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Millennium Challenge Corporation

Impact Evaluation Baseline Report of the MCC Tanzania Water Sector Project (WSP)

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Impact Evaluation Baseline Report of the MCC Tanzania Water Sector Project (WSP)

Prepared by Social Impact, Inc.
for the Millennium Challenge Corporation

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ABBREVIATIONS

BUWASA	Bukoba Water and Sewerage Authority
CE	Consumption Expenditures
CI	Confidence Interval
CMD	Coliform Microbial Density
DAWASA	Dar es Salaam Water and Sewerage Authority
DAWASCO	Dar es Salaam Water and Sewerage Corporation
DEO	District Education Officer
DHS	Demographic and Health Surveys
DMO	District Medical Officer
DQM	Data Quality Monitoring
EA	Enumeration Area
ERR	Economic Rate of Return
EDI	Economic Development Initiatives, Ltd.
F	Focus group facilitator
FCR	Free Chlorine Residual
FGD	Focus Group Discussion
GIS	Geographic Information System
GPS	Global Positioning System
GPSM	Generalized Propensity Score Matching
HBS	Household Budget Survey
HH	Household
HQ	Headquarters
I	Interviewer
IE	Impact Evaluation
JMP	Joint Monitoring Programme (for Water Supply and Sanitation)
KII	Key Informant Interview
MCA-T	Millennium Challenge Account - Tanzania
MCC	Millennium Challenge Corporation
MLD	Million Liters per Day
MORUWASA	Morogoro Urban Water Supply and Sewerage Authority
NBS	National Bureau of Statistics
NPS	National Panel Survey
NTU	Nephelometric Turbidity Units
P	Focus group participant
PCA	Principal-Components Analysis
PCPD	Per capita per day
PPP	Purchasing Power Parity
R	Respondent
QA	Quality Assurance
SE	Standard Error
SES	Socioeconomic Status
SI	Social Impact
SSI	Semi-Structured Interview
TMA	Tanzania Meteorological Agency
TZS	Tanzanian Shilling
WHO	World Health Organization
WSP	Water Sector Project

1 EXECUTIVE SUMMARY

1.1 Tanzania Compact Water Sector Project (WSP)

The United States Millennium Challenge Corporation (MCC) and the Government of Tanzania (GoT) entered into a five-year Millennium Challenge Compact to provide assistance to facilitate poverty reduction through economic growth in Tanzania starting in 2008. The Millennium Challenge Corporation's $698 million Compact is implemented by the Millennium Challenge Account – Tanzania (MCA-T) and includes a $64.2 million Water Sector Project (WSP), which comprises interventions aimed at achieving improvements in the supply and quality of water through investments in water infrastructure in two urban centers: Dar es Salaam and Morogoro (Figure 1).

The Lower Ruvu Plant Expansion Activity aims to expand the capacity of the Lower Ruvu water treatment plant serving the Dar es Salaam area from 180 million liters per day (MLD) to approximately 270 MLD, and the Morogoro Water Supply Activity addresses the water supply in Morogoro by rehabilitating two water treatment plants (Mafiga and Mambogo) and increasing water supply in the existing distribution network (from 18 to 33 MLD), while also improving the quality of water produced (Figure 1-Figure 5).

The overall objective of the Tanzania Compact WSP is to increase investment in human and physical capital and reduce the prevalence of water-related diseases. The project logic posits that improvements in the quantity and reliability of the water supply will reduce the real and opportunity costs associated with scarce and low-quality water, thus allowing households to allocate more time and resources to income-generating activities, and promoting the overall Compact goal of poverty reduction through economic growth. Interventions in Morogoro were completed in mid-2014. The estimated project completion date for Dar es Salaam is early 2015 (Lower Ruvu improvements cannot be operationalized until the GoT completes construction of a new transmission main). According to MCC economic rate of return (ERR) projections, these interventions will benefit an estimated 2.8 million people by 2027.

FIGURE 1: MAFIGA WATER TREATMENT PLANT IN MOROGORO

FIGURE 2. CONSTRUCTION AT MAFIGA WATER TREATMENT PLANT IN MOROGORO

1.2 Summary of Impact Evaluation

Social Impact has designed a rigorous impact evaluation (IE) to evaluate the water project interventions in Dar es Salaam and Morogoro, which will analyze baseline and end-line data, collected before and after the implementation of project activities, respectively. The methodology will estimate project impact by comparing households that experience different levels of change in their water supply after the intervention. Using baseline values of water supply and other demographic and socioeconomic variables, a statistical matching approach[4] will be applied to evaluate the impact of the intervention on comparable households that experience different changes in water supply.

For example, two households that are considered comparable before the intervention, in terms of water supply, demographic composition, and socioeconomic status, may experience different levels of water supply changes after the intervention, e.g., depending on where they live and how the water is directed through the network. Using the matching methodology, the evaluation will identify impacts on such households that are attributable to the Water Sector Project.[5] Specifically, impacts of the WSP on health, labor supply, and other intermediate outcomes such as household members' time spent collecting water, expenditures on water, and volume of water consumed, will be evaluated.

This methodology is innovative within the water supply evaluation literature. Most evaluations define water access in binary terms, such as "improved" or "unimproved" while this evaluation considers that in the urban context households use a variety of sources, and explicitly models access as continuous (e.g., hours per week), rather than binary. The impact evaluation will utilize data collected in two phases – baseline and end-line. Baseline data collection was completed in 2013 (April through August), and end-line is planned for 2016. This baseline report presents a summary of the data collection approach, methodology, data quality monitoring activities, and a detailed presentation of baseline data, describing the present situation and challenges related to water access in both cities.

This impact evaluation utilizes a mixed-methods approach, which synthesizes several types of data to produce a robust and triangulated set of findings. Baseline data include a comprehensive set of quantitative, qualitative, and geospatial data.

FIGURE 3: MAFIGA WATER TREATMENT PLANT OPERATIONS

[4] Generalized propensity score matching (GPSM).

[5] Other factors that could bias the estimation of impact will have been controlled for statistically through the matching methodology.

Quantitative data capture a wide range of indicators, including: demographic characteristics, socioeconomic status, water access and availability, water supply, time spent collecting water, volume of water collected, expenditures on water, household water consumption, water-related illness, schooling among children, labor supply among adults, and water security. The sampled households were surveyed face-to-face at baseline, and three times by phone over the following three months to gather robust data about water availability and water supply.

In addition, water quality was measured directly, using water samples collected from household and community taps from a sub-set of households and locations. A variety of geospatial data was collected at baseline, and a series of maps have been developed to present the current water distribution network, locations sampled for data collection, and water quality results. Finally, a robust set of qualitative data was collected and analyzed, from interviews, focus group discussions, and site visits. Insights shared by city residents, health facilities, schools, and a variety of water vendors provided in-depth, nuanced perspectives on the current state of water availability and related challenges. The qualitative data collection also focused on gender considerations and vulnerable sub-populations, such as the poorest segments of the population. Interviews with TWSP stakeholders – project staff, construction engineers, and water utilities – were also conducted and provide valuable context related to project implementation, challenges faced to date, and expectations of impact and sustainability.

While the final impact analysis will be conducted at end-line and will employ the matching method described above, a preliminary set of statistical analyses have been conducted using the baseline data. The baseline report describes the statistical modeling approaches utilized and presents the results of the baseline analyses. Because the context of the interventions in Dar es Salaam and Morogoro differ substantially, the data and results presented in the report are presented separately for each city. Quantitative data is disaggregated by age, gender, and socioeconomic status; disaggregation by primary source of drinking water, season, and other relevant variables is also presented when applicable.

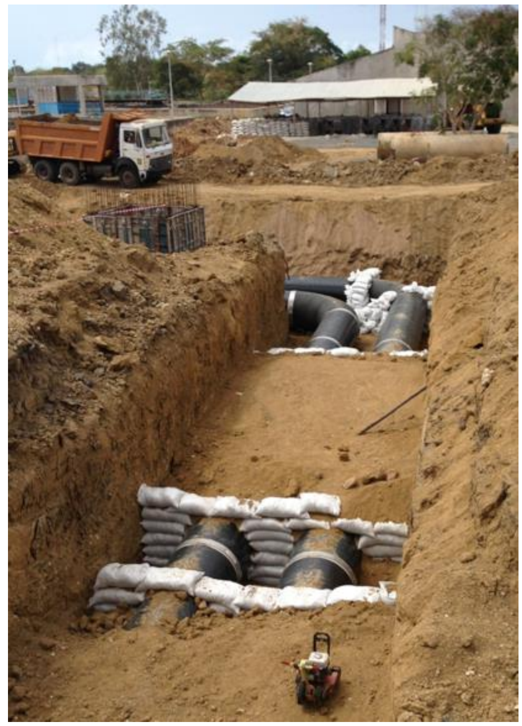


FIGURE 4: CONSTRUCTION AT LOWER RUVU

FIGURE 5: LOWER RUVU WATER TREATMENT PLANT OPERATIONS

1.3 Baseline Data and Preliminary Analysis

Although this evaluation is still in progress and the post-intervention data collection has not yet occurred, the analysis of baseline data yielded a variety of compelling findings, which are summarized below.

Descriptive analyses show substantial variation across the population in water access, use, expenditures, and consumption, as well as health and economic outcomes, disaggregated by socioeconomic status, and across seasons. Examining the unique context of the two cities, data show that residents of Morogoro have greater access to improved water sources than those in Dar es Salaam. In total, 52% of residents in Dar es Salaam, and 91% in Morogoro, reported using piped water (either their own tap, or another piped source such as a neighbor's tap or a nearby kiosk) as their primary source of drinking water.[6] In Dar es Salaam, only a small proportion of households have piped water connections on household premises (either in the dwelling or on the plot), and approximately 13% report using their own tap as their primary source of drinking water. In Morogoro, an estimated 52% of households use their own tap as their primary source of drinking water (Figure 6). Access to piped water aligns closely with socioeconomic status. In Dar es Salaam, among the poorest fifth (quintile) of the population, less than 10% of households have a connection to the public water distribution network on premises, compared with about 25% in the wealthiest quintile. In Morogoro, approximately 30% of households in the poorest quintile have a connection compared to about 70% of the wealthiest.[7] In both cities, water shortages are common for households connected to the public water distribution system: approximately half of households in each city who are connected to the distribution system reported a water shortage (any interruption in the water supply) in the past seven days. Even households not connected to the system reported suffering consequences from system-related shortages of water. Households dependent on neighbors' taps, water kiosks, and even those relying on water vendors reported problems related to shortages in the public system (Figure 7).

Water quality testing conducted as part of the household interviews measured chlorine levels and bacterial contamination (fecal coliform) in water samples drawn from residential taps and from community sources. The availability of piped connections in each city influenced the availability of water for quality testing. Since more households in Morogoro have access to their own tap, the majority of water samples in that city were collected from residential taps (83%). Conversely, in Dar es Salaam, only 24% of water samples were drawn from household taps.

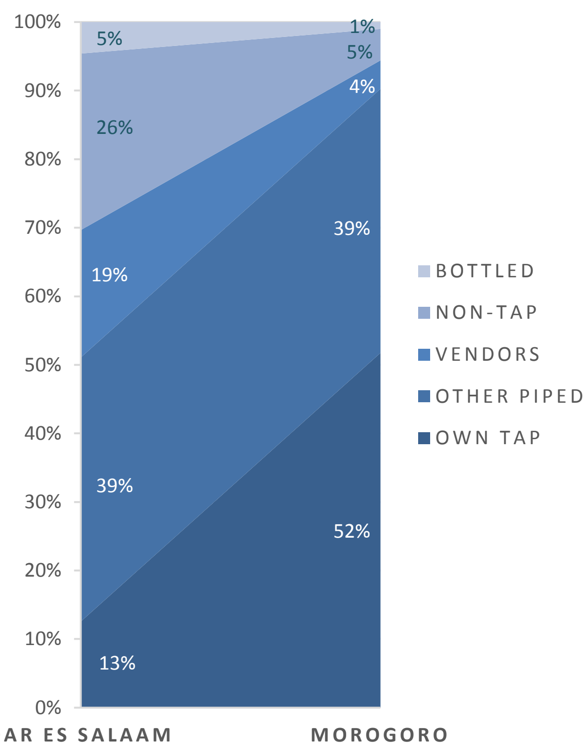


FIGURE 6. PRIMARY DRINKING WATER SOURCES

[6] Unless otherwise specified, all percentages are city-representative, adjusted for the sampling design in each city.

[7] Households are separated into quintiles of socioeconomic status on the basis of consumption expenditures, reported during the household survey.

FIGURE 7: WATER KIOSK IN MOROGORO

At the household level, the results were similar for both cities, with approximately one quarter of water samples sufficiently contaminated to merit an unsatisfactory risk rating – meaning above zero levels of fecal bacteria present in the sample.[8] However, the quality of the community sources was worse and varied more, with 35% of community sources receiving the high risk rating in Dar es Salaam compared to 52% in Morogoro. The majority of the contaminated water samples measured quite low levels of fecal bacteria, although even small amounts of contamination can have substantial health impacts. Community sources were the most contaminated water sources within the sample. While the mean contamination for water samples drawn from the household taps was similar across cities, the community water sources in Morogoro were far more contaminated (Figure 8). Free and total chlorine tests showed that the majority of water samples have practically no free chlorine (the type of chlorine that is still available in the water to kill bacteria), and very low concentrations of total chlorine (capturing the amount of chlorine originally added to the water). Low levels of free chlorine in water imply that there may be insufficient chlorine remaining to disinfect against bacteriological contamination. Thus, any contamination of water occurring after it is drawn from the source, such as during the process of hauling, storage, or retrieval for consumption, could result in water unsafe to drink without further treatment. Households were found to vary substantially in their water treatment behavior: those that use piped water as their main drinking source were more likely to boil or otherwise treat their water, compared to households using any other source for drinking. To mitigate against shortages, many households, facilities and vendors store water on a regular basis, but storage introduces opportunities for further contamination.

Water quality tests were also conducted at distribution-level locations, including the outlets of the water treatment plants. The results of the turbidity testing suggest that turbidity is not a problem in Dar es Salaam, but is in Morogoro, where almost all samples exhibited high levels of turbidity. Chlorine tests at the distribution level indicated that most samples contained free chlorine levels in the acceptable range, though several samples in Dar es Salaam and a few in Morogoro had chlorine concentrations that would be considered too low to disinfect tap water.

FIGURE 8: WATER FROM COMMUNITY SOURCE IN MOROGORO

[8] This risk designation follows Tanzania Bureau of Standards (TBS) recommendations for presence or absence of fecal bacteria.

FIGURE 9: WATER COLLECTION FROM KIOSK IN MOROGORO

Although better-off households are more likely to have access to piped water, households from all socioeconomic quintiles spend time hauling water (i.e., collecting it from another location to bring it back to the household) for household consumption (Figure 9).

Households spend significant time collecting water regardless of their main source of drinking water, though those with their own tap, or who use bottled water for drinking, tend to spend slightly less time than others. On average across cities and seasons, households spend just four hours per week hauling water, and time spent collecting water does not differ substantially by socioeconomic status, after controlling for other factors. Less water is available through improved sources during the dry season and hauling times are higher during this period. Households whose main source of drinking water is from unprotected sources are relatively unaffected by seasonal water shortages in terms of time spent hauling water. Those in the wealthiest quintile tend to spend less time collecting water than others overall. Examining the average time spent hauling water by season and by socioeconomic status, a familiar relationship emerges for Morogoro, where the poorest households spent the most time hauling water, although all households spend substantially more time on water collection in the dry season.

Notably, the difference between rainy and dry season collection times among households with their own tap in Morogoro is substantial, which was confirmed by focus group participants in Morogoro, who reported dramatic changes in water availability between seasons. The relationship between poverty and time spent hauling water is not as straightforward in Dar es Salaam, where fewer households have tap connections and water supply shortages are more common.

FIGURE 10: FLOW METER AT MAFIGA

FIGURE 11: WATER METER AT KIOSK IN MOROGORO

In a survey module where households were prompted about certain types of economic shocks experienced in the past two years (i.e., situations that had substantial economic consequences), a third of households reported a severe shock related to water in the past two years. In Dar es Salaam, a fifth of respondents stated that a shock to their water supply was the most severe economic shock they faced (with the most common shock reported to be increases in food prices), while in Morogoro 15% of households reported a water shock to be their most severe shock. Uncertainty about water supply can place not only an economic but also a psychological burden on households; about a quarter of households reported that they were concerned about their access to water over the past 30 days and qualitative results produced a wealth of context related to the anxiety that households face related to ensuring an adequate supply of water for the household. Water supply shortages or disruptions are highly associated with water insecurity for households that rely on piped sources, although regardless of source, a high proportion of households are concerned about their water access.

Baseline values of outcomes related to children – health and schooling – were also investigated. The incidence of diarrheal illness does not appear to be closely tied to the household's primary source of drinking water; and similar proportions of children report experiencing at least one instance of diarrheal illness in the past fourteen days regardless of their main source of drinking water.

However, the health effects are notoriously difficult to estimate since diarrhea incidence is challenging to measure, and there many influences affecting health outcomes (e.g., sanitation and hygiene, water quality, treatment, and environmental conditions). Health studies usually require massive sample sizes to measure impacts more accurately. The smaller sample size of this study means that the direct impact of the water project will be very challenging to uncover, especially if sanitation, hygiene, or other factors mentioned also strongly influence the incidence of diarrheal illness in addition to the quality of water supply.

FIGURE 12: VENDOR'S TANKS IN DAR ES SALAAM

FIGURE 13: WATER COLLECTION FROM STANDPIPE IN MOROGORO

Data on health spending due to diarrheal illness suggest that this type of expenditure is higher in Dar es Salaam than in Morogoro, and the wealthiest households tend to spend more on diarrheal illness treatment in both cities. Despite the irregularity of water supply and the relatively high time burden of collecting water, few households reported school absences due water collection activities; this was again reiterated in the focus groups, which reported that parents usually enlisted children's help for water collection outside of school hours.

Not surprisingly, access to piped water sources is closely related to outcomes such as the likelihood of use of piped water as a main source of drinking water, higher water consumption, and time saved hauling water for household use. Piped water access also appears to be associated with higher rates of school attendance and lower water insecurity. Still, analyses suggest that residents of both cities are subject to substantial water insecurity. For households with own piped water access and other households relying on piped sources, increased disruptions are associated with increased concern for water insecurity. Statistical analyses examining the relationship of wealth to water access indicate that given more disposable income, households will generally spend more on water. Increased supply reliability (e.g., hours per week) is also associated with increased per-capita consumption. Demand for water remains relatively stable as water prices increase (i.e., demand is inelastic), though decreases in water prices are associated with some increases in volume of consumption. Households with a more regular supply of water from the public distribution network also tend to consume more per capita. This suggests that increasing water supply may produce widespread benefits to consumers. Findings were supported by multiple descriptive and statistical analyses and provide evidence of the potential impacts of the Tanzania Compact Water Sector Project investments. While the poorest households presently bear the greatest burden of water insecurity, households of all socioeconomic status experience water-related problems. Ultimately, this evaluation shed light on whether the MCC intervention could achieve its goals of increasing investment in human and physical capital and reducing the prevalence of water-related disease.

FIGURE 14: RESIDENTS COLLECT WATER FROM A STANDPIPE IN MOROGORO

1.3.1 Findings from Qualitative Analysis

The qualitative component of the baseline data collection and analysis yielded valuable insights from residents of Dar es Salaam and Morogoro through focus group discussions, site visits to health facilities and schools, interviews with water vendors, and key informant interviews with WSP stakeholders. Respondents in the focus group discussions were asked about a variety of water-related topics, including the sources they depend on most, the accessibility, reliability, and quality of these sources, perceptions of how additional water supply might affect their households, challenges related to water scarcity (including health, school, and gender-related concerns), and perceptions about the performance of the public utilities. Qualitative data provided valuable context for understanding the water-related challenges across Dar es Salaam and Morogoro. Overarching insights are summarized below.

Tap water is the preferred water source, particularly for drinking water. In Morogoro, piped water is more available and therefore serves as the primary source of water for the majority of the households interviewed; households in Morogoro use well or borehole water much less frequently than households in Dar es Salaam, and mostly in times of dry season shortages. On the other hand, in Dar es Salaam, shallow well or borehole water is the most commonly used source of water for households. The use of additional sources of water to supplement households' water supply is common across all households – such as neighbor's taps, tanker-trucks, kiosks, and other vendors – but each is associated with its own set of challenges. The use of multiple sources is particularly pronounced in Dar es Salaam. Similarly, even those who can access water from the public distribution network do not rely on tap water exclusively, due to the irregular schedule and frequent rationing associated with the public network. This suggests that the water supply that households obtain from the network may be overestimated in the quantitative data. Seasonality affects water supply in some areas more than others, depending on the set of water sources most used.

FIGURE 15: WATER-TANKER TRUCK DELIVERING WATER

Water-related illness is common; sanitation conditions of households, health facilities, and schools can be poor as a result of a lack of clean water. Water treatment behavior differs across cities, and is highly variable even within neighborhoods. In general, areas using piped water with greater frequency also tend to report treating their drinking water more regularly.

Women still bear the largest burden of water collection – though opinions and practices can differ even within distinct neighborhoods in either city. Interview respondents reported that erratic hours of supply, and the cost of obtaining water from various sources may incite domestic disputes and misunderstandings, while conferring risk to personal safety (e.g., increased risk of traffic accidents or injury). Children are affected by the water supply situation in a variety of ways: they are often enlisted to help their mothers collect water (although water collection tends to take place after school hours rather than before); children depend on water supply for regular bathing and uniform washing (without which some mothers are not willing to permit school attendance); and learners are often expected to bring water to school. However, water collection duties and water-related illness did not appear to prevent children from attending school. Perceptions of the performance of the public utilities are mixed; many respondents believe that they are trying to serve the populations well but there is widespread frustration about the lack of transparency surrounding billing practices and the erratic water schedules.

FIGURE 16: PATIENTS OFTEN HAUL WATER TO HEALTH FACILITIES

Educational and health facilities experience negative effects from a lack of a reliable access to clean water, which affects the performance and operations of these institutions. Water scarcity presents tangible and substantial pressures on limited resources, especially among public facilities. Health facilities report that the lack of consistent supply of clean water makes it difficult to perform essential tasks, including conducting surgery, sterilizing equipment, washing soiled linens, flushing toilets, and ensuring that patients are properly bathed. Unpredictable shortages or a loss of water pressure from utility connections have prompted some health facilities to supplement utility water with expensive investments in boreholes, desalinization technology, or contracts with private tankers on an as-needed basis. However, tankers are also vulnerable to fluctuations in water availability and are not always reliable, and borehole water is not preferred when it is saline because it is not appropriate for many medical applications. Piped water is strongly preferred – both in health facilities and in schools – but is universally not considered to be reliable. When facilities must order water from tankers, long waits can result in delays in service delivery. In these cases, only emergency operations are performed, and others are delayed. One respondent described suggested how health facility operations may benefit from improved water supply: "First, the money used to purchase water will now be used to purchase medicines and other medical equipment […] also it will increase more time for doctors because instead of doctors wasting time to call the tankers they will now dedicate time for attending patients, but also assurance to staff that they will be sure that they will be assured of [cleanliness] after let say serving mothers during delivery, it will also reduce the chances for infection prevention."

Administrators from health facilities and schools reported that shortages were a chronic, year-round concern, but were worse in the dry season, aligning with focus group discussion reports. Lack of information from utilities about when planned shortages and rationing will occur was common in both Dar es Salaam and Morogoro.

FIGURE 17: LAUNDRY ACCUMULATES WITH NO WATER AT HEALTH FACILITIES

Importantly, women and children are the primary users of lower-level health facilities such as dispensaries, which often face the most severe water supply challenges, and therefore are simply more likely to interact with a facility having trouble maintaining an adequate supply.

Schools also reported using a mixed portfolio of water sources including piped water, boreholes, rainwater, and water tankers. Students are affected in numerous ways by water scarcity at schools, the most prominent being the poor sanitary conditions, which can contribute to absenteeism among female students increase the incidence of illness. The ratio of students to toilets was also reported to be extremely high, often exceeding recommended standards by orders of magnitude. Water scarcity can also affect student learning, as it affects drinking water availability, meal preparation, and classroom time. Students may be asked to bring water to school; teachers may leave the premises to collect water or use nearby toilet facilities, sometimes interrupting or delaying lessons.

Water scarcity presents tangible and substantial pressures on limited resources, especially among public facilities. One respondent summarized: "So when you have water the health of students becomes stable, the health of school civil servant becomes stable, the health of neighboring community will be good; for example once [the school] gets sufficient water, [and] the neighboring community will get water, even the relationship between the community and the school society will be enhanced. Because when the school has water, the community will know the value of that school, they will ensure the school security, they will like the students, [compared to] the current relationship, in which students go to beg for water from the neighbors which is taken as a burden to them."

FIGURE 18: CHRONICALLY DRY TAPS AT PUBLIC SCHOOLS

FIGURE 19: WORD CLOUD REPRESENTING HEALTH FACILITY AND SCHOOL INTERVIEWS

1.4 Conclusion

This baseline report documents the pre-intervention status of relevant characteristics, indicators and outcomes related to the Tanzania Water Sector Project, including demand for water, household water consumption, water expenditures, water hauling, water-related illness, schooling, and labor force participation, along with beneficiary and stakeholder perceptions of water sector challenges and related issues. Although the impact evaluation is still in progress, this report's analysis based on baseline data suggests that the variability in water supply and quality does have an impact on some of the main outcomes of interest. These impacts often differ by socioeconomic status, suggesting that the poorest households bear a greater burden of the challenges related to safe water access in urban Tanzania.

The next step of this evaluation is to conduct follow-up data collection to gather post-intervention data and carry out the final analyses using the impact evaluation's matching methodology to identify the impacts of the Tanzania WSP.

The populations of Morogoro and Dar es Salaam are continually increasing, putting substantial pressure on the system as a whole in the long-term. This rapid growth can provide both opportunities and threats to urban development. While urban migration offers opportunities for additional customers, development throughout the city simultaneously increases demand for reliable and safe sources of water. The extent to which the Tanzania compact WSP may alleviate some of the pressure on the system and improve household economic wellbeing will be explored in the final impact evaluation in 2016.

FIGURE 20: DRY WATER DRAINAGE CANAL IN MOROGORO

2 INTRODUCTION AND BACKGROUND

2.1 Tanzania Compact Water Sector Project

The United States Millennium Challenge Corporation (MCC) and the Government of Tanzania (GoT) have entered into a Millennium Challenge Compact with the Government of Tanzania to provide assistance to facilitate poverty reduction through economic growth in Tanzania. The Millennium Challenge Corporation's $698 million Compact is implemented by the Millennium Challenge Account – Tanzania (MCA-T), and includes a $64.2 million Water Sector Project (WSP), which comprises interventions aimed to achieve improvements in the supply and quality of water through investments in water infrastructure in two urban centers, Dar es Salaam and Morogoro.[9] The Lower Ruvu Plant Expansion Activity aims to expand the capacity of the Lower Ruvu water treatment plant serving the Dar es Salaam area from 180 million liters per day (MLD) to approximately 270 MLD and improve water quality, and the Morogoro Water Supply Activity addresses the water supply in Morogoro by rehabilitating a water treatment plant and increasing water supply in the existing distribution network, from the current 18 to 33 MLD, while also improving the quality of water produced.

The overall objective of the WSP is to increase investment in human and physical capital and reduce the prevalence of water-related diseases. The project logic posits that improvements in the quantity and reliability of the water supply will reduce the real and opportunity costs resulting from scarce or low-quality water, thus allowing households to allocate more time and resources to income-generating activities, and promoting the overall Compact goal of poverty reduction through economic growth. The estimated project completion dates range between mid-2014 in Morogoro and August 2014 in Dar es Salaam.[10] According to the MCA-T Monitoring and Evaluation Plan (April 2012), beneficiaries are estimated as the sum of existing and new customers by 2027. It is estimated that by this time, these projects will benefit an estimated 2.8 million residents, as shown in Table 1.[11]

TABLE 1: ESTIMATED NUMBER OF WATER SECTOR PROJECT BENEFICIARIES BY CITY AND YEAR

City	2013	2020	2027
Dar es Salaam	1,261,077	1,805,829	2,585,898
Morogoro	90,816	140,025	215,961
Total	**1,351,893**	**1,945,854**	**2,801,859**

[9] Initially, a third component was included in the Tanzania WSP for Dar es Salaam, but was subsequently canceled before implementation due to budget constraints. This component focused on non-revenue water, with the stated goal of "improving system efficiencies in Dar es Salaam through reduction of non-revenue water via reduction in physical leaks and commercial losses." No activities under this component were planned for Morogoro.

[10] The MCC Tanzania Compact officially closed out in September 2013, but construction work on the interventions is ongoing through final completion in 2014. Project works at the Lower Ruvu plant are expected to be completed in early 2014, however the improvements cannot be operationalized until the Government of Tanzania completes construction of a new transmission main between Lower Ruvu and Dar es Salaam. The main is expected to be completed in late 2014.

[11] Customers include residential, industrial and commercial connections. Using the 2027 projections and estimates of annual population growth rates, SI calculated the population benefitting from the Water Project by city during the 15-year period from 2013-2027. An average annual population growth rate of 5% was assumed for Dar es Salaam and 6% for Morogoro during the period from 2013 to 2027. This assumption is consistent with recent population growth rates in Dar es Salaam and Morogoro; estimates have not been updated with 2012 census information.

2.2 Objectives

The overall objective of the WSP is to increase investment in human and physical capital and reduce the prevalence of water-related diseases. Both outcomes are expected to reduce poverty; the project logic posits that improvements in the quantity and reliability of the water supply will reduce the real and opportunity costs resulting from scarce or low-quality water (e.g., expenditures on water from vendors, time spent caring for sick members of the household), thus allowing households to allocate more time and resources to income-generating activities, and promoting the overall Compact goal of poverty reduction through economic growth. The MCC project logic is described in detail below. Through increasing water availability and access, and decreasing water costs, the program is expected to increase water security, which is determined by water volume, water quality, and consistency of water access (UNICEF 2002).

2.3 Impact Evaluation

Social Impact (SI) has been contracted by the MCC to carry out an impact evaluation (IE) of the Tanzania Water Sector Project. This IE examines the effect of the WSP interventions on outcomes directly related to the project logic, such as water consumption, time spent collecting water, diarrheal illness, and investments in human and physical capital. Given that the impacts of the upgraded water infrastructure are expected to be diffuse across each city, identifying a counterfactual through experimental methods is not feasible. Instead, SI has designed a rigorous quasi-experimental impact evaluation, using generalized propensity score matching (GPSM). This matching method enables comparisons of outcomes between similar households that experience differing levels of improvements to water supply due to the intervention. The focus in this IE is primarily on the effect of the WSP on short-term objectives, as outlined by the Tanzania Compact Water Sector Project Logic (see Figure 21). Data for this impact evaluation is to be collected in two waves – baseline in 2013 and end-line in 2015, with the completion of the interventions in the two cities becoming operational in 2014.

While the impacts can only be assessed after project completion, baseline data has already been collected and this report presents the results of the baseline data collection exercises. While the impact evaluation design is a matching method that will be carried out at end-line once the interventions have become operational, collecting high quality data at baseline provides the critical advantage of capturing baseline values of important outcomes that can be controlled for in the final analysis, including residential water consumption and expenditures, among others. Since households' baseline values can be strongly related to their end-line values of these indicators, the ability to control for baseline values provides additional control against bias in the estimation of impacts attributable to the WSP interventions.

2.4 Project Logic

The main objectives of the WSP are (i) to increase investment in human and physical capital and (ii) to reduce the prevalence of water-related disease, in order to reduce poverty through economic growth. The immediate outcome of the expansion of the water supply in Dar es Salaam and Morogoro is an increase in availability of water for households across the utilities' coverage areas. As increased volume of water flows through piped water system, water access should increase. The full project logic is presented in Figure 21.

The project logic posits increased access to occur through both increased continuity of service and also through increased number of customers or connections. However, since the WSP does not support the extension of the distribution network, increases in customer numbers must be developed through one of three pathways:

1. Increased network investment by water utilities as they have additional water available to sell and see potential returns to infrastructure investments;
2. Households currently in the network coverage area but unconnected because of cost or perceived lack of water availability;
3. Reactivated connections among previously inactive customers that did not receive water through the connection.

As a result of increased water access, the amount of time spent fetching water decreases, and household members can allocate this time to more productive activities, including income-generating activities. Moreover, with increased availability of water across the city, the cost of water should decrease, which could lead to increases in water consumption. Households will likely depend less on water vendors, leading to decreased prices, as vendors face increased competition, and reduced water expenditures (with potential negative side-effects on livelihoods for water vendors). Another potential area of impact is in water security or vulnerability. Water security is related to water service quality and is defined by water volume, water quality, and consistency of access. A water secure household should have enough clean water year-round to ensure its members' survival, health, and productivity (UNICEF 2002). Through increasing water availability and access and decreasing water costs, the program is expected to increase water security, which is measured both through households reporting of water shocks and through lower defensive expenditures.

The interventions in both cities are also expected to have an effect on the quality of water accessible to households in the distribution networks. The Morogoro works are expected to have direct effects on the quality of water in the distribution network, since one of the sites involves building a treatment plant where one did not exist before. In Dar es Salaam, households may have increased access to better quality water as they substitute utility provided water for unimproved sources.[12] The assumption that increased availability of water from the utility will improve the quality of water consumed is a critical hypothesis. Households without connections typically rely on water vendors or community connections, many of which are already connected to the utility distribution network. Also, storage, transport, and retrieval procedures may reduce water quality. Alternatively, persistence of regular interruptions in service could reduce water quality through the leakage of effluence into empty pipes.

Assuming the interventions lead to better quality water, this cleaner water is expected to result in decreased water-borne diseases, including diarrhea. The potential health outcomes of increased access to clean, piped water, particularly the lower prevalence of water-related disease, also permits an increase in the time beneficiaries engage in productive activities. Directly, adults can increase participation in income-generating activities as water-related sickness occurs less frequently. Indirectly, adults will spend less time in opportunity costs, such as caring for sick children. It is important to note that while potential impacts on health-related outcomes is part of the project logic, and is measured during data collection, it is highly unlikely we will be able to detect statistically significant changes in the incidence of water-related disease given the very large sample size requirements (as discussed in the IE design report). The expected result of both the expanded water supply and increased water quality is the reallocation of time to activities that increase household income.

With regard to human capital, the expected increase in water supply and decrease in water-related disease both increase the likelihood that children will attend school, overcoming previous

[12] In Dar es Salaam, the upgrades to the water treatment plant at Lower Ruvu will duplicate the technology currently used to treat water; however, additional enhancements beyond what is currently used to treat water at the plant in Dar es Salaam are not part of the intervention.

obstacles such as household chores (collecting water) or sickness. Though less certain, it is also possible that adults will perceive increased returns to sending children to school if they are healthier. In terms of physical capital investments, businesses may find it less risky to invest in employees (through expanded hiring or additional training) when they require fewer sick days or less time off to care for sick children. Moreover, with additional disposable income (through reduced water expenditures and time off work) as well as increased returns to investment (again from improved health), households and businesses are expected to increase investments in productive assets.

2.4.1 Antecedent and Intervening Variables

A direct relationship is posited between the number of households, as well as businesses and institutions such as health facilities and schools, using improved water sources, increasing water consumption, and experiencing reductions in the prevalence of water-related diseases and increased investment in human and physical capital. For these relationships to hold, a number of antecedent and intervening variables, which are seen as necessary conditions, must be considered. Increased availability of improved water is an antecedent to the increased use of improved sources and increased consumption. This means that the interventions must be completed, operate effectively, and result in the intended outputs of water production through the systems in each city. If, for example during a drought or during the dry season, water intake to the treatment plant is constrained – as droughts may increase pressure on the pipe system as alternative sources of water become unavailable – we would not expect to see an increase in output of treated water. Based on discussions with MCA-T and the utilities, we do not expect this to be a significant issue. In addition, we would not expect to measure any change in outcomes in Dar es Salaam until the new transmission main that is being built to accommodate the increased water supply is completed. This second assumption does not affect Morogoro.

The intervening variables in this relationship include accessibility, reliability, and adequacy of the improved water supply. In terms of accessibility, this includes factors such as whether the increased water production is available only overnight through household taps, or even whether a household is able to connect to the network if they desire to do so. Reliability refers to the consistency of water flow through the system, and whether frequent and unpredictable outages persist. Adequacy of the improved supply relates to how the outputs in terms of water production relate to the total demand for water in each city. In addition, increased consumption will depend not only on having water available and accessible, but also whether a household can afford to increase their consumption.

In terms of diarrheal illness, one antecedent includes the availability of better quality water than that which households currently use. This again relates directly to the effectiveness of the interventions and whether they produce better quality water (or induce people to switch to better quality water). The intervening variables with respect to health are considerably more complex. Contamination of water supply happens through various channels after it is drawn from the source, including transport, storage, and retrieval. In addition, illness is further influenced by hygienic behaviors, as well as sanitation conditions and disposal of waste Lastly, increased investment in human and physical capital require access to schooling activities, the ability to reduce water collection duties and expenditures, and reduced incidence of illness and other causes of opportunity costs. Physical capital investments depend on the business climate, access to capital, and a host of other contextual factors.

WATER SECTOR PROJECT LOGIC

Lower Ruvu Plant Expansion and Morogoro Water Supply

PROCESS

Activities	Indicators
Finance feasibility, design activities	**Value of feasibility/design contract ($)***
	Value of feasibility/design contract disbursed ($)*
	Certificate for Environmental Impact Assessment (EIA) issued (Date)
Finance construction activities	**Value of construction contract ($)***
	Value of construction contract disbursed ($)*

OUTPUTS

Result	Indicators
Improve treatment plants	**Schedule of Performance Ratio (ratio)**
Increase water production	**Volume of water produced (liters/capita/day)***
Reduce water losses	**Non-revenue water (%)***
Improve financial sustainability	**Operating Cost Coverage (ratio)***
Increase temporary employment	**Total number of people temporarily employed/contracted by MCA-IEs (#)***

OUTCOMES

Result	Indicators
Improve water service coverage	**Number of non-domestic customers (#)***
	Number of domestic customers (#)*
	Percentage of non-active customers to total customers (%)
	Percentage of households with access to improved water supply (%)
Improve quality of service	**Continuity of service (hours/day)***
Improve quality of water	**Nephelometric turbidity units (NTU)**
	Coliform Microbial Density (per 100 milliliters)
	Free Chlorine Residual (FRC)
Increase water consumption	**Volume of commercial water consumption (cubic meters per month)***
	Volume of residential water consumption (liters/capita/day)*

SHORT-TERM OBJECTIVES

Result	Indicators
Decrease incidence of water-borne related morbidity	Percentage of population with diarrhea in the last 2 weeks (%)
Improve human capital accumulation	Average hours worked last week (hours)
	Percentage of school children who missed any in the last 4 weeks (%)
	Average time spent fetching water from home in last week (min)

MEDIUM-TERM OBJECTIVES

Result	Indicators
Decrease in mortality	National level <5 mortality rate (per 1000 births)
	National level Adult mortality rate (per 1000)
Increase investment and economic activities	Average current value of household assets per capita ($)
	Average value of commercial assets ($)

COMPACT GOAL

Result	Indicators
Poverty Reduction and Economic Growth	Average annual household income per capita ($)

Bolded text refers to Indicator Tracking Table (ITT) Indicators which will be reported on a *quarterly* basis. All other indicators will be reported on as data is available.

* Refers to Millennium Challenge Corporation Common Indicators for the Water Sector

Source: MCA-T Monitoring and Evaluation Plan, April 2012

FIGURE 21: MCA-TANZANIA COMPACT WATER SECTOR PROJECT LOGIC

The potential links between water sector improvements and the longer term objectives and goal, including increased human and physical capital investment, reduced mortality, and increased income) are less obvious than the short-term objectives (e.g., households with access to more water, lower incidence of water-related disease, etc.), are observed over a much longer time horizon, and are expected to represent much smaller effect sizes. While these features make establishing attribution difficult, the evaluation design aims to provide a thorough and nuanced understanding of project impacts, although the focus is on measuring impact on the short-term objectives.

To effectively evaluate project impact and achievement of these objectives, the evaluation design considers outcomes and short and medium-term objective results, and aims to identify how these outcomes and results are distributed among sub-groups of interest in the population (e.g. female and low-income sub-groups). The baseline data collection phase of the impact evaluation is designed to measure baseline values of the key intervention outcomes and objectives, which will be measured using a household survey and a treatment effects approach to establish a causal link between increased access to water and human capital investment. Indicators of outcomes and short- and medium-term objectives are presented in Table 2, with the expected results due to the WSP intervention.

In addition, the exercise is meant to speak to the antecedent and intervening variables described in the project logic, and explore the mechanisms by which these outcomes and results objectives could be reached. Primary, quantitative data collection activities provide information for the main indicators of interest from the project logic, while a combination of quantitative and qualitative data address contextual factors and intervening variables. The data collection strategies designed for these purposes are described in Section IV.

TABLE 2: WSP OUTCOMES AND OBJECTIVES WITH EXPECTED RESULTS

Result	Expected Impact	Gender Specific Impact	Differential Impact on Poor?
Outcomes			
Water service coverage	Positive	N/A—household-level effect	Larger impact on poor
Water service quality	Positive	N/A—household-level effect	Unclear
Water quality	Positive	N/A—household-level effect	Unclear
Water consumption	Positive	N/A—household-level effect	Larger impact on poor
Water expenditures	Negative	N/A—household-level effect	Unclear
Water security	Positive	N/A—household-level effect	Larger impact on poor
Short-term Objectives			
Water-related morbidity	Negative	Unclear	Larger impact on poor
Human capital accumulation	Positive	Larger impact on women	Larger impact on poor
Medium-term Objectives			
Mortality	Negative	Unclear	Larger impact on poor
Economic activity	Positive	N/A—household-level effect	Larger impact on poor
Compact Goal			
Poverty	Negative	N/A—household-level effect	Larger impact on poor

3 CONCEPTUAL FRAMEWORK AND LITERATURE REVIEW

The primary long-term goals of the water-sector investments are to improve human capital and economic production and to decrease the prevalence of water-related disease. A wide literature holds that improved access to clean water in the developing world is associated with significant health gains, particularly among children (Jalan and Ravallion 2003, Merchant et al. 2003, Fink et al. 2011). More broadly, the literature generally concludes that interventions increasing access to improved water have positively impacted target populations, particularly by reducing occurrence of diarrhea and other water-related illness (Waddington et al. 2009). Evidence also indicates that increased water access can have positive economic benefits, particularly by increasing household savings and freeing up funds and time for other pursuits (Galiani et al. 2008).

In an urban setting, a number of confounding variables must be addressed. As the water projects are mainly designed to expand water production, benefits to the population will depend on the expansion of water availability. Transmission mains, connection rates, and distribution mechanisms are all major intervening variables that must be considered. In addition, it is important to control for household income and education levels since these are correlated with health outcomes (Jalan and Ravallion 2003, Lee et al. 1997, Novak 2011). Another factor is maternal education, which has been linked to child health (Desai & Alva 1998). Finally, children are often responsible for water collection so differential impacts by gender and age must be considered. The presence of seasonal variability could result in significant differences between the rainy and dry seasons in water sources used, water availability, and outcomes such as the time spent collecting water, employment, water expenditures and health. For example, diarrhea incidence is significantly lower during the dry season.

Most evaluations of water sector investments in developing countries conceptualize the treatment as a binary variable: water supplies are either “improved” or “unimproved.” For example, in a rural system, treatment households have access to water from a newly protected borehole while comparison households do not. The households with newly improved water source access are easily categorized as treatment units, while the remainder can be classified as a control group (see Jalan and Ravallion, 2003). Such studies are limited in two ways. First, binary models do not account for other water sources that may still be used by the household (Novak 2011). Most households avail of multiple sources of water for different uses and binary classifications fail to account for these additional water inputs.

Second, access to water is often continuous. In other words, even if a household has pipes or installed water access nearby, constraints on the water system’s capacity may influence the actual water availability differently in various locations. One household may have substantially less water access than a comparable household simply due to variable access within the system. Water quality can also vary over a continuum and by source. These considerations make the improved-unimproved binary classification inappropriate for many situations, since they fail to capture the complexity of factors affecting water collection and use.

These limitations are especially salient in the case of this evaluation. All urban Tanzanian residents already have access to some level of water – the question is whether more water and higher quality water will cause measurable improvements. Increased water production will reach potential beneficiaries through a distribution system to which households are able to connect, whether directly or indirectly, relatively easily. System capacity constraints will maintain spatial variability in access to water. Therefore, the intervention could effect changes in the portfolio of water consumed by a household and increases in total water consumption. We use continuous or generalized propensity-score matching and instrumental variable regression analysis to estimate the effects of differential water access experienced by Tanzanian households.

Notably absent in the literature on water impact are impact evaluations of urban-focused water projects. Most evaluations have been rural, partially due to the relative ease of performing a rural water-sector impact evaluation. Rural projects typically involve providing water to populations who previously had negligible access to clean water, while urban water reforms involve many more clients and widely varying levels of water access, creating substantial measurement challenges. Our evaluation makes an important contribution to this literature as we examine how variability in quantity and quality of piped water in urban areas of Tanzania affect a number of outcomes.

3.1 Economic model

The underlying conceptual model is simple: access to increased quantity and improved quality of water enter as arguments in a dynamic household production model. In this model, lifetime household utility is maximized through a choice of inputs into various production processes, including food preparation and household maintenance, health production, and investments in schooling. Decisions are constrained by the production technologies, an overall budget constraint, and a time constraint. The time constraint is partially determined by the number and ages of household members. The availability and quantity of water directly affect the production processes and have an indirect effect on outcomes through time and money costs. The model identifies several outcomes of interest, each measured at the individual or the household level: incidence of water-borne illnesses, expenditures due to water-borne illness, household water demand (volume and expenditures), time spent collecting water, labor supply, and schooling investments. Household-level perceptions of water insecurity will also likely be affected. Better water supply (quantity and quality) should reduce illness and defensive expenditures, lower expenditure shares for water, reduce time spent collecting water and increase labor supply and schooling.

4 EVALUATION DESIGN

4.1 Overview

The broad approach of this evaluation is to exploit variability in the intensity of treatment, where the treatment is conceived as access to and quality of water. The water investments will affect, either directly or indirectly, virtually all residents in Dar es Salaam and Morogoro, but households will be affected differentially depending on their starting conditions (availability of water) and their position along the distribution grid. A continuous treatment approach is therefore needed and a generalized propensity score matching (GPSM) approach will be combined with the use of instrumental variables (IV) to control for potential sources of selection bias. At this stage, baseline values of key indicators are described along with the results of preliminary statistical analyses that will inform the final impact analyses.

4.2 Evaluation Questions

After consultation with MCC, MCA-T, local stakeholders, and SI, a set of thirteen original evaluation questions were developed, which are presented in Table 3, organized by the MCC project logic framework. Given the wide range of evaluation questions, different evaluation and data collection methods must be utilized. Importantly, most questions require multiple methods to be fully addressed. Even questions that rely primarily on quantitative data benefit greatly from additional, contextual information generated through qualitative methods. By answering these questions credibly, the evaluation will provide a strong basis for understanding program effects, and fill significant gaps in the evaluation and project design literature regarding effectiveness of urban water programs, providing evidence for programmers and policy makers in the sector.

TABLE 3: IMPACT EVALUATION QUESTIONS

Intervention implementation
Was the MCC investment implemented according to plan? (Q13a)
What challenges were encountered? How were the challenges addressed? (Q13b)
What are the lessons learned from the design and implementation? (Q13c)
What variations in this activity might be worth considering in the future? (Q13d)
OUTCOMES: Increased Availability and Quality, Improved Service Quality
What is the project’s impact on water supply at the utility level? (Q1)
What is the project’s impact on the availability of, and access to, water? (Q2)
What is the project’s impact on water quality (at the source, along the distribution channel, and ultimately at the point of consumption)? (Q4)
OBJECTIVES: Increase Water Consumption, Decrease Water-Related Morbidity, Improve Human Capital Accumulation, Increase investment and economic activity
What is the project’s impact on the consumption patterns of water at the household level? (Q3)
What is the project’s impact on health, particularly on the incidence of diarrhea for children under five? (Q5)
Do households increase investment in physical and human capital as a result of increased access to water? (Q7)
Do the project’s benefits and costs accrue differently to men and women (and other important sub-groups)? If so, what are the differences? What are the reasons for these differences? (Q8)
What effects does the program have on businesses, schools, and health centers? (Q9)
GOAL: Reduce poverty
What is the project’s impact on poverty and income? (Q6)
Questions to be addressed post-intervention
Does water supply change create additional customers? (Q1a)
What are the unintended (positive or negative) results of the project? (Q10)
What is the likelihood that results will be sustained over time? (Q11)
What is the cost effectiveness or re-estimated economic rate of return (ERR) based on realized benefits and costs of the project? (Q12)

4.3 Data Sources

SI is utilizing a large volume of primary data for this impact evaluation, including quantitative, qualitative, and geospatial data. These primary sources are supplemented by secondary data, obtained from relevant public agencies in Tanzania. The full baseline survey data was collected between May and August 2013 in both cities. This phase involved the following data collection components:

- Baseline household survey (full-length questionnaire)
- Water quality tests, from a sub-sample of households
- Water quality tests, from distribution system intake and outlet locations
- Phone follow-up survey, focusing on water supply and illness indicators
- Qualitative interviews (focus groups, key informant, and semi-structured interviews)
- Geospatial data of the public water distribution networks and kiosk locations
- Secondary data including utility reports and rainfall data

Table 4 summarizes the data sources included in baseline data collection. Prior to the main phase of data collection, a "mini-baseline" phase was carried out only in Morogoro. The evaluation team had received information from MCC at the end of January 2013, stating that the Mafiga plant upgrades in Morogoro – supplying an estimated three quarters of the municipality's water supply – would be put into operation by the end of April 2013. Given this change in estimated time of upgrade completion, the evaluation team determined that it would be necessary to accelerate the data collection by implementing a streamlined data collection exercise to ensure that an accurate baseline was established. A top priority was to collect pre-intervention data of the sub-set of indicators likely to change in the short term after the intervention (e.g., water consumption, health measures). The mini-baseline therefore included the following primary data collection components:

- Mini-baseline household survey
- Water quality tests, from a sub-sample of households
- Water quality tests, from distribution system intake and outlet locations

However, the plant upgrades were not finished by April 2013, and thus the full baseline data for Morogoro was also conducted prior to the intervention. Due to these continued delays in project completion, the data from the full baseline phase represents a true baseline for both cities. Therefore, the data from the Mini-Survey in Morogoro are not analyzed and reported as part of the main baseline analyses. While the primary impact analyses will be based on the full baseline datasets, the possibility of integrating the data from the mini-baseline into the descriptive analysis at end-line will also be explored.

4.4 Timeline

The baseline data collection was conducted by Economic Development Initiatives, Ltd (EDI), a Tanzanian firm selected through a competitive bidding process administered by the Millennium Challenge Account-Tanzania (MCA-T). Data collection components were staggered between April and September 2013 according to the timeline presented in Figure 22. EDI established a number of processes to ensure quality data collection, summarized below.

TABLE 4: DATA SOURCES

	Source	Unit of analysis	Sampling	Sample Size	Frequency
QUANTITATIVE	Baseline Household Survey	Households and individuals	Two-stage cluster random sample (with stratification in Dar es Salaam)	Dar: 2504 Mor: 2504	One interview per household
	Household Water Quality Tests	Geographic clusters	From within each cluster: random sub-sample of up to 2 eligible HHs; or other shared "community" source in absence of eligible HHs	Dar: 124 HH, 391 Comm Mor: 494 HH, 104 Comm	Once per sampled household or community source
	Phone Follow-Up Survey	Households and individuals	Full household sample	Round 1: 4240 Round 2: 4289 Round 3: 4378	Three phone calls per household
	System-Level Water Quality Tests	System (point of test)	Dar: 6 distribution sites Mor: 9 distribution sites	Dar: 24 Mor: 54	Twice per month
GEOSPATIAL	Public Water Distribution Network	Water Distribution Network; Kiosks	DAWASA/CO MORUWASA	N/A	N/A
QUALITATIVE	Focus Group Discussions	Interviewees/ Communities	Female residents of low-income areas	Dar: 8 Mor: 6	N/A
	Semi-Structured Interviews	Interviewees/ Communities	Community-level water sector stakeholders	Dar: 34 Mor: 18	N/A
	Key Informant Interviews	Interviewees/ Communities	Municipality- and National-level water sector stakeholders	Dar: 8 Mor: 2	N/A
SECONDARY	Rainfall Data	City	Rainfall measurement stations; Dar: 3, Mor: 4	N/A	Daily for the duration of the study period
	Utility Reports	City	DAWASA/CO MORUWASA	N/A	Monthly

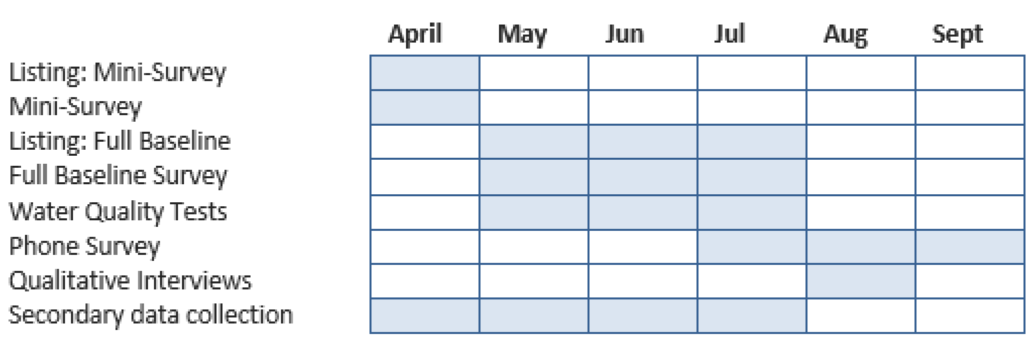


FIGURE 22: BASELINE DATA COLLECTION TIMELINE

5 DATA COLLECTION METHODS

5.1 Implementation

5.1.1 Field Staff Recruitment and Training

EDI's key field staff included a project manager, data manager/assistant team leader, and field manager. Field teams were composed of two Field Coordinators, 12 listing supervisors, and 72 interviewers. Water quality staff included two laboratory supervisors and six laboratory technicians. A data processing coordinator and quality control coordinator supported the survey teams. Qualitative interviews were conducted by two facilitators. EDI recruited veteran field staff for this evaluation. In addition, EDI trained extra field staff in order to be able to send the highest-performing staff to the field as well as secure back-up personnel in the event that any enumerator became unavailable. Training was required for all field staff, including supervisors and HQ staff, which included classroom training followed by a full-scale pilot of listing, sampling, and interviewing. For qualitative interviews, two experienced qualitative research consultants were hired by EDI.

5.1.2 Pre-testing and Piloting

SI worked closely with EDI to develop, pre-test, refine, and finalize all data collection instruments, including the mini-survey, household survey, water quality test result forms, and all qualitative interview guides. Field staff trainings culminated in a full-scale pilot of the survey protocols, including household listing exercises, random selection of households, interviews using the final household survey tools, and collection of water quality samples from eligible households. The full-scale pilots of the mini-survey and household survey took place in the Bukoba urban area in March 2013 (mini-survey) and May 2013 (full baseline). The mini-survey was also piloted in Morogoro in several households prior to the start of data collection. Qualitative interview guides were piloted in July 2013 in Dar es Salaam. SI participated in survey pre-testing, enumerator training, and piloting of all primary data collection protocols with the exception of the phone follow-up surveys.

5.1.3 Data Capture and Transfer

EDI used its in-house electronic data collection system, called Surveybe, to administer the household survey data collection. There are several advantages to using electronic data collection. First, it eliminates error due to manual data entry from paper to electronic databases. Second, Surveybe allows programming of survey logic, implementation of consistency checks across responses to different questions, and validating checks to alert interviewers to potentially anomalous or unacceptable responses. These capabilities dramatically reduce the error related to skip patterns, inconsistent values, or outliers. For example, validation checks programmed into Surveybe display red flags on the screen to alert the enumerator when responses need attention. In this data collection effort, a total of 79 validation rules were programmed within the full baseline household survey and 57 in the phone survey. Interviewers were required to run the automatic validation checks once per screen, and again at the end of the interview. The interview would not be considered complete and would not be uploaded to the database if validation flags had not been addressed by interviewers. Interviewers also have the ability to input comments that provide explanation for seemingly inconsistent or outlier responses. All data from the Surveybe system were delivered to SI via MCA-T in Stata format. Final instruments were produced as PDF documents, exported from Surveybe, and included information on variable names, labels, response choices, validation rules, skip patterns, and the data table to which that data would export. Water quality test results were recorded on paper and subsequently transferred into a database uploaded through the Surveybe system. System-level water quality tests were recorded directly into Microsoft Excel. Qualitative interviews were audio-recorded and transcribed directly into English in Microsoft Word.

5.1.4 Field Operations, Supervision, and Quality Control

The EDI Field Manager, who was responsible for overseeing all data collection teams in the field, was assisted by two Field Coordinators, who directly managed the survey and listing teams and collected the system-level data. This management team was based in Dar es Salaam and Morogoro for the entirety of data collection. During the data collection period, they oversaw the field teams (supervisors, enumerators, interviewers, and laboratory staff) and coordinated all logistics, communicating any issues to higher management as needed. The Data Manager made several visits to the data collection sites throughout the preparation, piloting, and data collection implementation phases to oversee activities and address any outstanding issues. Listing teams worked closely with community representatives to develop the sample frame. For each cluster, the frame was verified by randomly selecting a number of households to visit and verify; frames were not accepted if two or more households could not be verified. During the survey, supervisors were responsible for reviewing the interviews conducted by their teams at the end of each day. This included reviewing each completed interview manually, as well as running the automated validation checks to ensure that all issues picked up by the Surveybe validation rules have been identified. Any errors or inconsistencies detected at this stage were to be addressed with interviewers and reconciled before being uploaded into the database. EDI's policy was to conduct a full re-interview if the supervisors detected substantial discrepancies. In addition, supervisors were to complete direct observations of interviews several times per week, and upload a weekly report summarizing the performance of the interviewers and any actions taken in response. Supervisors were also required to conduct re-visit spot-checks in three to six households per week to ensure data collection quality using a standardized set of thirteen questions selected from the household questionnaire. In total, 116 spot-checks were conducted (51 in Dar es Salaam, 65 in Morogoro) and 86 interviews were observed (40 in Dar es Salaam, 45 in Morogoro). This process was used to monitor interviewers and to provide constructive guidance as needed. Supervisors were also responsible for conducting re-interviews of the entire questionnaire if any interviewers were suspected of fraudulent behavior; no re-interviewers were necessary over the course of data collection.

5.1.5 Data Processing and Quality Control

EDI employed a data processing and quality control team, which was tasked with ensuring the quality of data collected through the Surveybe system. Daily checks of questionnaire data were conducted in Stata using a continually updated checking do-file, which flagged discrepancies and data inconsistencies. Each supervisor was provided a set of data checks to address with each team on a continuous basis. Data processing and quality control staff were primarily based at EDI headquarters, but were present in the field for several weeks during the beginning stages of each phase of data collection. This presence allowed them to participate in feedback sessions with interviewers demonstrating how data checks were conducted and how errors would be communicated to supervisors. The data processing team updated their checks periodically to accommodate new checks arising during the survey period, often in coordination with SI. Further details regarding EDI's data quality assurance procedures are contained in separate reports.

5.2 Data Collection Protocols

5.2.1 Sampling overview

Sampling procedures were developed by SI for all primary data collection. Each procedure was tested and refined as needed during pilot exercises, with SI participation. Households were sampled from both cities using a two-stage cluster sampling methodology, with stratification in Dar es Salaam by the current water supply to an area. Clusters were defined as census enumeration areas (EAs). The sample frame for clusters was an inventory of EAs used for the 2012 census in Tanzania, obtained from the Tanzania National Bureau of Statistics (NBS). Following power calculations (described in the IE Design Report), the required sample size was set to comprise 8 households from each of 626 clusters (EAs), split evenly between the two cities, yielding a total sample of 5008 households. Therefore, 313 clusters were sampled from each city's EA inventory. For each of the selected clusters, EDI's field teams completed a listing of all households to generate a sample frame of households. From each cluster's household list, 8 households were randomly selected for the household survey; additional households from the list could be accessed in order to replace households as needed due to non-response (for details on field implementation and protocols see Annex C1: EDI Field Implementation Manual). After the households were interviewed, a sub-set of eligible households – up to two per cluster – was selected for water quality testing. Following the household survey, the full household sample was included in three rounds of a follow-up survey administered by phone, by the EDI team. The household data collection procedures are summarized in Figure 23, and elaborated below.

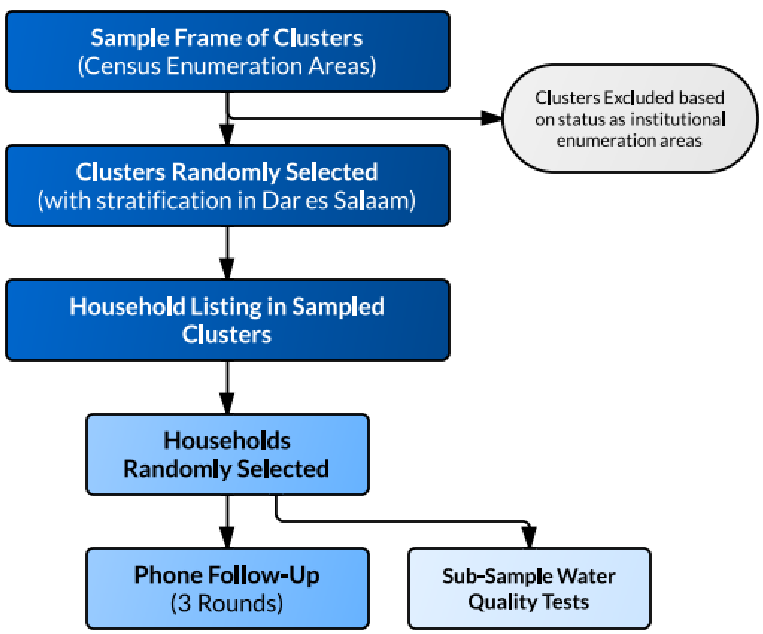


FIGURE 23: SAMPLING METHODOLOGY FOR HOUSEHOLD DATA COLLECTION

TABLE 5: CLUSTER SAMPLING DESIGN

City	Stratum – Weekly Water Supply	Number of EAs (%)		Replacements
		Frame*	Sample	
Morogoro	No Strata	717	313	11
Dar es Salaam	0 Hours, No Infrastructure – non-Lower Ruvu	3,523 (23)	16 (5)	2
Dar es Salaam	0 Hours, No Infrastructure – Lower Ruvu	127 (1)	8 (2.5)	0
Dar es Salaam	0 Hours, Infrastructure (all plants)	2,077 (14)	47 (15)	0
Dar es Salaam	Supply < 24/7 (all plants)	7,263 (48)	211 (67.5)	0
Dar es Salaam	Supply 24/7 (all plants)	2,300 (15)	31 (10)	15
Total		**15,290**	**313**	**17**

* Cluster sample frame reflects revisions after replacements made during sampling

5.2.2 Cluster sampling

To execute cluster sampling, SI first cleaned each sample frame of clusters supplied by the NBS to eliminate duplicate observations. Since the IE focuses on measuring the impact of interventions on households, only residential EAs (clusters) were eligible for selection, so clusters that delineated institutions were to be excluded before the sample was drawn. After exclusion of institutional factors, the sample frame contained 728 clusters for Morogoro, and 15,307 clusters in the sample frame for Dar es Salaam, which were further whittled after exclusions during listing exercises, as detailed below. Final sample frames for both cities are presented in Table 5.

The approach to excluding clusters containing institutions differed slightly between Dar es Salaam and Morogoro. Due to rapid mobilization necessary to conduct the mini-survey before the estimated project completion date, a simple random sample of clusters was drawn from the sample frame in Morogoro. Prior to sampling, clusters that contained fewer than 16 households per cluster according to the NBS inventory were excluded from the sample frame (9 EAs). This exclusion criterion was implemented for two reasons: 1) to ensure sufficient number of households for interviewing, including at least one replacement household per selected household, and 2) to exclude EAs that are likely to contain institutions. EAs with very small numbers of households are likely to represent institutions (schools, hospitals, prisons, military areas), or facility residences.

Sufficient preparation time before the start of Dar es Salaam data collection afforded SI the opportunity to obtain a list of institutions included in the EA sample frame from the NBS ahead of the listing activities, and excluded them from the sample frame before sampling clusters, rather than using household numbers from the NBS inventory as a proxy for EAs that were likely to represent institutions. Based on instructions from the NBS, SI excluded EAs in Dar es Salaam associated with particular institutional codes, including military areas (95 EAs), tourist areas (5 EAs), refugee camps (0 EAs), health facilities (9 EAs), education facilities (62 EAs), and other non-residential areas (3 EAs). In both cities, the objectives of these exclusion criteria were developed to keep residential clusters in the sample and exclude institutional clusters.

Coordinated by MCA-T, SI also worked with the water utility's private operator in Dar es Salaam (DAWASCO) to determine the supplying water plant and the current level of water supply for each ward across the city. DAWASCO provided ward-level supply data, including the number of days per week service is available and the average number of hours of service on those days. SI used this information to identify a set of five strata using the supply levels provided by DAWASCO. Stratification offers the opportunity to ensure the inclusion of households from areas with particular characteristics. Strata definitions were informed by the hypotheses that greatest impacts could be expected in areas that (a) are connected to the distribution network, and (b) currently experience less than 24/7 supply. The large majority of the sample (80%) was thus allocated to these areas. In addition, areas without any current supply, and no infrastructure in place to enable household connections, are not expected to experience pronounced impact in water supply as a result of the intervention. They may, however, experience indirect or spillover impacts through intermediate suppliers of water. Therefore, less than 10% of the sample was allocated to these areas. Each EA in Dar es Salaam was assigned to a stratum based on the ward in which it is located. Sampling weights will be applied during analysis to adjust for stratification.

Selection of clusters was done using a random number generator in Stata 12 software. After selecting 313 EAs in each city, SI requested maps of each selected cluster from the NBS in order to guide EDI's field teams. If EDI's listing team encountered any EAs in either city that contained an institution but had not been previously excluded from the sample frame, that EA was replaced by the next eligible EA from the list based on its random number, and the institutional cluster was excluded from the sample frame altogether. Maps of the final cluster samples are presented in

Figure 24 and Figure 25.Household listing. Since SI was not permitted to obtain the household lists for the selected clusters from the NBS, EDI was conducted listing exercises in the 626 selected clusters, in order to draw a random sample of 16 households from within each cluster (including replacements) to yield 8 interviews per cluster. Using the maps, and with the assistance of local chairpersons, EDI produced household lists for each cluster. Households were then randomly selected from the household lists, in the presence of the community chairman in the interest of full transparency; the local representative was asked to inform the selected households that they would be visited for the survey.

EDI follows a standard listing protocol for household sampling, whereby Listing Supervisors visit the sampled EAs and work with a community representative through the local government, to list the area using a structured form. After verifying the list and making any necessary revisions, the Listing Supervisor draws a random sample of households from the list using a different random number table for each cluster. The community representatives are asked to obtain the contact information of the selected households. The Listing Supervisors then contact sampled households to inform them of the upcoming enumerator visit. During analysis, sampling weights will be applied to adjust for the different selection probabilities of households from EAs, given that total EA populations will vary.

5.2.3 Household survey sampling

Eight households per cluster were randomly selected from the lists generated by EDI, using a separate random number table for each EA. Eight additional households were programmed into the Surveybe system up-front, in case the interviewer needed to draw a replacement for a household that refused or was otherwise non-responsive. The number of replacements input into Surveybe (8) was simply a practical matter of convenience and interviewers were not limited to those eight households for replacement purposes. If all eight in the system were exhausted, interviewers were able to call their supervisor to obtain the information for additional households, as needed, such that no EA should have had fewer than eight households sampled. The cap on in-system replacements limited incentives for enumerators to skip over households based on geography or other factors.

Interviewers made attempts to visit each of the eight sampled households, and were allowed to set a time to return to households who consented to participate but were not available at the time the interviewer first reached their home. Non-response was recorded in the cases where all residents of the sampled household were absent (on holiday, moved, abandoned household, or not present for another reason), completely unavailable to participate, or otherwise declined to participate. In several cases, interviews were completed on a second visit to the household. All attempts, response rates, and completed interviews are documented in Table 6 and Table 7.

Household names, phone contacts, and plot numbers served as the primary identifiers for tracking households between the first interview and follow-up. In Morogoro, listing activities took place during the mini-baseline period in April 2013. To ensure that a full sample of households from Morogoro was obtained during the full baseline period, since some attrition was to be expected between the mini-survey and main baseline (and because the main baseline could now serve the purpose of a real baseline for Morogoro), if a household moved from the EA, a replacement household within that EA was to be interviewed instead. If the household moved within the EA and could be located, that household would still be included in the sample and interviewed. If an original household had split into more than one household, the household with the original respondent was to be surveyed and the situation noted in a comment. If a household could not be tracked at all, that household was considered lost to follow up and replaced with another household from within the EA.

