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# Water Access Today and Tomorrow: Domestic Water Sustainability under Informal Water Supply Markets in Dar es Salaam, Tanzania

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**Abstract**

The article examined domestic water access sustainability under informally driven water supply market, drawing on suppliers-consumers' perspectives. Analysis was done on the capacities of the informal water suppliers for sustainable water provision, how the informal water markets operate, and clients' perspectives of water access today and tomorrow. Four different data set were comparatively analyzed from interviews with the Municipal Water Engineer (MWE), Ward Health Officer (WHO), 3 *Mtaa* leaders from 3 informal settlements, interviews with 43 informal water sellers from three informal settlements, including a survey of *(n = 292*) clients in three informal settlements. It was realized that though informal water suppliers are sociocultural capable of providing flexible and gender-sensitive water supply services, households have unsustainable access to improved water due to the financial, hydro-technical, institutional and organizational in capacities of the informal water sellers coupled with the low financial abilities of low-income earning households to continuously purchase water for domestic activities. It was observed that informal settlements' dwellers are less likely to meet their water supply needs in the near future if their income status together with the financial, hydro-technical, organizational and institutional capacities of the informal water sellers are not improved.

**Keywords:** informal water markets, water sellers, water access, sustainability, informal settlements

## 1. Introduction

Sustainable access to water is well epitomized in both the past and recent global development agendas (UN, 2016). Access to improved water has reflected in both the Millennium Development Goal (MDGs) and the Sustainable Development Goal (SDGs). The recognition of access to water in development agendas demonstrates its universality to the human development agenda (Mehta, 2014). Yet, though the developed world is on a steady progress to achieving the targets of the SDG 6 (UN, 2016), a roadmap to realizing the SDG target 6.1 — universal and equitable access to safe and affordable water for everyone by 2030 in Sub-Saharan Africa—will require a collective effort from both the public and the informal water supply actors (UN, 2016). This is obvious because informal water markets drive the water economy in the global south due to states incapacity. Water sellers dominate in the urban water supply network serving more than half a proportion of the urban population (UNDP, 2011; WHO/UNICEF, 2015; Ahmad, 2017). Comparatively, informal settlements' dwellers are the most served by the informal water markets due to limited or no public water extension, the rising urban population, haphazard spatial development in the informal settlements, and fear of recovery public water supply cost due to the lack of legal rights of occupancy of the dwellers (Kyessi, 2011; Cain, 2018; Wutich et. al., 2016; Braimah et. al., 2017).

Informal settlement dwellers are most at risk of water poverty (Wutich et. al., 2016; Ahmad, 2017; Braimah et. al. 2017). A review of experiences further shown that access to improved water in the informal settlements is more challenging, in cities that experience erratic public water supply yet with predominantly geogenic water contaminants (i.e. high salinity and arsenic of water groundwater) (Rondi et. al. 2015). In such circumstance, the technologies used by water sellers are often less capable of improving and sustaining the quality of water produced (McGranahan et. al. 2016). The burden and cost of treating groundwater, are often transferred to the water consumers who are also in capable to bear the cost of water quality treatment (Nganyanyuka et. al. 2014; Dakyaga et. al., 2018). Most residents either cope by operating a dual or multi-purpose water access and storage systems (Dakyaga, 2017; Dakyaga et. al., 2018). Others devise local water treatment mechanisms for geogenic

contaminated water (Nganyanyuka et. al., 2014; Kombe et. al. 2015; McGranahan et. al. 2016), or cope by partially relying on other water supply system as alternative to fulfill their domestic water required needs (Nganyanyuka et. al., 2014; Wutich et. al., 2016; Kariuki and Schwarz, 2005; McGranahan et. al. 2006; Kjellén & McGranahan, 2006; UNDP, 2011; Baker, 2012; Wutich et. al., 2015).

Though, some scholarly works recounted the positive roles of water sellers; including their ability to ensure that the unserved urban population realise their human right, bridging the gap between urban water provisions and consumers requirements (Porter and Haller, 2010; Wutich et. al., 2016; Wutich et. al., 2016; Ahmad, 2017; Brown and Heller, 2017), and in serving population beyond the municipal water network (*See* Rooijen et. al. 2008; Wagah et. al. 2010; Kyessi, 2011; Mudege and Zulu, 2011; UNDP, 2011; Onyenechene and Osuji, 2012; Crow and Odaba, 2014; Kosoe and Osumanu, 2015; Ahmad, 2017; Peprah et. al. 2015; Youngstedt et. al. 2016; Dakyaga, 2017; Allan, 2018). The cost of their operations maybe more severe, given that, the population most served are the urban poor, who are also less capable to seeking alternatively improved water to fulfill domestic water needs (Dagdeviren & Robertson, 2016). It is more likely that, unsustainable access to improved water may predispose the urban poor with ill-health requiring more finances to sustain good health (Corburn and Karanja, 2014; Dakyaga, 2017). This is much paramount as the operations of these informal water markets are less regulated in terms of quality of water and pricing mechanisms (Braimah et. al., 2016; Dakyaga et. al., 2018).

The outbreak of cholera in many Sub-Saharan African cities had less influenced the involvement and operations of petty water selling (UN-Habitat, 2010; UNDP, 2011; Ahmad, 2017; Dakyaga et. al., 2018). Even when other categories of informal actors particularly squatters are cruelly handled through force evictions in cities, informal water sellers are treated with the human face, despite the strong relationship between water consumption and human health (WHO, 2011). Scholarly works on informal water supply have moved beyond eviction to the management of their operations (*See* Roy, 2005; Franceys, 2010; Marston, 2014). Informal water sellers are known to hold adequate local knowledge, innovations and more capable of responding to the water needs of clients they live with, in their day-to-day operations (Kyessi, 2005; McGranahan et. al. 2006; UNDP, 2011; Dagdeviren and Robertson, 2011; Nyanyanyuka et. al. 2014; Crow & Odaba, 2010; Ahmad, 2017; Allan, 2018).

Conversely, there is the need to draw suppliers and consumers' perspectives to re-look at the operations of informal water markets, the capacities of the informal water suppliers and clients' perspectives of domestic water access sustainability under the informal water supply markets. This is much required, given that, the global water agenda in contemporary times staked on ensuring availability and sustainable management of water for all (UN, 2016; Brown and Heller, 2017).

## 2. Theoretical Review: Informal Water Supply Markets and Water Access Sustainability in Sub-Saharan Africa

Despite the centrality of water to human development (Brown & Heller, 2017; UN et. al. 2010; UNHRC, 2013; Mehta, 2013), access to municipal water supply remain a major challenge in Sub-Saharan Africa (Braimah et. al. 2017). A bulk of the urban population of about 80% in Sub-Saharan Africa depends on the informal water supply markets for water supply. These markets exist side by side the formal water supply systems, as conventionally acceptable modes of domestic water supply (Dagdeviren & Robertson, 2011; Crow & Odaba, 2014; Ahmad, 2017; Braimah et. al., 2017). In reality, the proliferation of informal water markets has not only received academic gigantic but has also overthrown the strong argument against "water as a social good" in favor of "water as an economic good" (Bacho, 2002; Kjellén, 2006). Water is now a commodity of which sellers and buyers openly convoke in a spatial locality and build amendment of access eligibility. Though this might have justified the hypothesis of the freely functioning market system's theorist: where open market structures accommodate consumers preferences and choices (Layne, 2001; Harvey, 2005; Prasad, 2007); and where free entry and exit in the water market is perceived as a remedy to high cost of water and water supply quality improvement (Solo, 1999). In reality, the challenges may be mega than desire, given the socioeconomic conditions of the urban population served by these water markets (Crow & Odaba, 2010; Porter, 2011; EU, 2015 WHO, 2011; Marx et. al. 2013; UN-Habitat, 2015). Most of which are the urban poor living in predominately poor building structures, overcrowding, unhealthy or hazardous environment, amidst widespread poverty and exclusion (WHO, 2011; Marx et. al., 2013; EU, 2015; UN-Habitat, 2016; Corburn & Severdlik, 2017).

Under the informal water supply markets, daily commuting for water from water sellers is now a grown convention in urban Sub-Saharan Africa. In Nigeria, it is estimated that only 5% -10% of the megacity's population is served by the public water supply system and the remaining population commute to purchase water from informal water markets (Brown and Heller, 2017). In Tanzania, Kenya, Niger, Angola, women, and children travel to purchase water from water vendors who buy, store in over-head tanks and sell through

standpipes (Crow and Odaba, 2014; Ahmad, 2017; Cain, 2018). The effects are enormous and may manifest in both financial and non-financial cost; including reduction in productivity as active workers leave offices in search of water (Bacho, 2002). How domestic water supply is sustained through the informal water supply markets is the major issue of concern (See Table 1).

