a single month for the first $6m^3$. The costs of connection is issued as a credit facility and equal monthly repayment bill for water of Kes 150 and for sewerage of Kes 450.

However, the researcher noted that the entrepreneurial model is not so clear to the water users. Confirmed by some respondents who noted that their capacity have not been built on calculation of water bill. “We are just given the bill which we have to settle despite not having received water for which the bill is calculated and the sentiments were strongly supported by other clients citing that NCWSC is imposing doubtful water bill to them that could not be verified.” As earlier indicated, over 2217 meter installations completed in SK, with the World Bank financial support.

From the NCWSC records, by end of the 2020, only 1000 customers were paying their water bills. Averagely the number of customers paying is rarely above 800 at any given point in time. Probing the worrying trend further about the variation and fluctuation of low level of customer activity, the utility management narrated that “we have had some problems with the system, which confirms that the user confidence was lost for some period.” At the initial stage of JM introduction, World Bank as the financier expressed high hopes on the entrepreneurial model to increase effectiveness and efficiency on revenue collection.

One month after the launch in 2014, a positive trend was noted (World Bank Group, 2015). In contrary, for the last four-year period, the efficiency on revenue collection dropped again. The sales and revenue records from NCWSC indicate a large gap between revenue collection and billing. The period between November 2016 and November 2020, the total billed amount was Kes 51.7M while total revenue collected Kes 32.7M, which a 63% collection ratio correspondence. Poor indications on revenue collection ratio is strong precursor for accumulation of debts that can result to disconnection.

NCWSC management conceded the non-willingness of holders of contract to remit payment to the water utility present a huge challenge. Another vital finding in relation to entrepreneurial model misalignment is the utility customers not identical with the final consumers. A customer is the owner of the property and the contractual agreement is established and signed with him/ her. He or she is the person whom NCWSC offers the “social connection policy” with soft repayable loan with tariff favourable to them. Tenants are the final consumer as they fall in the lower and more insecure income as compared with the landlords in SK.

The researcher found out that while the landlord remit with regards to usage, tenants remit a monthly flat rate to his landlord. The landlords charge between Kes 350 and Kes 650 in addition to the monthly rent, even if the availability of water supply is only for 8-10 hours per week, or

in shorter period. The income per month for the landlord or landlady caters for the sewerage and water supply charges amount ranging from Kes 4240 and Kes 8800 in the plots we visited. In contrary, with reference to NCWSC sales records, landlords remit averagely between Kes 1000 and Kes 2000 on monthly for sewerage services and water supply while the research findings mirror a tiny statistical numbers of final users in SK and therefore recommends that the JM entrepreneurial model is considered exorbitant for the final users. Figure 4.15 shows some of the images captured at the time of data collection and interviews depicting the real situation on the ground on how the locals queue for water at the water points while Table 4.4 presents the actual bills paid to the landlords/ property owners connected to the JM systems by the tenants on monthly basis.

Figure 4.15: Residents queuing to fetch water at water points in Soweto Kayole (SK).

Table 4.4: Water Users Prices in 10 Mapped Plots in Soweto Kayole (Obunga et al., 2021).

Plot Number	Number of installed JM systems	Number of houses rented within a plot	Water bill remitted to landlords/ ladies on monthly basis (Kes)	Total amount remitted to landlords (Kes)
1	1	12	500	6000
2	1	16	550	8800
3	1	10	530	5300
4	1	13	530	6890
5	1	20	350	5200
6	1	9	500	4500
7	1	15	450	6750
8	1	13	500	6500
9	1	8	530	4240
10	1	14	550	7700

Figure 4.16 shows the number of customers paying for their water bills on monthly basis through the JM technology (NCWSC, 2014 – 2018) while Figure 4.17 illustrates water billing and remittance received via the JM system on monthly basis (NCWSC, 2014 – 2018).

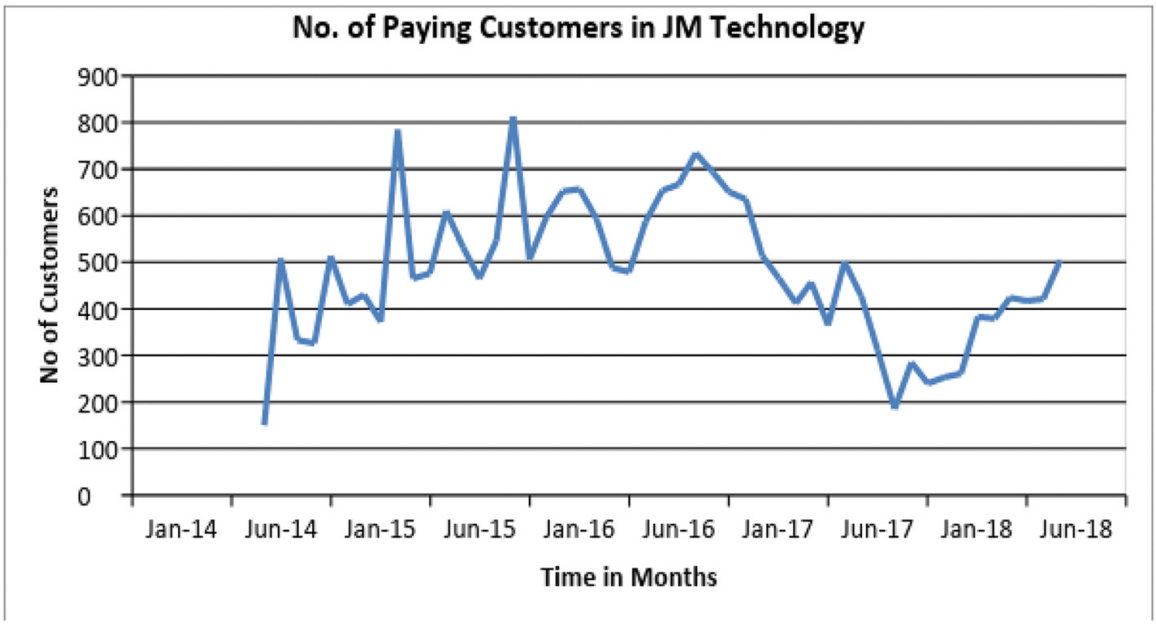

Figure 4.16: No. of customers remitting payment on JM connections, monthly basis

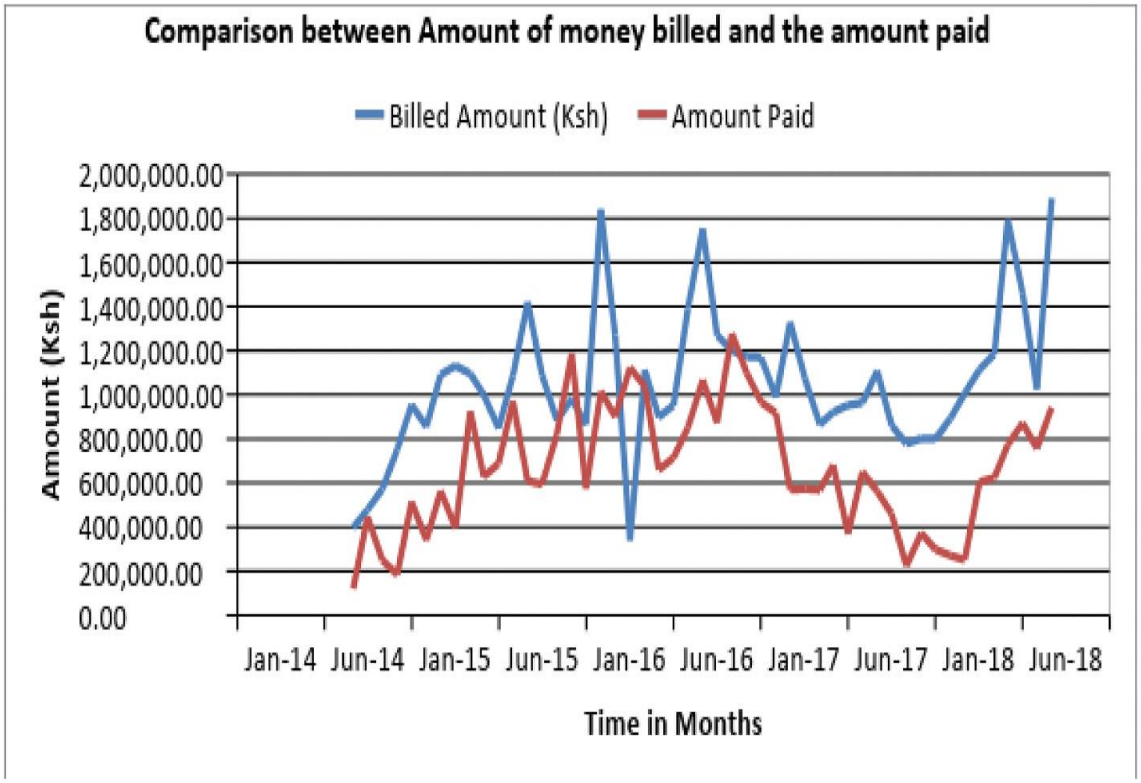

Figure. 4.17: Water billing and remittance received through JM on monthly basis

4.17. Political and Social Interaction and or Mismatches

The most pronounced misalignment with regards to socio-political is presented by the architecture of JM project, even though, to some extent variations noted as it entirely limits itself to operations and regulation. The cardinal and core idea of the JM was to some sanity to the residents or water users and lessen the dependency on the water vendors and cartels by providing water services closer to the people of Soweto Kayole (SK) at affordable prices and enhanced on accessibility to all. However, the researcher noted that this is not actually the situation on the ground as in the JM gadget, the final users especially tenants do not remit the rates determined by the Nairobi City Water and Sewerage Company (NCWSC). The tenants or the residents are subjected to pays the price determined by their landlords or landladies which the study revealed is much higher than what is set by NCWSC.

