

*Full Length Research Paper*

# **Influence of a quasi-delegated management framework on sustainable distribution of quality drinking water in Umoja Innercore Estate, Nairobi**

**Nyakundi Victor<sup>1\*</sup>, Munala Gerryshom<sup>1</sup>, Makworo Micah<sup>2</sup>, Shikuku James<sup>1</sup> and Ali Muhammad<sup>1</sup>**

<sup>1</sup>Center for Urban Studies, Jomo Kenyatta University of Agriculture and Technology, Nairobi, 62000-00200, Kenya.

<sup>2</sup>Department of Landscape Architecture, Jomo Kenyatta University of Agriculture and Technology, P. O. Box 62000-00200, Nairobi, Kenya.

Received 22 July, 2020; Accepted 25 August, 2020

**Managing drinking water in its distribution pathways is one of the main indicators of the quality of service provided to the consumer. Its quality management is important since human health and livelihoods depend on adequate, clean, reliable water supplies. Unfortunately, this is not true to many neighborhoods in developing countries and the quality of water distributed in Umoja Innercore is no exemption. This research sought to evaluate how the management of water affects its distribution in the entity from source to the household. Six borehole owners and 5 water bowsers were interviewed and 156 households' questionnaires were administered in a systematic random manner through a survey carried out over a period of 10 days. The study found out that 29.3% of respondents get treated water directly from Nairobi City Water and Sewerage Company (NCWSC), 32.7 and 25.3% get untreated water from water bowsers and water carts through jerrycans, 10% indicated water kiosk and 3% from rainwater. The cost of water ranges from Ksh. 20 per 20-L jerry can to Ksh., 50 during scarce periods. 89% of sampled households treat all water out of which, 52% boil water, 20% use filtration cans, 26% further chlorinate the water, and 3% strain water through sieve clothe. The study reveals the inconsistency of monitoring by NCWSC of the available sources of water and unregulated cartels compromising water quality. The study recommends regulating and incorporating private boreholes distributors to the network through a quasi-delegated model using an inter-estate bulk treatment for quality measures before supplying to households.**

**Key words:** Nairobi, Quasi-delegated management, sustainable distribution, Umoja Innercore, quality drinking water.

## **INTRODUCTION**

Management of drinking water in its distribution pathways is one of the main indicators of the quality of service

\*Corresponding author. E-mail: [victor.nyakundi@jkuat.ac.ke](mailto:victor.nyakundi@jkuat.ac.ke).

Author(s) agree that this article remain permanently open access under the terms of the [Creative Commons Attribution License 4.0 International License](https://creativecommons.org/licenses/by/4.0/)

provided to the consumer (WASREB, 2008). Managing quality is important since human health and livelihoods depend on adequate, clean and reliable water supplies. According to Unver (2015), water management for sustainable access to safe drinking water and sanitation are the most important to achieve an adequate healthy life expectancy. As further argued by Connor (2015), by 2050, global water demand is projected to increase by 55%, mainly due to growing demands from manufacturing and rapid urbanization. Sustainable Development Goal Number 6 is a dedicated to “ensure availability and sustainable management of water and sanitation for all” (Unver, 2015) which simultaneously aims to improve water quality by reducing pollution and halving current levels of untreated wastewater, while substantially increasing recycling and safe water reuse (United Nations, 2019).

Okeyo (2011) argues that access to water in Kenya has been compounded by two legacies. First Kenya has extremely limited per capita (696 m<sup>3</sup>/person/year) endowment of fresh water resources and high hydrological variability, both temporal and spatial. The second legacy is management one characterized by a rapidly growing demand for water from various sectoral uses and, on the other hand, a diminution of natural storage capacity (wetlands, catchment, and aquifer recharge areas) and lack of development for artificial storage capacity (dams and reservoirs) to meet the demand. These two legacies have led to a serious compromise on quality exacerbated by poor-monitoring from point sources to household level. According to Ledant (2013), since Nairobi's creation, the struggle has been constant to expand the water supply in greater proportions and at a greater pace in track with the fast-growing demand of the metropolis. Ledant (2013) further argues that despite three consecutive large scale water supply projects completed in 1995 (total design capacity of supply: 524,800 m<sup>3</sup>/day), rapid urbanization has created a demand in Nairobi that already outstripped supply sometimes around 2007 (World Bank, 1996).

Urbanization has created a water crisis in Nairobi with the demand for clean water far outweighing its supply. Currently, Umoja is one of the most populated high rise neighbourhoods in Nairobi making the available infrastructure to be unable to cater for the high population density within the area (Atanda, 2014). The estate faces a structural water shortage likely to worsen until the further expansion of the current water system. A big percentage of Umoja residents lack clean drinking water for local consumption. The initial infrastructure laid down could only cater for the middle-density population around 1970. This has tremendous implications on all the other aspects of water management, since water has to be rationed.

Today, another major expansion of the system is needed without which the water situation in Umoja Innercore will deteriorate further (Ledant, 2013). Water

shortage in the estate is evidenced by the presence of many private water distributors in the form of water bowsers, water tanks and private boreholes whose source is unknown and therefore quality uncertain. As reported by Kimuyu (2005), the majority of resident's do not trust the water that is sold by the vendors because they do not know how clean the vendors jerrycans are. But since there exists no other alternative, residents are forced to buy untreated water transported by bowsers or handcarts and stored in jerrycans. Connor (2015), reports that these constraints fall chiefly on the mismanagement of this available water which has had a direct effect on the quality supplied to households.

There is a potential of private sector involvement in meeting the deficit. In involving the community partially in managing water, the community would have a sense of ownership hence as assumption that water would be managed better. However, private-sector participation in urban water supply has had a particular challenge by focusing more in the involvement of international corporations as compared to small private operators in the management of water supply networks (King, 2008). However, it is only in recent years that partnerships with small operators have begun to receive serious attention from researchers, planners and policy-makers (King, 2008).

This study delves on the intricacies of small-scale water supply and Quasi-management of the distributed water between Umoja Residents and NCWSC management to understand the intricacies of involving them in the provision of potable water to households.

### Source of water for Umoja Innercore

According to the report by the Government of Kenya - UNEP (2007), Ndakaini, Ruiru, and Susumua dams are the principal sources of water for Nairobi. These dams are all on rivers emanating from the Aberdare Forest and environmental degradation both within the city and in the surrounding countryside. Ndakaini dam (Thika Dam) produces 430,000 m<sup>3</sup> of water a day, which is about 84% of water supply to Nairobi residents and holds about 70,000,000 m<sup>3</sup> at full storage. The Nairobi City Water and Sewerage Company (NCWSC) supply the city with 505,000 m<sup>3</sup> of water a day, against a demand of 760,000 m<sup>3</sup> a day in 2007 (Gilbert, 2012). Health is one of the major sectors affected by the poor provision of water supply and sanitation services. The reforms outlined by the strategic report by NCWSC (2014), are guided by the Water Act 2002 that is based on the principles of separation of supervision from regulation and policy-making (Gilbert, 2012). King (2008) in his report, business models for delegated management of local water services: experience from Naivasha (Kenya), outlines that the provision of water and sanitation services for low-income urban communities necessarily