This article focuses on the commercial pushcart carts, mechanized borehole, tanker trucks, water kiosks, private taps to wells water markets. In literature, they are either termed "independent water actors" (Van Dijk, 2008), small-scale private water services providers (Wutich et. al. 2016; UNDP; 2011; Dakyaga, 2017), water vendors (Kjellén & McGranahan, 2006; Crow & Odaba, 2010; Wutich et. al. 2016; Ahmad, 2017) and Small-scale entrepreneurs (Solo, 1999; Mkanga & Materu, 2006; Wutich el. al, 2016).

Table 1. Elements for domestic water supply sustainability

| *Authors* | *Indicators of sustainable water supply* |
|---|---|
| *Rogers et al. 1998; UN et. al. 2010; Peprah et. al. 2011; Mimrose et. al. 2012; UNHRC, 2013; Giovannoni & Fabietti 2013; Kyessi & Ka'Bange, 2014; Rondi et. al. 2015; Brown & Heller, 2017.* | *Economic abilities;*<br>- Financial management<br>- Financing & cost recovery abilities<br>- Operations and maintenance of facilities<br>- Strong knowledge of the local economy served |
| *UN et. al. 2010; Mimrose et. al. 2012; UNHRC, 2013; Kyessi & Ka'Bange, 2014; Rondi et. al. 2015; Gonzales and Ajami, 2015* | *Socio-Technical abilities;*<br>- Human resources<br>- Sustain coordination<br>- Treatment of water for safe consumption<br>- Appropriate technologies<br>- Design and construction of facilities<br>- Operation and maintenance |
| *UN et. al. 2010; UNHRC, 2013; Kyessi & Ka'Bange, 2014; Rondi et. al. 2015; Wutich et. al., 2016; Crow & Odaba, 2010; Brown and Heller, 2017.* | *Organisational and Institutional abilities;*<br>- Acceptance of local institutions<br>- Strong partnership with other actors<br>- Unionized operation<br>- Collective interest and mutuality<br>- Legal and regulatory framework |
| *OHCHR, 2007; UN et. al. 2010; Water-Aid 2011; WHO, 2011; Mimrose et. al. 2012; Kyessi & Ka'Bange, 2014; Rondi et. al. 2015; Wutich et. al., 2016; Brown & Heller; 2017.* | *Socio-cultural abilities;*<br>- Knowledge of local culture<br>- Knowledge of local water supply needs<br>- Sensitivity of water services to gender, race, income groups and health<br>- Willingness to sustain operations |
| *UN et. al. 2010; WHO, 2011; Rondi et. al. 2015; Mimrose et. al, 2012; Giovannoni & Fabietti, 2013; Kyessi & Ka'Bange, 2014; Brown and Heller, 2017.* | *Environmental & Health management abilities;*<br>- Hydro-Technical knowledge (water quality regulations)<br>- Physically accessible<br>- Safe water production<br>- Safe water distribution<br>- Water supply sensitive to health |

Though informal water supply market is an old urban development phenomenon and has received abundant of

scholarly rhetoric (Kjellén & McGranahan, 2006; Wutich et. al., 2016; Ahmad, 2017), the complexities and spatiality surrounding their operations in Sub-Saharan Africa, make research on this phenomenon largely unexhaustive. Historical recounts of the evolution of informal water supply markets are inconsistent. Whilst some studies trace its origin to the World Bank's pronounced privatisation as a concept for good governance (Wutich et. al. 2016), others see it as a product of state incapacity in Sub-Saharan Africa (Crow & Odaba, 2014; Kombe et. al. 2015; Braimah et. al. 2017; Cain, 2018). Nevertheless, the usefulness of informal urban water markets has been severally commended in the literature (Solo, 1998; Kjellén & McGranahan, 2006; Wutich et. al. 2016). Major augments have been the flexible operation and the social capital that govern access to water in the informal water markets (Kyessi, 2011; Cain, 2017).

The contribution of this article is not limited to how these markets function, but also how their operations sustain supply for sustainable water access. From the conceptual perspective of sustainability, water supply and access sustainability are interlinked with several components (World Commission on Environment and Development, 1987; Rondi et al. 2015). Sustainable water supply exists where water supply market's services meet the current water supply needs of the served population with the possibility of meeting the needs of the future generations with less or no supply intermittency (WCED, 1987; Rondi et al. 2015).

The components of sustainability are highly related requiring equally set of interrelated actors for sustain water supply (WCED, 1987; Katz et. al., 2004). Key factors such as mutuality, interdependence, cooperation, resourcefulness and interest among the water sellers are relevant for domestic water access sustainability (Katz et. al., 2004; White and Harary, 2001). Other factors include, environmental, socio-cultural, technical, economic and organisational and institutional abilities of both the water sellers and clients (Rondi et. al. 2015; Giovannoni & Fabietti, 2013). This is crucial, particularly where the operations of water supply sellers are based on wholesaler and retailer relationship (Katz et. al., 2004). Cooperation may not only build assets and governance capacities (hydro-technical, socio-social, economic and environmental/health, organisation and institutional) (Mimrose et. al, 2012; Rogers et. al. 1998; Rondi et. al. 2015; Gonzales and Ajami, 2015; Brown and Heller, 2017) (See Table 1), but may contribute in sustaining water and building water access security and reliability in the informal settlements (See Table 1).

In sum, domestic water access sustainability depends on sustainable water supply, local economic conditions, water availability, spatial distance, the capacity of the water supply actors for quality water supply. The human rights particularly noted that lack of economic efficiency in water supply is a pathway to services retreat and a verge of burdening the poorest (UNHRC, 2013; Mehta, 2014; Brown and Heller, 2017), which implies that affordable water supply is a prerequisite for domestic water access sustainability (Rogers et. al., 1998; Giovannoni & Fabietti, 2013; Brown & Heller, 2017). Besides, direct involvement of clients in the planning of the water for the future is useful for negotiating prices of water for the present and in the future (WHO, 2011; Rondi et. al. 2015; OHCHR, 2007; WaterAid, 2011; Brown and Heller, 2017). In addition, water pricing intrinsically affects domestic water access sustainability and thwart the possibility of the urban poor to accessing improved water (Rogers et. al., 1998; Savenije and Van der Zaag, 2006; Hannemann, 2006; Echternacht, 2014). It is observed that, domestic water access sustainability is challenged, when water service provision is driven by the profit motive of the providers and (Brown and Heller, 2017; Hannemann, 2006; Brown and Heller, 2017). As such, water pricing mechanism must be based on the marginal cost to promote cost recovery, access equity, quality and sustain availability for continuous access (Rogers et. al. 1998).

## 3. Materials and Methods

### *3.1 Research Setting*

The city of Dar es Salaam, is one of the fastest growing cities in Sub-African Africa, ranked 3$^{rd}$ in Africa and 9$^{th}$ worldwide in terms of growth (Kombe et. al. 2015; McGranahan et. al. 2016). Its urbanization rate stands at 5.6%, with 76% of the settlements in the city being informal, possessing a challenge to safe and clean water access (Kombe et. al. 2015). Four major reservoirs serve as water sources for development and distribution by the formal water supply companies; the Lower Ruvu near Bagamoyo, Upper Ruvu near Mlandizi and Mtoni in the Temeke District and boreholes. The Lower Ruvu Scheme is the largest waterworks of the city of Dar es Salaam, commissioned in 1976. The treatment plant had a design capacity of 182,000m$^3$/day, and recent maintenance has increased the capacity to 270 m$^3$/day. Dar es Salaam Water Supply Company (DAWASCO), the Dar es Salaam Water Supply Agency (DAWASA) and Non-Governmental Organisations (NGOs) such as WaterAid, PLAN International are the formal water institutions managing and supplying water in Dar es Salaam (Kombe et. al. 2015; McGranahan et. al., 2016). Other efforts to improving urban water supply included the establishment of Community-Owned Water Supply Organizations (COWSO) for the management of mechanized

boreholes in peri-urban areas as partners for water supply (Kombe et. al. 2015; McGranahan et. al. 2016). The average water production capacity of the entire water supply system stands at about 569, 294$m^3$/day of 356, 355 domestic connections, water demand of 898,591 $m^3$/day respectively, with yet 44% of the households non-connected (GIZ, 2012). It is postulated that urban water poverty is likely to be worsen in major parts of Dar es Salaam, as population demand for safe and clean drinking water doubles the supply (McGranahan et. al., 2016). Though some informal settlements are connected to the municipal water supply network, water supply largely favor the formal settlements to the neglect of the low-income earners due to production limitations (McGranahan et. al., 2016; Mkanga & Materu, 2006). Even where metering connections exist in the informal settlements flow is erratic or completely not in existence. This has led to the evolution of the informal water sellers in the urban water supply network. Households rely on the Pushcarts, tanker trucks, water kiosks' operators, mechanized boreholes, private standpipes and Wells' water actors for water supply services.