The challenge is lack of recognition by Kenyan constitution water utility - NCWSC nor the national agencies or regulator - WASREB, to have complete and water tight control over the end consumer rates or prices as this is a transaction that takes place on private property and outside the jurisdiction of the water utility. The documented information confirms that the WASREB which is the national regulator are well informed of the exploitation of the tenants by the property owners but can only recommend awareness creation through outreach services by the NCWSC staff – Community Development Officers to the tenants.

The NCWSC is limited in what they can offer in terms of solution as they are prohibited by law to reveal information regarding bills due to data privacy protection hence putting the transparency of the system in question. The water utility also confirmed that the mandate of NCWSC terminates at the issuance and installation of meters and thereafter revenue collection from the water users hence worsening the socio-political misalignment of the JM system.

The JM technologies and innovations or architecture studied under this thesis proved some success stories of the slum dwellers especially SK focusing on their socio-economic and political aspects. Soft loans with favourable tariffs were given to low-income customers to enable them repay/ make flexible remittance arrangement and to suit their needs.

The strategies and guidelines adopted of using public institutions to support the uptake of the innovation developed for the last three years and institutionalized to guarantee sustainability. Despite leveraging on these structures, more support is required for scale up in terms of coming up with additional finance, policy and mobile support solutions levels. Typical example is where the Nairobi Metropolitan Services is committed in drilling water to the slum dwellers, Figure 4.18 is a pictorial view of free borehole water kiosk sunk and constructed.

Figure. 4.18: Water Kiosk providing free borehole water to the residents of Soweto Kayole.

4.18. Misalignment between STI and the Societal Challenges

Internal misalignment concerns or comes about when technology and innovation approach, strategy and routine methodology adopted by the implementing company or organization causing conflict with already created and domiciled routines, approaches, innovations and technologies within the organization. With reference to the researcher's case study of the JM technology and innovation, it is imperative to magnify the picture of water service provision by the NCWSC in the City of Nairobi and the regime level broaden; different institutions in the water sector in Kenya, infrastructure networks, knowledge base, companies and best practices in water use that matches the existing management of water by the Nairobi City.

Making concrete comparison or reference to the strategy or approach adopted by the JM system, the researcher noted serious cases of internal misalignment within the JM ecosystem, and the most outstanding one was rationing of water supply to the residents. Nairobi City for the last ten decades has faced water shortage characterized by water rationing is not a new phenomenon (Nilsson, 2017).

The current water rationing schemes is a decision made by NCWSC at regime level and Nairobi City County which is jeopardizing the conditions for success for technology oriented and JM system innovations. As earlier reported by the researcher, water is supplied only once weekly and averagely for 8–10 hours which may not be significant to the residents or water consumers. Building, operating and maintaining a piped water supply and sanitation infrastructure require a huge initial and running capital investment which ultimately jeopardize water service provision especially to the informal settlement with low and irregular sources of income from benefiting from NCWSC. Consequently, internal misalignment realized by rationing of water

and other interruptions, it is justified to conclude that the JM capital is to extent getting idle and underutilized.

However, water service providers' benefit from the technologies and innovations as the innovations have expanded and increased their customer base and consequently improved and increased revenues and efficiency in revenue collection. Nairobi City Water and Sewerage Company initiative to establish local office at the same staffing with relevant caliber of experts was important for a successful execution of the policy on social connection at the same introduction of JM system. Dedication of more human and financial resources to SK slum was another success factor to the deployment of the JM system as well as building a strong relationship of staff at NCWSC with the community consequently repairing worn community's trust in the project as they addressed effectively customers' complaints and provision of clarification on information on the use of JM.

Emerging technologies and innovations normally require a paradigm shift to conceive, develop and execute. The policy on social connection, subsidizing output-based credit facility, billing of consumption and self-meter reading innovations planned, designed, built and executed in four years' period. The scenario at NCWSC wasn't much different as a number of actors were consulted and involved to buy into and own the approaches before and during execution.

Figure 4.19 is a **c**onceptual framework or scheme about the JM in SK depicting reality on the ground as can be seen the exclusion of the water sector in the slum settlement. The unfortunate case is where the property owners i.e. landlords control JM connection and remit their yearly actual consumption but charges her/his tenants on monthly fixed rates. From what is happening currently when the study was conducted, it is crystal clear that JM system is favouring the averagely rich landlords/ landladies as opposed to end consumers of water. Table 4.5 portrays summarized version of the broader comparison between internal and external misalignments based on the study conducted in Soweto Kayole (SK) JM project site.

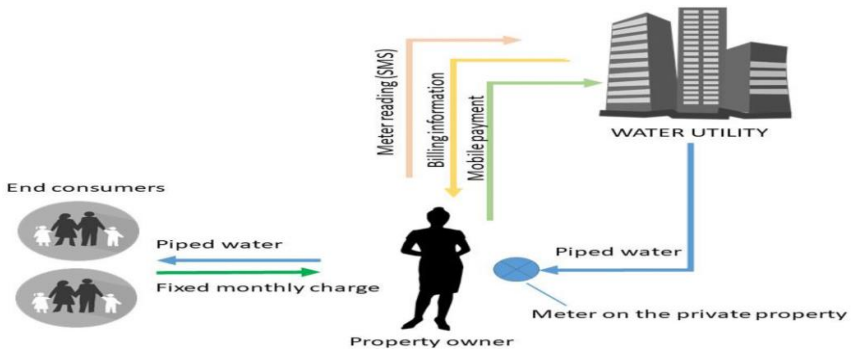

Figure 4.19: Misalignments depicted by JM Architecture on the ground

Table 4.5: Summary of all misalignments observed in JM Project

External misalignments			Internal misalignments
Technologies	Entrepreneurial model	Political and Social	
12.5% of the 80 installed JM systems investigated were mal-functional	Proposed tariff unsuitable for the tenants as it can push them into a higher rates category	Socio-economic status of the locality, most of the plots owned by few powerful landlords who are politically connected and untouched	The general daily water supply shortages in the city for the residents forces the water utility to perform water supply rationing within the nine zones in Soweto Kayole, hence reducing and counteracting the perceived benefits from the investments made in JM networks and distribution
The meters aren't durable, lack of spare parts and requiring high maintenance costs noted by users.	Entrepreneurial model for billing usage only benefiting landlords who use flat rates to compensate for undue charges.	Non willingness and absenteeism of landlords/ ladies to provide formal land ownership required for connection hence commitment levels low.	
Data backup system and maintenance of software expensive and not available.	Competing private vendors proved tricky as most of the times JM system is dry only available once a week	Difficulty to control final consumers rates since the transaction id done on private property	Through the National Government, the Nairobi Metropolitan Services [NMS] managed to sink a number of boreholes which the residents fetch for free for their domestic use.
Water supply in the JM gadget is only available in the pipes for 8-10 hrs weekly due to rationing.	Some distrust built as a result of parallel readings of meter carried out by NCWSC staff to the end users/ project beneficiaries.	Change from norms normally take time hence JM innovation faced resistance by local water "cartels" trying to discredit the JM system	
More containers required by the tenants due to irregular &unreliable water supply	Project beneficiaries noted concern of lack of knowledge on how rates are computed and how the metering works	NCWSC staff in some incidences faced violence and attack when visiting the site due to insecurity and lack of trust	Lack of effective coordination at the NCWSC resulted to vandalization of the newly installed water supply infrastructural network during construction works in the area.
Quality of water in the JM not trusted due to lack of proper plumbing, illegal connections and disruption of the networked infrastructure by road construction	Some of the landlords and landladies were not positive as they weren't willing to remit payments as scheduled	There exist a tensed relationship between the state/ NCWSC and local users subsequently enhancing and or promoting more lack of trust	
		water is free notion making some users sort to non-payment and illegal connections	

4.19. The Challenges and Successes

The community development assistants (CDAs) supported the rolling out of JM system by actively involving, engaging and creating awareness to the community through outreach and sensitization. SK youths were employed as CDAs supported by Water and Sanitation Program (WSP) through provision of mobile phones. Landladies and lords were trained on the use of JM by the CDAs who were moving from door-to-door distributing flyers of the new ICT system and hence instilled some level of confidence as they felt empowered to manage their usage. As had earlier mentioned, residents read their meters and then make payment based on their bills. Capacity building session s were organized for the NCWSC customer care staff to help them familiarize with the functionalities of JM system and instill confidence in them. These were part of the strategies to manage the resistance initially experienced to adopt the new, not yet proven, and not known concept. Meter reading and remittance or payment of bills by the residents also casted some levels of doubts as their willingness and ability was not yet clear.