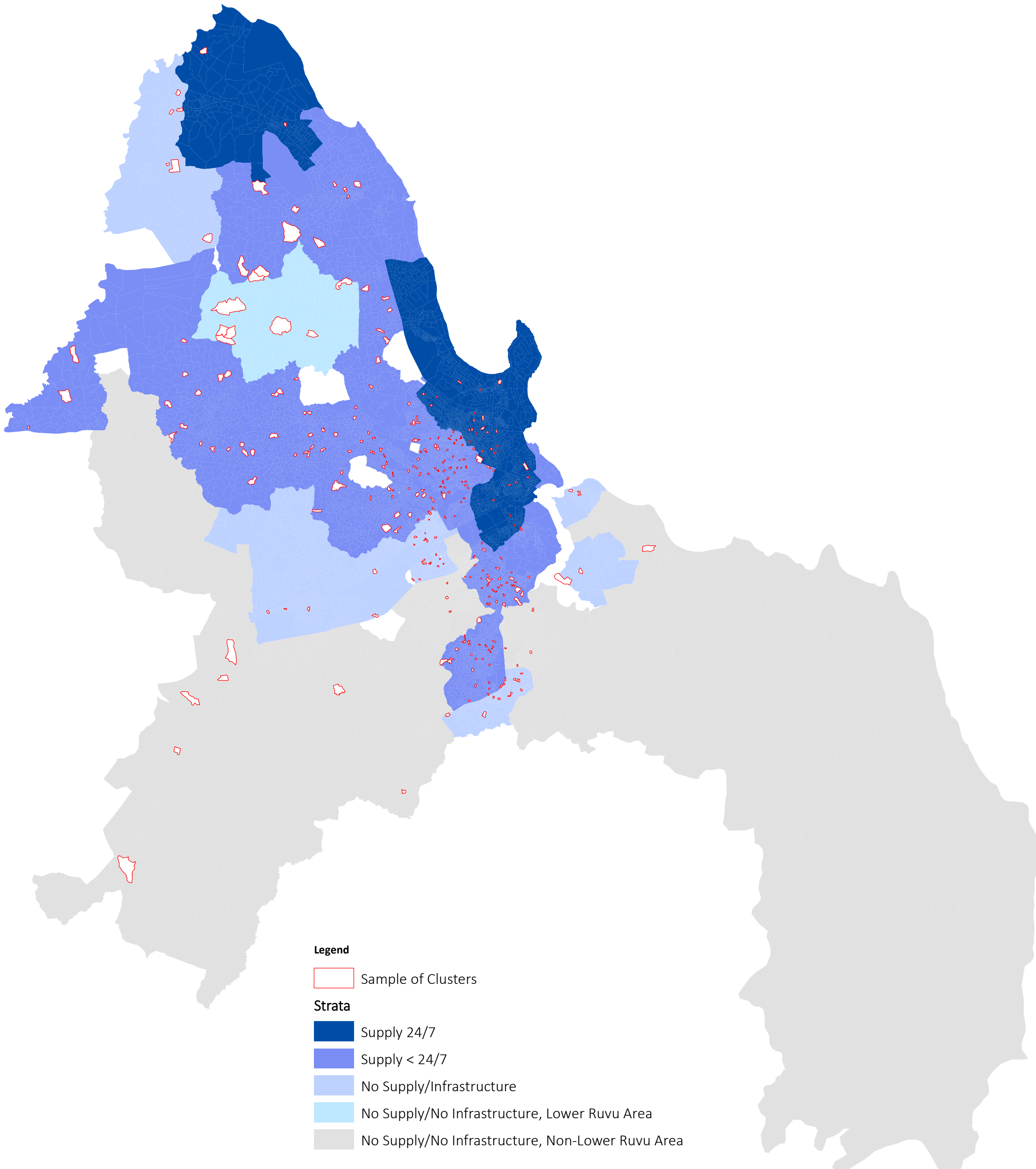


FIGURE 24: STRATIFIED CLUSTER SAMPLE IN DAR ES SALAAM

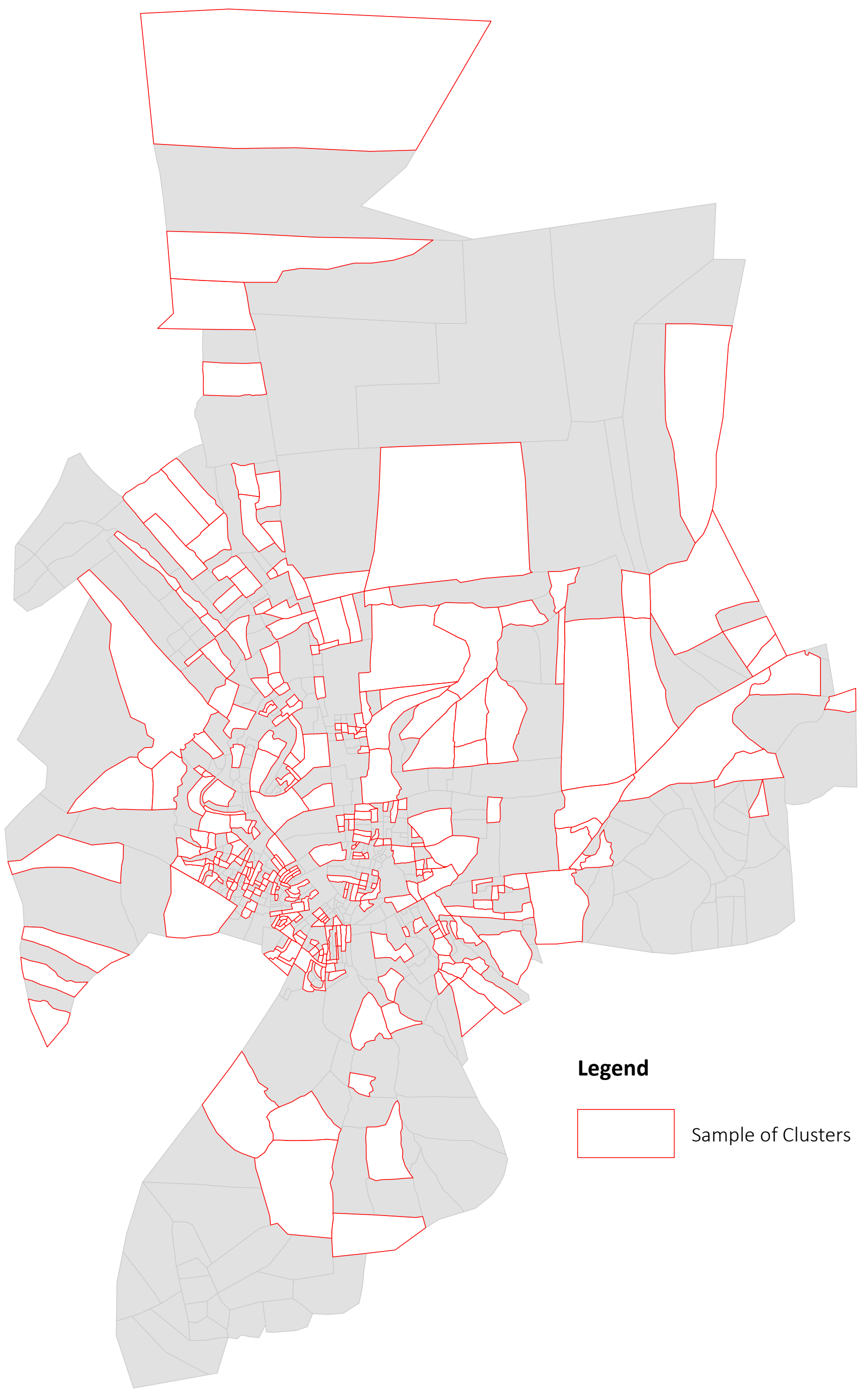


FIGURE 25: CLUSTER SAMPLE IN MOROGORO

TABLE 6: HOUSEHOLD SURVEY RESPONSE RATES, FIRST VISIT ATTEMPT

Result of First Visit Attempt	Dar es Salaam		Morogoro		Total	
	Freq	%	Freq	%	Freq	%
Complete	2,437	87.7%	2,480	92.9%	4,917	90.2%
Partially complete (to be revisited)	94	3.4%	33	1.2%	127	2.3%
Partially complete (with comment)	9	0.3%	6	0.2%	15	0.3%
Eligible respondent not available	15	0.5%	4	0.2%	19	0.4%
Household on vacation/holiday	30	1.1%	18	0.7%	48	0.9%
Household absent for another reason	104	3.7%	30	1.1%	134	2.5%
Household moved	62	2.2%	83	3.1%	145	2.7%
Empty household (abandoned)	2	0.1%	1	0.0%	3	0.1%
Household declined to respond	21	0.8%	9	0.3%	30	0.6%
Other	6*	0.2%	6**	0.2%	12	0.2%
Total	2,780	100.0%	2,670	100.0%	5,450	100.0%
Response rate	87.7%		92.9%		90.2%	
Refusal rate	0.8%		0.3%		0.6%	
% desired sample achieved, in visit 1	97.3%		99.0%		98.2%	

*Other reasons included: Building is used for business purpose, HH was not reached, HHID 8 and 3 belongs to same individual, respondent is student, listed HH out of EA, listed person lives somewhere else

**Other reasons included: HH unknown (3), Respondent is sick and lives alone, mistakenly listed, doesn't live here, went to Dar for medical reasons

TABLE 7: HOUSEHOLD SURVEY RESPONSE RATES, SECOND VISIT ATTEMPT

Result of Second Visit Attempt	Dar es Salaam		Morogoro		Total	
	Freq	%	Freq	%	Freq	%
Complete	67	75.3%	24	80.0%	91	76.5%
Partially complete (with comment)	12	13.5%	1	3.3%	13	10.9%
Eligible respondent not available	1	1.1%	0	0.0%	1	0.8%
Household on vacation/holiday	1	1.1%	3	10.0%	4	3.4%
Household absent for another reason	8	9.0%	8.99	6.7%	10	8.4%
Total	89	100.0%	37	100.0%	119	100.0%
Response rate	75.3%		64.9%		76.5%	
Refusal rate	0		0		0	
% desired sample achieved, by visit 2	100%		100%		100%	

5.2.4 Phone follow-up survey

The objective of this follow-up was to gather additional data points for each household specifically related to water supply and water-related illness. The questions in the phone survey concerning water supply were designed to provide information on the within-household variation in water supply over time.

All households were to be contacted via phone three times, after the full baseline survey. For households that did not supply adequate contact information during the household survey, EDI revisited them to obtain contact numbers – any households revisited to acquire contact information were administered the first round of the phone survey in-person at the time of revisit. However, 19 households were excluded from the phone sample completely, as they did not provide adequate contact information and were interviewed during the last week of the baseline household survey period and could not be revisited since the field teams had to leave the field after the end of household surveying. Therefore, sufficient contact information was available for a total of 4,989 households, which could then be included in the phone survey. The characteristics of the 19 households that were not contacted by phone at all were assessed to determine whether there are any significant differences between those households and the rest of the phone survey sample. In addition, households may have moved between the household survey and phone survey, or between rounds of the phone survey. Therefore, at the start of each phone survey round households were asked if they had moved since the last interview. As it would have been too difficult to confirm whether the household had moved out of the EA, households were replaced only if they reported moving entirely out of the neighborhood (*mtaa*). All other households remained in the phone survey sample.

In addition, since households could become connected or disconnected to the network between survey rounds, households' water supply connection status was reconfirmed at the start of each round of follow-up telephone surveying conditional on their response in the previous survey round, to ensure that the appropriate modules were administered to each household. Not all households were successfully reached in each phone survey round. Households that could not be interviewed in a particular round of the phone survey were still contacted for each subsequent round of phone surveys. The results of interview attempts for each round of the phone survey are displayed in Table 8 through Table 10.

TABLE 8: PHONE SURVEY RESPONSE RATES, ROUND 1 INTERVIEW

Round 1 Call Results	Dar es Salaam		Morogoro		Total	
	Freq	%	Freq	%	Freq	%
Complete	2,153	86.3%	2,087	83.7%	4,240	85.0%
Household temporarily absent	14	0.6%	5	0.2%	19	0.4%
Household moved out of area	5	0.2%	6	0.2%	11	0.2%
Could not get through to household	276	11.1%	347	13.9%	623	12.5%
Household declined to respond	10	0.4%	9	0.4%	19	0.4%
Incomplete, other Reason	38	1.5%	39	1.6%	77	1.5%
Total	2,496	100.0%	2,493	100.0%	4,989	100.0%
Response rate	86.3%		83.7%		85.0%	
Refusal rate	0.4%		0.4%		0.4%	

TABLE 9: PHONE SURVEY RESPONSE RATES, ROUND 2 INTERVIEW

Round 2 Call Results	Dar es Salaam		Morogoro		Total	
	Freq	%	Freq	%	Freq	%
Complete	2,176	89.3%	2,113	86.7%	4,289	88.0%
Household temporarily absent	2	0.1%	3	0.1%	5	0.1%
Household moved out of area	6	0.3%	11	0.5%	17	0.4%
Could not get through to household	232	9.5%	280	11.5%	512	10.5%
Household declined to respond	4	0.2%	7	0.3%	11	0.2%
Incomplete, other Reason	16	0.7%	22	0.9%	38	0.8%
Total	2,436	100.0%	2,436	100.0%	4,872	100.0%
Response rate	89.3%		86.7%		88.0%	
Refusal rate	0.2%		0.3%		0.2%	

TABLE 10: PHONE SURVEY RESPONSE RATES, ROUND 3 INTERVIEW

Round 3 Call Results	Dar es Salaam		Morogoro		Total	
	Freq	%	Freq	%	Freq	%
Complete	2,214	91.0%	2,164	89.1%	4,378	90.1%
Household temporarily absent	13	0.5%	12	0.5%	25	0.5%
Household moved out of area	19	0.8%	6	0.3%	25	0.5%
Could not get through to household	177	7.3%	226	9.3%	403	8.3%
Household declined to respond	3	0.1%	2	0.1%	5	0.1%
Incomplete, other Reason	6	0.3%	19	0.8%	25	0.5%
Total	2,432	100.0%	2,429	100.0%	4,861	100.0%
Response rate	91.0%		89.1%		90.1%	
Refusal rate	0.1%		0.1%		0.1%	

5.2.5 Household water quality tests

The objective of the water quality tests was to obtain a cluster-level measure of water quality within the public distribution network. Tests were carried out by trained enumerators in two households per enumeration area, randomly selected from eligible households that already participated in the household questionnaire. Households were eligible for water quality tests if the household or plot had access to piped water through the public distribution network. Two households per cluster were selected for a test of fecal coliform bacteria, while one sample per cluster was tested for free chlorine residual.

If a cluster did not have any households connected to the public distribution network or had piped connections but no running water for some time, samples were taken from commonly used water sources within that cluster (Table 11). Similarly, if only one household per cluster was eligible, a community source was sought for a second water sample in that cluster. For each selected household, SI instructed enumerators to draw samples from the tap that did not flow through a storage tank. If the household had multiple taps, the enumerators were to select the tap that was most commonly used for drinking or cooking water. Taps were not disinfected prior to drawing a sample due to concerns that it could generate a large number of refusals amid respondents' perceived suspicion of the sterilizing measures. Enumerators noted each spout's cleanliness and condition when drawing a sample. Taps were run for one minute prior to the sample being collected.

If a household randomly selected for water quality testing needed to be replaced for any reason, the survey software randomly selected another eligible household in the same cluster for water testing. This included replacements needed at the time of sampling, as well as at the time of the re-visit to collect the water sample at the household. In several cases, in EAs from which replacements were needed the field team collected water samples from households in that EA that were connected to the public distribution network, but which had not been included in the household survey. Replacements at the time of visit could be taken if:

- Nobody was home in the selected household when the interviewer returned
- Household refused to participate for any reason when interviewer returned, even if consented earlier
- Household did not have running water when interviewer returned
- Household did not to have a tap preceding a storage tank
- It was not feasible to take a test for some other reason at the time of revisit
- There was an EA-wide water shortage, so no households had running water

After the water samples were collected, they were transported to a professional field laboratory for testing. On the same day, trained lab technicians performed chlorine tests on one of the two samples for each cluster. The samples were carefully prepared and tested for fecal coliform 18 hours after the chlorine test. A set of quality control measures was established in the field laboratories. The laboratory set-up was directed by a microbiology expert from a leading institution in Tanzania, and lab staff was supervised by a trained microbiologist with experience working in the laboratory of the water utility in Bukoba (BUWASA). After drawing water from the source, the team placed sodium thiosulfate in test containers to inactivate the chlorine, fixing the quantity of bacteria in the water that is present at the time of drawing the sample and allowing for more accurate fecal coliform measurement.

SI also helped develop standardized paper forms for results reporting and EDI took photos of each sample of the baseline phase. Each slide was read by two different lab technicians; any difference in the readings exceeding 5% was to be subjected to a third reading by a different laboratory technician to break the tie. The lab supervisor re-checked approximately 25% of the slides. Results were eventually entered into the Surveybe system and connected with the household survey data.

TABLE 11: WATER QUALITY TEST SAMPLES DRAWN

Water samples	Dar es Salaam		Morogoro		Total	
	HH	Community	HH	Community	HH	Community
Total number of samples	131	423	494	104	625	527
Samples with valid test results	124	391	494	104	618	495
From surveyed HHs*	115	N/A	486	N/A	601	N/A
Total valid samples	515		598		1113	
Household Refusals	0		0		0	
Clusters Covered	*302*		*312*		*614*	

* NB: Several samples were taken in replacement households that had not been included in the household survey. More details on the sampling procedure can be found in the EDI documentation.

5.2.6 System level water quality tests

Twice a month, EDI's Field Coordinator visited the system-level water quality sites to conduct water quality testing. While utilities regularly track the quality of water at the outlet of water treatment plants, primary data collection included these system level tests in order to obtain an independent measure of water quality. Test locations included water intakes as well as outlets of water treatment plants (Table 12). EDI staff was directed to the appropriate locations, where needed, by the operating staff at the water treatment plants.

5.2.7 Rainfall data

EDI collected rainfall data via the Tanzania Meteorological Agency (TMA) for Dar es Salaam and Morogoro. EDI liaised with the TMA to determine the rainfall stations from which data would be collected. In Morogoro, teams collected data from each rainfall station individually, whereas in Dar es Salaam data for each of the stations was obtained from the central TMA office. The rainfall stations sampled in each city are presented in Table 13.

TABLE 12: SYSTEM LOCATIONS TESTED FOR WATER QUALITY

Dar es Salaam	Morogoro
Lower Ruvu Raw Water from the source	Mindu Dam
Lower Ruvu Treatment Plant	Mafiga Treatment Plant
Upper Ruvu Raw Water from the source	Kola Disinfection Point
Upper Ruvu Treatment Plant	Vituli
Mtoni Water Source	Mgolole
Mtoni Treatment Plant	Kigurunyembe
	Kibwe
	Mambogo Disinfection Point
	Kingorwila Water Reserve

TABLE 13: RAINFALL STATIONS SAMPLED

Dar es Salaam	Morogoro
Julius Nyerere International Airport (JNIA)	Mazimbu Campus
Port Met	Mindu Dam
Ubungu Met	Morogoro Met
	Morning Side

5.2.8 Qualitative interviews

The sample size allocations for qualitative interviews initially proposed by SI were refined after collaborative discussions between SI and EDI, and approved by MCC, to ensure that all respondent categories were adequately represented given the time and resource constraints for the qualitative fieldwork. Table 14 shows the final sample sizes allocated to each respondent category, by city. Sampling for qualitative data collection components was purposive, in order to include specific types of respondents and target areas of each city with specific characteristics (e.g., lower income areas). Qualitative fieldwork was originally planned to take place before the quantitative surveying. However, given the unexpected implementation of the mini-survey in Morogoro, qualitative activities were postponed for several months to allow sufficient preparation time for the mini-survey and to balance the availability constraints of the qualitative team members. Since qualitative data collection was postponed until August 2013, the household datasets from the baseline could be utilized to guide the sampling for the qualitative component.

TABLE 14: QUALITATIVE SAMPLE COMPONENTS

Respondent Category	Dar es Salaam	Morogoro	Total
FGD: Female residents of low-income areas	8*	6	14
SSI: Water kiosks	8	4	12
SSI: Water tankers	4	2	6
SSI: Other water vendors	6	3	9
SSI: Water-reliant businesses	6	4	10
SSI: District Medical Officers	3	1	4
+ Health Facility Site Visits	3	2	5
SSI: District Education Officers	3	1	4
+ School Site Visits	5	2	7
SSI: Community-managed Water Supply System	1	1	2
SSI: FGD respondents with exceptional experience	3	2	5
Key Informant Interviews	8	2	10

* The first focus group in Dar es Salaam was conducted with a mixed group of males and females

5.2.9 Focus group area selection

To select areas for focus groups, SI prepared a matrix of information for "candidate areas." Candidate areas were defined as neighborhoods (*mtaa*). The neighborhoods are generally considered to contain relatively homogenous groups of households, and have the benefit of being a more salient geographical delineation for local community members. For example, each *mtaa* has an elected representative and an appointed chairperson, who are responsible for different aspects of community organization and liaising with local government. *Mtaa* selection was based on a combination of information, including household survey data at the ward level, such as water shortages and connectivity to piped water through the network; and at the *mtaa* level, such as poverty indicators (e.g., asset index, consumption expenditures, female household head). In addition, SI elicited suggestions for areas to target from key informant respondents in Dar es Salaam and Morogoro.

Ward-level water supply was calculated using household survey data reports of water shortages in the last 7 days. The indicator was calculated at the ward level instead of the *mtaa* level because rationing is planned at the ward level, and water supply areas are delineated by ward. *Mtaa*-level characteristics were tabulated from the main household survey data tables, and the *mtaa*-level distribution of socioeconomic status quintiles, using an asset index of consumer durables was calculated by SI at the household level and aggregated to the *mtaa* level. The final baseline household data as delivered by EDI, prior to final data quality monitoring checks, were used to calculate the indicators. Final selection of areas to target for the qualitative work used the following factors to maximize the probability of choosing areas with the potential to benefit from the WSP: geographic location; water supply and connection status variation; low-household socioeconomic status (SES); supplying source (emphasis on Lower Ruvu); variation in household characteristics (aggregated to *mtaa* level). The full process of selecting areas for the qualitative fieldwork is summarized in Figure 26.

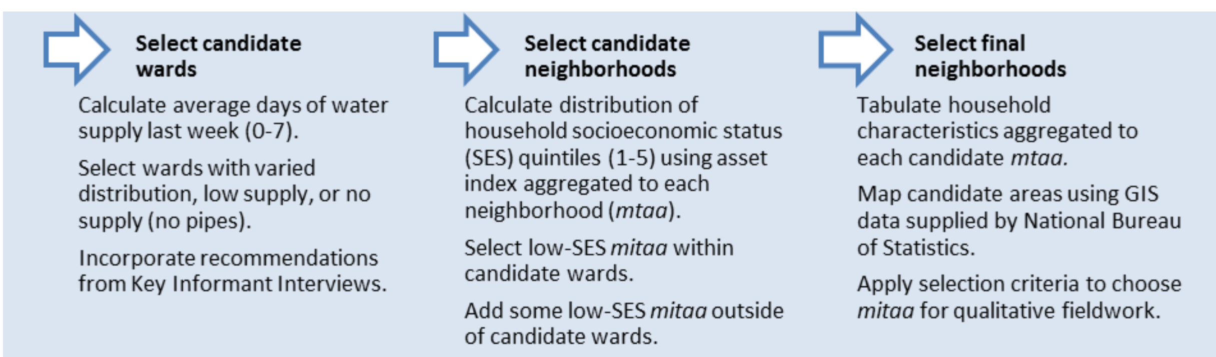


FIGURE 26: AREA SELECTION PROCEDURE FOR FOCUS GROUP DISCUSSIONS

5.2.10 Focus group participant selection

A Field Coordinator from EDI visited either the Mtaa Executive Officer (MEO) or Village Chairman (*mwenyekiti*) of each selected *mtaa* to arrange the focus group to take place in the following one or two days. The MEO or *mwenyekiti* was asked to work with the Field Coordinator to arrange a suitable venue and to convene a group of eight female residents from households spanning the geographic area of the *mtaa*. This process helped avoid a disproportionate recruitment of the households closest to the guide's office or own residence, or his/her closest acquaintances or relatives. Participants were selected to meet two main criteria: 1) community residents above 16 years of age, and 2) knowledge of water issues in their households and neighborhoods. The MEO/Chairman was not allowed to participate in the focus group as this could potentially inhibit the comfort of the participants to respond honestly, provide detail or discuss specific examples. The composition of focus group discussions within each city is presented below in Table 15.

TABLE 15: PARTICIPANT COMPOSITION OF FOCUS GROUPS

	Dar es Salaam		Morogoro	
Participant Characteristics	**# Participants**	**%**	**# Participants**	**%**
Occupation *				
Government or public organization	0	0%	1	2%
Construction	0	0%	0	0%
Business	36	56%	9	19%
Exporter	0	0%	0	0%
Factory worker	0	0%	0	0%
Food seller	9	14%	2	4%
Operate a guesthouse	0	0%	0	0%
Other services	3	5%	0	0%
Non-public	2	3%	0	0%
Self-employed	14	22%	13	27%
Farmer	1	2%	25	52%
Other	2	3%	0	0%
None provided	0	0%	1	2%
Gender				
Male	4	6%	0	0%
Female**	60	94%	48	100%
Age				
15-24	2	3%	2	4%
25-34	13	20%	13	27%
35-44	24	38%	16	33%
45-54	14	22%	10	21%
55-64	11	17%	3	6%
65 or older	0	0%	4	8%
None	0	0%	0	0%
Total number of participants	*64*		*48*	

*Some participants listed more than one job; therefore, sum of percentages exceed 100. Those that checked "Business" and "Self-employed" were just included in the self-employed category.

**Female-only focus groups were established after the first FGD in Dar es Salaam took place.

5.2.11 Semi-structured interview respondent selection

Water Kiosks: Water kiosks were eligible for selection if they were connected to the public distribution network and operational at the time of the interview. A list of eligible kiosks was compiled by EDI from a list provided by DAWASCO. To the extent possible, SI purposefully selected kiosks to interview that were located in the same general areas as the focus group discussions. Kiosks whose water came exclusively from non-DAWASA sources were categorized as "other water vendors."

Water Tankers: Water tankers were eligible for interview selection if they primarily provided water from the public distribution network to their customers. EDI therefore visited public network filling stations to find such tankers, rather than parking stations, to identify eligible operators who were knowledgeable about the function and operation of the tanker. However, respondents in the water tanker group were not to be excluded if, during the course of the interview, it was discovered that they provide water from non-utility sources a majority of the time.

Other Water Vendors: Other water vendors were categorized as informal, mobile, or vendors that did not provide utility water all of the time. Some examples include boreholes, pushcart operators, water bag or bottle vendors, and individuals who sold water from their own tap. Also included in this category are kiosk and tanker operators who supply only non-utility water (e.g., kiosks who provide water from boreholes). A list of these types of vendors was compiled by through focus group discussions, and directly identifying such vendors in their place of work.

Water-Reliant Businesses: This category included businesses that rely on water to run their operations, produce goods, or maintain equipment, and that cannot reasonably conduct their business without water (e.g., restaurant, car wash, or agricultural business). These businesses were identified primarily through suggestions gathered during focus group discussions. In addition, several respondents were identified through discussion with the MCA-T Gender Integration Program (GIP) Lead, who suggested several woman-owned businesses in Morogoro to be included in the sample.

Community Managed Water Supply Systems: Community managed water supply systems are defined as any community-managed scheme providing water to the surrounding community, typically managed by an individual or organization, keeping its own records of sales and billing and responsible for the maintenance and operation of the water system. To the extent possible, systems that manage utility-provided water were selected. Thus, to gather recommendations of community-managed systems to visit, EDI consulted the utilities in each city.

Schools/Education Facilities: EDI visited District Education Officers (DEOs) to collect broad district-wide information about water supply issues at schools in Dar es Salaam and Morogoro. Enumerators conducted joint meetings with the primary and secondary school DEOs when possible, or separate interviews with one or both, to capture variation in water supply issues between school types. DEOs were able to designate another knowledgeable official as needed. Following the interview, DEOs were asked to suggest specific sites that illustrated the points discussed during the interview. EDI field coordinators visited these sites at a later time and conducted brief discussions with the facility/school manager by following the key discussion points developed by SI. Interviews were recorded if the respondent consented. The field coordinator photographed visible issues at each site that were related to water quality. Given the diversity of education facilities, care was taken to visit an array of institutions, including government and private boarding schools, primary schools, and secondary schools. If DEOs could not make recommendations about private schools to visit, EDI contacted a private school association in order to gather appropriate suggestions.

Health Facilities: EDI visited District Medical Officers (DMOs) to collect broad district-wide information about water supply concerns at health facilities in Dar es Salaam and Morogoro within each of the cities' districts. DMOs were able to designate another knowledgeable official if he/she was unavailable. DMOs were asked to suggest specific sites that illustrated the points discussed during the interview. Field coordinators visited these sites at a later time and conducted brief discussions with the facility manager by following the key discussion points developed by SI. The field coordinator photographed visible issues at each site that were related to water quality. Other health facilities were selected to represent both public and private sites as well as a range of treatment offerings, including dispensaries, clinics, and hospitals. If DMOs could not make recommendations about private health facilities to visit, EDI contacted a private health facility association in order to gather appropriate suggestions. A total of six health facilities and seven schools were visited.

5.2.12 Geospatial data

Although the majority of the geospatial data will be utilized in the final impact analyses, GIS data has already been used during the baseline data collection and analysis to inform sampling procedures in both cities, as well as to calculate distances from households to the distribution network (which is the main instrumental variable analysis planned for end-line impact evaluation), and to connect household locations with rainfall data that can be used as an important covariate in certain analyses. The collection of GPS points of each household in the sample introduces the possibility of a host of spatial analysis that can be done using household-level data projected spatially, including additional spatial analyses using data collected from the survey, qualitative interviews, site visits, and through water quality tests. Extensive GIS analysis has not been conducted at this stage. Some preliminary analyses have been done with the water quality data, focused on identifying spatial patterns in the data, and are presented in this report within the discussion of water quality results. The data requirements are in place such that SI may discuss MCC and MCA-T's priorities for any follow-on analysis as part of baseline or end-line that may inform ERR calculations, planning for end-line, or respond to local stakeholder requests. This section provides a brief summary of the collection methods and use of GIS data during the baseline phase, and presents maps of the water distribution network, kiosks, and rainfall stations at baseline in Figure 28 and Figure 27, that will be used for the distance-to-network and rainfall control variables (described below) in the main impact evaluation analysis at end-line. In addition, preliminary spatial analysis of water quality data, specifically, the fecal coliform colony count data, in both Dar es Salaam and Morogoro, are presented in this report as part of the water quality results. Methods followed for these analyses are also described below.

5.2.12.1 Data Sources

- National Bureau of Statistics: Enumeration Area sample frame, shapefiles, and maps
- Public Water Utilities (DAWASCO, MORUWASA): Water distribution network shapefiles
- Primary data collection (EDI): Household GPS points, rainfall stations, system-level water network points tested for water quality
- Revision of secondary data and additional primary data collection (SI): SI contracted a Tanzanian GIS specialist in Morogoro, who works on a regular basis with MORUWASA, to digitize updates to the public water distribution network files for Morogoro city as well as take GPS measurements of all kiosks in the city.

5.2.12.2 Sampling

Since listing was carried out by the EDI listing team, maps of each EA were required in order to develop the household frames from which households would be selected for surveying. Further, the sampling design in Dar es Salaam was stratified by supply area. SI projected utility-provided lists of supply levels in the city onto the EA shapefiles provided by the NBS. This visual display of supply across the city considerably informed how each stratum was defined. Lastly, GIS data was used to ensure that areas selected for qualitative interviews were geographically dispersed. While household data was used to identify candidate areas, projecting those areas onto the maps of each city formed part of the criteria used to select an area for focus groups and semi-structured interviews.

5.2.12.3 Household distance to distribution network

As part of the evaluation methodology elaborated in the SI IE design report, an instrumental variable regression utilizing the distance of each household to the distribution network is planned for the final impact analysis. At baseline, measurement of this indicator was operationalized through the collection of GPS points during the household survey for all households interviewed. GPS points were inspected and cleaned as part of SI's routine data quality monitoring, then projected in the city boundaries, and overlaid with files for the water distribution networks, as well as operational kiosks. The straight-line distances from each household to the nearest point on the distribution network were calculated in two ways: (1) using only the distribution pipeline, and (2) using the distribution pipeline as well as operational kiosks. As elaborated in the design report, distance to the distribution network may serve as an exogenous measure of exposure to the increased water supply expected as a result of the WSP.

5.2.12.4 Rainfall controls in the analysis

Weather patterns can influence several of the indicators of interest in this IE, such as water quality and diarrheal illness. EDI collected daily rainfall data during baseline by visiting rainfall stations operated by the Tanzania Meteorological Agency (TMA) in Dar es Salaam and Morogoro. Daily rainfall affords several advantages over aggregated data. First, the seasonality during the data collection period can be explored. Rainfall data indicates that surveying took place largely during the driest periods of the year. While the baseline survey sample size was not designed to be representative of each season separately, the findings can now be contextualized to the specific weather conditions. Daily rainfall data enables the calculation of a running 30-day average rainfall in the days preceding each household interview. Since diarrheal illness is mediated by weather conditions that affect water source quality and sanitation, a monthly average is not likely to be as relevant for a household interviewed early in the month, compared to a household interviewed later in the month. Therefore, when conducting the impact analysis for health outcomes, the average rainfall over the previous 30 days of each household interview can be utilized, to control for the household's exposure to rainfall.

5.2.12.5 Preliminary Spatial Analysis

The evaluation team examined spatial patterns in the water quality data, to examine spatial clustering with water quality data. Since spatial patterns in water quality can be indicative of particular factors that may cause contamination, whether relating to the source, the piped infrastructure, the environment around the place from which water samples were drawn, or other factors, these results are important as part of the analysis of water quality and in helping to determine areas of focus for further rounds of data collection. Therefore, while not the primary focus of the baseline analysis, some preliminary spatial analyses are presented, including tests of Spatial Autocorrelation, Cluster and Outlier analysis, and Hot Spot Analysis; methodology and results are presented in detail in Section 8.5.7.

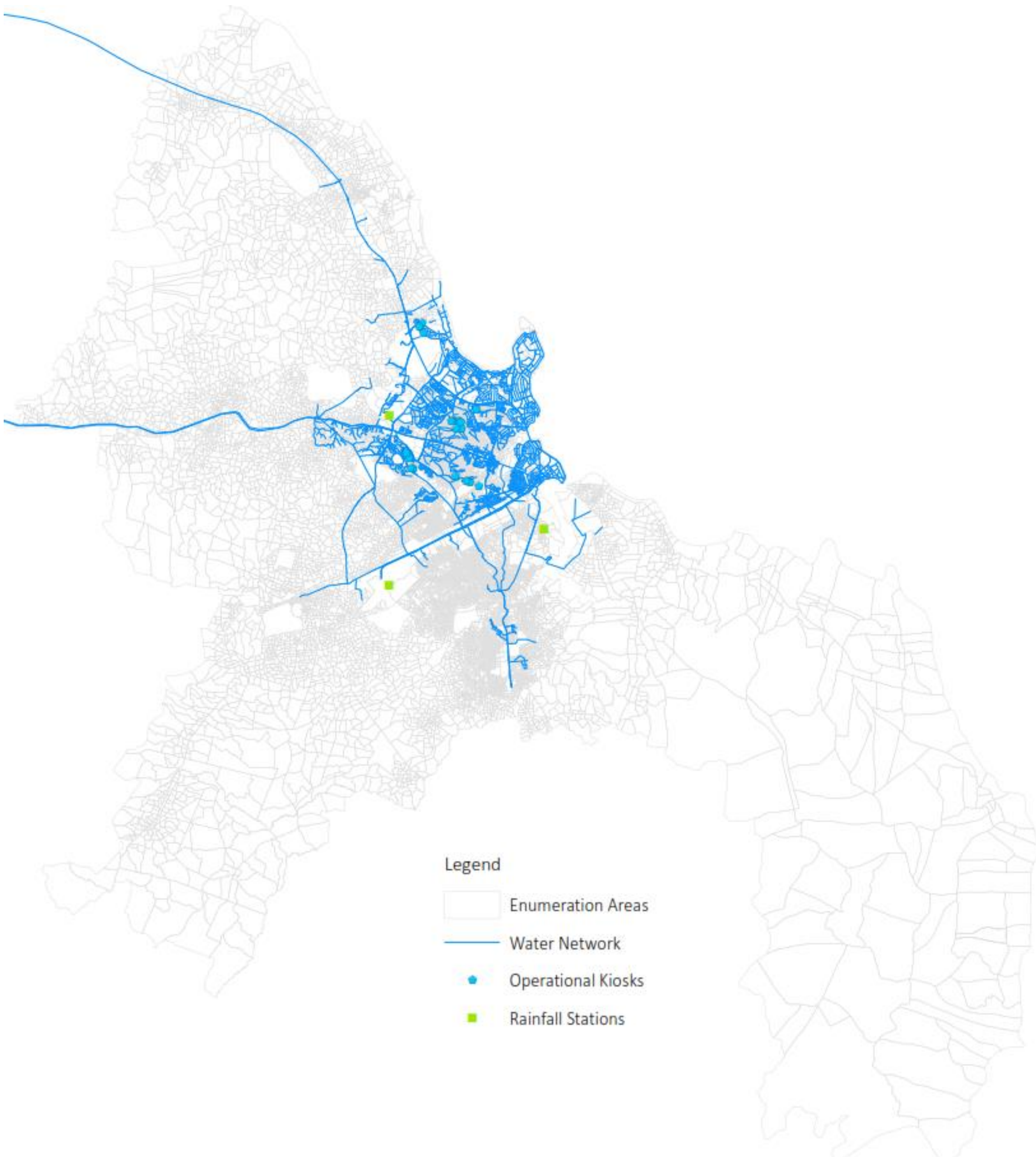


FIGURE 27: DISTRIBUTION NETWORK, KIOSKS, AND WEATHER STATIONS IN DAR ES SALAAM

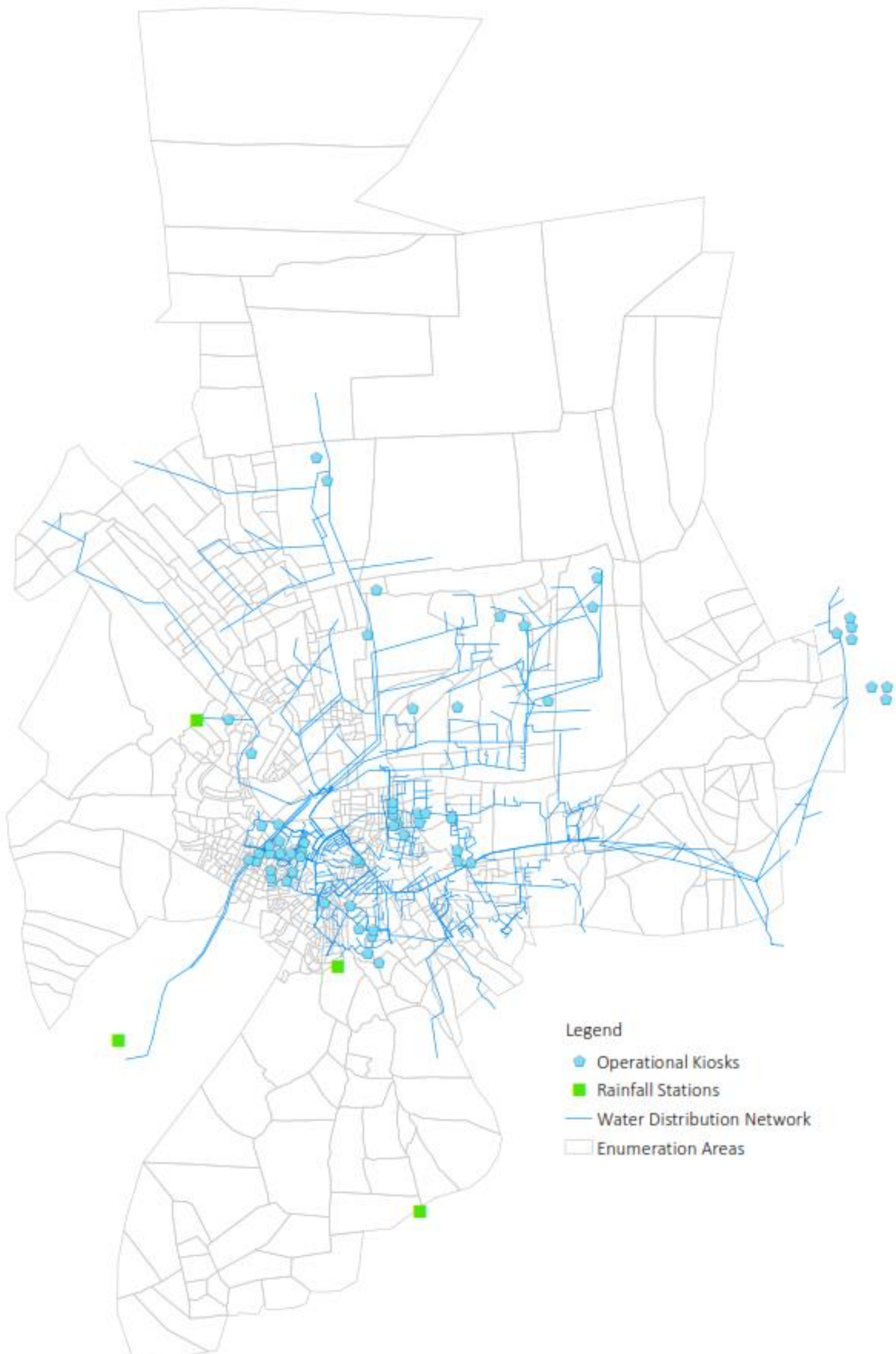


FIGURE 28: DISTRIBUTION NETWORK, KIOSKS, AND WEATHER STATIONS IN MOROGORO

5.3 Ethical Precautions for Research with Human Subjects

The household survey, data collection protocols, and consent forms for this evaluation were approved by the Social Impact Institutional Review Board. All SI staff involved in the study were trained and certified in ethical precautions for research with human subjects. Informed written consent was obtained for each respondent, documenting agreement to participate in the study. A modest incentive in the form of a 500 TZS phone credit was provided to each participant during the second round of phone surveys to thank and compensate each for time spent responding to the numerous survey rounds. These small payments were given to provide a gesture of appreciation without being so high as to coerce participation. EDI also obtained country research clearance from the Tanzania Commission for Science and Technology (COSTECH). Enumerators were instructed and trained to respect the rights of the respondents and to keep collected data in strict confidence. The use of electronic data collection rendered privacy and confidentiality measures easier to implement.

To comply with the ethical requirements of conducting research on topics that may affect the health of respondents, several options to notify households whose taps were tested of the water quality test results were considered. To aid this effort, SI prepared a memo summarizing water quality test results for fecal coliform bacteria using the mini-baseline data collected in Morogoro. The memo contained overall water quality results, information summarizing the protocols and activities of the field lab, and results disaggregated by the location of tap tested (inside dwelling vs. on the plot in the yard). MCC coordinated a working session to bring together representatives from MCC, MCA-T, EDI, Social Impact, and the water utility in Morogoro, MORUWASA, to discuss how to proceed with result dissemination. MORUWASA representatives modified the memo into a format that could be delivered through loudspeaker from a vehicle moving around Morogoro municipality, which they agreed to coordinate weekly until construction is completed. Since this dissemination method did not fully meet the IRB requirements, survey respondents were also informed of the same message during the third and last round of follow-up phone calls conducted by EDI.

6 DATA QUALITY MONITORING SUMMARY

SI's data quality monitoring strategy included the following activities:

1. Continuous Monitoring during Data Collection
Social Impact provided continuous technical support to EDI over the entire period of data collection. The SI team communicated with EDI at least weekly to discuss the progress of data collection, actions taken to mitigate challenges in the field, and any outstanding issues noted in EDI's weekly or bi-weekly reports to MCA-T. These informal check-ins allowed SI to provide important input into replacement protocols for clusters and household level sampling, clarify the sampling protocols, and explain survey questions and enablement criteria in the Surveybe system. As a result, EDI was able to make mid-course corrections more rapidly and efficiently. This process also established an efficient feedback loop to allow SI to communicate any questions about interim datasets to EDI.

2. Participation in Field Preparations
Social Impact ensured field presence at all critical junctures during preparations for data collection. Project Manager, Dr. Olga Rostapshova, travelled to Tanzania at the start of the mini-survey (March 2013) and full baseline survey (May 2013), while Senior Analysts Dr. Jeffrey Alwang and Dr. Charles Pendley participated in the piloting of field protocols at the beginning of the mini-survey (April 2013) and qualitative interviews (July-August 2013), respectively. During these field visits, SI worked collaboratively with EDI to conduct intensive desk reviews of all instruments, oversee and provide technical input during enumerator training, supervise pre-testing of instruments in the field, and conduct random visits during full-scale piloting.

3. Independent Data Verification
EDI's use of an electronic data collection system enabled SI to conduct periodic data quality checks on interim datasets, as provided by EDI. SI wrote cleaning do-files for the mini-survey and full baseline survey, updating them on a continuous basis, and ran through each of the datasets delivered by EDI for the mini-survey, full baseline survey, phone survey, and water quality tests at numerous points between May and September 2013. Each time the dataset was reviewed in full, and a log of queries was sent to EDI for response and clarification. Any checks or minor clarifications needed between these full reviews were included in email check-ins with EDI.

The SI baseline data quality report (see Annex D) elaborates on these quality assurance procedures and monitoring activities implemented as part of the primary baseline data collection. Data quality concerns extend across all stages of the evaluation, including questionnaire design and indicator development, sampling protocols, fieldwork supervision, and dataset monitoring. SI Data Quality Monitoring report addresses measures taken by SI in each of these areas to ensure quality, describes the challenges faced during data collection and actions taken to mitigate them, and outlines the concerns that remain despite SI's due diligence. The data quality monitoring focused on primary data collection; the quality of secondary data sources, such as utility data,[13] was not assessed within this framework. The data quality

[13] Secondary data included indicators related to the utilities' customer base (i.e., domestic customers, non-domestic customers, and percent of non-active customers), which were reported by the utilities on a monthly basis to MCA-T via the Indicator Tracking Table (ITT). EDI also collected this information from the utilities, which will be described in the full baseline report. Since these types of data are secondary sources, SI is not in a position to comment on the methodology used by the utilities to collect and record this data, thus, the assessment of data quality of these indicators is not within the scope of this report.

monitoring document serves as a reference for information relevant to the use and interpretation of primary evaluation data presented within this report.

The overall data quality was assessed to be adequate, with the baseline data collection deemed successful and the desired sample size for this phase reached, although some observations are missing and have been affected by problems with programming mistakes, inadvertently excluded questions and other concerns. Although during the data collection some legitimate and enduring concerns related to the adequacy of staff supervision in the field did arise, the data quality does not appear to be affected. The data has been shown to be of relatively high quality and the field teams appear to have exhibited professional behavior and diligence in data acquisition.

Benchmarking of population data showed that the sampling procedures worked well and the household listing exercises conducted by EDI were shown to be thorough and relatively accurate (described in more detail in Section 8.2). Consumption expenditure comparisons to NPS show that the survey instrument was successful in estimating household consumption with relative accuracy, which will allow the disaggregation of data for the outcomes by socioeconomic status. On the other hand, there were some challenges in assigning the treatment variable based on the shortages module, so the analysis makes use of indexes to combine several measures and relies on instrumental variable methodology, in this case distance to distribution network, to construct a robust treatment indicator. For this reason, the analysis would benefit from updates to the geospatial distribution network data in Dar es Salaam; similar to the recent update conducted for Morogoro.

Finally, some concerns remain with regard to water quality measurements. Fewer observations were collected than expected, as many households did not have access to tap water from the utility, and a large fraction of the water samples came from community level tests, particularly in Dar es Salaam. In addition, a number of water quality tests were invalid due to contamination of the sample, which reduces the water test sample size further. Despite these challenges, the available household data and the system level water quality measurements do provide evidence for water quality in the sampled areas prior to the intervention.

In summary, SI's data quality management process has concluded that while no data collection exercise is perfect in every aspect, the baseline data obtained for this IE is overall of high quality. Numerous checks have been conducted on all aspects of primary data collection, and many concerns have been addressed by the data collection firm. EDI was able to make adjustments in data collection methods and survey instruments during data collection in response to SI's feedback on certain data quality deficiencies discovered in the ongoing data quality checks; utilized household re-visits and follow-up phone calls to clarify responses and obtain missing data; and has commented extensively on the data concerns raised by SI.

In this report, SI deploys sensitivity analysis and other methodologies for data management to cope with the outstanding data concerns during baseline data analysis. This data collection effort has yielded a rich set of mixed-format quantitative and qualitative data, including water quality and GIS data, which enabled various robust analyses of the baseline indicators prior to the intervention.

7 METHODOLOGY

7.1 General Analytical Approach

Identification of causal impacts of increased availability and quality of water requires comparisons of outcomes for households with increased availability of water against a counterfactual: the outcomes for the same households had they not experienced increased availability or quality of water. As the "treatment" is continuous, comparisons can be made to similar households with less access. Since it is impossible to directly observe the counterfactual, a mechanism is needed to estimate one with minimal bias. The preferred method is to randomly assign participation in the intervention within a sample of potential participants, creating a treatment and control group. Through random assignment, the treatment and control groups could be balanced along all characteristics that could affect the outcome of interest. In the absence of the project, both groups would have the same expected outcome and any differences between the two groups after project implementation can be attributed to the project.

For water improvements, however, participation cannot be randomly assigned. A large fraction of the population in both cities will be affected by the change in access to and quality of water, although to varying degrees. Current access varies widely and it is not possible to randomly assign treatment levels. In place of randomization, our study uses quasi-experimental methods for identifying counterfactual outcomes: generalized propensity score matching (GPSM) and a structural instrumental variables (IV) approach. As noted by several authors, matching methods and regression-based model adjustments should not be seen as competing but rather as complementary. Studies have shown that the best approach is to combine multiple methods (e.g., Rubin and Thomas 2000; Ho et al. 2007; Galiani et al. 2005). For example, regression analysis (such as IV) can be conducted on matched samples. Selecting matched samples reduces bias due to covariate differences, and regression analysis on the matched samples can adjust for small remaining differences and lead to increased efficiency (Stuart and Rubin 2007).

7.2 Indicator Definitions

Robust analysis requires high quality data and well-constructed indicators, which reflect context and reduce systematic error. The definitions and methods for calculating key indicators are elaborated in this section, and generally follow the organization of the evaluation questions within the project logic. Considerations of poverty and gender were integrated comprehensively into our baseline analyses – all major variants of the indicators described below are disaggregated by age, sex, and/or socioeconomic status when applicable. Other relevant disaggregation was conducted in some cases, such as by primary source of drinking water.

7.2.1 Project Outcome: Increased Availability and Quality

Ultimately, the objective of the WSP intervention is to expand access to safe, reliable sources of water in Dar es Salaam and Morogoro. The household-level indicators under this outcome from the project logic include the percentage of households with access to an improved water supply, and several measures of water quality. The three main indicators for water quality are measurements of nephelometric turbidity, coliform microbial density, and chlorine residuals (free and total). Measures of turbidity and chlorine were collected at the system level, and measures of chlorine and coliform microbial density were collected from water samples taken from taps at the household levels (or from other sources in the surveyed communities from which households frequently obtained water, in the cases where no household taps were available).

7.2.1.1 Indicator: Percentage of households with access to improved water supply

The measure of households' access to an improved water supply was formulated using primary data collected in the baseline survey. Respondents were asked to report whether they had access to piped water (specifying whether the connection was in the dwelling or elsewhere on the plot), and to specify the source of that piped water (distribution network, private network, special project, etc.). While the intervention does not include an explicit effort to increase demand for connections to the public network, it is anticipated that greater supply through the network may encourage households to connect.

In addition, at the start of the household survey, respondents were asked for each activity including drinking, cooking, washing, cleaning, gardening, and running a household-owned business to report all water sources used by any members of the household for each activity. Households could specify multiple sources used for each activity, and responses were allowed to span both rainy and dry seasons. This module captured information reflecting the plurality of water sources used by households in these settings; this data also pairs well with results from the qualitative interviews.

To maintain comparability with standard, internationally validated indicators, the primary drinking water sources for households were assessed with respect to the categories established by the World Health Organization Joint Monitoring Programme on Water Supply and Sanitation (WHO/JMP). These classifications are shown in Table 16.

However, WHO/JMP categories were not always adequate to capture variation in source quality that best reflected the local context, especially given the urban focus of this evaluation. Therefore, drawing on qualitative and household data, the results were disaggregated by households' primary drinking water source category, as presented in Table 17. This is the main water source classification scheme used throughout the baseline analysis.

TABLE 16: WHO/JMP WATER SOURCE CATEGORIES

WHO category	Definition
Piped on premises	Piped water onto premises (in dwelling or on plot)
Other improved	Neighbor's tap; public tap/standpipe; water kiosk; piped water into business (used for household activities); borehole/tube-well; protected well (covered); protected spring; rainwater
Unimproved	Water vendor; tanker-truck; unprotected well (open); unprotected spring; bottled water; bagged water; surface water

TABLE 17: SI WATER SOURCE CATEGORIES

SI category	Definition
Own Tap	Own tap on dwelling or plot
Other Piped	Neighbor's tap; kiosk; public tap; tap to a HH-owned or nearby business
Vendors	Water tanker trucks; mobile water vendors (i.e., push-carts)
Non-Tap	Borehole; protected and unprotected wells and springs; surface water
Bottled[14]	Bottled water

[14] This category also includes bagged water. While the evaluation team realizes that the general perception is that bottled water is of higher quality than bagged water, the number of bagged water observations were very few (only 2 households out of the entire sample said that bagged water was their primary source of drinking water, both in Morogoro. Adjusting estimates with sampling weights, the percentage of households from each city estimated to use bagged water as the primary source of drinking water is negligible; therefore it is not used as a category in the estimates (household observations have been folded into bagged water but removing them would not change results in any substantial way.

The other three indicators from the project logic under this outcome include:

1) The number of domestic customers;
2) Number of non-domestic customers; and
3) Percentage of non-active to total customers.

These were not measured using primary data collection, but rather secondary data from the utilities that represent their customer base in either city, over the months during which baseline data was collection, was obtained from the utilities and is also presented in the results.

7.2.1.2 Indicator: Nephelometric turbidity

The turbidity indicator was measured only for water samples at the system level, and is expressed in Nephelometric Turbidity Units (NTU) per 100 ml of water. Water samples were collected from designated water distribution system intakes and outlets by EDI field coordinators. NTU was measured using a turbidity tube and read by trained staff. Three complete readings were conducted to ensure quality. The detailed procedures are presented in the EDI Water Quality Testing Protocol.

7.2.1.3 Indicator: Coliform microbial density

The coliform microbial density is a measure of the bacteriological contamination of the water sample. It is measured as the number of fecal coliform bacteria colonies per 100 ml of water. This indicator was operationalized by drawing a water sample from the system or a tap outlet, and then transporting the sample to the EDI field laboratory. There, the EDI staff recorded the number of fecal coliform bacteria colonies per 100 ml of water in each water sample. The indicator can be evaluated as a continuous variable based on number of colonies. However, following the risk classification system utilized by utilities (based on Tanzania Bureau of Standards), a binary indicator for each sample was also constructed, specifying whether the water quality is *Satisfactory* or *Unsatisfactory* based on whether any bacteria was present in the water sample. A *Satisfactory* designation indicates that the water sample contains no colonies, while a sample that contains any colonies is designated as *Unsatisfactory*.

7.2.1.4 Indicator: Free Chlorine Residual

The measure of free chlorine residual (FCR) in tap water is a major indicator of whether the initial level of water chlorination at the system level is sufficient to disinfect the water from bacterial contamination. Thus, the presence of free chlorine residual is an indicator of whether the water is potable. If FCR is present in the water sample, this indicates that an adequate amount of chlorine had been added to the water to destroy bacteria and that the water is protected from bacterial recontamination. The presence of free residual chlorine in drinking water is correlated with the absence of disease-causing organisms, and is thus another way to assessing the quality of the water. Finally, tap water should contain chlorine in sufficient amount to control pathogens, and the chlorine test permits the estimation of the chlorine levels added to the water (total chlorine) and how much of the chlorine is still active.

This indicator is operationalized through the measurement of the concentration of free chlorine residual (in milligrams free chlorine per liter of water). FCR testing was carried out on one of the water samples per cluster, and on all system level water samples. The data quality checks of the reliability of the free chlorine data suggested that this measurement was relatively accurately collected.

7.2.2 Project Outcome: Improved Service Quality

Quality of service is conceptualized as the reliability of the water supply through the public network. The MCC project logic defines the quality of service indicator as the average number of hours per day of service through the public distribution network. While identified as an outcome of the WSP intervention according to the project logic, the variation in service quality as defined by the continuity of service has been conceptualized as the main treatment of interest for this evaluation – that is, changes in the indicators under short- and medium-term objectives will be evaluated on the basis of comparisons made between households that experience varying levels of improvements with respect to continuity of service.

7.2.2.1 *Indicator: Continuity of Service*

This indicator was operationalized through primary data collection by including a module in which household respondents provided information about the number, duration, and consequences of water shortages in the seven days preceding the survey. The survey module used to create this indicator included the following questions: *To your knowledge, were there any water shortages, or any rationing, from your tap in the last week (7 days)? On which day did this shortage occur? Approximately how many hours did this shortage last?* Respondents were also asked to report consequences such as minutes spent collecting water and expenditures on water as a direct result of any of these shortages.

The average number of service hours per day was calculated for each household by subtracting the total duration of shortages in the last 7 days from "full access" hours (168 per week), and standardizing this quantity per day. This information was collected in the main baseline and in each of the phone follow-up surveys. Since not all households were reached for all three rounds of the phone survey, households have between one and four data points for this indicator over the baseline period. Measuring this indicator over several time captured variability in continuity of service over time. These observations over time were not combined into a single aggregate for the baseline phase to maintain the detail of time variation; we present the average supply-days from each round separately.

In response to experiences in the field during qualitative research, one question was added during the third round of the phone survey phrased in the opposite manner to shortages, asking respondents: *How many days per week do you usually get water from the network (in this season)? On those days, for how many hours does water flow?* The responses to this question, presented in the results, provide a rough measure of supply using a different method of measurement. While not explored in depth in the analysis since this questions was only included in the third round of phone surveying, it will be a useful launching point for further discussions about how to best measure supply at end-line.

7.2.2.2 *Indicator: Household distance to distribution network*

This indicator can be used as an instrumental variable to proxy exposure to the WSP intervention, since households closer to the distribution network would be more likely to experience direct benefits. This indicator can be calculated for every single household (with valid GPS points) regardless of their primary water source, which mitigates part of the challenge of using the continuous measure of supply-days that is only directly applicable to households with a piped connection. As described in previous sections, the household's distance to nearest distribution network (meters) is measured by collecting the GPS coordinates for each household in the baseline survey. From the water utilities in each city, SI obtained geospatial data of each public water distribution network and water kiosk locations. SI contracted a local GIS specialist in Morogoro to update the digital maps of MORUWASA's distribution network, update the GPS coordinates for each kiosk in the city and record its operational status. By overlaying these two datasets, the distance from each household to the distribution network can be calculated. The inputs are mapped above in Figure 28 and Figure 27.

While similar data is available for Dar es Salaam, the digital maps of the distribution network, kiosk point locations and operational status have not been systematically updated in those datasets obtained from DAWASCO for at least three years. For this reason, the distances calculated for Morogoro are expected to be substantially more reliable than for Dar es Salaam for the baseline phase. SI recommends contracting another local consultant to update the Dar es Salaam files as has been done in Morogoro.

7.2.3 Project Outcome: Increase Water Consumption

7.2.3.1 Indicator: Volume of residential water consumption

Residential water consumption (liters per capita per day) is identified as an outcome of the WSP intervention, following the project logic that water scarcity prevents households from obtaining and consuming adequate water for household needs. Baseline values of this indicator will therefore be essential to include in the final impact analysis after end-line data collection. To calculate the baseline values of this indicator, volume consumed from all sources used by households on a weekly basis were aggregated.

First, household questionnaires asking respondents to list all water sources used for any activities in the household. For each water source reported by the household, respondents were asked a series of questions specifically related to each source that required collection, including:

1. *In which season(s) is this source used?*
2. *Each time water is collected from this source, how much is collected?*
3. *How often is water collected from this source?*

Responses to the second question were standardized to liter quantities, and responses to the third were standardized to days. All source-specific volumes were aggregated at the household level, and divided by household size. Second, the volume of water used from a household's own tap (for any households reporting such access) was calculated by dividing the response to "*Average utility bill paid to utility per month*" by the current tariff for the utility in each city. These quantities were standardized to the day, and again divided by household size to reach a per capita quantity.

Volume of residential water consumption per capita per day was then calculated as the sum of collected and billed piped water.

7.2.4 Project Objective: Decrease Water-Related Morbidity

7.2.4.1 Indicator: Percentage of population with diarrheal illness, last 2 weeks

The main indicator to measure the short-term objective of decreasing the incidence of morbidity related to water-borne disease is the proportion of the population with diarrhea in the last two weeks. Diarrhea was defined as three or more episodes of loose or watery stools in a day within the previous 14 days. While information about diarrheal illness was collected for all children through ages 18 in the main baseline and through ages 13 in the phone survey, our analysis focuses on diarrheal illness among children under 5, given the relative significance of the burden of diarrheal illness on young children – both in terms of incidence and in terms of the consequences for caretakers – and the inherent difficulty in obtaining reliable estimates about older household members whose diarrheal illness may not be known by respondents of the household questionnaire.

To measure this indicator, questions related to diarrheal illness were asked during the household roster modules of the questionnaire. Respondents were asked whether each child had experienced diarrhea in the last 14 days, and for how many days the episode of diarrhea lasted. Results are reported at the individual level rather than the household; the percentage of the population in each city with diarrheal illness in the past 14 days was estimated using sampling weights. While the analysis focuses on children under 5, results for all age groups, and across main baseline and phone surveys, are presented.

In addition, household spending directly as a result of diarrheal illness (e.g., medical visits, medication) was included in the questionnaire, asked for each child that experienced diarrheal illness in the last 2 weeks. The MCC project logic, as elaborated in the design report and above, posits that any decrease in diarrheal illness that happens as a result of more reliable and higher quality water supply will reduce households' defensive spending against illness that is directly related to water supply factors.

7.2.4.2 Indicator: Water treatment behaviors

Given the emphasis on the safety of households' water supply, we also report summary statistics on household behaviors related to the treatment of water obtained from various sources. Using the primary source of drinking water reported by households, we look at whether households do anything to the water prior to drinking.

Water treatment behavior is important to consider as it influences some of the main objectives of this WSP investment. For example, child diarrheal illness is mediated not only by the quality of water that comes through the network (provided that is where the household obtains water), but also by the conditions in which water is stored, and whether or not it is treated in any way before drinking. There are many pathways (e.g., transport, storage, and retrieval) in which water can become contaminated after it is drawn from the source, and given that households may engage frequently in storage to avoid interruptions in their supply, treatment behaviors are an essential mediating factor to consider in analyses.

7.2.5 Project Objective: Improve Human Capital Accumulation

We assess several indicators related to human capital accumulation, as a short-term project objective of the Tanzania WSP, including:

1. Average hours worked last week;
2. Percentage of school children who missed any in the last 4 weeks;
3. Average time spent fetching water from home in last week (minutes).

In addition, we also explore how much time household members spent in the last 14 days caring for sick children younger than five years of age experiencing diarrheal illness. As described in the design report and above, any decrease in diarrheal illness is also expected to reduce the amount of time that adults miss from productive activities due to the need to care for sick children

7.2.5.1 Indicator: Average hours worked last week

The first indicator for productivity is the average hours worked by each household member in the past week. For any household member who reporting to be formally employed, self-employed, or working in the home, the hours worked in the past week were calculated from questions that asked the number of last 7 days that the individual was doing this work, and the average number of hours per day that they were working, on the working days in the past week. For each household member, the respondent was asked whether these hours were typical for the individual, and if not, what the typical hours were. These questions were asked of all household members aged 12 and older. Since the aggregate number of hours worked by the household will be positively related to the number of able-bodied adult household members, the indicator is normalized by the number of adult members of the household.

7.2.5.2 Indicator: Percentage of school-children missing any in the last 4 weeks

The second human capital accumulation indicator relates to schooling, and is defined as the percent of school children (ages 6 through 18) absent from school in the last four schooling weeks. Due to variability in dates of survey administration across the sample, enumerators were trained to explain to respondents that for each question related to absence from school, the reference period should be taken as the last 4 schooling weeks (i.e., last 20 schooling days), to avoid the introduction of errors due to differences in household survey timing, some of which may coincide with holidays or other school closures. School absences were captured in several modules within the baseline survey.

First, for each child in the household roster aged 6-18 and currently enrolled in school, the respondent was asked whether the child has missed any full or partial days of school in the last four schooling weeks, along with the reason for the absence. These data feed into the results for any-cause absenteeism presented in the results. Second, in the diarrheal illness module, for each child ages 6-18 currently enrolled in school, the respondent was asked whether the child has missed any days of school in the last two weeks due to diarrheal illness. Third, in the water sources module, for each child ages 6-18 currently enrolled in school, the questionnaire asked whether the child had been absent from, or late to, school because of duties to collect water in the last four schooling weeks.

7.2.5.3 Indicator: Minutes spent fetching water from home in the last week

The third human capital accumulation indicator is related to water collection, and is defined as the time spent fetching water in the last week. For each water source reported by the household, respondents were asked a series of questions specifically related to each source that required collection. For this indicator, the relevant questions include: *In which season(s) is this source used? How long does it take to make one round trip to this source (including time spent waiting at the source and collecting water)? How often is water collected from this source?*

Responses were standardized in units of minutes per week, and then all the per-source collection times were aggregated to the household level. The absolute levels of hauling-time per week are described in the results section. For statistical models, to account for different household sizes, hauling times are normalized by the number of household members (per-person hauling times). Households that reported using only piped water were not asked about hauling times, as hauling times were connected specifically to sources requiring water collection outside the household tap. Households that relied only on their own taps for all activities in the household were assigned null values for hauling-time per week. In addition, there are a number of cases where households report obtaining water from tanker-trucks, or other sources that deliver water or may be located nearby and may therefore report no hauling time, even though the quantities they report collecting from other sources may be quite high. In order to capture seasonality, each household was asked to report whether each source was used in the dry season, rainy season, or both, and hauling times per household were calculated accordingly. Season-specific values are analyzed separately in the statistical models presented in the results.

In addition to the household-level hauling times, characteristics of individual who collect water for their households are included in the descriptive statistics, because the intervention aims to decrease the time-burden on members of the household whose time could be alternately allocated toward productive income-generating activities.

7.2.5.4 Indicator: Time spent caring for sick children in the household

Summary statistics are also calculated for time spent by members of the household caring for children younger than five years of age experiencing diarrheal illness in the last 14 days. For each report of a child under five experiencing diarrheal illness in the last 14 days, respondents were asked whether any member of the household (aged 18 or above) missed work, school, or other normal activities in order to care for a sick child.

While this data was collected for each individual, the time spent by adults caring for sick children was aggregated at the household level and normalized, to control for households of different sizes, by total number of children under five years of age (regardless of whether they reported diarrheal illness in the last 14 days). We report the summary statistics for caregiving time for sick children, per child in the household.

7.2.6 Project Objective: Increase Investment and Economic Activities

Under this objective from the project logic, the baseline data collection addressed one indicator: current value of household assets per capita. This indicator is included in the project logic, since additional time and resources freed up from avoided spending and freed time (e.g., lower water expenditures, as well as defensive health spending) can be allocated to productive activities, or invested into homes and businesses.

7.2.6.1 Indicator: Current value of household assets per capita

Only the household level indicator was measured as part of primary baseline data collection, which was operationalized using the value of household durable assets, divided by household size. Data on the quantity of assets owned by households was collected in the household questionnaire using an assets module, as shown in Table 18. In order to estimate the values for each asset, the asset purchases from the Household Budget Survey were used to obtain average asset prices, which were then applied to assets owned by households in both cities. Mosquito nets were excluded due to the uncertainty of the directionality in terms of how this reflects on household wealth; for example, mosquito nets are often freely distributed or highly subsidized as part of pro-poor distribution campaigns, and the ownership of mosquito nets may have more to do with household size since they are a per-person item rather than a shared asset for the household. The value of washing machines, generators, and *bajaj* (rickshaw) could not be included as there was no comparable price to be derived from the Household Budget Survey. These asset calculations were utilized in the analysis to develop one measure of the household's socioeconomic status.