### *3.2 Selection of Study Settlements*

Given the prevalence of informal water supply markets in Tanzania, a multi-stage sampling technique was used to ensure that all informal settlements had equal chance of been selected. Comparatively, the city of Dar es Salaam was purposively selected base on its rate of urbanization (5.6%) and widespread informal settlements (URT, 2014; Andreasen and Møller-Jensen, 2015). Rapid urbanization has a relationship with informal settlements development and informal water services provision in Sub-Saharan Africa (*See* Kombe et. al., 2015; Andreasen and Møller-Jensen, 2015; McGranahan et. al., 2016; UN-Habitat, 2016). The city of Dar es Salaam had five municipal councils.

Secondly, to ensure a fair representative of the five municipalities of the Dar es Salaam province (*Ubungo, Ilala, Temeke, Kigamboni* and *Kinondoni*), the settlements within each municipality were analysed and categorized according to their planning statuses, and the prevalence of informal water supply markets. Data was drawn from the 2012 Tanzania Bureau of statistics' report and the Town planners. A random sampling (lottery method) was used to select one municipality out of the five municipalities. Through random sampling, *Ubungo* Municipal council was selected as the study Municipality largely dominated by informal settlements, most served by informal urban water supply actors and less served by the public water supply agency (DAWASCO).

Thirdly, a fair representation of all wards within the selected municipality (*Ubungo)* was ensured by listing all the 14 wards within the municipal council. The listed wards were then categorized according to the prevalence of informal water supply sellers and the number of public water stand pipes. Again, a simple random sampling technique (lottery method) was used to select one ward out of the 14 sampled wards. Through the process, *Goba* ward was selected as the study ward comprising of eight (8) informal settlements. Considering the homogeneity in terms of water access experiences in the eight (8) informal settlements, three (3) out the eight (8) informal settlements were randomly selected for the study. The sample informal settlements are less served by the public water (DAWASCO) but most served by the informal water supply markets.

### *3.3 Data Collection and Analysis*

Previous studies on this phenomenon entirely made used of either case study, qualitative or ethnographic research strategy (Kjellén, 2006; Kjellén & McGranahan, 2006; Van Dijk, 2008; Kyessi, 2011; Crow & Odaba, 2014; Ahmad, 2017; Wutich et. al. 2016; Youngstedt, 2016). A review of these studies show that these strategies are useful for taping the experiences and insight of the clients served but limited to depicting the proportion of urban households served by each of the informal water markets (Crow & Odaba, 2014; Wutich et. al. 2016; Youngstedt, 2016). Drawing lessons from the above methodological approaches, this study used the mixed research method to investigate the functionality of informal water supply markets, the capacities of the sellers and clients' perspectives of water access today and tomorrow. The study draws largely on qualitative data with less quantitative insight to harness both insight on water access today and tomorrow. This strategy was useful for understanding the functionality of each informal water supply market and the proportions of urban households served. The data collection was staggered in three levels; the institutional level interviews targeted the Municipal Water Engineer (MWE), and the *Mtaa (*ward) leaders, the Community level interviews targeted the Informal Water Supply Actors (IWSAs), whilst the community level survey targeted households (clients). Whereas the activities of clients were flexible for them to participate in the survey, the activities of the informal water supply actors and officials of the public water actors could not permit them to engage in the survey but rather through structured interviews. Due to the lack of data on the number of informal water supply actors and their locations in the study areas, transect trip was done in July, 2017 using a motorbike for reconnaissance observation. The transect trip was led by *Mtaa* (Note 1) leaders of each of the informal settlements to ascertain the existing water markets and their locations in the various settlements. The snowballing/chain referral sampling process was used

to identify one water supply seller after the other (mechanized borehole actors, well water supply actors, the tanker truck water supply actors, water-kiosks water supply actors, private taps operators, pushcart water actors) in the various settlements. Being a non-native speaker of *Swahili* (Note 2), Town planners assisted in the data collection process, translation, transcriptions, and providing further information.

During the transect trip, the questionnaire and structured interview guides were pre-tested in one non-sample informal settlement (*Kinzudi)* in the study municipality. The responses obtained were evaluated and the instruments restructured to suit the targeted respondents. The survey instruments that targeted the households consisted of semi-structured questions of 30 items. Data were collected between July and December, 2017 with the assistance of 13 enumerators who were native speakers of *Swahili.* A structured interview guide was used to gather data from the informal water supply actors, the Municipal Water Engineer (MWE) and the *Mtaa* leaders (Ward leaders), questionnaires were self-administered to clients at their households' levels.

In overall, (*n = 292* households) clients 3 *Mtaa* leaders, Ward Health Officer (WHO), Municipal Water Engineer (MWE) and 43 Informal Water Supply Actors (IWSA) from the three randomly sample informal settlements (*Goba-kunguru, Goba-Chaurembo,* and *Goba-Kibululu*) constituted the study sample. In each settlement, random sampling technique was used to select households for the study. At the households' level, household's head, or persons aged 18 years and above, and directly involved in households' water access or financing were selected and interviewed. The study interviewed a representative sample of (*n = 292*) households out of 1078 households across the three selected informal settlements. The representative of this sample was justified using the Yemane (1967) mathematical formula for sample size determination. In order to cater for non-responses, a total of 300 households were surveyed. During the editing process, 6 instruments were observed uncompleted. The study considered 292 instruments for analysis and discarded the 8 instruments. The interviews targeted, Private tap water sellers (9), pushcart water sellers (3), mechanized borehole water sellers (9), water-kiosks sellers (15), tanker-trucks water sellers (6), well-water sellers (3), Ward-Health officer (1), the Municipal Water Engineer (1), and Ward leaders (3) were interviewed using the semi-structured interview guide.

Survey data collected were cleaned, edited for accuracy, entered into Statistical Package for Social Scientists (SPSS) version 20 and processed, whilst the qualitative data collected through audio recordings were transcribed, edited and grouped along the major themes. To ensure validity and reliability of the result obtained, the study collected data from multiple sources and built on methods of previous studies (*See* Kjellén, 2006; Ayalew et. al., 2014; Wutich et. al., 2016; Ahmad, 2017). The results are presented in Tables, figures and interpreted appropriately.

## 4. Results and Discussions

### *4.1 General Households' Characteristics of the Respondents*

The socioeconomic and demography characteristics of households studied in the informal settlements equally influence domestic water access sustainability. In the study area, 149 (51.0%) of the respondents studied were females followed by 143 (49.0%) of the males' in the informal water supply markets. All the clients studied had formal education, 55.5% of the clients had primary education, 23.3% had secondary education and 21.2% had tertiary level education. A highest proportion of the respondents 85 (29.1%) studied aged between (26-31) years (See Fig. 1). The highest category of respondents' households' size 117 (40.1%) ranges between 5 and 6 persons per household (See Fig. 1).

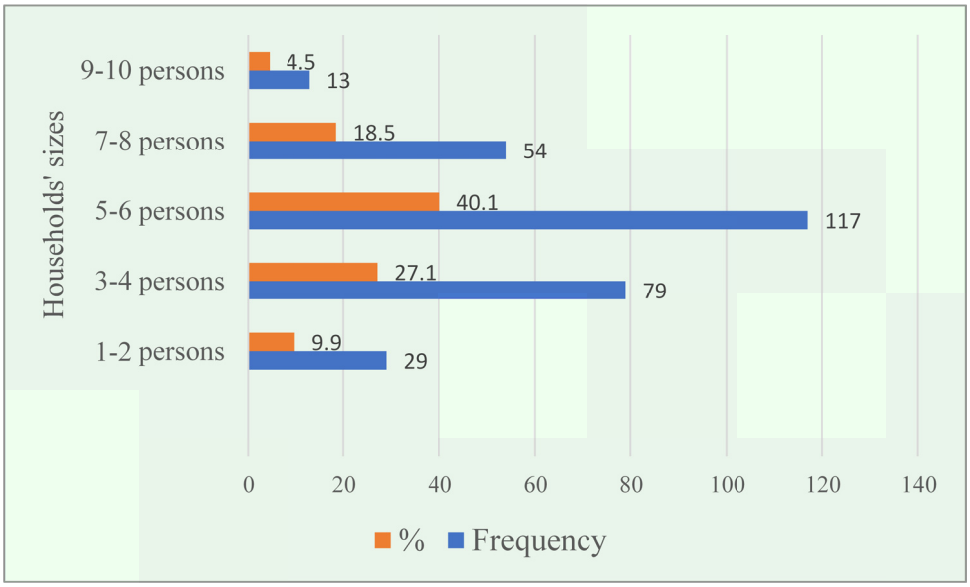


Figure 1. Households sizes of respondents

All the respondents studied earn income from varied occupational activities either from petty trading, government work, small/large business operations or into farming amongst others. However, most of the respondents studied were pretty traders. Of the (*n = 292*) households studied, 129 (44.2%) earn income from petty trading activities which showcase the predominant of low-income earners in the informal settlements. Petty traders equally have to purchase water daily, from their daily sales to satisfy their domestic water required needs. A few categories of clients 57 (19.5%) earn income from the small and large-scale business operation with only 49 (16.8%) being formal sector employers (government employees) (See Fig. 2).