Successful execution of the intervention was facilitated by the dedicated office situated within the locality and managed to handles water accounts under the social connection policy and complaints from customers related to JM system. The utility staff at SK were inducted into the concept at early stages and made commitment for mass roll out of the program. The cordial relationship between the residents of SK and water utility staff hugely contributed to the JM system acceptance by the beneficiaries. The less educated/ illiterate community members in SK exuded low levels of hopes that remittances made via SMS would “disappear” in the network and they are likely to be conned.

Availability of water supply flowing in taps was precondition for the commissioning of JM system. The WSP worked closely with NCWSC to improve reliability and accessibility of water services provision to the residents. Availability of water to the residents once a week per zone was a very crucial factor for JM system implementation. This justified customers’ satisfaction evidenced by water availability in the right quantities and qualities and as a result making payment based on the bill received.

The researcher was made aware that the residents’ accounts are not integrated into the CMS but located in a different system. Customer transactions and details aren’t accounted for in the CMS where all other NCWSC accounts are managed. Mobile money payment, meter reading and bill querying can only be executed via mobile. There are already attempts to explore fully strategies and interventions on how to integrate JM system with CMS, upgrade it to a new billing system or JM scaled-up to new billing system for all Nairobi City customers.

Capacity building initiatives such as dissemination, training and outreach were carried out to refine end users soft skills in operating the JM system. There has been some considerable improvement as initially, a number of system downtime were being experienced by customers, removing intermediary servers and connecting directly to Safaricom which eventually helped to stabilize the system. The design of JM envisaged full integration into Financial Management System of NCWSC. From the time of the study, researcher noted that all the interfaces are complete from JM side, even though the process of integration is on course and currently the processes are manually managed awaiting full integration.

CHAPTER FIVE

5.0. CONCLUSIONS AND RECOMMENDATIONS

5.1. Conclusions

It is deduced that the status of water services provision has to some extent improved as a result of adoption of the JM project which is a modernized and technology oriented gadget possessing functionalities such as e-billing, e-meter reading, e-querying systems and e-payment in Soweto-Kayole informal settlement. Thus, emerging Technologies and Innovations can be fully utilized by the water services providers to tremendously and continuously improve service delivery.

The creative space created by the JM whereby recalibration and rebranding of the technologies and innovations through processes of subversion, reinforcement, and reclamation has been observed by the users demonstrating their applicability in the urban water services provision. It is prudent and evidenced that there was a falsified conception of the active citizen contribution to the project, reassembling project in unanticipated ways that partially subverted the project's initial goal.

Adoption and uptake of the emerging innovations and technologies digital platforms radically transforming and impacting on basic services delivery, drive technology and innovations and improve competitiveness and productivity in the water service provision sector while ensuring sustainable management of water services provision and access. Nairobi City with the support of the MoWSI is squarely ready for the emerging innovations and technologies to help in transformation in the water services provision as evidenced in the recently passed national water policy of 2021. The emergence of the IoT and AI and their adoption, uptake and application in the water services is a major milestone that can't be underrated in digital space.

The concept of digitization considers integrated collaboration and partnership suites, workforce convergence and pervasive connectivity extension and penetration. A continuous technology and innovation orientation is within and across the digital space is already compelling the MoWSI, NCWSC, KEWI, AWWDA, NCWSC etc. to anticipate and plan for tomorrow to avoid obsolesce of their system and remain secured, easy to use and sustainable as possible. Water and sanitation demand by the unserved and underserved slum urban dwellers calls for a concerted efforts of all stakeholders involvement, more investments, creative and idealistic innovative solutions and feasible business models. The initiative has proved feasible and can be enhanced by deployment of STI enabled digital tools.

5.2. Recommendations

General recommendation on the JM innovation and other similar ones is that it should deliver the lowest price-performance ratio of the alternatives available to be considered; be delivered within specific and reasonable time frames; has to be fit for purpose; relatively have short duration to go to market and fit in with the overall strategy of the utility that is executing the policy on social connection. A business case for expansion of JM innovation can be considered if these metrics are measured against the above indicators to inform rollout to other informal settlements in Nairobi City County as already envisioned by NCWSC.

The following are the key specific recommendation based on the research findings:

1. Execution of the WSS projects in the slum areas need that NCWSC first comprehend fully the financial realities and expenditure trends of the target community. The idea of giving access to credit facilities in financing initial costs for installing meters then offer suitable and flexible repayment period for the loans together with the monthly water bill over an agreed period is highly recommended innovative financing approach.
2. Emerging digital platforms enabled pro-poor techs and innovations to support improved and affordable water supply services to slum settlement requires exploration, piloting and expansion of different financing mechanisms fit for the targeted beneficiaries. The emerging technologies and innovations can be effectively and efficiently managed by the water service providers at substantially affordable costs through leveraging on appropriate cloud techs, computing opportunities and vertical business process as a service.
3. Well-structured corporate policy to support extension of services to low income earners. For effective scaling and financing, a policy approach should be adopted to provide a channel for internal budgetary allocation and additional resource mobilization. Geographical approach is appropriate when targeting the poor urban slum residents and highly recommended. Policy on social connections and output based aid principle offered via the GPOBA allowing the low income earners of the slum settlements get access to subsidized credit facilities from banks is recommended and if possible be up scaled.
4. NCWSC and AWWDA need to carry out proper and evidence based assessment before recommending for any water distribution network expansion activities. Strengthening by employing staff with the right skill sets and teams in the field must be properly facilitated to enhance their operations. Finally, strengthen and mainstream existing institutional infrastructures, promote public private partnership for the deployment and uptake of the emerging techs and innovation in the water sector as well as for financing the initiatives.

5.3. Suggestions for Further Research

This research study scope was limited to the JM innovations in Soweto Kayole while there are other technologies and innovation in the water services provision. There is still need to conduct more comprehensive research on the STI initiatives similar to JM and assess their applicability, replicability, scale up and viability so that all the informal settlements in Nairobi City County can get access to safe drinking water. It is important to undertake more in-depth studies on the emerging technologies and innovations deployed in catalyzing sustainable water services provision especially tailored to suit the unserved and underserved in the informal urban settlements.

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APPENDICES

Questionnaire Key Focus Areas

1. Science, Technology & Innovations (Technical functionality of the technologies and innovations): Successes and failures of the technical and innovative ideas
2. Entrepreneurial concept/ business model functionality: Success stories between business owners and consumers
3. Political and Social Interaction and or Mismatches: Conflicting perceptions
4. Misalignment between technology, innovation and the societal challenges
5. Convenience / Affordability / Availability / Accessibility / Quality / Quantity

APPENDIX 3.1: HOUSEHOLDS DEMOGRAPHIC CHARACTERISTICS

1. Indicate your gender by use of (√) Male ( ) Female ( ) Don't know ( )

2. Indicate your age in the box: 18 – 28 ( ) 29 – 39 ( ) 40 – 50 ( ) 51 – 61 ( ) Over 62 ( )

3. What is your highest academic qualification? Primary ( ) Secondary ( ) Certificate ( ) Diploma ( ) Degree ( ) Masters ( ) Others ( ) If others specify

4. What is your marital status? Married ( ) Single ( ) Divorced ( ) Others ( ) if others, specify

5. What is your average household income per month in Kes? Less than 6,000 ( ) 6,001 – 9,000 ( ) 9,001 – 15,000 ( ) 15,001 – 24,000 ( ) Above 24,001 ( )