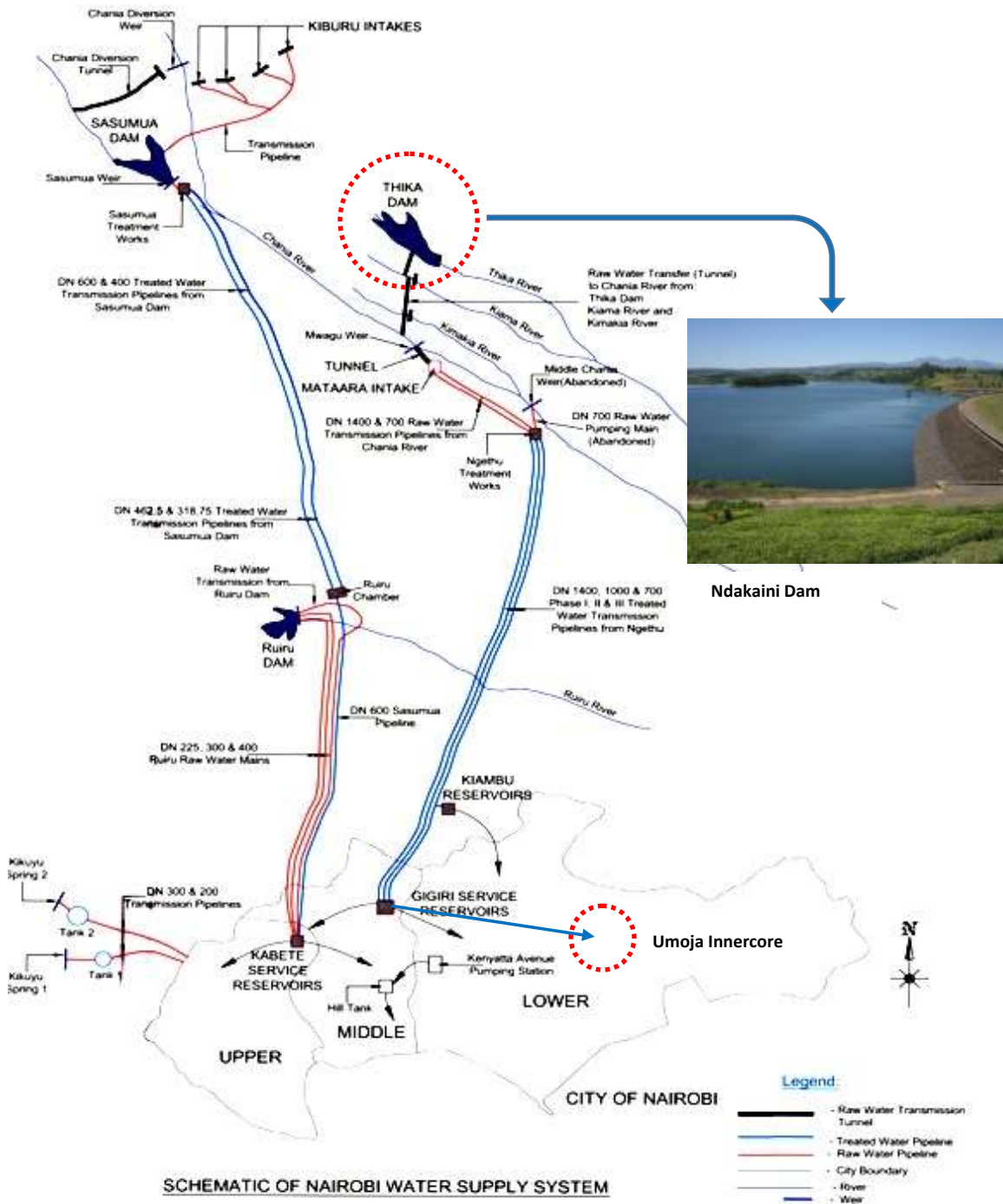


Figure 1. Water supply from Ndakaini to Umoja. Source: NCWSC (2019a).

requires several different actors to cooperate. In the case of water supply, these actors typically include one or more network operators, an asset owner, and a regulator. In such situations a clearly defined institutional architecture is essential, requiring a series of agreements that define each actor's role, responsibilities and incentives, and how each actor will work with the others

(Figure 1).

**The study site**

As shown in Figure 2, Umoja is a typical high-rise housing neighbourhood in the Eastlands of Nairobi

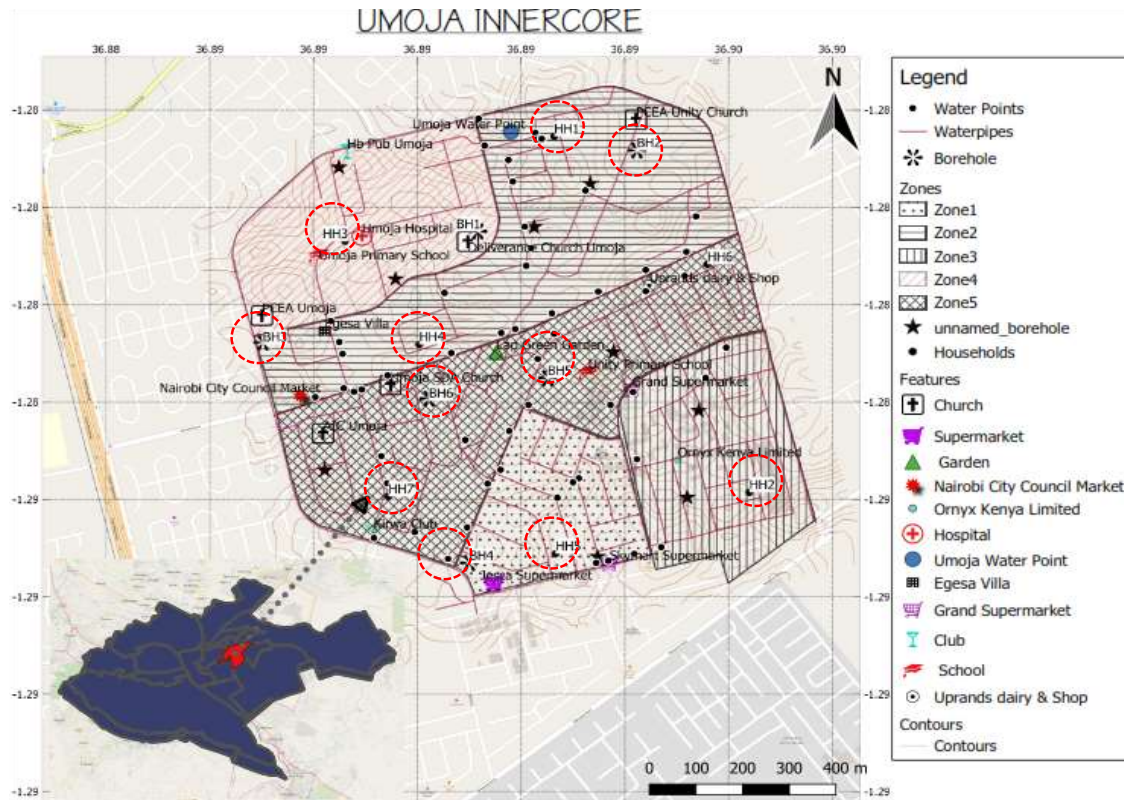


Figure 2. Umoja Innercore base map.

located approximately 15 km from the city center and measures approximately 120 ha. Its latitude and longitudes are 1.2843° S, 36.8923°E.

### Management failures in water distribution

Connecting households to networked water supply, urban water and management issues faced by residents may be in form of market, state, and governance failures.