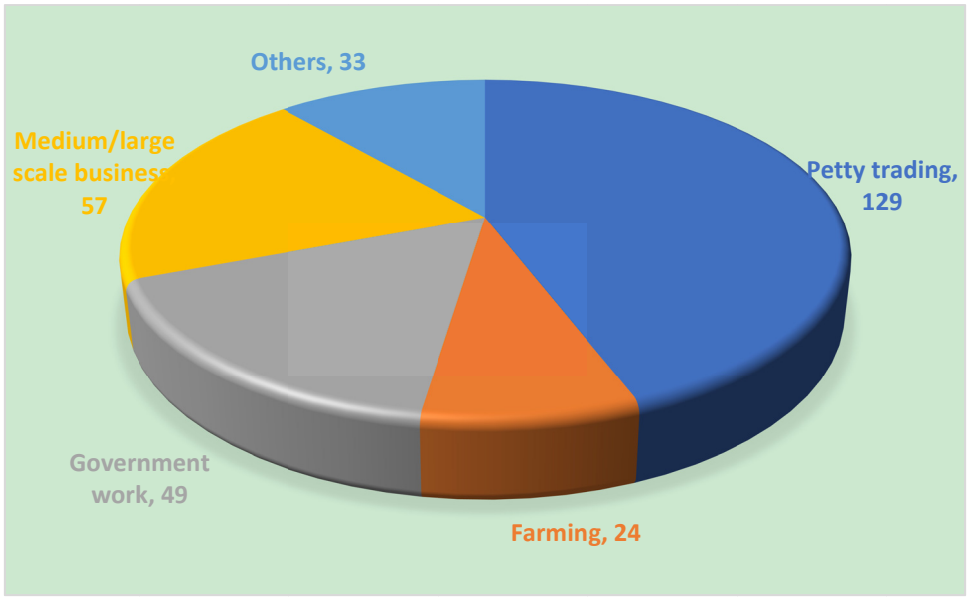


Figure 2. Income sources of respondents

The incomes obtained from the occupational activities of the clients can be classified into high, middle and low-income earning categories (See Table 2). About 154 (52.7%) of the clients studied earn an average of 109,999 TSZ or $ 48.48 per month classified as low-income earners, the middle-income earning groups comprised of 67 (22.9%) who earn an average of 399,999 TSZ or $ 176.29, while the few high-income households 71 (24.3%) earn an average of 3, 250,000 TSZ or $ 1432.35.

Table 2. Estimated average incomes of respondents

| ***Income classification*** | ***Average income (****TSZ or $)* | ***(n = 292)*** | ***%*** |
|---|---|---|---|
| High-income | 3,250,000 TSZ or $ 1432.35 per month | 71 | 24.3 |
| Middle-income | 399,999 TSZ or $ 176.29 per month | 67 | 22.9 |
| Low-income | 109,999 TSZ - $ 48.48 per month | 154 | 52.8 |
| Total | | 292 | 100 |

**Source:** Field Survey, 2017.

Invariably, the higher income earning households are persons employed and work in the public sector. Given the confidentiality associated with money and income earnings in the study area, this study reserve that the above income represents estimated incomes of respondents and might not reflect the exact incomes of all households in the study area (Table 2).

In addition, males dominate in the water supply markets in the informal settlements. The studied water sellers comprised of 29 males and 14 females, who aged between 22 and 56 years. Out of the 43 water sellers studied, 32 had formal basic education and the remaining 11 water sellers had no formal education.

*4.2 The Capacities of Informal Water Suppliers for Sustainable urban Water Supply*

In general, the synergy of the capacities of the various water sellers is useful for sustainable water supply in the informal settlements. Comparatively, mechanized borehole, protected wells, private taps and tanker trucks water sellers are more economically capable in sustaining domestic water supply compared to the other informal water sellers. Mechanized borehole water sellers invest an average of 20,567, 7000 TZS or $ 9000, private taps water sellers invest an average of 20,567, 7000 TZS or $ 9000, whilst protected wells water sellers invest an average of 19,431, 5000 TZS or $ 8,842.6 in the water production and supply. The average economic investment of Pushcarts, water kiosks was low (200,000 TZS or $ 87.52). Unlike the mechanized borehole and private taps water sellers, the water supply abilities of pushcarts and water kiosks was limited to their immediate neighbours due to less capacity to produce, finance supply, extend and sustain supply coverage. This can be deduced from the fact that these water sellers evolved not initially as commercial water suppliers, but rather as a system of self-help in Dar es Salaam in response to their own water needs. (Kyessi & Kjellén, 2006; Andreasen and Møller-Jensen, 2015).

Technically, informal water supply sellers were observed to devised local innovations, utilize a minimum level of technology and locally skilled plumbers to response to water needs of the urban poor through pipes extension.

However, these innovations are limited in improving and sustaining water quality. Mechanized borehole water owners employ between (1–5) persons for water supply services delivery in the informal settlements (*See* Table 3). Though not officially organized, water sellers are more mutual and cooperate with one another in the water supply network. The act of intimacy served as a major asset deriving the operations of informal water markets. Water sellers are responsive not only to the incapacities of one another; e.g. borrowing of generators for pumping of water, and petty lending, but only to their clients. Though sellers lack defined clients for water supply, they are more responsive to the water demands of clients of whom they have developed rapports even in seasons of erratic water supply.

Though this was observed as a significant institutional and organisational ability for sustaining domestic water access, sellers habitually develop rapports with clients who can frequently pay for the cost the water supply services. Though unionized system of operation was observed useful in Cochabamba (Bolivia) for streamlining prices and fosters collaborations with formal water institutions for water quality regulation and sustenance (Wutich et. al., 2016), informal water sellers expressed less interest in unions.

Table 3. Informal water supply actors and their capacities for sustainable water supply