6. What is the number of dependents in your house? 1 – 2 ( ) 3 – 4 ( ) 5 – 6 ( ) 7 – 8 ( )

Residents connected with the JM: Pro-poor strategies (Situation before the interventions)

This information will help to establish a baseline for assessing the current situation

1. How often did you use to pay for water? [ ] Daily [ ] Weekly [ ] Monthly [ ] Others: Specify
2. How much were you paying for water?
3. How can you describe the amount you were spending on water? [ ] Low [ ] Normal [ ] High [ ] Other: Specify
4. How can you compare the amount you were paying for water with electricity and comment on water availability?
5. From which infrastructure did you fetch water for your household? [ ] Water kiosk [ ] Yard tap [ ] Personal connection [ ] Other: Specify
6. How much water were you fetching on daily basis from this water source (Litres)?
7. Was this water enough for your household activities? [ ] Yes [ ] No

8. What household activities did you use water from this source for? [ ] Drinking [ ] Cooking [ ] Laundering [ ] Bathing [ ] Toilet flushing [ ] Other: Specify
9. How much water did you require for daily activities (Litres)?
10. Were you depending on other water sources to meet your daily water use? [ ] Yes [ ] No
11. Which other water sources you were depending on? [ ] Groundwater [ ] Surface water [ ] Rain water [ ] Cart pushers [ ] Other: Specify
12. What activities did you use water from these other sources and providers for? [ ] Drinking [ ] Cooking [ ] Laundering [ ] Bathing [ ] Flushing toilet [ ] other: Specify

Time spent collecting water

1. How far did you have to walk to collect water?
2. How long did you have to wait at the water source to collect water?
3. How many trips did you make to the water point in a day?

Continuity of water supply

1. How many days in a week did you receive water?
2. How many hours in a day did you receive water?
3. Did you experience supply interruptions at your water point? [ ] Yes [ ] No
4. How often did you experience these interruptions at your water point? [ ] Not often [ ] Often [ ] Very often [ ] Others: Specify
5. What was the response to maintenance whenever it is needed? [ ] Prompt [ ] Delayed [ ] If delayed Specify
6. Which of the aspects of your water supply did you think required improvement? [ ] Pressure [ ] Reliability [ ] Maintenance [ ] Cost [ ] None [ ] Other: Specify
7. How would you rate water supply service prior to the interventions? [ ] Very Good [ ] Good [ ] Average [ ] Poor [ ] Other: Specify

Residents connected with the JM: Pro-poor strategies (Situation after the interventions)

1. How often are you paid for the work you do? [ ] Daily [ ] Weekly [ ] Monthly [ ] Other: Specify
2. How much do you earn currently in kes (range)? [ ] < 500 [ ] 501–1000 [ ] 1001–1,500 [ ] 1501–2000 [ ] 2001–2500 [ ] 25001 – 3000 [ ] 3001 – 3500 [ ] 3501 – 4000 [ ] 0ver 4001
3. How often do you pay for you water for household use? [ ] Daily [ ] Weekly [ ] Monthly [ ] Others: Specify
4. How much do you pay for water?

5. How will you describe the current amount you spend on water? [ ] Low [ ] Normal [ ] High [ ] Other: Specify

Water availability

1. From which infrastructure do you collect water for your household? [ ] Water kiosk [ ] Yard tap [ ] Personal connection [ ] Other: Specify
2. How much water do you collect in a day from this water source (Litres)?
3. Is this water enough and or adequate for your household activities? [ ] Yes [ ] No
4. What household activities do you use water from this source for? [ ] Drinking [ ] Cooking [ ] Laundering [ ] Bathing [ ] Toilet flushing [ ] Other: Specify
5. How much water do you need for your daily household activities (Litres)?
6. Do you depend on other water sources or providers to meet your daily household water use? [ ] Yes [ ] No
7. Which are the other water sources you normally rely on? [ ] Groundwater [ ] Surface water [ ] Rain water [ ] Cart pushers [ ] Other: Specify
8. What activities do you use water from these other sources and providers for? [ ] Drinking [ ] Cooking [ ] Laundering [ ] Bathing [ ] Flushing toilet [ ] other: Specify

Time spent collecting water

1. How far do you have to walk to collect water?
2. How long do you have to wait at the water source to collect water?
3. How many trips do you makes to the water point in a day?

Continuity and reliability of water supply provision

1. How many days in a week do you receive water?
2. How many hours in a day do you receive water?
3. Do you experience water supply interruptions at your water point? [ ] Yes [ ] No
4. How often do you usually experience these water supply interruptions at your water point? [ ] Not often [ ] Often [ ] Very often [ ] others: Specify
5. What is the response to maintenance whenever it is required? [ ] Prompt [ ] Delayed [ ] If delayed Specify
6. Which of the aspects of your water supply do you think requires urgent attention and improvement? [ ] Pressure [ ] Reliability [ ] Maintenance [ ] Cost [ ] None [ ] Other: Specify
7. How would you rate the existing water supply services at Soweto Kayole? [ ] Very Good [ ] Good [ ] Average [ ] Poor [ ] Other: Specify

APPENDIX 3.2: FOCUSED GROUP DISCUSSION

Emerging Technologies and Innovations

1. What are the existing technologies and innovations focusing on infrastructure, financial and management/organisational mechanisms involved in water service provision in Soweto Kayole?
2. Are all your neighbourhoods served through or by the same innovative mechanisms above?
3. Who were involved in the training on the use of technology and innovation tools you are currently using?
4. Do you think the stakeholders were properly capacity built on the use and deployment of the technology (JM)?
5. Why are the different neighbourhoods served differently if any? What informed the decision?
6. How were these different innovative water service provisions or options mechanisms introduced?
7. Were alternative technologies and innovations options presented to the community?
8. Why were these specific technologies and innovative interventions chosen over others?
9. Are you aware how the concept of pro-poor water delivery evolved in Soweto Kayole?
10. Who or what is behind the promotion of this pro-poor concept? Are you aware of what informed the decision?
11. What criteria are used in the identification of the urban poor segment?
12. Who are involved in the identification process?
13. How is/was the process actually implemented in Soweto Kayole? Does the process capture the target groups especially in the informal settlement?
14. What does this mean for the selection and implementation of pro-poor interventions? Does it promote the selection of the right interventions/vice versa?
15. Are you aware of the laws, policies and regulations governing water service provision in Kenya?
16. Do you think these laws, policies and regulations capture the urban poor?
17. How did the present regulation governing water service provision come into force, notably in Soweto Kayole?
18. Are you aware of specific laws, policies and regulations targeting the urban poor in the informal settlements like Soweto Kayole?

19. How do these laws, policies and regulations influence decisions concerning pro-poor activities in Soweto Kayole?
20. Do you think these laws, policies and regulations capture the contributions of other practitioners in the water service provision sectors?
21. Are you aware of those involved in the implementation, monitoring and evaluation of the pro-poor activities in terms of the existing laws, policies and regulations in Soweto Kayole?
22. How are the actors in the water service provision identified? What roles do the actors play in the process? How do these actors fulfill the roles assigned to them?
23. What are the notable outcomes and or consequences on how the roles played by actors are fulfilled?
24. What does this mean for the selection and implementation of pro-poor interventions through technology and innovation in Soweto Kayole? Does it promote the selection of the right interventions in terms of the right technology and innovations?
25. A part from NCWSC, how do the other practitioners in the water service provision contribute to and influence the selection and implementation process of water delivery

APPENDIX 3.3: FOCUSED GROUP DISCUSSION (FGD) MEMBERS

The following participants were mapped out to participate in the focused group discussion of which ten members actually participated in the exercise.

1. Eng. Kagiri Gicheha – Nairobi City Water and Sewerage Company Limited
2. Eng. Okwogo Ambrose Awiti - Nairobi City Water and Sewerage Company Limited
3. Esther Muthoni - Nairobi City Water and Sewerage Company Limited - Training
4. Benson Margaret - Nairobi City Water and Sewerage Company Limited – Research
5. James Otieno – World Bank
6. Violet M Wambua – World Bank
7. Gacheru Joseph – Community Representative
8. Jacinta Moraa - Community Representative
9. Emilly Akinyi - Community Representative
10. Nehemiah Odhiambo - Community Representative
11. Robert Mwiruri - Community Representative
12. Okumu Joseph - Community Representative
13. Daniel Njenga - Community Representative
14. Rugoro Percy - Community Representative

APPENDIX 3.4: WATER UTILITY - NCWSC

Quality of service

1. Water coverage: the number of people served with quality potable drinking water by a utility expressed as a percentage of the total target population within the service area of a utility
2. Hours of water supply: the average number of hours per day that a utility provides water to customers in Soweto Kayole

Financial sustainability

1. Operations and maintenance cost: do you think the amount of monies spent on operations and maintenance in Soweto Kayole is feasible in terms of value for money and sustainability
2. Collection efficiency: the total amount of money collected by a utility expressed as a percentage of the total amount of money billed in a given period

Operational sustainability

1. Staff productivity: number of staffs per 1000 connections and their view or perception in deployment of science technology and innovation in the water service provision chain
2. Non-Revenue Water: difference between the amount of water produced and the amount billed
3. Metering ratio: number of Jisomee Mita connections/ installations with functional meters

APPENDIX 3.5: WATER POINT OPERATORS

1. Time spent collecting water: How long do residents have to wait at the water source to get water?
2. Cost of Water: At what price do you sell water? What is the approved price by the NCWSC?
3. Water Sales: How many people do you serve per day? And how much water do you sell in a day/week/month?