TABLE 18: ASSETS MEASURED IN THE HOUSEHOLD SURVEY

Car / truck other motor vehicle	Generators*
Bicycles	Electric stoves
Motorbikes / mopeds / motorcycles	Gas stoves
Bajaj*	Other stove (Charcoal)
Tractor	Air Conditioning
Mobile telephones	Washing machines*
Computers	Water-heater
Refrigerators/Freezers	Electric Fans / Ceiling Fans
Sewing Machines	Kerosene lamps / lanterns
Televisions	Irons (Charcoal or electric)
Radio or radio cassette	Fishing Boat or Canoe
CD/DVD player	Cart

***** Not included, since no price is available from HBS

7.2.6.2 *Indicator: Reduce water-related expenditures*

This indicator is operationalized as household weekly expenditures on water per capita and the water shares of total household consumption expenditures. The measure of weekly expenditures per capita on water is calculated using the aggregate sum of expenditures for both own-tap sources and all other sources at the household level, divided by the number of household members to arrive at the expenditures on water per capita. Expenditures for own-tap water are calculated based on the amount paid per month on a water bill, divided by the current tariff in each city. For sources other than own tap, as described in sections above, a series of questions was administered to elicit information about the collection of water from each source used by the household, including: *In which season(s) is this source used? How often is water collected from this source? Each time water is collected from this source, how much is collected? Per unit, how much do you usually pay for water from this source?*

The responses to the questions above were standardized to Tanzanian shillings per week (TZS), and were aggregated to the household level, per season. The expenditures reported by households who paid a bill to the utility were added to these amounts, to calculate total weekly water expenditures in each season reported by households. This analysis uses the absolute value of household water expenditures, in Tanzanian shillings, weekly by season, as reported by each household.

7.2.7 Project Objective: Increase Water Security

While not explicitly included in the project logic, the water insecurity experienced by the population in this context underlies the motivation for MCC's investment in water infrastructure in Tanzania. The concept of water security has been defined in many ways, but for this evaluation the following indicators were collected as part of the household survey, each related to the perception of water security:

- Percentage of households reporting water shock as a top 3 shock faced in the last 2 years
- Percentage of households worried about the adequacy of their water supply in the last 30 days

Also utilized were reports of water shocks, which were incorporated in this evaluation's statistical models to explore the determinants of the severe water shock experiences. In addition, households have established a number of mechanisms to smooth water supply, given that in this context water scarcity is a deep-seated reality in everyday life. The following variables were used for this analysis:

- Whether the household normally stores drinking water in the household
- Whether household with taps have a storage tank at the household

These mechanisms can be used to minimize interruptions in households' water supply, including in service from the public distribution network, or in other sources by which households obtain water.

In some cases water scarcity induces households to spend additional time or resources collecting water from secondary sources used in the event of shortages, reflected in the following indicators:

- Minutes in the past week spent collecting water as a direct result of water shortages through the public distribution network
- Expenditures on water as a direct result of water shortages through the public distribution network

7.2.8 Goal: Reduce Poverty

Socio-economic status (SE status or SES) was calculated using two methods:

(1) Asset-based socioeconomic status quintiles: Households re categorized into five categories

of wealth based on an asset index using reports of consumer durables.

(2) Consumption Expenditure-based proxy for socioeconomic status quintiles: Aggregating consumption expenditures at the household level, poverty are assessed in terms of poverty headcounts below particular cut-offs, or households can be organized by quintiles of wellbeing based on consumption expenditures.

To categorize households based on asset ownership, a principal components analysis (PCA) was conducted using variables for the quantity of each household asset owned by the surveyed households. The list of assets used includes all the assets listed in Table 18 above, as well as acres owned by the household (other than the dwelling plot, if applicable), and number of persons per sleeping room in the household. Based on this analysis, scores were used to construct five quintiles of wealth, lowest to highest, 1 through 5. This method has been shown in numerous cases to provide a smooth distribution of household socioeconomic status that can be useful for disaggregating outcomes.

Consumption expenditures are also a commonly used measure for estimating socioeconomic status (SES) and poverty levels. A full consumption expenditure module was administered to all household respondents. This module included different groups of items, and the frequency with which they were purchased. Food expenditures were disaggregated in detail, with a reference period of one week. Other items were grouped into categories with reference periods of a month or year. Households were categorized based on each of these indicators, allowing stratification of descriptive statistics and outcomes by SE status. Consumption expenditures per capita were calculated using the PPP exchange rate of 553 TZS to dollars and the adjusted household per capita expenditure measure, SES/poverty measures were assessed by comparing poverty lines to per capita consumption expenditures (CE), calculated as total monthly CE (PPP) / (number of household members). To check the reliability of the consumption expenditures data, two expenditure variables were created using the NPS Wave 2 survey data. The first aggregated household expenditures for all items that were also reported in our household survey. The second used the full expenditure aggregate to create the NBS's measure of household wellbeing (that was used in the NPS report's poverty profile). The share measured by our survey was calculated as the first aggregate divided by the second, or the share of expenditures for which the survey accounted in total household expenditures. The survey mean for this share was 92.6%, so in the context of the NPS, our survey measure of expenditures represents about 92.6% of total household expenditures. Based on the calculation of consumption expenditures, values for each household were again used to construct five quintiles of wealth, lowest to highest, numbered 1 through 5, respectively. This consumption expenditure wealth index correlated well with the index calculated based on the asset register, i.e., the categorization of wealthy and poor in each of the indexes was internally consistent.

In order to disaggregate outcomes by socioeconomic status, the consumption expenditure index was chosen; therefore, all breakdowns by SES described in the descriptive sections of the report represent quintiles (1 lowest to 5 highest) based on consumption expenditures per capita (PPP) per day. For the statistical models presented in this paper, on the other hand, the asset index is used. There are benefits and drawbacks to each wealth index method. Economic analyses of poverty usually employ money-metric measures of well-being with consumption expenditures being the preferred measure for use in developing countries (Deaton, 1997; Larochelle and Alwang, 2014) This measure is usually taken to represent a short-term measure of well-being, and durable asset ownership likely better reflects long-term wealth (Filmer and Scott, 2008). An asset index measure will evolve slowly while measured consumption may fluctuate substantially in the short-term (Booysen et al., 2008; Filmer and Pritchett, 2001). The household expenditure measure is generally preferred because units (value in money terms) are consistent and expenditures are usually easier to measure than income. Challenges with the use of an asset index include difficulties in determining the weights of different assets and adjusting for household size. Generally, larger households have more assets than smaller sized-households, and unless size is taken into account during construction of the index, a bias will emerge (Larochelle and Alwang, 2014). As noted, the asset index reflects longer-term household wealth and this wealth is likely to exhibit fewer endogeneity problems than the consumption expenditure quintiles. Since the asset index is a closer representation of a household's permanent income than consumption expenditures, unobserved factors affecting schooling and other outcomes are more unlikely to be correlated with asset ownership than with consumption expenditures (Filmer and Pritchett, 2001).

Given that poverty reduction is the central goal of the Compact, all key indicators will be broken down by SES, when applicable. Again, quintiles of consumption expenditures per capita per day are used to disaggregate main outcomes, while quintiles of the asset-based index are used for statistical models (for reasons elaborated above). The two measures are internally consistent so the choice of SES measures should not affect the conclusions drawn from the statistical models.

8 RESULTS

8.1 Data Summary

The sampling design of the baseline household survey for both cities is presented in Table 19. The sampling procedures were implemented as planned, and over five thousand households from 626 enumeration areas across Dar es Salaam and Morogoro were included in the survey. In Dar es Salaam, about one third of the sample came from the stratum with less than 24/7 supply, a group that will be very important to analyze at end-line with respect to changes in the availability of water as the main treatment variable. After excluding 7 households due to interviewer comments that suggested responses from those households may not be reliable, the final sample of households used to tabulate descriptive statistics included 5,001 households: 2,501 from Morogoro and 2,500 from Dar es Salaam. Given that the data collection partners were not able to re-locate 5% of households from the mini-survey, attrition will be a major concern between baseline and end-line, and any steps to monitor and update the contact information of this panel of households will assist in reducing the attrition at end-line. The sample size for each round of household data collection is presented in Table 20, including the initial survey conducted at the household, and the three rounds of phone follow-up surveys.

Table 21 summarizes the household sample participation in the three rounds of data collection. Overall, 81% of the households in the sample participated in all three phone survey rounds.

TABLE 19: SAMPLING DESIGN

City	Stratum	EAs (clusters)	Households	% HHs
Morogoro	*No Strata*	313	2501	50%
Dar es Salaam	Supply/No Infra/Non-Lower Ruvu	16	128	2.6%
Dar es Salaam	No Supply/No Infra/Lower Ruvu	8	64	1.3%
Dar es Salaam	No Supply/Infrastructure	47	376	7.5%
Dar es Salaam	Supply < 24/7	211	1686	33.7%
Dar es Salaam	Supply 24/7	31	246	4.9%
Total		**626**	**5001**	**100%**

TABLE 20: HOUSEHOLD SAMPLE SIZE, BY SURVEY ROUND

City	Households	Phone Round 1	Phone Round 2	Phone Round 3
Dar es Salaam	2,500	2,151	2,175	2,213
Morogoro	2,501	2,086	2,111	2,163
Total	**5,001**	**4,237**	**4,286**	**4,376**

Notes: 95% of the households in Morogoro were the same households interviewed in the mini-survey. A total of 130 households had to be replaced due to attrition (5.2% attrition rate). Interviews with 19 households were not attempted in any of the phone surveys since insufficient contact information was available and their interviews were some of the last conducted during the main baseline survey round.

TABLE 21: HOUSEHOLD PARTICIPATION IN PHONE SURVEY

# Rounds	Dar es Salaam		Morogoro		Total	
	HHs	%	HHs	%	HHs	%
No phone survey	246	9.8%	241	9.6%	487	9.7%
One round	54	2.2%	120	4.8%	174	3.5%
Two rounds	115	4.6%	180	7.2%	295	5.9%
Three rounds	2,085	83.4%	1,960	78.4%	4,045	80.9%
Total	**2,500**	**100%**	**2,501**	**100%**	**5,001**	**100%**

8.2 Sample Weighting

Sample weights were applied to the baseline dataset to adjust for the cluster sampling design and stratification in Dar es Salaam. Sample weights are equivalent to the inverse probability of being selected into the sample. The objective of sample weighting is to adjust for the cluster selection probabilities (and the selection of households from a sample frame), as was done in both cities, as well as disproportionate sampling from within strata, as we did in Dar es Salaam, such that estimates made using survey data are representative of the larger city populations. Sampling weights were the product of the probability of a cluster's selection from the national inventory of Enumeration Areas in each city (in Dar es Salaam this involved the probability of the cluster's selection from within its stratum), and the probability of each household being randomly selected from the cluster household lists prepared by EDI's listing teams. Unless specified that results apply to the household sample only, estimates presented in the results are derived after the application of sampling weights and are therefore representative of the city populations.

8.2.1 Benchmarking

As part of the procedure of applying sampling weights, SI tabulated estimates of city population size and percentage of households with access to piped water, benchmarking against other key datasets, to ensure that descriptive statistics and analyses using the baseline data are representative of the populations in Dar es Salaam and Morogoro. Table 22 shows the benchmarking of the piped water access using WHO/JMP data. The distribution of the household sample was compared to the population estimates from the 2012 Tanzanian Census, broken down by gender and age. This distribution and the average household size are shown in Table 23, along with the population composition disaggregated by gender, and city derived from population weighting of the sample. Figure 29 shows the full estimate, applying the sampling weights, of the population composition in each city. The estimates of the total population benchmarked by applying survey weights to the sample are 13% lower than the estimates from 2012 Tanzanian census. This was most likely due to use of different sample frame as SI was not granted access to the 2012 census sample frame and thus the data collection team carried out its own listing exercise within the 626 selected clusters to conduct random sample of households.

TABLE 22: BENCHMARKING PIPED WATER ACCESS AGAINST WHO/JMP DATA

WHO/JMP estimate, urban Tanzania Piped onto premises: 23%		
Baseline sample only (no weights)		
Dar es Salaam	**Morogoro**	**Total**
20%	**59%**	**39%**
Population estimate (sampling weights)		
Dar es Salaam	**Morogoro**	**Total**
17%	**55%**	**20%**
95%CI (13, 21)	95%CI (51, 58)	95% CI (16, 23)

TABLE 23: POPULATION BENCHMARKING ESTIMATES (COMPOSITION AND HOUSEHOLD SIZE)

Tanzania Census 2012				
	Males	**Females**	**Total**	**Average HH Size**
Dar es Salaam	2,125,786	2,238,755	4,364,541	4.0
Ilala	595,928	624,683	1,220,611	4.0
Kinondoni	860,802	914,247	1,775,049	4.0
Temeke	669,056	699,825	1,368,881	3.9
Morogoro	151,700	164,166	315,866	4.1
Baseline Sample (no sample weights)				
	Male	**Female**	**Total**	**HH Size**
Dar es Salaam	4,932	5,184	10,116	5.4
Ilala	929	927	1,856	5.6
Kinondoni	2,447	2,698	5,145	5.3
Temeke	1,556	1,559	3,115	5.5
Morogoro	5,177	5,629	10,806	5.7
Baseline Data (with sample weights)				
	Male	**Female**	**Total**	**HH Size**
Dar es Salaam	1,693,307	1,808,372	3,501,679	4.0
Ilala	443,198	451,485	894,683	4.0
Kinondoni	617,042	692,760	1,309,803	3.9
Temeke	633,066	664,127	1,297,193	4.0
Morogoro	142,943	153,431	296,375	4.3

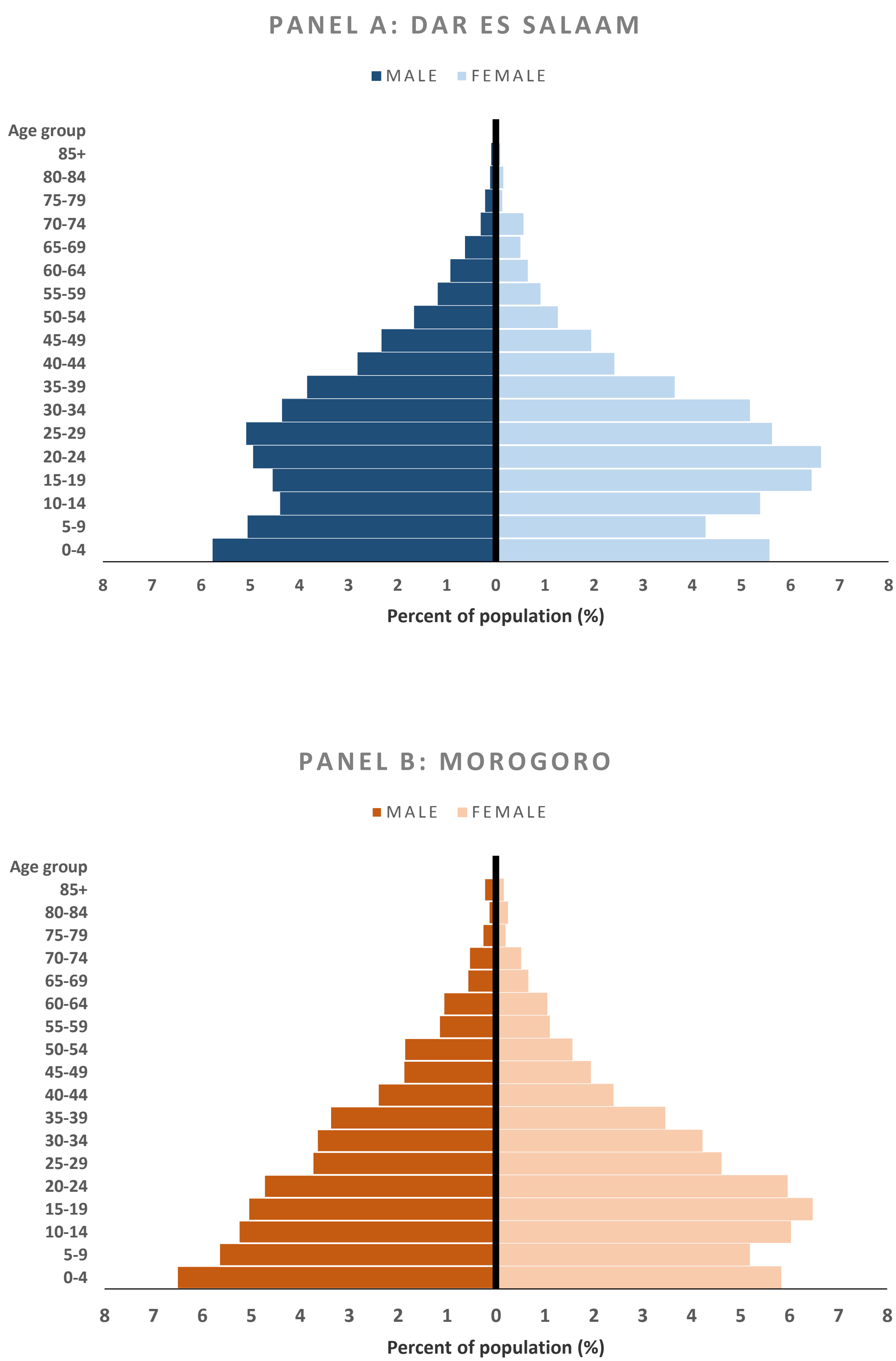


FIGURE 29: ESTIMATED POPULATION COMPOSITION

8.3 Disaggregation by socioeconomic status

As the Compact goal is ultimately poverty reduction through economic growth, the evaluation of socioeconomic status for this evaluation is not considered simply as an indicator on its own, but rather as a lens through which to explore the variation in other key indicator within MCC's project outcomes and objectives. Therefore, whenever applicable, key indicators are disaggregated by SE status. Two different measures of household SES were utilized to determine calculate indices: assets and consumption expenditures as explained in previous sections.

8.3.1 Asset-based wealth index

For the asset-based wealth index, information was collected on durable asset ownership (quantities of each asset owned by the household), access to utilities or infrastructure (main water source, municipal sewerage, sanitation facilities), and housing features (building type, wall material, roof material, floor material, main cooking and lighting fuels). Principal components analysis was utilized to create an asset-based wealth index, based on which the population was divided into fifths, to create wealth quintiles. This allowed the disaggregation by population of main indicators, and allowed the analysis to isolate the effects on the poorest 20% (bottom quintile) of households. One important caveat is that such derived indices are relative measures of socioeconomic status (SES), so this type of measure can only be used to considering inequality between households, and is not a reliable source of information on absolute levels of poverty within a community (Vyas 2006).

8.3.2 Consumption expenditure-based SES quintiles

Each household was assigned an SES quintile based on the mean consumption expenditures (CE) per capita per day. The fraction of population below standard poverty lines of 1.25 and 2.50PPP per capita per day (PCPD) were also estimated using the household sample data (Table 24).These results are lower than the expected from international poverty lines. Data from the Tanzania National Bureau of Statistics, 2011/12 Household Budget Survey show that both extreme and basic needs poverty are more present in rural areas. While 10% of the population is below the national average food extreme poverty line, the 11% of rural households fall into this category. Dar es Salaam has the lowest percentage of population in extreme poverty at only 1%, followed by other urban areas in which 9% of the population is extremely poor.

The use of 1.25 and 2.50 in PPP terms is consistent with international comparisons. The poverty lines are constructed in reference to a particular consumption aggregate and, for example, the $1.55 line used by Tanzania as the national poverty lines measures poverty with respect to the Household Budget Survey (HBS) consumption aggregate. The National Panel Survey (NPS) report notes that the NPS questionnaire produces a less comprehensive measure of consumption expenditures than other data sources, and, for that reason, poverty measures based on it cannot be directly compared to others Since our questionnaire is not directly comparable to other sources, it is more appropriate to compare using international norms rather than local norms.

Figure 30 and Figure 31 show the distributions of the total and in-home food shares of consumption expenditures, another common way of exploring poverty through consumption expenditures. The estimated food shares are higher than expected, especially given the relatively low estimates of poverty from the survey. It is likely that the questionnaire is slightly unbalanced with more emphasis on food consumption and less on non-foods. The coverage of food items is likely to be more comprehensive in the data collection instruments, and therefore this has been identified as an area that needs further analysis prior to fielding the end-line survey.

The consumption expenditures per capita per day were used to separate the population into fifths, quintiles of SE status based on per capita spending, to distinguish households in such a way that all outcomes and objective indicators can be broken down accordingly. The summary of consumption expenditures within each of the quintiles are shown in Table 25. Breaking consumption expenditures into quintiles allows the poorest – bottom quintile (1) – to be isolated, to examine differences between the poorest 20% and other segments of the population. We use quintiles of consumption expenditures per capita per day to break down key indicators and call them SES quintiles. In many of the statistical models, the asset index quintiles are used as a long-term measure of wealth, and used as a proxy for socioeconomic status in that context.

TABLE 24: HEADCOUNT RATIOS BELOW 1.25 AND 2.50 PPP (PER CAPITA PER DAY)

	Dar es Salaam			Morogoro		
	%	SE	95% CI	%	SE	95% CI
1.25 PPP per capita per day	0.1%	(0.04)	[0.01, 0.23]	1%	(0.32)	[0.79, 2.08]
1.55 PPP per capita per day: national line	1%	(0.45)	[0.47, 2.44]	4%	(0.53)	[3.21, 5.30]
2.50 PPP per capita per day	15%	(1.88)	[12.04, 19.45]	23%	(1.23)	[20.58, 25.39]

TABLE 25: MEAN PER CAPITA CONSUMPTION EXPENDITURES ACROSS QUINTILES (PER CAPITA PER DAY)

SES quintiles	Dar es Salaam			Morogoro		
	Mean	SE	95% CI	Mean	SE	95% CI
1	2.22	(0.03)	[2.16, 2.28]	1.85	(0.02)	[1.81, 1.89]
2	3.25	(0.02)	[3.21, 3.29]	2.83	(0.01)	[2.80, 2.85]
3	4.30	(0.03)	[4.24, 4.35]	3.77	(0.02)	[3.74, 3.80]
4	6.01	(0.05)	[5.92, 6.11]	5.08	(0.03)	[5.02, 5.13]
5	12.32	(0.41)	[11.52, 13.12]	10.11	(0.25)	[9.62, 10.59]
Total	5.62	(0.17)	[5.28, 5.96]	4.72	(0.10)	[4.53, 4.92]

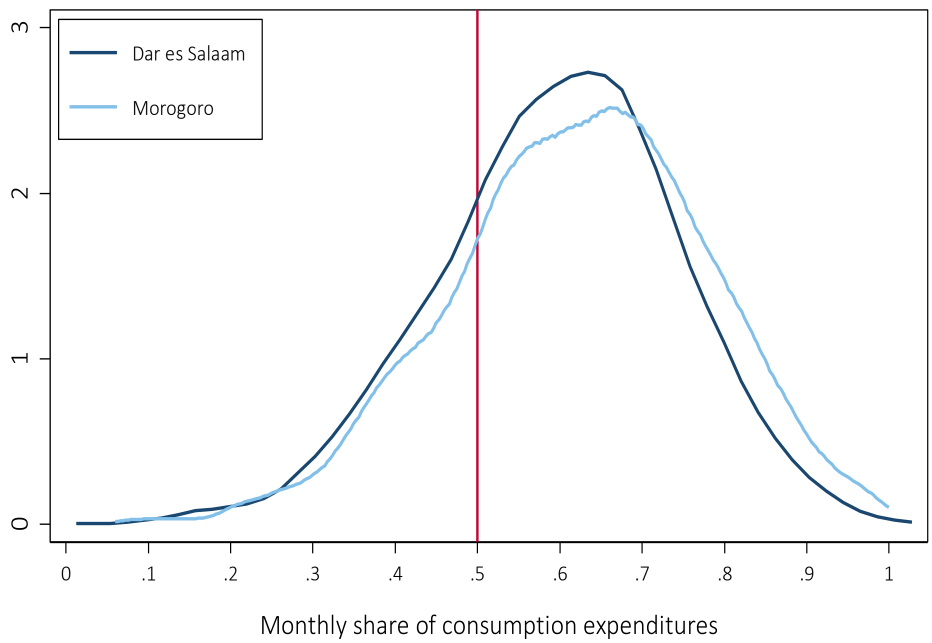


FIGURE 30: TOTAL FOOD SHARES OF MONTHLY HOUSEHOLD CONSUMPTION EXPENDITURES (PPP)

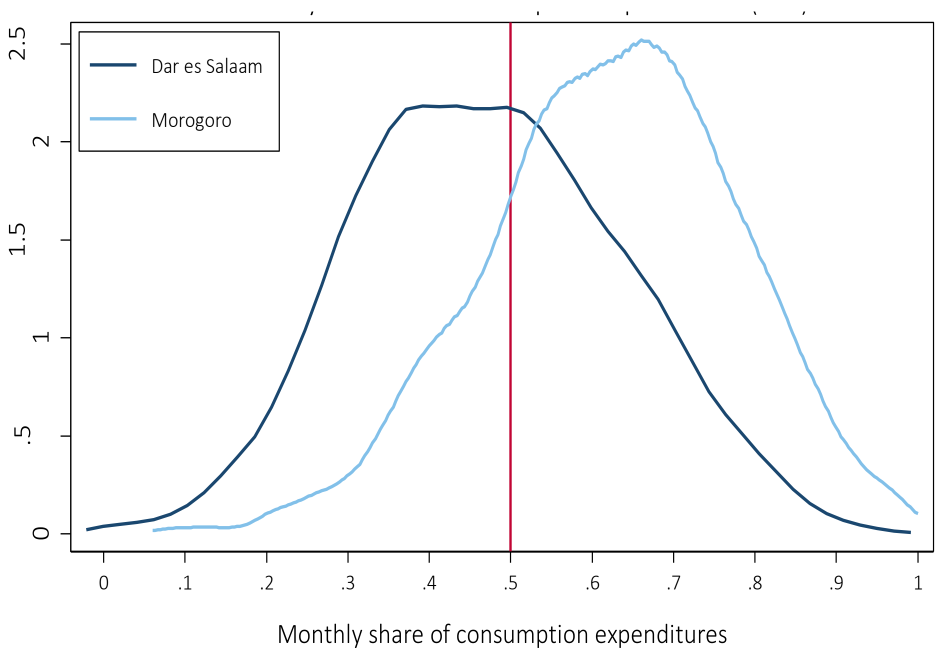


FIGURE 31: IN-HOME FOOD SHARES OF MONTHLY HOUSEHOLD CONSUMPTION EXPENDITURES (PPP)

8.4 Description of the Population

The characteristics of adults for Dar es Salaam and Morogoro are presented in Table 26 and Table 27. These tables present column-wise percentages, showing the distribution of population characteristics across the categories of age, marital status, Kiswahili and English literacy, relationship to head of household and employment status, disaggregated by gender. The majority of the population is married, most are young (under 30 or 40), the vast majority (95-97%) is literate in Kiswahili, and most work for pay. Table 28 shows the distribution of the characteristics of parents of children under 5. Parental characteristics are broken out since presence and education levels of parents are used frequently in statistical models looking at health outcomes, given that these individuals perform much of the daily activity that feeds directly into child health. As expected, children's mothers tend to be slightly more present than the fathers, and a larger proportion of fathers have completed secondary education. Table 29 presents the average ages of heads of household for each city, showing that less than a quarter of household heads in each city are female. The average ages of household heads by gender is shown in Table 30, demonstrating that female heads of household tend to be older than male heads of household; the average household head ages in Morogoro (43 years for males, 47 for females) are higher than in Dar es Salaam (41 years for males, 42 for females). The educational attainment of household heads is disaggregated by gender in Figure 32 showing that male heads of household have substantially higher levels of education (detail in Table 78).

TABLE 26: ADULT POPULATION CHARACTERISTICS: DAR ES SALAAM

	Male			Female		
	%	SE	95% CI	%	SE	95% CI
Age						
18-19	7%	(0.60)	[5.44, 7.81]	9%	(1.14)	[6.77, 11.28]
20-24	16%	(1.01)	[14.32, 18.28]	20%	(0.89)	[18.55, 22.03]
25-29	17%	(0.98)	[14.83, 18.70]	17%	(1.15)	[15.07, 19.59]
30-34	14%	(0.94)	[12.50, 16.21]	16%	(1.13)	[13.71, 18.17]
35-39	13%	(1.17)	[10.49, 15.09]	11%	(0.70)	[9.86, 12.60]
40-44	9%	(0.76)	[7.84, 10.83]	7%	(1.00)	[5.66, 9.63]
45-49	8%	(0.89)	[6.05, 9.58]	6%	(0.51)	[5.04, 7.05]
50-54	5%	(0.56)	[4.47, 6.67]	4%	(0.50)	[3.04, 5.01]
55-59	4%	(0.54)	[2.95, 5.11]	3%	(0.35)	[2.20, 3.61]
60-64	3%	(0.44)	[2.28, 4.04]	2%	(0.41)	[1.37, 3.01]
65+	4%	(0.57)	[3.50, 5.77]	5%	(0.76)	[3.40, 6.45]
Marital status (12+)						
Single/Never Married	37%	(1.29)	[34.66, 39.73]	31%	(1.37)	[28.63, 34.03]
Married	56%	(1.45)	[53.62, 59.32]	52%	(1.36)	[49.03, 54.39]
Living together	2%	(0.31)	[1.03, 2.28]	1%	(0.28)	[0.90, 2.05]
Separated	3%	(0.48)	[2.30, 4.19]	6%	(0.86)	[4.93, 8.34]
Divorced	0%	(0.07)	[0.05, 0.35]	1%	(0.31)	[0.54, 1.82]
Widow(er)	2%	(0.28)	[1.11, 2.25]	8%	(0.81)	[6.78, 9.99]
Literacy: Kiswahili						
Literate (Read/Write)	97%	(0.76)	[95.06, 98.17]	92%	(0.94)	[89.77, 93.50]
Not literate	3%	(0.76)	[1.83, 4.94]	8%	(0.94)	[6.50, 10.23]
Literacy: English						
Literate (Read/Write)	30%	(2.24)	[25.58, 34.39]	18%	(1.79)	[15.02, 22.06]
Not literate	70%	(2.24)	[65.62, 74.42]	82%	(1.79)	[77.94, 84.98]
Relationship to head of household						
Head of household	65%	(1.50)	[61.99, 67.91]	16%	(0.97)	[14.58, 18.41]
Spouse of head of household	1%	(0.19)	[0.32, 1.10]	48%	(1.45)	[44.86, 50.56]
Child (includes stepchildren)	19%	(1.22)	[16.59, 21.37]	16%	(0.97)	[14.47, 18.28]
Parent (Father or Mother)	0%	(0.11)	[0.07, 0.57]	1%	(0.36)	[0.77, 2.24]
Father-in-law/Mother-in-law	0%	(0.03)	[0.02, 0.18]	0%	(0.08)	[0.14, 0.49]
Brother/Sister	4%	(0.55)	[2.84, 5.02]	4%	(0.47)	[2.97, 4.85]
Brother-in-law/Sister-in-law	1%	(0.15)	[0.47, 1.08]	2%	(0.27)	[1.06, 2.13]
Grandparent	0%	(0.01)	[0.00, 0.07]	1%	(0.51)	[0.08, 3.49]
Grandchild	2%	(0.88)	[1.07, 4.84]	1%	(0.34)	[0.75, 2.15]
Uncle or Aunt	0%	(0.12)	[0.26, 0.76]	1%	(0.18)	[0.32, 1.05]
Niece or Nephew	0%	(0.17)	[0.11, 0.89]	0%	(0.17)	[0.14, 0.89]
Other relative (male or female)	6%	(0.69)	[5.12, 7.85]	7%	(0.75)	[5.42, 8.40]
Friend	0%	(0.09)	[0.18, 0.55]	0%	(0.05)	[0.04, 0.27]
House girl/boy	1%	(0.41)	[0.49, 2.23]	3%	(0.51)	[2.26, 4.29]
Employment status						
Paid employee	31%	(1.41)	[28.51, 34.06]	14%	(0.91)	[12.61, 16.19]
Self-employed (paid, non-agriculture)	44%	(1.95)	[40.36, 48.00]	27%	(1.13)	[24.40, 28.84]
Unpaid family helper (non-agriculture)	2%	(0.29)	[1.13, 2.30]	7%	(0.94)	[5.22, 8.95]
Unpaid family helper (agriculture)	1%	(0.38)	[0.37, 2.03]	1%	(0.29)	[0.41, 1.65]
Home management / Work in the home	5%	(0.81)	[4.09, 7.31]	38%	(1.94)	[34.66, 42.29]
Work on own farm or *shamba*	0%	(0.28)	[0.06, 1.76]	0%	(0.26)	[0.04, 1.72]
Not working - too young	0%	(0.02)	[0.01, 0.12]	0%	(0.12)	[0.03, 0.735]
Not working - retired	4%	(0.49)	[2.77, 4.71]	2%	(0.58)	[1.53, 3.88]
Not working - other	4%	(0.52)	[3.15, 5.21]	5%	(1.01)	[3.04, 7.13]
Not working - in school/ studying	8%	(0.78)	[6.82, 9.90]	5%	(0.51)	[4.31, 6.33]

TABLE 27: ADULT POPULATION CHARACTERISTICS: MOROGORO

	Male			Female		
	%	SE	95% CI	%	SE	95% CI
Age						
18-19	8%	(0.54)	[6.94, 9.08]	9%	(0.54)	[7.64, 9.75]
20-24	17%	(0.78)	[15.48, 18.56]	19%	(0.77)	[17.87, 20.91]
25-29	13%	(0.73)	[12.04, 14.92]	15%	(0.69)	[13.67, 16.39]
30-34	13%	(0.76)	[11.66, 14.66]	14%	(0.66)	[12.46, 15.04]
35-39	12%	(0.70)	[10.80, 13.56]	11%	(0.63)	[10.06, 12.53]
40-44	9%	(0.57)	[7.57, 9.83]	8%	(0.49)	[6.88, 8.83]
45-49	7%	(0.50)	[5.86, 7.83]	6%	(0.49)	[5.41, 7.35]
50-54	7%	(0.54)	[5.72, 7.84]	5%	(0.45)	[4.28, 6.06]
55-59	4%	(0.39)	[3.44, 4.97]	4%	(0.38)	[2.92, 4.43]
60-64	4%	(0.39)	[3.15, 4.69]	3%	(0.37)	[2.77, 4.25]
65+	6%	(0.51)	[5.45, 7.46]	6%	(0.48)	[5.00, 6.88]
Marital status (12+)						
Single/Never Married	36%	(1.07)	[34.27, 38.48]	28%	(1.02)	[26.38, 30.39]
Married	53%	(1.08)	[50.79, 55.05]	49%	(1.19)	[47.01, 51.67]
Living together	4%	(0.49)	[2.97, 4.92]	4%	(0.47)	[2.79, 4.68]
Separated	4%	(0.45)	[3.64, 5.42]	8%	(0.57)	[7.35, 9.58]
Divorced	0%	(0.05)	[0.04, 0.28]	0%	(0.14)	[0.28, 0.87]
Widow(er)	2%	(0.30)	[1.82, 3.00]	10%	(0.66)	[8.58, 11.19]
Literacy: Kiswahili (Read/Write)						
Literate	95%	(0.48)	[94.42, 96.33]	90%	(0.76)	[87.99, 90.96]
Not literate	5%	(0.48)	[3.67, 5.58]	10%	(0.76)	[9.04, 12.02]
Literacy: English (Read/Write)						
Literate	27%	(1.24)	[24.31, 29.17]	19%	(1.15)	[17.34, 21.85]
Not literate	73%	(1.24)	[70.83, 75.69]	81%	(1.15)	[78.15, 82.66]
Relationship to head of household						
Head of household	63%	(1.10)	[60.89, 65.23]	18%	(0.73)	[16.44, 19.33]
Spouse of head of household	1%	(0.18)	[0.48, 1.22]	45%	(1.17)	[43.18, 47.77]
Child (includes stepchildren)	20%	(1.00)	[17.97, 21.90]	19%	(0.83)	[17.25, 20.50]
Parent (Father or Mother)	0%	(0.13)	[0.21, 0.75]	2%	(0.31)	[1.37, 2.59]
Father-in-law/Mother-in-law	0%	(0.06)	[0.03, 0.33]	1%	(0.13)	[0.33, 0.87]
Brother/Sister	5%	(0.58)	[4.18, 6.47]	5%	(0.46)	[3.75, 5.55]
Brother-in-law/Sister-in-law	1%	(0.26)	[0.75, 1.82]	2%	(0.33)	[1.42, 2.74]
Grandparent	0%	(0.02)	[0.00, 0.12]	0%	(0.05)	[0.01, 0.29]
Grandchild	3%	(0.35)	[1.91, 3.32]	2%	(0.35)	[1.42, 2.84]
Uncle or Aunt	1%	(0.18)	[0.32, 1.07]	1%	(0.17)	[0.33, 1.05]
Niece or Nephew	0%	(0.09)	[0.07, 0.480	0%	(0.07)	[0.08, 0.41]
Other relative (male or female)	5%	(0.48)	[3.81, 5.73]	4%	(0.43)	[3.20, 4.92]
Friend	0%	(0.08)	[0.08, 0.46]	0%	(0.03)	[0.01, 0.19]
House girl/boy	1%	(0.31)	[0.75, 2.01]	2%	(0.26)	[1.41, 2.46]
Employment status						
Paid employee	29%	(1.15)	[27.15, 31.68]	15%	(0.75)	[13.57, 16.54]
Self-employed (paid, non-agriculture)	37%	(1.27)	[34.27, 39.28]	21%	(0.90)	[19.76, 23.29]
Unpaid family helper (non-agriculture)	2%	(0.35)	[1.59, 2.98]	7%	(0.72)	[5.76, 8.57]
Unpaid family helper (agriculture)	7%	(0.71)	[5.28, 8.07]	7%	(0.75)	[5.68, 8.64]
Home management / Work in the home	6%	(0.60)	[4.43, 6.82]	36%	(1.35)	[33.28, 38.58]
Work on own farm or *shamba*	2%	(0.35)	[1.24, 2.63]	1%	(0.35)	[0.85, 2.26]
Not working - too young	0%	(0.17)	[0.14, 0.92]	0%	(0.09)	[0.07, 0.49]
Not working - retired	4%	(0.42)	[3.64, 5.31]	2%	(0.28)	[1.58, 2.69]
Not working - other	5%	(0.53)	[4.47, 6.55]	4%	(0.53)	[2.85, 4.97]
Not working - in school/ studying	7%	(0.54)	[6.07, 8.21]	6%	(0.52)	[4.75, 6.78]
Other (unemployed)	1%	(0.18)	[0.34, 1.10]	1%	(0.15)	[0.30, 0.92]

TABLE 28: CHARACTERISTICS OF PARENTS OF CHILDREN < 5

	Dar es Salaam			Morogoro		
	%	SE	95% CI	%	SE	95% CI
Mother present						
No	1%	(0.30)	[0.34, 1.65]	2%	(0.53)	[1.26, 3.42]
Yes	99%	(0.30)	[98.35, 99.66]	98%	(0.53)	[96.58, 98.74]
Father present						
No	8%	(2.08)	[5.04, 13.42]	10%	(1.29)	[7.62, 12.71]
Yes	92%	(2.08)	[86.58, 94.96]	90%	(1.29)	[87.29, 92.38]
Mother's education						
None	6%	(1.90)	[2.86, 10.74]	5%	(0.99)	[3.62, 7.59]
Pre-primary or some primary	4%	(1.30)	[2.32, 7.68]	4%	(0.80)	[2.54, 5.75]
Completed primary	64%	(3.45)	[57.23, 70.71]	69%	(1.94)	[65.34, 72.95]
Some secondary	4%	(0.90)	[2.26, 5.91]	4%	(0.89)	[2.71, 6.29]
Completed secondary	17%	(2.53)	[12.24, 22.21]	14%	(1.38)	[11.57, 17.00]
Diploma	2%	(0.89)	[0.81, 4.74]	1%	(0.22)	[0.24, 1.19]
Adult/Vocational	0%	0.00		0%	(0.13)	[0.02, 0.99]
Some university (1-2 yrs)	2%	(1.31)	[0.30, 7.75]	0%	(0.16)	[0.05, 0.92]
Completed university (3+ yrs)	2%	(0.63)	[1.11, 3.72]	3%	(0.67)	[1.51, 4.25]
Father's education						
None	2%	(1.28)	[0.81, 6.71]	2%	(0.56)	[1.01, 3.32]
Pre-primary or some primary	5%	(1.83)	[2.36, 10.05]	4%	(1.05)	[2.82, 7.08]
Completed primary	57%	(3.37)	[50.09, 63.25]	65%	(2.26)	[60.08, 68.92]
Some secondary	2%	(0.79)	[1.11, 4.43]	1%	(0.53)	[0.55, 2.87]
Completed secondary	24%	(2.59)	[19.69, 29.87]	20%	(1.79)	[16.85, 23.89]
Diploma	1%	(0.36)	[0.45, 2.01]	1%	(0.29)	[0.27, 1.55]
Adult/Vocational	0%	0.00		0%	(0.21)	[0.127, 1.11]
Some university (1-2 yrs)	0%	(0.06)	[0.04, 0.34]	1%	(0.36)	[0.37, 1.923]
Completed university (3+ yrs)	8%	(1.93)	[5.10, 12.86]	6%	(1.05)	[4.02, 8.22]

TABLE 29: GENDER DISTRIBUTION OF HOUSEHOLD HEADS, BY CITY

	Dar es Salaam			Morogoro		
	%	SE	95% CI	%	SE	95% CI
Male	79%	(1.23)	[76.17, 81.00]	76%	(1.02)	[74.17, 78.16]
Female	21%	(1.23)	[19.00, 23.83]	24%	(1.02)	[21.84, 25.83]
Total	100%			100%		

TABLE 30: AVERAGE AGE OF HOUSEHOLD HEAD, BY GENDER AND CITY

	Dar es Salaam			Morogoro		
	Mean	SE	95% CI	Mean	SE	95% CI
Male	41.1	(0.555)	[40.05, 42.23]	42.9	(0.379)	[42.11, 43.60]
Female	42.0	(0.876)	[40.28, 43.72]	47.1	(0.773)	[45.62, 48.66]
Total	41.3	(0.518)	[40.31, 42.34]	43.9	(0.369)	[43.15, 44.60]

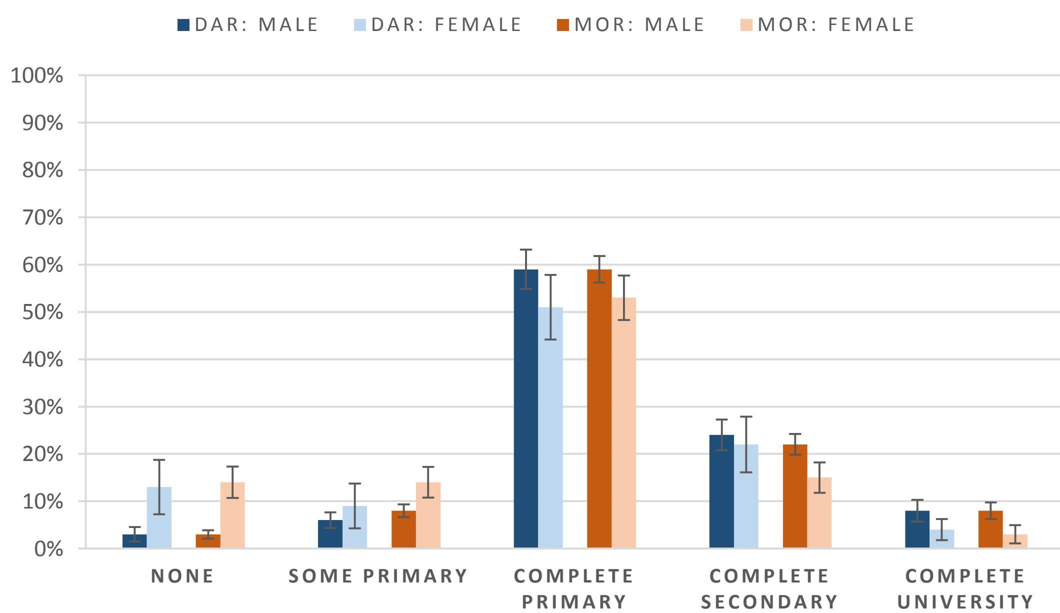


FIGURE 32: EDUCATIONAL ATTAINMENT OF HOUSEHOLD HEADS

8.4.1.1 *Household Size and Dependency Ratios*

Next, household size and dependency ratios were broken out by socioeconomic status.

Table 31 and Figure 33 present the average household size for each consumption quintile, by city. As expected, households with the lowest per capita per day consumption expenditures have the largest households. These estimates align with the 2012 Tanzania Census, which found the average household size in Dar es Salaam and Morogoro to be 4.0 and 4.4, respectively.

TABLE 31: HOUSEHOLD SIZE, BY SES

SES quintiles	Dar es Salaam			Morogoro		
	Mean	SE	95% CI	Mean	SE	95% CI
1	5.4	(0.19)	[4.97, 5.73]	5.8	(0.15)	[5.54, 6.12]
2	4.6	(0.15)	[4.32, 4.91]	5.0	(0.11)	[4.76, 5.19]
3	3.9	(0.12)	[3.69, 4.15]	4.3	(0.12)	[4.08, 4.54]
4	3.6	(0.19)	[3.25, 3.98]	3.8	(0.11)	[3.54, 3.98]
5	2.3	(0.15)	[2.02, 2.60]	2.7	(0.10)	[2.52, 2.93]
Total	4.0	(0.09)	[3.78, 4.14]	4.3	(0.06)	[4.20, 4.44]

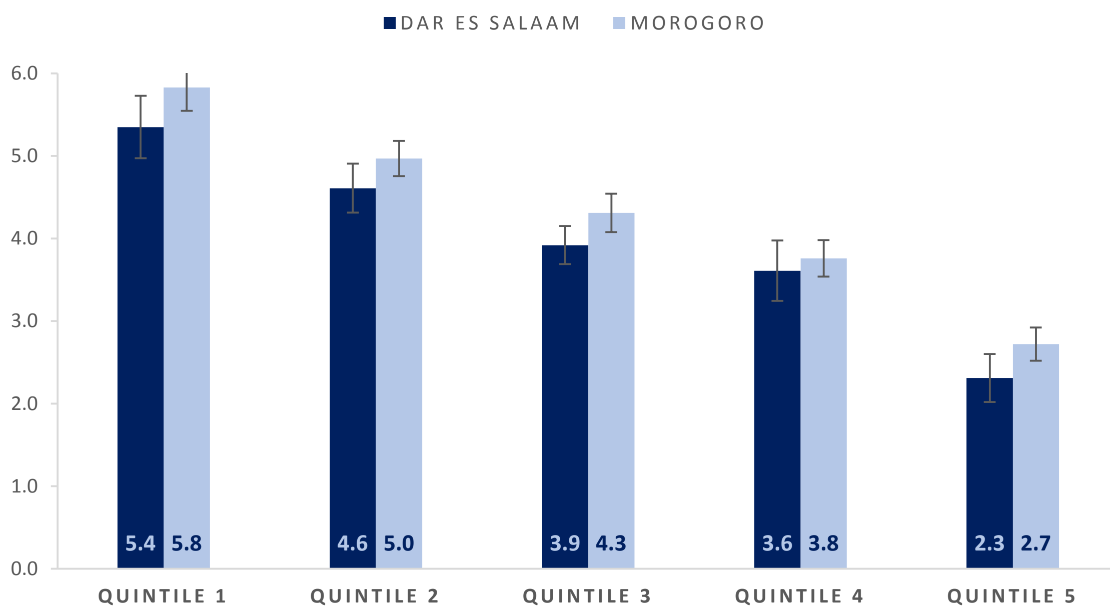


FIGURE 33: HOUSEHOLD SIZE, BY SES

The age dependency ratio is the ratio of dependents (age 0-14, or 65 and over) to the total population between the ages of 15 and 64, the latter considered the most productive segment of the population. Table 32 and Figure 34 display the dependency ratios disaggregated by city and consumption quintile and show that dependency ratios are generally lower in Dar es Salaam than in Morogoro, and are inversely related to the consumption quintile (i.e., highest among households with lowest per capita spending). These dependency ratio estimates are lower than countrywide estimates from other data sources, such as the Demographic and Health Surveys (DHS) and World Bank, which are closer to one. It is important to note that the sample frame utilized for this IE was developed specifically for this evaluation; and variation in estimates using different sample frames is to be expected. In addition, estimates from sources such as the DHS are often presented as national averages, or averages across urban areas, while our sample is drawn only from rapidly growing urban areas of Dar es Salaam and Morogoro.

TABLE 32: DEPENDENCY RATIOS, BY SES

SES quintiles	Dar es Salaam			Morogoro		
	Mean	SE	95% CI	Mean	SE	95% CI
1	0.84	(0.06)	[0.72, 0.95]	1.05	(0.05)	[0.96, 1.14]
2	0.72	(0.04)	[0.65, 0.79]	0.91	(0.04)	[0.83, 1.00]
3	0.50	(0.03)	[0.46, 0.55]	0.68	(0.04)	[0.61, 0.75]
4	0.38	(0.04)	[0.31, 0.45]	0.50	(0.03)	[0.44, 0.56]
5	0.14	(0.02)	[0.11, 0.18]	0.25	(0.02)	[0.21, 0.29]
Total	0.52	(0.02)	[0.48, 0.56]	0.68	(0.02)	[0.64, 0.71]

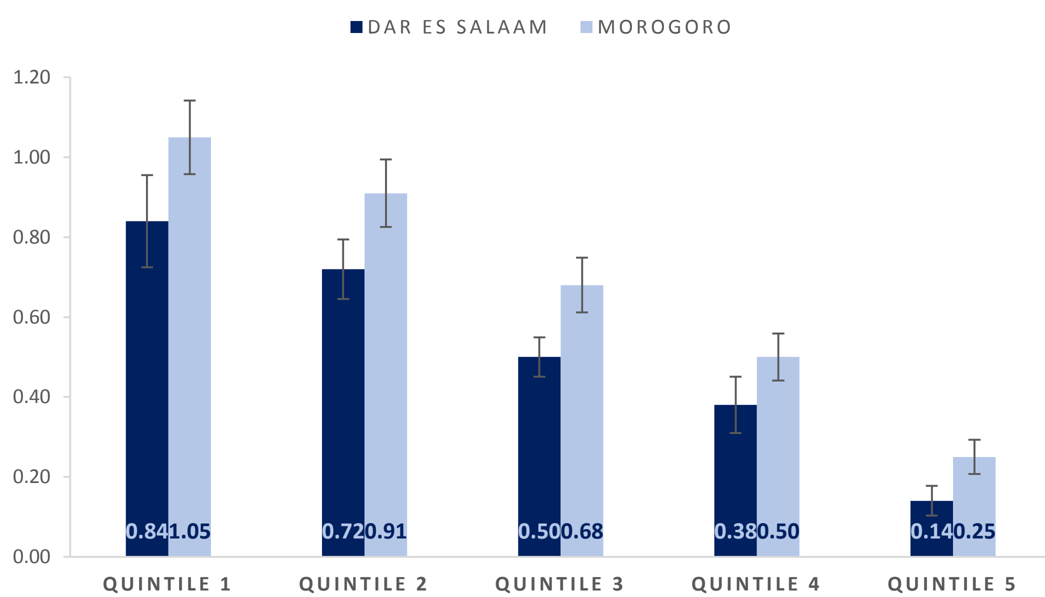


FIGURE 34: DEPENDENCY RATIOS, BY SES

8.5 Access, Source Choice, and Water Quality

8.5.1 Improved water supply

Table 33 shows the distribution of water sources available to households in Dar es Salaam and Morogoro, with water sources classified using WHO criteria into unimproved, piped on premises and “other improved” categories.

Table 34 shows the same distribution, but using Social Impact’s classification of water sources into various categories (see Indicator definition for further detail, Section 7.2.2). Definitions for each classification are presented at the bottom of the tables. The majority of households have access to improved water sources, with only 24% of population in Dar es Salaam and 9% in Morogoro using unimproved water sources as their primary source of drinking water, as defined by WHO/JMP.

SI made adjustments to the WHO/JMP water source categories for two reasons: (i) to make categories more consistent with the urban Tanzanian reality, and (ii) because an alternative categorization was needed given the objectives of the study In urban Tanzania, the quality of water differs greatly depending on the source and piped water is generally of better quality than wells and springs, regardless of whether the latter are protected or not For the purposes of the analysis, it was important to identify households with piped sources because a major outcome of the intervention will be to increase this access. One of the hypothesized effects of the intervention is to increase the reliability of the piped system water supply. This effect will largely be felt by those with access to piped water sources. Measurement of changes in this reliability relies on perceptions of those households whose main water source is a piped source.

TABLE 33: DISTRIBUTION OF SOURCES OF DRINKING WATER - WHO/JMP CLASSIFICATION

WHO water source category	Dar es Salaam			Morogoro		
	%	SE	95% CI	%	SE	95% CI
Piped on premises	13%	(1.70)	[9.59, 16.30]	52%	(1.77)	[48.28, 55.21]
Other improved	63%	(2.63)	[58.07, 68.35]	40%	(1.65)	[36.29, 42.75]
Unimproved	24%	(2.64)	[19.27, 29.63]	9%	(1.08)	[6.87, 11.14]
Total	100%			100%		

WHO/JMP water source category definitions**:** *Piped on premises*: Piped water onto premises (in dwelling or on plot). *Other improved:* Neighbor's tap; public tap/standpipe; water kiosk; piped water into business (used for household activities); borehole/tube-well; protected well (covered); protected spring; rainwater *Unimproved:* Water vendor; tanker-truck; unprotected well (open); unprotected spring; bottled water; bagged water; surface water

TABLE 34: DISTRIBUTION OF SOURCES OF DRINKING WATER - SI CLASSIFICATION

SI water source category	Dar es Salaam			Morogoro		
	%	SE	95% CI	%	SE	95% CI
Own tap	13%	(1.70)	[9.59, 16.30]	52%	(1.77)	[48.28, 55.21]
Other piped	39%	(2.92)	[32.96, 44.40]	39%	(1.64)	[35.34, 41.79]
Vendors	19%	(2.71)	[13.82, 24.50]	4%	(0.81)	[2.83, 6.06]
Non-Tap	26%	(2.94)	[20.41, 31.93]	5%	(0.77)	[3.28, 6.37]
Bottled*	5%	(0.65)	[3.47, 6.05]	1%	(0.21)	[0.65, 1.52]

SI water source category definitions**:** *Own Tap:* Own tap on dwelling or plot. Other *Piped*: Neighbor's tap; Kiosk; Public Tap; Tap to a household-owned or nearby business. *Vendors*: Water tanker trucks; Mobile water vendors (i.e., push-carts. *Non-tap*: Borehole; Protected and unprotected wells and springs; Surface water. *Bottled*: Bottled water; bagged water (note that bagged water responses were so rare that they are negligible from city-wide representative estimates.

As Figure 35 and Figure 36 show, access to tap water differs significantly between the two cities. In Dar es Salaam, only an estimated 13% of the population report using their own tap as their primary source of drinking water, compared to 52% in Morogoro. In total, 52% of residents in Dar es Salaam, and 91% in Morogoro, reported a piped source (own tap, or other piped) as their main source of drinking water.

In Dar es Salaam, an equal share (38%) of the poorest 20% of households get their water from other piped sources (neighbor, kiosk, nearby tap) and from non-tap sources (boreholes, wells, springs, surface water). In addition, a sizeable share of these households (18%) obtain drinking water primarily from vendors (18%). Qualitative findings, presented in Section 8.8, suggest that within these broad categories, neighbor's tap and boreholes/wells represent the most significant sources of water for residents in various areas of each city. Only 6% of the poorest quintile in Dar es Salaam obtain water from a tap on premises for drinking water. In Morogoro, over half of the poorest households get their water from other piped sources (55%).

Less than one third of the poorest households in Morogoro get their primary drinking water from their own tap (29%). The results show that the poorer the household, the more likely they are to rely on drinking water from sources of potentially lower quality, which may also require more time and expenditures to collect.

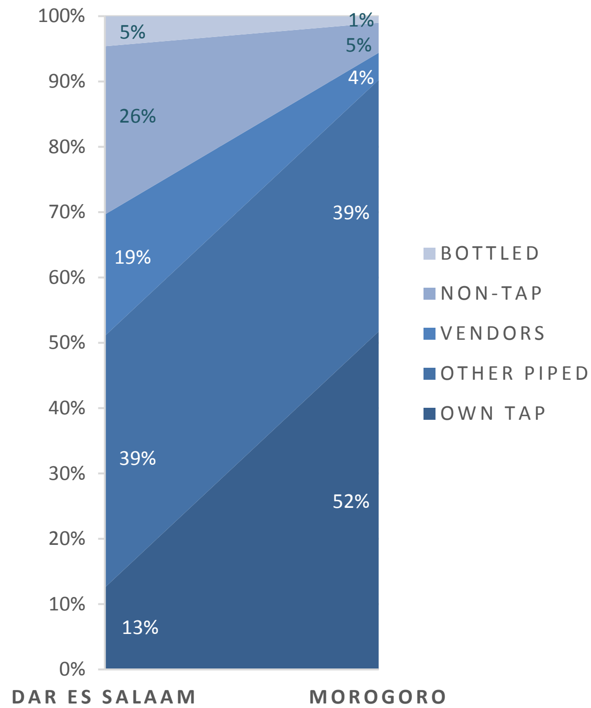


FIGURE 35: PRIMARY DRINKING WATER SOURCE

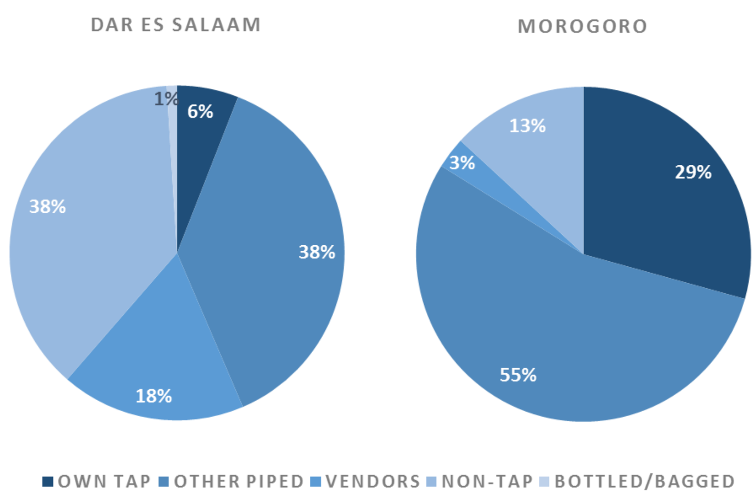


FIGURE 36: PRIMARY WATER SOURCE AMONG POOREST QUINTILE

8.5.2 Access to public distribution network

Figure 37 shows access to public network disaggregated by SES quintile. Households of the lowest socioeconomic status have the lowest rates of connection to the public distribution network, and the pattern is consistent such that the wealthiest households have the highest rates of connection. This pattern is pronounced in both cities, although tap access is substantially lower across the board in Dar es Salaam, with only 3% of the poorest households connected to a public network tap, and 24% of those in the highest consumption quintile; compared to 31% and 70%, respectively in Morogoro. The low rates of tap connections in Dar es Salaam may thus limit the direct benefits experienced by that city's population as a whole, although many households will indirectly benefit if there is increased supply to other piped sources and vendors. In Morogoro, the impact of increases in supply is more likely to be apparent given that the connection rates are much higher. Detailed data is presented in the appendix Table 79. Table 35 shows the primary sources of drinking water by SES. The differences in piped water access by SES are substantial. In Dar es Salaam, "other piped" sources are most frequently used for primary drinking water. In the poorest 20% of households, the same share of households also get their primary drinking water from non-tap sources, which are often perceived as having lower quality water. In Morogoro, the wealthiest three quintiles rely on their own tap on premises for primary drinking water. An approximately equal share of households in the second-poorest quintile obtains water from own tap and other piped sources. Households in the poorest quintile rely the most on "other piped" sources for drinking water.

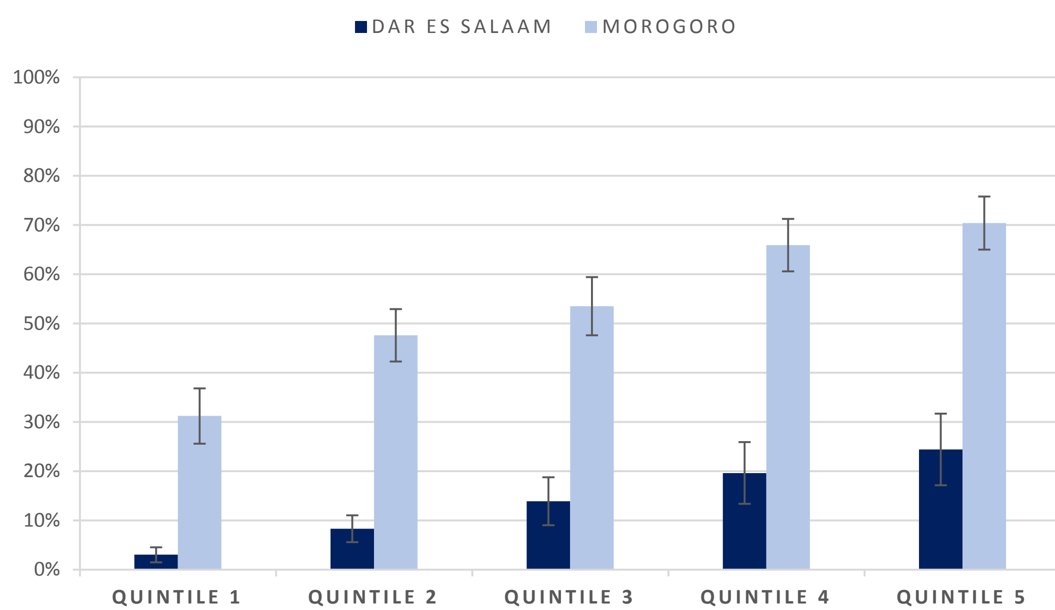


FIGURE 37: CONNECTION TO PUBLIC NETWORK BY SES

TABLE 35: HOUSEHOLD PRIMARY DRINKING WATER SOURCE, BY SES

	Dar es Salaam					
	Own tap	**Other piped**	**Vendors**	**Non-Tap**	**Bottled**	**Total**
SES quintile						
1	6%	38%	18%	38%	1%	100%
SE	(1.8)	(6.0)	(6.0)	(7.1)	(0.3)	
95% CI	[3.04, 10.34]	[27.26, 50.28]	[9.05, 32.85]	[24.90, 52.32]	[0.15, 1.85]	
2	9%	43%	16%	30%	2%	100%
SE	(1.7)	(4.6)	(3.4)	(5.5)	(1.1)	
95% CI	[6.15, 12.77]	[34.41, 52.14]	[10.44, 23.83]	[20.35, 41.63]	[0.72, 5.83]	
3	14%	42%	20%	24%	1%	100%
SE	(2.89)	(4.1)	(3.1)	(3.97)	(0.4)	
95% CI	[9.00, 20.47]	[33.82, 49.77]	[14.16, 26.45]	[16.94, 32.52]	[0.63, 2.33]	
4	16%	40%	23%	16%	5%	100%
SE	(2.7)	(3.5)	(3.7)	(3.2)	(1.0)	
95% CI	[11.62, 22.27]	[32.99, 46.66]	[16.29, 30.72]	[11.1, 23.64]	[3.30, 7.44]	
5	18%	30%	16%	21%	14%	100%
SE	(3.6)	(3.5)	(2.7)	(4.1)	(2.3)	
95% CI	[12.189, 26.41]	[23.88, 37.53]	[11.81, 22.49]	[13.93, 30.08]	[10.21, 19.25]	
Total	13%	39%	19%	26%	5%	100%
SE	(1.7)	(2.9)	(2.7)	(2.9)	(0.7)	
95% CI	[9.59, 16.31]	[32.95, 44.41]	[13.81, 24.51]	[20.40, 31.94]	[3.46, 6.05]	

	Morogoro					
	Own tap	**Other piped**	**Vendors**	**Non-Tap**	**Bottled**	**Total**
SES quintile						
1	29%	54%	3%	13%	0%	100%
SE	(2.8)	(3.1)	(1.0)	(2.5)	(0.2)	
95% CI	[24.29, 35.08]	[47.89, 59.81]	[1.91, 6.15]	[8.84, 18.79]	[0.03, 1.51]	
2	46%	45%	5%	4%	0%	100%
SE	(2.7)	(2.7)	(1.4)	(1.1)	0.00	
95% CI	[40.60, 51.18]	[39.82, 50.37]	[3.31, 8.88]	[1.97, 6.68]		
3	52%	42%	5%	2%	0%	100%
SE	(3.0)	(3.1)	(1.4)	(0.62)	(0.11)	
95% CI	[45.88, 57.66]	[35.61, 47.66]	[2.9061, 8.40]	[0.79, 3.43]	[0.01, 0.43]	
4	65%	27%	3%	4%	1%	100%
SE	(2.8)	(2.44)	(1.0)	(1.1)	(0.3)	
95% CI	[59.67, 70.44]	[22.92, 32.51]	[1.77, 5.83]	[1.94, 6.37]	[0.16, 1.67]	
5	66%	25%	4%	1%	4%	100%
SE	(2.9)	(2.5)	(1.1)	(0.5)	(1.0)	
95% CI	[60.68, 71.84]	[20.08, 29.88]	[2.0, 6.57]	[0.38, 2.81]	[2.61, 6.62]	
Total	52%	39%	4%	5%	1%	100%
SE	(1.8)	(1.6)	(0.8)	(0.77)	(0.2)	
95% CI	[48.27, 55.21]	[35.34, 41.80]	[2.83, 6.06]	[3.28, 6.37]	[0.65, 1.52]	

8.5.3 Access to electricity and sanitation

Household access to two other types of infrastructure - electricity and sanitation - was also assessed as part of the baseline surveys. To measure access to municipal sewerage connections, each respondent was asked about the main toilet type utilized by the household, which was then assigned to one of the following two categories based on WHO/JMP classifications:

1) "Improved" sanitation, comprising flush toilet, piped sewer system, septic tank, flush/pour flush to pit latrine, ventilated improved pit latrine (VIP), pit latrine with slab, composting toilet, special case;
2) "Unimproved" sanitation, including flush/pour flush to elsewhere, pit latrine without slab, bucket, hanging toilet or hanging latrine, no facilities or bush or field.

The household survey did not have a single variable to measure electricity access, and did not define access to electricity as residing within the area where a household is able to connect to the distribution grid (just as access to piped water, in this evaluation, is not defined as living in an area where connection to the public distribution network is possible). Instead, a household was designed as having access to electricity if the respondent listed electricity as main fuel for cooking or for lighting, or indicated expenditures for electricity in the consumption module; these measures served as proxies for a households' effective access to electricity for household activities.

TABLE 36: ACCESS TO ELECTRICITY AND SANITATION FACILITIES

	Dar es Salaam			Morogoro		
	%	SE	95% CI	%	SE	95% CI
Electricity						
Electricity access	40%	(3.47)	[33.04, 46.60]	49%	(1.64)	[45.45, 51.88]
No electricity access	60%	(3.47)	[53.40, 66.96]	51%	(1.64)	[48.12, 54.55]
Sewerage						
Has municipal sewer connection	4%	(1.12)	[2.33, 6.93]	6%	(0.62)	[5.12, 7.57]
No municipal sewer connection	96%	(1.12)	[93.07, 97.67]	94%	(0.62)	[92.43, 94.88]
Sanitation						
Flush toilet (to a sewer, tank, or latrine)	59%	(2.45)	[54.18, 63.77]	56%	(1.53)	[53.43, 59.43]
Pit latrine (VIP or with slab)	40%	(2.44)	[35.21, 44.76]	41%	(1.48)	[37.84, 43.65]
Composting toilet	0.1%	(0.08)	[0.01, 0.53]	0.02%	(0.02)	[0.00, 0.14]
Flush to elsewhere	1%	(0.19)	[0.24, 1.03]	1%	(0.21)	[0.34, 1.21]
Open pit latrine	0.5%	(0.13)	[0.26, 0.78]	2%	(0.36)	[1.29, 2.74]
No facilities	0.02%	(0.02)	[0.00, 0.15]	0.3%	(0.11)	[0.14, 0.63]

More than half of the residents in each city reported having electricity access at the time of the survey (60% in Dar es Salaam and 51% in Morogoro), which could have implications for the productivity outcomes of interest (e.g., if electricity is also a barrier to allocating household time to certain income-generating activities). The rates of connections to the municipal sewerage systems are extremely low in both cities – only around 5%. The majority of households (56-59%) utilize a toilet connected to the sewer, septic tank or pit latrine. Since sanitary and hygiene conditions mediate the relationship between water use and health, the absence of access to adequate sanitation affects the health outcomes of interest in this evaluation. Table 37 presents the reasons cited by respondents why they are not connected to i) public water network, and ii) sewerage system (for (i), respondents include only households who had a non-public distribution network tap, see note after table). The reasons for the rare municipal sewer access are consistent: most households cannot connect due a lack of available sewer infrastructure in there are. On the other hand there is substantial variation in reasons cited by households for not connecting to the public water distribution network and differences between cities. In Dar es Salaam, a lack of infrastructure in the area was cited as the main barrier by one third of households asked, compared to only 7% in Morogoro. In Dar es Salaam, the major reasons for not connecting to the water network included a lack of infrastructure (33%), status as renter (25%), and satisfaction with present arrangement (18%). Another 9% of households chose to disconnect as due to dissatisfaction with the service, while 8% remain on the waiting list for a connection; 7% of households found the connection costs too high. In Morogoro, about one third of households maintain that their present arrangement is satisfactory (32%), a quarter was dissatisfied and disconnected (24%), and another 12% are renters. 14% of households are on the waiting list for a connection while 11% of households cited the connection cost as the main barrier to connection. Only 7% cited the lack of infrastructure as the reason for not connecting. These results suggest different priorities may exist in each city with respect to the demand for connections. For example, expanding the distribution network would likely benefit residents of Dar es Salaam, while improving customer satisfaction may attract customers in Morogoro. One caveat limiting the interpretation of this data is that the questions on barriers to connecting to the public network questions was only asked of households who had a piped connection to a system other than the public distribution center, thus no data is available for those without any piped connection. During end-line, this question will be asked of all households regardless of their primary source of water.