| **Actors** | **Informal water supply and their capacities for sustainable water supply services delivery** | | | | |
|---|---|---|---|---|---|
| | *Technical & Technological abilities* | *Economic abilities (financially)* | *Social-cultural Abilities* | *Environmental & safe water supply abilities* | *Organizational & Institutional abilities* |
| *Mechanized borehole actors* | The use of generators or electricity to pump water, PVC pipes connected, and water distributed to households, Local plumbers-led extension of water for interested households. | Individual investor contract hydrologist, financed the drilling of water source and extension on average of 20,567, 7000 TZS or $ 9000, Recover cost through monthly billing & cash and carry. | Conversant with local norms and values, services are more flexible, limit water extension to households who can pay for cost of connection. | Disinfections of the water done during the drilling processes, actors lack disinfectants & reversed osmosis technology for geogenic contaminants. | No legal and regulatory framework guiding operations of actors. Exhibit self-interest, established partnerships but lack unionized organisations for operation, as self-help. |
| *Private Taps actors* | Actors hire local plumbers to develop and extend PVC pipelines to central points through standpipes for households' water collections. Purchased poly-tank for water storage & distribution. | Individuals financed cost of drilling of about 20,567, 7000 TZS or $ 9000 or lesser, recover cost through daily sale of the water, either through monthly billing and cash and carry system. | Adequate knowledge of local customs, water consumption needs, pays attention to different income groups, services are more flexible. | Disinfection of water during drilling of groundwater, no quality regulation of water hauled from DAWASCO for sale. | No legal and regulatory framework guiding operations. Exhibit self-interest, established partnerships with other actors, Lack of unionized organisation of operation. |
| *Pushcart Water actors* | The use of carts for easy transport of water to clients (6-10 jerry-cans of water). | Individual or households' investor financed cost of storage-cans, cart and operations of water, invest an average of 200,000 TZS or $ 87.52, Recover cost from sale of the water. | Familiarity with local customs, water needs and operate to meet their inabilities in more flexible manner, provides services at clients' door-steps, No room for credit purchase. | Water fetched from DAWASCO already of improved quality, Regular water handling results in water quality deterioration, (e.g. taste, odor, turbidity, & color). | No legal and regulatory framework guiding operations of actors. Actors exhibit self-interest with established partnerships, Lack of unionized operations and organisation. |
| *Well-Water actors* | The use of rubber or metallic galloons tide with robes for groundwater access. Construct concrete for protecting water source | Households finance the drilling and operation of about 19,431, 5000 TZS or $ 8,842.6 or lesser. Cost recover from sales of the water. | Actors are familiar with local customs, pay attention to different income groups, allows credit purchase. | No knowledge of water disinfection, ensures quality by washing gallons for frequent water access, annual deepening of the wells. | No legal and regulatory framework guiding operations. Actors exhibit self-interest and partnerships Lack of unionized operations and organisation. |
| *Water-kiosks Operators* | Store improved water accessed from public water agency in over-head, poly-tanks for sale, finance and construct platforms for water sales and distribution point. | Households or individual finance construction of over-head blocks, cost of 10,000 water liters storage containers, Cost recover from daily sales (cash & carry system). | Familiarity with local customs, water needs, operate to meet their inabilities in more flexible manner, allows credit purchase. | Water fetched from DAWASCO already of improved quality, poor storage in poly-tanks results in water quality deterioration, (tastes, turbidity, & color). | No legal and regulatory framework guiding operations of actors. Actors exhibit self-interest and partnerships. Lack of unionized operations and organisation. |
| *Tanker truck operators* | Water hauled and transported directly to clients' homes. | Finance as a group, individuals, organizations or families, operators purchased tanker trucks or hire trucks to operate | Familiarity with local customs, transport water directly to clients in more flexible manner, no credit. | Fetched water of improved quality, poor storage results in water quality deterioration, (tastes, turbidity, & color). | No legal and regulatory, framework, Actors either in unionized operations or non-unionized. Actors exhibit self-interest and partnerships |

Rather, informal water suppliers disclosed that a unionized operation will limit their operations and minimize returns from their operations due to the different sources in which they haul water for sale. Among all other

factors, the lack of registration, organization and hydro-technical abilities were observed not only as a weakness to water quality management but also a barrier in sourcing funding from formal credit institutions and expanding and sustaining supply coverage to other unserved urban communities. Informal water sellers are less capable in water quality treatment and management.

From the interview, a Water Kiosk operator shared her view; *"I buy water from the tankers for sale, who also hauls it from DAWASCO for sale, I know that the water is clean but I do not do any quality check after storing it in the poly-tank"* From the perspective of a client; *"There is no proof of water quality treatment before sales, all we know is that they are always willing to sell water as fast as you can pay"* With the exception of tanker truck operators, informal water sellers hold significant knowledge of local culture and water supply needs. Water sellers deliver water to persons in need but without immediate cash. They demonstrate willingness to sustain operations by regularly hauling and storing water in poly-tanks against seasons of water shortages.

In conclusion, no complete system of informal water supply capacities exists within the urban water supply landscape. Rather, the capacities of water sellers are dependent on the formal water supply infrastructure system, sellers utilised the technologies of the formal water infrastructure, such as electricity for water distribution in the urban fringes. They serve not only the needs of clients and but acts complementary actors to the formal urban water supply companies.

*4.3 Informal Water Market Operations and Domestic Water Access in the Informal Settlements*

*(a) Private tap water supply market: Water availability, supply and access*

Private tap water supply services constitute the second largest water supply market in the informal settlements of Dar es Salaam. They represent 9 (20%) of the informal water sellers studied. Water sellers purchase water from tanker trucks water operators or haul water from protected wells, store in poly-tanks and supply to households through the pipe system. Electricity of the formal water infrastructure or hired generators is either used to pump water to over-head poly-tanks for distribution when the system depends on groundwater (Ahler et. al., 2014). Domestic water access under the private taps water market is dependent on the frequent availability of either the tankers trucks or protected wells water. In term of managerial abilities, relatives are commonly employed for the day to day administration of the pipes. Each standpipe has a central control point where the water is locked with a padlock by the care-takers at the end of each day's operations. Few of the households rely on private-taps. Most of the households served are the middle and low-income earners, representing 26.4% of the studied sample. In terms of distances, 76% (222) of the sampled households surveyed get access to private taps water in less than 10 meters, the remaining 24% of the households get access to water above 10 meters distances. Clients walk to the central points and fetch water using buckets and jerrycans. Water is available for an average of 5 hours per day, virtually below the 24 hours duration for reliable water access. Except for water from the public water supply network (DAWASCO), water hauled from drilled boreholes and wells contains high level of salinity. As a result, the cost of a liter of water varies by the kind of water stored for sale, the water required activities and consumers' value for the water.


Figure 3. Private-standpipe operator water source; Photo by Dakyaga (2017) in Dar es Salaam

A 20 liter (*Jerry-can*) of water accessed from drilled boreholes/wells (hard water) was sold 200 TZS (Note 3) or $ 0.088, whilst the same 20 liters of water accessed from DAWASCO water (soft-water) by the private taps sellers was sold at 400 TZS or $ 0.18. Comparatively, a 20 liter of water was sold at 100 TZS or $ 0.044 by the public water supply company (DAWASCO), which implies that households served by private-tap water supply market spend an additional amount of 200 TZS or $ 0.088 per 20 liters of water purchased which is twice the cost of the public water supply company. Given that 52.8% of informal settlement dwellers fall within the low-income bracket, this cost challenge sustainable domestic water access in the informal settlements and interferes with regular households' water consumption needs (Fig. 3).

The operation of private-taps is sustained by the selling of the water to households. Traditional system of cash and carry lead the transaction processes for water access. Besides, water supply services are more flexible to local needs comparing to the Municipal water supply system. On occasion of lack of physical cash, households get access to water by basis of social relation; a contractual agreement, being friends or customers, which might be largely influenced by the African culture. The quality of the water supply was observed questionable (Ahmad, 2017), water sellers only wash the storage tanks on quarterly bases. As a result, 103 (35.3%) of the households perceived the water as acceptable in quality for drinking, 103 (35.3%) perceive it as moderate in quality for cooking, whilst 86 (29.4%) of households served by this water sellers perceived the quality as poor in general. Despite the perceived poor quality and salinity, water accessed from private-taps is basically used for cooking, washing, drinking and households' sanitation needs.

*(b) Pushcarts water supply market: Water availability, supply and access*

Pushcart water supply market has gained ground in major cities. The informality of this system of water supply is deduced from the lack of registration, regulatory and formal coordination. Though this system of water supply commonly exists in most cities of Africa, Asia and Latin America, (Kjellén and McGranahan, 2006; Crow & Odaba, 2010; Wutich et. al., 2015; Youngstedt et. al., 2016; Ahmad, 2017, Allan, 2018). There exist some spatial variations in the nature of operations and technology use. Whereas pushcarts were observed to utilize metallic pushed bicycles in Niamey (Niger) and Dala (Nigeria) for home water services delivery (Youngstedt et. al., 2016; Ahmad, 2017), in the case of Dar es Salaam and Nigeria, pushcart utilised a walking carts that accommodate fewer number of water containers (10-12 jerrycans). Pushcarts haul water commonly from municipal pipes and mechanized boreholes (Ahmad, 2011). Similarly, the usage of jerry-cans for water storage and supply dominate in the operations of pushcarts, as observed in Delhi, India (Kjellén and McGranahan, 2006), Niamey (Niger) (Youngstedt *et. al.* 2016) and Dar es Salaam (Tanzania). Pushcart water supply system constitutes the lowest urban water distribution network in Dar es Salaam. Pushcart water sellers supply represent 3 (6.7%) of the sample study. Arrangements for water supply was observed more flexible, less tedious and suitable to local norms and values. Whilst jerrycans (oil-containers) were observed to have been fading-off among pushcarts

operators in Niamey, (Niger) due to consumers' complaints of water quality deterioration (Youngstedt et. al., 2016), in Dar es Salaam, Jerrycans form the major water storage containers of pushcarts. Pushcarts water sellers introduced the innovation of mobility and the simple system of water supply involving the replacement of an empty jerrycan with a full jerrycan of water by clients.