(1) State failure-water supply systems is owned and operated or regulated by governments may fail to operate effectively when one or more of the following occur: Rent-seeking (by officials), Unincorporated externalities, Poacher-gamekeeper problem (if both supplier and regulator are public) and Regulatory capture (if the supplier is private) (Bakker et al., 2008).

(2) Market failure-water supply networks operated by private companies may fail to operate efficiently when one or more of the following occur: Imperfect competition, Asymmetric information (between regulator and company), Unincorporated externalities and Public good (health benefits of universal water supply provision are non-exclude-able and non-rivalrous) (Bakker et al., 2008).

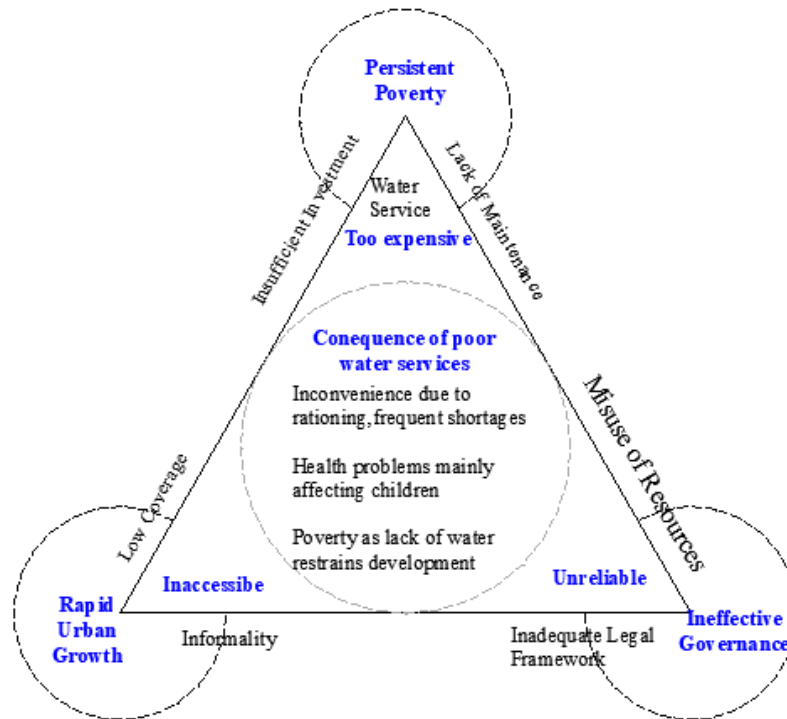
(3) Governance failure-as further discussed by Kellen

(2006) in Figure 3, the decision-making process for water management may fail to address the needs of poor households because of the absence of consumer entitlements to basic services (e.g., lack of universal service requirement on the part of utility), political disenfranchisement (e.g., lack of “voice” on the part of poor households), culture of governance (e.g., elite-focused, top-down) and economic disincentives for connecting poor households (Bakker et al., 2008) (Figure 3).

(4) Individual households may be subject to institutions, incentives, or other factors, which undermine their capability to connect to the water supply system, tenure system (lack of clear property rights), lack of skills (e.g., literacy), facilitating interaction with the service provider, cultural beliefs (e.g., appropriate water treatment protocols), and tariff structure (e.g., high connection fees) (Bakker et al., 2008).

### Pro-poor water distribution model and urban water issues

Pro-poor model (PPG) is a development policy strategy in order to enable (extremely) poor and disadvantaged men, women and youths, who are excluded from growth processes, to contribute to and benefit from them.



**Figure 3.** Framing the development problem of poor urban water services.  
Source: Kellen (2006).

According to Munala (2009), pro-poor partnerships take advantage of recent reforms undertaken in the water sector. These include first, devolution of service provision to the local level to create a sense of ownership and secondly, encouragement of cost recovery tariffs to enhance sustainability.

### Co-sharing partnership approach

Munala (2009), further argues that a co-sharing partnership approach would therefore involve coordination of water service provision at the community level in an effort to

- (1) Improve contact efficiencies for users, that is, locals are made more aware of their water situation hence they manage it better;
- (2) Improve knowledge sharing with other water providers
- (3) Reduce investment costs by incorporating local resources e.g. labour, local sources
- (4) Tap into local knowledge, innovativeness and flexibility (Munala, 2009).

Through delegation, public functions would be transferred through a semi-autonomous community association with some discretion to make decisions. This will further eliminate the informality and illegality of operators through

official recognition (Munala, 2009). Some of the stakeholders involved would be NCSWC, community associations, operating groups, consumers, and NGOs and financiers, all who will have their roles defined.

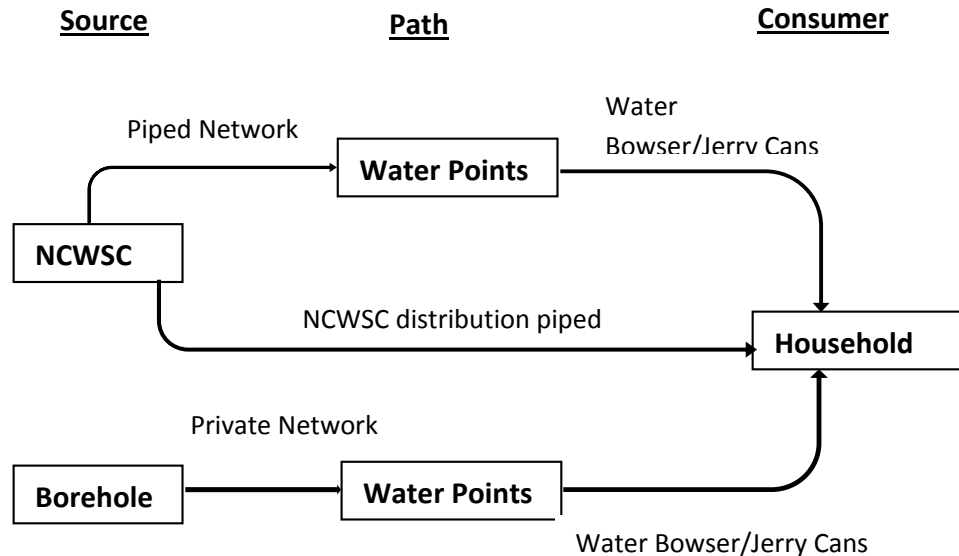
The general concept of co-sharing goes beyond “public-sector bureaucrat management” and “private-sector management” and involves residents. It also builds upon existing community resources, assets and processes through the elimination of unfair competition. The community is viewed as the central point; ensuring adequate quality water is provided by the supplier, efficiency of providers and protection of the users (Munala, 2009).

A delegated management within the estate would ensure that there is:

- (1) The separation of the management of the water resources from the provision of the water services
- (2) The separation of policy formulation on water issues from the day to day administration and regulation
- (3) Decentralization of the functions in the water and sanitation sector to the lower level state organs
- (4) Involvement of non-governmental entities in the management of water resources.

By involving private companies:

- (1) The distribution company is in full control of the



**Figure 4.** Water distribution paths in Umoja Innercore.

scheme (tariffs, service levels, technical standards, water quality and customer care)

(2) Staff members assigned to the scheme, residents of the project area are involved in the operation of the water supply scheme,

(3) Collection efficiency of revenue is high,

(4) Groups will be investing in community projects (such as the upgrading of roads),

(5) The scheme provides job opportunities for residents of the area

(6) Non-performing groups can be replaced without this having a negative impact upon supply (no disconnections) (Orwa and Karimi, 2008).