TABLE 37: REASONS FOR LACK OF CONNECTION TO PUBLIC WATER AND SEWERAGE SYSTEMS

	Dar es Salaam			Morogoro		
	%	SE	95% CI	%	SE	95% CI
Main reason do not have a connection to public water distribution network (% of respondents indicating each answer)						
Connection cost too high	7%	(3.58)	[2.15, 18.45]	11%	(10.49)	[1.26, 52.22]
Connection network not available in this area	33%	(8.05)	[19.12, 50.47]	7%	(6.35)	[1.27, 33.69]
Present arrangement satisfactory	18%	(6.66)	[8.19, 35.18]	32%	(12.13)	[13.32, 58.98]
Rented house	25%	(7.59)	[13.11, 43.06]	12%	(7.38)	[3.43, 35.60]
Was dissatisfied and disconnected	9%	(5.20)	[2.70, 26.11]	24%	(8.79)	[10.58, 45.22]
Waiting list	8%	(5.48)	[2.02, 27.79]	14%	(13.26)	[1.71, 59.84]
Main reason do not have a municipal sewer connection (% of respondents indicating each answer)						
Connection cost too high	4%	(0.98)	[2.84, 6.80]	4%	(0.55)	[2.93, 5.10]
Monthly charge too high	0%	(0.15)	[0.23, 0.85]	1%	(0.24)	[0.68, 1.67]
Sewer network not available	72%	(3.10)	[65.94, 78.09]	71%	(1.83)	[67.64, 74.81]
Present arrangement satisfactory	2%	(0.43)	[1.29, 3.04]	8%	(0.87)	[6.72, 10.17]
Rented house	20%	(2.98)	[14.91, 26.64]	15%	(1.18)	[12.37, 17.02]
On installation waiting list	1%	(0.20)	[0.30, 1.16]	1%	(0.20)	[0.56, 1.36]

** Note the difference in enablement criteria for these questions: reason not connected was only asked of those who listed having access to a piped source other than a connection to the public distribution network (n=104, with estimates at the population level having been adjusted for sampling design). This enablement will be fixed in subsequent stages of data collection to allow any household without a connection to the public network to respond. In contrast, any household without a sewerage connection was eligible to answer this question (n= 4,682).*

8.5.4 Water source usage by activity

Since households were given the opportunity to list each source they used for each major household activity, the dataset yields a picture of the way that multiple sources used by households are prioritized across household activities.

Table 38 shows the plurality of water source usage disaggregated by activity. In these tables, the blue highlighting indicates which water sources are used at least by one quarter of households use for that activity, and the shading reflects the intensity of use, with the top source used for each activity the darkest. These results provide some interesting insight into the choice of water sources for particular uses in the household. In Dar es Salaam, non-tap sources appear to be the most frequently used sources for all activities other than drinking, with more than half of all households reporting the use of this set of sources for these activities. Given that this category includes wells and boreholes, this finding is ground-truthed by the qualitative interviews and much of the modeling presented in this report on water source choice. For drinking, in Dar es Salaam, other piped sources are the most frequently used for drinking, with non-tap sources and vendor water following directly from that. In stark contrast, in Morogoro, water from a tap on premises was the most commonly used source of water for all activities, with other piped sources next, and non-tap sources third, consistently. This reflects the higher connection rates in Morogoro, and is also echoed in much of the qualitative findings. The qualitative evidence elaborates the context behind these findings, in Section 8.8.

These results are interesting with respect to the outcomes and objectives of the Tanzania Compact Water Sector Project interventions. In terms of the types of changes to look for between baseline and end-line, given that the intervention targets supply through the public network, it will be important to assess changes in the overall portfolio and ranking of use of various sources in Dar es Salaam – that is, we will explore whether the intervention appears to induce households to shift to own tap or other piped sources. In Morogoro, it is certainly interesting to evaluate whether some who rely on other sources may shift to piped sources as well, but this breakdown also suggests that changes may be felt more acutely through quality improvements since a majority of the population is already accessing piped water with high frequency.

TABLE 38: WATER SOURCE USAGE BY ACTIVITY

	Dar es Salaam			
Water Source	**Drinking**	**Cooking**	**Washing**	**Cleaning**
Own tap	15%	17%	17%	17%
Other piped	51%	52%	51%	51%
Vendors	29%	25%	24%	23%
Non-Tap	39%	57%	64%	65%
Bottled	12%	2%	1%	1%
Other	1%	1%	1%	1%
	Morogoro			
Water Source	**Drinking**	**Cooking**	**Washing**	**Cleaning**
Own tap	57%	58%	58%	58%
Other piped	52%	52%	51%	51%
Vendors	8%	8%	7%	7%
Non-Tap	25%	30%	36%	36%
Bottled	6%	0%	0%	0%
Other	2%	2%	2%	2%

Note: Cells are % of households in each city that reported using each source for the given activity.

8.5.5 System water quality

The system water quality was assessed approximately twice a month throughout baseline data collection: in June and July in Dar es Salaam, and from April until end of July in Morogoro. Three types of measurements were made on each water sample: two tests of chlorine content (free chlorine and total chlorine) and one test for turbidity. Tests were conducted at intake and outlet points, as well as several customer points, such as taps and a water kiosk. Water quality was assessed at the three major treatment plants in Dar Es Salaam: Lower Ruvu, Upper Ruvu and Mtoni; and three in Morogoro: Mafiga, Kola and Kibwe). Additional water samples were collected in Morogoro from a customer tap near the Mambogo disinfection point and a water kiosk supplied by the Kingorwila water reserve. The system level water quality results are presented in Table 39 for Dar es Salaam, and Table 40 for Morogoro.

The total chlorine measurements for all samples were higher than free chlorine readings, supporting the validity of the chlorine test results While the presence of free chlorine residual (FCR) is an indicator of whether the water contains active chlorine in sufficient amount to control pathogens, the total chlorine indicates whether an adequate amount of chlorine had been added to the water during initial treatment, and includes chlorine that has already been utilized to destroy bacteria prior to sample collection. The measure of free chlorine residual (FCR) in tap water is a major indicator of whether the initial level of water chlorination at the system level is sufficient to disinfect the water from bacterial contamination.

Although for most samples drawn in Dar es Salaam the free chlorine levels were in the acceptable range, several samples had chlorine concentrations that would be considered too low to disinfect tap water. The Center for Disease Control (CDC) recommends a minimum dosage of 0.5 mg/L of free chlorine[15] to maintain the quality of water through a distribution network. Thus, free chlorine observations under .5 mg/L are highlighted in pink in the results tables. The Lower Ruvu treatment plant appeared to exhibit particular challenges complying with this CDC guideline, with only one of the four water samples meeting the threshold. All water samples from the Upper Ruvu treatment plant contained sufficient free chlorine concentrations, while only one of the four samples did not meet the guideline at the Mtoni plant. In Morogoro, Mafiga, Kola and Kibwe outlet points almost all water samples contained sufficient levels of free chlorine, with only two samples measuring below the recommended minimum of .5 mg/L (at .2 and .1 mg/L). However, for water quality tests conducted at the customer tap and the water kiosk, virtually all water samples contained extremely low levels of free chlorine. While, it is possible that sufficient levels of chlorination were achieved when the water left the plant, since these points were destinations of the water, the data suggests otherwise. Similarly low rates of total chlorine measurements were observed for these water samples, indicating that insufficient chlorine had been added at the source. This result implies that there is insufficient free chlorine in the supplied water to allow safe water storage without additional treatment, and that water that travels substantial distances to its ultimate destination may not be adequately chlorinated to resist bacterial contamination.

The results of the turbidity testing suggest that turbidity was not a problem in Dar es Salaam, with all measurements lower than 5 NTU. In Morogoro, on the other hand the opposite results were observed; almost all samples exhibited high turbidity.

[15] US CDC Chlorine Residual Testing Fact Sheet, Available at: http://www.cdc.gov/safewater/publications_pages/chlorineresidual.pdf

TABLE 39: SYSTEM WATER QUALITY: DAR ES SALAAM

Source	Type	Date				
		6/6/13	6/20/13	7/6/13	7/22/13	*Average*
Free Chlorine (mg/L)						
Lower Ruvu treatment plant	Outlet	0.5	0.2	0.4	0.3	*0.35*
Upper Ruvu treatment plant	Outlet	0.6	1	0.8	1.5	*0.98*
Mtoni treatment plant	Outlet	0.3	0.8	1.5	3.5	*1.53*
Average		0.47	0.67	0.90	1.77	*0.95*
Total Chlorine (mg/L)						
Lower Ruvu treatment plant	Outlet	0.9	0.3	0.6	0.4	*0.55*
Upper Ruvu treatment plant	Outlet	0.7	1.5	1	2	*1.30*
Mtoni treatment plant	Outlet	0.4	1	2	4	*1.85*
Average		0.67	0.93	1.20	2.13	*1.23*
Turbidity (NTU)						
Lower Ruvu treatment plant	Outlet	<5	<5	<5	<5	*<5*
Upper Ruvu treatment plant	Outlet	<5	<5	<5	<5	*<5*
Mtoni treatment plant	Outlet	<5	<5	<5	<5	*<5*
Average		*<5*	*<5*	*<5*	*<5*	*<5*

TABLE 40: SYSTEM WATER QUALITY: MOROGORO

Source	Type	Date							
		4/15/13	4/26/13	5/19/13	6/1/13	6/17/13	7/1/13	7/15/13	7/31/13
Free Chlorine (mg/l)									
Mafiga treatment plant	Outlet	0.5	0.5	2	4	0.8	0.2	0.8	0.5
Kola disinfection point	Outlet	0.1	0.8	1.5	0.5	3.5	2.5	0.1	2.5
Kibwe	Outlet	>1	>1	>5	>5	3.5	3	2	3.5
Mambogo disinfection point	Tap	0.1	0.1	0.3	0.2	4	0.1	0.1	2.5
Kingorwila water reserve	Kiosk	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Total Chlorine (mg/l)									
Mafiga treatment plant	Outlet	0.8	0.7	4	>5	1.4	0.2	0.5	1
Kola disinfection point	Outlet	0.2	1	2	0.8	5	4	0.2	3
Kibwe	Outlet	>1	>1	>5	>5	5	5	2.5	4.5
Mambogo disinfection point	Tap	0.1	0.1	0.4	0.3	5	0.1	0.1	3
Kingorwila water reserve	Kiosk	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Turbidity (NTU)									
Mafiga treatment plant	Outlet	12	<5	6.5	7	11	>5	6	7
Kola disinfection point	Outlet	13	14	13	14	12	12	5	22
Kibwe	Outlet	<5	<5	<5	<5	31	8	<5	<5
Mambogo disinfection point	Tap	12	<5	9	<5	<5	<5	<5	<5
Kingorwila water reserve	Kiosk	9	18	9	18	<5	11	<5	<5

8.5.6 Household water quality

For household water quality tests, the sampling protocol dictated that in the absence of eligible households, a water sample could be drawn from a shared source in the neighborhood (also referred to as a "community" source). Many of the water quality results come from these public sources. In Dar es Salaam, a majority of the tests came from community sources, since a small proportion of households was eligible for water testing due to low levels of tap connectivity within the households. Results are therefore disaggregated to present separately tests taken from piped sources at the residence of the household, and shared community sources. One of the main goals of conducting water tests on a sub-sample of households was to obtain a cluster-level measure of water quality from the public distribution system. However, given that many water test samples were ultimately drawn from community sources, it is difficult to obtain a cluster-level measure of water quality that relates specifically to household connections to the public distribution system, and main community water sources from which samples were ultimately drawn included boreholes, surface water, etc. Thus, the cluster-level measures of water quality are more likely to reflect the quality of water consumed, rather than that supplied by the network. The sampling protocol also allowed a water sample to be collected from a replacement household within the cluster, even if that household was not interviewed for the baseline survey, if that household provided water for others in the neighborhood (e.g., a "neighbor's tap" used by many nearby residents). Therefore, some water tests of a household tap source do not have corresponding household survey data, and therefore, cannot be connected to specific household characteristics. The water quality data from these tests, however, can be utilized in cluster-level estimates of local water quality.

The results of microbiological testing of samples collected at the household and the shared taps are presented in Table 41, which shows the distribution of the water samples by city, water source type and risk rating outcome. As described previously, based on the fecal coliform bacterial colony counts measured for each sample, each result was classified as "satisfactory" or "unsatisfactory," based on the risk rating system from the Tanzania Bureau of Standards.

Since many more households in Morogoro have access to their own tap, the majority of samples in that city was collected from residential taps (83%). The situation was reversed in Dar es Salaam, with more water samples collected from community instead of household sources (24% of samples were from households in Dar es Salaam). At the household level, the results were similar for both cities, with around 23-27% of samples sufficiently contaminated to merit an unsatisfactory risk rating. However, the quality of the community/shared tap sources was worse and varied much more drastically, with 35% of all sources receiving the high risk rating of "unsatisfactory," compared to 52% in Morogoro. Community sources were the most contaminated water sources within the sample.

Similar findings can be seen in Table 42, which presents the details of the fecal coliform colony counts per 100 mL by city and type of source. While the mean contamination for water samples drawn from the household taps was similar across cities, the community water sources in Morogoro were far more contaminated, even conditional on an unsatisfactory rating, comparing both the mean and the medians for the groups. Figure 38 focuses only on household tap samples with unsatisfactory risk rating, and presents the distribution of fecal coli colony counts (per 100 ml). In both cities, the majority of the contaminated samples have quite low levels of fecal coli, although even small amounts of contamination can have substantial health impacts.

TABLE 41: WATER QUALITY TEST RESULTS FOR FECAL BACTERIA, BY TAP TYPE

	Dar es Salaam			Morogoro		
Fecal bacteria risk rating	**Household**	**Community**	**Overall**	**Household**	**Community**	**Overall**
Satisfactory	90 73%	254 65%	344 67%	378 77%	50 48%	428 72%
Unsatisfactory	34 27%	137 35%	171 33%	116 23%	54 52%	170 28%
Total	**124** 100%	**391** 100%	**515** 100%	**494** 100%	**104** 100%	**598** 100%

TABLE 42: FECAL COLIFORM COUNTS FOR HOUSEHOLD AND COMMUNITY TAPS

	Household Tap					
City	**n**	**Mean**	**SD**	**Min**	**Median**	**Max**
	Overall results					
Dar es Salaam	124	9.3	26. 5	0	0	144.5
Morogoro	494	6.9	21.4	0	0	156.5
	Unsatisfactory results only					
Dar es Salaam	34	34.0	41.8	1	12.5	144.5
Morogoro	116	29.5	35.8	1	9.5	156.5

	Community Tap (cluster-level)					
City	**n**	**Mean**	**SD**	**Min**	**Median**	**Max**
	Overall results					
Dar es Salaam	391	10.0	27.6	0	0	179.5
Morogoro	104	21.0	35.6	0	1	189.5
	Unsatisfactory results only					
Dar es Salaam	137	28.5	40.7	1	12	179.5
Morogoro	54	40.3	40.8	1	26	189.5

Table 43 shows the distribution of the free and total chlorine test results by city. Many more chlorine tests were performed in Morogoro, with only 54 chlorine tests in Dar es Salaam. The majority of water samples have practically no free chlorine, and very low concentrations of total chlorine. The relationship between the free chlorine and total chlorine for virtually all water samples was as expected, with free chlorine residual concentration measurements consistently lower than the total chlorine measurements.

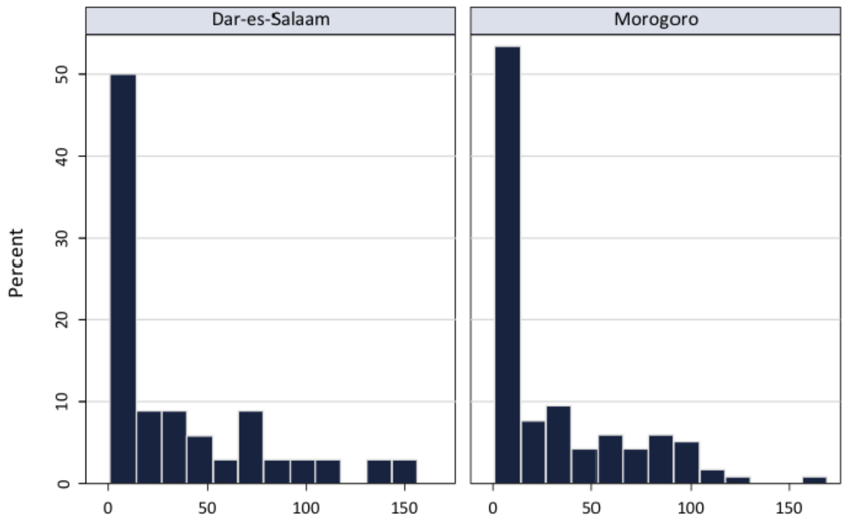


FIGURE 38: HISTOGRAM OF FECAL COLI COLONY COUNTS, HOUSEHOLD SAMPLES RATED UNSATISFACTORY

TABLE 43: DISTRIBUTION OF FREE AND TOTAL CHLORINE RESULTS

Chlorine concentration	Morogoro		Dar es Salaam	
	Total Chlorine	Free Chlorine	Total Chlorine	Free Chlorine
0.1	57	80	39	39
0.2	11	28	1	6
0.3	16	11	2	1
0.4	7	6	2	0
0.5	8	2	2	1
0.6	10	2	1	3
0.7	2	0	1	0
0.8	10	3	4	3
1	9	2	1	1
1.5	2	0	1	0
2	1	2	0	0
2.5	2	0	0	0
3	1	0	0	0
4	0	1	0	0
5	2	1	0	0
Total	**138**	**138**	**54**	**54**

The fecal coliform colony counts were negatively associated with free chlorine residual concentrations in the water samples, providing further evidence that the water quality testing was appropriately conducted. Figure 39 presents these results by city for both sample tests, and demonstrates that the majority of samples with bacterial contamination have almost no free chlorine, while samples with higher levels of free chlorine are much less likely to have fecal coli. It is important to note that the scales for the two cities are different, showing that the range of free chlorine measurements for Morogoro samples was much wider than in Dar es Salaam.

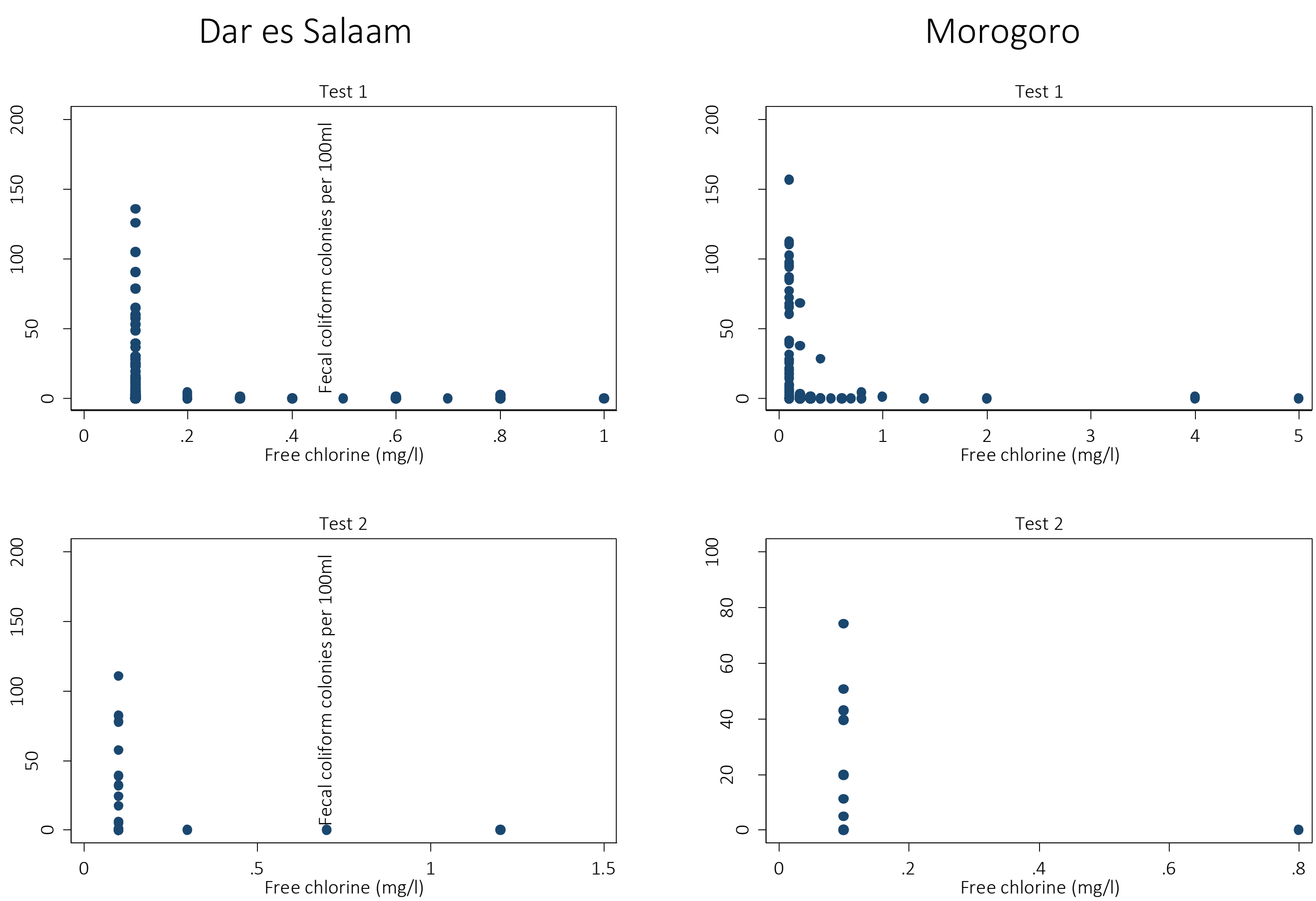


FIGURE 39: BACTERIAL CONTAMINATION VERSUS FREE CHLORINE IN HOUSEHOLD TAP SAMPLES

When the enumerators drew the water sample at the household level, they were instructed to record any observed instances of unhygienic conditions present at the test tap, including rust, slime or leaking from the tap or the connected pipe. These conditions could be associated with lower water quality because contamination could occur through these channels Table 44 presents the summary of the distribution of the locations of household tap spouts and nozzles that had hygienic conditions of note. As expected, the vast majority of instances of rusting were found in samples in which the tap was located outside the home, as was the case with the majority of leaking outlets or those with slime.

However, as Table 45 shows, the tap condition had almost no effect on water quality, with the exception of slime, which had opposite effects in the two cities. However, given the small sample size, conclusions about statistical significance of this finding cannot be made.

TABLE 44: HYGIENIC CONDITIONS AT SAMPLED HOUSEHOLD TAPS

	Dar es Salaam		Morogoro	
Condition	**In-House**	**On Plot, In Yard**	**In-House**	**On Plot, In Yard**
Rust	0%	100%	3%	97%
Slime	20%	80%	10%	90%
Leaking	27%	73%	3%	97%

TABLE 45: HOUSEHOLD TAP HYGIENE, BY RISK RESULT

	Dar es Salaam		Morogoro	
Condition	**Satisfactory**	**Unsatisfactory**	**Satisfactory**	**Unsatisfactory**
Rust	6%	6%	7%	11%
Slime	6%	0%	3%	8%
Leaking	12%	12%	14%	12%

Note: Percentages are cell percentages, representing the % of samples taken with given hygienic condition

There are several limitations to the household level test results. The time of day when the water sample was drawn may affect the bacterial contamination in the water sample, as quality can vary depending on whether water has been flowing through the taps. Every effort was taken by the field data collection team to take water samples at approximately the same time slot each day (in the evening between 5 to 7 pm). In some cases, however, where rationing prohibited the team from taking samples at this time, data collectors returned to the area to collect water at a time that it was flowing through the taps, which could introduce some variability in water quality across tests conducted at different times and in different water flow conditions. Rainfall can also affect water quality, as rain causes greater run-off into water sources and increases leakages in the pipe system, thus increasing the amount of bacterial contamination. Therefore, water quality results are reported with respect to the sample of water tests conducted, rather than extrapolating in any way to the population using sampling weights, since the subset of tap samples actually tested likely represents only a specific subset of households from which water was actually flowing and at specific times of day. Lastly, in Morogoro, the utility engaged in a large-scale effort to flush water from a major intake, the Mindu dam, in April 2013. According to the utility, this exercise takes place periodically in order to prevent turbid and potentially contaminated water from the lower depths of the dam to be released into the distribution system. It is unclear to what extent the timing and intensity of such activities affected the water quality tests conducted in the baseline survey.

8.5.7 Water quality spatial analysis

With the assistance of the Center for Geographic Analysis at Harvard University, SI conducted some basic spatial analysis on the water quality data, using the household GPS coordinates collected during the household survey and the enumeration area geospatial files provided by the National Bureau of Statistics, and the values of the water quality results for fecal coliform colony counts from both household and community source test locations. These findings should be considered preliminary analyses, which can be expanded upon at end-line.

The purpose of conducting spatial analysis is to identify geographic trends in data. Here, the objective of carrying out preliminary analysis at baseline is to potentially identify areas or topics of interest for further examination in later stages of the evaluation. While trends may often be visually apparent on maps, some of what is apparent can be influenced by the way data is classified or separated on a map and therefore spatial statistics can add great value to an analysis to confirm whether apparent patterns are statistically significant based on the value of the data. In other words, there are a set of tools available to quantify the spatial relationships of point data (e.g. points of poor water quality) to find out if they are statistically significantly different from other surrounding areas, and therefore whether further examination may be warranted. Importantly in the case of this impact evaluation, spatial analysis can also be used to track changes in clustering over time (e.g. baseline to end-line). While a host of spatial analyses are possible using the geo-referenced data of the household survey, only preliminary analyses have been conducted at baseline, using water quality data. Three analyses have been run, using spatial statistics tools in ArcGIS 10.2 Desktop software: Spatial Autocorrelation tests, Cluster and Outlier Analysis, and Optimized Hot Spot Analysis. [16] Spatial Autocorrelation tests are presented in the Appendix in Figure 76 and Figure 77; the Cluster and Outlier Analysis results (maps) and Hot Spot Analysis results (maps) are presented below in Figure 40 through Figure 43.

8.5.7.1 Spatial Autocorrelation

The purpose of the spatial autocorrelation test is to examine whether there are spatially dependent relationships in a set of data, e.g. whether water quality results for fecal coliform bacteria from locations around a city is random, or if values tend to be spatially dependent. In other words, this tool quantifies and statistically tests spatial patterning in a set of data with geographic attributes. In brief, the test is based on comparisons of one geographical unit's mean, to the mean of its neighbors, and the mean of all the units in the dataset. The test calculated a statistic called the Global Moran's I, which represents how similar features close to each other are, i.e. the extent to which data are random, dispersed, or clustered, and ranges from -1 to 1. The result of the analysis is a z-score, with indicates how spatially clustered the data are, with an associated p-value, interpreted the same way as a traditional statistical test would be, representing the probability that the pattern observed occurred by chance alone. The results from the spatial autocorrelation tests run on fecal coliform counts from water samples tested in Dar es Salaam and Morogoro are presented in the Appendix, in Figure 76 and Figure 77. In short, in both cities the patterns were statistically significant, indicating that water contamination, in the form of fecal

[16] The analyses presented below included both household and community tests. Geographic adjustments were made in cases where variation and error in GPS values placed a given sample location outside of the survey EA from which it came from, such that a given test was re-located into the centroid (the geometric center-point), of its EA, ensuring that the value would be represented in the correct EA. Any tests for which GPS locations were not available (from the time of the household survey), observations were excluded. In total, the analysis made use of 515 of the 515 tests from Dar es Salaam and 565 of the 598 tests from Morogoro. The conceptualization of the spatial relationship parameter used for spatial autocorrelation is the Inverse Distance.

coliform bacteria colonies, across both Dar es Salaam and Morogoro, are not randomly distributed but rather are clustered in specific locations. The z-scores in each city (Dar es Salaam: z=7.62, p-value<0.01; Morogoro: z=7.41, p-value<0.01), indicate that there is a less than 1% likelihood that these clustered patterns could be the result of random chance.

8.5.7.2 Cluster and Outlier Analysis

Cluster and outlier analysis identifies areas where data are clustered and where spatial outliers may exist within a set of clustered data; rather than looking at averages in geographic units, it is performed in order to look at the relationship of an individual unit to its neighbors. This analysis distinguishes between a statistically significant (at the 0.05 level) cluster of high values (High-High, HH), cluster of low values (Low-Low, LL), outlier in which a high value is surrounded primarily by low values (High-Low, HL), and outlier in which a low value is surrounded primarily by high values (Low-High, LH). The test statistic calculated here is called the Anselin Local Moran's I, which ranges from -1 to 1; a positive value indicates that the feature is surrounded by similar values (i.e. there is a cluster in that location), and the negative value indicates that the feature is surrounded by dissimilar values (i.e. is an outlier).[17] The results from the cluster and outlier test run on fecal coliform counts from water samples tested in Dar es Salaam and Morogoro are presented in Figure 40 and Figure 41. In both cities, there are a number of High-High clusters, or clusters of locations where high colony counts were found. This cluster analysis is then expanded upon below in the hot spot analysis, and further examination in later stages could reveal characteristics about the areas (environmental, demographic, infrastructural, etc.) that drive these results. On the other hand, results for both cities also indicated a few places where there is a High-Low outlier, i.e. values of high coliform counts surrounded by areas of lower relative coliform counts. These areas are interesting, as it is possible that they could indicate that specific locations from which samples were gathered are contaminated, i.e. because of leakages in the pipe or consequences of the area surrounding the tap or water outlet, rather than the reflecting the quality of the supply itself. Outliers of low colony counts in areas of high colony counts are not apparent in either city.

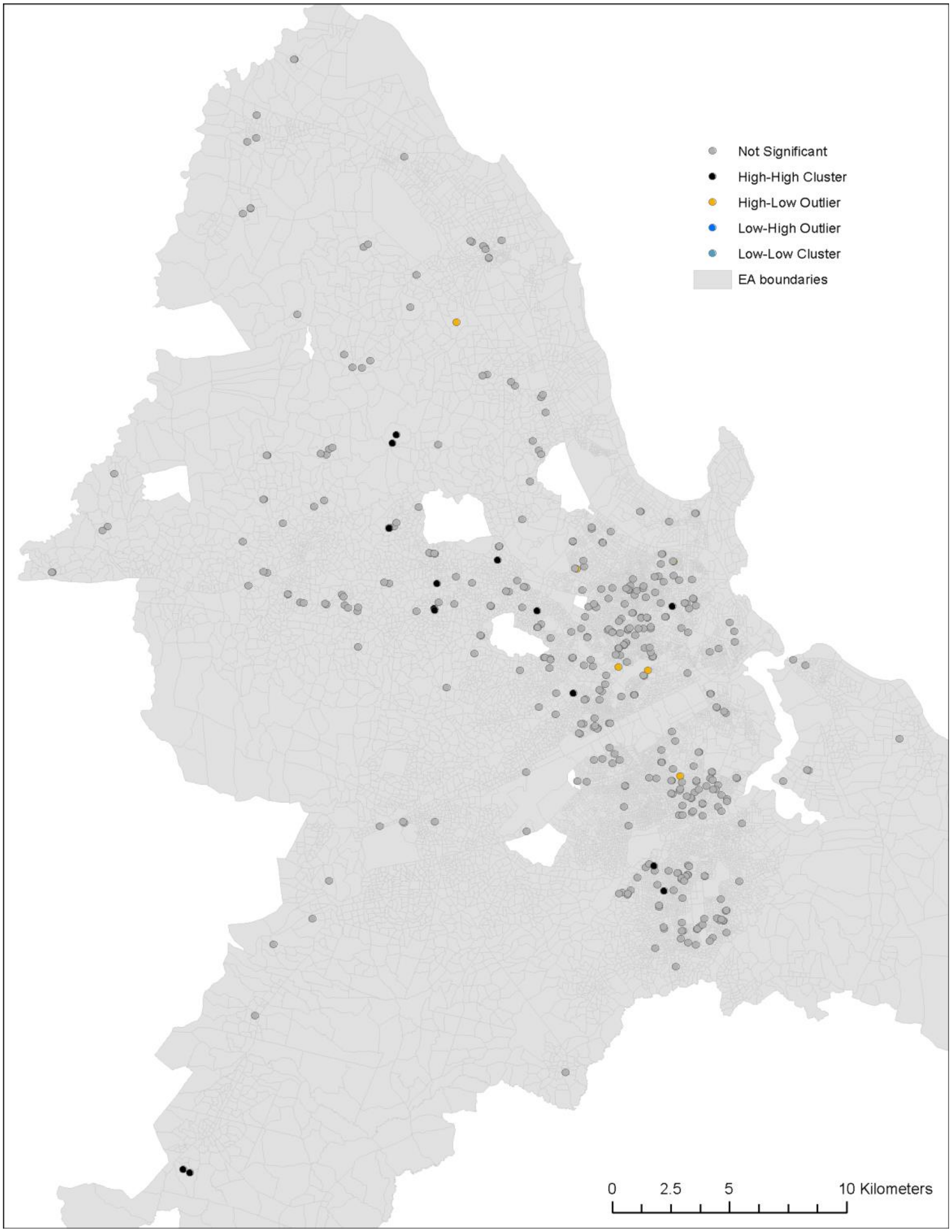
8.5.7.3 Hot Spot Analysis

This tool identifies statistically significant spatial clusters of high values (hot spots) and low values (cold spots). Our purpose is to assess whether there are hot spots of poor water quality in specific areas of each city. In essence, the hot spot analysis will test whether areas of poor quality are surrounded by areas of poor quality and whether areas of good quality are surrounded by other areas of good quality. This analysis is done using the Optimized Hot Spot Analysis tool[18] and utilizes the Getis-Ord Gi* (G-i-star) statistic, a different statistic than the cluster and outlier analysis, to identify statistically significant spatial clusters of high values (hot spots) and low values (cold spots), using which tests the relationships between area values and their surrounding values, as described above. Hot spots are statistically significant clusters of high values; cold spots are statistically significant clusters of low values (a hot spot is defined as an area with a high positive z-score and a low p-value. A very low z-score (i.e. high negative) and low-p-value represents statistically significant cold spots. A z-score near zero indicates little or no spatial clustering, i.e. randomly distributed values of the data). Maps for

[17] See ESRI Reference for further detail: http://resources.arcgis.com/en/help/main/10.2/index.html#//005p0000000z000000

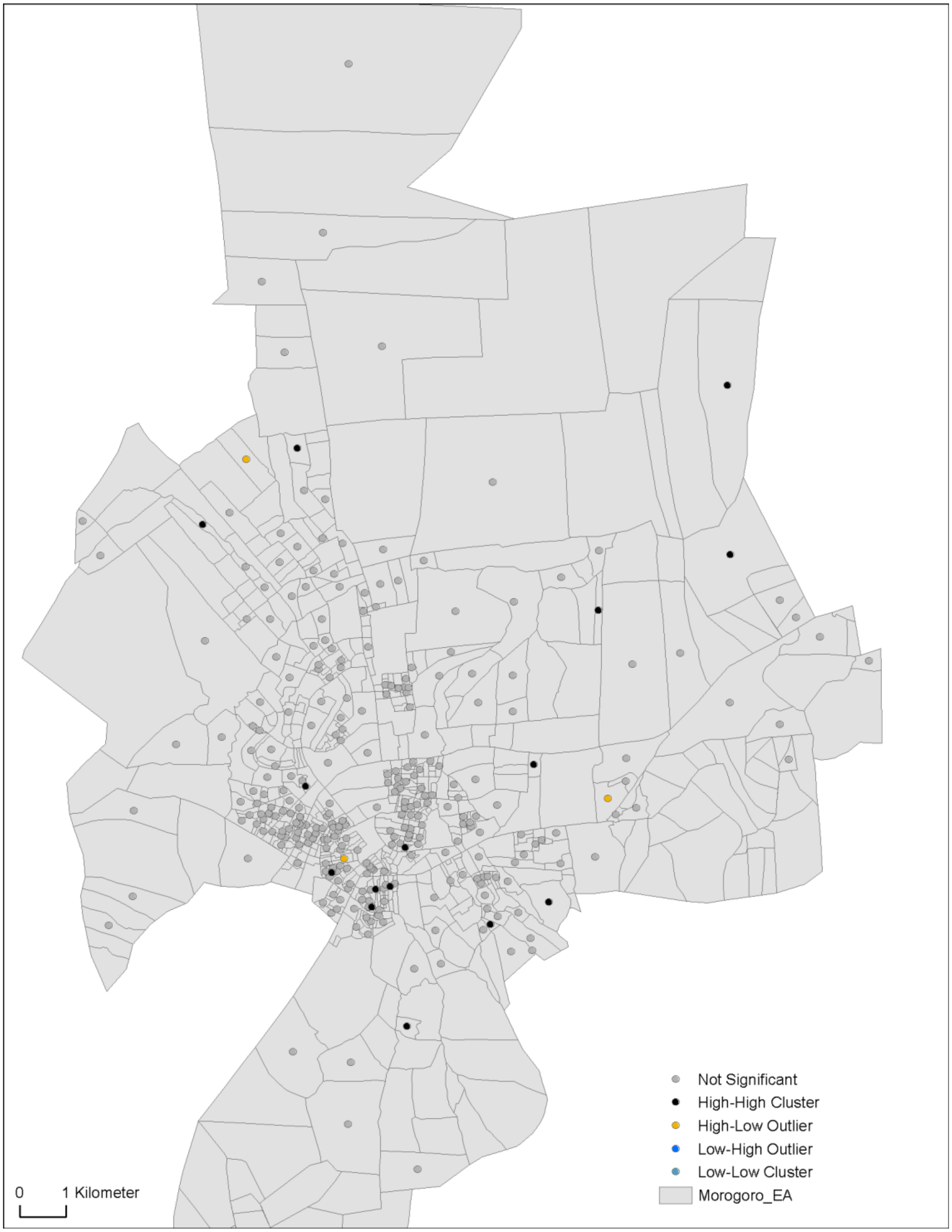
[18] The "optimized" hot spot analysis tool in ArcGIS Desktop 10.2 assesses the dataset in order to determine settings that will produce optimal hot spot analysis results. This includes aggregating incident data (presence/absence data), identifying the appropriate scale of analysis, and making other statistical adjustments related to testing and spatial dependence. A regular Hot Spot Analysis tool is available for users who prefer full control over these parameters. The optimized version has been utilized for the analysis presented in this report. See ESRI Reference for further detail: http://resources.arcgis.com/en/help/main/10.2/index.html#//005p00000058000000
http://resources.arcgis.com/en/help/main/10.2/index.html#//005p00000057000000

each city showing the results in terms of statistical significance are presented in Figure 42 and Figure 43. In Dar es Salaam, no statistically significant cold spots were identified, but a few hot spots were pinpointed. In Morogoro, the results are quite different, with a range of hot and cold spots identified in a striking pattern with cold spots in the center of town and statistical significant hot spots getting stronger emanating away from the center of town. To look further into these patterns, we mapped the distribution of z-scores along with the water distribution network (not shown) and found that values far from the distribution network tend to have higher positive z-scores (moving toward hot spots), while those closer have lower z-scores. It is also important to note that very little data was collected from Temeke district (the southeastern part of the city), and estimates can only be made where data is available. While some of the values are not statistically significant clusters, there is also an area where z-scores are relatively higher, along the Upper Ruvu pipeline area, west of the downtown area in Dar es Salaam. In Morogoro, the wards on the outskirts of the municipal boundary, again just reflecting the results of the hot spot analysis, have higher distributions of z-scores. Overall, in both cities, it is apparent that areas closer to the distribution network are generally less likely to be in areas with hot spots of poor water quality, confirming that safer water may be available through the piped network in both cities, but also underlying that improvements to the system, barring any expansion to the network or increase in household or community connections to the public distribution network, are likely to impact only those areas that rely on some direct or indirect access to the network. Further, these results reflect quality of the source water, but not quality of water that is consumed. Any contamination of water occurring after it is drawn from the source, such as during the process of hauling, storage, or retrieval for consumption, may affect key outcomes such as health beyond what can be gleaned from the water quality results in these analyses.



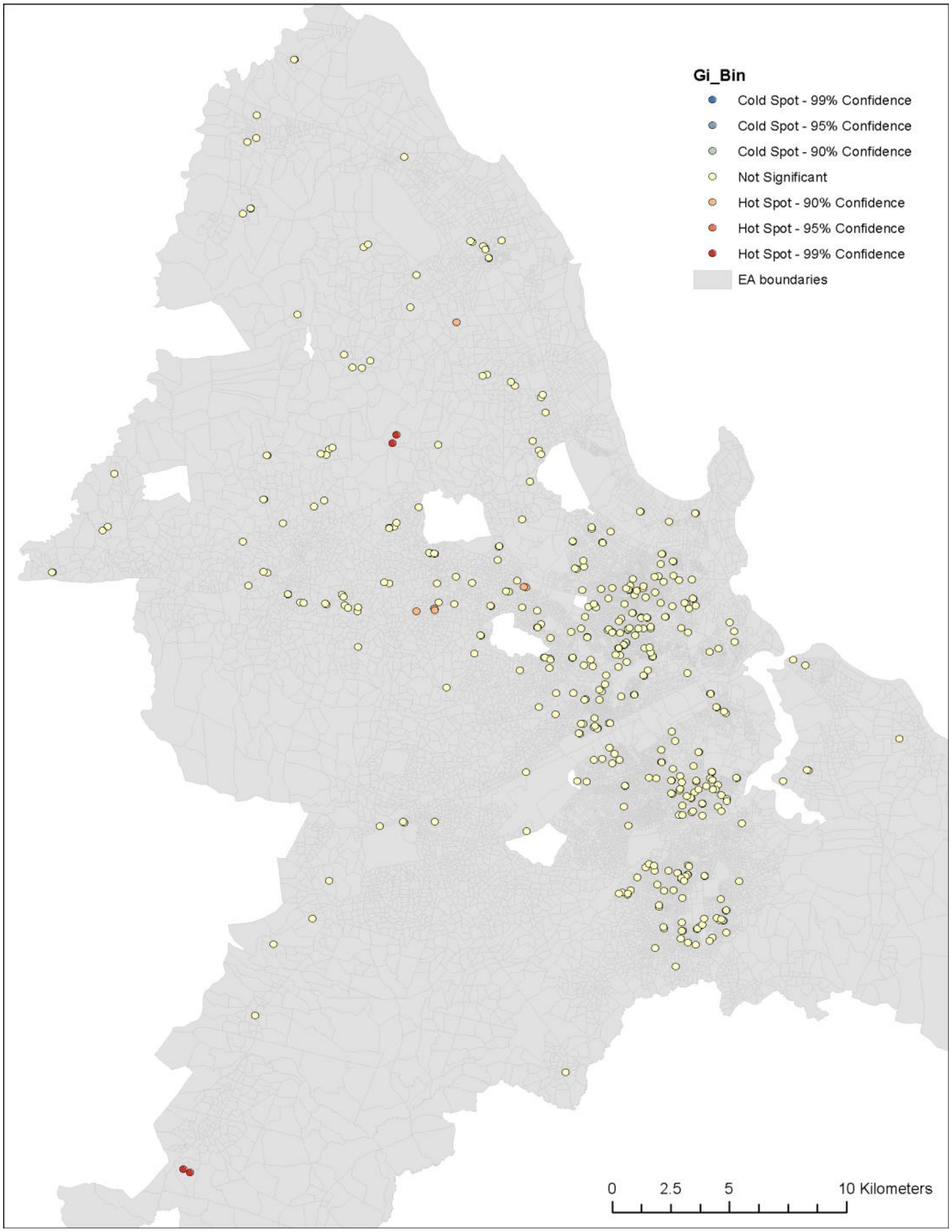
Note that several points above are the "centroid" of the enumeration area, not actual household locations.

FIGURE 40: CLUSTER AND OUTLIER ANALYSIS OF FECAL BACTERIA COLONIES: DAR ES SALAAM



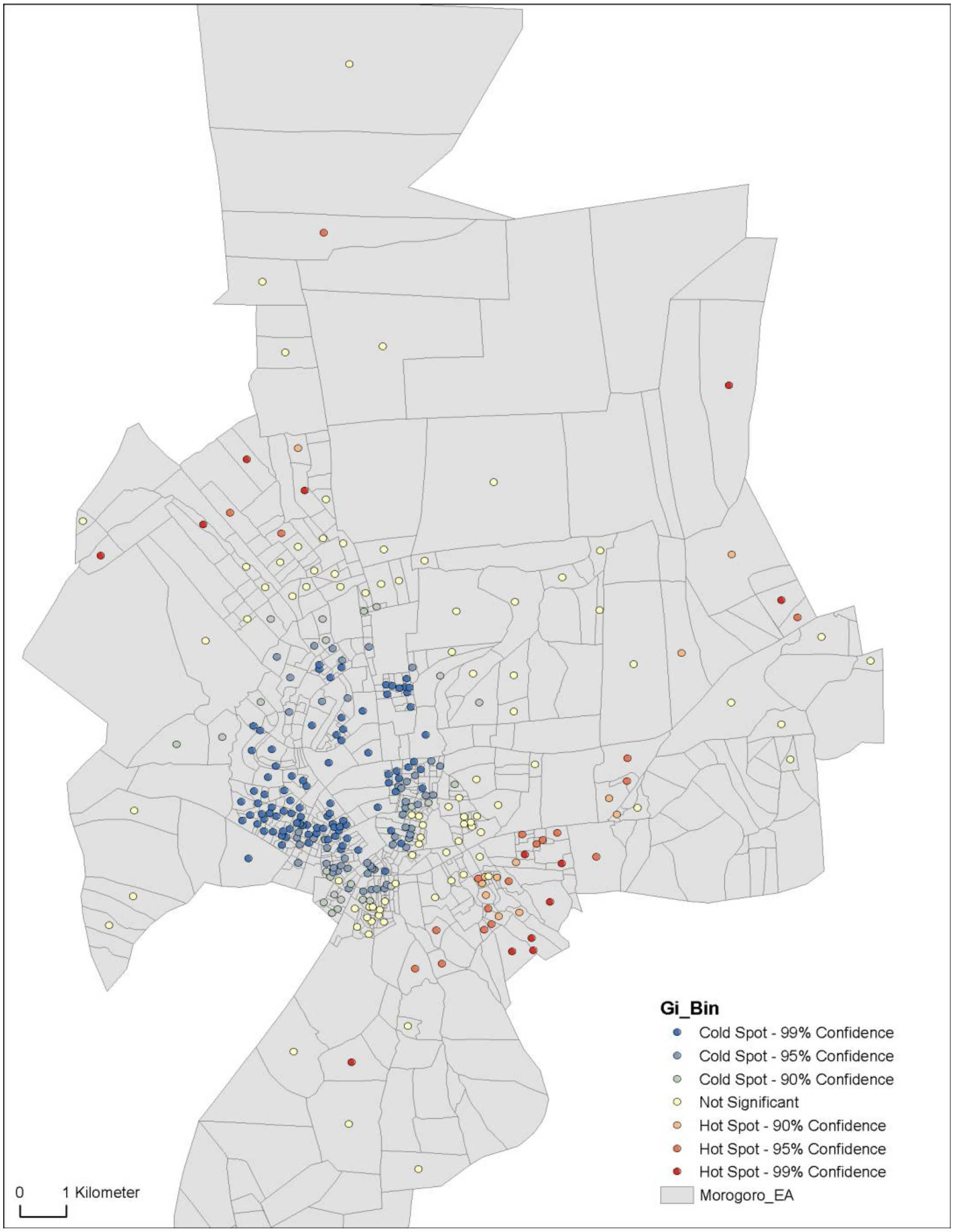
Note that several points above are the "centroid" of the enumeration area, not actual household locations.

FIGURE 41: CLUSTER AND OUTLIER ANALYSIS OF FECAL BACTERIA COLONIES: MOROGORO



Note that several points above are the "centroid" of the enumeration area, not actual household locations.

FIGURE 42: OPTIMIZED HOT SPOT ANALYSIS OF FECAL BACTERIA COLONIES: DAR ES SALAAM



Note that several points above are the "centroid" of the enumeration area, not actual household locations.

FIGURE 43: OPTIMIZED HOT SPOT ANALYSIS OF FECAL BACTERIA COLONIES: MOROGORO

8.5.8 Water treatment

Figure 44 and Figure 45 present the water treatment practices by primary source of drinking water, in terms of the percentage of respondents who report boiling, disinfecting, filtering, letting water stand and settle, or not treating their water at all.[19] Bottled water sources are not included in this question. It is striking that many respondents do absolutely nothing to treat their water, especially if the water comes from non-tap sources. In both cities, tap water is most likely to be treated, while water that does not come from a tap is the least likely. For example, in Dar es Salaam, 76% of households report boiling water, while 20% do not treat water from their own tap in any way. Among households using non-tap sources for drinking water, 30% boil the water before use, and 67% do nothing. A similar pattern is observed in Morogoro, with the exception of water obtained from vendors, which Morogoro residents are more likely to treat than Dar es Salaam residents. Poor households are least likely to treat their water, with the proportion of households treating their water rising with income (Figure 44). The water treatment practices could reflect the resident's perception of water quality, or differences in convenience of treating water from different sources.

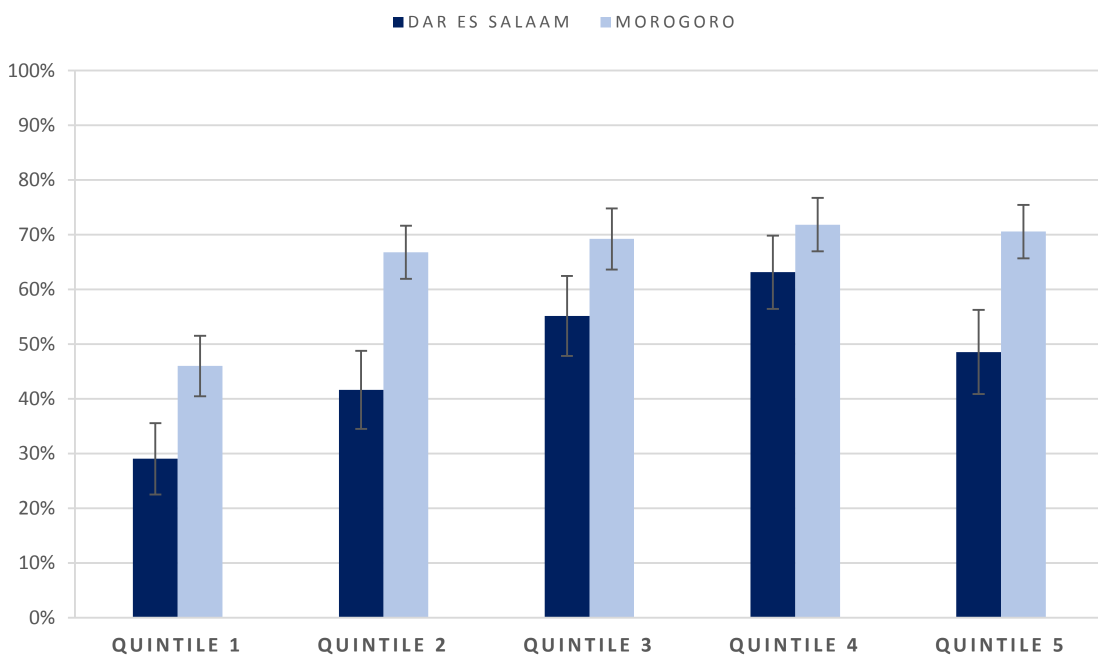


FIGURE 44: PROPORTION OF HOUSEHOLDS TREATING PRIMARY DRINKING WATER, BY SES

[19] Note: The water treatment method variable presented had been separated into the following water treatment methods listed representing appropriate categories from the household survey: Boil ("boil"); Disinfect ("water guard, bleach, chlorine"; "solar disinfection"*); Filter ("filter through a cloth", "water filter"); Other ("let stand and settle"; "aluminium sulfate"*); None ("none"). *Note that starred categories were not mentioned by any households from either city. Therefore, the category "other" in the case of our data represents only "let stand and settle", and therefore we present the data in this way.

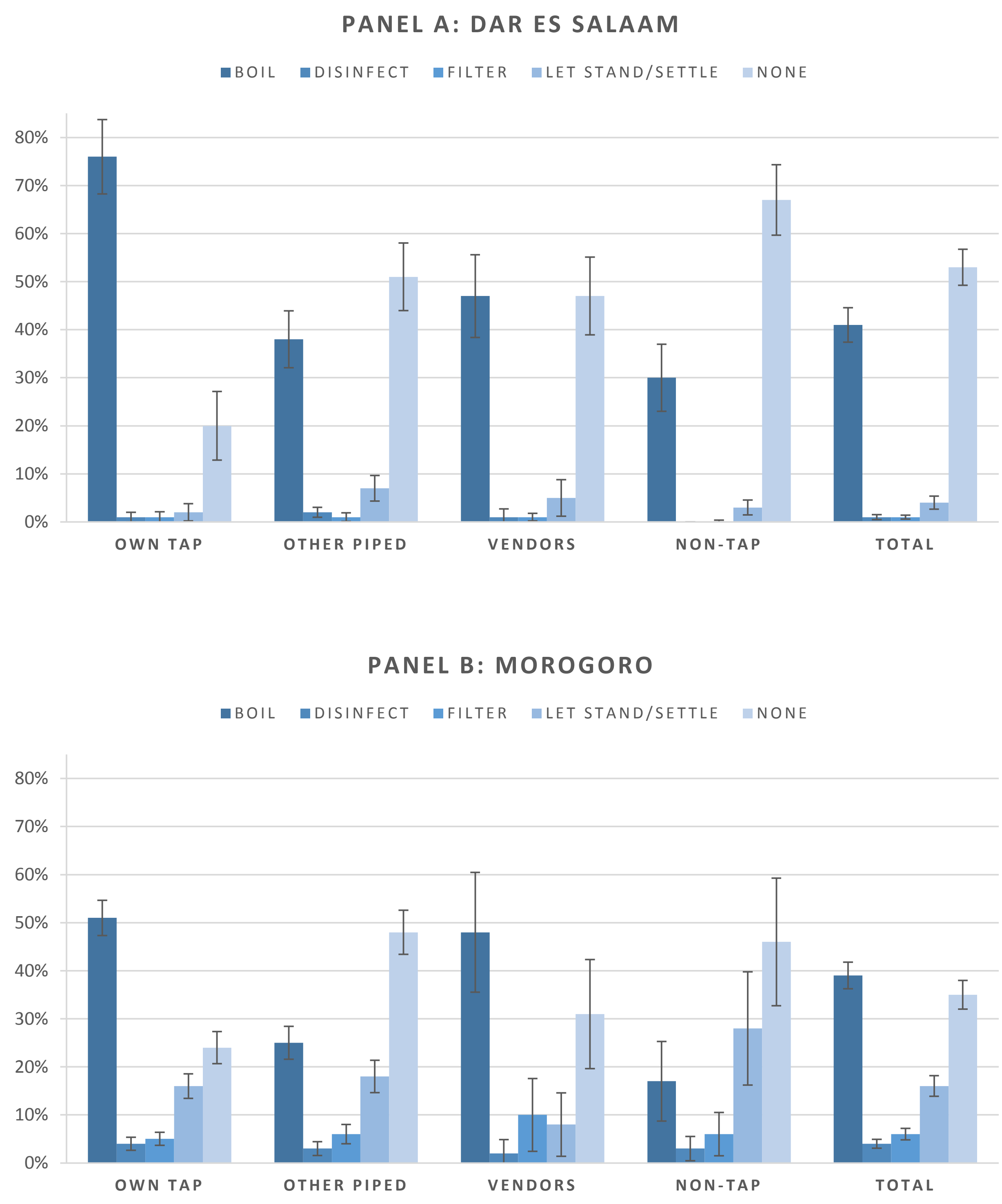


FIGURE 45: TREATMENT METHOD FOR DRINKING WATER FROM PRIMARY DRINKING WATER SOURCE

8.5.9 Modeled water source choice and water treatment

The following sections summarize the econometric analysis that was conducted on the baseline data, and present the results. Further discussion of each of these analyses and model specifications are presented in Annex A.

8.5.9.1 Determinants of primary water source

Households in Dar es Salaam and Morogoro obtain water from many sources, but little is known about factors affecting the choice of water source The choice analysis consisted of two parts: (i) an evaluation of the determinants of having a piped source (either piped into own dwelling/lot or from a neighbor or other piped source) and (ii) an evaluation of the determinants of choice of main source of drinking water out of five options With discrete outcomes, estimation involved use of a *probit* (determinants of whether the household's main source of drinking water is from a piped source) and a *multinomial logit* model (main source of drinking water among multiple sources) The information from this estimation is useful because an important outcome of the MCA water investment will be to make public piped water more available and increase the number of users of this relatively safe source of water. Understanding the determinants of water sourcing will allow the water utilities to target particular groups of users and promote increased connections to the public system.

Independent variables in both models included variables reflecting household characteristics, education levels, socioeconomic status, housing quality, access within the sample cluster to piped water sources, and city. The analysis is at the household level. The main measure of access to piped water is the count within the survey enumeration area of households reporting their main source of water to be a piped source.[20] This variable takes integer values from 0-8 and can be thought to be reasonably exogenous to household decisions. In the current analysis, it is treated as exogenous.

In *probit* and *multinomial logit* (MNL) models, estimated coefficients cannot be directly interpreted; to address this problem, marginal effects are estimated and presented. Marginal effects show the impact of a one-unit change in the independent variable on the probability of observing a particular outcome.[21] For example, in the *probit* model, the marginal effect shows the change in probability that a household uses a piped water source as its main source of drinking water In the *MNL* model, the marginal effects reflect the change in probability of using each of the five sources.

8.5.9.2 Determinants of use of a piped source

Results from the *probit* model show that the probability of a household using a piped water source is almost completely determined by neighborhood characteristics—specifically the count of households in the enumeration area reporting a piped source. When this variable is excluded from the regression, factors such as household composition and housing characteristics appear to exert significant influence on this decision, but once this neighborhood characteristic is included, the influence of the other variables drops to the point of insignificance Holding other variables constant, for each additional source of piped water in the household's immediate enumeration area, the probability of the household receiving water from a piped source increases by 5.8%. When the analysis was run separately by city, the estimates remained consistent, with the point estimate of the marginal effect for Morogoro being slightly lower (5.2% compared to 5.8%—results are not shown because specification tests indicate that the pooled model—that with all observations

[20] Piped sources include either piped directly into the house or into the lot or piped into a neighbor's house or lot or a kiosk or public tap connected to the public piped water system.

[21] These probabilities are estimated at sample means.

included—is the appropriate one). These results suggest primarily that use of piped water sources is mainly constrained by supply factors and that clusters of high use are the norm. Under these circumstances, efforts to make piped water more available throughout the cities should spread its use substantially.

8.5.9.3 Determinants of main source of drinking water

As noted above, for the purpose of this analysis, the main source of drinking water is grouped into five classes as described elsewhere in this report (own tap, other piped, vendors, non-tap, bottled); the household decision to select from these sources is a multinomial process. As the main interest is in the determinants of use of piped water sources, the discussion focuses on the determinants of selecting main drinking water source as piped water on premises (own tap) and piped sources either at neighbors or kiosks/public stands (other piped). The use of piped water into the household or lot is closely related to household socioeconomic status as reflected through the asset index. Households in the fifth quintile (wealthiest relative to other households) are almost 13% more likely to obtain their drinking water from this source compared to households in the first socioeconomic quintile (the reference category, the least wealthy by this measure, relative to other households). Those in the fourth, third and second quintile are, respectively, 10%, 10%, and 6% more likely than lowest-quintile households to have tap water in their homes or lots. Households with more rooms and access to electricity are also more likely to use tap water, further confirming the relationship of used of piped water to socioeconomic status. Female-headed households and those with very well-educated adults are also more likely to obtain their main drinking water from tapped water sources, but the variables are not statistically significant.[22]

Other piped sources has the reverse relationship to socioeconomic status, as all the upper quintiles are less likely compared to the first quintile to source their water from another tapped source. In fact, households in the upper quintile are almost 18% less likely than those from the lowest quintile to obtain water from a neighbor's tap, a kiosk or another tapped source. These findings show an interesting impact of the spread of water taps in these areas—wealthier households are more likely to benefit directly from an expansion in supply of tapped water (by obtaining taps in their own households or lots), but those from the lowest quintiles will also benefit. The benefits to the lowest quintiles are indirect—they are likely to substitute away from inferior surface and well sources toward tapped sources as the latter become more available.

As in the *probit* analysis, the results clearly show that increased access to piped water sources in neighboring areas[23] is associated with increased use of the piped water sources (own tap on premises and other piped). Holding other factors constant, an addition of one household with a piped water source in the immediate survey enumeration area raises the probability that a household has as its main source of drinking water its own tap (by nearly 4%) or a neighboring or kiosk tap (by about 3%). These effects are highly statistically significant and show important spillovers in access. Neighborhood access to piper water significantly reduces the probability of a household receiving water from other, non-piped, sources, and its effect on obtaining water from non-tap sources (the least sanitary source) is especially strong as it lowers this probability by more than 4%. The data also show that water infrastructure is more widely spread in Morogoro, where households are almost 16% more likely to

[22] The household head sex variable is coded as =1 if male =2 if female. Thus, a positive sign is associated with a higher probability of the outcome among female-headed households. For the education dummy variables, the omitted category is households whose highest-educated adult has no formal education and each estimated coefficient should be compared to this omitted category.

[23] In heavily urbanized areas, enumeration areas are geographically compact and exhibit properties of being a neighborhood.

have piped water into their house or lot, holding all other factors constant.

An additional interest is in factors associated with lower probability of the household obtaining water from non-piped water from boreholes, wells, springs and surface sources. These sources are likely of the lowest quality and one of the effects of the water investments should be to induce households to use more piped water. Use of non-tap water is closely related to socioeconomic status and household education. Better-educated households and those from the upper socioeconomic strata are substantially less likely to use this low-quality source. The level of education of the best-educated adult has a strong negative impact on use of this water source—even households whose best-educated adult member has only attended primary school are as much as 36% less likely to use this source compared to households with no educated adults. Once this minimum education threshold has been passed, however, the probability of sourcing water from boreholes, wells, springs and surface sources do not fall substantially with increased education.

Socioeconomic status is also significantly associated with the probability of sourcing water from these relatively unsafe sources—higher SES households are 10% (quintile 4) and 14% (quintile 5) less likely than the lowest-quintile households to obtain drinking water from boreholes, wells, springs and surface sources. As noted, each additional household in the enumeration area with access to piped water lowers the probability (by about 4%) of using this source.

TABLE 46: MODEL FOR DETERMINANTS OF PIPED WATER AS MAIN DRINKING WATER SOURCE

Probability of main source of drinking water being a piped source	Restricted Model				Full Model			
	ME	SE	z	Sig.	ME	SE	z	Sig.
Household size	0.01	0.02	0.88		0.01	0.01	1.29	
Dependency ratio	0.10	0.04	2.57	***	0.02	0.02	1.58	
Number of 5-15 year olds in household	-0.07	0.03	-2.47	**	-0.01	0.01	-1.45	
Number of under 5s in household	-0.07	0.03	-2.05	**	-0.01	0.01	-0.85	
Number of adult females	0.04	0.02	1.73	*	0.00	0.01	0.18	
Adult education pre-primary or adult ed. only	0.00	0.14	-0.02		0.02	0.04	0.47	
Adult education primary or some secondary only	0.14	0.12	1.19		0.02	0.03	0.54	
Adult education completed secondary	0.10	0.12	0.81		0.00	0.03	0.14	
Adult education completed college	0.06	0.13	0.45		-0.03	0.03	-1.03	
Household head sex	0.04	0.04	1.15		0.02	0.01	1.3	
Number of rooms	0.03	0.02	1.87	**	0.00	0.01	-0.17	
Electricity in the home	0.09	0.04	2.36	**	-0.01	0.01	-0.76	
Home owned by residents	-0.08	0.04	-2.16	**	0.00	0.01	-0.38	
Second socio-economic quintile	0.01	0.05	0.15		-0.02	0.02	-0.93	
Third socio-economic quintile	0.00	0.05	0.09		-0.01	0.02	-0.58	
Fourth socio-economic quintile	0.04	0.05	0.84		0.03	0.02	1.42	
Fifth socio-economic quintile	0.04	0.06	0.75		0.00	0.02	0.07	
Quantity of households w/ piped water					0.06	0.00	46.83	****
Lives in Dar es Salaam	-0.43	0.02	-23.2	****	0.00	0.01	-0.29	
Pseudo R^2	0.06				0.71			
N	4,937				4,937			

*Notes: Significance levels calculated using p-values as: *=<.1, **<.05, ***<.01, ****<.001.*

TABLE 47: MODEL OF DETERMINANTS OF CHOICE OF PRIMARY DRINKING WATER SOURCE

	Non tap				Own tap				Other piped				Vendors				Bottled/bagged			
	ME	SE	z	Sig.	ME	SE	z	Sig.	ME	SE	z	Sig.	ME	SE	z	Sig.	ME	SE	z	Sig.
Household size	-0.01	0.01	-0.36		0.00	0.01	0.23		0.01	0.01	0.51		0.00	0.01	0.02		0.00	0.00	-0.49	
Dependency ratio	0.03	0.03	0.98		0.03	0.02	2.05	**	0.03	0.02	1.36		-0.02	0.03	-0.79		-0.07	0.03	-2.35	**
Number of under 5s in household	-0.01	0.02	-0.25		-0.02	0.01	-1.38		0.00	0.02	0.17		0.01	0.02	0.46		0.01	0.01	1.21	
Number of 5-15 year olds in household	0.02	0.02	0.92		-0.01	0.01	-0.80		-0.02	0.02	-1.02		-0.01	0.02	-0.31		0.02	0.02	1.00	
Number of adult females	-0.03	0.02	-1.41		0.00	0.01	-0.09		0.03	0.02	1.99	**	0.02	0.02	1.06		-0.02	0.01	-3.03	***
Adult ed. pre-primary/adult education only	-0.36	0.09	-4.15	****	-0.04	0.05	-0.89		-0.24	0.07	-3.46	***	0.09	0.11	0.81		0.56	0.06	8.87	****
Adult ed. primary/some secondary only	-0.47	0.07	-6.48	****	-0.02	0.04	-0.40		-0.26	0.06	-4.67	****	0.21	0.10	2.11	**	0.54	0.06	9.25	****
Adult ed. completed secondary	-0.43	0.07	-5.71	****	0.02	0.04	0.40		-0.30	0.06	-5.12	****	0.15	0.10	1.52		0.56	0.06	9.69	****
Adult ed. completed college	-0.39	0.08	-4.70	****	0.11	0.05	2.32	**	-0.47	0.06	-7.33	****	0.16	0.10	1.54		0.60	0.06	9.77	****
Household head gender	-0.01	0.03	-0.35		0.06	0.02	3.30	****	-0.07	0.03	-2.64	**	0.01	0.03	0.37		0.01	0.01	0.51	
Number of rooms	0.03	0.02	2.00	**	0.02	0.01	2.22	**	-0.03	0.01	-2.25	**	-0.01	0.01	-0.50		-0.01	0.01	-1.54	
Electricity in the home	-0.03	0.03	-1.01		0.09	0.02	3.93	****	-0.06	0.03	-2.40		-0.01	0.03	-0.43		0.02	0.01	1.11	
Home owned by residents	0.03	0.03	0.97		-0.01	0.02	-0.86		0.00	0.02	0.17	**	-0.01	0.03	-0.32		-0.01	0.02	-0.70	
Second socio-economic quintile	-0.01	0.04	-0.30		0.06	0.03	2.24	**	-0.08	0.03	-2.55	**	0.01	0.04	0.17		0.02	0.03	0.91	
Third socio-economic quintile	-0.06	0.04	-1.51		0.10	0.03	3.79	****	-0.07	0.03	-2.29	**	0.01	0.04	0.31		0.02	0.02	1.04	
Fourth socio-economic quintile	-0.10	0.04	-2.26	**	0.10	0.02	4.48	****	-0.10	0.03	-3.12	**	0.07	0.05	1.41		0.03	0.02	1.46	
Fifth socio-economic quintile	-0.14	0.05	-2.92	***	0.13	0.03	5.12	****	-0.18	0.04	-4.85	****	0.13	0.05	2.56	**	0.07	0.02	2.86	***
Number households w/ piped water	-0.04	0.01	-8.40	****	0.04	0.00	11.02	****	0.03	0.00	8.70	****	-0.02	0.00	-4.33	****	0.00	0.00	-1.58	
Lives in Dar es Salaam	0.09	0.02	3.73	****	-0.16	0.01	-15.65	****	0.06	0.02	3.47	****	0.00	0.02	-0.19		0.01	0.01	0.84	
N		4937																		
Adjusted R2		0.39 49																		

*Notes: ME=Marginal effect. Significance levels calculated using p-values as: *=<.1, **<.05, ***<.01, ****<.001.*

8.5.9.4 Determinants of water treatment behavior

Improved water supply is expected to reduce costs associated with obtaining water from other sources and improve health outcomes associated with drinking unsanitary water. For example, those with access to piped water spend less time hauling water from alternative sources. Since treatment practices are a major mediating factor between water supply access and illness prevalence, we also investigated the relationship between access to piped water and treatment behavior. In theory, piped water access may also decrease use of water filters, fuel for boiling water, and other treatment costs. However, if piped water supply is not perceived to be higher quality than alternate sources, water treatment costs may not fall with increased access to piped sources; alternatively, the same factors that lead a household to seek piped water connections could also influence their decision to treat water. Our analysis investigates the tradeoff between piped water access and water treatment utilizing a recursive bivariate probit model to account for the potential joint endogeneity of water treatment and use of a piped source (more detailed methodology is presented in Annex A).