Figure 4. Pushcart water supplier; Photo by Dakyaga, 2017, Dar es Salaam

Clients are required to provide an empty jerrycan equivalent to the jerrycan of water in which they want to purchase, or by simple transfer of the water purchased. In the informal settlements of Dar es Salaam, pushcart water supply complements the water supply services of other networks. Sellers carry 6-10 jerrycans of water on a small cart and push around the neighbourhoods (Kjellén and McGranahan, 2006; Ahmad, 2017) (*See* Fig. 4). However, the market segment is virtually low due to the quantity of water pushcarts carry per given time. This contrast the case of *Dala*, (Nigeria), where retail pushcarts dominate the informal water supply network (Ahmad, 2017). The volume of water they carry per given time, might be the reason for their less patronage. Within the study area, 43 (14.6%) of the households in the informal settlements were observed to have been habitually served by this water supply market.

Pushcart water supply is highly intermittent and largely influenced by the availability of water in the wholesales (DAWASCO, Water Kiosks, mechanized boreholes and tanker trucks). Given their mobile nature, 52.9% out of the 14.5% households were observed to have been habitually served water through home delivery, whilst the remaining 47.1% served outside their homes. Among the three categories of households studied, the low-income earning households are the most served 79 (51.4%), follow by 33 (48.6%) of the middle-income households in the informal settlements. However, none of the high-income earning households were served by pushcarts. (See Fig. 5). This was observed to be either shaped by the inability of the low and middle-income earning households to operate and sustain the *dual water access and storage system* (Note 4) as the high income earning households (Dakyaga, 2017). In terms of cost, pricing of a 20 liter of water (jerrycan) of water is determined by the level of scarcity of improved water, the value consumers accord to the water, the water required activities as well as the sources and distances from which a pushcart water seller fetches water from (Dakyaga et. al., 2018). A 20 liter (jerrycan) of water with high salinity (hard-water) was sold at 400 TZS or $ 0.18 and 500 TZS or $ 0.22 of the same liter (soft-water) when fetched from the public water source (DAWASCO) for sale. This also implies that low and middle-income households in the informal settlements served by pushcarts spend an additional amount of 400 TZS or $ 0.18 than their counterparts served directly by DAWASCO. Thus, four times the amount spent by population served by the public water supply network. Cost recovery for continuous operation was also based on the conventional cash and carry system. The quality of water supplied by pushcarts was observed as highly questionable and less acceptable in quality. According to the studied households, the frequent carrying of water in carts by the pushcart water sellers result in an increase in the temperature of the water particularly, in sunny

days.

*(c) Mechanized borehole water market: Water availability, supply and access*

Mechanized borehole water supply market was observed as the second most common commercialization of water in the informal settlements. It forms part of the Community-based water supply model (Kyessi, 2011). A collective group of people or households' respond to water access difficulty by contributing to provide water for themselves through drilling and subsequently extend to other neighbourhoods who are equally deprived of municipal water supply services. In Dar es Salaam, they represent 9 (20%) of the water supply sellers in the informal settlements. Though this system of water supply is equally observed in Ghana (Kosoe and Osumanu, 2015), the innovation for water supply differs. In Ghana, water supply extension is limited to the owner of the infrastructure. Households get access to water from external outlets at the owners' homes (Kosoe and Osumanu, 2015), whilst in Dar es Salaam, mechanized borehole water supply actors introduced the innovation of the municipal water supply system, where households are served running water at their various homes through the polymerizing vinyl chloride (PVC) pipes extension to subscribed households.

Figure 5. Means of transport of the Technicians for homes water extension; Photo by Dakyaga, Dar es Salaam, (2017)

All mechanized borehole water sources observed were registered and drilled to serve domestic water needs of the owners. Local demand for the water gradually shaped the conversion of what was registered as domestic water supply source to commercial water source. The operators of mechanized boreholes comprised of local technicians and plumbers who play the role of pipe networkers and layers from the main water distribution system to their clients' households. The actors build a tower, place poly-tanks and pump groundwater into the poly-tanks for daily water distribution using electricity. Water extension coverage is without distance but based on the financial abilities of clients to finance the cost of extension process.

Cost recovery mechanism was observed to take the form of the municipal water supply system, where serviced households make monthly payments for water consumed. Mechanized borehole water supply was observed to cater for the water needs of the different socio-economic groups. Considering that water extension is based on the ability of the clients to finance the cost of water connection, access to mechanized borehole water supply varies by income categories and largely favor the middle and high income earning households. About 38 (54%) of the high-income households were observed connected to the mechanized borehole water supply system due to their ability to finance the cost of extension and connection process, compared to 23 (34.5%) of the middle-income households, and as low as 11.5% of the low-income households in the informal settlements. Depending on the water consumption capacity of the household, a fixed levy between 35, 0000 TZS or $ 15.40

and 100,000 TZS or $ 44 is paid per month. Sustainable water access and consumption was observed to be challenged by power outages, high salinity of the water, information provision and cost recovery. Mechanized boreholes water supply services were observed more reliable as connected households get access to water for 24 hours of time/per day. About 151 (51.8%) of the studied households served by mechanized boreholes get access to water in less than 10 meters distance (home-connection) whilst the remaining non-connected households 141 (48.2%) have physical access in 100 meters and above, which is virtually within 200 meters distance. The management of the water system is either a reserve of a family member or a hired worker. However, when operated by a hired labour, a daily monetary account is rendered to the owner of the business. The charges serve as the funding sources for the continuous maintenance of the source water for water provision.

*(d) Tanker truck water market: Water availability, supply and access*

From the survey, the Tanker trucks water supply market was observed as the most patronized water supply market and serve the largest segment of the low, middle and high-income categories of households. In general, Tanker water sellers constitutes 6 (13.3%) of the water sellers studied. It comprised of unionized (registered tankers) and non-unionized (unregistered tankers) operators. Tankers serve 37 (52.1%) of the high-income households, 98 (65.7%) of the middle-income households and 27 (38.3%) of the low-income earning households. Clients switch from unionized to non-unionized tanker operators to fulfill their right to water access depending on water availability. Tankers play pivotal roles between the public water supply network and households that are beyond the water supply network. The connection between the unionized tanker truck operators, DAWASCO, and households is due to the following; the inability of the public water supply network to deliver pipe water services to households at the peripheral, the existing non-served households in which the utility has the mandate to serve (Gasson, 2017), network failures and seasonal pricing fluctuations as hindrance to public water services delivering, and the limitations of the utility network to meeting the water needs of all households within the network. Water supply services are available for an average of 10 hours per day throughout the year. Though water supply source is classified as an unimproved source (WHO, 2011; Gasson, 2017), 225 (76.2%) the surveyed households perceived it as an improved water source, based on the view that tankers haul water from the public water reservoirs. This corroborates with what Dakyaga et. al., (2018), described as divergent between consumers perspective of improved water and that of the global definition of improved and unimproved water. Invariably, people's location and their environmental conditions shape what they classify as improved and unimproved water supply source. The erratic public water supply services, coupled with the high salinity of water from private sources influenced consumers classification of tankers water as an improved water source.

Given the large segment of households served by the tankers, tankers experience longer queues at the public water reservoir in the course of water access. The longer queues compound the procedural and interactional processes for water access sustainability (Wutich et. al., 2016). From the perspectives of clients; *"...it depends on the line, and your call time that makes you get water from Tankers, right now it is still raining we don't suffer arranging for water because we depend on rain water, if you call the tanker trucks in this rainy season you easily and immediately get clean water, but in the dry season you have to arrange to buy clean water from tankers, the prices do not change but the arrangements normally change, instead of immediately, they will tell you if you want water tomorrow call today! how to get them and book their services to enable them to supply water to you is a problem, Kaka! (my brother) before you get clean water from the tanker trucks in the dry season, your order has to be there earlier before your name..."* Depending on the number of requests made within 10 hours period a day, a potential household is either supplied water in the afternoon when the arrangement is done in the morning, or in the evening when the arrangements are made in the afternoon. Households that make arrangements in the evening are supplied water in the following morning. The cost of the (liter) of tanker truck water also influence the demand water supply services. A 20 liter was observed to be sold at 130 TZS or $ 0.057, which is slightly above the cost of a liter 100 TZS or $ 0.044 water sold by the public water supply network. Tanker services were observed to be socially accessible, regardless of gender, religion, race and ethnicity, but economically unsustainable for poor and disadvantage society due to their inability to purchase water in bulk quantity to escape the daily incremental financially and non-financial cost of accessing water. However, whilst the prices of unionized tankers (registered tankers) and water quality are regulated and certified by public water institutions in *Cochabamba* (Bolivia) (Wutich et. al., 2016), non-unionized operations hinders quality regulation. According to Municipal Water Engineer (MWE), water quality tests are irregular but mostly based on occasions of speculation of outbreak of water related-diseases. As a result, a large segment of tanker trucks remained unregistered and supply water based on their own prices and quality determination in Dar es Salaam. In both cases, clients' views are not incorporated in prices determination, only unionized tankers are able to response to local water quality concerns because of their collaboration with the public water bodies

compared to the non-unionized tanker trucks operators.