## MATERIALS AND METHODS

The research was designed as a cross-sectional survey between 1st January 2019 and 31st December 2019. Primary sources included field surveys, observation and interviews. The data was analyzed and presented using images, tables, charts and bar graphs. A user-focused methodology was adopted for the study to achieve the objective of developing a management framework that can involve the public in water management and distribution. The qualitative and quantitative research methodology focused on the water structure, ownership, control, costs and quantities since the research is a survey. Six borehole owners and 5 water bowzers were interviewed and 156 households' questionnaires were administered in systematic random manner through a survey carried out over 10 days. In each of the zones, existing roads were systematically identified and the third plot along the road was selected. Within the plots, the third households were extracted from the spatial database of the enumeration and mapping. The households were then selected through a systematic and stratified manner. Out of the 24 boreholes in Umoja, 13 were randomly selected under guidance from public health officers within Umoja. This represented a 55% sampling frame. Interviews were purposively

conducted for water local borehole owners and health officers at Umoja Health Center and Mama Lucy Hospital.

## RESULTS AND DISCUSSION

### Water management structure in Umoja Innercore area

As shown in Figure 4, water in Umoja Innercore is channeled to the households through three routes: NCWSC directly to households, NSCWC to private vendors to households and boreholes through private vendors to households. This water is distributed either by the networked system by NCWSC or by water boozers and jerrycans by private distributors.

Water supplied from NCWSC is sold to vendors at water points who own storage tanks at designated spots. The tank owners pay tariffs at the rate of Kenya Shillings (Ksh.) 53/1000 m<sup>3</sup> directly to the NCWSC and in turn sell water to residents at the cost of Ksh. 5/20 L jerrycan translating to Ksh.1000 m<sup>-3</sup>. According to financial records from NCWSC in (2019b), the government has subsidized the cost of water from approximately Ksh. 1000 to around 400 KES/m<sup>3</sup> shillings for water kiosks.

Water supplied to households is charged at 53 shillings/1000 m<sup>3</sup> of water directly supplied from NCWSC.

Water supplied from NCWSC directly to households is owned by the company. 72% of residents receive water at most once a week citing frustrations due to the frequent shortages. As reported, this water is rationed and is opened late at night from 10 pm up to 5 am forcing residents to stay very late at night to tap water and store it in jerrycans and drums. These containers are also rarely cleaned with 22% of residents reporting that they

**Table 1.** Boreholes treatment practices.

Zone	Borehole name	Chlorinate water	Wash tank every month
1	Borehole 1	Yes	No
2	Borehole 2	Yes	No
3	Borehole 3	Yes	Yes
4	Borehole 4	No	Yes
5	Borehole 5	No	No
6	Borehole 6	No	No

never clean the containers while 60% of residents clean the containers at least once in every 3 months. As reported by Mabonga (2019) about 60% of residents spend up to Ksh. 2,000 every week to buy water from vendors who were not reliable, and the safety of their water is also questionable. This has in turn affected the health of residents with the number 3 reported condition at both Umoja and Mama Lucy hospitals being diarrheal and stomach infections due to deteriorating hygiene in the populous estate. The residents end up paying up to Ksh. 400 m standing charges to NCWSC every month but they were not receiving water.

Water supplied from boreholes to households through hand-driven carts with jerrycans or water bowsers is owned by private owners.

### Borehole ownership

All boreholes in Umoja Innercore neighbourhood are run by private individuals. Sentiments by residents indicated that the mushrooming of commercial boreholes across the city is a cause of frequent water shortages. Business people collude with officials at the NCWSC, resulting in rationing as they exploit residents desperate for the commodity. 60% of residents further noted that an owner who is not a resident of the estate can have up to 20 boreholes and they blame these cartels and other unscrupulous water vendors for colluding with officials from NCWSC who were deliberately creating the crisis in order to exploit residents for coordinating artificial scarcity (Mabonga, 2019). All residents reported that whenever there is a water shortage, there are always either water tanks or hand cart vendors ready to supply water to residents.

### Borehole water treatment

Water to be consumed by the households needs to meet the WHO and Kenyan standards of portability. In Umoja Innercore, households interviewed reported as shown in Table 1 that 67% of boreholes do not wash their tanks and 50% of boreholes do not chlorinate water before supplying citing high operating costs in chemicals and

labour to wash tanks.

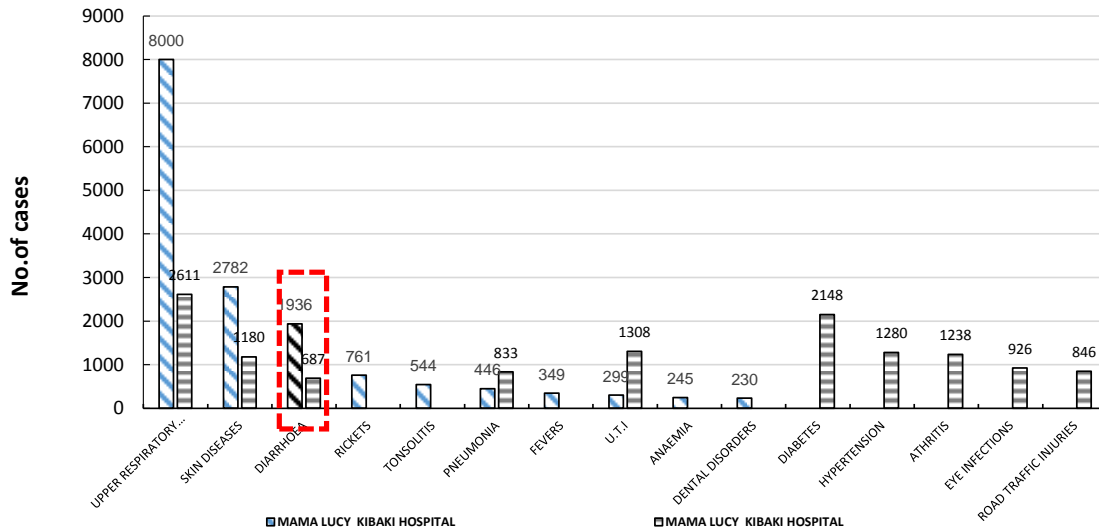
Of key note are boreholes 5 and 6 whose owners cited high operating costs that result from chlorinating and 6 that never chlorinate water nor wash tanks. The owners also reported that officials from NCWSC did not have a regular schedule of picking water samples for testing and quality monitoring. This results to supply of residents that is not tested for pathogens.

Borehole 3 owner chlorinates water and washes their tank every month since the water point is owned and run by a local church. The church adheres to strict monitoring by a committee set aside to run the church. They chlorinate their water every two weeks and take water to Umoja Health Center which is close by for constant testing for pathogens. Once a month, borehole 3 does not supply water the entire day since they dedicate a day to wash the tanks and test water.