TABLE 48: MODEL FOR PROBABILITY OF TREATING DRINKING WATER

Probit	Probit model				Marginal effects (Delta-method)			
Variable	**Coef.**	**SE**	**z**	**P>z**	**dy/dx**	**SE**	**z**	**P>z**
Piped water*	0.317	0.085	3.74	0	0.109	0.029	3.84	0
Number of under 5s in household	0.042	0.063	0.67	0.502	0.014	0.022	0.67	0.502
Girls 6-13 in household	-0.029	0.062	-0.46	0.644	-0.010	0.022	-0.46	0.645
Girls 14-18 in household	-0.024	0.087	-0.27	0.784	-0.008	0.030	-0.27	0.784
Number of adult females	0.114	0.048	2.38	0.017	0.039	0.016	2.4	0.016
Boys 6-13 in household	-0.057	0.059	-0.98	0.329	-0.020	0.020	-0.98	0.329
Boys 14-18 in household	-0.068	0.081	-0.84	0.403	-0.023	0.028	-0.84	0.403
Number of adult males	-0.129	0.047	-2.72	0.007	-0.045	0.016	-2.75	0.006
Adult education pre-primary or adult ed. only	0.096	0.244	0.39	0.693	0.033	0.084	0.4	0.692
Adult education primary or some secondary only	0.528	0.250	2.12	0.034	0.182	0.085	2.16	0.031
Adult education completed secondary	0.769	0.270	2.84	0.004	0.265	0.091	2.91	0.004
Household head sex	0.064	0.113	0.57	0.568	0.022	0.039	0.57	0.569
Access to sanitation (toilet)	0.221	0.088	2.5	0.012	0.076	0.031	2.5	0.012
Second socio-economic quintile	0.363	0.132	2.74	0.006	0.125	0.045	2.78	0.005
Third socio-economic quintile	0.350	0.121	2.88	0.004	0.121	0.041	2.94	0.003
Fourth socio-economic quintile	0.639	0.124	5.16	0	0.221	0.041	5.42	0
Fifth socio-economic quintile	0.732	0.146	5.02	0	0.253	0.048	5.25	0
Lives in Dar es Salaam	-0.375	0.056	-6.69	0	-0.130	0.019	-6.79	0
N	4997							
Log Pseudolikelihood	-764246.24							
Wald chi-squared	2193.75 (35 degrees of freedom)							

Outcome=drinking water is treated
** Endogenous variable*

As described above, water treatment varies drastically by primary water source (Table 49), and by socioeconomic quintile (Figure 20) with households in the lowest quintiles less likely to treat their water. These findings are corroborated by the model results (shown in Table 48). To facilitate interpretation, the marginal effects are shown in the right panel. Access to piped water increases the probability of the household treating its drinking water by 11%, holding all other variables constant. Increased education of the best-educated adult and higher socioeconomic status are also positively associated with water treatment. Those from the highest socioeconomic quintile are 25% more likely to treat water compared to the lowest quintile, while households whose best educated adult has more than secondary education are 26% more likely than the least-educated. Residents of Dar es Salaam are nearly 13% less likely to treat their water, in line with the findings that system water quality in Dar es Salaam is substantially higher than in Morogoro. These results suggest that water system investments are not likely to have a large effect on household water treatment expenditures. However, in Morogoro, where improved/increased water treatment capacity is part of the intervention, a structural shift in the source/treatment relationship may emerge following completion of the project.

8.6 Service Quality, Water Consumption, and Expenditures

8.6.1 Continuity of service (supply-hours)

The indicator of tap water supply was based on reported shortages in the last seven days among households who had access to a tap on premises, across the main baseline and three rounds of phone surveys. Overall, in Dar es Salaam, an estimated 41% of households with a tap on premises reported a shortage in the last week, in contrast to 51% of similar households in Morogoro. Figure 46 presents the average number of days households in each city had running water, based on a survey module asking about water shortages, and using that data to calculate the water supply per week. In both rounds, the water supply appeared higher at baseline (between 5 and 6 days in Dar es Salaam, and just above 6 days in Morogoro), and lowest during the first phone round (approximately 4 days in Dar es Salaam and 5 days in Morogoro). In all cases except for the third phone round, Dar es Salaam households had fewer supply-days than Morogoro; since Morogoro is a smaller city and a greater fraction of its population is connected, this finding is not surprising. This aligns with qualitative evidence from the focus group discussions (presented in Section 8.8), in which Dar es Salaam residents described more erratic supply from the network than their counterparts from Morogoro. In line with these findings, there is substantially greater uncertainty around the estimates for Dar es Salaam. Nevertheless, in both cities the number of supply-days is relatively high, relative to expectations given the qualitative accounts some areas receiving water less than half of the week, and only a few hours on those days.

Figure 47 explores how supply, as calculated through shortage reports, varies across households that use different drinking water sources, *all of whom have access to a tap on premises*. The objective of this disaggregation is to explore potential correlations between the source of drinking water and the reported supply levels from the public network. As expected, households with a more reliable supply from their own tap on premises are somewhat less likely to report a source other than own tap as main source of drinking water (i.e., below “higher” on the graph than the piped water line). The notable exceptions are households who use bottled water in Dar es Salaam, who report fewer shortages (and thus a higher supply level) in all of the phone survey rounds compared to households who use a tap on premises for their own drinking water. Note that in Morogoro, the results showing that those who use non-tap water for drinking report higher supply than those whose primary drinking water is their own tap on premises, must be interpreted with caution as these values of "7 days per week" was the only value within that group. This data is presented in greater detail, with the appropriate standard errors for comparison, in Table 81. Disaggregating the reported supply-days (as calculated through shortage reports) further did not yield any significant differences between SES quintiles with respect to the supply-days from their taps (see Table 82 for further detail).

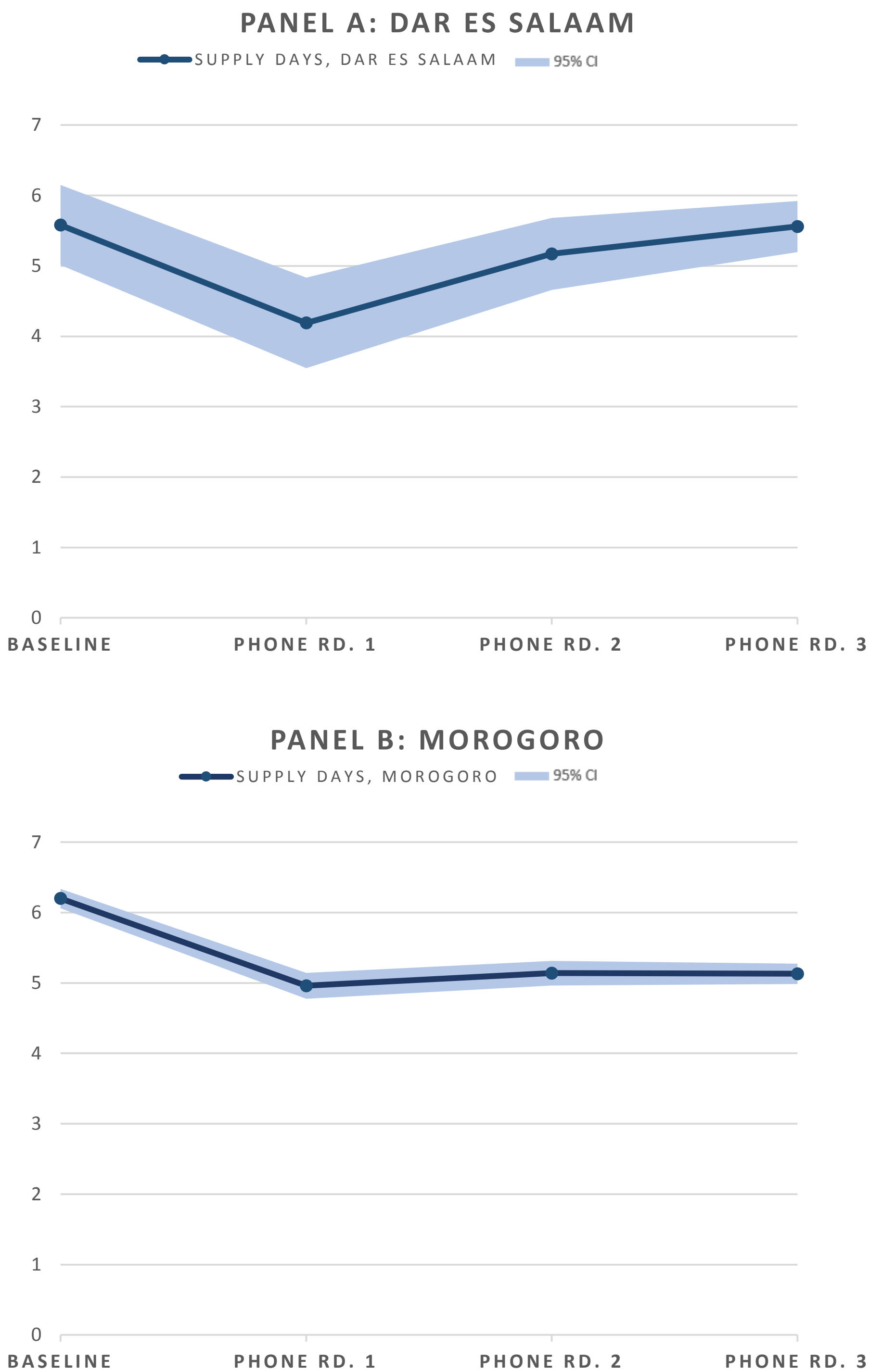


FIGURE 46: DAYS OF WATER SUPPLY IN LAST 7 DAYS (MEAN), BY SURVEY PHASE

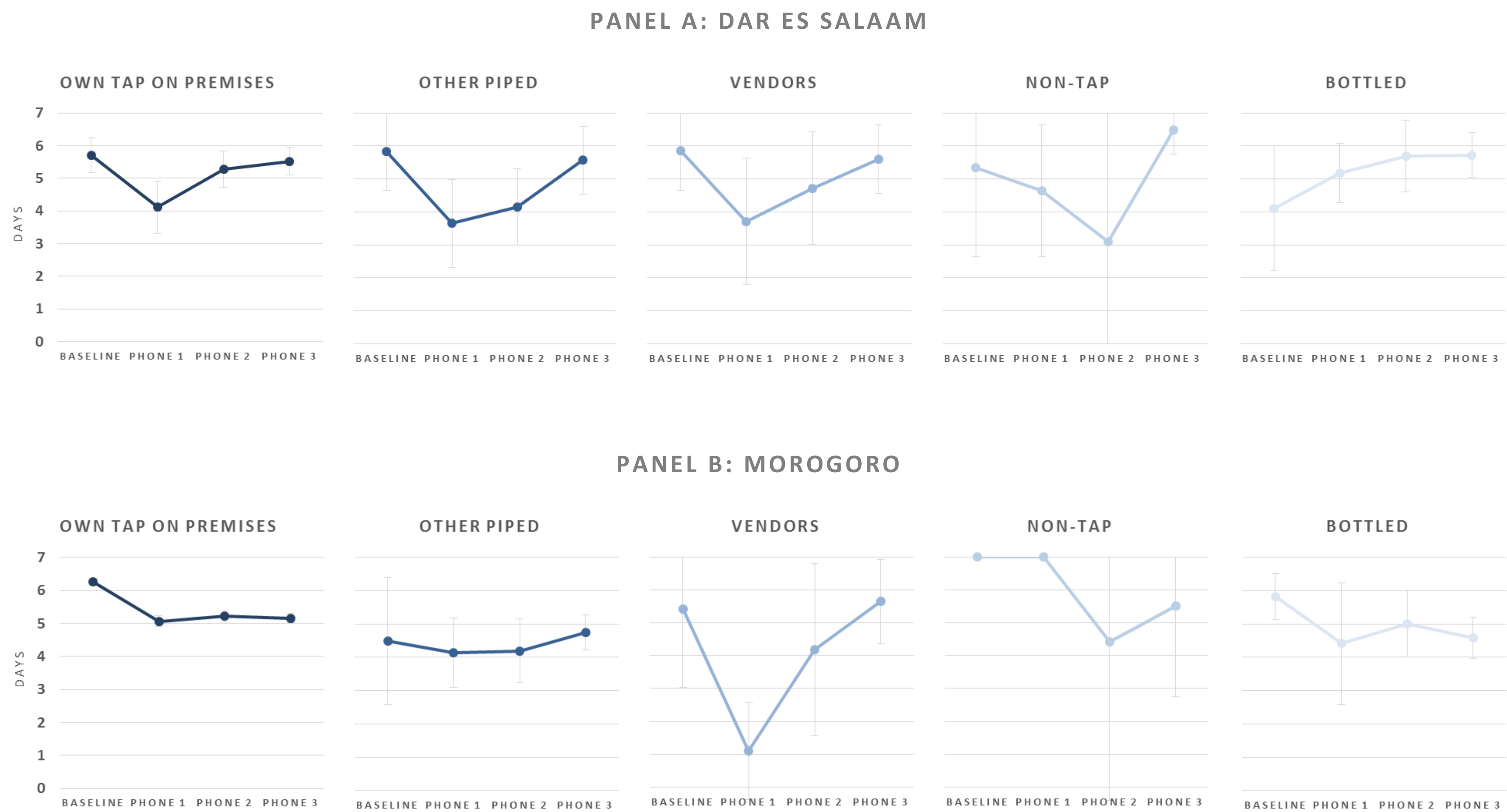


FIGURE 47: DAYS OF WATER SUPPLY IN LAST 7 DAYS, BY PRIMARY DRINKING WATER SOURCE

Since the way that the questions about continuity of service are worded matters (water availability versus water shortages), a more positively phrased question was added to collect direct data on water availability in the third round of the phone survey. This question was phrased as: "*How many days do you get water from your tap? On these days, about how many hours is the water usually flowing?*" This question was added after the qualitative focus group interviews, through which we learned that this is how many residents think and converse about water supply. Although this is not a direct inverse of the questions asked in the shortages modules, the answers to this question lead to lower average estimates compared to the shortages approach. The data from this question is presented in Table 49 and indicates an overall supply level of approximately 4.2 days in Dar es Salaam, and 3.9 days in Morogoro. Because the way the question is asked produces such different responses, measurements of continuous levels of water access should be interpreted with caution. Asking about shortages has the disadvantage that awareness of a shortage is conditional on the respondent attempting to draw water. On the other hand, the question about availability may also produce noisy estimates, if respondents reply based on knowledge of a rationing schedule that may not be accurate in practice. For the end-line, it would be beneficial to use both measures of water availability, ensuring that the survey is appropriately structured to avoid framing effects In addition, by end-line data collection, hopefully exogenous measures of bulk meter readings will be available for each areas to enable direct comparison of self-reported versus metered supply.

TABLE 49: SUPPLY-DAYS, ALTERNATIVE ESTIMATE (PHONE RD. 3)

	Dar es Salaam			Morogoro		
Source	**Mean**	**SE**	**95% CI**	**Mean**	**SE**	**95% CI**
Own tap	4.2	(0.185)	[3.85,4.58]	3.9	(0.082)	[3.75,4.07]
Other piped	3.6	(0.424)	[2.77,4.44]	3.5	(0.235)	[3.01,3.94]
Vendors	4.7	(0.744)	[3.26,6.18]	4.6	(0.870)	[2.93,6.35]
Non-Tap	6.1	(0.767)	[4.55,7.57]	5.5	(1.410)	[2.75,8.30]
Bottled	4.3	(0.462)	[3.40,5.22]	3.7	(0.487)	[2.69,4.61]
Total	4.2	(0.167)	[3.89,4.55]	3.9	(0.079)	[3.73,4.04]

8.6.2 Utility service

Comprehensive monthly reports were available from MORUWASA but not from DAWASA. For both utilities, summary service indicators were collected from the MCA-T Indicator Tracking Table. First, the key points from MORUWASA's monthly reports are presented.

Table 50 summarizes MORUWASA's documentation of the number of connections, by customer type, between February and June 2013, gathered through their comprehensive monthly reports. During this period, 818 customers were added. Domestic connections comprised approximately 94% of customers. Table 51 demonstrates the proportion of billable water estimated by MORUWASA compared with actual sales denominated in cubic meters (m^3). Notwithstanding an apparent reporting anomaly in March (which indicates the same number of quantity produced and billed), in April 2013 MORUWASA had the least amount of billable water, selling 540,844 m^3 of the 607,750 m^3 that was produced for sale. The utility reported that over the period February to June 2013, the average service hours of water per day ranged between 13 and 18, with no more than 28% of the population having 24/7 access during this period. The utility also reports the total and operational numbers of kiosks, which may later be juxtaposed with the GIS data of kiosk locations. The monthly reports indicated that MORUWASA pays the bills of close to 500 households each month. Table 52 shows the volume of water produced, estimated demand, consumption, and lost or unaccounted for water in Morogoro. Demand consistently exceeded supply by about double in most months. Production amounts varied slightly from month to month, but averaged 701,500 m^3. Notably, approximately one fifth of all water produced is unaccounted for.

TABLE 50: CONNECTIONS TO MORUWASA BY CUSTOMER TYPE

	February	March	April	May	June
Number of connections, by type					
Domestic	21,793	21,851	21,918	22,319	22,608
Institution	535	532	533	533	533
Commercial	691	694	696	696	696
Industrial/Garages	92	92	92	92	92
Total	**23,111**	**23,169**	**23,239**	**23,640**	**23,929**
Number of metered working connections, by type					
Domestic	17,685	17,683	17,760	17,859	17,859
Institution	334	323	332	343	343
Commercial	560	561	566	568	568
Industrial/Garages	50	48	49	50	50
Total	**18,629**	**18,615**	**18,707**	**18,820**	**18,820**
Number of metered non-working connections, by type					
Domestic	2,360	2,374	2,314	2,223	2,223
Institution	110	120	113	101	101
Commercial	108	110	106	105	105
Industrial/Garages	26	28	27	26	44
Total	**2,604**	**2,632**	**2,560**	**2,455**	**2,473**
% of non-working connections	12	12	12	12	12

**Notes: The June MORUWASA report presents a total of 18,821 connections in June, however the sum of the quantity of each connection type is 18,820.[1] The March MORUWASA report presents a total of 2,631 metered non-working connections, but the sum of the quantity of each connection type is 2,632. The April MORUWASA report presents a total of 2,559 metered non-working connections, but the sum of the quantity of each connection type is 2,560. The May MORUWASA report presents a total of 2,554 metered non-working connections, but the sum of the quantity of each connection type is 2,555. The June MORUWASA report presents a total of 2,545 metered non-working connections, but the sum of the quantity of each connection type is 2,473.*

TABLE 51: BILLING AND CONNECTION DATA FOR MORUWASA

Billing	February	March	April	May	June
Quantity of water billed (m^3)*	562,031	540,000	540,844	597,500	556,906
Quantity of billable water (m^3)	590,750	540,000[24]	607,750	606,050	568,000
Poor households water bills paid	482	482	482	482	482
Access and kiosk data	**February**	**March**	**April**	**May**	**June**
Average service hours per day	18	18	13	13	14
Customers with 24/7 access (%)	28%	28%	28%	28%	31%
Kiosks	105	105	105	105	105
Working kiosks	77	62	76	76	76
Disconnected kiosks	28	43	29	29	29
Cost of 20L jerry can by vendor (TZS)	100	100	100	100	100
Cost of 20L jerry can by authority (TZS)	14	14	14	14	14

*Note: For data related to March 2013, SI suspects that one of the values has been recorded in error, since contrary to other months, the reported quantity of water billed is equal to the reported quantity of billable water

TABLE 52: MORUWASA PRODUCTION, DEMAND AND CONSUMPTION

	February	March	April	May	June
Volume of water produced (m^3)	695,500	675,000	715,000*	713,000	709,000
Estimated monthly demand (m^3)	1,104,320	1,222,640	1,183,200	1,222,640	1,183,000
Estimated consumption (m^3)	562,031	675,000	540,844	597,500	556,906
Unaccounted for water (%)	19%	25%	24%	16%	22%**

*Note: The April report mentions two different water production values, 715,000 m^3 and 750,000 m^3. However, the May report includes the previous month's production data which is 715,000m^3.

**NRW estimates for Morogoro are <25% through June 2013 in MORUWASA monthly reports as well as in MCA-T ITT (indicator tracking table) data. MCA-T ITT data for Q20 of the Compact (Jul-Sept 2013) have an estimate for NRW in Morogoro that has been revised upward, to approximately 46%.

Table 53 presents utility data from the MCA-T Indicator Tracking Table, from April-June 2013 (WSP Quarter 19) and June-September 2013 (WSP Quarter 20), covering the baseline data collection period. The number of domestic and non-domestic customers increased slightly between these two periods in both cities. While in Morogoro, the percentage of non-active customers was indicated at 2% and 6% in each of these periods, the analogous figures for Dar es Salaam were constant at a much higher 33%.

TABLE 53: UTILITY DATA INDICATORS, APRIL-SEPTEMBER 2013

(Quarter 19: April – June, 2013; Quarter 20: June – September, 2013)

MOROGORO	Q19	Q20
Production, Consumption & Billing		
Volume of water produced (million liters/day)	23	30
Volume of water billed (million liters/day)	18	16
Volume of commercial water consumption (litres/capita/day)	184,327	132,371
Volume of residential water consumption (litres/capita/day)	98	77
Volume of water produced: Mafiga Plant (million liters/day)	18	24
Volume of water produced: Mambogo Plant (million liters/day)	4	5
Customers		
Proportion of non-active customers (%)	**2%**	**6%**
Percentage of households with access to improved water supply	No data	No data
Access		
Total number of current domestic customers	**22,608**	**22,802**
Total number of current non-domestic customers	**1,321**	**1,372**
Continuity of service: Wet Season	No data	No data
Continuity of service: Dry Season	No data	No data

Note: access and continuity data will be made available after the 2013 baseline survey results are published.

DAR ES SALAAM	Q19	Q20
Production, Consumption & Billing		
Volume of water produced: Lower Ruvu (million liters/day)	188	171
Volume of commercial water consumption: Lower Ruvu (m3/month)	811,766	897,094
Volume of residential water consumption: Lower Ruvu (liters per capita/day)	75	73
Volume of non-revenue Water (%)	54	51
Volume of water billed (million liters/day)	122	120
Volume of non-revenue water: Lower Ruvu (million liters/day)	0.54	0.51
Customers		
Number of customers with connection to line but no water (zero meter reading): Lower Ruvu	66,338	66,204
Total number of customers: Lower Ruvu	201,991	201,681
Total number of current domestic customers: Lower Ruvu	**126,847**	**127,985**
Total number of current non-domestic customers: Lower Ruvu	**6,186**	**6,418**
Proportion of non-active customers: Lower Ruvu (%)	**33%**	**33%**
Access		
Continuity of service: Lower Ruvu Dry Season	No data	No data
Percentage of households with access to improved water supply: Lower Ruvu	No data	No data
Continuity of service: Lower Ruvu Wet Season	No data	No data
Continuity of service: Lower Ruvu Dry Season	No data	No data

Note: access and continuity data will be made available after the 2013 baseline survey results are published.

8.6.3 Water consumption and expenditures

Households' water consumption and water expenditures are important indicators of wellbeing, and have important implications for health, productivity and capital accumulation. A key feature of the project logic posits that given an increase supply of water from the public distribution system, households will increase their water consumption. Depending on sources used, seasonal effects may also influence consumption and expenditures. Summaries of these two outcomes, disaggregated by season and primary drinking water, are shown in Table 54, Figure 48, and Figure 50. These values are disaggregated by socioeconomic status in Figure 49 and Figure 51. Detailed tables are presented in the Appendix (Table 83 and Table 84).

Levels of consumption differ drastically between cities, with Morogoro residents consuming almost three times the water volume as Dar residents; this difference is likely due to the variation in sources of water by city. These results must be interpreted with caution since relatively accurate measures of water consumption were only obtained for households with a tap on premises (using the cost of the last utility bill divided by the tariff, in addition to any other water consumption reported by the household, as a proxy), which may account for the much higher measured consumption in Morogoro, since more households receive water from piped sources. In Dar es Salaam, water consumption is by far the highest for households that rely on their own tap as their primary water source, and expenditures are also highest for the same group. In Morogoro, the households that depend on bottled water for their drinking water spend slightly more than others except for those using their own taps. There are no apparent changes in consumption by season across the socioeconomic quintiles. There is, however, a striking relationship between poverty and consumption. Water consumption rises monotonically with socioeconomic status (SES), with the top SES quintile enjoying four times the water consumption per capita of the bottom SES quintile.

Notably, the average total residential expenditures on water are far higher in Morogoro, almost twice the expenditures by residents of Dar es Salaam. The results did not show very large differences in consumption or expenditures between seasons, although the expenditures in both cities are slightly higher in the dry season. Expenditures for users of all water sources are slightly higher in the dry season, although the consumption appears to be virtually inelastic, with no seasonal changes. The expenditures follow the same pattern across SE quintile in both cities, with the wealthiest spending five to six times more on water than the poorest.

TABLE 54: WATER CONSUMPTION AND EXPENDITURES, BY SEASON

	DAR ES SALAAM					
	Rainy Season			*Dry Season*		
Outcome	Mean	SE	95% CI	Mean	SE	95% CI
Consumption (Liters per capita per day)	57	(3.31)	[50, 63]	62	(3.39)	[55, 69]
Total Expenditures (TZS per capita per week)	2056	(133.51)	[1793, 2318]	2411	(153.05)	[2111, 2712]
	MOROGORO					
	Rainy Season			*Dry Season*		
	Mean	SE	95% CI	Mean	SE	95% CI
Consumption (Liters per capita per day)	74	(2.56)	[69, 79]	80	(2.66)	[75, 85]
Total Expenditures (TZS per capita per week)	1073	(64.04)	[948, 1199]	1386	(79.88)	[1229, 1543]

Note: Variances scaled within each stage to handle strata with a single sampling unit

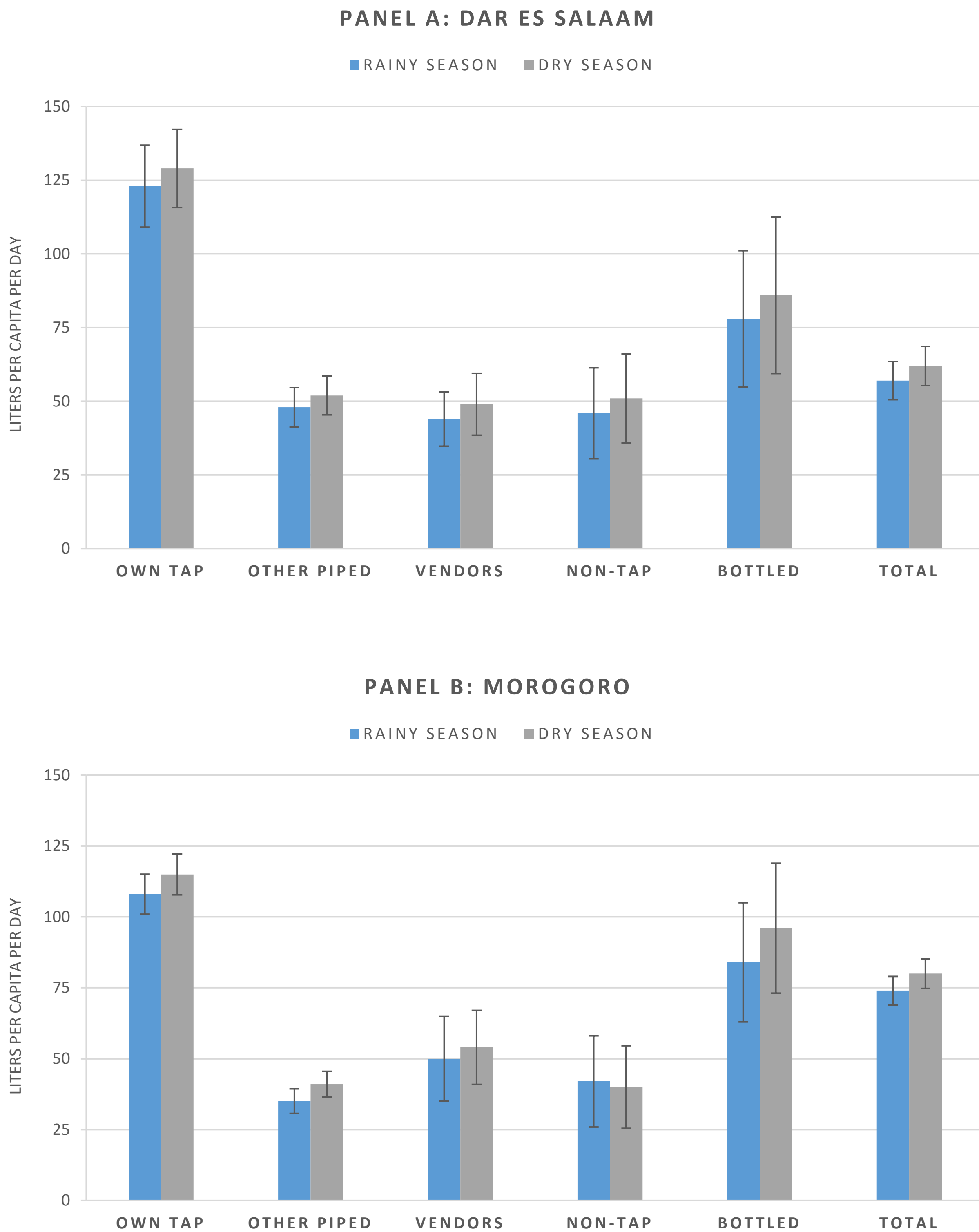


FIGURE 48: DAILY WATER CONSUMPTION (LITERS/CAPITA), BY PRIMARY DRINKING WATER SOURCE

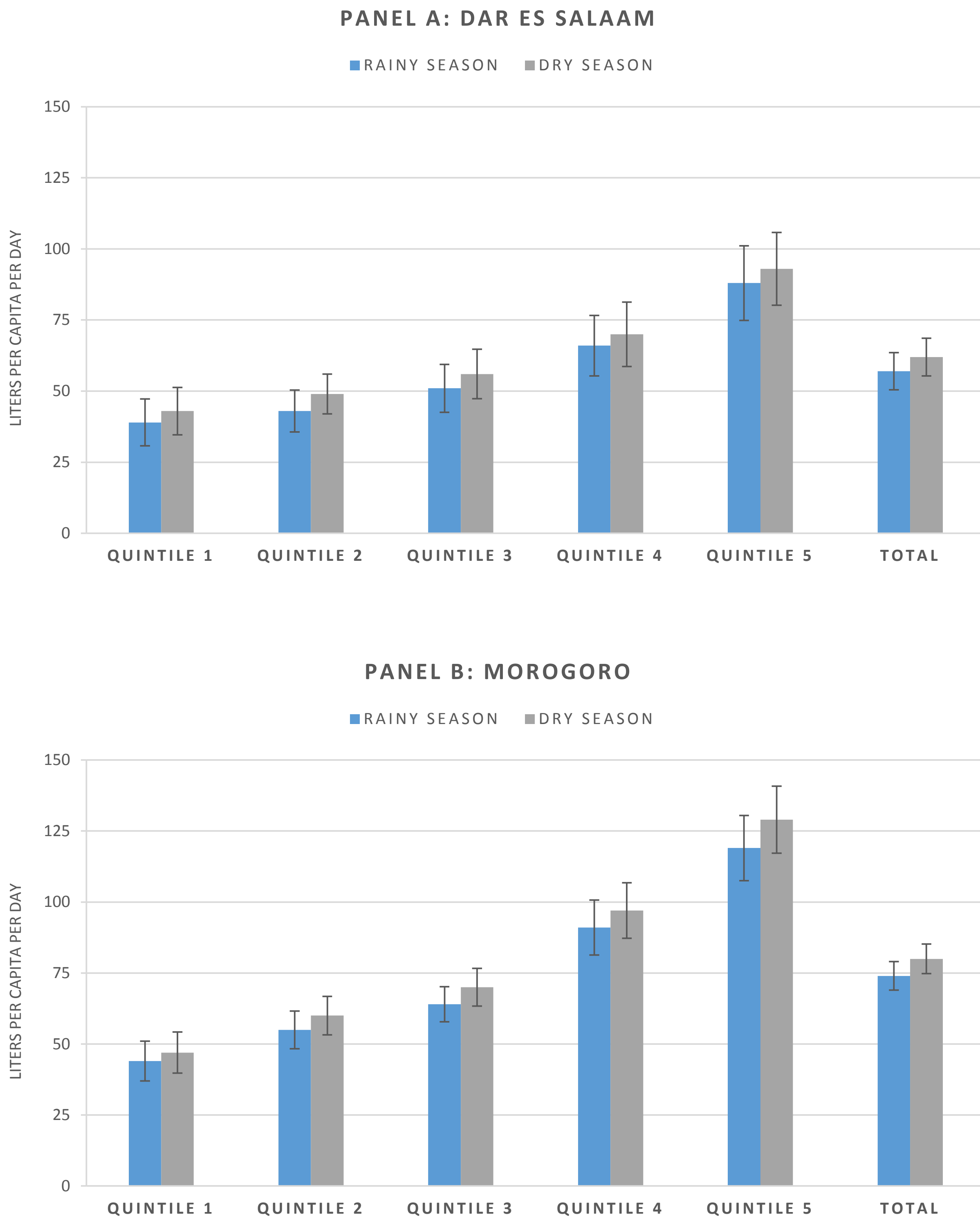


FIGURE 49: DAILY WATER CONSUMPTION (LITERS/CAPITA), BY SOCIOECONOMIC STATUS

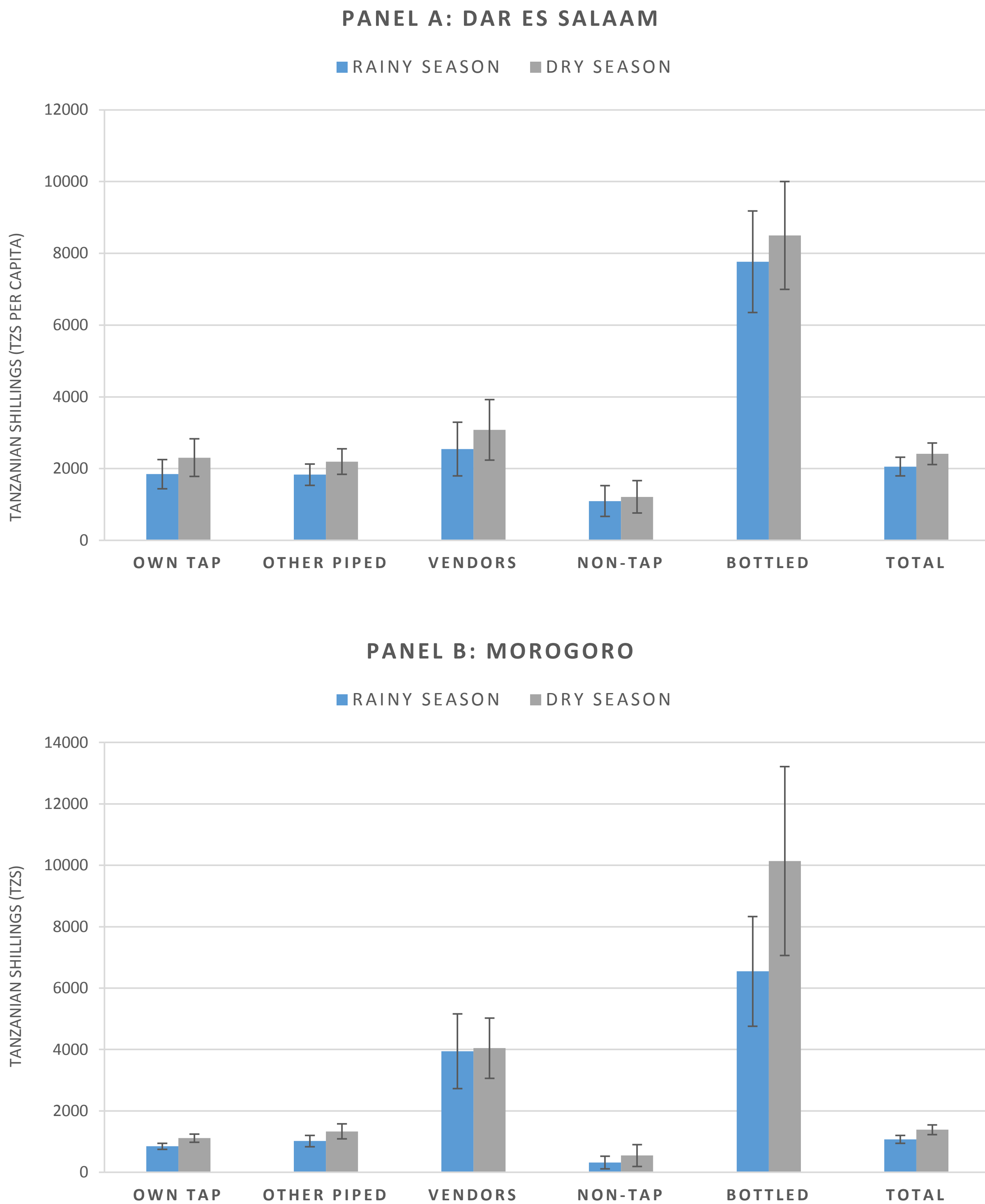


FIGURE 50: WEEKLY WATER EXPENDITURES (TZS PER CAPITA), BY PRIMARY DRINKING WATER SOURCE

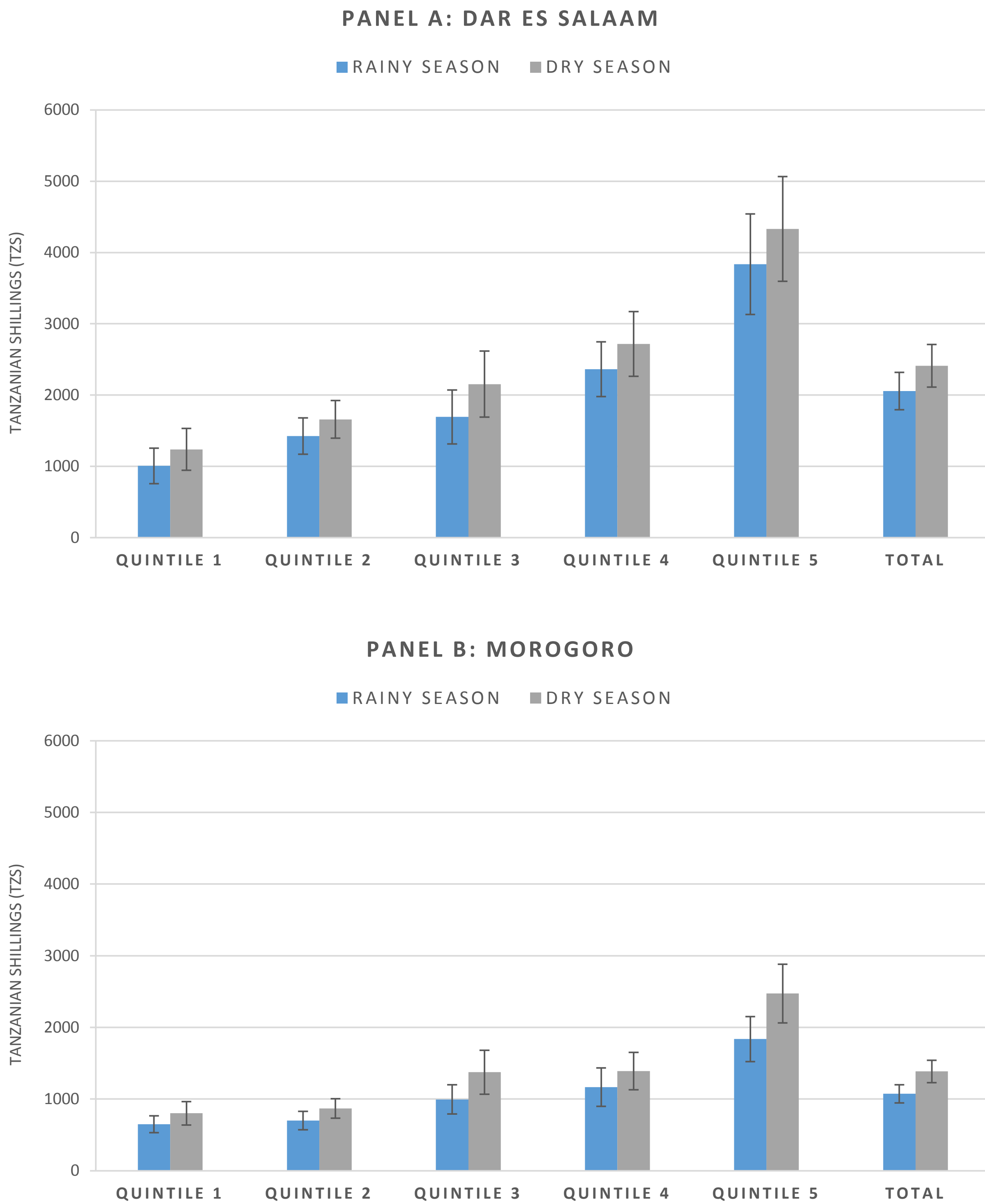


FIGURE 51: WEEKLY WATER EXPENDITURES (TZS/CAPITA), BY SES

8.6.3.1 *Caveats related to interpreting results of residential volume of water consumption*

There were three main limitations inherent in the measurement of water consumption at the household level. First, under-reporting of water collection could be a concern if households are using illegal connections, since respondents could fear being reported, and billed or penalized accordingly. This would imply that reported water consumption underestimates actual water consumption. A second potential source of error is that no measures were taken to confirm the size of the container used to fetch water. Similarly, no questions were asked about whether the containers are filled completely when fetching water. The younger the person collecting the water, the more likely s/he is to bring home a less than full jerry-can. Since the household questionnaire identified the household member in charge of fetching water from each source, it is possible to examine the relationship between volume hauled and the age of the individual collecting water.[25] Finally, greater distance of the household to the water source may be associated with higher incidence of load lightening during water collection events, with containers not completely full when water is being fetched if the carrier must travel a long distance to collect water. While distance to the water source was not explicitly captured in the household survey, the round-trip time to the water source is used to calculate the hauling times and could be used a useful proxy for distance in future analyses.

8.6.4 Modeled water consumption

As discussed in the project logic, the water investments are expected to impact household through two pathways: increased quality and quantity of water consumed. The quantity consumed depends on household size and structure, its "production technology" (the water using equipment it has for household production tasks), its income,[26] the price of water and the out-of-pocket costs associated with fetching and hauling water. Since water is sourced in many ways, the price faced by the household will depend on its choice of source. The "unit value" of water, or total expenditures from multiple sources divided by total consumption, is used to reflect the price In order to allow the price to vary by main source, this unit value is also entered as an interaction with dummy variables reflecting the main source of water.

In addition to these factors, the analysis addresses the issue of whether demand for water is affected by whether the neighborhood (represented in this analysis by the enumeration area) receives piped water. The hypothesis is that increased access to piped water will increase household consumption, holding all other factors constant. Household utility maximization subject to these constraints and costs leads to a per-capita household demand for water expressed as:

$$\ln WC_i = f(\textit{household composition}, \textit{capital}, \ln(\textit{price}), \ln(\textit{income}); \textit{water source})$$

Estimates of this demand function are shown in Table 55. Preliminary analysis showed that water demand differed drastically by city of residence and the results were thus calculated separately for each city. The continuous variables were included in log form, thus the coefficients are directly interpretable as elasticities. The demand models fit the data well - R^2s are relatively high and all models passed comprehensive tests of misspecification Results show that per-capita consumption is inversely related to household size and the household size effect is slightly stronger in Morogoro. An additional child in the household lowers per-capita water consumption by about 10%, and additional infants lower it by about the same proportion in Morogoro (not significant effect of infants in Dar es Salaam). The

[25] Additional information on this topic can be found in Section 8.12.

[26] The survey did not contain sufficient information to calculate an income variable, and in an expenditure system, the proper right-hand side variable is total expenditure (not income). For these reasons, total household expenditure per capita is used instead of income in the water demand analysis.

presence of additional adults also lowers per-capita consumption by 6-8 % depending on the city. These effects are relatively stable across season (wet and dry seasons).

Controlling for other factors, socioeconomic status (as reflected by the asset index quintiles variables) affects per-capita water consumption in Dar es Salaam, but the effects vary by season. Households in the highest quintile (SES 5) in Dar es Salaam consume 26% more water per person in the wet season and 44% more in the dry season compared to those in the lowest quintile. During the dry season, wealth effects are particularly pronounced; all quintiles have significantly higher consumption than the lowest quintile in Dar es Salaam, with the magnitude ranging from 18% (4th quintile) to the 44% advantage for the 5th quintile. In the wet season, wealth effects are significant for the 2nd (marginal significance), 3rd and 5th quintiles (also marginally), but the magnitudes are considerably lower than those in the dry season. In Morogoro, seasonal differences are minimal. The 3rd, 4th, and 5th quintiles having significantly higher per-capita consumption than the lowest quintile in the wet season (the magnitudes range from 15-38%) and the same quintiles have higher consumption compared to the reference group in the dry season (magnitudes ranging from 16-39%). These results are consistent with expectations as higher asset quintile households are more likely to possess household equipment such as automobiles, full bathrooms, kitchens with sinks, and these assets use water intensively. While marginal responses of water consumption to income growth are rather modest, over time, better-off households invest in technologies that require more water.

Price and income effects are generally as expected, but some surprises arise and differences across the cities are important. The income elasticity in Dar es Salaam is about 0.4. This indicates that water is a normal good with a relatively low-income elasticity. Water demand in Dar es Salaam is more income elastic than in Morogoro, with income elasticities of water consumption in Morogoro relatively low: around 0.33 for both seasons. The income elasticities are precisely estimated and remain stable across season. As noted above, consumption of water is relatively insensitive to marginal changes in household income. Given this information about differences in income elasticities by city, the patterns of the estimated own-price elasticities are to be expected. In Dar es Salaam, water demand is more responsive to changes in the price of water than in Morogoro. The own-price elasticity of water demand in Dar es Salaam is around -0.3 in the wet season, but much higher (-0.6) during the dry season. In Morogoro, demand for water is very unresponsive to price during both seasons (around -0.2). Generally, more price-inelastic demands (those in Morogoro) are associated with increased benefit flows to water consumers (reflected by increases in consumer surplus) as supply expands, so that measured benefits of the water investments in Morogoro are likely to be greater, holding other factors constant, compared to Dar es Salaam. Elasticities of consumption demand clearly vary according to the source of water, particularly in Dar es Salaam. These differences are evident in the coefficients of the dummy variables for main water source interacted with the water price variables.

The water interventions are likely to have a direct effect on the volume of per-capita consumption in three ways. First, they are likely to change the price of water to the customers—the impacts of these changes are primarily seen through the price effects discussed above Second, they are likely to expand the supply of connections in the immediate neighborhood. These regression results indicate that as the number of tapped sources in the enumeration area increases, household water consumption per-capita falls slightly in Morogoro, but increases lightly in the dry season in Dar es Salaam. The result for Morogoro is unexpected and may reflect increased efficiency of water use when tapped (and, hence, metered) sources become more prominent. The magnitudes of the coefficients are, however, relatively small and imprecisely estimated, with a roughly 4-5% reduction in per-capita consumption for each additional tapped water source in the household's enumeration area. These effects are dwarfed by the third pathway of direct effect. The third direct effect is the strongest and comes through reduction in supply disruptions. The water supply variables tell this story. These variables represent an interaction between the household's main source of drinking water and the ordinal variable reflecting reported (by household) days of water supply. The latter variable ranges from 0 (no supply) to 8 (24/7 water supplied). The results show that as the supply of water to the household through the public network increases, households that report receiving their drinking water from a tap in the house or on the lot increase their consumption considerably. Each increment (day) of supply reliability increases per capita consumption for these households by 3-4% in Dar es Salaam and by about 6% in Morogoro. This indirect effect outweighs the negative effect noted for the proportion of residents with access to piped water, and increased network supply reliability has an unambiguously positive effect on per-capita water consumption.

The coefficients on the last supply variable show a different effect. As water sources become more reliable and days of piped water supply increase, households reporting using other tapped sources as their main drinking water source see their water consumption decline by 2-5% depending on the city and season. This result possibly indicates less precautionary (that is collecting and storing water to avoid problems related to availability) consumption, but without further investigation, no conclusions can be made.

In summary, demand for water generally follows expected patterns. Water is a necessity and thus the relatively low own-price elasticities are to be expected. The water investments will benefit people by inducing more connections to piped sources and making water from these sources more reliable. This preliminary analysis of the baseline data provides some indication of the impact pathways and shows that the investments are likely to have strong impacts on well-being.

TABLE 55: MODEL FOR WATER CONSUMPTION PER CAPITA

	Wet Season								Dry Season							
	Dar es Salaam				Morogoro				Dar es Salaam				Morogoro			
	Coef.	SE	t	Sig.	Coef.	SE	t	Sig.	Coef.	SE	t	Sig.	Coef.	SE	t	Sig.
Intercept	1.77	0.79	2.24	***	3.08	0.55	5.55	****	2.26	0.76	2.95	***	3.20	0.54	5.96	****
Number of kids under 15	-0.11	0.04	-2.87	***	-0.11	0.02	-4.99	****	-0.08	0.03	-2.61	***	-0.12	0.02	-5.82	****
Number of kids under 5	0.00	0.07	0.02		-0.08	0.04	-2.36	**	0.02	0.05	0.42		-0.12	0.03	-3.54	****
Number of adult males	-0.02	0.04	-0.50		-0.09	0.03	-3.08	***	-0.04	0.04	-1.05		-0.07	0.03	-2.89	***
Number of adult females	-0.07	0.04	-1.76	*	-0.06	0.03	-2.24	**	-0.07	0.04	-2.02	**	-0.04	0.03	-1.67	*
Uses a sanitary toilet	0.06	0.08	0.72		0.16	0.05	3.14	***	0.01	0.06	0.16		0.14	0.05	3.02	****
Second SES quintile	0.19	0.11	1.80	*	-0.04	0.08	-0.54		0.23	0.10	2.16	**	-0.05	0.08	-0.62	
Third SES quintile	0.24	0.11	2.13	**	0.15	0.08	2.02	**	0.33	0.11	3.13	***	0.16	0.07	2.34	**
Fourth SES quintile	0.14	0.10	1.42		0.20	0.08	2.54	**	0.18	0.10	1.86	*	0.21	0.07	2.92	***
Fifth SES quintile	0.26	0.14	1.81	*	0.38	0.09	4.20	****	0.44	0.10	4.25	****	0.39	0.09	4.55	****
Log of price	-0.28	0.11	-2.58	***	-0.17	0.14	-1.25		-0.65	0.20	-3.24	****	-0.22	0.09	-2.39	**
Avg. price/liter (Primary DW own tap)	0.16	0.13	1.25		0.17	0.15	1.13		0.65	0.21	3.12	***	0.21	0.10	2.17	**
Avg. price/liter (Primary DW other piped)	-0.07	0.11	-0.62		-0.10	0.15	-0.67		0.42	0.20	2.08	**	-0.01	0.10	-0.10	
Avg. price/liter (Primary DW vendor)	-0.29	0.10	-2.82	***	-0.13	0.14	-0.90		0.24	0.19	1.23		-0.10	0.10	-0.99	
Avg. price/liter (Primary DW bottled)	-0.11	0.10	-1.05		-0.09	0.16	-0.56		0.34	0.20	1.73	*	0.06	0.12	0.48	
Ln of total expenditures per capita	0.46	0.08	5.89	****	0.33	0.05	6.45	****	0.39	0.07	5.28	****	0.33	0.05	6.76	****
# HHs w/ piped water	0.00	0.01	0.25		-0.04	0.02	-2.39	**	0.03	0.01	2.66	***	-0.05	0.01	-3.66	****
Supply days w/ own tap	0.04	0.02	2.17	**	0.06	0.02	3.12	***	0.03	0.02	1.92	*	0.06	0.02	3.61	****
Supply days w/o own tap	-0.05	0.02	-3.39	****	-0.05	0.02	-2.60	***	-0.05	0.01	-3.95	****	-0.04	0.02	-2.03	**
Pseudo R^2	0.30				0.41				0.30				0.42			
N	2,087				2,206				2,117				2,227			

Note: Significance levels calculated using p-values and are defined as: *=<.1, **<.05, ***<.01, ****<.001.

8.7 Health

8.7.1 Diarrheal illness

Table 56 shows the percentage of children who experienced diarrhea in the last two weeks, stratified by age and survey round. Overall, the rates of diarrhea are higher across the board in Morogoro, and children under five are most likely to report episodes of diarrhea in the previous 14 days, although this effect could be somewhat attributable to diarrhea under-reporting of older household members due to methodological issues discussed above.

TABLE 56: DIARRHEA PREVALENCE IN LAST 14 DAYS, BY SURVEY ROUND AND AGE

Diarrhea in last 14 days	Dar es Salaam			Morogoro		
	%	SE	95% CI	%	SE	95% CI
Main Baseline						
Ages <5	7%	(1.09)	[5.08, 9.43]	13%	(1.12)	[10.76, 15.16]
Ages 5-13	2%	(0.66)	[1.44, 4.16]	5%	(0.69)	[3.86, 6.59]
Ages 14-18	1%	(0.25)	[0.32, 1.39]	3%	(0.66)	[2.41, 5.05]
Phone Survey 1						
Ages <5	5%	(1.49)	[3.15, 9.23]	12%	(1.20)	[9.43, 14.05]
Ages 5-13	3%	(1.66)	[0.95, 8.69]	5%	(2.50)	[1.62, 12.90]
Phone Survey 2						
Ages <5	4%	(0.97)	[2.48, 6.43]	4%	(0.80)	[3.10, 6.26]
Ages 5-13	2%	(1.04)	[0.70, 5.48]	3%	(1.40)	[1.39, 7.25]
Phone Survey 3						
Ages <5	1%	(0.45)	[0.36, 2.38]	3%	(0.60)	[1.95, 4.35]
Ages 5-13	0%	(0.28)	[0.04, 2.02]	4%	(1.70)	[1.41, 9.11]

Figure 52 shows the proportion of children under five years old who reported diarrhea in the last 14 days, disaggregated by their primary source of drinking water. Few differences were observed by water source, consistent with findings of other studies, such as the DHS. Again, the rates of illness for children in Morogoro were higher. One limitation of this data is that the reported prevalence of diarrhea was quite low overall, which severely limits the precision of the estimates, leading to wide confidence interval estimates. In addition, the timing of the survey was such that the data was collected primarily during dry season, so these measures are not representative of the rainy season or the entire year. Sex disaggregation for children under five is shown in Figure 53. Interestingly, across Morogoro, illness is reported more frequently for males. The opposite is true in Dar es Salaam, where diarrheal illness was reported more frequently for almost all female groups.

Diarrhea prevalence for children under 5, disaggregated by sanitation facility, is presented in Figure 54 and Figure 55. There are no discernable patterns except that there are high rates of illness among males in Dar es Salaam who use pit latrines; and males in Morogoro who do not use sanitation facilities. These result should be interpreted with caution, however very few observations were available for the subgroup with no sanitation facilities so the mean estimate is highly imprecise (as is indicated by the wide confidence interval). While it is not surprising that the highest incidence of children's diarrhea for every age group is within the households that have no access to sanitation facilities, this effect was only observed in Morogoro since there were no observations for the subgroup with no toilet facilities in Dar es Salaam. In general, point estimates should be interpreted with caution, given the very few observations available. Differences by socioeconomic status are shown in Figure 56 and Figure 57. While there are no clearly visible trends across SES, here again diarrheal illness is reported for more females in Dar es Salam and more males in Morogoro. The detailed data for other age groups is shown in the Appendix (Table 85 and Table 86).

There were several limitations in the measurement of this indicator. First, there is a potential for under-reporting of diarrheal illness for members of the household above six years old, who may not share information about illness with other members of the household (i.e., the survey respondent). Under reporting is therefore likely to be positively correlated with household member age, so the reliability of this indicator will decline with the age of the household members. This is one of the reasons the reported results focus on under illness for children under five. Second, under-reporting may vary systematically by gender, depending on the relationship between the survey respondent and other members of the household (e.g., if a female respondent tends to know more about the health of her 17 year old daughter and one year old baby), and may depend on how comfortable the respondent feels discussing such sensitive issues with the interviewer. Third, the season during which baseline data was collected may likely plays a role in diarrheal incidence, since water quality and water sources used by the household vary with the season. Because the survey was conducted in the period from May to August, it is not representative of a particular season. The seasonal conditions associated with the time of a particular household interview affect the disease burden experienced by the population at that time, and thus influence the measurement of this indicator.

Overall, a relatively low proportion of survey respondents reported episodes of diarrhea in the last 14 days. Within the group of most interest, children under five, no distinct differences were seen by drinking water source or socioeconomic status. This could potentially pose challenges to detecting statistically significant changes as a result of the intervention, since the reported incidence at baseline is already quite low.

8.7.2 Determinants of diarrheal illness

Improved access to water is expected over time to reduce the incidence of diarrhea, particularly among young children. The survey asked about recent (past two weeks) diarrhea events, what was done in response to the event, and the consequences. Consequences included missed work and absence from school. It is expected, however, that the most severe burden from diarrheal-related disease will fall on the most vulnerable – such as children younger than 5 - so the analysis focused on this cohort. The main objectives of this analysis were to determine the relationship between access to piped water and diarrhea incidence and the relationship between irregular supplies of water and diarrhea in young children.

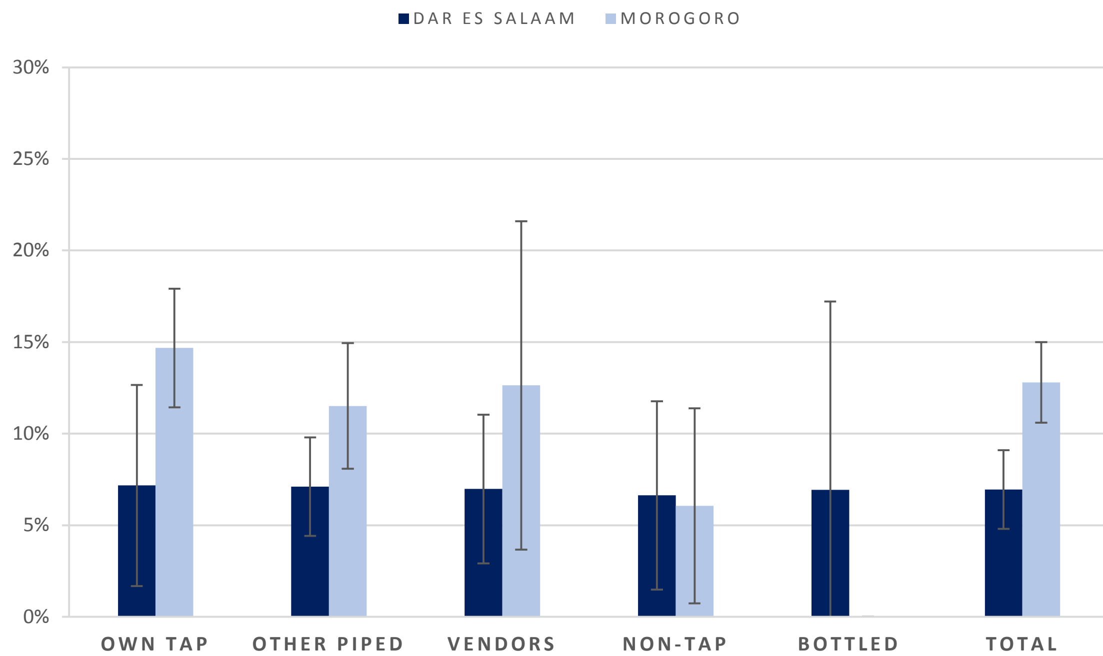
The analysis consisted of two parts: (i) an econometric model of the determinants of diarrhea outcomes, using a *probit* model; and (ii) a matching analysis which examines differences in diarrhea incidence among matched cases of under-5 children. The *probit* analysis uses the binary outcome (=1 if the child experienced diarrhea in the last 15 days, =0 otherwise) and expresses this outcome as a function of determining variables. These variables consist of child characteristics, household demographics and other conditions, education levels of female adults, and socioeconomic status of the household. The analysis was conducted on the sub-sample of 2,422 children under 5 within the sample (1,104 from Dar es Salaam and 1,318 from Morogoro).

Table 57 displays the results (as marginal effects), which show that few of the independent variables are significantly associated with the diarrhea outcome, holding other variables constant. While the overall model fit is reasonable (about 8% of the total variation in the outcome is explained which is not bad for this type of model), few of the variables are significant. Surprisingly, none of the education variables (included in the model as dummy variables representing the education level of the best-educated adult woman) was statistically significant in any of the models. Socioeconomic status (reflected by the SES quintile variable) has a minor effect: infants from households in the second socio-economic quintile are less likely to experience diarrhea compared to those from the lowest quintile (the reference class), but significant differences were not detected for children from households in the other (3rd-5th) asset quintiles.

Importantly, none of the water access variables appeared significant in these regressions. Additional regressions were also run, one excluding piped water as an independent variable and the other including it. Neither piped water nor the number of households surveyed in enumeration areas with access to piped water was significant in any of the regressions. In addition, several exploratory regressions were run including variables reflecting the main source of drinking water for the household and examining the impact of water shortages for households reporting piped water as their main source. None of these variables reflecting access to piped water was significant in any of the regressions, and often their effect direction were not as expected. These results indicate that the presence of diarrhea is difficult to predict, particularly given the large number of mediating variables, such as water treatment.[27] As a result, the sample may not be large enough to clearly identify differences for this idiosyncratic variable.

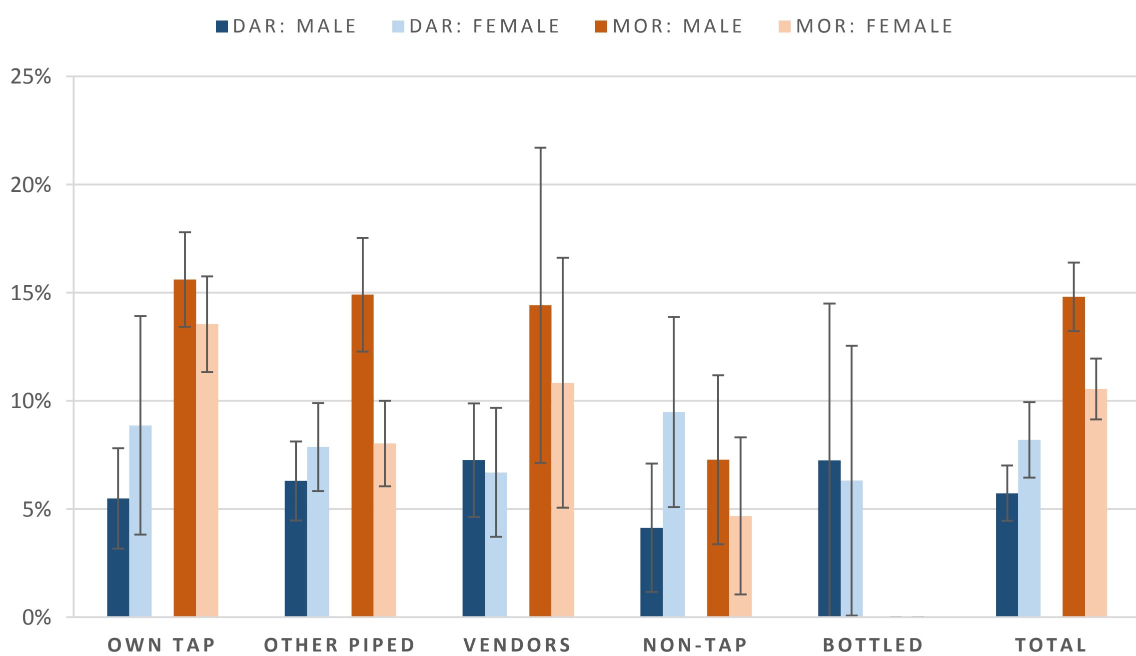
The matching analysis was conducted using a similar group of covariates as in the *probit* analysis Propensity score matching was conducted using the household's main water sources to investigate the impact on a binary diarrhea outcome variable (whether the child aged 0-5 had diarrhea). When the analysis was run on the combined Dar es Salaam/Morogoro samples (2,422 children), the matching estimate showed a 3.4% (p=.001) higher incidence of diarrhea due to piped water—an effect opposite the expected one. However, when the results were separated by city of residence, the effects became negative (-1% in Dar es Salaam and -46% in Morogoro), but were not statistically significantly different from zero (p=0.243 in Dar and p=0.073 in Morogoro) When the other treatments were employed, the estimated effects never approached statistical significance. The evidence from the cross-sectional analysis shows that diarrhea incidence is an idiosyncratic outcome and very little evidence was found that access to water is significantly associated with differences in the likelihood of suffering from diarrhea, and further work is necessary to shed more light on the determinants of diarrhea among young children

[27] Further analysis is required to examine these mediating factors. For example as many as ½ the households reported not treating drinking water regardless of its source.



Note: Female category omitted from bottled as a result of 0% in sample

FIGURE 52: DIARRHEA PREVALENCE, CHILDREN <5, BY PRIMARY DRINKING WATER SOURCE



Note: Female category omitted from bottled as a result of 0% in sample

FIGURE 53: DIARRHEA PREVALENCE, CHILDREN <5, BY PRIMARY DRINKING WATER SOURCE AND GENDER

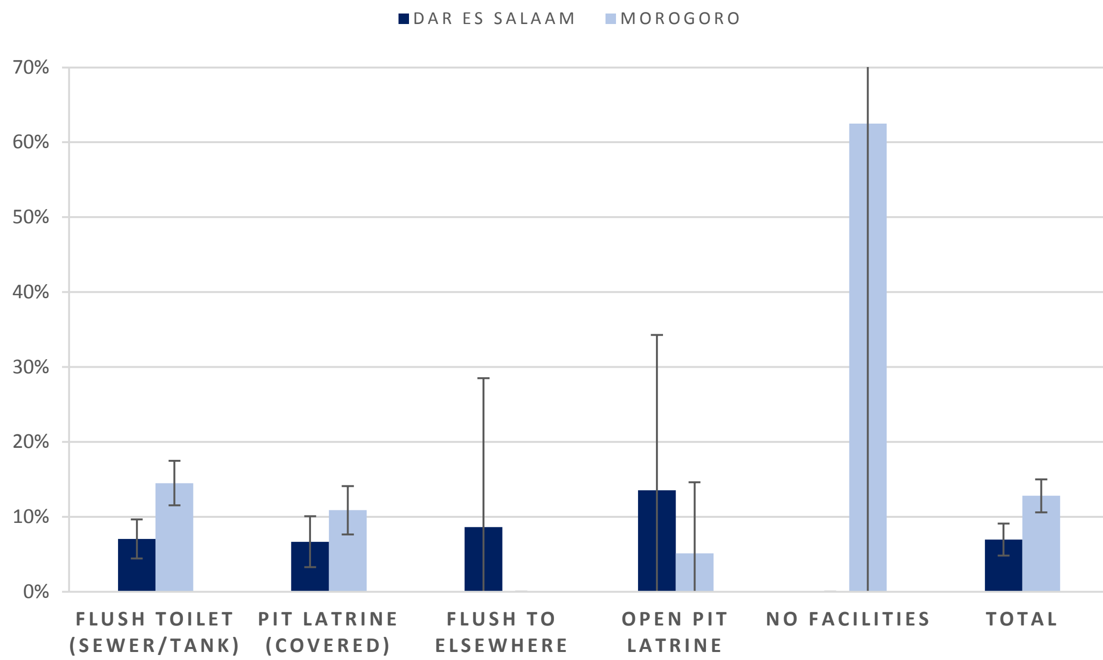
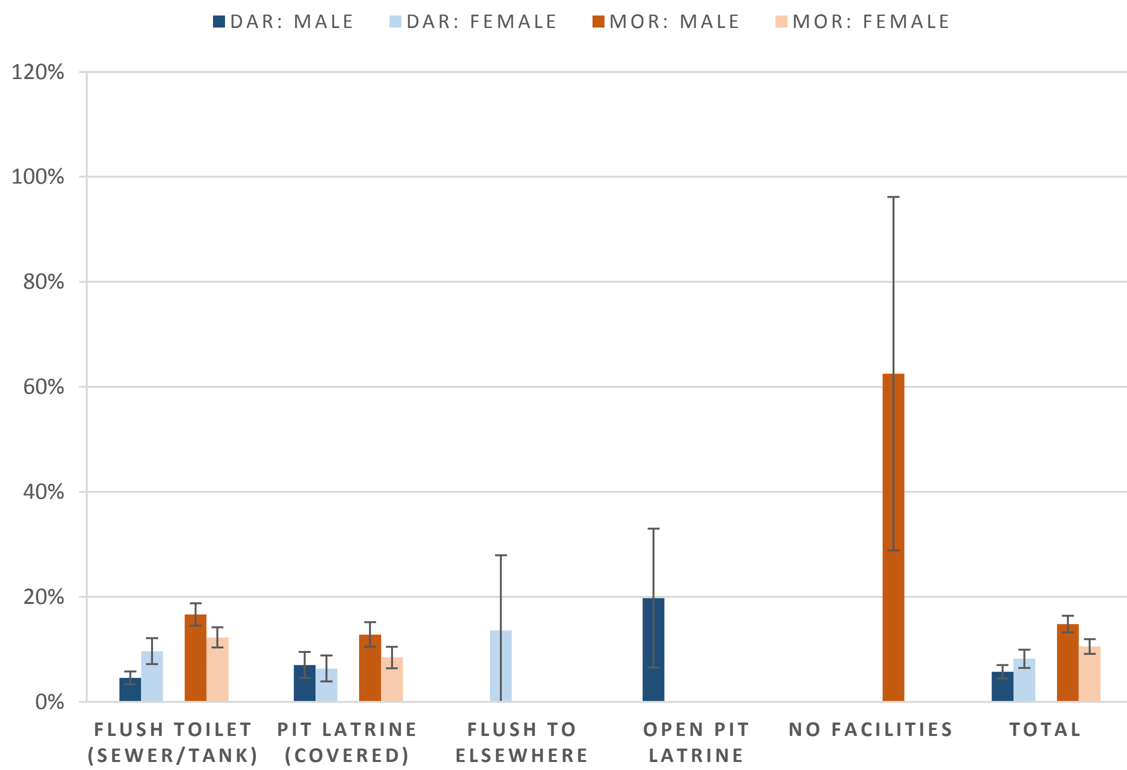


FIGURE 54: DIARRHEA PREVALENCE, CHILDREN <5, BY MAIN SANITATION FACILITY



Note: extremely high estimate among households using no sanitation facilities is due to very few observations and therefore volatile mean and large uncertainty band. This estimate should be interpreted with caution, given the very few observations used to estimate it.