*(e) Kiosk water supply market: Water availability, supply and access*

The kiosk water supply system was observed as the spatially distributed water supply network in the informal settlements, located more accessible to clients' households. Comparatively, water kiosks constitute 14 (33.3%) of the informal water sellers studied in the urban fringes of Dar es Salaam. This system of water supply is neither a system of self-help nor mere social good but rather a form of business in response to public water access deficit and households demand for water in the informal settlements. They complement the formal water supply agency. Water kiosks operators purchase water mostly from tanker trucks operators, retail and resell to households. The major mechanisms of storing water is through the poly-tanks, either situated on blocks or over-head block. From interviews with water-kiosks operators, it cost an average of 800,000 TZS or $ 350.08 to construct an over-head block for water supply. The cost incurred through the construction of the block, operating and maintenance of the services are recovered from consumers through the pricing of the water. The pricing of water is thus determined by multiple factors, the cost of water purchased from wholesalers, the type of water purchased *(Hard or soft* water), the demand for the water, the season and the distance from which water is transported from. Of all the water supply markets studied, water kiosks water supply centers were widely observed as the most spatially accessible water supply markets in terms of distance. Majority of the households 264 (90.3%) get access to water from kiosks within 200 meters. Only 28 (9.7%) of the households were located above 200 meters of the spatial distance from the nearest water kiosk. Despite the spatial proximity of households to the various water kiosks, only 61 (21%) of the surveyed households purchase water from water kiosks, comprising 30 (19.5%) of the low-income earning households and 1 (1.5%) of the middle-income earning households. However, none of the high-income earning households depend on water kiosks for water supply services. This was observed to have been shaped by the perceived poor quality of water from water kiosks resulting from the long-term storage of water in tanks, exposure of the water storage poly-tank to excessive sun and coupled with lack of disinfection of the water stored. Nonetheless, the poor-quality state of the water has less influenced the cost of a unit of water. Similarly, to other sellers, water accessed from the public water reservoir (DAWASCO) was sold 400 TZS or $ 0.18 per 20 liters, whilst water accessed from other sources besides the public water supply reservoir was observed to be sold at 200 TZS or $ 0.088. Comparatively, consumers rated water kiosks water supply services are highly erratic for sustainable access, but however suitable for their location conditions. Aside, water supply services are flexible as they provide the opportunity for consumers to fetch water on credit in the event of lack of cash.

*4.3 Clients' Perspective of Domestic Water access Sustainability in the Informal Settlements*

From interviews with clients, domestic water access sustainability is a dilemma in an informally driven water supply system. Clients likened water access sustainability as uncertain due to the unpredictable cost of accessing water in the informal water supply markets, the quality of water supply, and the variations in the procedures to accessing water amongst others. These and many other factors were observed as dis-incentive for water access sustainability.

*(a) Cost as a dis-incentive to domestic water access*

Prices per unit of water sale are largely in-marginal. Except for the public water supply and the tanker trucks, the cost of a liter of water from the Water kiosks, Pushcart, Mechanized boreholes amongst others vary from season to season and by source and distance of the water. The pricing mechanism contributes to cost recovery to favor actors' business operation rather than affordable water provision to salvage the water demand of the urban poor in the informal settlements. As client remarked: *"Kupata maji leo na kesho itaendelea kuwa shida hapa, kwa kuwa nimekuja hapa idadi ya wauzaji wa maji yameongezeka lakini bei kwa lita moja ya maji haikupungua"* which implies "Getting water today and tomorrow will continue to be problem here, since I came here the number of water sellers has been increasing yet prices per liter of water have not decreased" For some clients: *"Namba yetu inaongezeka kila siku hata ingawa wauzaji wa maji wanaongezeka bado tunalipa maji zaidi, ninahitaji kununua maji kutoka kidogo niliyopata kutokana na mauzo yangu na sija shaka kwamba watoto wetu watalipa zaidi kwa maji kwa sababu maji ya umma hayatoi mara kwa mara"* which implies "our number is increasing every day even though the water sellers are increasing we still pay more for water, I have to buy water from the little money I get from my sales and I have no doubt that our children will pay more for water in the future because public water is irregular" The income statuses of the urban poor are highly incompatible with the water tariff of the informal water markets. From the survey, 192 (65.8%) of the clients spent more than 5% of their monthly households' disposable income on water despite the spatial proximity to the water markets.

As clients remarked; "…*there are two types of waters here, the soft water and the hard water, the hard water is*

*common here, but the soft water which we used for drinking is not common, few cars/tankers are selling the soft water and it is expensive and difficult to get to buy, so some of us end up drinking the hard water (high salinity) which we used for washing..."*

From the perspective of the Ward Health Officer (WHO): *"In this location, there is a big problem of water, though there are DAWASCO water supply pipelines, water supply is periodic, when it flows one day, there is no water again. Cars selling water here is most common and buying water for private operators is common because if you depend on DAWASCO you will lack water at home, I have been here for four years, water access problem today has not changed and I don' t think it will change because the tanker water suppliers has increased not DAWASCO water*"

From another client; "*Water is not affordable here, the affordable drinking water is the DAWASCO water which also does not flow, for the cost of the water sellers, many of us cannot afford the clean water they sell, we drink the hard and salty water here"*

However, the lack of unionized system of operation resulted to the lack of non-collective pricing fixing body or established basis for a unit cost of clean and safe water (Wutich et. al., 2016; Ahmad, 2017). This contrast the observation of similar operators in Bolivia, where informal water vendors form an association as the basis for collective pricing of water (Wutich et. al., 2016). Though mutuality, collective self-interest exists among the actors, it does not culminate in communal water pricing, for affordable and reliable water supply to the urban poor (Ahmad, 2017). Rather, each water seller is self-motivated by profit, determine water price based on the value consumers attach to the water, the scarcity of improved water and the distance of the water wholesaler (Ahmad, 2017). This non-collective pricing predisposes the purchasing power of the poor households and renders them inaccessible to improved water supply services despite their spatial proximity to water in the informal settlements. Again, the cost of accessing water has led to many impoverished households to reduce their budgetary commitment of equally significant basic needs such as decent clothes, health needs, food and transport. From the survey, 85 (29.1%) of the clients disclosed their inability to purchase adequate food for domestic consumption due to the cost involved in accessing water, 52 (17.9%) are unable to cater for their health needs due to the frequent purchase of water.

*(b) Non-inclusive participation in water pricing as a dis-incentive to domestic water access*

Informal water supply markets are more detrimental to the water access needs of the urban poor, due to the lack of involvement of the urban poor who represent the major clients in water prices negotiation and determinations. As observed, the price of liters of water sold by informal water supply actors is four times the municipal water pricing. The pricing mechanism was observed to rather contribute to salvaging cost recovery and profit maximization to meeting the interest of the sellers to the detriment of the water consumers due to lack of inclusive participation. Clients are neither involved in price setting nor decision regarding the modes of water delivery. Rather, water sellers take advantage of the rising population and the demand for water. Though the tanker trucks water is perceived as the most acceptable water quality, their services largely favor the high-income households to the detriment of low-income earning groups. Whilst the high and middle-income groups could purchase water in bulk quantity for storage, the impoverished households lack storage containers for bulk quantity of water and at the same time, cannot afford the cost of the bulk quantity of water to store against water supply fluctuation. As a result, whilst the poor can afford 200 liters of water from the tankers, tanker operators limit domestic water delivery to 10,000 liters which is wholly above the financial abilities of the urban poor. From the perspective of the Ward Officer (WO), "Kushiriki katika kuamua bei ya maji na watendaji wa soko la maji isiyo rasmi ni 50-50 hapa, watoa faragha hawajiandikishi katika kiwango cha Ward kufanya kazi, wanaanza kuanza kufanya kazi bila ujuzi wako na kwa sababu watu wanahitaji maji wanaendelea kununua na wao katika biashara" which implies "getting involve in water prices negotiation with the informal water market actors is 50-50 here, private operators do not register in the Ward level to operate, they just start operating without your knowledge and because the people need water they keep buying and that keep them in business" The lack of inclusive participation has virtually resulted to lack of information provision on days of water availability and quality for domestic consumption. Information about water availability at the sale centers is through the physical presence of the water sellers.