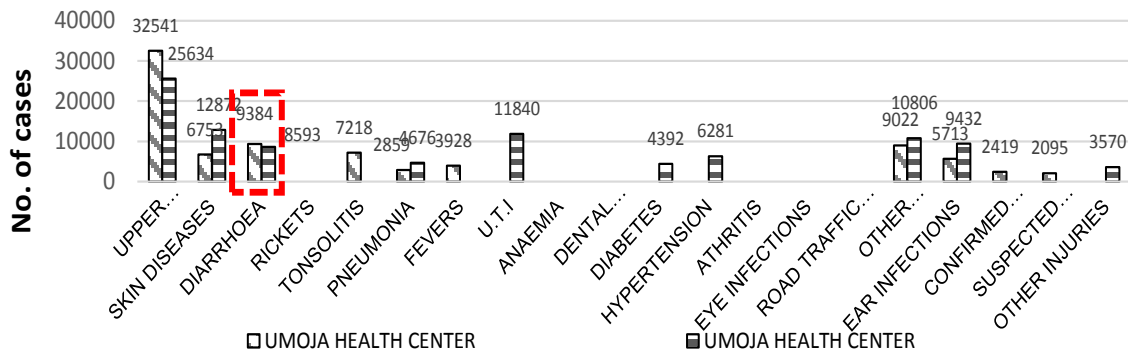
### Water quality management vs. health of residents

From data obtained as highlighted in Figures 5 and 6, the two main hospitals, Umoja Health Centre and Mama Lucy Hospital report that diarrheal cases are the third-highest condition affecting residents and is directly associated with water situation in the estate. Mama Lucy Hospital handled 1936 diarrheal cases while Umoja Health Center handled 9384 cases from July 2018 to March 2019. This accounts for the third-highest condition in terms of patient numbers. The lack of trust the water that is sold by the vendors due to dirty jerrycans is evidenced by health records and supported by health workers within the institution who attributed this to the poor quality of water within the estate often associated with poor quality water consumed within the estate and this water being a primary product in preparing food sold in food kiosks. The vendors who supply jerrycans are also not cleaned regularly with 20% vendors reporting to never cleaning their jerrycans. 50% of boreholes owners, vendors on hand pulled carts with jerrycans and water bowsers do not chlorinate water before supplying citing high operating costs in chemicals and labour to wash tanks and jerrycans.

From data obtained in Umoja health centers as shown in Figure 5, the second highest condition affecting



**Figure 5.** Top ten over five years' causes of outpatient morbidity July 2018-March 2019 in Mama Lucy Kibaki Hospital.



**Figure 6.** Top ten over five years' causes of outpatient morbidity July 2018-March 2019 in Umoja Health Center.

residents over 5 years in diarrheal diseases clustered to include cholera, typhoid and other water-borne diseases. Data from District Health Information System (DHIS) further shows that of the top ten over five years' causes of outpatient morbidity July 2018-March 2019 in Mama Lucy Hospital, diarrheal diseases in residents over 5 years old ranks number 3. This is attributed to the hygiene and sanitation standards that are directly affected by the quality of water supplied to the estate. Most of the water is of foul smell indicating possible contamination with sewer or faecal matter hence the possibility of contamination with *Escherichia coli*.

**Cost of water**

The cost of water in Umoja Innercore was regarded not to be regular especially for water supplied by private distributors who often hike tariffs based on demand after

creating artificial shortages. The cost of water paid by the respondent's ranges from is Kenyan Shilling (ksh) 20/20 L jerrycan to Ksh.50 during scarce periods. This translates to an average of Ksh. 200 shillings a day and Ksh. 350 a day during scarce periods since most households uses about 150 L per day for a standard household having 5 people. As shown in Figure 7, this translates to Ksh. 4000 per month during constant supply and Ksh. 10,500 per month during scarce periods. Residents getting supply through NCWSC pay a standard rate of Ksh.53 m<sup>-3</sup> of water with a maximum of Ksh.2,500 per month and a mean payment is Ksh. 812. This payment is received by the agents employed by owners to directly manage the boreholes.

**Household water management practices**

Transport from source to household, 60% of residents



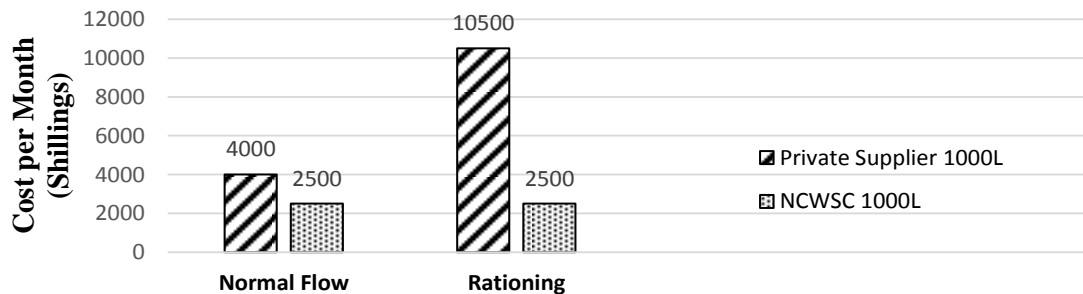


Figure 7. Cost of water by various suppliers.



Plate 1. Water bowser for transport.

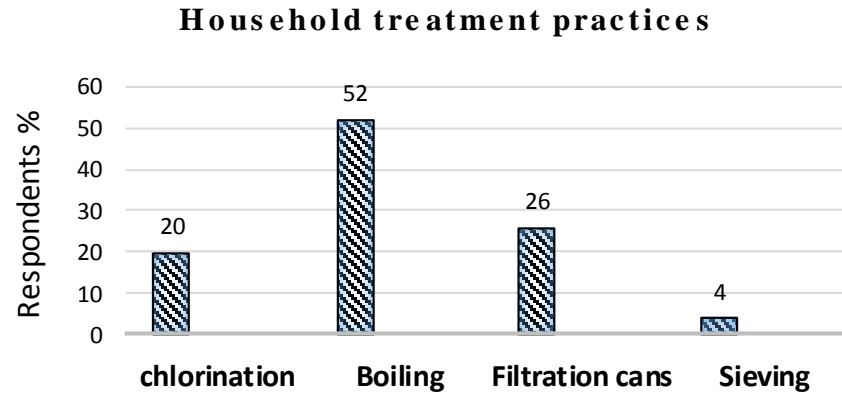


Plate 2. Water carts drawing water using jerrycans.

source water directly from boreholes. This water is supplied by two main means. Through carts that transport it from source to household using jerrycans from and through water bowzers that pump it to overhead tanks in apartments as shown in Plates 1 and 2. These two sources from boreholes directly to household and also

pump to underground and overhead storage tanks in the apartments for use by residents.

Sixty seven percentage of these commercial boreholes are drilled without the county's approval resulting to boreholes drilled in road reserves, along pipes of the Nairobi city and very close to septic tanks which are not



**Figure 8.** Home water treatment options.



**Plate 3.** Filtration can in a household.

lined with impermeable layer, hence water is not tested regularly before supplying making it unfit for human consumption. Jerrycans and bowsers are also never cleaned regularly creating room for bacterial contamination during transport of water from the source of household.

Household water treatment as indicated in Figure 8, out of the 89% of residents who treat the water from taps before consuming it, 52% boil water, 20% use filtration cans as shown in Plate 1, 26% further chlorinate the water and 3% strain water through clothes. Respondents prove that there is a lack of trust when the quality of the then water sources they consume from by using alternative treatment options like a filtration can as shown in Plate 3. While residents who directly receive water from NSWSC spend up to 2500 shillings per month, those receiving from private supply spend up to 300 shillings per month in buying chlorine to treat the water incurring additional costs beyond the normal 4000 shillings on average per month.