FIGURE 55: DIARRHEA PREVALENCE, CHILDREN <5, BY MAIN SANITATION FACILITY AND GENDER

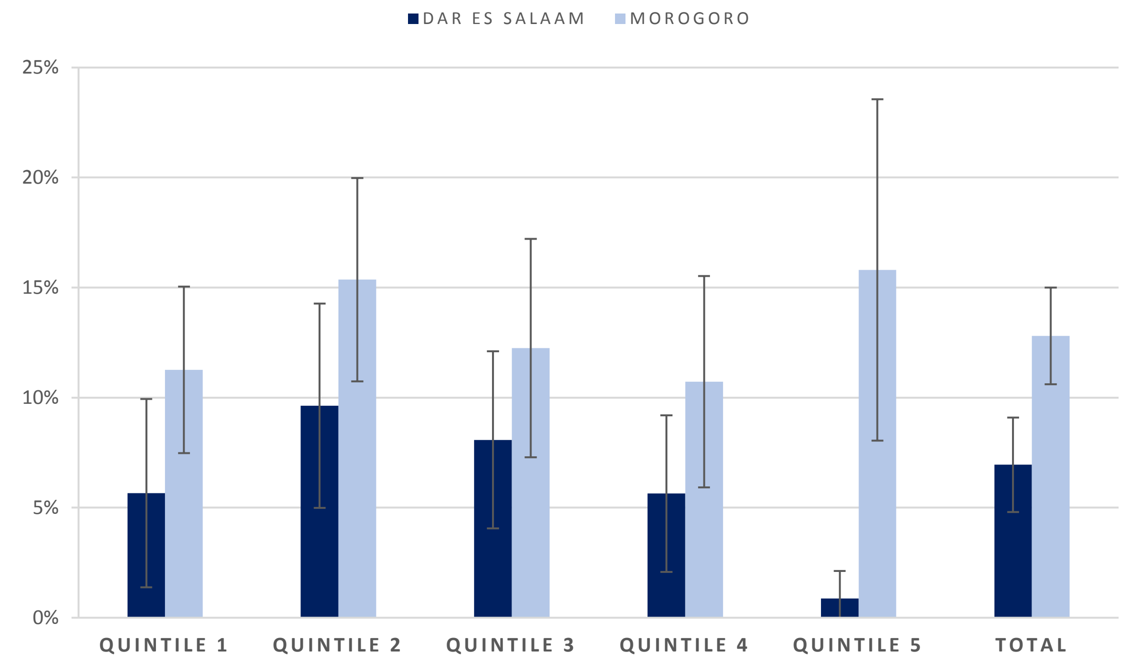
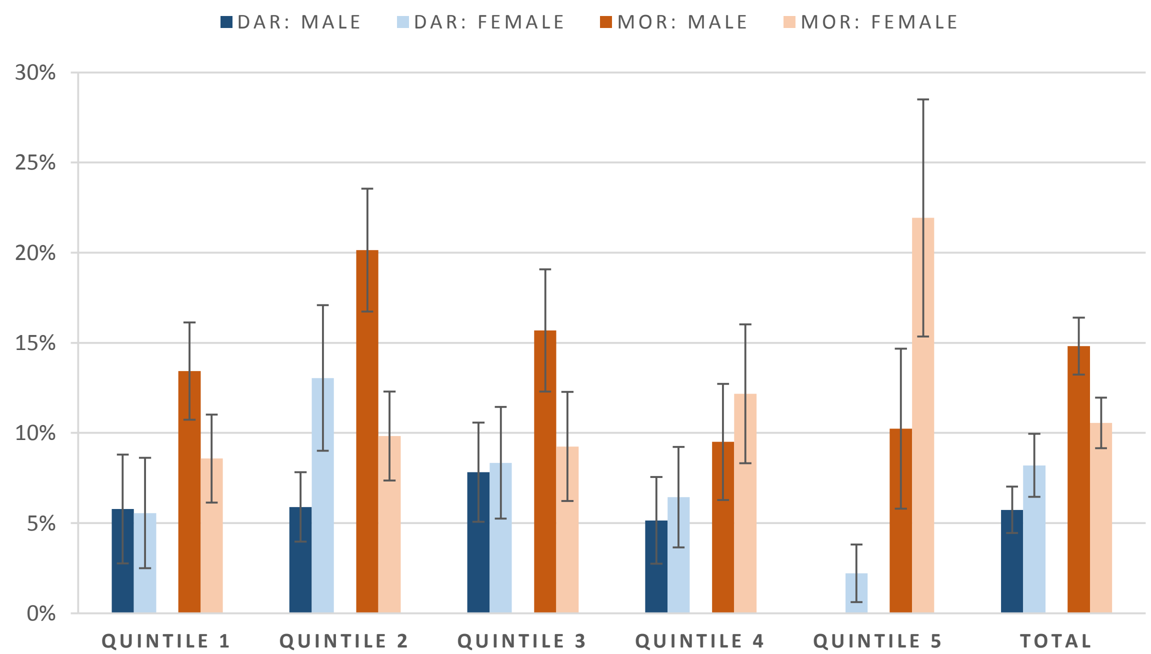


FIGURE 56: DIARRHEA PREVALENCE, CHILDREN <5, BY SES



Note: Quintile 5 not estimated for Dar es Salaam males (omitted) for lack of observations

FIGURE 57: DIARRHEA PREVALENCE, CHILDREN <5, BY SES AND GENDER

.

TABLE 57: MODEL FOR DETERMINANTS OF DIARRHEAL ILLNESS, CHILDREN < 5

Probit	Full Sample				Dar es Salaam				Morogoro			
	ME	SE	z	Sig.	ME	SE	z	Sig.	ME	SE	z	Sig.
Age	-0.01	0.01	-1.75	*	-0.01	0.01	-1.39		-0.03	0.01	-3.55	****
Household size	0.01	0.01	0.52		0.01	0.01	0.78		-0.01	0.01	-0.7	
Dependency ratio	-0.01	0.02	-0.36		-0.01	0.03	-0.35		-0.02	0.02	-1.01	
Kids ages 5-15	-0.01	0.02	-0.59		-0.01	0.02	-0.52		0.00	0.02	-0.01	
Kids and infants under 5	0.00	0.02	0.02		0.00	0.02	0.03		0.03	0.02	1.54	
Number of adult females	0.00	0.02	-0.14		0.06	0.04	1.46		-0.02	0.04	-0.64	
Most educated female has primary or some secondary	0.04	0.03	1.5		0.04	0.04	0.97		-0.05	0.05	-1.04	
Most educated female completed secondary or some college	0.03	0.04	0.85		0.03	0.06	0.48		-0.06	0.07	-0.89	
Most educated female completed college	0.02	0.06	0.34		0.03	0.03	1.02		-0.01	0.03	-0.25	
Child head of household	0.02	0.02	0.91		0.02	0.06	0.26		-0.02	0.04	-0.34	
Quantity of rooms	-0.02	0.01	-1.8	*	-0.02	0.02	-1.57	*	-0.02	0.02	-1.17	
Electricity in the home	0.03	0.03	1.07		0.03	0.03	0.9		0.04	0.03	1.47	
Uses a sanitary toilet	0.01	0.02	0.47		0.01	0.02	0.46		0.02	0.02	0.98	
Home owned by residents	-0.01	0.02	-0.24		0.00	0.02	-0.18		0.00	0.03	0.07	
Second SES quintile	-0.06	0.03	-2.09	**	-0.08	0.04	-2.04	**	0.00	0.03	-0.03	
Third SES quintile	0.04	0.03	1.3		0.04	0.03	1.26		-0.02	0.03	-0.69	
Fourth SES quintile	-0.02	0.03	-0.51		-0.02	0.04	-0.47		-0.01	0.04	-0.18	
Fifth SES quintile	0.00	0.05	0.04		0.00	0.05	0.04		-0.01	0.04	-0.34	
Number of households w/ piped water	0.01	0.01	1.24		0.01	0.01	1.16		0.01	0.01	0.84	
Lives in Dar es Salaam	-0.06	0.01	-5.06	****								
Pseudo R^2	0.08				0.09				0.05			
N	2,422				1,104				1,318			

Note: Dependent variable =1 if child experienced diarrhea in past 15 days and =0 otherwise. Table shows marginal effects and their standard errors. These are interpreted as the marginal change in the probability of having diarrhea given a 1-unit change in the independent variable.
*Significance levels calculated using p-values and are defined as: *=<.1, **<.05, ***<.01, ****<.001.*

8.7.3 Expenditures for diarrheal illness

As part of the baseline survey, respondents were asked to report their medical spending in the last two weeks on children under five suffering from diarrhea. Figure 58 and Figure 59 present data on household spending within the last 14 days per child under five residing in the household, disaggregated by primary source of drinking water, SES quintiles (for detailed data see Table 87). The patterns are quite different within each city. The highest spending is for the wealthiest quintile in Morogoro, who spend 1,832 TZS per young child, compared to only 290 TZS for the same quintile in Dar es Salaam. The spending by the less wealthy groups is lower, but the patterns are not monotonic. There is also no clear relationship to the source of drinking water: in Dar es Salaam the highest spending is by households who tend to purchase water from vendors, while in Morogoro those who primarily use their own tap spend the most. It is important to remember that this is descriptive analysis of the data, and does not control for other possible influences on spending. Thus, a causal relationship cannot be established between these characteristics and the outcome since many other factors, many correlated with source, poverty and sanitation use variables could be influencing spending, sometimes in opposing directions.

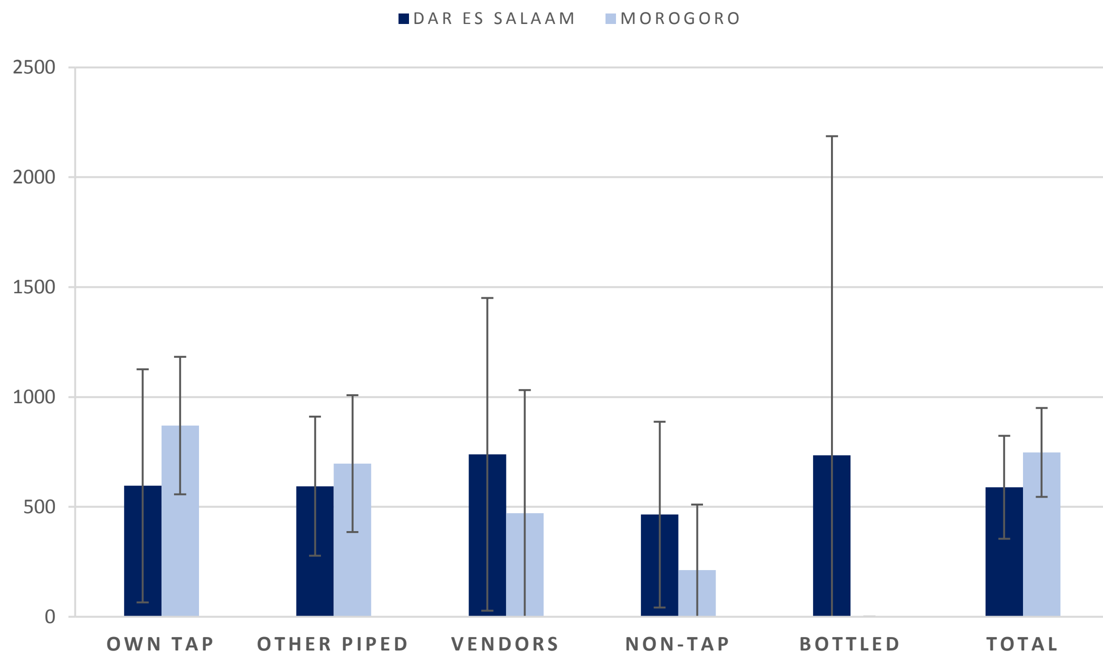


FIGURE 58: EXPENDITURES FOR DIARRHEAL ILLNESS (CHILDREN <5), BY PRIMARY DRINKING WATER SOURCE

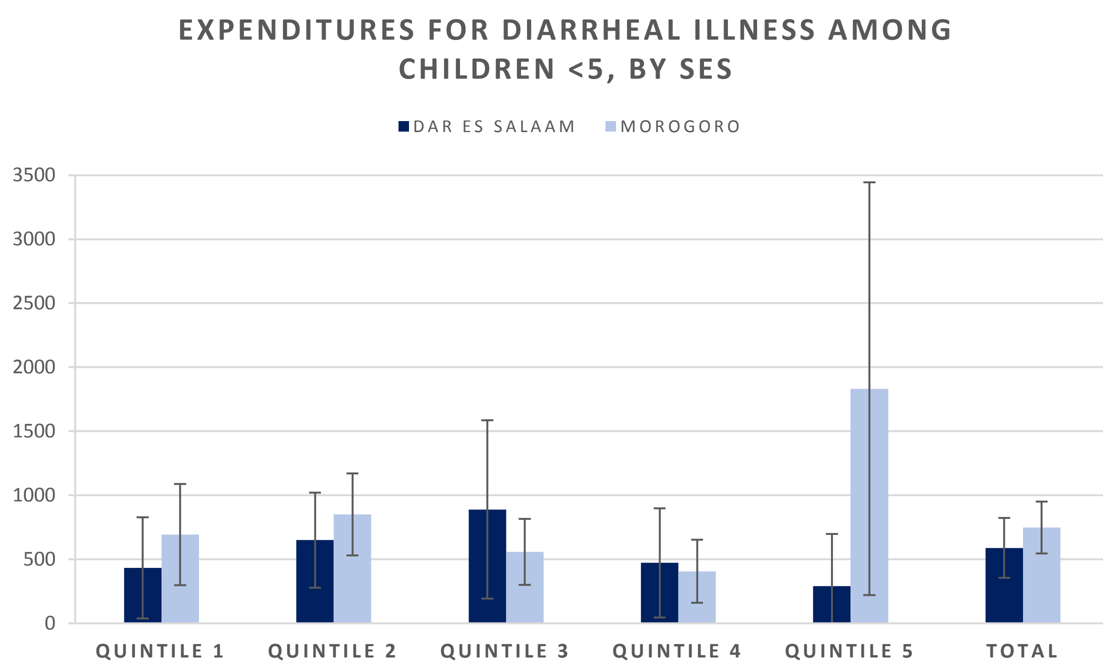


FIGURE 59: EXPENDITURES FOR DIARRHEAL ILLNESS (CHILDREN <5), BY SES

8.8 Qualitative Insights: Overarching Themes and Findings

Qualitative interviews were designed to supplement and contextualize the quantitative baseline data, and were conducted in areas with varying levels of access to piped water. Focus group discussions (FGDs) produced valuable information that further clarifies the context of water access and quality challenges in Dar es Salaam and Morogoro. Respondents were asked about a number of water-related topics, including the sources they depend on most, the accessibility, reliability, and quality of these sources, perceptions of how additional water supply might affect their households, challenges related to water scarcity (e.g., health, school, and gender-related concerns), and perceptions about the performance of the public utilities. In general, qualitative findings are well aligned with the quantitative survey data. Overarching insights from this qualitative research are presented below, and neighborhood-specific details are further elaborated in the following section.

Tap water is preferred and sought out for drinking in both cities. In Morogoro, piped water is more available and serves as the primary source of water for most households; in Dar es Salaam, shallow well water[28] is the most abundant and most commonly used source of water for household tasks. In contrast, households in Morogoro use well water sparingly, mostly in times of dry season shortages. Insights from the qualitative research in Dar es Salaam demonstrate that tap water is the preferred source of drinking water in the city, and is generally regarded as the safest source of water for drinking, although supply is unreliable. In Dar es Salaam, there are relatively few network connections and service to available connections is unpredictable. As a result, most households almost always use other sources to supplement, or completely replace, tap water, depending on the connection rates and availability in a given area. Respondents from Morogoro were more likely to describe utility water as being of good quality than respondents from Dar es Salaam, though turbidity was a frequent complaint in Morogoro. Notably, the cost of connections was often described as being prohibitive in both cities. In Dar es Salaam, respondents described that wells produce saline (or "hard") water, not suitable for consumption and for several other household tasks. Saline water cannot be used for cooking, it cannot be consumed, is uncomfortable for bathing, and soap does not dissolve for washing clothes (though some report resorting to using it for these purposes when no other water is available). Residents perceived that boiling it increases the salinity. Households respond to water shortages and rationing by increasing their storage capacity and/or drilling private, unregulated boreholes, even within the utilities' existing service areas. Some private residences have several elevated polyethylene tanks which fill up (and sometimes overflow) when water is available in the network, though ownership of tanks is related to socioeconomic status, with poorer households less likely to have them. While residents of Dar es Salaam acknowledge that their reliance on saline water is not ideal, this remains the most abundant source of water and affords households the independence and dignity of collecting water whenever they need it and for a lower price. Wells are considered reliable in the sense that shortages are not experienced the way they through the public distribution network (e.g., due to rationing). That this water is not used for drinking suggests that piped water shortages affect drinking water supplies more than water supplies for other household activities.

Additional sources of water used to supplement households' water supply are abundant in both cities, though much more so in Dar es Salaam (e.g., neighbor's taps, tanker-trucks, kiosks, and other vendors), but each other source can

[28] The word "well" was used almost exclusively in the English transcriptions of the focus groups conducted in Kiswahili. In many cases, the respondents may have been referring to boreholes that provide saline water, but for the sake of fidelity to the translation, we have kept the word "well" as it was translated in the FGD transcripts.

present its own set of challenges. The qualitative data indicates that respondents tend to utilize multiple sources simultaneously, using water from different sources for different purposes, in agreement with the survey data. So while "clean" or non-saline water is used primarily for consumption as well as business-related tasks that absolutely require clean water, respondents indicated they did use lower quality or saline water for such household activities as cleaning. Consistent with the survey findings, respondents described that they prioritize buying high quality water for drinking and cooking, and use water from other, lower-quality sources for other uses (e.g., washing, toilet use, etc.). Deep wells that produce soft (non-saline) water are expensive, and one must own a plot in order to commission such a well. The use of water from tanker trucks was reported more often in Dar es Salaam, where they are accessible by households who can afford the higher cost and have the adequate storage capacity to store the entire tanker's load. While neighbor's taps are also a commonly used source of water, relying on the physical presence of the neighbor to obtain water can be inconvenient. In addition, residents may be subject to high mark-ups for water provided by neighbors who use motorized pumps to fill the storage tanks from which they re-sell, or when they are selling out of their reserves rather than straight from a flowing tap. Respondents complained of price mark-ups by all vendors, and price variations from all sources of water were commonly cited. For example, the price for a 10L bucket of water varied between 50 to 200 shillings, and for a 20L bucket, between 100 to 500 shillings. Price variations reflect the source from which it is obtained (e.g., neighbor, well, tanker etc.), whether water is currently flowing or is purchased from within a storage reserve, whether it is soft or saline, or sometimes the distance from which it has been brought to an area by a vendor. In a few neighborhoods, NGO or other community-based projects were designed to bring additional well water to the area, but almost invariably these projects were described by respondents to be stalled, out of supply, or in disrepair.

Even those who can access water from the public distribution network do not rely on this water solely due to irregular schedules and frequent rationing experienced through the network. This finding suggests that the supply from the network may have been overestimated in the quantitative data. Focus group participants commonly reported water from public distribution network taps flowing only overnight, preventing many households without storage tanks from obtaining adequate supplies of water from such taps and inconveniencing those who are mostly responsible for water collection (most often women in the household). In Dar es Salaam, participants described that this can create a situation where households with storage tanks, especially those connected to motorized pumps (albeit illegal), can siphon water and re-sell it during waking hours to others in the area. These reports were consistent across the qualitative transcripts, implying that survey estimates of supply-days based on shortage reports are likely to overestimate the effective availability of water through the public distribution network. [29] Qualitative discussions suggest a high level of variability and erratic timetable through the public distribution network.

Seasonality affects water supply in some areas more than others, depending on the primary water sources utilized. Effects of seasonality on water supply appear to differ by area in each city, depending on which sources residents rely on the most. For example, residents from areas in Dar es Salaam that prefer to use rainwater cite that

[29] Indeed, the supply days variable presented in Section 8.6.1 is a weekly sum of all hours of availability as calculated using reports of shortages in the last 7 days. The presentation of that data does not take into account the *timing* of the availability, which is also an important dimension of access. Later reporting will present timing along with hours, which was also collected in the survey. During qualitative interviews, respondents reported the variability in supply by stating the number of days in which any water flows at all, and then either the timetable (e.g., midnight to 5am) or the number of hours (e.g., 2 hours) on those days that water is flowing. This type of recall method was used in the third round of phone interviews and will also be used to guide questions about water supply in future rounds of the survey.

obtaining water in the dry season is relatively more difficult. In Morogoro, most respondents reported increased water supply challenges during the dry season. Those using water from the distribution network also experience difficulty in the dry season, with an increase in rationing from the network. Residents stated that utility water is dirtier in general during the rainy season, although it can improve over the season. In contrast, well water does not change as dramatically but can be less salty during rainy season. Therefore, in Dar es Salaam, during rainy season, the quality of utility water decreases, while the perceived quality of the well water increases. In Morogoro, seasonal challenges were tied more frequently to discussions about water quality – consistently, respondents said that water was plentiful but muddy and turbid in the rainy season, while it was scarce and green in color in the dry season. In addition, in the future it may become increasingly difficult to make a clear distinction between dry and wet seasons due to climate variability. Changing weather patterns were mentioned in several interviews, and greater stability of water supply given climate variation will be important to ensuring a reliable supply for residents in these areas.

Water-related illness is common, but the scope of illnesses cited by residents is wider than diarrheal illness. Further, sanitation conditions of households, health facilities, and schools, can be poor due to a lack of clean water. Discussions regarding water quality and health brought to light several important themes. First, with regard to water quality, residents are just as concerned with salinity as with safety in terms of bacteria or other pathogens and pollutants in the water. In other words, the salinity of the water, which makes it unsuitable for drinking, was almost always part of the discussion on water quality. With regard to the safety of the water in terms of consumption, several groups from around the city reported having contracted typhoid and sometimes bilharzia (Schistosomiasis) from contaminated water. In a few cases, intermittent cholera outbreaks were reported by focus groups in both cities. Other diseases mentioned by participants include fungus, ringworm, rashes and itchiness, and urinary tract infections (UTIs), all of which relate more to topical contact with water, an area not explored in the quantitative survey during baseline, as the focus of the quantitative survey was on diarrheal illness; this narrow focus may therefore be expanded in further rounds of data collection. In most cases, the respondents did attribute the illnesses to water, though in some cases they were not entirely sure. Qualitative data also revealed that illness often has a cyclical nature; respondents sought treatment, but were still exposed to the same risk factors and would become sick again. Further, sanitation conditions in the household, health facilities, and schools, as described by focus group participants, can be poor due to poor water access, with insufficient water resources to allocate to maintaining toilet facilities.

Water treatment behavior is inconsistent across both cities, and highly variable even within neighborhoods. In general, those using piped water with greater frequency also tend to report treating their drinking water with more regularity (in agreement with the quantitative survey findings). Reports of households treating water prior to drinking vary widely. Within the same area, some individuals report boiling water while others do not. Notably, discussions of boiling in both cities revealed that boiling is often done "in bulk" to save time, rather than daily or on an "as needed" basis. For example, a few buckets worth of water may be boiled on one day to last several days; allowing time for possible re-contamination before water is consumed (e.g., through retrieval instruments). This finding further supports the hypothesis that even when households draw clean supply from an improved water source, contamination is possible during storage or retrieval, which could still lead to water-related illness. Some households do not boil water because they do not want to spend time waiting for the water to cool down. In some areas, residents use additional methods such as

Waterguard (chlorine treatment) or filtering. Focus group discussions revealed some misunderstandings about the correct dosage or potential side effects of Waterguard on health. Overall, households did not report consistently treating water. Respondents did appear to understand that they should be boiling water, but do not always do so; many said that they are accustomed to the way the water is, whether it is good or poor quality. The decision to treat water was often driven by the associated expense (e.g., the cost of Waterguard, fuel for boiling). Firewood and coal were most often used to boil water, although firewood was preferred, and the use of these fuels present additional expenses for the household.

Women still bear the largest burden of water collection, including challenges such as erratic supply hours, the cost of obtaining water from various sources which may incite domestic disputes and misunderstandings, and risks to personal safety while collecting water (e.g., traffic accidents or injury). Three major themes related to gender emerged in the qualitative data. The first relates to the descriptions of the roles and responsibilities women and girls bear related to water. In general, gender roles for water collection were distinct, with responsibilities falling squarely on women within the household. Children in were also mentioned, though less often than anticipated, by the WSP project logic, and female children were more likely to help women collect water than male children. Some respondents mentioned that men will contribute to water collection when driving is required, occasionally when using a push-cart is necessary, or in times of exceptional shortages. Opinions about gender roles tended to diverge between different respondents. While in most areas women still bear the responsibility of water collection, some respondents reported that gender roles are becoming more blurred with husbands and male children starting to assist the women by taking a larger share of these responsibilities. In other areas the gender roles remain deeply entrenched. During a focus group in Morogoro a respondent stated: "Unless the girls are sick, then the boys will help. Otherwise you cannot ask a boy to collect water when there are girls." The second main theme was that water collection could compromise the safety of the residents. Interviewees reported that collecting water increased the risk of suffering from traffic accidents in both cities, and injuries while collecting water were commonly mentioned in Morogoro since water was typically collected over more challenging terrain. Several described recent incidents in which women (or even children) have been injured by vehicles in the road while collecting water. Women reported being at risk of being hit by a vehicle en route to fetch water, as the following excerpt from a FGD in Dar es Salaam demonstrates: "Many are robbed and others get [in] car and motorbike accidents. The problem is our drivers who do not consider [the] zebra sign. In fact you can stand in the zebra for so long and fail to cross the road." The third major theme relates to the impact of water collection on domestic relationships and budget. Respondents reported that men tended to supply the money for the women to take care of household needs for the day. However, women often feel that not enough is allocated to water, and therefore they resort either to economizing for other things, using their own money, or asking their husbands for more money, which could lead to quarreling in some cases. Aside from expenditures, domestic disputes can be incited based on misunderstandings about the time spent (or time of day spent) collecting water – either the woman could be accused of taking too long and having an affair, or the women suspect that all the time away from the home opens the possibility that the man will have an affair while she is gone. Most respondents said that men do not understand the time and physical burden required to collect enough water for the household.

Children are affected by water access in a variety of ways: they are often enlisted to help their mothers collect water; they depend on

water supply for regular bathing and uniform washing (without which some mothers are not willing to send them to school); and students are often expected to bring water to school. Water collection duties and water-related illness did not appear to keep children from attending school. Water collection duties do not seem to affect children's school attendance in either Dar es Salaam or Morogoro; parents say that they understand the importance of school and water collection duties do not interfere with attendance. In only a few instances did respondents mention that children might help collect water in the morning and be late to school if the water collection queue is long. Children often help their parents collect water, but most often after school hours. Female children are enlisted more frequently to haul water than male children, especially after a certain age, as discussed in the gender themes above. According to focus group participants, the scarcity of water results in two distinct situations. The first is that children often carry water to school. In Dar es Salaam, this happens frequently across seasons, whereas in Morogoro it is more common in the dry season. Households either contribute money to schools to ensure there is water on the premises, or the children are asked to bring water in jerry-cans for themselves (e.g., for drinking, watering gardens or flowers, and for sanitation and cleaning the area around the toilets). The sanitary conditions that children experience at school are quite poor due to the lack of water, which could lead to illness. Some FGD participants described children leaving the school premises during the day to collect water (from nearby households, or other water sources such as surface water). Parents are concerned that their children leave school during the day, that places they go to collect water are often dirty or dangerous, and they are at increased risk of being hit by a vehicle while crossing roads to fetch water during the day. Children are also affected by water shortages within the household since water tends to be prioritized for drinking, cooking, and cleaning toilet over washing clothes and sometimes bathing. Therefore, if there is not enough water, they often cannot bathe or wash their uniforms, and parents are hesitant to send them to school "unclean." In such situations, children may not be allowed to attend school. Respondents did not mention that children stayed home from school due to water-related illnesses, even though they spoke frequently about children contracting illnesses and infections as a result of poor quality water.

Perceptions regarding the performance of the public utilities are mixed; many respondents believe that they are trying to serve the populations well but there is widespread frustration about the lack of transparency surrounding billing practices, and erratic water schedules. Qualitative findings regarding the perceptions of the public utilities MORUWASA and DAWASCO align with a number of the quantitative findings. Generally speaking, individuals in Morogoro spoke more favorably about the public utility compared to Dar es Salaam. This is not surprising given that households from Morogoro had significantly greater access to water from the tap. Respondents from Dar es Salaam were more vocal about their frustrations with the public utility, whereas those in Morogoro were somewhat more likely to grade the utility's performance favorably. Most frustrations revolved around the billing practices of the utilities. Households with taps said that they often received bills that did not reflect their monthly consumption – either the amount on the bill did not match the meter, there were additional charges, or they received bills even when no water or very little water had flowed through the tap during the previous month. Even when water consumption fluctuated, households were likely to get similar bills from the utility month to month and when they attempted to follow up with the utility to rectify the bills, they were frequently unsuccessful or faced frustratingly long wait times. Other major concerns were water rationing and irregular and inconvenient schedules of water flow. Many respondents named the days of the week and times that water was consistently rationed and unavailable. In addition, sometimes the publicized schedule that was distributed to customers was not accurate or a schedule had not been made available at all. Those who experienced the greatest challenges with service inconsistency were individuals who collected water from sources other than a tap on premises. During focus group discussions, some water users revealed that there were times that utility-provided tap water would start flowing in the middle of night, which required them to travel to collect water during unsafe or inconvenient hours. Respondents also believed that the public utilities have done little to reach the individuals with the greatest need for water. In Dar es Salaam, participants reported that while the quality of the water was good, the utility did not distribute the water equally across communities. Similarly, in Morogoro, respondents reported that services were not reaching customers with the greatest need. As a result, those with lower incomes collect water from non-piped sources frequently, or in some cases, buy from those with taps.

8.9 Qualitative Insights: Detailed Context from Focus Group Discussions

The locations of neighborhoods in which FGDs were conducted have been redacted to maintain respondent anonymity. The household survey estimates of each area's connectedness are presented in Figure 60. Within this study, a neighborhood is defined as the *mtaa*, the second to smallest administrative boundary, and a salient area for the urban communities. However, the exact administrative boundaries may not be known by individuals participating in the focus groups, and respondents' perceptions of their neighborhood boundaries may differ, so some variation is naturally to be expected between quantitative and qualitative data. The following narrative describes in more detail the main themes and water-related challenges experienced by households, organized by general discussion topic and then by city.

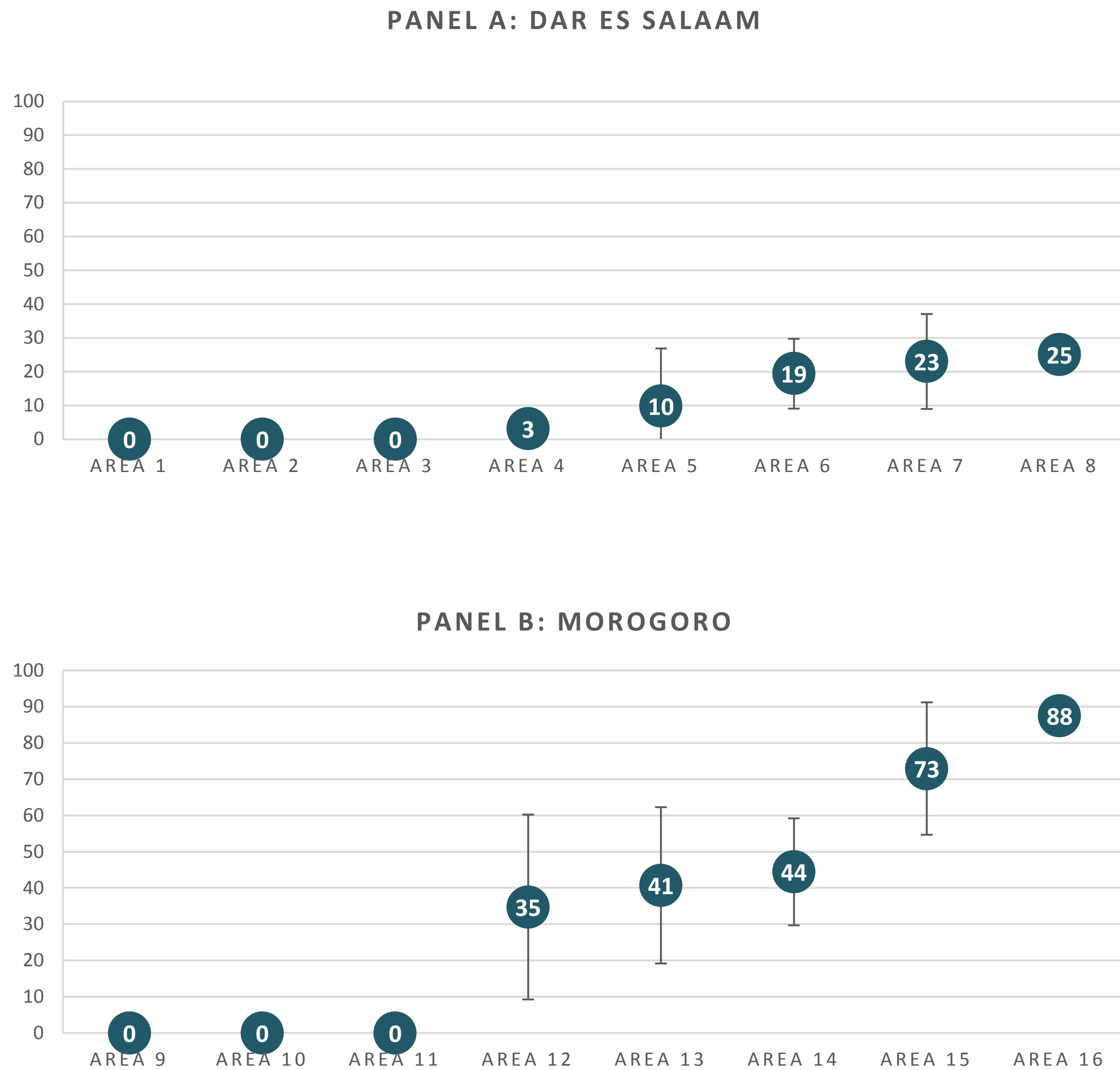


FIGURE 60: HOUSEHOLDS FROM EACH FGD AREA WITH ON-PREMISES TAP (%)

8.9.1.1 Qualitative Insights: Access and source choices

FGD Area 1, Dar es Salaam: In FGD Area 1, no households interviewed in the survey had an on-premises tap (which may reflect that the Lower and Upper Ruvu pipelines do not pass through this area). The main sources of drinking water for surveyed households were water tankers (50%) and kiosks (38%). Focus group discussions suggested that deep wells and rainwater were also major sources of water in this area. Residents obtained water from deep, motorized wells, and harvested rainwater during the wet seasons for all household purposes including drinking, washing, and food preparation. Respondents reported that poorer households dig shallow wells or pits to obtain water. Alternatively, residents rent carts to transport water buckets from other locations (such as kiosks), making multiple trips and storing water at home. Residents said that buying water from tankers is cheaper when the household has a large water storage tank, since tankers prefer to sell their entire tank (1,000 liters) at once. Tankers often will not sell less than a full tank, since they incur opportunity costs themselves filling and transporting that load; therefore, if a home does not have the capacity for storing 1,000L of water, they may not be able to obtain tanker water. Higher prices are charged by the water tankers for smaller amounts of water, if they are even willing to sell them. For example, a bucket that would normally cost 300 TZS could cost 500 TZS when purchased from a tanker. Further, prices may vary depending on the source of water and distance: tap water is more expensive from tankers, especially if from a farther distance.

"If water increased, one of the benefits I would get is that expenditure on water would decrease because I would no longer have to buy water from wells. I spend [1200 TZS] every day on water, therefore if if I pay DAWASCO bills the cost would be lower, maybe I will be paying [500 TZS] per day, which would be cheaper." -FGD, Dar es Salaam

What is done when not enough money is left at home for water? "That's when you squeeze the budget; you will have dagaa [small fish] with your children and save enough for two buckets…The situation is bad, water disrupts [the] home budget." – FGD, Dar es Salaam

One respondent spoke poignantly about her difficult experience in accessing water, since she lives on a hill at a higher elevation. For example, an order of tanker water made on a Monday may only arrive on a Friday, and she found well-water to be unsuitable for drinking and even for bathing. In this area, deep wells are preferred as they produce soft water, but they are expensive and building them depends on construction contractors who are often reported to be unreliable. One resident mentioned that an 80 meter deep well was quoted to cost 6 million TZS but when the well was nearly done, the contractor demanded additional payment, which the resident did not provide; therefore the well was left unfinished. Residents reported that water was scarce even in areas with household connections, One respondent said: *"People on the other side people have taps but they don't have water, [DAWASCO] are just torturing them. Taps are there but water is twice a week."* Respondents in this area admitted going to great lengths to ensure enough water in the household: women said they are willing to spend their own money on water, beyond what is provided by their husbands for the household budget, because of its importance in the household. As one respondent remarked: *"If a household has no water nothing can be done, you can tell him there is no water for bathing, but will you tell your children that there is no water so I am not going to cook?"*

FGD Area 7, Dar es Salaam: Focus group participants in this area also reported using deep wells. Some residents have piped water, and survey results indicated that a quarter of the households have on-premises taps, although FGD respondents said very few people in this area have connections. Rainwater harvesting in the rainy season was another commonly used water source. Very few people in this area have water storage tanks; most use drums, buckets, and jerry cans in their households, up to about twenty containers at a time. Tap water is not readily available and in the dry season, hard (i.e., saline) water from the wells is used frequently since shallower wells produce saltier water. Access to water becomes more difficult when there are power cuts. Residents have been waiting for a long time for a deep well dug by the government to become operational, while others have been connected to the network, paying about 250 thousand TZS per connection. The cost of the connection ranged from 250 to 500 thousand TZS across surveyed areas, depending on the distance to the pipeline and supplementary equipment that needs to be purchased. Residents described that in order to dig their own well, they need to own a plot of land; therefore, those who do not own land cannot commission the digging of a well on the premises, which affects lower income residents the most. As in other areas, residents here described piped water as particularly erratic: *"Once in two weeks…it flows twice a month, and there is no specific day; water may start flowing at night when you are asleep and when you wake up in the morning it is no longer flowing."* Respondents noted the consequences of water shortages were severe, occasionally preventing them from bathing, cleaning, or washing clothes; and households may turn to saline water for clothes-washing which can damage the clothes. Household businesses can suffer decreased revenue during water shortages. Respondents felt the level of supply in the area was too low: *"No [it is not sufficient], it is possible that the whole area water flows in only two or three houses; all people have to struggle to get water from these two or three houses."*

> ***"We here [in] Vingunguti we experience a difference when the electricity is off because our wells use electricity therefore once the electricity is off it is like a dry season." – FGD, Dar es Salaam***

> ***"[Health services] do not have water, the day before yesterday my wife gave birth I had to go and find water on the street. The well is there, but its safety is questionable, doctors prohibit taking medicine with that water." -FGD, Dar es Salaam***

FGD Area 2, Dar es Salaam: Households do not have DAWASCO connections in this area. All surveyed households reported using water tankers for their primary source of drinking water. In the FGDs, respondents said that they used well water, unless "cars" (with small tanks) or tankers (with large tanks) brought tap water. Well water is used predominantly by those who cannot afford to buy DAWASCO water brought in by car or tanker: *"Cooking, washing to those with low income unable to buy the water brought by cars i.e., the DAWASCO's water, they normally drink wells water."* However, respondents expressed some doubt as to whether the water brought in by tankers was actually from the public network. They also mentioned that the quantity of water available from tankers is not adequate. For those relying on well-water, electricity supply can has caused some interruptions in water supply, just as was described in some other areas. Respondents also reported obtaining water from neighbors; pushcarts were often used to collect the water. In addition, respondents said that in this area, PLAN International had drilled a tap about 10 years ago but it has not yet supplied water. One woman who sells second-hand clothing in this area reported that she uses mainly saline water in the dry season due to lack of tap water, but saline water does not bind well with soap, driving up business expenses.

FGD Area 5, Dar es Salaam: FGD respondents reported using piped water and well water. There are two functioning wells, operated by the municipality, but many people live in areas that are not supplied adequately by these wells. Survey results suggest that only approximately 10% of households have an on-premises tap in this area.

"[DAWASCO water from pipes] comes by chance it can be twice a week, sometimes once it can be even [once] a month. Sometimes it turns to be a big problem even in a month you can miss that service, but they are pulling up their socks in these two days we had water. These days we are happy! They are serious [when] we can have water four times." -FGD, Dar es Salaam

Respondents estimated, however, that two-thirds of residents in the area had tap connections. As in other areas, piped water was used mainly for drinking while well water was used for washing, bathing, and watering gardens, and cannot be consumed because of the salinity. FGD participants reported that some other wells (not owned or set up by the municipality) were in final stages of construction. Residents in this area raised poultry, and said that water was not only needed to keep those areas clean but also to mix medicines for the animals, which needed to be prepared with water daily. The food for the animals is often mixed with water as well, and some residents noted that they could not use well water for this because of the "soda" (salinity); others reported that they do use well water because it was their only or most available option.

Residents report that the age of the infrastructure from Lower Ruvu is partly responsible for disruptions in supply, inability of the system pump "up" to this area, and a lack of water in the dry season. In general, residents noted that it is more difficult to obtain water in the dry season; in times of drought, respondents said they sometimes buy water from those who bring it in cars. They say that water officials report when water will not be there to the village officials, but sometimes that information is not widely disseminated. As one resident described: As one resident described: *"For sure this piped water of DAWASCO, they have quality and well managed and its supply is good regardless of its poor distribution, it's sad that you can have clean water twice in a month in hours for example today Wednesday the people have to struggle to have water, but we who are in the other side we are using water from the well. Or the other day the water is out midnight at three so those people with tanks fill up their tanks first and let you when they have filled theirs, and sometimes you get the information late when the water is finished."*

Residents in this area mentioned that some places in the area receive water from *Ruvu juu* (Upper Ruvu) and have water much more frequently than those areas relying on water from *Ruvu chini* (Lower Ruvu). Respondents also discussed the process of obtaining a connection to the network, noting that individual applications for a connection are much more expensive than group connections, whereby an individual would pay 1-2 million TZS for own connection; compared to only 200-350 thousand TZS as part of a group application. However, overall, well water is their cheapest option, at 50-100 TZS per bucket from a DAWASCO-owned well. Likewise, when asked about potential improvements to their water supply, residents were resigned to the idea that more wells would be their best option, especially in the short term. Residents preferred more privately owned wells because the schedule of DAWASCO supplied water is so unreliable. Wells that provide soft (as opposed to saline) water were viewed as especially desirable, and potential well locations can be tested for water quality. Indeed, the demand for water relative to the scarcity here, as in other places, is apparent. One respondent said that she'd rather have no electricity than no water, because it's not possible to do any household activities without water.

"There is a certain man [who] has drilled a deep well [...] [actually it] is a pit latrine that has not been covered but now is filled with water. Because he has not covered it and we have no water, so many people are fetching water for free." – FGD, Dar es Salaam

> *"We have to fetch the well water or sometimes we buy water from the hawkers along the road despite [that] we don't trust their water because we don't know where they get that water from. Sometimes you find we suffer from diseases such as diarrhea and [others]. Since you don't have alternative you have to use it as it is." -FGD, Dar es Salaam*

FGD Area 4, Dar es Salaam: FGD respondents reported primarily using DAWASCO tap water, but when tap water was unavailable, they use water from wells. Only approximately 3% of households in this area have their own connection on premises; the primary source of drinking water was the neighbor's tap, used by the vast majority (92%) of households in this neighborhood. As one resident described, perhaps overestimating the connectedness of households in the area, *"…Many people depend on water taps from the neighbors. In 100%, only 20% have their own [tap]."* Obtaining water from neighbors, however, is not necessarily more convenient. Respondents said that neighbors are often busy in their own activities, especially on the weekends, and if they are not there, they will say have to return at a later time. If the need for water is urgent, the individual has to move around the neighborhood looking for another place from which water can be obtained. Further, respondents reported that water demand exceeds the supply substantially and the tap water sources are insufficient, therefore the respondents sometimes prefer drawing water from wells due to immediate availability of water and the ability to draw it when the need arises, even if the water quality is lower. Wells used in this area are shallow wells dugs by individual residents. Residents report using well water mainly for washing and cleaning, and if there is no tap water they say they will boil it for drinking, as these wells have only a small amount of salt. Residents said recently that someone (unspecified) had done research in the area and recommended that two wells be built, but they have not seen any proceedings from that time. In this area, one of the participants in the FGD happened to be a member of the neighborhood's water committee, and spoke in detail about the rationing timetable for the public distribution network. Residents report substaintial problems with water during the dry season, and say that even though the rationing schedule is known there can still be times where no piped water is supplied for a week.

In some cases, residents go to considerable lengths to avoid paying for water, saying that they will go fetch free water from a hole with standing water which has actually been drilled to be made into a pit latrine, but has not yet covered. Residents expressed knowing that this was a "dangerous" way to proceed, and they know that the water gets dirty from these ditches. Those selling food in the area say in times of water shortage they have to purchase water from more expensive sources; not being prepared for water shortages results in a loss of customers. In contrast to other areas, 95% of households in this area were reported treating water before drinking (aligning well with the statistical models showing that those who rely on tap water to a greater extent are also more likely to treat their water).

FGD Area 8, Dar es Salaam: Residents from this neighborhood use water from public taps and deep wells; most rely on tap water, and many households have taps. Similarly, this neighborhood had the highest connection rates of any area chosen for a focus group discussion in Dar es Salaam (25%). Interestingly, residents said that vendors did not do business selling water here, but they did come to collect water from this area to sell elsewhere. They said that sometimes they are informed of water rationing for 5-6 days but water is usually available. As in other areas, residents prefer tap to well water since well water is salty. However, even in this area, interviewees reported that the water mostly flowed overnight, ending in the morning; in some areas, it flows even until the afternoon. Those who run businesses, e.g. vending food, say that if water cuts out at one's home, they will go to collect it elsewhere, and if the queue is long, and they do not get enough water in time to start cooking, they may give up doing business for the day. Residents stated that the overnight hours during which water flows interrupt sleep and that they would rather the water flowed during the morning hours after they had woken up.

> ***"Normally when we make a follow up the problem is found to be in Lower Ruvu, either the water level has been reduced or water pipe has burst, so it takes even two or three weeks for the problem to be rectified, and most of the time I am the one who makes a follow up to DAWASCO. And right now there is a project that has been established of taking out all worn out pipes and put the new ones therefore water can be cut off even without being informed. You find you are not prepared at all." -FGD, Dar es Salaam***

FGD Area 3, Dar es Salaam: Residents from this area reported using mostly water from vendors (cars/tankers) who bring water to the area from other neighborhoods for most household consumption and uses, and from deep wells, though well water is not used for activities other than cleaning, due to its salt content. The survey showed, and FGD corroborated, that there are no piped connections in this area, Residents here report higher per-bucket prices (200-300 TZS per bucket, 500-800 TZS during shortages) charged by the vendors, and that water quality is relatively poor: sometimes the water contains salt or is mixed with salt water. Since most residents here depend on water from car vendors, those who have storage tanks may maintain adequate water supply, but those who do not own tanks often are unable to do so. Respondents said that despite the fact that salt water is not preferred (e.g., has negative effects on skin and can't be consumed), given its low price (50-100 TZS/bucket), it is still often used. Despite this, residents say they are very willing to pay the amount required to connect to the piped network if there were viable supply to their area and if the utility would extend them connections. Residents mention having contributed 3,000 TZS each to a Belgian-sponsored community water project in another ward which has not yet started. At the time of the interview, respondents said they expected the project to begin in December 2013.

FGD Area 6, Dar es Salaam: In this area, approximately 19% of residents have their own tap, and also rely on wells and piped water from the utility; although wells are used more often due to the low water pressure in the pipes. Although many have connections, they are not receiving adequate water through the piped network, and respondents report that piped water was only available for about two hours twice per week. Further, participants said that they know which taps in the neighborhood do get water, twice per week for several hours, and they use those sources to obtain tap water; although due to low pressure and scarcity, they all agree to take just one bucket each. Hard water is used for washing, bathing, and cleaning. Residents report an increase in water shortages after road construction began in the area. A community water project by CARE had been installed in the past, but water was not coming through that well. Residents are grateful for the wells they do have at their disposal, but cannot get by solely with hard water: hard water discolors clothes, does not properly cook food, and is considered to cause urinary tract infections. In the rainy season, residents also report using iron sheets to harvest rainwater; sometimes they obtain water from tankers, both those who sell piped water and other private cars with tanks that sell water. Tankers, however, have been disallowed until they are licensed to sell water by the utility, information that has been corroborated by the KIIs with the water regulatory agency in Dar es Salaam. Since residents in this area prefer tap water (soft water), they had requested a deep, drilled well from the utility. However, their request was denied. Also, some residents had motors to pump water from the pipes into their tanks when the water is flowing; and then re-sell the stored water to others in the neighborhood. However, selling water from own taps is not legal; one woman is said to have been caught multiple times by the utility and punished. Residents said that the water rationing schedule, with water flowing starting at 3am, benefits those with pumps because everyone else is sleeping and cannot collect water at that time. Those with pumps are able to collect water overnight and start selling to others in the morning. While disgruntled that the water is siphoned to these tanks, the other residents do not want to report their neighbors engaging in this practice to the utility for fear of confrontation, and say that they will not benefit from doing so anyway if the individual bribes the utility official to allow them to continue pumping water.

FGD Areas 10 and 11, Morogoro: In these FGDs residents said they previously used river water for everything, but when factories started discharging water into the river, discoloring the water, they began to buy water from town instead. None of the surveyed households had a tap on premises; although interviewees reported that they had pipes in the past, which had become dysfunctional with the destruction of the river through pollution, as trash was now dumped into the river; after that residents say that some were stealing the pipes, evidenced by the dug-up soil, and re-selling them. Residents said that the cleanest water comes from the hills, while water from the *Mindu* area (dam and reservoir) is also used for fishing and becomes dirty. Wells in the area are saline and their water is used for washing, but it cannot be used to cook food properly and cannot be consumed. Respondents reported going to other neighborhoods to buy water, and either cycling or hiring bicycles to transport it back. One respondent stated: *"with this problem of water everybody has to learn cycling."* An hour to hire a bicycle costs 300 TZS, compared to the cost of 100 TZS per bucket of water. Respondents said that fetching water on a bicycle, depending on the location, could take up to three hours round trip and that that they cannot carry more than 2-3 buckets via bicycle. Collecting water via bicycle can also post safety risks, and may lead to accidents and injuries, especially in the dry season, when shortages are a lot worse and a lot of time is taken to fetch water.

Residents also have to go to different areas when there is rationing, which can last for 1-2 weeks; in the dry season – when water availability is lowest – there are other areas they go to look for water. The time spent hauling water displaces other household activities, as well as time spent on business. One woman who runs a pastry business said that she needed clean water to operate her business, and was therefore affected by water shortages and by the time it takes to collect clean water during those times. Unsafe water can also put the customers at risk of illness, she says. One respondent said that with enough water, the family would be very satisfied as they would be able to bathe three times per day, and that she would no longer have to close her business for lack of water. Another woman said that she would wash her clothes at the time she needed to do so, instead of waiting until whenever water became available.

"Sometimes you find [tap water] even smells muddy, they treat it but when they do once you open the tap what comes out first is a kind of foam which smells bad, after an hour it flows muddy or we can say red like water then clean water comes. You don't have alternative for bathing." … "When it is muddy you can't use it for washing clothes, and if you take shower with the green one you itch. If you boil it then it gives foams and if you keep it for two days you will find the whole bucket smelling bad and slippery." – FGD, Morogoro

FGD Area 13, Morogoro: In this area, closer to the center of town, approximately 41% of surveyed households have taps on-premises. However, FGDs suggest that only some residents – those who can afford it – have their own connections, whereas others rely on getting water from neighbors. Residents estimate that the cost of connection is approximately 300 thousand TZS, including labor charges, inputs, trench digging, and meter expenses, Households also pay monthly meter fees and there is a high cost of meter replacement should it become damaged or broken (50K TZS) which residents say happens often when cars negotiating a tricky corner can damage meters. Respondents say that their piped water comes from Mindu, but during dry season water is rationed and it becomes dirty and green in color. As a result the water is treated, but residents say that the effects of the extra dirt in the water and the treatment measures taken are apparent in their taps, as they get foamy and discolored water for some time before clean water flows later in the dry season. Residents say that announcements are made about when repairs are being done and will affect the water supply, and that they try to keep reserves of water for these specific times. On the other hand, respondents say that during the rainy season the water pressure is higher but the water is very muddy, so much so that it cannot be used for bathing. One respondent stated her dilemma plainly: *"It is muddy during rainy season and green during dry season."* The cleanest water comes, according to respondents, in the "purely dry" times when "they" (presumably, the utility) have administered water guard (chlorine) to the water supply. Residents here say that there is not sufficient water available from the public network, and they are not satisfied with collecting water from their neighbors because it takes more time and they are not able to collect as much as they need. This time could have been spent on other tasks including tending to one's business, and the expense of collecting water (e.g., hiring a cart or a bicycle to haul the water back) would be avoided. Residents in this area do not report using water from kiosks, as kiosks are not prevalent in this area, and most households use neighbors' water. The most severe periods of water shortage occurs in October to November. Residents of this area admit that households in other areas have even worse water problems whereas they at least have the benefit of being in the lowlands. Respondents here echoed the grievances of those in other areas with regard to the rationing schedule, saying that sometimes water can start flowing at midnight, so instead of going to sleep women must collect water in the middle of the night. Residents leave the taps open to be able to hear when water starts to flow, so they can then get up to collect water. Residents in this area described that potential outcomes of an improved water supply would include fewer water-borne illnesses, more time to spend on businesses and more profitable businesses, water to use for gardens, and decreased water expenditures both because of an expected fall in prices and the reductions in expenditures.

"Only those who can afford have been connected, the majority of us can't afford the connection costs. You find the costs from surveying to connection is up to TZS 130,000 so for a peasant like me [I] will end up buying water from neighbors." – FGD, Morogoro

FGD Area 12, Morogoro: Survey results show that about 35% of households in this area have a piped connection on premises and residents reported using primarily piped water through the public distribution network, from the Mambogo source. FGD participants estimated that a tenth of households in the neighborhood were connected. Those who do not have their own tap collect and purchase water from neighbors, for 50 or 100 TZS for a small or large bucket, respectively. Previously, there was a community tap from which residents bought water – in the past a small bucket was 20 TZS, but prices had risen to 50 and 100 TZS for a small or large bucket, respectively; at the same prices as buying from a neighbor, residents preferred to collect water from a closer neighbor's house. That community tap is now out of service. When there is a shortage of tap water, residents collect water from the Morogoro River. However, river water is usually used only for washing and bathing, but is not suitable for drinking. In the dry season, residents are also able to collect water from boreholes.

Participants did not feel that the water supply to the area was sufficient. Those who live uphill reported experiencing particular problems with water supply. Those who collect water from tanks say that they haul water for up to an hour each time and the terrain is not favorable. When fetching water from such far away sources, residents are able collect only about three buckets of water per day. While a typical household uses 3-4 buckets of water a day, when washing clothes 8-10 buckets of water are usually needed.

> ***"Water is needed even more than electricity. So water is the first thing. So when water is not available we women are [having] problems [...] most of the women's works use water. If you miss water even the business works are halted. You have first to go around looking for water so that at least when children come back from school they should find water." – FGD, Morogoro***

Households store water in the household in buckets, usually using water within 2-3 days of collection. Participants in this focus group described stark differences in water availability between rainy and dry seasons. In the rainy season, water flow is not a problem, but during the dry season water supply is unpredictable. Water collection from other sources, such as the river and boreholes, are much more common in the dry season. The challenging dry season period is September through December. While in other areas residents reported some challenges in obtaining tap connections, residents in this area said that paying the connection fee and completing the relevant paperwork, were sufficient to obtain a connection. The main challenge was the high expense of obtaining the connection, as one respondent described: *"…our place is different from other mtaa, in our place there are low income people, so for someone to work on his own to connect water up to his residence is difficult."* In this area, many businesses depend on water such as food vendors, saloons, vegetable sellers, and brick-makers. One brick maker said that she gets water from a small spring that supplies saline water, which is not suitable for any other functions, and would use tap water like other brick-makers in the neighborhood if it were closer than the spring. Further, bricks cannot be made at all during periods of water shortage, and water shortages of tap water can last all day in the dry season. Residents also described having to decide between spending money on water and school fees. For example, the utility had asked the community for contributions for a tank for the area, but this was at a time when payment for children's school fees was due; many households thus opted to pay the school fees for their children and could not contribute to the water project. Residents said they knew their water situation was better than in other where households could go a week without water for drinking or cooking.

FGD Areas 14 and 16, Morogoro: These areas are close to the town center and approximately 44 and 88 percent of surveyed households in each of these areas, respectively, have an on-premises taps. Respondents in the FGDs confirmed that they obtained most water through the piped network, and said they use piped water for all household uses. Respondents said that in September and October, in the dry season, the water volume reduces but does not get cut off completely, rather there is rationing and they will know which days they will be getting water. During the dry season, water is reported to be green. No wells, apart from one private one, are available in the area and the residents do not want them since they would provide saline water. Yet residents did say that when they do not have water, they will resort to getting it from "pumping machines" (likely, wells or deep boreholes) which do supply saline water.

FGD Area 15, Morogoro: Approximately 73% of households in this neighborhood have on-premises taps, according to survey results; most of the population uses either their own taps, or taps near the area. FGD participants reported that water is plentiful during the rainy season, but that there is frequent rationing during the dry season when the water levels drop and water is saltier during the dry season (August to January). While more water is available during the rainy season, it can appear black due to the mud from the mountain. In the dry season, shortages of water can last up to two weeks, and residents resort to collecting water from a well near the dam. Women must often walk considerable distances to collect water, and sometimes must collect water during the night. Residents in this area also collect water from a nearby well at a mosque, at certain times of the day when classes are not in sessions; although the guard on duty does not always permit entry into the mosque compound. Some residents have businesses that depend on water, such as selling tea or raising poultry, and need water to feed the animals and keep their area clean. Respondents reported that they need a more reliable source of water, and more households would be willing to connect to the piped network rather than relying on a few unpredictable sources.

8.9.2 Qualitative Insights: Water quality and health

FGD Area 1, Dar es Salaam: A resident in this area indicated that she contracted fungus by using lower-quality water and noted she would rather spend money on bottled water than paying to treat UTIs and water-related illnesses. Some respondents in this area boil or otherwise treat water before drinking, but many do not. One respondent said that she will dispense Waterguard into a reserve of 1,000 L of water only at times she can afford the Waterguard. Some residents boil water due to negative past experiences with water-borne illness. Those who feel they must resort to drinking saline water do not boil it because they believe that salinity worsens after boiling. In response to a prompt about what would change with an adequate, safe water supply, one resident said that without water shortages, she would experience several positive changes: *"So many advantages, I will sell ice creams, I will sell ice blocks, will grow vegetables. First of all if you have water even your home surrounding will be clean, you will grow flowers and the house will look beautiful, cholera will be ended."*

Another respondent explained in detail her concern with water purchased from vendors in the area:

> *"Even that tap water we buy we are not sure how safe it is, the supplying vehicles [look] like those dealing with sewage. Sometimes when you pour it in a bucket and let it settle you will find something like rust at the base of the bucket…One day I got water with cockroaches, besides, the cleanness of the [equipment] they use is doubtful, say a vehicle fills in water here say from a well and you [order] tap water they can bring you that from wells simply because it's not salty and you can't tell. In fact when it comes to water we are in trouble, we now call for donkeys to fetch us water."*

What are the dangers from the well water? "Bilharzia, UTI, rashes. There is salty water that if you bath with the moment you come from the bathroom you scratch a lot, if you wash clothes with it they go fade in two days, after all it doesn't get hold of soap." How do you fight those waterborne diseases like UTI and bilharzias? "One will just buy some medicine and take, after a week you get it again... that's how it is." -FGD, Dar es Salaam

FGD Area 7, Dar es Salaam: In this area, illnesses such as diarrhea and typhoid are present, but most residents do not boil water. One respondent, acknowledging that few households in the area boil their water before drinking, described a link between water and illness *"…This water needs boiling and filtering before drinking, but only a few do so. These (sic) are the ones who are infected with typhoid, although typhoid is not caused by this alone but also eating cold food, [unclean] fruits and vegetables."* The FGD also revealed that there is a widespread belief that since Waterguard can bleach clothes; it is therefore is a powerful chemical that can damage intestines and even cause cancer, thus it is not used by many residents. Some respondents expressed a concern that they do not know the appropriate dosage, so it is best to leave water treatment to DAWASCO. Residents say that utility-provided piped water is of lower quality during the rainy season, sometimes malodorous. Well water does not change so dramatically by season but can be less salty during rainy season. Therefore, during rainy season, the quality of utility water decreases while the perceived quality of the well water increases. Residents say that over the course of the rainy season, the pipes are cleared out, and the water becomes cleaner, while at the beginning of the rainy season piped water is dirty and can contain contaminants, including even bugs and larva. Notwithstanding, when focus group discussants were asked to informally grade the quality of utility water versus well water 1 through 10, ratings for well water ranged between 1-5 and utility water between 6 and 10, with completely proportional ratings (i.e., those who rated utility water 10 rated well water 1, and those who rated utility water 6 rated well water 4, etc.). Again, a strong preference for piped water is revealed, and that piped water is viewed as of relatively better quality.

"Stomach fever, typhoid, diarrhea, sometime[s] you just become familiar so when you see the symptoms you just buy ciproflaxin and take it for three days rather than going for the checkup which cost[s] 5000 shillings." -FGD, Dar es Salaam

FGD Area 2, Dar es Salaam: In this area, residents said that households were more likely to boil water when hosting guests. Given the relative dependence on saline water, water was not boiling often as boiling is perceived to increase the salinity. Residents of this area also mentioned that wells are often close to toilets and therefore the hygienic conditions around them can be poor; in addition, the source of the water brought by tankers is unclear and its quality is not perceived to be very high. Respondents noted that they would prefer to have access to DAWASCO water, which they believe to be safer, so that children would not contract diarrheal illness and UTIs as frequently. Typhoid was also reported in this area. Although respondents said they knew that boiling and/or using Waterguard were proper treatments of water, again many respondents did not report treating water regularly. One respondent said that most people do not treat the water until they have an experience with typhoid, after which they may even put cattle bones or a coconut husk in with boiling water.

FGD Area 4, Dar es Salaam: Residents fo this area reported that they buy water from vendors only if other sources are not available, and do not trust the quality of water from these sources. Most survey respondents said they treat water before drinking and most households seemed to be aware of the benefits of boiling water. FGD respondents said they boil water when they can but sometimes they only filter the water because they do not want to wait for the water to cool down. When water is not boiled, adults and children tend to contract illnesses like diarrhea, typhoid, ringworm, and fungus, and must often seek treatment. Respondents also reported turbid water, especially during construction. Residents say that open wells in the area are sometimes used as toilets by people or animals passing by, or for people to bathe, which results in water contamination. Parents also report water scarcity at schools, often treating their children for UTIs, and that children sometimes bathe only every 2-3 days, resulting in skin infections like fungus and ringworm (tinea capitis). Further, accessible lower-level health facilities may not have necessary medicines, save for UTIs, and parents are often told to go elsewhere and buy the medicines that are needed to treat their children.

FGD Area 8, Dar es Salaam: Focus group participants in this area reported boiling water and using Waterguard, although some did say they drink water without treating it.

FGD Area 5, Dar es Salaam: Respondents in this focus group discussion said that in the rainy season some residents have contracted cholera due to a lack of clean water.

FGD Area 3, Dar es Salaam: Residents from this neighborhood report that the water they have access to is not of good quality, and is often dirty, containing sediment or bugs, including jigger bugs. Residents said that sometimes a child will take some water and drink it without knowing it is not potable and had been put aside for washing clothes. In this area, households with access to tanks may have consistent water supply the tanks can be quite dirty, with bugs, dead animals, or dirt collecting inside, and they are not properly cleaned on a regular basis. These participants also reported water-related disease, such as fungus, itching (rashes), and UTI, as well as ringworm on the scalp in children (tinea capitis). Residents reported incidents of cholera two years ago. A respondent said they would be glad to be able to have a cleaner house, if there were enough water available to use for cleaning toilets.

FGD Area 6, Dar es Salaam: Residents claim that the use of hard water can cause UTIs in women. In addition, they say that the water was tested "by experts" and was found not to be safe, especially as it is located near sanitation facilities, and reported that water smells, causes itching, and UTI infections. One respondent mentioned that she uses Waterguard to treat her water, while another reported using "shabi" - a chemical that helps filter the water.

FGD Areas 2 and 3, Morogoro: Residents from these areas mentioned having to treat the water that comes from the Mindu source (dam and reservoir) with Waterguard, since it was contaminated and dirty. When asked about water-borne illness, respondents mentioned outbreaks of cholera as a result of dirty water. They also mentioned malaria, but that after nets were distributed this is no longer a problem (note that this is likely due to standing water; many Morogoro residents live near surface water that may attract mosquitoes, though the implicit pathways of illness related to water and mosquitoes were not explored in the FGD).

FGD Area 13, Morogoro: Respondents from this area claim they can tell when the utility is short of chemicals (for treating the water) - when they find insects in the water; they also reported contracting diarrheal illness and typhoid when the utility water is not "treated." Respondents in this area reported boiling their water, even though boiling the dirty water often resulted in the formation of a foam-like substance of the water; regardless residents called boiling water a "must." With respect to other forms of treatment, one respondent said that at times when the water turns green, the water is filtered as follows: *"We store it as it is on the drums, we leave it to settle then the green layer floats on the top, we then take that out then we use the clean water for washing and the dirty one for watering gardens. In short we filter it."* Residents say of the health facilities in the area: *"They do have reserve water from tanks but the general cleanness of the hospital is not as good compared to when the water is plenty."* Respondents say that unclean water leads to fungus and UTIs, especially among girls.

"The hospital is nice but its toilets are horrible and sometimes there is [a] shortage of services due to lack of water." – FGD, Morogoro

FGD Area 12, Morogoro: Residents of this area said that the quality of water from taps connected to the Mambogo source is good. One resident reported that when she was living in another location and was getting water from the Mindu dam, she often suffered from typhoid, but has not become ill since moving to this location. Another participant said that she drinks water from the tap here, but will not drink from the taps in town and buys bottled water. Some of the participants mentioned that poor quality water can lead to fungus in children.