Continuity and reliability of water supply:

1. How many days in a week do you receive water?
2. How many hours in a day do you receive water?
3. Do you experience supply interruptions at your water point? [ ] Yes [ ] No
4. How often do you experience water supply interruptions at your water point? [ ] Not often [ ] Often [ ] Very often [ ] others: Specify
5. What is the response to maintenance whenever there is a burst and like technical hitch? [ ] Prompt [ ] Delayed [ ] if delayed: Specify
6. Which of the aspects of your water supply do you feel require some urgent attention and technical / innovative improvement? [ ] Pressure [ ] Reliability [ ] Maintenance [ ] Other: Specify
7. How would you rate the existing water supply provision services in Soweto Kayole? [ ] Very Good [ ] Good [ ] Average [ ] Poor [ ] Other: Specify

APPENDIX 3.6: RESEARCH PERMIT FROM NACOSTI

REPUBLIC OF KENYA

NATIONAL COMMISSION FOR SCIENCE,TECHNOLOGY & INNOVATION

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APPENDIX 3.7: RESEARCH PERMIT FROM NCWSC

NAIROBI CITY WATER & SEWERAGE COMPANY LTD.
KAMPALA RD, P. O. Box 30656-00100, Nairobi, Kenya
Tel: +254 0703 080 000
Email: info@nairobiwater.co.ke
www.nairobiwater.co.ke

NCWSC/HR/TRG.14/VOL.8/111/MMM/ak 8th June, 2021

Patrick Ouma,
University of Nairobi,
P.O Box 30197-00100,
Nairobi.
Cell: 0733335836.

Dear Patrick,

RE: RESEARCH ON ASSESSING DEPLOYMENT OF SCIENCE TECHNOLOGY & INNOVATION IN CATAYSING SUSTAINABLE WATER SERVICES PROVISION IN NAIROBI CITY COUNTY, KENYA: CASE OF SOWETO KAYOLE JISOMEE MITA

Reference is made to your letter dated 26th May, 2021 on the above-mentioned subject.

Approval is hereby granted to you to collect data on **9th June, 2021 to 28th June, 2021** for your master's project titled ***"Accessing deployment of science, technology & innovation in catalyzing sustainable water services provision in Nairobi City, Kenya: case of Soweto Kayole Jisomee Mita.***

The Regional Manager whose office is at National Water Office; Dunga Road will assist you with the relevant Data/information in relation to your project.

All findings/information on Company matters should be accorded utmost confidentiality.

Please note upon completion, you will be expected to submit a copy of the findings to the office of the undersigned.

By a copy of this letter the following Officers are hereby informed accordingly.

I. Regional Manager- Informal Settlement Region, National Water Offices, Dunga Road
II. Research and Development Manager- National Water Offices

N.B: Kindly ensure you observe the Government directives on Covid -19 pandemic.

Yours Sincerely,

Eng. Nahason Muguna
Managing Director

APPENDIX 4.1: PROCESSED OUTPUTS OF STATISTICAL DATA ANALYZED (STATA)

```
                                                  ___  ____  ____  ____  ____(R)
                                                 /__    /   ____/   /   ____/
                                                ___/   /   /___/   /   /___/
                                                  Statistics/Data Analysis

                                                       User: okemwa

      ___  ____  ____  ____  ____ (R)
     /__    /   ____/   /   ____/
    ___/   /   /___/   /   /___/   14.0   Copyright 1985-2015 StataCorp LP
      Statistics/Data Analysis             StataCorp
                                           4905 Lakeway Drive
          Special Edition                  College Station, Texas 77845 USA
                                           800-STATA-PC        http://www.stata.com
                                           979-696-4600        stata@stata.com
                                           979-696-4601 (fax)

    65-user Stata network perpetual license:
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             Licensed to:  Riethwaan Salie
                           University of Cape Town

    Notes:
          1.  Unicode is supported; see help unicode_advice.
          2.  Maximum number of variables is set to 5000; see help set_maxvar.
          3.  New update available; type -update all-

1 . import excel "C:\Users\josephat\Downloads\MergedcleanDATA.xlsx", sheet("Sheet1") fi
  > rstrow

2 . tab Indicateyourageinthebox

    Indicate your age in the box |      Freq.     Percent        Cum.
---------------------------------+-----------------------------------
                          18>28  |        109       34.17       34.17
                          29>39  |        150       47.02       81.19
                          40>50  |         44       13.79       94.98
                          50>60  |          5        1.57       96.55
                        Over 60  |         11        3.45      100.00
---------------------------------+-----------------------------------
                           Total |        319      100.00

3 . br

4 . br Whatisyourhighestacademicqu

5 . clar
command clar is unrecognized
r(199);

6 . tab Whatisyourhighestacademicqu

    What is your highest academic qualification |      Freq.     Percent        Cum.
------------------------------------------------+-----------------------------------
                                      Secondary |        112       35.11       35.11
                                certificate     |        106       33.23       68.34
                                    diploma     |         81       25.39       93.73
                                    primary     |         20        6.27      100.00
------------------------------------------------+-----------------------------------
                                          Total |        319      100.00
```

```
7 . tab Whatisyourmaritalstatus
```

What is your marital status	Freq.	Percent	Cum.
Married	183	57.37	57.37
divorced	13	4.08	61.44
single	123	38.56	100.00
Total	319	100.00	

```
8 . tab Whatisyouraveragehouseholdi
```

What is your average household income per month in Ksh	Freq.	Percent	Cum.
15001>24000	24	7.52	7.52
6001>9000	72	22.57	30.09
9001>15000	148	46.39	76.49
<6000	49	15.36	91.85
> 6000	26	8.15	100.00
Total	319	100.00	

```
9 . tab Whatisthenumberofdependents
```

What is the number of dependents in your house?	Freq.	Percent	Cum.
1>2	67	21.00	21.00
3>4	215	67.40	88.40
5>6	34	10.66	99.06
6 and above	3	0.94	100.00
Total	319	100.00	

```
10 . tab Howoftendidyouusetopayfor
```

How often did you use to pay for water?	Freq.	Percent	Cum.
Daily	180	56.43	56.43
Monthly	108	33.86	90.28
Weekly	31	9.72	100.00
Total	319	100.00	

```
11 . tab
varlist required
r(100);

12 . tb Howmuchwereyoupayingforwat
command tb is unrecognized
r(199);

13 . tab Howmuchwereyoupayingforwat
```

How much were you paying for water	Freq.	Percent	Cum.
20	13	4.08	4.08
25	3	0.94	5.02
30	43	13.48	18.50
35	16	5.02	23.51
40	63	19.75	43.26
45	10	3.13	46.39
50	27	8.46	54.86
70	5	1.57	56.43
150	5	1.57	57.99
200	13	4.08	62.07
233	12	3.76	65.83
245	5	1.57	67.40
250	6	1.88	69.28
300	15	4.70	73.98
400	30	9.40	83.39
407	13	4.08	87.46
450	23	7.21	94.67
500	5	1.57	96.24
560	12	3.76	100.00
Total	319	100.00	

```
14 . sum Howmuchwereyoupayingforwat
```

Variable	Obs	Mean	Std. Dev.	Min	Max
Howmuchwer~t	319	178.9561	177.2926	20	560

```
15 . tab Howcanyoudescribetheamount
```

How can you describe the amount you were spending on water	Freq.	Percent	Cum.
High	151	47.34	47.34
Low	10	3.13	50.47
Normal	158	49.53	100.00
Total	319	100.00	

16 . tab Howcanyoucomparetheamounty

How can you compare the amount you were paying for water with electricity and co	Freq.	Percent	Cum.
Cheaper	74	23.20	23.20
Expensive	26	8.15	31.35
Fair	35	10.97	42.32
High	40	12.54	54.86
Low	117	36.68	91.54
Normal	12	3.76	95.30
still the same	15	4.70	100.00
Total	319	100.00	