### Mode of storing water in households

The bigger the storage equipment the more water stored. From Plates 4 and 5, 20-L jerrycans are preferred since they are cheaper than tanks and can be easily carried to and from water points. However, as shown in Figure 9, residents store water in these cans which are rarely clean on their inside leading to a possible contamination. About 84% of the respondents indicated that they store the water from taps when it is pumped since the supply is not constant through the week. About 64% store water in 20-L plastic jerrycans, 20% use 200-L drums while 16% store the water in open buckets. This is further evident from results in Figure 10 that shows that upto 70% of respondents clean their storage equipment every 3 months and about 20% never clean the equipment.



**Plate 3.** A 20 L water storage jerry can without cover.

## Network management practices

### *Ownership and supply of water*

The study revealed that all water through the network is owned by NCWSC. The company is mandated to provide clean water and sewerage services to the residents of Nairobi County, in a financially sustainable manner and within the government regulations (NCWSC, 2019a). The county government does not have the express authority to control the approval process of new boreholes. The approval to dig a borehole is granted by Water Resources Management Authority (WARMA) and National Environment Management Authority (NEMA), both which only ask for ownership documents such as the Land Reference (LR) number and title deed for the location. The county is only involved in the approval process by issuing the 'no objection' document after approvals by WARMA and NEMA (Omulo, 2019). The county cannot fully control the mushrooming of commercial boreholes as it currently does not have the mandate to regulate the digging of boreholes since these roles have been allocated to WARMA and NEMA.



**Plate 4.** Dirty storage container.

Therefore, since WARMA do not communicate their findings to the county for monitoring and compliance of the approved boreholes, there is a gap and cartels seize the opportunity to supply water that does not meet the required public health standards as defined by the County Health docket.

### *Payment of water bills*

The study revealed that only 29.0% of residents pay rates monthly to NCWSC. 80% of the residents reported to staying up very late into the waiting for water to be

supplied through the network for them to tap and store (Wahito, 2019). Missing the chance to store means a struggle throughout the week and buying from vendors. Residents get physical water bills or through short messaging service notification (SMS) where these bills are paid monthly either by visiting the NCWSC offices and paying, by visiting a bank and depositing the payment or by paying via M-pesa, a mobile funds transfer system managed by a local telco. 94% of residents preferred to pay the water bills through M-pesa since it is faster, convenient and does not require queuing at the bank or a physical visit to NCWSC offices. The other 4% preferred a physical visit since they do not fully trust the system of payment wanting to be issued an actual receipt while only 2% visit NCWSC and only to question during disconnections as shown in Figure 10.

Borehole water is paid on the spot in cash or via M-pesa depending on the amount purchased. This money is paid to agents employed by the borehole owners to sell the water on their behalf. Residents prefer using the cash since they can easily track their daily expenditure.

However, this method is a more expensive method since they end up spending more since the cost is determined by the borehole owners.

Vendors fetch water on behalf of residents and transport in jerrycans through hand driven carts to resident's households. 85% of residents who use non-network water prefer vendors because the residents are not physically involved in carrying the water. Vendors transport the water directly to their houses and pour it into jerrycans and tanks for storage. They charge between 20 shillings during normal periods and up to 50 shillings during scarce periods per jerrycan.

Residents getting supply from tankers do not pay water directly to the tankers. The landlords purchase the water in bulk and it gets pumped to overhead storage tanks in the apartments. They then distribute to every household in a metered manner where they charge between 150 and 200 shillings/unit of water equaling 1000 m<sup>3</sup>. Whereas NCWSC supplies a unit for 53 shillings, the landlords charge up to 200 shillings clearly charging up to 4 times the cost by NCWSC. Failure to pay leads to disconnection for the resident.

### *Rationing, repairs and shortages*

As shown in Figure 11, 24.5% of residents indicated that the water was supplied on once a week on Sunday while 35.3% receive it on Wednesdays only or up to Thursday very early in the morning. Their respondents stay very late into the night on these days waiting for the water which they store as much of it as possible to cater for the rest of the week. 22.5% indicated that it was supplied 4 to 5 days a week while 17.6% indicated that it was supplied the whole day continuously.

The study revealed that 48.24% of the respondents channel their complaint to NCWSC through a phone call,

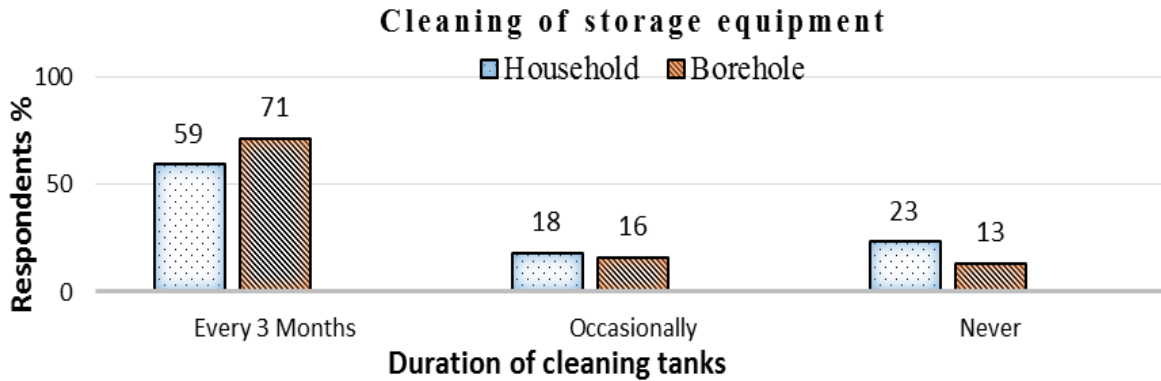


Figure 9. Cleaning of storage equipment.

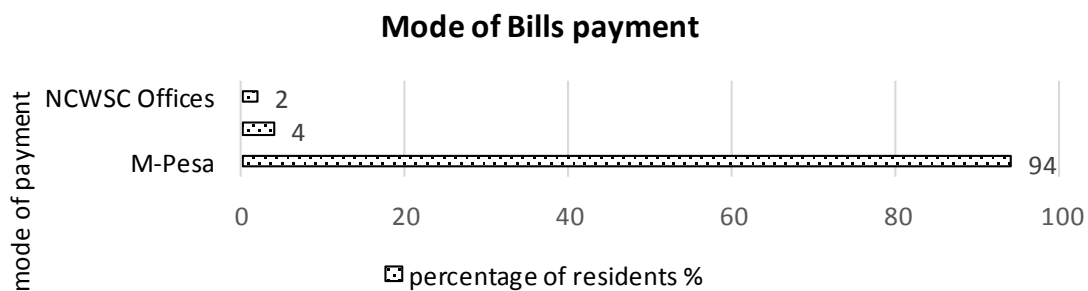


Figure 10. Mode of payment of bills.



Figure 11. Umoja Innercore weekly water supply frequency.

9.5% channel through letters, 36.26% through physical communication, 4.3% through E-mail and 1.7% through complement form as shown in Figure 12. The study also revealed that 34.3% of the respondents indicate that the requests are responded to immediately, 14.7% are responded to after a day, 23.5% are responded in 2 to 3 days, 20.6% more than a week and 6.9% are never responded to.