FGD Areas 14 and 16, Morogoro: In thse areas, residents said that they boil water when it is dirty, and not when it is clean. While drinking water is boiled, water used for cooking is not boiled as residents said it "boils itself" during the cooking process. In addition, they reported boiling lots of water at once, to avoid boiling it one day and having to do it again the next. Residents said that if green, when left for a while sometimes the green color will decrease. This group mentioned water-borne diseases such as typhoid, diarrhea, nausea, and vomiting. Malaria was also mentioned again here, although it is unclear whether the implication was that it was water-borne or just a result of standing bodies of water that breed mosquitoes. There are nearby health facilities, but just like the households who consult them for water-related illnesses, the health facilities themselves also have water problems. One respondent said, *"The hospital is nice but its toilets are horrible and sometimes there is [a] shortage of services due to lack of water."* Residents here say it is easy to detect whether water is being treated because of the smell (of "medicine in the water") and bubbles in the water, without which they can tell it has not been treated.

FGD Area 15, Morogoro: In this area, as in others, some respondents said they boiled their water while others did not, with several respondents who do not boil their water reporting that boiled water caused diarrhea and another claiming that boiled water is sweet. One respondent who does boil water reported doing so to kill bacteria.

8.9.2.1 Qualitative Insights: Gender roles and challenges

FGD Area 1, Dar es Salaam: In this area, women are in charge of water (according to respondents, because children go to school and husbands work long hours), some women said they had to apply pressure to men to set aside money for water; and related that their husbands would not leave enough money for them to take care of food and water. As a result, women report economizing with the allowances left from their husbands and trying to be flexible with their budget in order to accommodate water expenses. Respondents also discussed whether husbands should be expected to help with water, and opinions differed among participants. Some women pitied their husbands who do manual labor; others believed they should pitch in to collect a couple of buckets of water when needed. Neighbors will often help each other out with water collection, as one respondent's anecdote exemplified: *"There is a [neighbor] of mine who once knocked at my door at midnight, she had a severe fever and she had [diarrhea]. I asked her; do you have drinking water in the house? Just be free and tell me. She did not have any; luckily, I had Kilimanjaro bottle water I had bought for my child and I gave her two. Just tell me, man, the lady just gave birth and you cannot supply her drinking water in the house? We, the women, shed tears, early in the morning we had to go and fetch tap water and put in there. But we had a serious talk with than man, we told him, he can deny her food but not water."* FGD participants also said that marital disagreements can ensue if a husband does not understand the length of water collection queue; some women recounted accusations by their husbands that the long amount of time taken to collect water left room for extra-marital affairs. Some women collect water by pushing a cart with many buckets rather than making multiple and exhausting trips carrying water in arms or on head.

FGD Area 7, Dar es Salaam: Respondents noted that it is the man's responsibility to ensure that money is available to buy water; while the wife and/or children bear the responsibility for obtaining the water. Some female respondents did say their husbands shared equally in chores including water collection, while others said quite distinctly that these were women's responsibilities: *"Seeing my husband carrying a bucket to fetch water pains me a lot. It makes me feel I have not fulfilled my responsibilities."* Domestic servants often collect water in wealthier households.

FGD Area 2, Dar es Salaam: Respondents from this area said that water does not cause domestic disputes because the wells in the area are abundant. Therefore, unlike in the past, males cannot use an excuse of leaving early in the morning to collect water (despite the respondents saying males usually do not collect water), or that a woman is too tired at night, as both parties do not have reason to be fetching water for long periods of time or from far away any longer.

FGD Area 4, Dar es Salaam: Women spend most of her time caring for children, so when a child is sick and needs to care, it is the woman's activities that must be postponed in order to take care of the sick child. Respondents say this can affect their daily activities and/or business, but also takes a psychological toll. In this area, respondents said that if a woman has to borrow money to get to the hospital to seek treatment for herself or the children for water-related diseases, and the husband does not give money to pay the debt, then it will be the woman's debt. Men differ in terms of whether they help with water collection, but in this area for the most part, women will be primarily responsible unless they are unable to do any heavy lifting (e.g., if they are pregnant or injured). Time spent out collecting water can result in domestic disputes, as the woman could be accused of being out with another man during that time.

FGD Area 8, Dar es Salaam: Women in this area said that it collecting water is regarded as their responsibility. They do enlist the help of female children, but male children do not participate – even though they will be the first to use the water once it has been brought back to the household.

FGD Area 3, Dar es Salaam: This area's residents also reported that the primary responsibility for water collection lies with women and girls. Men get involved in fetching water in emergencies (e.g., such water scarcity such that the household members had not bathed for three days) or when transport is needed, such as driving to another area to get water and bring it back. Otherwise, men just provide the money for the women to go collect water. One respondent mentioned that arguments can start over the amount of money that is left for all household needs ("ending in slaps"). One woman said she has been robbed twice, coming in from fetching water and having thieves push her into the household behind her. Another woman said she fell and injured herself while collecting water, and is now not able to carry heavy objects. Someone else complained that children can have trouble collecting water, as they sometimes will leave the bucket, go elsewhere, and come back without anything saying there was a long queue. Some women feared that leaving to collect water gave men a chance to bring another woman into the house. Other women reported safety concerns associated with water collection - that they have been pickpocketed or sexually assaulted while out collecting water; and there was a danger of being hit by cars.

"During the dry season the situation is even overwhelming because mothers endanger their lives as we have said earlier, we normally go to find water in other side of the road which may result in accidents from bicycles, motorcycles and even cars. In recent days they are about three or four who have encountered accidents due to this water problem so we are [scared]." - FGD, Dar es Salaam

FGD Area 6, Dar es Salaam: These participants reported a high frequency of traffic-related accidents involving women who collect water outside their household. Respondents reported waiting until 5am or later in the morning to go collect water due to fear of pickpockets or thieves. Collecting water is a woman's responsibility, respondents say, and a married man would never collect water; the only men collecting water do it for re-selling, not for home consumption.

***FGD Areas 10 and 11, Morogoro*:** In these areas, respondents said that only women collect water either because this is not a man's responsibility, because men work long hours, or because he doesn't know how to ride a bicycle; while others in the group said that their husbands did collect water when they had time. Respondents mentioned that some women collecting water have been beaten by thieves, had their bicycles stolen, or were chased by those who would attempt to sexually assault them. Some women said that they sometimes ask husbands to escort them if they are collecting from very far away.

FGD Area 13, Morogoro: As in other areas, opinions and practices about the responsibilities of water collection are quite mixed in this area. Some women feel that water collection is a female's responsibility, as thus articulated by one woman: *"Unless the girls are sick then the boys will help otherwise you can't ask a boy to collect water while there are girls."* Other women say that the responsibilities are split, saying they do chores collectively, and another saying*, "I do collect on my own because my child is still young, will help once grown but if I had old enough children I wouldn't care, they would collect regardless of their sex."* Respondents say that while collecting water, women sometimes get hit by cars.

FGD Area 12, Morogoro: In this focus group discussion, a new topic was raised with regard to women's challenges and water. Women expressed that it is much harder for them to follow-up the construction of a local tank, toward which the community has contributed money to the utility, simply because they are women. One respondent said that it should be a man who follows up, saying that women do not know where the money was contributed (to which bank account) and would have more difficulty getting an answer from those who collected the money (the utility representatives). While this is the first instance where gender was explicitly offered as a reason for difficulty in following up with promised projects, the women echoed a sentiment expressed in many other focus groups across both cities, that *"our leaders should get the information."* Responsibilities for water collection fell on women in this area; with some support from children when the mother is tired or sick, and rare assistance from men when the woman is sick. Men's working hours (from early in the day until late at night), are also not conducive for water collection, according to respondents, adding that there is not a place from which water can be collected when they come home at night. In terms of personal safety, women cited the frequency of injury due to carrying water over rocky terrain. Some women reported encounters with snakes or monkeys along the way, one woman joked: *"If you [fall] down, the monkey says thanks, as it got water."*

FGD Area 14 and 16, Morogoro: Here, women said that men did frequently help them collect water when needed, understanding that it would help ensure that other things get done on time. One woman said, *"[men] know the importance of water, he knows if he does not help […] 'my wife will be tired by traveling long distance and this will make her skip some work to be attended on time'."*

FGD Area 15, Morogoro: In this area, respondents said that women are responsible for collecting water, along with children. Also in this neighborhood some women said that men become suspicious if women spend a long time collecting water, and that this can lead to domestic disputes. In one case, a woman said she avoided going home to avoid being beaten but cannot stay away from home long since she needs to care for her children.

8.9.2.2 Qualitative Insights: Children and school attendance

"Most parents are now very keen on school matters. If they [children] need to fetch water it is done after school. Not in the morning as many parents are now enlightened about education matters." -FGD, Dar es Salaam

Dar es Salaam: Respondents reported that children are highly affected by water shortages, and noted the deplorable sanitation conditions at some schools. Girls are most responsible for collecting water in this area. Children can also be required to bring water from home for drinking or for gardens at the school. Mothers said that if they if they cannot properly clean a child the student will not be sent to school. Some parents said that children do not have water with which to wash at schools, and therefore could defecate in their clothes, and leave school early to come home and wash. In FGD Area 1, households said they contribute funds to the school to provide water for children on site. In FGD Area 6, children who go to one local school were asked to contribute funds toward water expenses each year; while those who go to local public schools must bring water from home for watering flowers. If they do not bring water to school they may be beaten and sent to fetch water. In FGD Area 7, respondents indicated that water collection does not get in the way of school attendance for children since parents now understand the importance of school attendance. However, residents in FGD Area 3 said that children are sometimes late to school if there is a long queue to collect water. Respondents from FGD Area 4 reported that the tap at the school has not been operating for 3-4 years, resulting in a situation of severe water scarcity for children going to school. Water taps were supposedly placed in some of the teachers' homes but parents disagreed about how much this was really used. Some said children had to bring water from home, and that sometimes they asked to use the toilet facilities of the houses that are located near the schools. In FGD Area 8, participants said that when water flows overnight, sometimes households will not be able to collect water before it stops flowing, which can affect children's ability to bathe or wash clothes, which are viewed as necessary for school attendance.

Morogoro: Residents from the FGD Areas 10 and 11 reported that children attending schools in the area have no access to clean water, since wells around the schools are reserved for private use and the children must resort to collecting water from dirty, surface sources and which are poorly suited for use. Children in these areas tend to help parents fetch water after school hours, after the age of 7 or 8 when they can ride a bicycle. Residents in FGD Area 13 reported that children must bring their own water to school, and that the sanitary conditions at the schools are poor. Respondents describe the toilet facilities as follows: *"The surroundings become dirty especially the toilets, for instance on dry season it reaches a point they have to carry water with them to school."* Children have to carry water to school more frequently in the dry season, while in the rainy season water does flow on site. In FGD Area 12, water is typically available at schools, but in times of shortage, children are asked to bring jerry cans of water to school. In FGD Areas 14 and 16, residents said that children bring water to school for drinking, while water needed for watering flowers at school was collected from the river. Parents were apprehensive about their children going to collect water from the river as it is perceived as dirty and dangerous for children. If a child is seen going there, according to respondents, he can be reported to his parents and is punished. In FGD Area 15, children collect water with women as they need water to wash their uniforms, and carry water to school in small containers. Those collecting water are at a greater risk for accidents, as in a recent case when a child was hit by a motorcycle while crossing a road to collect water.

> ***"Pupils are much affected with water because they don't have tanks or piped water and those wells near the school are for the business the water is sold, that means to fetch water from unsafe water from the river, very dirty water to be used for cleaning and washing even for the toilets it irritates when taken for bathing. We sometimes use it when you don't have alternative for bathing." –FGD, Morogoro***

8.9.2.3 Qualitative Insights: Perceptions of water utility performance

Dar es Salaam: A main theme across the focus group discussions was a considerable amount of tension and frustration toward the utility's billing procedures, and the accompanying lack of transparency. Many customers reported that the bills from DAWASCO are often higher than actual consumption (as they calculate their own consumption based on the meter times the known tariff) and that bills are sometimes high even when there was no water flowing from the tap at all, because of air-logs or faulty devices. Respondents expressed a preference to have their own taps in the household, so that each household can have its own meter, track water use, and monitor and honor their bill.

In FGD Area 7, there appeared to be a lack of understanding among customers about what leads to tariff increases imposed by the utility, especially given the perceived low quality of customer service. Respondents also cited faulty infrastructure, such as leaking pipes, as one reason for the lack of water from the public distribution network. The limited volume of available water implies that customers who are able to obtain more water by installing illegal motors (to supply elevated storage tanks) are perceived as essentially taking from others. One respondent described this as follows: *"I do not know whether the problem is with motors or pressure, it is not enough…Some problems are caused by us customers; a person finds water pressure is low and he installs a motor, making others go without water completely."* Some residents are accused of using motors to collect and store DAWASCO water to resell for a marked up price to other residents when the utility water is not flowing.

Residents also complained that due to illegal connections, those legally connected were billed for a much higher volume than they were actually accessing themselves. However, interviewees reported that the utility is very strict in disconnecting those who are found stealing from the network, if they are caught. Some household connections had been disconnected - although water had been flowing from the tap when residents moved in, they speculate the tap must have been connected to another household's account, and therefore they had not been paying for it.

In FGD Area 1, residents expressed frustration at the disconnection of the community-managed system and at the alleged corruption of some utility workers who were reported to take money to install illegal connections for some residents. To provide some context, there had been a DAWASCO-sponsored community-managed water supply project in the area, a tank that had been supplied by the utility to which some households could be connected, or from which water was sold for 50 TZS per bucket. However, this system has since been disconnected for at least a year, since some households were siphoning water through illegal connections. Recently, in advance of local elections, a candidate promised to bring water to this area; respondents indicated they would be willing to support a candidate who could do so. Some respondents reported that one of the reasons efforts to reconnect this network were stalled was because the electricity utility was not being paid.

In FGD Area 4, the major concern about network water was the lack of information from the utility on unplanned or irregular interruptions to water supply. One resident claimed that the utility would not give him water due to a misunderstanding about payment and that the utility had requested that the customer pre-pay an amount of 130 thousand TZS for three months of water. Residents also reported that the utility fines those caught using a non-DAWASCO connection by levying a penalty of 1.5 million TZS.

"And another problem with them is that their water flows once a month; now how can I wait for water that comes once a month or once in two months? That is why some people decide not to pay, and they [DAWASCO] still demand service charges and others up to 60 thousand [shillings] or so. One asks himself, where do all these charges come from? … Even when you open the tap and only air comes out, it reads as if water was flowing." -FGD, Dar es Salaam

Residents were also frustrated at being told they could not connect because of the hilly terrain, while they know that others in the same area are connected; the utility also asked them to contribute to fuel expenses for their car, which would be used for the surveyor to come to the area to check if they could be connected. Several residents contributed 5K for the fuel, as requested, but in the end were told they would not be able to connect. Residents also reported that some utility officials demanded bribes to act on any request; in some cases, the local managers are bribed by households to keep water flowing for their gardens when the rationing timetable actually dictates that water should be flowing elsewhere. Respondents suggested that such problems were mostly related to the utility's area managers.

In FGD Area 8, residents reported that they were aware that the utility had been considering installing prepaid meters (*luku*) which would make the water shut off if the meter credits had run out; these reports were consistent with key informant interviews conducted with the utility in Dar es Salaam. As in some other areas, residents had been aware of the pipes being installed near a nearby road due to apparent construction, but were not aware that the intention was to increase the supply from Lower Ruvu. As in other areas, residents felt that the utility recorded consumption volumes higher than what shows on their meters; some said they brought their meters to DAWASCO to pay and saw that the DAWASCO log-books had recorded higher numbers than what their meters read. Residents feel that the meter-readers do not record accurately, and that those households who do not know how to read their meter, or who do not know the price of a unit from the utility, may be taken advantage of.

Similarly, residents of FGD Area 6 complained of receiving high bills even when there was no water flowing through the pipes. They also reported that utility officials can be bribed to allow those with pumps to continue taking the water disproportionately into their tanks and then re-selling it; and that a bribe would be needed for the utility to agree to drill a deep well in the area.

Morogoro: As in Dar es Salaam, residents of Morogoro were highly concerned about the water bills they received from the utility which, in their opinion, did not accurately reflect their use of tap water, though in general had much less to say about the utility's performance. Residents from the FGD Area 13 described receiving utility bills even after long periods of water shortage, and said they did not know what they were being charged for since water had not been available. Residents from FGD Area 15 described having to pay the water bill even when no water had flowed, and were told by the utility that they left an air-log in the meter so it had been running even without water, and payment was still due. Other participants also expressed frustration at the lack of transparency in billing, recounting paying for services that they can't account for by reading the meter themselves, even knowing the price (correctly reported in the FGD) of a unit of water (at that time, 720 shillings per cubic meter). One respondent said, *"[These] people are eating our money. It is true with this saying that the goat eats the length of its rope!"* Residents said that even when water use fluctuates, they receive the bill for the same amount.

8.10 Qualitative Insights: Health Facilities and Schools

Data from health facilities and schools was collected through semi-structureed interviews with district-level representatives as well as through interviews and site visits at facilities. Overall, both educational and health facilities experience negative effects from a lack of a reliable access to clean water, which affects the performance and operations of these institutions. Even when not the foremost challenge, water scarcity presents tangible and substantial pressures on limited resources, especially among public facilities.

8.10.1.1 Health facilities

Semi-structured interviews were conducted with District Medical Officers (DMOs)[30] in each municipal district (three in Dar es Salaam, and one in Morogoro), to gather information about the current level of water access, consumption, and water related challenges in each city. During each interview, facilitators collected recommendations for health facilities in each district to visit, to observe directly the water situation at these sites and glean further context for the water issues from site administrators. Three site visits were conducted in each city. Recommendations for site visits were collected from these interviewees, after which site visits to facilities – 3 in each city – were conducted in order to further discuss and observe challenges and issues around water access and use in public and private hospitals and dispensaries. A variety of facilities including dispensaries, clinics, and hospitals, were chosen in such a way to ensure a mix of facilities in terms of their size, capacities and services, and public or private ownership.[31]

Water is a critical input to the operation of all health facilities. Interruptions in water access along with compromised water quality can have ramifications on the health facilities' ability to provide high-quality and reliable services to their patients. Piped water is preferred but is universally not considered to be reliable; health facilities therefore also rely on boreholes, tanker-trucks, and rainwater to maintain a water supply, and it is not uncommon for patients to bring their own water to facilities for personal use.[32] Health facilities have varying levels of access to the public distribution network. Across the board, respondents noted that tap water is preferred because it is perceived to be of the highest quality relative to other water sources. However, tap connections do not supply an adequate volume of water for facility operations, and facilities rely on other sources in order to maintain their water supply, as no single source met their water demand. Health facilities therefore tend to rely on some combination of piped water, borehole water, and tanker-trucks. Some harvested rainwater, and a few even collected surface water from nearby standing bodies of water. It appears that facilities at lower tiers (small outpatient facilities like dispensaries) are the least likely to have piped connections. Some facilities own their boreholes (each borehole providing either soft or saline water), while others may purchase water from nearby boreholes that are privately owned. Boreholes owned by facilities have often been sponsored by local companies or other private institutions, and in some cases NGOs or donor agencies.

Health facilities employ additional water sources like boreholes, tanker-trucks, and storage reserves to mitigate against water shortages, but each water source poses additional challenges. Unpredictable shortages and water pressure losses from utility connections have prompted some health facilities to supplement utility water with investments in boreholes, desalinization technology, or contracts with private tankers on an as-needed basis. Multiple facilities have even invested in more boreholes or other solutions such as desalinization technology. Salinity is the main constraint to the use of borehole water as such water is not appropriate for use in many procedures in health facilities. Water from boreholes is suspected to be of poor quality for medical uses; one respondent mentioned that it causes instruments to rust and discolors sinks. Often, when facilities resort to saline borehole water, they dilute borehole water with piped water to reduce the salinity and prevent damage

[30] In some cases, DMOs delegated another district health officer or representative for the SSI.

[31] The information collected from these facilities was collected with an agreement of confidentiality in light of media sensitivity, and therefore respondents' privacy has been maintained by excluding the facility name and specific respondent and district with the data presented below. Nevertheless, key themes were echoed across all cities visited.

[32] Note that these findings are according to SSIs with district offices and site visits to facilities; this was not a representative sample of health facilities and no attempt is made to draw any inferences, merely to represent the information that was supplied to the data collection team and provide context

to machinery or equipment. In some facilities, even boreholes on the premises were damaged or running dry. In one case, where the pump was damaged, buckets were being used to take water from the borehole, increasing the likelihood of contamination. Numerous facilities use tanker water, as well. However, tankers are vulnerable to fluctuations in water availability and are not always reliable; in addition, tanker provided water tends to be the most expensive. Some respondents noted they use a single municipal tanker for distributing water to facilities in shortage situations, but that a single tanker at their disposal could not handle the demand so facilities contract individual tankers to fill their reserves as needed. The quality of the water from the utility is understood to be more reliable than tanker water, and tanker water is treated at some facilities. The fluctuating cost of water can have cost implications, as well. Unfortunately, not all facilities are able to afford tanker water. Sometimes during shortages, patients are asked to purchase or bring water for their needs from home or through visiting relatives. Many health facilities have elevated storage tanks or underground reserves, to which can be used to store tanker water, but many do not have the storage capacity to ensure the required amount of water. In addition, the storage tanks are not regularly cleaned, and can contaminate water. Mirroring concerns of focus group participants, health facility administrators expressed a strong preference for piped water, and to have dedicated lines to the health facility with guaranteed hours of flow or wider pipes to increase the water volume, but tend to see boreholes as a permanent or semi-permanent solution to water scarcity, and have little faith that the system can be repaired in such a way that will meet their demand permanently.

Health facilities report that the lack of consistent supply of clean water makes it difficult for them to perform essential tasks (e.g., surgery, sterilizing equipment, washing soiled linens, flushing toilets, and ensuring that patients are properly bathed.) When facilities have to order water from tankers, long waits can result in delays in service delivery. Water at health facilities is used for surgical activities and equipment, sterilization of equipment, for health workers' washing hands before, during, and after operations; use in the labor ward during deliveries; cleaning all areas of the facilities; showers; and sanitation and toilet facilities. At larger institutions, water can also used for gardens on the premises. Some facilities also use water for boilers (i.e., for laundry and cooking). In Morogoro, the injury burden of traffic accidents is very high and surgeries need to be performed regularly, but can be delayed or compromised by inadequate water supply and the resulting substandard hygienic conditions. During a shortage, facilities economize in their consumption of water with essential functions prioritized, leaving out washing laundry, gardening, and mopping or cleaning as non-priorities compared to sterilization of equipment, and sometimes only emergency operations can be performed. In addition, the facility workers need water during the day at their place of employment just as a matter of working environment, which is compromised during water shortages.

Frequent piped water shortages at taps on the premises were reported by almost all facilities interviewed. These shortages were ascribed to power cuts, supply fluctuations, and road constructions, in addition to lack of water from the ultimate source (rivers, dams, reservoirs that feed into water treatment plants) and seasonal fluctuations. Shortages were reported to be a chronic, year-round concern, but were more common in the dry season, aligning with focus group discussion reports. Some facilities were experiencing cuts in their piped water supply during the site visits, and stressed that these were not isolated events but reflected chronic and ongoing circumstances. One dispensary located in a ward with generally intense water rationing had no piped water supply for the preceding three months before the site visit. This facility sometimes procured water from tankers, but often could not afford the high cost, and therefore resorted to rainwater harvesting. Lack of information from utilities about when planned shortages and rationing will occur was common across types of facilities. Some respondents also expressed doubts about the accuracy of the utility bills, which some said fluctuated even when consumption was relatively constant, just as respondents during the focus group discussions expressed concern over the accuracy of utility billing.

Water scarcity can affects patients as services can be delayed if water is not available to clean or prepare equipment for a given procedure, sanitary conditions at the facilities suffer greatly, and infection control cannot be properly implemented. Interviewees mentioned that women, children, and low-income residents were more likely to be affected by these conditions. Women are the primary users of health facility services, especially at lower tiers such as dispensaries; children are more vulnerable to infection; and low-income residents must rely on under-resourced government facilities since they do not have the ability to pay for care at a private facility that may have adequate water and other resources. On the other hand, private facilities visited were not immune to water supply issues, and all facilities cited similar challenges in ensuring hygienic conditions and maintaining enough water to carry out all other normal activities at the facility.

Cleanliness tends to be poorly maintained in many wards, which results in unpleasant and uncomfortable inpatient stays for patients and their families. Patients' recovery times can also be longer due to a lack of adequate volume of clean water. Water shortages can also disproportionally affect female patients and children since their water needs are greater for washing and cleaning themselves and their families during their stay in the facility. During water shortages female patients often receive priority. In addition, women and children are the primary users of lower-level health facilities such as dispensaries, which often face the most severe water supply challenges, and therefore are simply more likely to interact with a facility having trouble maintaining an adequate supply. In some dispensaries, especially during the dry season, patients are often instructed to bring their own water in order to take medicine due to lack of access and the expense of water procurement. One dispensary visited had a tender to provide health services to a nearby school, therefore any shortages at the facility would affect students there seeking care.

Water access consistently ranked high on the list of challenges faced by health facilities. Some said it water was the utmost concern, while others listed water closely behind other important challenges such as supplies of drugs, human resources, equipment, and infrastructure. One respondent noted that water was a bigger challenge than retaining qualified personnel or dealing with drug shortage problems. In both cities, respondents said that their challenges were continually amplified by rapidly increasing populations, which drives demand for services up faster than they can be addressed, putting pressure on all of their resources. For example, facilities must use some of their emergency funds to secure water when rationing and unplanned shortages occur. One respondent described expectations in terms of how health facility operations might improve given an improved water supply:

> *"First, the money used to purchase water will now be used to purchase medicines and other medical equipment […] also it will increase more time for doctors because instead of doctors wasting time to call the tankers they will now dedicate time for attending patients, but also assurance to staff that they will be sure that they will be assured of [cleanliness] after let say serving mothers during delivery, it will also reduce the chances for infection prevention."*

A representative from a health care center in Morogoro acknowledged the effects of the lack of regular access to clean water sources:

> *I: How about serving patients? Has it ever affected the service, that there was no service to patients?*
> *R: You cannot even stop serving patients but there are little problems including cleanliness and so on.*
> *R: You can find little water for uses*
> *R2: Cleanliness level becomes poor because they have no water for doing cleanliness at a required standard. For instance, water is required to run during hand washing, you scoop water and a person washes his/her hands. Infection prevention becomes poor.*

8.10.1.2 Education facilities

Semi-structured interviews were conducted with District Education Officers (DEOs)[33] in each municipal district (three in Dar es Salaam, and one in Morogoro), during which the evaluation team gathered information about the current situation of water access, consumption, and related challenges in schools around the city. During each interview, facilitators collected recommendations for sites to visit. A total of seven schools were visited as part of the baseline data collection, including primary, secondary, public, private, boarding, and day schools. These visits highlighted a number of issues that affect students and staff due to limited water availability. School administrators cited a lack of reliable sources of clean water as a key challenge they face on a regular basis. Commonly cited consequences included poor sanitation conditions, absenteeism among females, and reductions in teacher and student motivation, in addition to the financial and administrative burden placed on the district and school administrators who deal frequently with the need to secure water on school premises.

Schools reported using a mixed portfolio of sources to maintain a water supply, using combinations of piped water, boreholes, rainwater, and water tankers. As in health facilities, piped water seems to be the most preferred source, but not reliable. Therefore, many schools rely on boreholes, tankers, and other sources for their water supply. One facility reported collecting water from a puddle pooling under a nearby leaking pipe. Some schools have multiple connections to the network on-site, each with their own meter, some in better condition than others, but which do not supply enough water on their own. As some focus group respondents, some schools with piped water connections, report water flowing at night due rationing; but for facilities with little to no storage capacity, the taps cannot be left open and water will still not be available during the day. Several schools have a tap on premises that is disconnected or inactive. One school was previously connected to the network, but has been disconnected for years since it was unable to pay utility bills, leaving a debt that the school is now paying off in installments. Another school had a prior utility connection that had long been dismantled. This school is using an electrical pump to supply water from a borehole about four kilometers away, which, due to frequent electricity cuts, is often powered by a diesel generator. Another school had no public utility connection, nor any boreholes of its own, and used a nearby privately owned borehole, contributing some payment to the owner. Schools also sometimes purchase, at marked up prices, water from vendors. In some cases, owners of nearby boreholes allow schools to access a certain amount of water per day for use at the school. Several schools keep storage tanks or reserves on site, but these are often not large enough to keep an adequate supply. Large storage tanks at one facility have started to crack and leak, as a result of storing corrosive saline water.

Respondents mentioned that the most severe water shortages occur during the dry seasons, and

[33] In some cases, DEOs delegated another district education officer or representative for the SSI.

sometimes water supplies dry up almost completely, increasing schools' reliance on tankers for their water. However, one respondent stated that in the rainy season, other challenges arise. The roads can become impassable, such that if rainwater – even after rains – is not adequate, tanker trucks can then not pass through to deliver water to the premises. At one school, staff bag water from a nearby borehole to bring to the school for hand-washing. The staff at many schools is often engaged in attracting funding for water-related pursuits. Several schools have found funders for boreholes, whether charitable organizations, private companies, or even in some cases multilaterals or aid agencies working in the area. Some districts encourage teachers to seek out such funding for individual school-level projects.

Students are highly affected by water scarcity at schools, especially by the resulting poor sanitary conditions, which can spread infections, and contribute to absenteeism among female students. Site visit observations confirmed that some schools' toilet facilities were in very poor sanitary condition. One respondent noted a recent outbreak of cholera among students, which luckily did not lead to any deaths. More commonly, though, respondents noted increase in diarrheal illness and general stomach ills during water shortages or when the sanitary conditions were especially dire. Respondents noted that female students were more likely to be affected by these conditions, citing a high incidence of urinary tract infections (UTIs). Further, without adequate sanitary conditions or enough water, girls may miss school during menstrual cycles, sometimes for several days at a time. According to respondents, in some schools toilets are rarely flushed or cleaned, which can contribute to the spread of bacteria and students sometimes prefer to use the bushes or other unsanctioned locations around the school in place of toilets. A recurring theme was the high ratio of students to toilets, often exceeding recommended standards for municipal schools by orders of magnitude. One respondent mentioned that with the lack of water, toilets could not be used, and the ratio reached over 100 students to a pit latrine (the recommended ratio is 25 male students to a toilet, and 20 female students to a toilet). In addition, while secondary students have the habit to bring toilet paper to school, primary school students do not typically do this. In some areas, schools rely on pit latrines in some areas, where they know the water is unreliable, rather than constructing flush toilets. In one case, a school had received a grant to build modern flush-toilets, but due the lack of water, these were not being used. Teachers also bear the burden of inadequate water access: the poor hygienic environment, due to lack of water, can discourage teachers and result in lowered motivation; and teachers are said to seek toilet use at nearby households, bars, or cafeteria if those at the school do not have water.

Water scarcity also affects student learning, by depriving them of drinking water, meals, or adequate classroom time during the day. Many schools (both boarding and day) often struggle to prepare meals for their students as the cost per liter of water causes each meal to exceed the school's feeding budget. One school had previously prepared breakfast for its students, but the cost of water was too high so this service was discontinued. Another school would like to provide a breakfast meal to all students but does not have enough water, so can only offer breakfast only to the youngest (kindergarten) students. At one site, teachers contribute their own money to buy water for student breakfasts. Similarly, some teachers report that students occasionally find it difficult to focus when water supplies are lowest, which effects academic achievement. When water is scarce on premises, students are often asked to bring a few liters of water to school. Shortages are more acute during the dry season, and children tend to bring water for themselves more in these times. However many students report that they also do not have access to water at home, and therefore families cannot spare water for the child to bring to school. In these cases, students might leave the premises to collect water during the day, risking accidents and injury crossing nearby roads, or missing lesson time. Some schools ask parents to contribute to the funds used to purchase water, so that children do not have to cross the roads to go find water during the day. Low-income students are often especially affected, as they may not be able to afford to purchase water for drinking, and therefore depend on borehole water that is not adequate in quantity nor safe for drinking. Teachers may also leave the premises to collect water or use nearby toilet facilities, sometimes interrupting or delaying lessons. Other effects of water scarcity were also cited. One boarding school noted that student exercises are often cancelled because there is not enough water for all the students to bathe daily. At some schools repairs to aging infrastructure is could not be completed due to a lack of water for construction. The schools that have gardens on-site (with grass, flowers, and fruit) that are used for teaching purposes have trouble maintaining them in the absence of sufficient water.

Water scarcity can also impact student absenteeism, through challenges in bathing or washing uniforms (and not primarily due to water collection responsibilities as originally posited by the project logic). At boarding schools, water is also needed for bathing and washing clothes. Teaching staff who live on campus are also affected by water shortages in similar ways as students (just as in households), where bathing and washing are de-prioritized during shortages. Even outside of boarding schools, water is needed for bathing and washing uniforms, which take lower priority when households do not have adequate water. Echoing the focus group results, respondents said that while they could not be sure that water collection activities were keeping any children from school, they were confident that water scarcity at the household level meant that washing is not always prioritized, causing children to miss school if there was insufficient water to bathe or wash their uniform. Respondents also reiterated findings from the focus group discussions, reporting that in most girls are asked to help with water collection after school in most households.

Water challenges feature prominently on the list of main issues faced by schools, presenting tangible and substantial pressures on limited resources, especially among public facilities. One respondent described his view of problems faced by public schools as follows: *"If I was a big leader in this country I'd say there is no government leader with authority to take his/her children to private schools. I'd have established a policy that if you are the leader in this country, your child should study in public schools […] because, this would make children when they go back home to talk about the poor schools condition, I mean where they are studying, their [complaints] would facilitate improvement at schools. But because leaders' children are taken to private schools and sometimes schools abroad no one cares about poor conditions in our public school."* Just as in health facilities, schools struggle to finance the cost of clean water. In some locations, tanker water is the only – or the final – option, which is quite costly and may divert resources from educational opportunities. A few communities donate water to schools on a regular basis, but typically in low quantities. One respondent stated that when money is constrained in the schools, and more of it has to go to water from tankers during shortages, other priorities suffer such as the purchase of basic books; the respondent said that *"four students can share the book but when it comes to water you can't compromise."* Respondents stated that the teaching and learning environment in schools would be much improved if access to safe water supply were increased. This would decrease the schools' reliance on more expensive and lower quality sources (e.g., tankers), and serve to decrease water expenditures at schools. This would also allow schools to spend less time dealing with issues related to water shortages and focus on academic issues. One respondent summarized this as follows:

"So when you have water the health of students becomes stable, the health of school civil servant becomes stable, the health of neighboring community will be good; for example once [the school] gets sufficient water, [and] the neighboring community will get water, even the relationship between the community and the school society will be enhanced. Because when the school has water, the community will know the value of that school, they will ensure the school security, they will like the students, [compared to] the current relationship, in which students go to beg for water from the neighbors which is taken as a burden to them."

FIGURE 61. WORD CLOUD OF HEALTH FACILITY AND SCHOOL SITE VISIT INTERVIEWS

8.11 Qualitative Insights: Water Vendors

The data collection team conducted semi-structured interviews from a variety of water vendors, including tanker-truck operators, kiosk operators, push-cart vendors and other mobile vendors. The purpose of these interviews was to gather perspectives from vendors, related to the current water situation in both cities and understand how vendors – whether they rely on the public water distribution or not – expect improvements in the water supply to affect their businesses and their customers. Findings from interviews with vendors aligned with findings from other qualitative interviews.

Overall, it appears that vendors are filling a real and continued need of the populations of each city, especially considering the population growth and lack of commensurate network expansion activities, leaving much of the population in need of additional ways of gathering water. It is likely that sections of the population in each city will continue to rely on vendors for water – who provide water from the piped networks, and sometimes other sources like saline boreholes or even water from nearby rivers.

Water vendors of all types cited frequently unplanned rationing, or deviations from the expected timetable, as a consistent frustration with respect to carrying out their businesses. Not surprisingly, vendors who used water from the public distribution system had knowledge of the schedule during which they were supposed to get water from the public network, but all types of vendors mentioned rationing as an ongoing challenges. Many respondents named the days of the weeks or times that water was consistently rationed and unavailable, as demonstrated in this exchange between a kiosk operator in Dar es Salaam and an interviewer:

> *I: Normally, when is your rationing? In a week when is your rationing?*
> *R: I'm getting water on Friday, Saturday, Sunday and Monday water goes off.*
> *I: So you get water on Friday, Saturday and Sunday?*
> *R: Yes, Sunday water goes away.*
> *I: So in other weekly days you don't have water?*
> *R: Yes, no water in these days.*

Kiosks in Dar es Salaam that rely on water through the public distribution network complained about low water pressure and the frequency of rationing – in one case, jerry cans were piled up and waiting at a kiosk, until the next day when water would arrive. Others, however, explained that sometimes the publicized schedule that was distributed to customers was not accurate or that a schedule had not been made available at all. A vendor in Dar es Salaam expresses his frustration with the inaccuracy of the schedules, when asked if it is known when the water supply will be cut:

> *No, because DAWASCO cut off water, sometime they make announcement, however, they can announce that today we will cut off water and they don't cut off water…They announce completely that may be starting from 06hrs there will be a cut off but when you pass over the source at the mentioned time you see water flowing and the next day they don't cut off water up to the third day that is when cut off is happening…their information is not valid.*

Because of variability of supply, some vendors sell water from multiple sources. While some tankers said they only sold water from the public distribution network, and therefore did not do business when water was in short supply, others said they could collect water from sources such as saline boreholes, or even as one tanker mentioned in Morogoro, rivers or wells. Water unavailability and long queues also greatly affect those who depend on vendors. One tanker in Morogoro explains how his inability to get water due to a water shortage affected one of his customers trying to do business that relies on water:

> *"For example the customer I was talking with through the phone, he has several sacks of tree seeds amounting to two tones, and he has to wash them all with water, I supplied him with*

water the day before yesterday but now the water is finished. Today, he has been calling since morning ordering for water at 7.00am in the morning, it's now 1.00pm I have not yet got water, and those seeds need to be washed for a specific time, it was supposed at 10.00am to have replaced water with the fresh one and it's now 1.00 pm still he has not changed water and that's why he is telling to get out of this queue and go to fetch water from Ngerengere river for him."

Several vendors echoed the pattern of water source choice discussed at length in the focus groups, regarding the prioritization of piped water for consumption as opposed to saline water which is used for other activities, which often affected their business – e.g., kiosks with network water getting customers when non-saline water is needed, or tankers getting orders for saline water when washing was a household's priority. One kiosk owner in Dar es Salaam said: *"There are a lot of boreholes. For cooking they are looking for drinking water and that is when they come this way."*

The biggest wish that vendors expressed in terms of potential results of improvements to the water supply, are a more reliable and steady flow of water, so that they could operate a more stable business instead of having fluctuations in customers that mirror water service through the public distribution network.

Water tanker operators face a major challenge of having to spend many hours queuing waiting to fill up their tanks or drums, meaning that their customer volume per day is very low, often 3 or 4 customers or less in a day. Tanker operators report that their business faces challenges because of the large number of tankers and trucks and a limited number of water filling stations; they are therefore restrained by the amount of water they can take for filling orders per day. One tanker operator says he may feel fortunate to wait only an hour in the queue to collect water, since the wait can often be three to four hours, depending on the number of tankers and the number of orders received in a day. Larger water tankers typically supply larger customers such as hotels, businesses, embassies, and wealthier households, whereas pushcart operators typically supply individual households and small businesses. A second vendor who echoed this concern said that his working hours are typically 4 am until 7 pm due to the long waiting times. When water is not available from the public network, some tankers reported getting water from boreholes that provide saline water. One tanker from Dar es Salaam explained the variation in his own prices and the amount sold, which depend on the type of water:

> "*You can notice that I paid more for salty water but I sell at a lower price while I sell DAWASCO water at a higher price even though I bought at a lower price*," which he says is due, of course, to the greater demand for "clear" water as opposed to salty, from the public distribution network; later he says, "*There is plenty of salty water but fewer customers."*

Several tankers noted that customers may turn to another source if it takes too long for them to deliver water; one noted that there are times he may arrive to deliver an order and find that the customer has already purchased water from another source. Many tankers do not have many customers since waiting times to fill up the tank are so long; many reported having only up to about four customers per day, though most of these tankers tend to fill larger bulk orders and therefore are paid more per order than other vendors.

One tanker in Dar es Salaam, when talking about what might happen if the water flowed 24 hours per day, did not imply that he would have no business, but rather cited the expected drop in water prices:

> "*If [DAWASCO] could supply water for twenty four hours then water could be available and cheap, we could even sell for eight thousand [instead of fifteen thousand]*."

Another tanker expected that he might have more customers because he could fill his tank eight times per day from the station instead of four, also saying that what would help him serve more customers is an increase in filling stations in the city so that the line wouldn't take so long for the cars to wait idly to fill up. Tankers prefer not to sell in bucket-amounts or single drums (from cars that drive around delivering drums of water), but rather try to find customers who want to buy the whole amount that they are carrying. As one vendor, who carries three drums on his truck, relates:

> *"Also if a customer takes all of the three drums, then he/she gets a first priority [...] so the last priority is given to a customer who takes one drum, I cannot go to deliver one drum somewhere, and take the remaining two to Kimara, its wastage of fuel. Also we like a customer who is near that [filling] station so that you can deliver fast and return for another trip."*

However, one tanker in Morogoro said that when there is a lack of orders, he may go to two areas that lack infrastructure, and sell "retail" by the bucket for 200 TZS each until he has emptied his tanker. In these cases it is clear that customers who need bulk amounts of water (for which the same quantity may not be available through the piped network) and those in areas to which the infrastructure has not yet been extended, may continue to rely on various types of water vendors.

Water kiosk operators selling water from the public distribution network are almost completely dependent on the rationing schedule in order to do business, and if located in an area with household tap connections, are likely to lose business if water supply improves to household taps.[34] Further, kiosks list additional challenges such as frequent maintenance (e.g., caused by pipe leakages or meter damage), that are not often not addressed in a timely manner. Also, several kiosk operators mentioned that customers sometimes try to pay for fewer buckets than they filled up, or will use the water to wash their buckets and not pay for the water that was used to do so, or fill their containers beyond the agreed upon standard. One kiosk owner said it was not in their favor to argue too much with customers who use water from the kiosk to wash their buckets as they might just decide to shift to another vendor instead. This puts some financial strain on the kiosk operators, who sell water to customers for some of the lowest prices (sometimes as low as 15-50 shillings per bucket depending on size), and then may not recover all their costs, even though they pay a lower unit price to the utility. Like focus group respondents, kiosk operators were concerned that monthly bills are sometimes high even in months when water has not been flowing due to shortages.

Push-cart operators faced different challenges compared to tankers and kiosks, including risk of accidents with vehicles in the road, and worn out push-carts that need to be replaced. In addition, due to the physical nature of the push-cart work, the amount of water that can be transported depends on the energy of the vendor, and/or on the road conditions. For example, one vendor mentioned avoiding serving an area with hilly terrain. Push-cart vendors sell from smaller containers and must therefore also maintain the cleanliness of their containers even as they move around dusty neighborhoods. According to one interview, customers will be put off by any dirt in the water that they perceive to be coming from the vendor's containers, and then may not repeat business with that vendor. A vendor in Dar es Salaam noted that some repeat customers sometimes promise payment at a later date, on occasion leaving the vendor with less cash in hand

[34] The data collection firm had some difficulty in determining the actual number and operational status of utility-owned water kiosks in Dar es Salaam. It appears that the number of operational kiosks managed by DAWASCO has declined significantly over the last few years, and a list was not readily available from the utility, but rather was obtained only after frequent follow-up with the utility in Dar es Salaam (additional details in SI's Data Quality Report, Annex D). It seems that in neither city are water kiosks a popular idea among utility staff as they require additional management and operation costs, and the water is sold at a low tariff.

at the end of the day. Because of the nature of the work, a limited number of trips can be made to fill orders in a day. One push-cart vendor in Morogoro says he can only make a maximum of 9-10 trips per day, and even that when he is "working hard," and this figure is consistent with estimates by other vendors.

The issue of livelihoods for vendors is not always straightforward with regard to water supply. While customers tend to turn to vendors in times of water shortages from the public distribution network, thus increasing business for some vendors, vendors who depend on network water for their own businesses may also suffer a loss of business if they cannot procure any water to sell. Echoing reports from focus groups, vendors report that their customer bases fluctuate based on the availability of water from the public network. One vendor from Dar es Salaam stated that he has recently experienced a decrease in the number of customers, due to an increase in the availability of the public network water.

> *"Together with well water I think another thing is the availability of DAWASCO's water, it is not like in previous where we were staying even for two weeks without water but nowadays the water is flowing, because when it flows it helps and as it flows there it is how it flows even in other places."*

On the other hand, several vendors and tankers reported losing business or profits when water was less available or not easily accessible to them. For example, some tanker operators reported that when there was a reduction in water availability this often resulted in long queues at the filling stations/kiosks, which effectively reduced the number of trips they could make and decreased their revenue and income. One vendor from Dar es Salaam reported that when there is no water, he must turn customers away. Owners of kiosks explained that, *"During the dry season even if we don't have water we use water from the tanker, and we are doing business."* Respondents who operated tankers often reported having to travel further distances to procure water during the dry season, although this was the season during which they experienced a peak in business as during the rainy season many people harvest rainwater. They also reported that there were instances when water would not become available for days at a time, and they would not be able to serve their customers. A number interviewed vendors indicated that they relied on a network of tanker-truck drivers, to whom they could pass business (customer orders) if they were unable to fill them. So if they did not have water available, they would call one of their friends who also operated tankers, and ask that they deliver water on their behalf to one of their customers.

While respondents from both Morogoro and Dar es Salaam mentioned that the overall supply of water from the public utilities has been improving, they did acknowledge that further improvements were still needed. The inconsistency in the schedule and the infrequent availability had consequences for all water sellers that relied on the public utilities. Vendors and tank operators in both Morogoro and Dar es Salaam revealed that they are unable to work certain days of the week due to the rationing. Some made up for this by selling saline water on the days that water from the public utilities was not available, while others experienced a loss in income. One kiosk interviewed in Dar es Salaam noted that his business is diverted when there is rationing. He pointed out two saline boreholes where customers go to collect water when it is not flowing at his kiosk. In contrast, when he does have water, it may also mean that people are receiving water through their own household taps as well, implying there may not be many customers on those days.

Infrastructure weaknesses in the public distribution system were often raised by water vendors as one of the main drivers of water insufficiency through the public distribution network. Even with water supply improvements, the potential customer base is growing as

population continues to increase, but without commensurate effort and interventions to increase connections to the network or improve its structural integrity. Even assuming the ability of the network and utility to manage an expanded network, many residents are likely to depend on water vendors for considerable time to come. Consistent with other findings, the most frequently cited cause of the lack of availability was poor infrastructure. The poor state of the infrastructure resulted in the rupture of pipes, leakages, as well as low water pressure. Tankers that rely on the public utility for water cited poor infrastructure as a driver of the lack of water. As an operator of one tanker in Dar es Salaam described:

> *"…in most cases we were told that all of the pumps are damaged. It once happened in 2007, or 2008. Yes, we stayed almost one week and a half passed without selling a single drop of water…because I think there was a problem with the transformer. That period, people stayed without water for a long time and hence they used salty water."*

An operator from Morogoro echoed a similar concern:

> *"MORUWASA system needs to improve the infrastructure because town is now growing and expanding…I think to improve MORUSWASA should think and look where to distribute water and why there is a water shortage. For example areas like Kihonda..water becomes scarce as it becomes difficult water to reach up there. So they are supposed to find a pump which can push water until it reaches to all those places and increase water supply pipes in those places…They all depend on tankers."*

Population growth, as in other qualitative interviews, was also cited frequently as a reason that current infrastructure did not meet the needs of the city populations. As one respondent from Dar es Salaam stated:

> *"So think about the population of 400,000 by then compared to now, how many people have increased? But the water system is still the same even if they will find another water source to Dar, for example there is water in Rufiji, there is a big river and water is just flowing without being harvested why they don't put the water system at Rufiji and push water to Dar es Salaam?"*

One kiosk operator in Dar es Salaam reiterated this, using the situation of tankers to illustrate the situation:

> *"What I know there is water problem in Dar; this is true as everybody is complaining about this. Look about tankers, they are selling water. They are going here and there to look for water thus is because there is no water. As the city grows people are increasing and people need good water service."*

While this problem was more pronounced in Dar es Salaam, there were also locations in Morogoro where population growth negatively effecting the availability of water. Vendors in Morogoro summarized:

> *"There are many people who migrated and are still migrating to Lukobe juu and Lukobe kambi tano hence the available wells do not produce sufficient water especially in the season of drought."*

> *"The water being supplied is safe but their work performance is so low due to poor infrastructure outdated infrastructure and the rapid expansion of town compare to the past."*

Several vendors from both Dar es Salaam and Morogoro reported that they believed the utilities were trying their hardest to serve the populations of each city, despite citing the same weaknesses in management or in preventing some individuals from taking advantage of the system. However, many believe that the public utilities have done little to reach the individuals with the greatest need. An excerpt from an interview with a tank operator from Morogoro demonstrates this:

> *"On my case, on the other hand I can say they are doing well because there was a period when the quality of water was questionable and people were complaining. But after the discussion with MORUWASA in the presence of our member of parliament, currently the water quality is in a very excellent condition, in fact very excellent! But I think it's not enough and if water is not enough we cannot blame the MORUWASA people. I do not know but I think this is the responsibility of the water ministry, but I'm sure there are the ongoing efforts to solve the problem but also may be the population increase may contribute to the problem."*

One tanker in Dar es Salaam noted that they are concentrating more on follow-up of suspected water theft than on extending the network to distribute services better. Perhaps most telling was an interview with a vendor in Dar es Salaam who discussed the need for better distribution by DAWASCO:

> *R: On my side, DAWASCO are doing great to some extent. But to some extent not, they haven't extended the services well to residents.*
> *I: Haven't extended services to citizens directly?*
> *R: I mean citizens directly, this is because in this street I'm living it is just few households are producing water. So majority of the households do not get water.*
> *I: Thanks a lot, what could be improved so that they can extend the services efficiently?*
> *R: I think the problem is administration, if the administration is good everything will be ok. Because as a leader will be making follow up that residents are complaining for example you find residents striking that they are not getting water services, if our leaders [DAWASCO administrators] would have making follow up I think we wouldn't have all of these.*

Respondents echoed a theme discussed in the focus groups, comparing the abundance of electricity to the scarcity of water, with one tanker in Dar es Salaam saying: "*Electricity is in every corner; but no water.*"

Respondents from Morogoro were more likely to rate utility water as being of good quality than respondents from Dar es Salaam, though turbidity was a relatively frequent complaint in Morogoro. Others acknowledged that the quality of water from the public utilities varied. According to vendors, this affects their businesses with respect to customer satisfaction or suspicion about the quality of the water. It is possible that the inconsistency in rating of utility water quality correlates with changes in the quality related to the primary source, the delivery system, changes in the seasons, as well as the respondent's recent experiences. For example, in this exchange with a vendor in Morogoro, the interviewer explores how the quality of water, even from MORUWASA, may change with the season:

> *R: It is good but there is a period it is terrible.*
> *I: Which season? Dry or rainy season?*
> *R: Dry season, like this.*
> *I: Is it bad during dry season?*
> *R: Yeah, sometimes green water can be released.*
> *I: That is during dry season?*
> *R: Yeah, it either be black or green. Sometimes, you may take to customer water which is smelling. But you tell the customer that it is tap water released today. Or during heavy rain season. Water becomes dirty due to water sources collecting rubbish.*
> *I: In which season does it become very dirty?*
> *R: During rainy season.*
> *I: Does it become very dirty during rainy season?*
> *R: Yeah, dirty is caused by rainfall.*

A tank operator in Dar es Salaam stated:

> *"Frankly speaking, water here is not of good quality. Because, even the one from DAWASCO*

> *sometimes comes as if they are from a river-very colored. I think they have no disinfectant and if they have then it is not enough. Generally, water is of low quality but since they are from DAWASCO people tend to ignore that."*

Overall, qualitative findings suggest that despite any improvements to the water supply in Dar es Salaam and Morogoro, populations of both cities will likely continue to rely on water vendors, especially residents who cannot connect to the public distribution network, although residents who have their own taps may rely less on vendors. It is commonly assumed that increases in the volume of water available and extension of the utilities' network will result in loss of business for water vendors. The validity of this opinion is not clear, and can be examined in more detail during the end-line study. Most key informants interviewed from utilities and other policy-level organizations felt that even if the water improvements had the "unintended" effect of negatively affecting the livelihoods of water vendors in these cities, ultimately those who currently sell water could turn to sales of other goods, or transition to other jobs. When these questions were posed to vendors themselves, responses were mixed. Some vendors expressed doubt that the project would even be accomplished, based on their experiences with similar "promises" in the past without visible results. Others suggested that the project would have positive outcomes for them, with the filling stations receiving more water and allowing the vendors to make more trips per day and serve additional customers. Vendors also mentioned having other sources of income, such as selling bricks, working as a security guard, and casual labor; and tanker operators mentioned they don't carry out very much of their tanker business during rainy seasons, implying other sources of income are available. Some vendors said they knew that if the supply of tap water increased, they would lose some customers and their businesses would suffer, but many implied that if piped water supply became reliable in the city, ultimately this would be a positive outcome for the city residents.

One tanker operator in Morogoro explained:

> *"You know I'm doing this business of taking water to the customer because he has water problem. It comes a period you even feel sympathy to your customer, so if there is this possibility of bringing water such people, if he can get clean safe water close to him, to be honest to me it will not be a problem at all, I will find another means of getting money instead of water…This problem of water has broad effects, for sure if you could have happened to see the hardship people are suffering in search for water; you would have agreed with me that this is not the right business to do. For example we are selling water at eighty thousands per tanker, it's not that we want to sell at that price to make money, this is not true, sometimes there are critical situation of water scarcity."*

This sentiment was shared by a kiosk operator in Dar es Salaam, who said:

> *"That will be good, we can say don't add water because we need customers, if water flows in large volume that will be good for the users."*

8.12 Human Capital Accumulation

8.12.1 Water hauling

Table 58 shows characteristics of individuals who are responsible for water collection in both cities. On average, 75% of all water haulers are female. The vast majority, around 88%, are adults over the age of 18, and 92-93% of water haulers are not enrolled in school. The spouse of the head of household is most likely to haul water, representing approximately 40% of all water haulers, followed by the head of the household, which accounts for approximately 30%. Between 13-17% of children bear the water hauler responsibility. Table 59 presents the hauling time and volume hauled for each season. Notably, time spent hauling water in Dar es Salaam increases from 243 minutes per week in the wet season to 275 minutes per week in the dry season. The difference in time spent collecting is more pronounced in Morogoro, where the average time spent during the dry season increases to 351 minutes per week from 247 minutes in the wet season.

Figure 62, Figure 63, Figure 64, and Figure 65 show the average total weekly hauling time and volume, disaggregated by primary source of drinking water and SES quintile. It is important to note than these water source specific estimates are aggregated for all sources used by each household for every household activity, then disaggregated by the primary drinking water source, as reported by the household. Households that use another piped source for drinking report spending the most time hauling water (from all sources used, for all household activities) per week, at an average of 326 minutes per week. Households with their own tap spend an average of 133 minutes.

The poorest households spend the most time collecting water, with the time spent hauling water decreasing with SES quintile. The poorest households in Morogoro spend more time hauling water than the poorest households in Dar es Salaam. In addition, all households in Morogoro spend considerably more time per week hauling water during the dry season than in the wet season. While not conducted as part of baseline analysis, it may be beneficial while planning for end-line data collection to consider the value of household members' time spend collecting and hauling water. For the final impact analysis, this indicator could be calculated to account for the non-monetary, indirect cost to the household attributable to this activity, using data on the amount of time spent collecting and hauling water; this would require further exploration of other datasets in order to derive a value of a person's time, based on the age of the water collector for age-adjusted wage rates.

As compared to the amount of time spent hauling water above, the opposite pattern is observed for the volume of water collected. The patterns of volume collected and time spent hauling appear opposing, which may be due to the wealthier households obtaining water from tankers and not spending much time actually hauling water – i.e., the total water of volume obtained from these sources for wealthier households is not actually hauled per se.

TABLE 58: CHARACTERISTICS OF INDIVIDUALS WHO HAUL WATER

	Dar es Salaam			Morogoro		
	%	SE	95% CI	%	SE	95% CI
Gender						
Male	23%	(1.13)	[20.45, 24.91]	28%	(1.29)	[25.21, 30.26]
Female	77%	(1.13)	[75.08, 79.55]	72%	(1.29)	[69.74, 74.79]
Age group						
<5	0%			0%		
5-13	1%	(0.34)	[0.73, 2.14]	2%	(0.37)	[1.68, 3.14]
14-18	10%	(1.15)	[8.08, 12.62]	9%	(0.75)	[7.85, 10.80]
18+	89%	(1.12)	[86.23, 90.64]	88%	(0.82)	[86.77, 89.99]
Enrolled in School						
No	93%	(0.89)	[90.60, 94.118]	92%	(0.70)	[90.62, 93.38]
Yes	7%	(0.89)	[5.88, 9.40]	8%	(0.70)	[6.62, 9.38]
Relationship to HOH						
Head of household	27%	(1.32)	[24.94, 30.12]	32%	(1.26)	[29.40, 34.36]
Spouse of head of household	44%	(1.64)	[41.08, 47.52]	38%	(1.30)	[35.90, 41.00]
Child (including stepchildren)	13%	(1.02)	[11.45, 15.48]	17%	(1.09)	[15.15, 19.43]
Parent	0.1%	(0.04)	[0.01, 0.25]	0.2%	(0.12)	[0.06, 0.65]
Father-in-law/Mother-in-law				0.1%	(0.10)	[0.02, 0.74]
Brother/Sister	3%	(0.50)	[2.32, 4.33]	3%	(0.48)	[2.61, 4.54]
Brother-in-law/Sister-in-law	1%	(0.16)	[0.49, 1.12]	1%	(0.31)	[0.66, 1.95]
Grandchild	1%	(0.40)	[0.78, 2.44]	2%	(0.40)	[1.80, 3.42]
Great grandchild	0.02%	(0.02)	[0.02, 0.10]			
Uncle or Aunt	0.4%	(0.17)	[0.16, 0.94]	0.4%	(0.21)	[0.15, 1.13]
Niece or Nephew	0.3%	(0.12)	[0.12, 0.64]	0.3%	(0.14)	[0.11, 0.77]
Other relative	5%	(0.73)	[4.19, 7.08]	2%	(0.36)	[1.56, 3.00]
Friend	0.1%	(0.04)	[0.03, 0.23]	0.1%	(0.08)	[0.01, 0.53]
House girl/boy	3%	(0.57)	[2.40, 4.69]	2%	(0.42)	[1.52, 3.20]
Grandparent				0.03%	(0.03)	[0.00, 0.19]
Total	100%			100%		

TABLE 59: WATER COLLECTION TIME AND VOLUME, BY SEASON

	Dar es Salaam					
	Rainy Season			*Dry Season*		
	Mean	SE	95% CI	Mean	SE	95% CI
Time spent hauling (minutes/week)	243	(13.06)	[218, 269]	275	(13.95)	[248, 303]
Volume hauled (L/capita)	240	(11.97)	[217, 264]	277	(14.15)	[250, 305]
	Morogoro					
	Rainy Season			*Dry Season*		
	Mean	SE	95% CI	Mean	SE	95% CI
Time spent hauling (minutes/week)	247	(13.57)	[220, 274]	351	(14.98)	[322, 381]
Volume hauled (L/capita)	141	(7.58)	[126, 156]	171	(7.94)	[155, 186]

Note: Variances scaled within each stage to handle strata with a single sampling unit

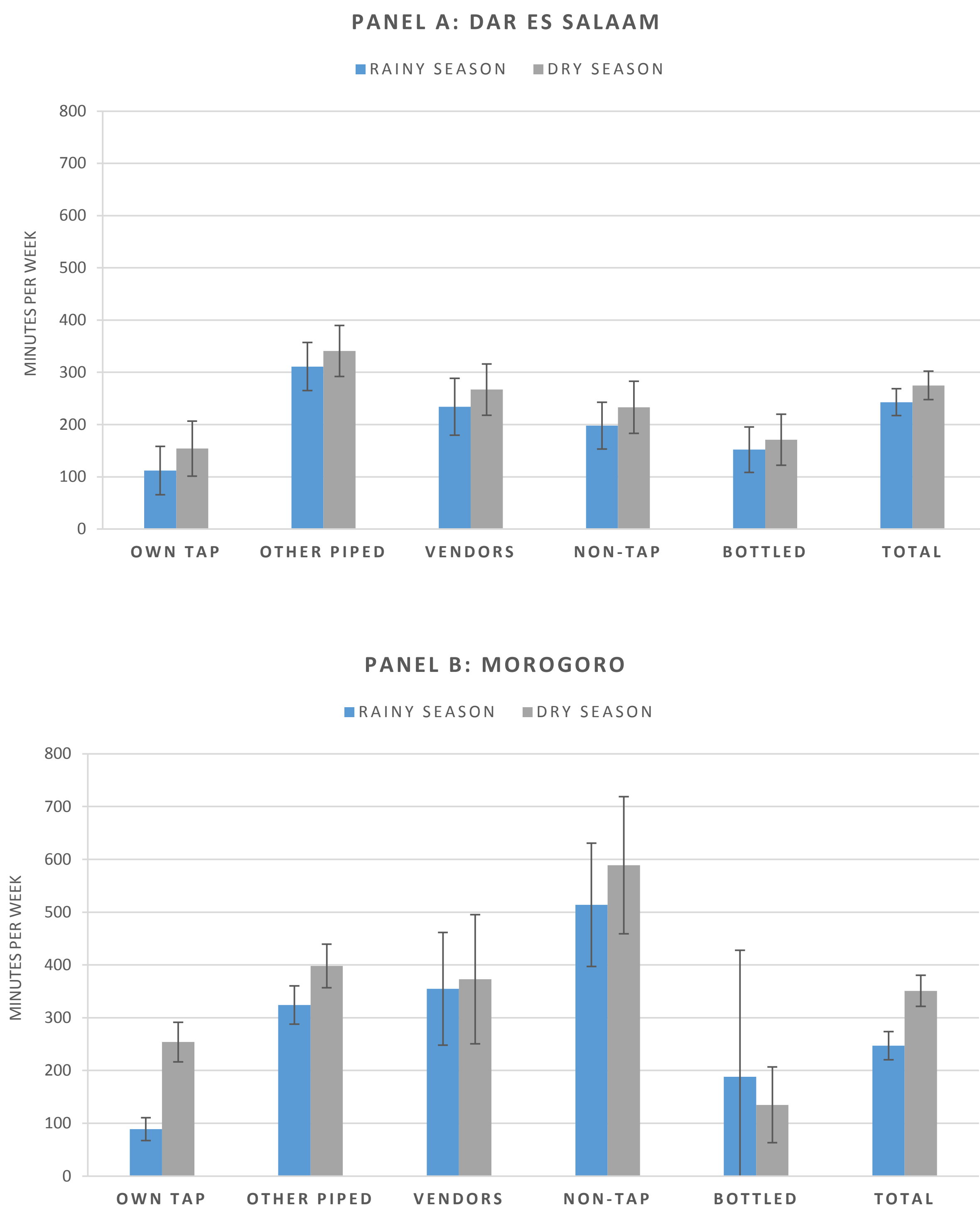


FIGURE 62: HOUSEHOLD TIME SPENT COLLECTING WATER (MINUTES PER WEEK) BY PRIMARY DRINKING WATER SOURCE

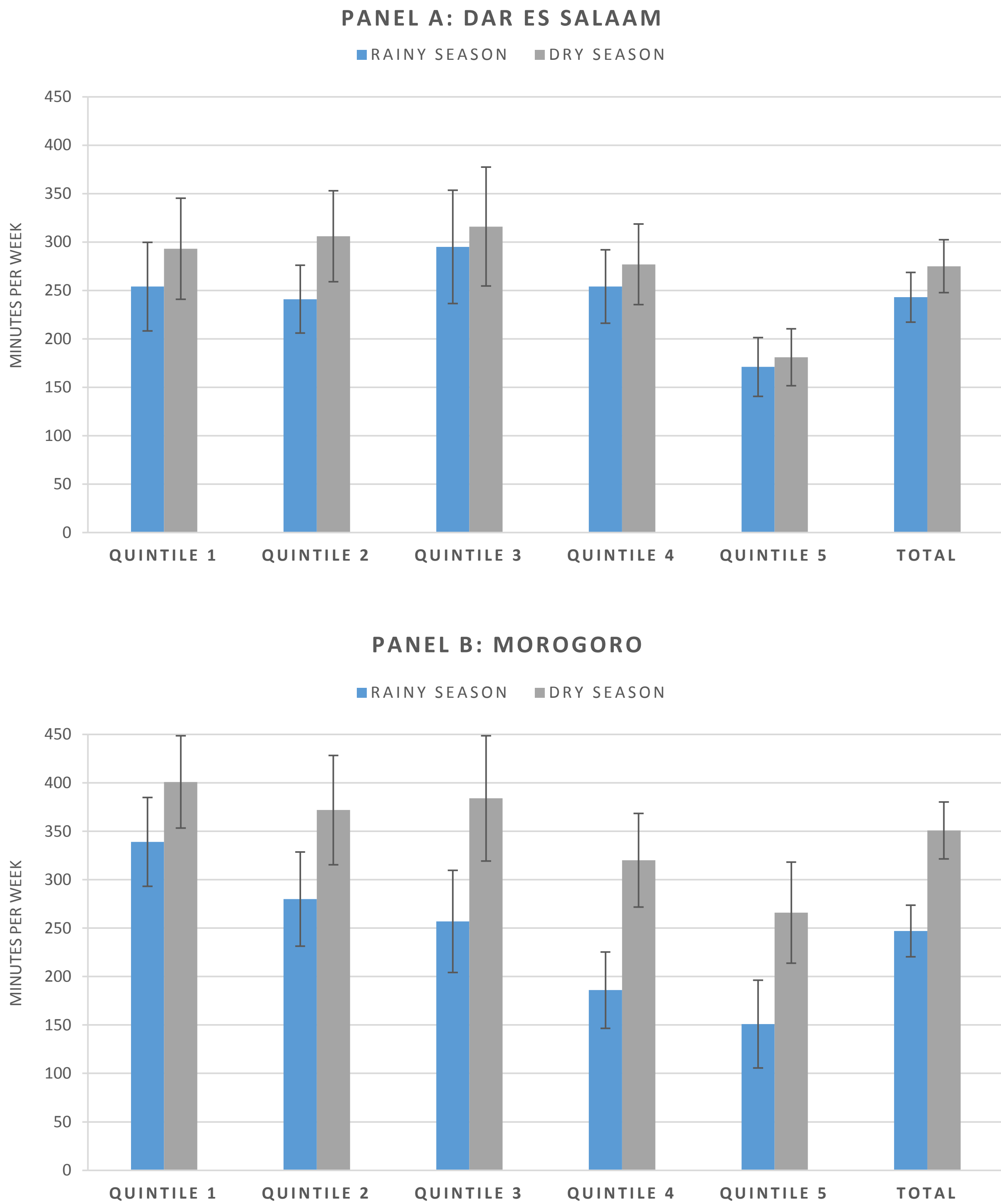
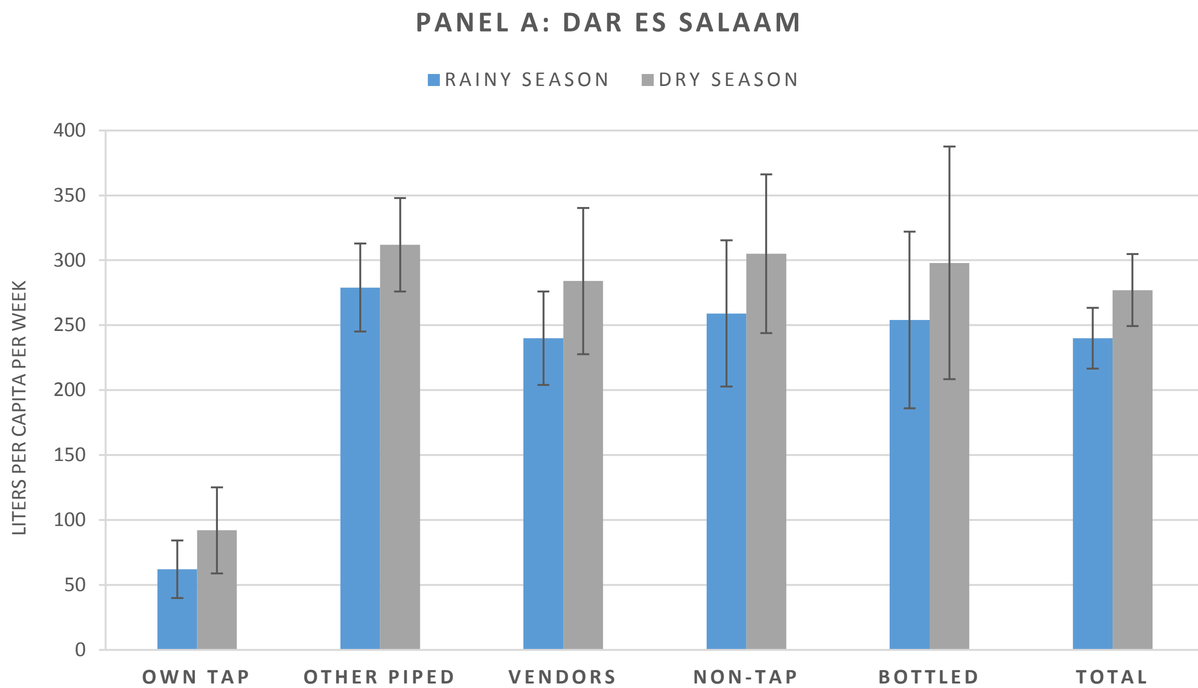