17 . tab Fromwhichinfrastructuredidyo

From which infrastructure did you fetch water for your household?	Freq.	Percent	Cum.
Pc/ Tap Yard	9	2.82	2.82
Tap Yard	96	30.09	32.92
Tap/kiosk	3	0.94	33.86
Water Kiosk	211	66.14	100.00
Total	319	100.00	

18 . tab Howmuchwaterwereyoufetching

How much water were you fetching on daily basis from this water source (Litres)	Freq.	Percent	Cum.
60	9	39.13	39.13
80	12	52.17	91.30
100	1	4.35	95.65
200	1	4.35	100.00
Total	23	100.00	

19 . sum Howmuchwaterwereyoufetching

Variable	Obs	Mean	Std. Dev.	Min	Max
Howmuchwat~g	**23**	**78.26087**	**28.86523**	**60**	**200**

20 . tab Wasthiswaterenoughforyourh

Was this water enough for your household activities	Freq.	Percent	Cum.
No	**141**	**44.20**	**44.20**
yes	**178**	**55.80**	**100.00**
Total	**319**	**100.00**	

21 . tab Whathouseholdactivitiesdidyo

What household activities did you use water from this source for?	Freq.	Percent	Cum.
Everything	**306**	**95.92**	**95.92**
Not Satisfied	**10**	**3.13**	**99.06**
Not enough	**3**	**0.94**	**100.00**
Total	**319**	**100.00**	

22 . tab Howmuchwaterdidyourequiref

How much water did you require for daily activities (Litres)	Freq.	Percent	Cum.
20	**13**	**4.23**	**4.23**
30	**10**	**3.26**	**7.49**
40	**38**	**12.38**	**19.87**
50	**26**	**8.47**	**28.34**
60	**32**	**10.42**	**38.76**
70	**21**	**6.84**	**45.60**
100	**18**	**5.86**	**51.47**
120	**4**	**1.30**	**52.77**
140	**22**	**7.17**	**59.93**
170	**7**	**2.28**	**62.21**
200	**55**	**17.92**	**80.13**
230	**1**	**0.33**	**80.46**
250	**4**	**1.30**	**81.76**
300	**14**	**4.56**	**86.32**
320	**12**	**3.91**	**90.23**
340	**12**	**3.91**	**94.14**
400	**17**	**5.54**	**99.67**
1000	**1**	**0.33**	**100.00**
Total	**307**	**100.00**	

23 . sum Howmuchwaterdidyourequiref

Variable	Obs	Mean	Std. Dev.	Min	Max
Howmuchwat~f	307	148.1107	122.5212	20	1000

24 . tab Wereyoudependingonotherwate

Were you depending on other water sources or providers to meet your daily water	Freq.	Percent	Cum.
Yes	136	42.63	42.63
no	183	57.37	100.00
Total	319	100.00	

25 . tab Whichotherwatersourcesyouwe

Which other water sources you were depending on	Freq.	Percent	Cum.
Ground Water	1	0.74	0.74
Rain Water	6	4.41	5.15
cart pushers	117	86.03	91.18
rain water/cartpushers	12	8.82	100.00
Total	136	100.00	

26 . tab Whatactivitiesdidyouusewate

What activities did you use water from these other sources and providers for?	Freq.	Percent	Cum.
Laundry	1	0.77	0.77
all activities	129	99.23	100.00
Total	130	100.00	

27 . sum Timespentcollectingwater

Variable	Obs	Mean	Std. Dev.	Min	Max
Timespentc~r	0				

```
28 . sum Howfardidyouhavetowalkto
```

Variable	Obs	Mean	Std. Dev.	Min	Max
Howfardidy~o	0				

```
29 . tab Timespentcollectingwater
no observations

30 . tab Howfardidyouhavetowalkto
```

How far did you have to walk to collect water (metres)	Freq.	Percent	Cum.
100	49	15.61	15.61
150	12	3.82	19.43
20	5	1.59	21.02
200	4	1.27	22.29
250	30	9.55	31.85
300	56	17.83	49.68
40	2	0.64	50.32
400	33	10.51	60.83
50	3	0.96	61.78
500	16	5.10	66.88
within plot	104	33.12	100.00
Total	314	100.00	

```
31 . sum Howfardidyouhavetowalkto
```

Variable	Obs	Mean	Std. Dev.	Min	Max
Howfardidy~o	0				

```
32 . tab Howlongdidyouhavetowaitat
```

How long did you have to wait at the water source to collect water (minutes)	Freq.	Percent	Cum.
1	16	7.44	7.44
2	35	16.28	23.72
3	52	24.19	47.91
4	34	15.81	63.72
5	53	24.65	88.37
6	16	7.44	95.81
10	8	3.72	99.53
15	1	0.47	100.00
Total	215	100.00	

33 . sum Howlongdidyouhavetowaitat

Variable	Obs	Mean	Std. Dev.	Min	Max
Howlongdid~t	**215**	**3.87907**	**2.003333**	**1**	**15**

34 . tab
varlist required
r(100);

35 . tab Howmanytripsdidyoumaketot

How many trips did you make to the water point in a day	Freq.	Percent	Cum.
1	**30**	**14.35**	**14.35**
2	**47**	**22.49**	**36.84**
3	**28**	**13.40**	**50.24**
4	**32**	**15.31**	**65.55**
5	**9**	**4.31**	**69.86**
6	**4**	**1.91**	**71.77**
7	**22**	**10.53**	**82.30**
8	**12**	**5.74**	**88.04**
9	**1**	**0.48**	**88.52**
10	**9**	**4.31**	**92.82**
15	**15**	**7.18**	**100.00**
Total	**209**	**100.00**	

36 . sum Howmanytripsdidyoumaketot

Variable	Obs	Mean	Std. Dev.	Min	Max
Howmany~etot	**209**	**4.684211**	**3.776928**	**1**	**15**

37 . tab Howmanydaysinaweekdidyou

How many days in a week did you receive water	Freq.	Percent	Cum.
1	**55**	**17.30**	**17.30**
2	**62**	**19.50**	**36.79**
3	**5**	**1.57**	**38.36**
no day	**196**	**61.64**	**100.00**
Total	**318**	**100.00**	

38 . tab Howmanyhoursinadaydidyou

How many hours in a day did you receive water	Freq.	Percent	Cum.
5	**5**	**4.10**	**4.10**
6	**36**	**29.51**	**33.61**
8	**31**	**25.41**	**59.02**
10	**13**	**10.66**	**69.67**
12	**37**	**30.33**	**100.00**
Total	**122**	**100.00**	

39 . sum Howmanyhoursinadaydidyou

Variable	Obs	Mean	Std. Dev.	Min	Max
Howmanyhou~u	**122**	**8.713115**	**2.524195**	**5**	**12**

40 . tab Didyouexperiencesupplyinterr

Did you experience supply interruptio ns at your water point	Freq.	Percent	Cum.
No	**4**	**3.25**	**3.25**
Yes	**119**	**96.75**	**100.00**
Total	**123**	**100.00**	

41 . tab Howoftendidyouexperiencethe

How often did you experience these interruptio ns at your water point	Freq.	Percent	Cum.
Not often	**64**	**53.78**	**53.78**
Often	**18**	**15.13**	**68.91**
Very often	**37**	**31.09**	**100.00**
Total	**119**	**100.00**	

42 . tab Whatwastheresponsetomainten

What was the response to maintenance whenever it is needed	Freq.	Percent	Cum.
Delayed	**79**	**64.23**	**64.23**
Prompt	**44**	**35.77**	**100.00**
Total	**123**	**100.00**	

43 . tab Whichoftheaspectsofyourwat

Which of the aspects of your water supply did you think required improvement	Freq.	Percent	Cum.
Cost	25	18.94	18.94
Everything	9	6.82	25.76
Maintainance	51	38.64	64.39
None	4	3.03	67.42
Reliability	43	32.58	100.00
Total	132	100.00	

44 . tab Howwouldyouratewatersupply

How would you rate water supply service prior to the interventions	Freq.	Percent	Cum.
Average	45	14.11	14.11
Good	9	2.82	16.93
Poor	265	83.07	100.00
Total	319	100.00	

45 . tab Currentsituationaftertheinte
no observations

46 . tab Fromwhichinfrastructuredoyou

From which infrastructure do you collect water for your household	Freq.	Percent	Cum.
Pc/ Tap Yard	9	2.82	2.82
Tap Yard	97	30.41	33.23
Tap/kiosk	3	0.94	34.17
Water Kiosk	210	65.83	100.00
Total	319	100.00	