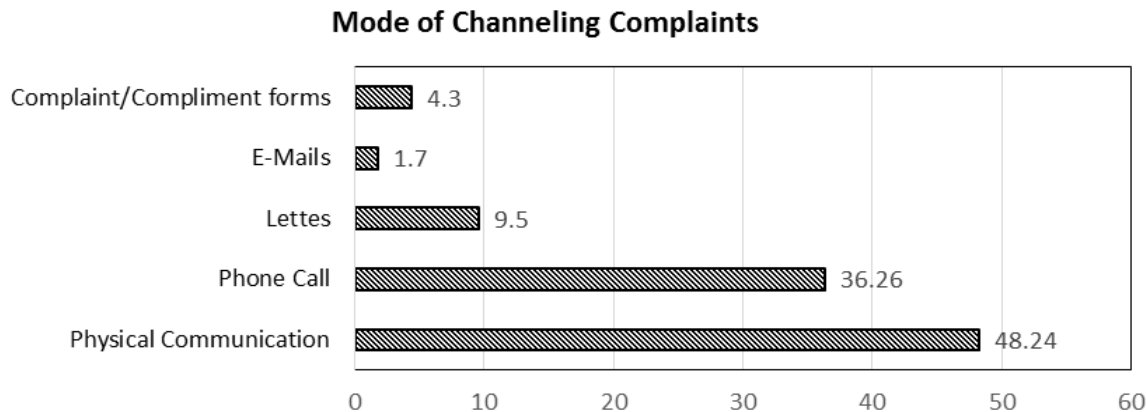
**DISCUSSION**

This study found out that the county lacks a clear role in the drilling of the water sources and that the buck stops

with the national government, through agencies such as the WARMA and NEMA. Approval to dig a borehole is granted by WARMA and NEMA, which ask for ownership documents such as the land registration number and title deed for the location. The work of the county is only to give the 'no objection' document after approvals by WARMA and NEMA do not communicate their findings to the county so that the county can take responsibility.

**Capacity of community to distribute water**

This study also found out that the capacity and resources of private borehole distributors is often relatively weak,



**Figure 12.** Mode of channeling complaints.

and therefore capacity development is required to help them to strengthen their operational skills and increase their production levels to reduce the existing shortage. This will help in ensuring more production volumes of high quality. As further explained in a report by WASREB (2008), the key issue for the success of the private distributors is to ensure financial viability by setting appropriate tariffs and regulating the amount and usage of the fees collected. Viable water tariffs tend to be relatively high, particularly private boreholes, which poses a challenge for households who use of alternative, unsafe sources of water supply. Options to achieve cost recovery while keeping tariffs affordable include professionalizing service management, selecting appropriate technologies, grouping individual schemes, and targeting subsidies. This agrees with King (2008), in his study that small operators may need access to investment and credit facilities to help them develop their operations and ensure sustainability. Capacity development in terms of build-and-operate contracts will create incentives for the operators to manage construction and operation effectively and efficiently. Private boreholes owners hence strengthen their operational skills and increase their production levels to reduce the existing shortage. This will help in ensuring more production volumes of high quality. Aggregating the operating costs across the system ensures commercial viability, scalability and a reduction in marginal costs of new installations. Water technicians will be much more cost-effective servicing several locations rather than one. "Scaling across" provides the economies of scale and volume needed to make the business model work.

### **Cartels' problem in distribution**

These study findings reveal a lack of formalization of the water sector and control of the system by cartels who occasionally create artificial shortages to increase the cost of water up. Omulo (2019) in his article in a local

daily report that the county government of Nairobi city lacks a clear role in the drilling of the water sources and that the buck stops with the national government, through agencies such as WARMA and NEMA. An audit of all boreholes in the estate needs to be carried out to stop the use of those drilled in road reserves and along pipes of the NCWSC. The mushrooming of commercial boreholes across the city is blamed for water shortages. Business people collude with officials at the NCWSC, resulting in rationing as they make a killing off residents desperate for the commodity (Omulo, 2019).

### **Formalization of water distribution**

The study found that the boreholes within Umoja are not formally registered and regulated by the County Government of Nairobi (CGN). Advani et al. (2011) advocate for a formalization of the water sector to ensure that the community-driven development approach to break the bureaucracy that in the past has delayed and blocked the flow of assistance to communities. The CGN discourages the drilling of commercial boreholes where there are Nairobi water pipes (Omulo, 2019). Approval to dig a borehole is granted by WARMA and NEMA, which ask for ownership documents such as the LR number and title deed for the location. The county only gives the 'no objection' document after approvals by WARMA and NEMA yet WARMA do not communicate their findings to the county for monitoring (Omulo, 2019). The fluoride levels in the boreholes are very high at over 15 mm/L against the required 0.5 mm/L for most boreholes meaning the water is of poor quality, hence bad for human consumption.

The study found out that the county cannot fully control the mushrooming of commercial boreholes as it currently does not have the mandate to regulate the digging of boreholes since these roles have been allocated to WARMA and NEMA. The report by Omulo (2019) further elucidates that only 20 commercial boreholes have been

approved by the county government since Finance Bill (2018) was signed into law. WARMA is in control as it grants approvals as mandated under Water Act, 2016, he also noted. Water experts can object but experts such as road and urban planners will approve, making it hard to control the proliferation of these boreholes. There is a need of harmonization of duplicated roles to have a centralized point of approval. Bodies such as KENHA, KURA, WARMA and NEMA should work hand in hand with CGN and NCWSC to ensure there is one point of approval of all the boreholes before drilling. Their roles to be streamlined to avoid conflict an unnecessary conflict of roles and bureaucracies in seeking water service. Structure water deals to include all value and avoid conflicts of interest, all local suppliers to be from registered companies and get tenders through the contract from one government body in case of new connections, tariffs payment or repairs. This will allow more people to be part of the supply chain, ensure sufficient accountability, and remove a monopoly of supply and cartels hence being able to easily control quality. Formalization of the water sector will ensure that there is a community-driven development approach to break the bureaucracy that in the past has delayed and blocked the flow of assistance to residents.

### Quasi-delegated framework

From the study, a high comparative cost of people gets their supply from jerricans compared to network. This clearly depicts a lack of control of private distributors who charge high costs of up to Ksh. 30/20 L jerry can as compared to NCSWC costs. Ownership records from NCWSC web page (2019b) state that NCWSC currently owns all water supplied through the network. There is a need of a co-sharing partnership with private borehole owners leading to a Quasi-delegated framework on payment models and reduced cost per tariffs from the current Ksh 53.00 m<sup>-3</sup> to between Ksh. 35 and Ksh. 50 of delegated management contracts of this type to address the frequent shortages. Under the new tariff structure which was introduced in 2015, consumers, who earlier enjoyed subsidized rates under the old pricing structure, will now pay market rate. This group lumped together with low-income earners to enjoy the subsidy will now see their bills rise by 93%. Low-income earners who consume 6 m<sup>3</sup> of water and below will still enjoy by regularizing and reducing monthly payments of bills since current residents pay up to Ksh. 50 per jerry can of 20 L. The unregulated payment of bills clearly shows that NCWSC which is mandated to distribute, bill and regulate quality is not effective in sealing these loopholes. Residents are forced to pay more for less quantity and poor quality due to cartels that have identified loopholes and utilized them at the expense of residents. It is therefore easy to track the spending of water and pay

bills monthly when the water is networked as compared to buying through jerricans.