*(c) Poor quality of water as a dis-incentive to domestic water access*

Poor quality of water serves as a major dis-incentive for domestic water access and consumption in the informal settlements. Even clean and safe water hauled from the public water reservoirs by the water sellers get deteriorated due to poor water handling and quality regulation. The quality of water supply by informal water sellers usually vary between seasons and highly unsuitable for domestic consumption in the dry season due to

water scarcity. In the rainy season, households haul rain water into storage containers for domestic consumption. In the dry season, water supply is often erratic and turbid. The major sources are either tanker trucks that haul water from the public water reservoir or the erratic water from the public water source. The struggles for water, longer queues, frequent transportation of water by tanker trucks often results to the ingress of particles in the water. Households bear the cost of water access as in water purification prior to drinking. As a result, even when water is made available through the informal water markets, domestic water access sustainability is often challenged by the quality state of the water, and the required cost for purification.

From the perspective of clients; *"…we are not always sure of the quality of water sellers provide to us, we only treat the water when we see particles, the tankers carry clean water for a longer period and distances, sometimes you get water with particles, there are few tankers here with clean water, in the dry season, water quality is worsened because of water scarcity, the water we get is often dusty but water is water, we normally have no option than to purify and use it like that…"*

From the perspective of the Municipal Water Engineer (MWE), *"relying on the private water market for water has high cost than good, private markets do not have capacity to control water quality, because they are suffering for money only but not anything…they do not check for turbidity, salinity, conductivity, sodium, bacteriological substances like fecal matter in the water before sale"*

From the survey, most served households go through multiple water purification processes of boiling 258 (88.3%) and filtering 20 (6.8%) water fetched from informal water markets prior to consumption. Commonly detected water contaminates that necessitated further processing included fungi in water storage containers, and turbid 141 (48.3%) due to long-storage of water, lack of regular cleaning of storage containers and water disinfection. Despite the tedious processes clients go through to exercise their human right to water, a large segment of clients suffers from water related diseases due to the continuous in-take of unimproved water.

According to the Ward Health Officer (WHO), *"The water most people buy and drink here has no proof of the treatment, most people particularly children are often affected by helminthiasis, cholera, typhoid and diarrhea…"*

From the households' survey, about 142 (48.7%) of the surveyed households have ever suffered from Typhoid, 88 (30%) ever suffered from diarrhea, 62 (21.3%) suffered from cholera, whilst 8% could not mention the name of the disease they suffered from. It therefore implies that even if the informal markets sustain water supply, the urban poor will continuously remain in poor health as they lack the financial capacity to purchase bottle and other improved sources of water for consumption.

(d) *Un-regulatory entry and exist of water sellers as incentive to spatial accessibility to water*

The frequent entry and exist of water sellers in the water selling market has contributed to sustaining spatial water access for the different socioeconomic groups. Though the Municipal Water Engineer (MWE) indicated that water sellers are required to obtain a health permit from the Ministry of Health (MOH), quality regulation permit from the Das es Salaam Water Supply Company (DAWASCO), and an operational permit from the Municipality, only a few registered DAWASCO tanker water sellers hold permits of DAWASCO. Rather, the entry and exists of the water sellers in the water supply market is determined by the individual financial ability, space availability for water vending, proximity to clients and the demand for water. Informal water sellers dominate in most parts of the informal settlements. From the survey, 55 (77.4%) of high-income households get access to water within 200 meters, 52 (77.6%) of the middle-income households get access to water within 200 meters distance, whilst as much as 123 (79.9%) of the low-income earning households get access to water within 200 meters from varied water sellers.

In view of the lack of regulatory mechanisms guiding the entry and exist of water sellers in the water supply market, this phenomenon has the possibility of further improving water supply coverage in the informal settlements. The proliferation of the water sellers has not only breed competition in the urban water supply network but has also introduced flexibility in domestic water services delivery. Even clients without access to running water, get homes delivery from pushcarts and tanker water sellers based on their ability to afford. Also, frequently served clients develop and sustain rapport with water sellers as customers. Water sellers become more responsive to the water needs of such clients by treating their water access needs with due urgency. This was observed as a major incentive for sustaining households' water access sustainability. Mostly, water sellers prefer to develop rapport with the high-income earning households who purchase water in bulk quantity and utilised the water not only for drinking, cooking and bathing but also for luxuries activities like watering of laws and washing of cars etc. However, considering the spatial accessibility of water sales centers in the informal settlements, a regulatory mechanism is useful for ensuring that the quality of water sold is regulated and

maintained to prevent the urban poor from buying unimproved water for domestic consumption.

*(e) Irregular and inconsistent water supply and access as a dis-incentive to domestic water access*

Irregular and inconsistent water delivery times were observed as a major challenge to domestic water access sustainability under the informal supply market. Water supply irregularity and inconsistency in the informal water market is influenced by seasonality shift, the level of independence of the water sellers, the economic status of the clients, and level of resourceful of the water sellers. Though interdependence, mutuality and collective-interest among the water sellers also contributed to an exchange of resources between resourced and less resourced water sellers (wholesalers verses retailers), clients experience procedural and interactional injustices when accessing water supply services through this system of water supply (Wutich et. al., 2016). The procedural and interactional arrangements get worsen in the dry season where improved water sales are limited. In such times, the arrangements and access to improved water is based on the financial capacity of the clients. Clients that bid more are supplied improved water by the tankers compared to other clients. Access to water among the impoverished households is often prolonged. As clients remarked "...it is very easy to get water from private water sellers in the raining season because most people assist themselves by harvesting the rain water, but in the dry season, getting clean and safe drinking water from the private water sellers is 50-50 here..." From another client; *"...it depends on the line, and your call time that makes you get water from Tankers, right now it is still raining we don't suffer arranging for water because we depend on rain water, if you call the tanker trucks in this rainy season you easily and immediately get clean water, but in the dry season you have to arrange to buy clean water from tankers, the prices do not change but the arrangements normally change, instead of immediately, they will tell you if you want water tomorrow call today! how to get them and book their services to enable them to supply water to you is a problem, my brother before you get clean water from the tanker trucks in the dry season, your order has to be there earlier before your name..."* In some cases, informal water supply services come to a halt, in events of longer queues at the public reservoirs and render clients water required activities into jeopardy. This often compel informal settlements dwellers to haul unimproved water (groundwater high salinity) from open wells to fulfill their water needs. Comparatively, low-income households are habitually affected in irregular and inconsistent water delivery times due to their inability to purchase tanker water in bulk quantity, store and refrain from daily water access charges.

## 5. Conclusion and Recommendations

Though water sellers are socio-cultural capacity in local water supply, the social good component of water is missing where these sellers dominate in the water supply market. The consequences are enormous ranging from the provision of un-affordable water to the urban poor, poor quality of the water due to lack of disinfection, and low reliability of water supply. Again, the observed potentials of the water sellers are worthier for formalization and improvement of water supply in water poor neighbourhoods. But prior to formalizing the informal water markets, there is the need to first of all, recognise the operations of the water sellers through registration, formation of associations to provide an avenue for regular monitoring of their activities and training to build their capacities in water quality management. Key partner such as DAWASCO should strengthen partnership with informal water sellers for sustainable water supply. Secondly, the integration of the informal water markets should be backed by legal recognition of informal water sellers. Legislation should spell out guidelines and measures required for water sellers to operate in the urban water distribution network. A legal recognition will provide opportunity for less financially capable vendors to seek financial assistance to expand their operations and increase water supply to the unserved urban population. Thirdly, mainstreaming the informal water markets requires the development of cooperation between utilities agencies, and the informal water sellers. Fourthly, given the fact that water consumption represents good health and ill-health, regulatory measures are required to control the quality and pricing of informal water supply. Finally, informal water sellers should be supported by water policy issues, to contribute to the implementation of water related policies and make them more effective and efficient in the urban water supply. This will at the same time increase their access to microfinance services and facilitate investment in water provision.

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**Conflict of Interest**

No conflict of interest

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**Notes**

Note 1. Leaders/officials at the ward levels, who represent the affairs of the communities.

Note 2. The official language of Tanzania and widely spoken language in Eastern Africa.

Note 3. Tanzania Shillings.

Note 4. A system of water access and storage where households fetch their perceived improved water mostly from Tanker trucks and DAWASCO water and stored mainly for drinking and the perceived less improved source water such as water from wells, mechanized boreholes, pushcarts, water kiosks for washing, bathing and other household sanitation purposes etc.