47 . sum Howmuchwaterdoyoucollectin

Variable	Obs	Mean	Std. Dev.	Min	Max
Howmuchwat~n	**35**	**80.57143**	**24.48804**	**60**	**200**

48 . tab Howmuchwaterdoyoucollectin

How much water do you collect in a day from this water source (Litres)	Freq.	Percent	Cum.
60	**10**	**28.57**	**28.57**
80	**19**	**54.29**	**82.86**
100	**5**	**14.29**	**97.14**
200	**1**	**2.86**	**100.00**
Total	**35**	**100.00**	

49 . tab Isthiswaterenoughandoradeq

Is this water enough and or adequate for your household activities?	Freq.	Percent	Cum.
No	**145**	**45.45**	**45.45**
yes	**174**	**54.55**	**100.00**
Total	**319**	**100.00**	

50 . tab Whathouseholdactivitiesdoyou

What household activities do you use water from this source for?	Freq.	Percent	Cum.
Everything	**310**	**97.18**	**97.18**
Not enough	**9**	**2.82**	**100.00**
Total	**319**	**100.00**	

51 . tab Howmuchwaterdoyouneedfory

How much water do you need for your daily household activities (Litres)	Freq.	Percent	Cum.
20	17	5.54	5.54
30	10	3.26	8.79
40	34	11.07	19.87
50	27	8.79	28.66
60	39	12.70	41.37
70	24	7.82	49.19
100	22	7.17	56.35
120	4	1.30	57.65
140	22	7.17	64.82
170	7	2.28	67.10
200	49	15.96	83.06
230	1	0.33	83.39
250	4	1.30	84.69
300	14	4.56	89.25
320	9	2.93	92.18
340	10	3.26	95.44
400	13	4.23	99.67
1000	1	0.33	100.00
Total	307	100.00	

52 . sum Howmuchwaterdoyouneedfory

Variable	Obs	Mean	Std. Dev.	Min	Max
Howmuchwat~y	307	136.9055	117.6174	20	1000

53 . tab Doyoudependonotherwatersou

Do you depend on other water sources or providers to meet your daily household w	Freq.	Percent	Cum.
Yes	140	44.03	44.03
no	178	55.97	100.00
Total	318	100.00	

54 . tab Whicharetheotherwatersource

Which are the other water sources you normally rely on?	Freq.	Percent	Cum.
Cart Pushers	119	85.00	85.00
Ground Water	1	0.71	85.71
Rain Water	2	1.43	87.14
rain water/cartpushers	18	12.86	100.00
Total	140	100.00	

55 . tab Whatactivitiesdoyouusewater

What activities do you use water from these other sources and providers for?	Freq.	Percent	Cum.
Bathing/Laundry/Flushing toilet	4	2.90	2.90
Laundry	1	0.72	3.62
all activities	133	96.38	100.00
Total	138	100.00	

56 . tab Howfardoyouhavetowalktoc

How far do you have to walk to collect water	Freq.	Percent	Cum.
100	33	16.42	16.42
150	4	1.99	18.41
20	5	2.49	20.90
200	6	2.99	23.88
250	11	5.47	29.35
300	38	18.91	48.26
40	2	1.00	49.25
400	26	12.94	62.19
50	5	2.49	64.68
500	10	4.98	69.65
Within the plot	61	30.35	100.00
Total	201	100.00	

57 . tab Howlongdoyouhavetowaitat

How long do you have to wait at the water source to collect water	Freq.	Percent	Cum.
1	12	8.22	8.22
2	17	11.64	19.86
3	37	25.34	45.21
4	27	18.49	63.70
5	31	21.23	84.93
6	10	6.85	91.78
10	10	6.85	98.63
15	1	0.68	99.32
300	1	0.68	100.00
Total	146	100.00	

58 . tab Howmanytripsdoyoumakestot

How many trips do you makes to the water point in a day	Freq.	Percent	Cum.
1	**14**	**10.85**	**10.85**
2	**31**	**24.03**	**34.88**
3	**17**	**13.18**	**48.06**
4	**21**	**16.28**	**64.34**
5	**12**	**9.30**	**73.64**
6	**2**	**1.55**	**75.19**
7	**14**	**10.85**	**86.05**
8	**5**	**3.88**	**89.92**
9	**1**	**0.78**	**90.70**
10	**3**	**2.33**	**93.02**
15	**8**	**6.20**	**99.22**
45	**1**	**0.78**	**100.00**
Total	**129**	**100.00**	

59 . tab Continuityandreliabilityofwa

Continuity and reliability of water supply provision	Freq.	Percent	Cum.
1	**49**	**15.46**	**15.46**
2	**65**	**20.50**	**35.96**
3	**7**	**2.21**	**38.17**
4	**1**	**0.32**	**38.49**
6	**1**	**0.32**	**38.80**
no day	**194**	**61.20**	**100.00**
Total	**317**	**100.00**	

60 . tab Howmanydaysinaweekdoyour

How many days in a week do you receive water	Freq.	Percent	Cum.
2	**1**	**0.82**	**0.82**
5	**7**	**5.74**	**6.56**
6	**35**	**28.69**	**35.25**
7	**2**	**1.64**	**36.89**
8	**30**	**24.59**	**61.48**
10	**17**	**13.93**	**75.41**
12	**30**	**24.59**	**100.00**
Total	**122**	**100.00**	

61 . tab Howmanyhoursinadaydoyour

How many hours in a day do you receive water	Freq.	Percent	Cum.
No	**4**	**3.23**	**3.23**
Yes	**120**	**96.77**	**100.00**
Total	**124**	**100.00**	

62 . tab Doyouexperiencewatersupplyi

Do you experience water supply interruptio ns at your water point	Freq.	Percent	Cum.
Not often	**68**	**56.67**	**56.67**
Often	**17**	**14.17**	**70.83**
Very Often	**13**	**10.83**	**81.67**
Very often	**22**	**18.33**	**100.00**
Total	**120**	**100.00**	

63 . tab Howmanyhoursinadaydoyour

How many hours in a day do you receive water	Freq.	Percent	Cum.
No	**4**	**3.23**	**3.23**
Yes	**120**	**96.77**	**100.00**
Total	**124**	**100.00**	

64 . tab Doyouexperiencewatersupplyi

Do you experience water supply interruptio ns at your water point	Freq.	Percent	Cum.
Not often	**68**	**56.67**	**56.67**
Often	**17**	**14.17**	**70.83**
Very Often	**13**	**10.83**	**81.67**
Very often	**22**	**18.33**	**100.00**
Total	**120**	**100.00**	

65 . tab Howoftendoyouusuallyexperie

How often do you usually experience these water supply interruptions at your wat	Freq.	Percent	Cum.
Delayed	76	61.29	61.29
Prompt	48	38.71	100.00
Total	124	100.00	

66 . tab Whatistheresponsetomaintena

What is the response to maintenance whenever it is required	Freq.	Percent	Cum.
Cost	30	23.26	23.26
Everything	5	3.88	27.13
Maintainance	53	41.09	68.22
None	4	3.10	71.32
Reliability	37	28.68	100.00
Total	129	100.00	

67 . tab BF

Which of the aspects of your water supply do you think requires urgent attention	Freq.	Percent	Cum.
Average	48	15.05	15.05
Good	10	3.13	18.18
poor	261	81.82	100.00
Total	319	100.00	

68 . tb Howwouldyouratetheexisting
command tb is unrecognized
r(199);

```
69 . tb Whataretheexistingtechnologi
command tb is unrecognized
r(199);

70 . tab CX
```

How many days in a week do you receive water	Freq.	Percent	Cum.
1	50	15.87	15.87
2	64	20.32	36.19
3	7	2.22	38.41
no day	194	61.59	100.00
Total	315	100.00	

```
71 . tab CY
```

How many hours in a day do you receive water	Freq.	Percent	Cum.
5	7	5.79	5.79
6	35	28.93	34.71
7	2	1.65	36.36
8	30	24.79	61.16
10	16	13.22	74.38
12	31	25.62	100.00
Total	121	100.00	

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72 .
73 . tab Doyouexperiencesupplyinterru
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Do you experience supply interruptions at your water point	Freq.	Percent	Cum.
No	4	3.28	3.28
Yes	118	96.72	100.00
Total	122	100.00	

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74 . tab Howoftendoyouexperiencewate
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How often do you experience water supply interruptions at your water point	Freq.	Percent	Cum.
Not often	66	55.93	55.93
Often	17	14.41	70.34
Very Often	35	29.66	100.00
Total	118	100.00	

75 . tab DB

What is the response to maintenance whenever there is a burst and like technical	Freq.	Percent	Cum.
Delayed	75	61.48	61.48
Prompt	47	38.52	100.00
Total	122	100.00	

76 . tab DC

Which of the aspects of your water supply do you feel require some urgent attent	Freq.	Percent	Cum.
Cost	29	22.83	22.83
Everything	5	3.94	26.77
Maintainance	52	40.94	67.72
None	4	3.15	70.87
Reliability	37	29.13	100.00
Total	127	100.00	

77 . tab DD

How would you rate the existing water supply provision services in Soweto Kayole	Freq.	Percent	Cum.
Average	47	14.87	14.87
Good	10	3.16	18.04
Poor	2	0.63	18.67
poor	257	81.33	100.00
Total	316	100.00	

78 .