### Conclusion

The study highlights that drinking water leaving the treatment works is of good quality and meeting the standards at 99% purity levels. Water reaching the residents of Umoja Innercore and by NCWSC is less contaminated. However, drinking water being supplied to the residents of Umoja Innercore and by various private distributors is highly contaminated. NCWSC which is responsible for the supply of safe drinking water to Nairobi residents, should be stringent towards safe distribution from storage point to the receiving end through the use of non-corrosive pipelines, replace broken pipelines and plug leakages of sewage pipes for the safe delivery. Shallow boreholes are dug close to septic tanks which are not lined with impermeable materials to prevent contamination of raw water and groundwater. Drinking water sources should be tested regularly to determine its microbiological quality to prevent outbreak of enteric diseases. Residents should be educated about the spread of water-borne diseases and their control measures.

A quasi-delegated framework of water distribution within Umoja Innercore is therefore preferred to regulate the private distributors and eliminate cartels while giving them some control over the commodity by incorporating them into the network. The bulk storage within Umoja open spaces will provide a room for water from NCWSC to be stored. Piping to be done from the existing boreholes within Umoja Innercore to ensure they supply clean drinking water to the boreholes and the owners to be paid monthly by NCWSC based on the amount they supply to the bulk storage hence preventing direct contact with residents. New borehole drilling to be managed by the quasi-delegated management company to ensure strict adherence to health and sanitation standards before issuing any approval to the NCWSC for approval of new boreholes. These standards to outline minimum distance to septic tanks, to give recommendations on septic tanks construction within the estate. They will also collect samples for water testing and monitoring every week by NCWSC for bacterial, chemical and physical contamination. Open spaces could serve as a spot for a large underground tank. Water supplied to the bulk storage is to be of higher chlorine and other chemicals concentration to dilute the water from the boreholes hence maintaining the quality. These ratios are to be determined by WASREB in conjunction with NSWSC experts who deal with quality issues. Distribution lines are then to be re-laid to the various courts to serve the current population from the bulk storage by NCWSC. Residents' payment of water bills is to be monthly to the NSCWC with regular maintenance of

distribution network and regular testing of water at the bulk storage done by engineers and experts from NCWSC. NCWSC will further pay private distributors for monthly supplies. Smart water monitoring on distribution lines from bulk storage with flow monitors is needed to avoid diversion since the pressure can be monitored continuously along the distribution lines. Introduction of leakage detection system on distribution lines is needed for early detection reducing contamination of clean water supplied from sewer and dirt. The smart sensors will regularize and track the spending of water and mode of payment of bills payed when the water is networked as compared to buying through jerrycans. This quasi-delegated system will therefore formalize and regulate Umoja Innercore, a decentralized and partly delegated water management structure of water by locals but regulated by NCWSC.

## CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

## ACKNOWLEDGEMENTS

The authors are grateful for the invaluable support of JKUAT for giving a fee waiver to carry out this study and staff members from the Department of Architecture, Center for Urban Studies (CUST) and Medical Microbiology (JKUAT) who allowed them to work in their laboratories. Gratitude is also due to the Public Health officers, NCWSC staff, water production manager and staff at Ng'ethu treatment works and residents of Umoja Innercore who sacrificed their time to participate in this study and whose contribution has made it possible.

## REFERENCES

- Advani RK, Baskovich MR, Birner S, Boyer AAC, Davies W, Draz M, Kleemeier EL (2011). Bringing water to where it is needed most: innovative private sector participation in water and sanitation (No. 63791). The World Bank pp. 1-76.
- Atanda BO (2014). Evaluating Housing Development Characteristics in Eastlands area; A Case of Umoja Innercore Estate, Nairobi (Issue May). University of Nairobi.
- Bakker K, Kooy M, Shofiani NE, Martijn EJ (2008). Governance Failure: Rethinking the Institutional Dimensions of Urban Water Supply to Poor Households. *World Development* 36(10):1891-1915.
- Connor R (2015). Water for a sustainable world. In United Nations World Water Development Report. [https://doi.org/ISBN\\_978-92-3-100071-3](https://doi.org/ISBN_978-92-3-100071-3)
- Gilbert JA (2012). Practical Design of Water Distribution Systems (Vol. 182). [www.PDHcenter.com](http://www.PDHcenter.com)
- Kimuyu H (2005). Taps run dry in Umoja, Tena estates. <https://nairobineews.nation.co.ke/news/taps-run-dry-in-umoja-tena-estates>
- King ML (2008). Business models for delegated management of local water services: experience from Naivasha (Kenya). In Pain.
- Ledant M (2013). Water in Nairobi: Unveiling inequalities and its causes L'accès à l'eau à Nairobi : des inégalités socio-économiques et spatiales. *Les Cahiers d'Outre-Mer* 66(263):335-348. <https://doi.org/10.4000/com.6951>
- Mabonga M (2019). Nairobi: Acute water shortage hits Umoja 2, residents blame cartels for coordinating artificial scarcity. *Daily Nation*.
- Munala GK (2009). A Viable Pro-poor Public-Private Partnership Management Model for Water Supply Services. Verlag der Technischen Universität Graz. <http://dnb.ddb.de>
- Nairobi City Water and Sewerage Company (NCWSC) (2019a). Nairobi City Water and Sewerage Company. Regular tariff adjustment in athi water services board (AWSB) AREA. <https://www.nairobiwater.co.ke/index.php/en/watertariffs>
- Nairobi City Water and Sewerage Company (NCWSC) (2019b). *Thika Dam*. <https://www.nairobiwater.co.ke/index.php/en/services-nwc/our-sources/thika-dam>
- Nairobi City Water and Sewerage Company (NCWSC) (2014). Nairobi City Water and Sewerage Company Limited Strategic plan 2014/15 – 2018/19. [https://www.nairobiwater.co.ke/images/strategic\\_plan/NCWSC\\_2014-15\\_to\\_2018-19\\_Strategic\\_Plan.pdf](https://www.nairobiwater.co.ke/images/strategic_plan/NCWSC_2014-15_to_2018-19_Strategic_Plan.pdf)
- Okeyo JO (2011). Public Private Partnerships in the Privatization of Water Service Delivery in Kenya. In: D. U. Uhlig (Ed.), *Current Issues of Water Management* (pp. 207-231). InTech. <https://doi.org/10.5772/27996>
- Omulo C (2019). Nairobi MCAs want illegal boreholes closed, drilling controlled. *The Sunday Nation*. <https://www.nation.co.ke/counties/nairobi/City-MCAs-want-illegal-boreholes-closed/1954174-5177352-wtwcr7z/index.html>
- Orwa J, Karimi S (2008). Water Services Trust Fund UPC Mission Report, Kisumu (Issue June).
- United Nations Environment Programme (UNEP) (2007). Chapter 5 : Nairobi and its Environment (C. S. Jane Barr (ed.) pp. 145-160).
- United Nations (2019). Goal 6: Ensure access to water and sanitation for all. <https://www.un.org/sustainabledevelopment/water-and-sanitation/>
- Unver O (2015). Water and agriculture for sustainable development. In "Water and Sustainable Development", *Water Monographies: Water for Life 2005-2015 (Vol. 3)*.
- Wahito K (2019). Nairobians grapple with water shortage as rains flood streets. *Daily Nation*.
- WASREB (2008). Guidelines on Drinking Water Quality & Effluent Monitoring (Issue March). Water Services Regulatory Board.
- World Bank (1996). Kenya Impact Evaluation Report Development of Housing, Water Supply and Sanitation in Nairobi (Issue 15586).