RAW DATA

APPENDIX 4.2: FOCUSED GROUP DISCUSSIONS (SAMPLE OF RAW DATA)

Emerging Technologies and Innovations

1. What are the existing technologies and innovations focusing on infrastructure, financial and management/organisational mechanisms involved in water service provision in Soweto Kayole? We are only aware of the JM in Soweto Kayole. There is also Prepaid water dispenser (PPD) in Makueni, Kitheme etc.
2. Are all your neighbourhoods served through or by the same innovative mechanisms above? NO, but Plans are underway
3. Who were involved in the training on the use of technology and innovation tools you are currently using? constraint is lack of adequate funding. A consultant was hired to train the staff of NCWSC then this training was cascaded downwards to the selected community Members.
4. Do you think the stakeholders were properly capacity built on the use and deployment of the technology (JM)? Yes. There has been some teething challenges but the training on capacity building was foreseen to be continuous. Refresher
5. Why are the different neighbourhoods served differently if any? What informed the decision? No, not served differently.
6. How were these different innovative water service provisions or options mechanisms introduced? Initially the residents were not totally connected and relying on water hawked. CDOs were trained by the NCWSC who subsequently conducted awareness training & sensitization drive to the local communi
7. Were alternative technologies and innovations options presented to the community? NO, only JM is the first. There are others but in other localities.
8. Why were these specific technologies and innovative interventions chosen over others? This was the only feasible technology for the locality considering their complexities.
9. Are you aware how the concept of pro-poor water delivery evolved in Soweto Kayole? World Bank earmarked/mapped out Soweto Kayole as one of the most deserving areas
10. Who or what is behind the promotion of this pro-poor concept? Are you aware of what informed the decision? This is inline with the Kenya 2010 constitution and Water act 2016. It is a fundamental right of the residents. The target is also to reduce significantly non-revenue waters by the water & sanitation-NCWSC.
11. What criteria are used in the identification of the urban poor segment? Household surveys and the economic status of the people. The level of water and
12. Who are involved in the identification process? sewer line networks for coverage and Stakeholders in the water sector/donors. interference of water issues related decision
13. How is/was the process actually implemented in Soweto Kayole? Does the process capture the target groups especially in the informal settlement? Yes the process reached the target audience in the key stakeholders. It was participatory where they were all involved or engaged in all the levels
14. What does this mean for the selection and implementation of pro-poor interventions? Does it promote the selection of the right interventions/vice versa? It is the most appropriate intervention. More effort & solid strategies need to be put in place to avoid misalignments/overlap of the plans
15. Are you aware of the laws, policies and regulations governing water service provision in Kenya? Some are aware but not every one. We are aware Water is a fundamental right of every citizen to access but this is not yet realized.
16. Do you think these laws, policies and regulations capture the urban poor? Yes. Only need sensitization
17. How did the present regulation governing water service provision come into force, notably in Soweto Kayole?

Most of us are not policy experts but we know it's a right of every citizen to access to safe and portable water for both domestic and many be industrial use.

RAW DATA

18. Are you aware of specific laws, policies and regulations targeting the urban poor in the informal settlements like Soweto Kayole? Pro poor policy and Water act 2016.
19. How do these laws, policies and regulations influence decisions concerning pro-poor activities in Soweto Kayole? Because of their wanting socio-economic status they should normally be given priority over other areas.
20. Do you think these laws, policies and regulations capture the contributions of other practitioners in the water service provision sectors? Yes. It has been committee and all stakeholders brought on board ie. AWWDA, WASREB, NCWSC.
21. Are you aware of those involved in the implementation, monitoring and evaluation of the pro-poor activities in terms of the existing laws, policies and regulations in Soweto Kayole? No, but I suspect NCWSC and AWWDA
22. How are the actors in the water service provision identified? What roles do the actors play in the process? How do these actors fulfill the roles assigned to them? The actors in the water service provision is clear as per the water act 2016 and the new constitution of Kenya 2010. with each role's distinctive.
23. What are the notable outcomes and or consequences on how the roles played by actors are fulfilled? Good or proper coordination and execution of various roles without overlap or conflict.
24. What does this mean for the selection and implementation of pro-poor interventions through technology and innovation in Soweto Kayole? Does it promote the selection of the right interventions in terms of the right technology and innovations? It gives clear implementation roadmap on who is expected to do what. Yes. Proper Planning on feasibility studies informs which best interventions to be adopted as per specific location.
25. A part from NCWSC, how do the other practitioners in the water service provision contribute to and influence the selection and implementation process of water delivery

WASREB - has specific role as well as other stakeholders such as AWWDA - Implementation/ Partnership.

RAW DATA

APPENDIX 4.3: WATER POINT OPERATORS (SAMPLE OF RAW DATA)

[redacted]

1. Time spent collecting water: How long do residents have to wait at the water source to get water? This vary from one water point to another and where the long lines resides. But it take like 30min to one hour.
2. Cost of Water: At what price do you sell water? What is the approved price by the NCWSC? They normally buy 9L or 20 or 15shillings. Ammount by NCWSC is 2Ksh/20L.
3. Water Sales: How many people do you serve per day? And how much water do you sell in a day/week/month? This vanes from day to day and we don't have record. We can only Service charge or the amount collected for daily basis. Which also vanes from less 5000 to 8000 depends on the season.

Continuity and reliability of water supply:

1. How many days in a week do you receive water? Approximately 3-4 days a week.
2. How many hours in a day do you receive water? Between 4-8 hours a day. Varies.
3. Do you experience supply interruptions at your water point? [✓] Yes [ ] No Most often.
4. How often do you experience water supply interruptions at your water point? [ ] Not often [✓] Often [ ] Very often [ ] others: Specify often
5. What is the response to maintenance whenever there is a burst and like technical hitch? [ ] Prompt [✓] Delayed [ ] if delayed: Specify There is normally delays but since introduction of JM they have improved.
6. Which of the aspects of your water supply do you feel require some urgent attention and technical / innovative improvement? [ ] Pressure [✓] Reliability [ ] Maintenance [ ] Other: Specify Water supply should be realiable and accessible and affordable.
7. How would you rate the existing water supply provision services in Soweto Kayole? [ ] Very Good [ ] Good [✓] Average [ ] Poor [ ] Other: Specify

They have (NCWSC) improved with the introduction of the JM system. They normally check on water pipe leakages and burst and do regular inspections as opposed to when the system had not been introduced.

RAW DATA.

APPENDIX 4.4: WATER UTILITY – NCWSC (SAMPLE OF RAW DATA)

[redacted]

Quality of service

will provide more data from the office.

1. Water coverage: the number of people served with quality potable drinking water by a utility expressed as a percentage of the total target population within the service area of a utility Not clear unless we refer (finance team)
2. Hours of water supply: the average number of hours per day that a utility provides water to customers in Soweto Kayole

Average between 6–8 hours a day. Retaining for other parts of the city also to get water.

Financial sustainability

1. Operations and maintenance cost: do you think the amount of monies spent on operations and maintenance in Soweto Kayole is feasible in terms of value for money and sustainability Vandalized pipes or gadget intacke/ common. No. The people are not yet fully connected. There are still NRW cases.
2. Collection efficiency: the total amount of money collected by a utility expressed as a percentage of the total amount of money billed in a given period There are some good improvement in terms of money collection technology in the area. More effort is still required with good funding to connect. every body.

Operational sustainability

1. Staff productivity: number of staffs per 1000 connections and their view or perception in deployment of science technology and innovation in the water service provision chain More informed data to be provided later. Note that the Water Utility has staff structure and the right experts are there it still rampant but the initiative (intervention "geared towards addressing the NRW problem.
2. Non-Revenue Water: difference between the amount of water produced and the amount billed lacking.
3. Metering ratio: number of Jisomee Mita connections/ installations with functional meters

There are a number of cases where the residents have vandalized the whole or in parts the system citing lack of continuous flow of water even though it is also not helping them by promoting extortion and exploitation by the rich landlords/landladies.