FIGURE 63: HOUSEHOLD TIME SPENT COLLECTING WATER (MINUTES PER WEEK), BY SES



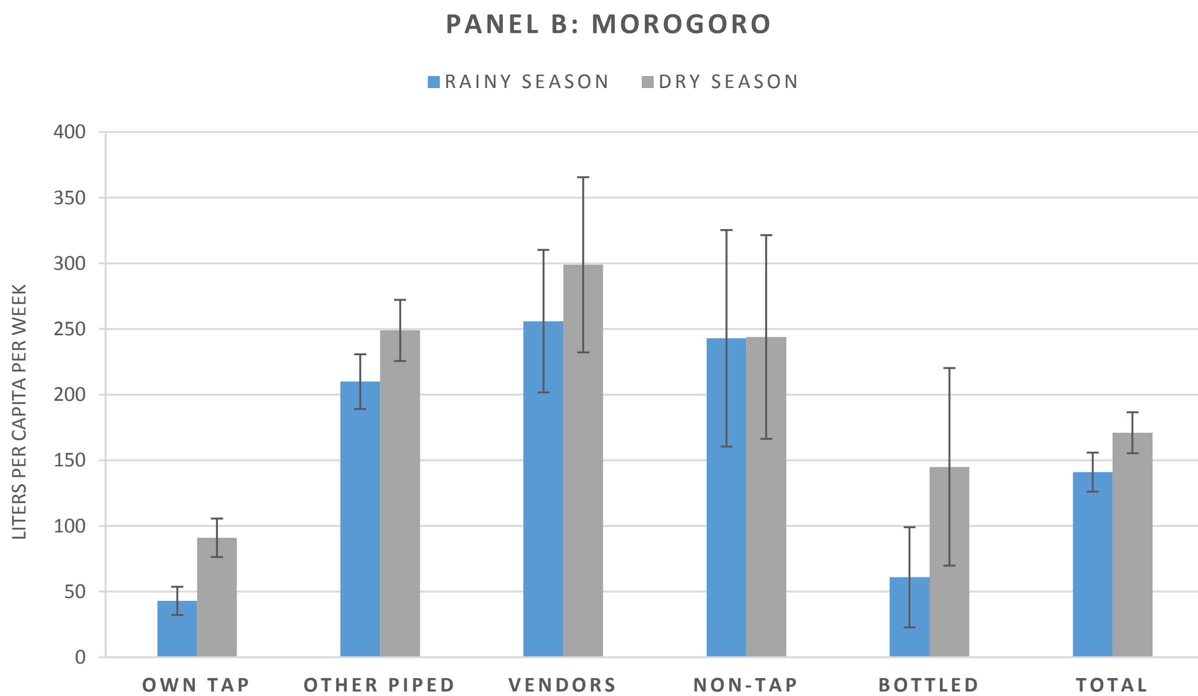


FIGURE 64: WEEKLY VOLUME OF WATER HAULED (LITERS/CAPITA), BY PRIMARY DRINKING WATER SOURCE

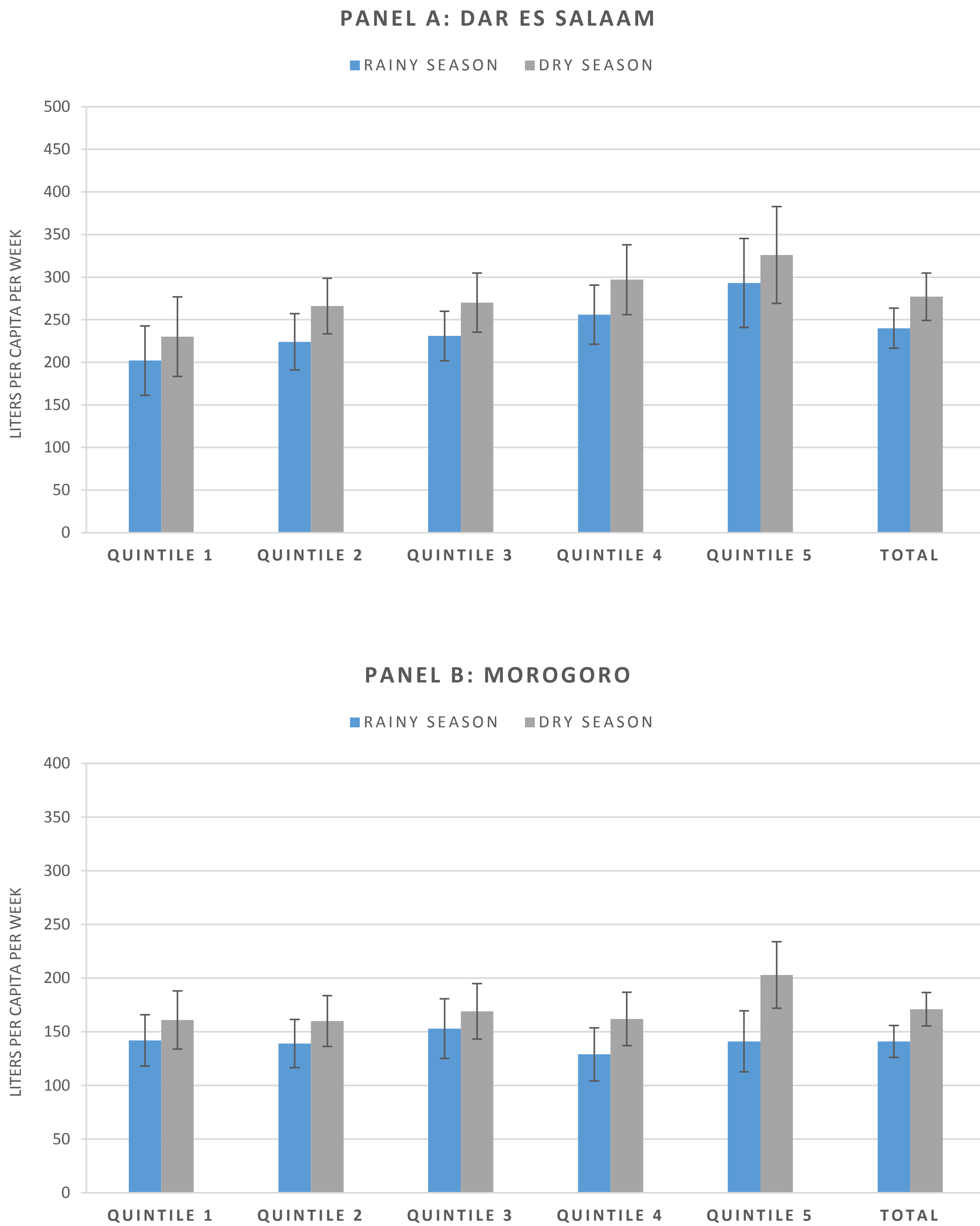


FIGURE 65: WEEKLY VOLUME OF WATER HAULED (LITERS/CAPITA), BY SES

TABLE 60: MODEL FOR PROBABILITY OF HAULING WATER, BY SEASON

	Wet Season								Dry Season							
	Restricted Model				Full Model				Restricted Model				Full Model			
	dy/dx	SE	z	Sig.	dy/dx	SE	z	Sig.	dy/dx	SE	z	Sig.	dy/dx	SE	z	Sig.
Dependency ratio	0.01	0.01	0.65		0.01	0.01	0.81		0.00	0.01	0.34		0.01	0.01	0.42	
# of girls ages 6-13	-0.01	0.01	-0.91		-0.02	0.01	-2.08	**	-0.01	0.01	-1.37		-0.02	0.01	-1.89	*
# of girls ages 14-18	-0.03	0.01	-2.39	**	-0.02	0.01	-1.55		-0.01	0.01	-1.12		0.00	0.01	-0.38	
# of adult females	0.01	0.01	0.82		0.01	0.01	1.51		0.01	0.01	0.94		0.01	0.01	1.54	
# of boys ages 6-13	0.01	0.01	0.74		0.01	0.01	0.66		0.02	0.01	1.74	*	0.02	0.01	1.81	*
# of boys ages 14-18	0.01	0.01	0.66		0.00	0.01	0.38		0.02	0.01	1.57		0.02	0.01	1.44	
# of adult females	0.01	0.01	1.47		0.00	0.01	0.59		0.01	0.01	1.52		0.01	0.01	1.07	
Adult edu. pre-primary/adult edu. only	0.08	0.05	1.46		0.09	0.05	1.89	*	0.13	0.04	2.89	***	0.12	0.04	2.88	***
Adult edu. primary or some secondary only	-0.03	0.06	-0.47		0.01	0.04	0.27		0.03	0.04	0.72		0.05	0.04	1.35	
Adult education completed secondary	-0.05	0.06	-0.88		-0.01	0.05	-0.25		0.01	0.04	0.24		0.03	0.04	0.81	
Adult education completed college	-0.07	0.06	-1.13		-0.02	0.05	-0.34		-0.01	0.04	-0.21		0.02	0.04	0.41	
Literate household head	-0.04	0.03	-1.29		-0.03	0.02	-1.41		-0.02	0.03	-0.49		-0.01	0.02	-0.36	
Household head sex	0.02	0.02	1.55		0.02	0.01	1.87		0.03	0.01	1.94	*	0.03	0.01	2.28	**
Quantity of rooms	-0.01	0.01	-1.02		-0.01	0.01	-1.01		-0.01	0.01	-1.87	*	-0.01	0.01	-1.91	*
Electrical connection	0.02	0.03	0.68		0.04	0.02	1.73		0.01	0.02	0.57		0.02	0.02	1.08	
Uses a sanitary toilet	-0.02	0.02	-1.15		0.00	0.01	0.27		-0.01	0.01	-0.73		0.00	0.01	0.05	
Home owned by residents	-0.02	0.02	-1.01		-0.01	0.01	-0.55		-0.02	0.02	-1.45		-0.02	0.01	-1.14	
Second socio-economic quintile	0.03	0.04	0.77		0.03	0.03	0.88		0.03	0.04	0.69		0.02	0.03	0.67	
Third socio-economic quintile	-0.01	0.04	-0.16		0.00	0.03	0.09		0.00	0.04	0.07		0.00	0.03	0.02	
Fourth socio-economic quintile	-0.06	0.04	-1.42		-0.04	0.03	-1.09		-0.04	0.04	-1.07		-0.03	0.03	-0.85	
Fifth socio-economic quintile	-0.07	0.04	-1.85	*	-0.04	0.03	-1.37		-0.04	0.03	-1.46		0.00	0.00	0.38	
# of households w/ piped water	0.00	0.00	0.2		0.00	0.00	-0.2		0.00	0.00	1.5		-0.01	0.01	-0.6	
Lives in Dar es Salaam	0.11	0.01	11.27	****	0.05	0.01	5.14	****	0.03	0.01	3.63	***	0.00	0.01	-0.38	
Primary source is own tap					-0.14	0.03	-4.06	****					-0.10	0.03	-3.25	***
Primary source is another piped source					0.09	0.03	2.96	***					0.04	0.02	1.73	*
Primary source is a vendor					-0.09	0.02	-4.03	****					-0.07	0.02	-3.33	***
Primary source is a bottle or bag					0.07	0.04	1.76	*					0.08	0.04	2.1	**
Pseudo R^2	0.17				0.41				0.14				0.28			
N	4,013				4,013				4,008				4,008			

Note: Significance levels calculated using p-values and are defined as: *=<.1, **<.05, ***<.01, ****<.001.

8.12.2 Determinants of water hauling

As a part of the analysis of water shortages and their impacts on household livelihoods, analysis was conducted of the determinants of whether a household reports spending time hauling water (from source of origin to the household) and how much time the household uses to haul (denominated in minutes per-person per week). Since the household survey asked about dry and wet season hauling, the analysis was conducted separately by season. Two sets of results are presented in Table 72—a *restricted* model where dummy variables reflecting source of water are not included, and a *full* model with these variables included.[35]

Households with taps in their own house or lot are less likely to haul water (14% and 10% less likely in the wet and dry season, respectively) as compared to households with surface or well water. [36] Households with taps also spend significantly less time (on average 56% less in the wet season and 30% in the dry season—see below) than those relying on well, borehole or surface water sources. Households relying on other tapped sources (neighbors, kiosks, etc.) are 8% more likely to haul water in the wet season and 3% (marginally significant) in the dry season. They also spend more time hauling water than households that rely on surface or well sources during both seasons (20% more in the wet season and 16% more in the dry season).

The presence of younger children in the household is generally not significantly associated with the probability of hauling water or of time spent hauling. The presence of teen-aged girls, however, is associated with a slightly lower probability (about 3% lower) in the wet season, but the variable is insignificant in the dry season. In the dry season, additional boys in the household are associated with slightly higher probabilities of hauling water (less than 2% increase per boy) during the dry season.

The data demonstrate that adult women largely bear the burden of hauling water, which is more pronounced in the dry season and in Dar es Salaam. Female-headed households are more likely to haul water than male-headed, but the differences are small. Female-headed households in Dar es Salaam are 6.5% more likely to haul water in the wet season compared to those in Morogoro, but this difference disappears during dry months. Households in Dar es Salaam are 11.5% more likely to haul water compared to those from Morogoro, particularly during the dry season, but the difference is mainly due to differences across the cities in water sources. When the main source of drinking water is controlled for the size and significance of the difference between the two cities disappears. Households spend time hauling water regardless of their socioeconomic status.

8.12.3 Model for time spent hauling water

The survey asked about time spent collecting water from various sources; this information was consolidated into a single variable representing the total household time in minutes per household member per week that is spent on water collection, by season. Results on time spent hauling in each season are presented in Table 61 and Table 62. As noted above, many households, particularly those with functioning water taps, do not haul water. Under these conditions, the variable time spent fetching water is censored at zero, and the *tobit* estimation technique is the most appropriate regression method.[37] It is hypothesized that per

[35] Results are presented this way since the source of water is an endogenous choice. The full model does not account for this endogeneity and parameter estimates may be biased. The restricted model does not suffer from this bias (it is a reduced form), but may be accused of missing variable bias. As noted in Annex A, a full evaluation of a structural causal model was not possible given time constraints.

[36] Marginal effects and standard errors from the *prob*it analysis are shown in table Hauling Water (probability).

[37] Some 826 households reported only using water from tap and never using another source. By definition, these households hauled no water and were excluded from the analysis. The *tobit* coefficients are not directly interpretable as marginal effects and these have to be computed at specific points. The margins discussed (as percentage change in time spent per person hauling water) are computed at data means and represent the conditional change; that is, conditional on positive water hauling time, what

capita hauling time is a function of availability of time for household members (and its opportunity cost). This is reflected by household structure, household production technology, including ownership of certain assets, and socioeconomic status. In addition, access to piped water in the immediate neighborhood and the household's main source of drinking water likely affect the time spent collecting water and eventual use.

8.12.3.1 Wet season

The initial analysis (Table 61) suggested that the hauling time decision during the wet season varies substantially by city of residence. As such, each city was analyzed separately. In both cities, household structure has important effects on time spent hauling water and the evidence points toward significant economies of scale. In general, households with more dependents, and with more children, particularly older children, spend less time per person hauling water than other households. More adults of either gender are associated with less time spent hauling per household member, and the impacts are similar across gender. There does not appear to be an undue burden on girls based on aggregate times spent hauling.[38] Household production technology, such as presence of a sanitary toilet, is associated with less time spent hauling water in both cities. Once other factors are held constant, education and socioeconomic status are only weakly associated with differences in hauling times. The only significant deviation was among households in Morogoro in the fifth socio-economic quintile, which implies that these households spend 26% less time per person hauling water than those from the lower quintiles.

The main difference across the cities is the effect of access to piped water sources in the survey enumeration area. One would expect access to piped water to lower time spent hauling water (although the probit analysis showed it had no significant relationship to *whether* the household hauled water or not), since more access to piped water in the area will likely increase the availability of water supplies and lower time spent per capita carrying it. In Morogoro, this variable has a highly significant negative coefficient, which demonstrates that each additional piped water source is associated with a reduction in hauling time of 12 minutes per person per week. In contrast, in Dar es Salaam, there was a small, but insignificant, positive value. The mechanics of water hauling are likely to be significantly between each city, and should be further investigated.

Part of the difference in the relationship between time spent hauling and availability of piped sources in the neighborhood is explained by differences in sources of water by city. When comparing variables that represent the main sources of drinking water in the regression, most of the results remain qualitatively similar, but for households in Dar es Salaam, the relationship is negative, but insignificant. In Morogoro, the relationship becomes smaller but the sign and significance remain unchanged. As expected, access to piped water in the household or in the lot is associated with far less time being spent hauling water in both cities, with the magnitude of the effect being much larger in Morogoro. In Dar es Salaam, households that receive water from a piped source not on their property spend more time per person hauling water in the wet season at 26% more time per person, while those in Morogoro from spend less time, although the difference is not statistically significant.

8.12.3.2 Dry season

Hauling and time spent hauling water is greater in the dry season as many sources of water become less regularly available. The determinants of time spent hauling water per person in the dry season are similar to those in the wet season (Table 62).

is the percentage change in time spent hauling associated with a one unit change in the independent variable?

[38] Further analysis is needed of the *individuals* involved in hauling water. This information is also available from the survey instrument.

The variables reflecting household structure show substantial economies of scale in water hauling, that is utilizing additional household members from different age groups to help haul water, are associated with lower average times spent hauling water per person.

The relationship between socioeconomic status and hauling time is similar across the cities. However, households from the 3rd quintile have a significantly different time spent hauling water than those households from the lowest quintile, and they spend about 20% more time. This pattern is similar to that found in the wet season and clearly needs further investigation.

As in the wet season, the presence of increased piped supply in the household's neighborhood has a small positive impact on time spent hauling in Dar es Salaam, but a strong negative impact in Morogoro. When the main source of household drinking water is controlled for, the effect disappears in Dar es Salaam, but remains in Morogoro. The regressions that control for main source of drinking water clearly demonstrate that piped access in the household or the lot substantially lowers time spent collecting water. In both cities, households with piped water in the dwelling or lot, spend about 35% less time per person collecting water. Public provision of more piped water will likely provide more time to households.

Households receiving their main source of drinking water from another piped source spend about 16% more time per person collecting water compared in Dar es Salaam, but the difference in time spent is negative, but insignificant, in Morogoro.

TABLE 61: MODEL FOR DETERMINANTS OF TIME SPENT HAULING WATER, WET SEASON

	Full Sample				Dar es Salaam				Morogoro			
	Coef.	SE	t	Sig.	Coef.	SE	t	Sig.	Coef.	SE	t	Sig.
Dependency ratio	-21.12	6.34	-3.33	***	-21.67	6.93	-3.13	***	-20.09	6.30	-3.19	***
# of girls ages 6-13	-3.34	4.16	-0.8		-3.44	4.50	-0.77		-0.13	4.71	-0.03	
# of girls ages 14-18	-28.19	5.82	-4.84	****	-28.49	6.16	-4.63	****	-17.83	6.90	-2.59	**
# of adult females	-15.26	3.70	-4.13	****	-15.06	3.91	-3.85	****	-19.28	5.42	-3.56	****
# of boys ages 6-13	-4.01	3.89	-1.03		-3.86	4.15	-0.93		-4.29	5.71	-0.75	
# of boys ages 14-18	-11.74	4.71	-2.49	**	-11.53	5.03	-2.29	**	-10.85	5.63	-1.93	*
# of adult males	-14.73	3.42	-4.31	****	-13.94	3.60	-3.87	****	-25.67	5.36	-4.79	****
Most educated female has pre-primary or some secondary	11.11	28.58	0.39		13.24	30.65	0.43		-40.36	41.56	-0.97	
Most educated female has primary or some secondary	20.63	28.77	0.72		26.32	31.58	0.83		-81.99	38.42	-2.13	**
Most educated female completed secondary or some college	14.08	32.06	0.44		19.62	35.11	0.56		-82.65	39.78	-2.08	**
Most educated female completed college	5.32	32.21	0.17		10.24	35.12	0.29		-73.71	44.69	-1.65	*
Literate household head	-6.08	25.42	-0.24		-6.12	28.62	-0.21		-4.93	13.00	-0.38	
Household head gender	18.66	9.11	2.05	**	20.41	9.78	2.09	**	-6.50	10.22	-0.64	
Number of rooms	0.52	3.66	0.14		-0.73	3.92	-0.19		13.27	5.62	2.36	**
Electrical connection	6.77	8.08	0.84		8.94	8.44	1.06		-28.45	11.23	-2.53	**
Uses a sanitary toilet	-21.81	6.66	-3.27	***	-20.54	7.00	-2.94	***	-31.98	10.95	-2.92	***
Home owned by residents	9.10	9.65	0.94		9.86	10.38	0.95		-5.63	9.95	-0.57	
Second socio-economic quintile	1.61	10.36	0.16		1.15	10.94	0.11		-0.58	10.01	-0.06	
Third socio-economic quintile	19.57	12.02	1.63		20.10	12.73	1.58		6.24	12.72	0.49	
Fourth socio-economic quintile	3.76	12.63	0.3		4.09	13.30	0.31		-15.69	15.51	-1.01	
Fifth socio-economic quintile	-2.42	13.54	-0.18		-1.01	14.27	-0.07		-37.76	16.51	-2.29	**
Number of households w/piped water	1.01	0.95	1.07		1.45	0.98	1.48		-12.46	1.63	-7.64	****
Lives in Dar es Salaam	20.36	6.60	3.09	***								
Intercept	70.78	22.75	3.11	***	81.61	22.48	3.63	****	297.91	45.16	6.6	****
N	4,013				2,268				1,745			

Note: Dependent variable is time (in minutes per household member per week)

TABLE 62: MODEL FOR DETERMINANTS OF TIME SPENT HAULING WATER, DRY SEASON

	Full Sample				Dar es Salaam				Morogoro			
	Coef.	SE	t	Sig.	Coef.	SE	t	Sig.	Coef.	SE	t	Sig.
Dependency ratio	-25.21	6.51	-3.87	****	-24.82	7.15	-3.47	***	-32.07	6.17	-5.2	****
# of girls ages 6-13	-4.90	4.21	-1.16		-5.30	4.59	-1.15		1.13	4.57	0.25	
# of girls ages 14-18	-20.20	5.54	-3.65	****	-20.27	5.93	-3.42	***	-17.95	5.83	-3.08	***
# of adult females	-16.36	3.76	-4.35	****	-15.99	3.98	-4.02	****	-24.33	5.01	-4.85	****
# of boys ages 6-13	-2.88	3.99	-0.72		-2.49	4.30	-0.58		-7.79	5.19	-1.5	
# of boys ages 14-18	-10.53	4.72	-2.23	**	-9.36	5.06	-1.85	*	-24.70	5.14	-4.8	****
# of adult males	-15.84	3.48	-4.55	****	-15.22	3.71	-4.1	****	-23.19	4.63	-5.01	****
Most educated female has pre-primary or some secondary	10.63	31.62	0.34		13.03	33.93	0.38		-44.68	46.88	-0.95	
Most educated female has primary or some secondary	8.78	29.80	0.29		14.24	32.61	0.44		-80.59	42.37	-1.9	*
Most educated female completed secondary or some college	2.44	32.65	0.07		7.24	35.61	0.2		-75.30	43.56	-1.73	*
Most educated female completed college	-4.87	32.94	-0.15		0.76	35.84	0.02		-92.11	45.88	-2.01	**
Literate household head	-2.03	24.75	-0.08		-2.83	27.76	-0.1		-1.30	13.45	-0.1	
Household head sex	25.22	9.67	2.61	***	27.27	10.39	2.62	***	4.04	9.26	0.44	
Quantity of rooms	-1.23	3.80	-0.32		-2.21	4.11	-0.54		10.25	5.07	2.02	**
Electricity in the home	5.30	8.34	0.64		5.11	8.76	0.58		2.04	11.35	0.18	
Uses a sanitary toilet	-15.09	7.10	-2.12	**	-14.97	7.47	-2		-13.53	9.77	-1.38	
Home owned by residents	6.68	9.76	0.68		8.03	10.49	0.77		-17.70	10.37	-1.71	*
Second socio-economic quintile	3.13	10.69	0.29		2.51	11.34	0.22		8.53	10.04	0.85	
Third socio-economic quintile	28.86	12.64	2.28	**	28.73	13.44	2.14	**	34.94	13.56	2.58	**
Fourth socio-economic quintile	12.80	12.65	1.01		13.53	13.41	1.01		-2.13	14.22	-0.15	
Fifth socio-economic quintile	18.80	13.39	1.4		19.95	14.25	1.4		5.02	15.61	0.32	
Quantity of households w/ piped water	0.13	1.49	0.09		0.44	1.55	0.28		-6.71	2.02	-3.33	***
Lives in Dar es Salaam	-38.51	15.66	-2.46	**	-43.78	17.30	-2.53	**	-52.49	22.42	-2.34	**
Intercept	22.12	11.38	1.94	*	21.92	11.78	1.86		-22.76	19.97	-1.14	
N	4,013				2,268				1,745			

Note: Dependent variable is time (in minutes per household member per week)

8.12.4 Absenteeism among school children

An additional pathway through which water sector investments are expected to manifest impact is through increased attendance in school. This increase is expected to come mainly from the supply side—through reduced illness days and more time available due to less time spent hauling water. Table 63 shows school enrollment of the population by age. In both cities, slightly higher percentages of girl children ages 5-13 are enrolled compared to boys. However, that trend reverses distinctly in the next age group. In Morogoro, in the age group 14-18, the average enrollment is 60%, but is split 54% of females and 67% of males. In Dar es Salaam, the average 62% figure is the result of 72% of males and 54% of females. Ages 18 and above, the percentages are much closer again with males slightly higher. This calls particular attention to the challenges in keeping girls in school after age 13, which appears to be a breaking point in enrollment rates. A gender breakdown is shown in Figure 66. In Dar es Salaam, 5% of children aged 6 through 18 reportedly missed any school in the last 4 weeks, compared to 14% in Morogoro; these are absenteeism reports for any reasons, not just directly related to hauling water. It was difficult to ascertain strong trends related to water-related absenteeism from the baseline data. In Dar es Salaam, 1% of females 6-18 missed school or were late to school as a direct result of their duties to carry water, compared to only 0.4% of boys. In Morogoro, 1% of females 6-18 missed school or were late to school due to duties to carry water, compared to 2.6% of boys. Of the children who did miss school or were late due to duties to collect water, 53% of them in Dar es Salaam were female, while 52% of them in Morogoro were female. Overall, only about 1-2% of children in the household ages 5-18 were delegated water collection duties. In each city, half of the household members who missed or were late to school due to water-collection duties were between the ages of 5 and 13. A small fraction of children 6-18 collect water for cash or in-kind payment: 0.1% and 3% of children in Dar es Salaam and Morogoro. The lack of evidence to support the hypothesis that water collection induces absenteeism or tardiness to school is corroborated by qualitative findings, presented in Section 8.8. Diarrheal illness-induced absenteeism was not assessed in depth in this baseline report, but examined descriptively (Figure 67). A substantial fraction of children (30 to 60%) report absenteeism due to diarrheal illness in the last 14 days, but the uncertainty bounds are very large; qualitative findings did not provide much evidence in support of a large burden of diarrheal illness on school absenteeism. One limitation of this indicator is the differences in reporting periods for questions related to school absences. Specifically, in the household member roster, school absences were measured for children ages 6-18, and for each of those children, respondents were asked the total number of full and partial days missed from school in the last 20 schooling days. In the diarrheal illness module, respondents were also asked whether the given individual missed any days of school due to diarrheal illness. The reference period for total absence days is last 20 schooling days, while the diarrheal illness reference period is the last 14 days. While the selection of these time periods facilitated the recall for the respondent (these also represent standard, validated recall periods used in other surveys), it is more difficult to compare the answers to these questions directly since both the reason for the school absence and the time period are varying. There may also be some under-reporting of absences, which is likely to be associated positively with the age of a child. This is because older children are less likely to inform parents or guardians about absences from school, and adults tend to know more about the activities and attendance of younger children.

TABLE 63: SCHOOL ENROLLMENT RATES, LAST 4 SCHOOLING WEEKS, BY AGE

Age	Dar es Salaam			Morogoro		
	%	SE	95% CI	%	SE	95% CI
5-13	92%	(1.1)	[90, 94]	93%	(0.7)	[92, 95]
14-18	62%	(3.6)	[54, 68]	60%	(1.6)	[57, 63]
18+	5%	(0.5)	[4, 6]	6%	(0.4)	[5, 6]
Total	28%	(0.6)	[27, 29]	31%	(0.6)	[30, 32]

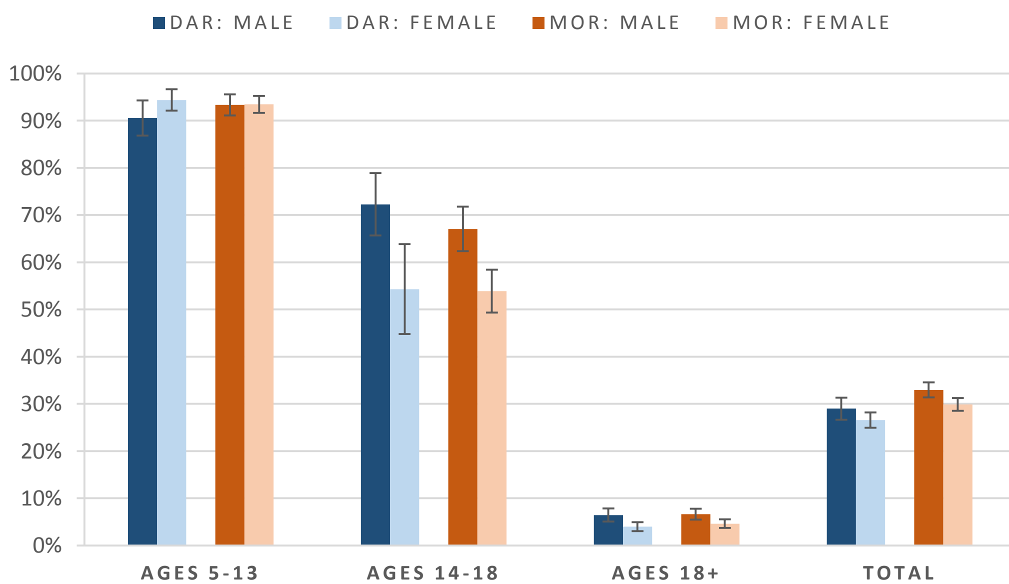
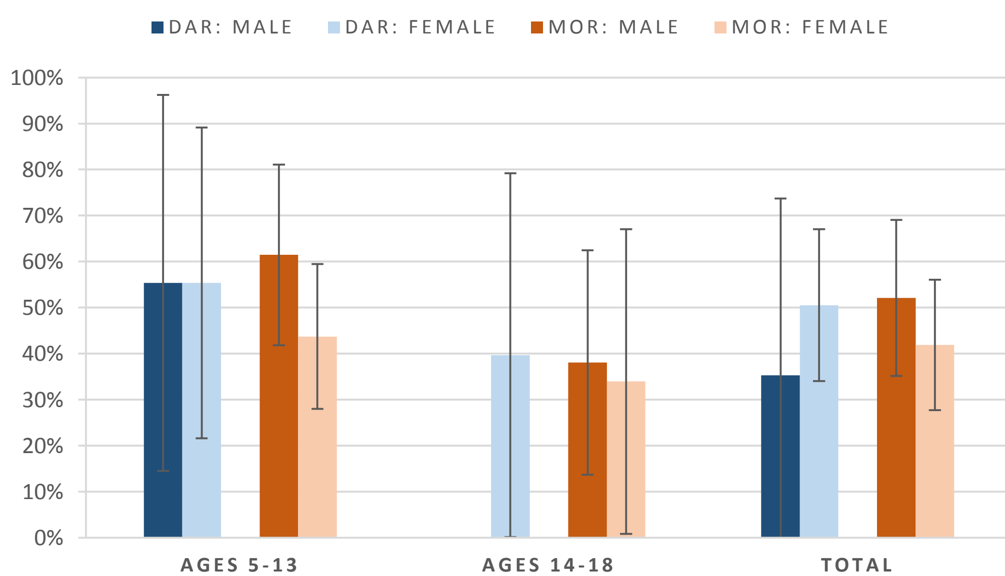


FIGURE 66: ENROLLMENT IN SCHOOL, LAST 4 SCHOOLING WEEKS, BY AGE AND GENDER



Note: The category of males 14-18 in Dar was omitted due to too few observation(s).

FIGURE 67: ABSENTEEISM DUE TO DIARRHEAL ILLNESS LAST 2 WEEKS, BY AGE AND GENDER

8.12.5 Model for absenteeism

The analysis of project impacts on schoolchildren begins with a simple model of determinants of participation in school (for children aged 6 up to age 18, the primary school-going age). Table 64 presents the result of this first step. The dependent variable is 1 if the child attends school, 0 otherwise. Since this is a limited dependent variable model, marginal effects are presented. These represent the change in the probability of attending school given a one-unit change in the independent variable.

Holding all other factors constant, school attendance is sensitive to age and gender of the child.[39] School attendance increases with age until around 9 years, beyond which the likelihood of attending falls as the student ages.[40] Boys are less likely to attend school than are girls up to 11 years.[41] Beyond 11 years, the likelihood of a male attending school exceeds that of females and grows with age. Children of the household head are 14% and 12% more likely, in Dar es Salaam and Morogoro, respectively, to attend school than other children in the household.

Household structure has subtle effects on school participation and these effects vary by city of residence. In Morogoro, more dependents are associated with an *increased* probability of attending school, but each additional infant (child) lowers the probability of being enrolled by about 3% (1%). Additional adults in the household have a weak effect on school attendance in both cities as the only statistically significant adult effect is found for additional females in Dar es Salaam (an additional female adult raises the likelihood of a child attending school by less than 3 percentage points). Interestingly, levels of education of adult household members and the literacy status of the head of the household have only minor and statistically insignificant impacts on the probability of attending school. Children in households whose best-educated adult has college education are statistically no more likely to attend school than those from households whose best-educated head has no formal education.

The socioeconomic status of the household, whether reflected by number of rooms in the household, ownership of the house, or the asset index quintile variables, is not significantly associated with school attendance in Dar es Salaam, but is important in Morogoro. Children from upper-quintile households (of asset ownership) in Morogoro are 7-11% more likely to attend school than those from the lowest quintile (the reference category). Home ownership status also has a small (4 percentage point change in likelihood) but significant association with school attendance in Morogoro.

From the perspective of the water investment, the econometric analysis found no evidence that better access to water would directly affect school participation in Dar es Salaam, but a relatively small, but statistically significant impact was found in Morogoro. Holding all other factors constant, households in Morogoro neighborhoods with more piped tap sources are more likely (at a rate of about one percentage point per tapped connection, up to a maximum of eight) to send their age-eligible children to school. To the degree that this variable can be considered to be exogenously determined, this finding provides evidence that in Morogoro increased spread of piped water access will increase school attendance.

Besides its impact on attendance, water supply can affect school absences through morbidity and other effects. An analysis was conducted on the determinants of absences, conditional on school

[39] The models shown in the tables presented are the models chosen after following numerous specification tests. It allows the determinants of school participation to vary by city of residence and includes, among other factors, indicators of household education and household socioeconomic status. Differences between Dar es Salaam and Morogoro are mainly seen in the socioeconomic status variables.

[40] Taking the derivative of the probability with respect to age—inclusion of the age-squared term allows for this non-linearity.

[41] Combining the *male* coefficient with the interaction of the coefficient with age.

enrollment for the same group of children as included in the enrollment analysis, in order to determine whether access to water and reliability of this access are associated with absenteeism. The survey asked whether enrolled students had been absent from school in any of the prior 20 school days and, if so, for how many days.

The main correlate of school absenteeism is whether or not the person has had diarrhea in the past two weeks. The marginal effect estimate shows that a child with diarrhea is absent 230% more time compared to a child without diarrhea. This finding was robust to model specifications. Due to endogeneity concerns, the relationship of diarrhea to absenteeism cannot be considered to be causal and more investigation of this relationship is needed. Notably, however, once diarrhea is controlled for, very few of the other variables are significantly related to absentee status. The number of female adults is associated with significantly fewer absentee days and students in Dar es Salaam present less absenteeism compared to those from Morogoro. Even when the presence of diarrhea was excluded from the regression, the water supply variables were not significantly related to absenteeism.[42] Notably, none of the water supply variables considered in the other analyses was not statistically significantly related to absenteeism.

TABLE 64: MODEL FOR DETERMINANTS OF SCHOOL ABSENTEEISM

Conditional on school enrollment	Dar es Salaam				Morogoro			
	Coef.	SE	t-stat	Sig.	Coef.	SE	t-stat	Sig.
DIARRHEA	8.50	1.54	5.52	****				
Age	0.63	0.81	0.78		0.73	0.84	0.88	
Age-squared	-0.02	0.03	-0.67		-0.03	0.04	-0.80	
Male	0.60	2.55	0.24		0.85	2.53	0.34	
Male age	0.02	0.21	0.11		0.03	0.21	0.13	
Child	-0.30	0.95	-0.32		-0.43	0.97	-0.44	
Dependency ratio	-0.54	0.63	-0.86		-0.37	0.61	-0.61	
Number of infants	0.71	0.56	1.27		0.45	0.58	0.78	
Number of kids	-0.68	0.46	-1.49		-0.62	0.45	-1.39	
Number of adult females	-2.17	0.55	-3.91	****	-2.26	0.56	-4.05	****
Number of adult males	-0.22	0.49	-0.46		-0.21	0.49	-0.42	
Most educated female has primary or some secondary	0.91	1.66	0.55		0.15	1.95	0.08	
Most educated female completed secondary or some college	0.53	1.74	0.30		-0.42	2.01	-0.21	
Most educated female completed college	2.87	1.98	1.45		1.80	2.21	0.81	
Literate household head	-0.75	1.32	-0.57		-1.18	1.40	-0.84	
Household head sex	-0.01	0.94	-0.01		-0.09	0.96	-0.09	
Number of rooms	0.28	0.43	0.65		0.38	0.43	0.88	
Home owned by residents	-1.67	0.82	-2.02	**	-2.20	0.85	-2.58	***
Second SES quintile	1.03	1.15	0.90		0.48	1.18	0.40	
Third SES quintile	-0.19	1.13	-0.17		-0.45	1.15	-0.39	
Fourth SES quintile	-0.62	1.15	-0.54		-1.02	1.20	-0.85	
Fifth SES quintile	-2.22	1.37	-1.62		-2.61	1.40	-1.86	*
Number of households w/ piped water	0.10	0.27	0.37		0.06	0.28	0.20	
Piped water	-1.72	1.82	-0.94		-1.67	1.85	-0.90	
Lives in Dar es Salaam	-4.82	0.69	-6.97	****	-5.43	0.72	-7.56	****
N	4,607				4,679			

Note: Dependent variable=Number of days absent in past 20 school days.

[42] Additional regressions were estimated including water sources separately, with diarrhea excluded, and allowing for different effects by city. In none of these cases was the water supply variable significantly associated with absenteeism. The variable indicating any tap connection among surveyed households within the EA was also not significant in any of the regressions.

TABLE 65: MODEL FOR SCHOOL ATTENDANCE AMONG GIRLS AGES 6-18

	Dar es Salaam				Morogoro			
	Coef.	**SE**	**z**	**Coef.**	**SE**	**SE**	**Coef.**	**SE**
Age	0.123	0.020	6.07	****	0.109	0.013	8.38	****
Age-squared	-0.006	0.001	-8.16	****	-0.006	0.001	-11.63	****
Male head of household	-0.200	0.078	-2.55	**	-0.121	0.046	-2.61	***
Male age	0.018	0.006	3.13	***	0.012	0.003	3.4	***
Child head of household	0.138	0.019	7.21	****	0.122	0.014	8.51	****
Dependency ratio	0.022	0.026	0.84		0.022	0.012	1.91	*
Number of under 5 in household	-0.055	0.017	-3.26	***	-0.028	0.008	-3.29	***
Number of 5-15 year olds in household	-0.004	0.009	-0.39		-0.013	0.007	-1.89	*
Quantity of adult females	0.026	0.013	2	**	0.009	0.008	1.17	
Quantity of adult males	0.005	0.011	0.42		0.007	0.009	0.73	
Adult education pre-primary or adult education only	-0.059	0.153	-0.38		0.029	0.078	0.37	
Adult education primary or some secondary only	0.022	0.146	0.15		0.062	0.070	0.88	
Adult education completed secondary	0.052	0.147	0.35		0.094	0.072	1.31	
Adult education completed college	0.018	0.150	0.12		0.057	0.076	0.75	
Literate household head	0.094	0.065	1.45		0.028	0.028	0.99	
Household head sex	0.001	0.027	0.04		0.022	0.018	1.2	
Quantity of rooms	-0.011	0.010	-1.04		0.009	0.007	1.31	
Home owned by residents	0.028	0.027	1.05		0.044	0.017	2.66	***
Second SES quintile	0.057	0.039	1.46		0.054	0.022	2.53	**
Third SES quintile	0.013	0.037	0.34		0.092	0.023	3.91	****
Fourth SES quintile	0.013	0.035	0.38		0.110	0.025	4.48	****
Fifth SES quintile	0.063	0.038	1.68	*	0.070	0.025	2.75	***
Count of surveyed households in EA with access to piped water	0.000	0.003	-0.01		0.010	0.000	3.78	****
Pseudo R^2	0.291				0.280			
N	2,649				3,207			

Note: Significance levels calculated using p-values and are defined as: *=<.1, **<.05, ***<.01, ****<.001.

Caregiving for children with diarrheal illness shows the summary statistics for the relationship between children's illness on caretakers, presenting the average number of days missed by adult members of household of their normal activities in order to take care of a sick child under 5, in the last 14 days. These results were calculated using data from the main baseline phase and calculated on a per-child in the household basis, to account for the fact that the number of children will theoretically be related to the number of days of child sickness. Therefore, it is important to keep in mind that the numbers presented are lower than might be expected for an individual sick child. Overall, the quantity of caregiving for sick children is higher in Morogoro than in Dar es Salaam. The most striking results from the summary table are the high caregiving days among households in Dar es Salaam with a "flush to elsewhere" sanitation facility and similarly in Morogoro with "no facilities"; these trends seemingly reflect what may be expected generally in terms of the incidence of diarrheal illness among children. However, this is not a strong or consistent trend, relative to the expected quality of sanitation facilities, in either city. Additional analysis at end-line will likely combine this data with diarrheal illness and other labor force participation data to shed greater light on the nuance that likely drives the inconsistent trends observed in the summary data.

TABLE 66: CAREGIVING DAYS PER CHILD <5, LAST 14 DAYS

Days per child<5 among households with children <5	Dar es Salaam			Morogoro		
	Mean	SE	95% CI	Mean	SE	95% CI
Primary drinking water source						
Own tap	0.11	(0.05)	[0.02, 0.20]	0.33	(0.05)	[0.23, 0.44]
Other piped	0.195	(0.05)	[0.10, 0.29]	0.346	(0.06)	[0.22, 0.47]
Vendors	0.078	(0.03)	[0.02, 0.14]	0.381	(0.16)	[0.07, 0.69]
Non-Tap	0.103	(0.05)	[0.00, 0.20]	0.304	(0.14)	[0.04, 0.57]
Bottled	0.236	(0.19)	[-0.14, 0.62]			
Sanitation facility						
Flush toilet (sewer/septic tank/pit latrine)	0.137	(0.03)	[0.07, 0.20]	0.356	(0.05)	[0.25, 0.46]
Pit latrine (VIP or with slab)	0.127	(0.04)	[0.06, 0.20]	0.319	(0.06)	[0.20, 0.43]
Flush to elsewhere	0.826	(0.87)	[-0.89, 2.54]	0.111	(0.12)	[-0.12, 0.34]
Open pit latrine	0.235	(0.21)	[-0.18, 0.65]	0.24	(0.22)	[-0.20, 0.68]
No facilities				0.625	(0.34)	[-0.04, 1.28]
SES quintile						
1	0.12	(0.05)	[0.03, 0.22]	0.322	(0.07)	[0.19, 0.45]
2	0.16	(0.06)	[0.05, 0.27]	0.356	(0.07)	[0.22, 0.50]
3	0.173	(0.05)	[0.07, 0.28]	0.277	(0.09)	[0.11, 0.45]
4	0.109	(0.04)	[0.03, 0.19]	0.300	(0.08)	[0.15, 0.45]
5	0.073	(0.06)	[-0.04, 0.19]	0.569	(0.20)	[0.18, 0.96]
Total	0.138	(0.03)	[0.09, 0.19]	0.338	(0.04)	[0.26, 0.41]

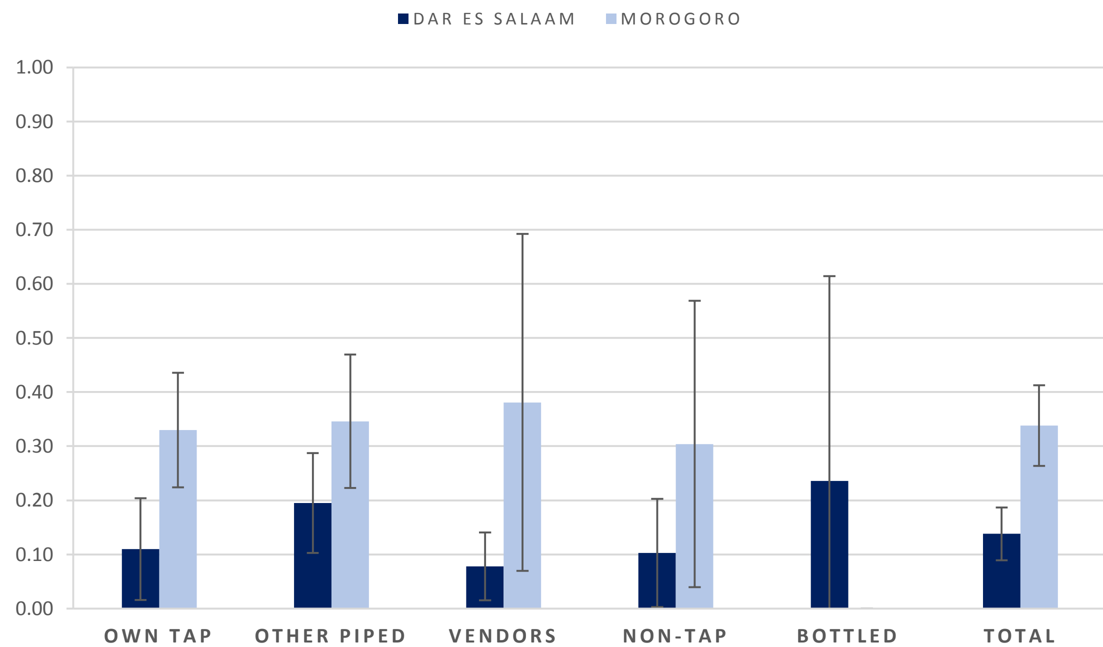


FIGURE 68: CAREGIVING DAYS PER CHILD <5, LAST 14 DAYS, BY PRIMARY DRINKING WATER SOURCE

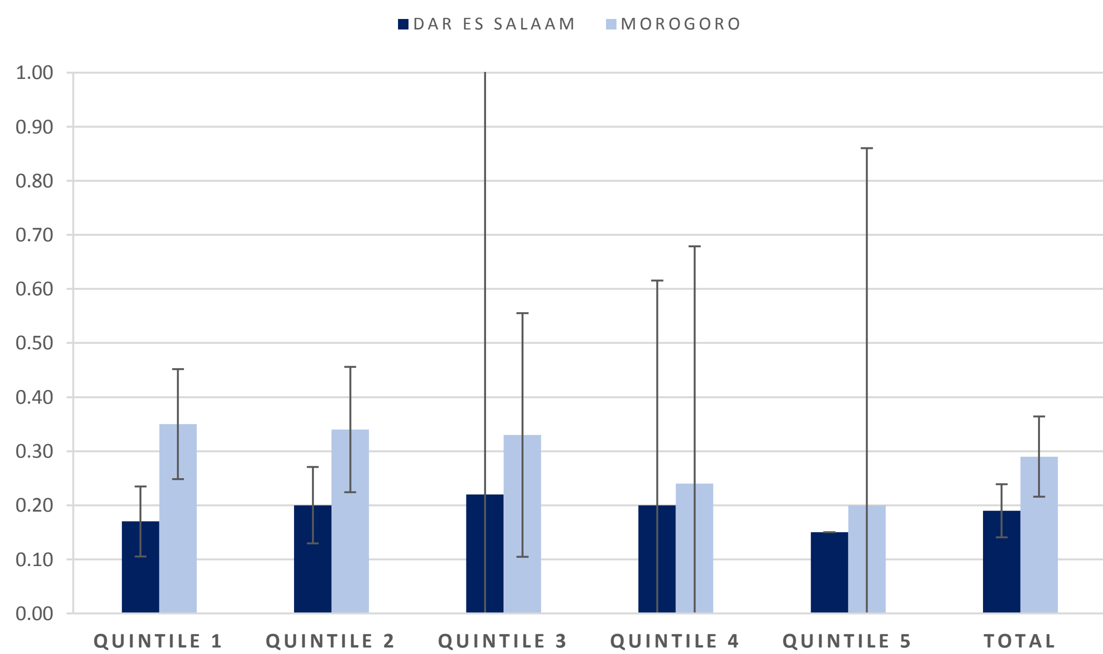


FIGURE 69: CAREGIVING DAYS PER CHILD <5 IN HOUSEHOLD, LAST 14 DAYS, BY SES

8.12.6 Hours worked last week

Another outcome included within the human capital accumulation objective is the hours worked in the last week. Normalizing this measure by the number of productive-age adults in the household, we calculated the average number of hours worked per adult in the household last week, and disaggregated this outcome by consumption expenditure quintile. The number of average hours worked (conditional on working) is similar in Dar es Salaam and Morogoro among those who reported any work (formal, self, secondary, or in the home,)[43] with an average of 56 hours per adult worker in the household (see Table 90). However, it is also important to look at the average hours worked last week among all able-bodied adults, as this indicator will be more sensitive to the type of changes in employment over time that is posited as part of this project logic (shifts from unemployment to employment will lead to increases in this indicator). These results are presented in Figure 70 and Figure 71, and in more detail in Table 91. No discernable patterns emerge by primary drinking water source or for socioeconomic status.

8.13 Investment and Economic Activities

The value of household assets is included in the MCC project logic, as described in earlier sections, under the assumption that freed-up labor may results in increased investment in household or commercial assets. The latter was not addressed by our data collection, but we report the summary of average current value of household asset by city and SES quintiles. Assets used to calculate this value are the same as those described in earlier sections used to calculate quintiles of wealth based on durable assets; the only exceptions are the exclusion of *bajaj* (rickshaw), generator, and washing machine, as prices were not available for those items from the Household Budget Survey (HBS). In addition, our survey collected one variable for the quantity of motorcycles and mopeds, while the HBS had separate prices for each; the average of these two HBS prices was used as the value of motorcycles and mopeds among the households in our sample. Table 67 contains the summary of average current value of household assets per capita, in Tanzanian shillings (TZS), and disaggregates by consumption expenditure quintile. The trend observed is in the expected direction, where households of higher quintiles have larger asset values per capita.[44]

[43] For formal or self-employed work hours, questions in the survey about "typical hours" allowed us to correct for work-hours in the week preceding the survey that were not representative of an individual's typical work week. The "typical hours" question was not asked with regard to working in the home, and therefore corrections for potential atypical schedules in the past week for this category of work were not made.

[44] With respect to the items that were measured in terms of quantity, but not included for lack of a corresponding price, one concern might be that the excluded assets might correspond to specific types of households – i.e. if poorer households tends to own bajaj, then excluding this asset is removing value from the lower quintiles. However, during the principal components analysis, the factor scores for all of these assets were positive, meaning that ownership would increase the wealth ranking of the household, dispelling this concern.

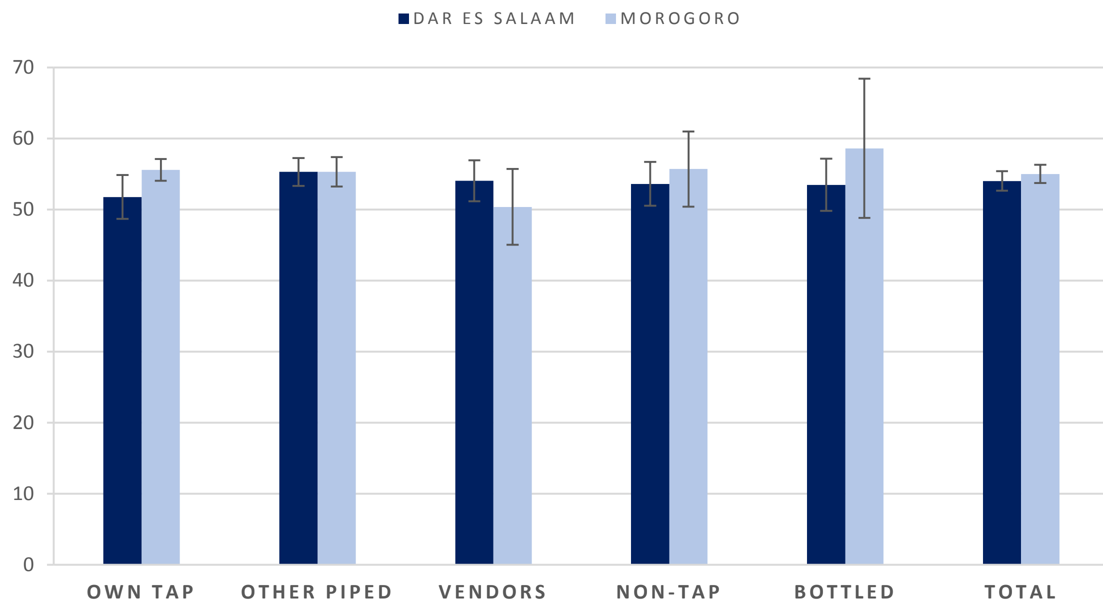


FIGURE 70: HOURS WORKED LAST WEEK PER ABLE ADULT, BY PRIMARY DRINKING WATER SOURCE

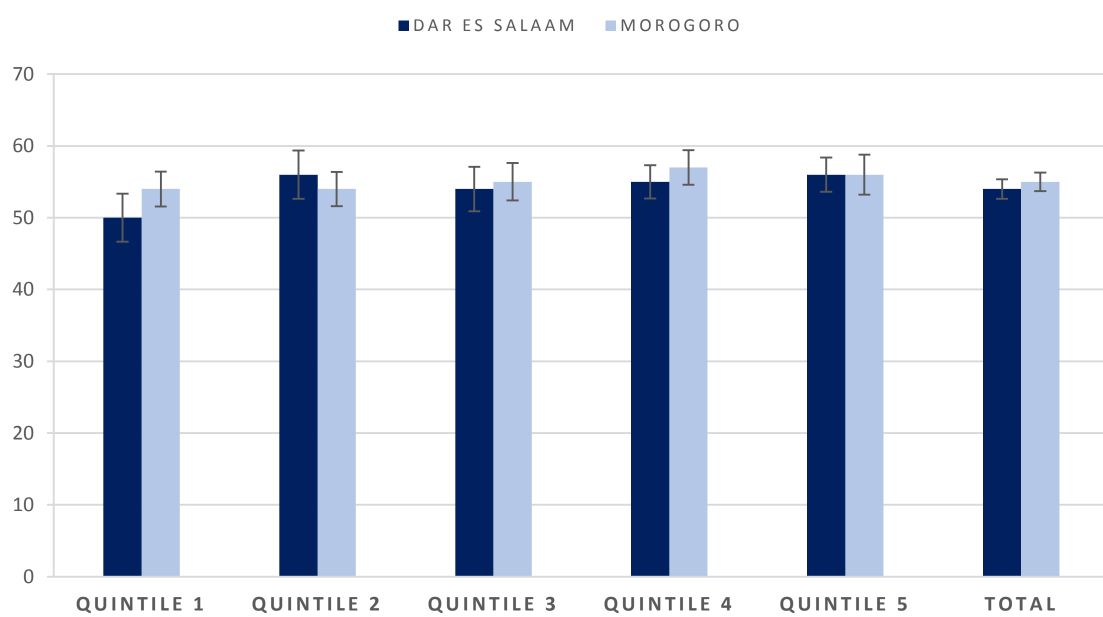


FIGURE 71: HOURS WORKED LAST WEEK PER ABLE ADULT, BY SES

TABLE 67: AVERAGE CURRENT VALUE OF HOUSEHOLD ASSETS PER CAPITA (TZS), BY SES

	Dar es Salaam		
	Mean	**SE**	**95% CI**
Dar es Salaam			
SES quintile 1	126,175	(20,342)	[86,228, 166,122]
SES quintile 2	292,424	(64,520)	[165,719, 419,128]
SES quintile 3	299,219	(30,644)	[239,039, 359,397]
SES quintile 4	702,521	(116,448)	[473,841, 931,201]
SES quintile 5	1,565,986	(285,697)	[1,004,935, 2,127,036]
Total	597,083	(75,953)	[447,926, 746,239]
Morogoro			
SES quintile 1	116,635	(15,196)	[86793, 146,478]
SES quintile 2	182,539	(15,780)	[151551, 213,527]
SES quintile 3	320,047	(50,909)	[220,072, 420,022]
SES quintile 4	438,726	(39,418)	[361,318, 516,134]
SES quintile 5	1,245,185	(106,525)	[1,035,992, 1,454,378]
Total	460,416	(28,962)	[403,542, 517,291]

One caveat with interpretation of self-reported asset registers is the potential for under-reporting of household durable assets. For example, systematic under-reporting of assets has occasionally been documented in cases where respondents suspect their level of wealth may be used to qualify them for a particular social program. In addition, the value applied to assets will not take account of the age and condition of the asset, which is a weakness in the assumption of equal value. This is likely to understate asset values of wealthier households and overstate asset values of the less wealthy as the former are more likely to own higher-quality assets.

8.14 Water Security

8.14.1 Water shocks

Figure 72 and Figure 73 display the characteristics of households who viewed water shocks as one of the top three shocks they have experienced in the last two years, disaggregated by primary drinking water source and socioeconomic status. There were considerable differences between the two cities and by the primary water source of the household. In Dar es Salaam, those obtaining water from other piped sources were most likely to report water shocks as a top three shock in the last 2 years (34%). In Morogoro, those obtaining drinking water primarily from other piped sources were most likely to report water shocks (45%). The largest difference between the two cities was among households primarily using non-tap sources: 40% of Morogoro households in this category stated that a water shock was one of the top three shocks in the last two years, and 8% of those in Dar es Salaam.

The experience of water shocks varied across SES quintiles, with 41% of the poorest households in Morogoro reporting that a water shock qualifies as one of the largest shocks. However, water shocks remained a concern for relatively wealth households as well, as 33% of households in the wealthiest quintile in Morogoro considered water shocks in the top three shocks. There was less variation among households in Dar es Salaam. In the cumulative Dar es Salaam respondent sample, 24% of households cited water shocks as one of the top three shocks.

Table 68 shows the percentage of the population that regarded a water shock as the top shock their household has experienced in the last two years, again disaggregated by source and SES quintile. In general, Morogoro residents are more likely to report water shocks in these categories, as are those who do not have access to their own tap as a primary source of drinking water. The relationship across SES quintiles is not consistent between cities.

Figure 74 presents the percentage of respondents reporting to worry about adequate water supply, disaggregated by primary source of drinking water and SES quintile. The survey question used to elicit these responses was: *"In the last 30 days, have you worried that there was not adequate water supply for the household?"* The percentage of respondents reporting 'yes' varied widely between Dar es Salaam and Morogoro among households what collect water from a non-tap source. In Dar es Salaam, four percent of these households reported worry about having an adequate water supply, compared to 42% of households in Morogoro. Similarly, those relying primarily on vendors in Morogoro were likely to worry (44%). Morogoro demonstrated the most variation across the SES categories: 35% of households in the poorest quintile of households report worrying about an adequate water supply, compared to 20% of households in the highest SES quintile (detailed data table can be found in the Appendix, Table 92.

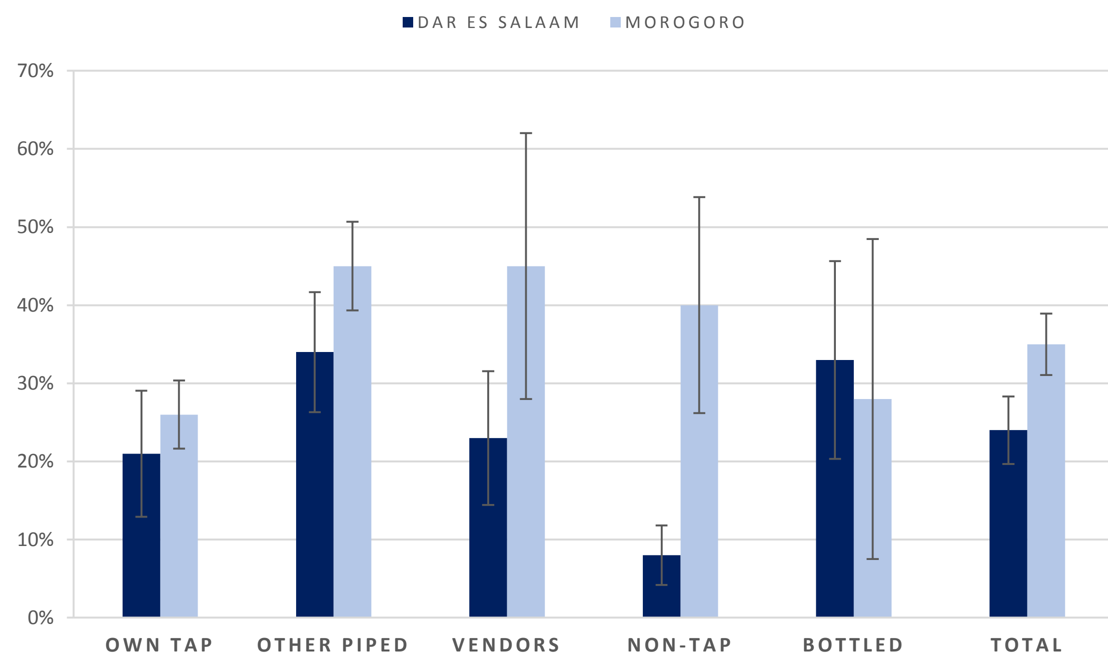


FIGURE 72: SEVERE WATER SHOCK AMONG TOP 3 ECONOMIC SHOCKS, LAST 2 YEARS, BY PRIMARY DRINKING WATER SOURCE

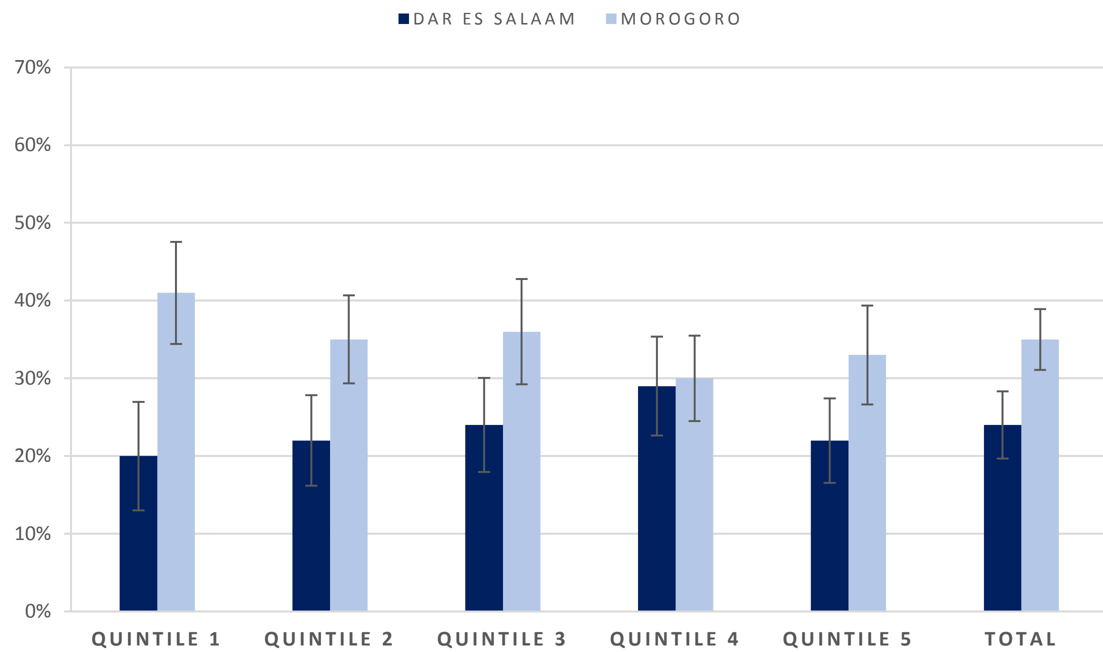


FIGURE 73: SEVERE WATER SHOCK AMONG TOP 3 ECONOMIC SHOCKS, LAST 2 YEARS, BY SES

TABLE 68: SEVERE WATER SHOCK AS TOP ECONOMIC SHOCK, BY PRIMARY DRINKING WATER SOURCE AND SES

	Dar es Salaam			Morogoro		
(Last 2 years)	**%**	**SE**	**95% CI**	**%**	**SE**	**95% CI**
Primary source of drinking water						
Own tap	9%	(2.66)	[5.29, 16.07]	13%	(1.74)	[10.29, 17.15]
Other piped	14%	(2.00)	[10.80, 18.72]	25%	(2.29)	[21.02, 30.04]
Vendors	16%	(3.17)	[10.67, 23.23]	27%	(6.46)	[15.95, 41.04]
Non-Tap	4%	(1.31)	[2.39, 7.80]	16%	(3.97)	[9.76, 25.54]
Bottled	23%	(4.96)	[14.61, 34.07]	4%	(3.11)	[0.97, 16.63]
SES quintiles						
1	8%	(1.87)	[4.71, 12.25]	20%	(2.51)	[15.39, 25.28]
2	11%	(1.95)	[7.70, 15.45]	16%	(1.95)	[11.99, 19.69]
3	13%	(2.09)	[9.55, 17.83]	22%	(2.91)	[17.21, 28.66]
4	16%	(2.03)	[11.90, 19.92]	18%	(2.33)	[13.55, 22.71]
5	12%	(1.93)	[8.57, 16.22]	17%	(2.50)	[12.86, 22.72]
Total	12%	(1.23)	[9.62, 14.46]	19%	(1.48)	[15.80, 21.62]

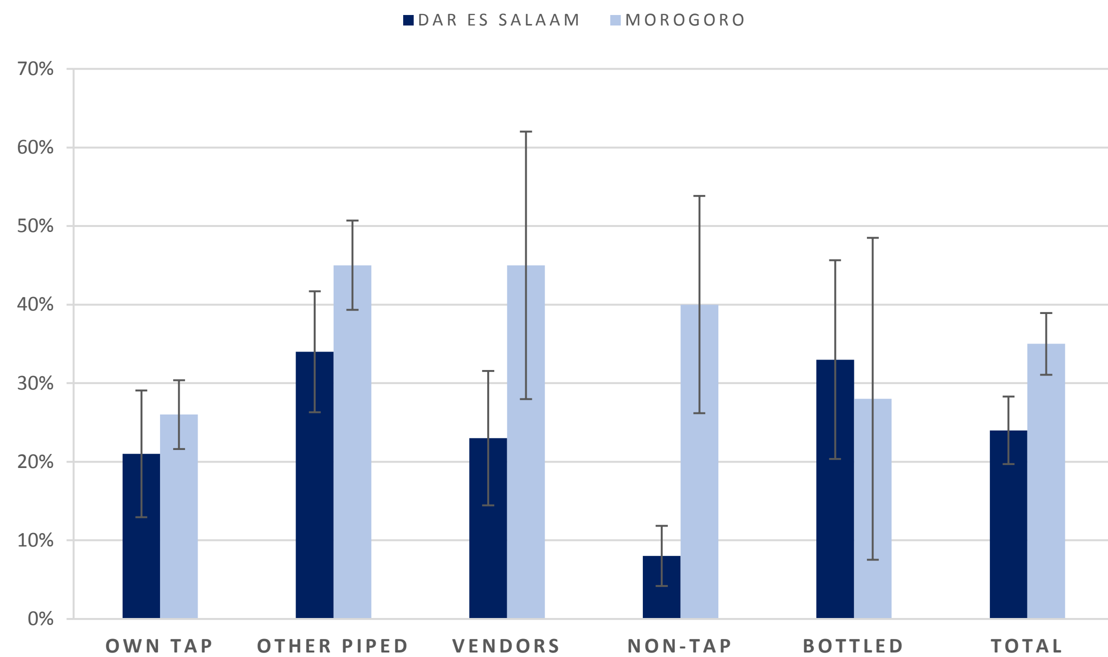


FIGURE 74: WORRIED ABOUT ADEQUATE WATER SUPPLY, LAST 30 DAYS, BY PRIMARY DRINKING WATER SOURCE

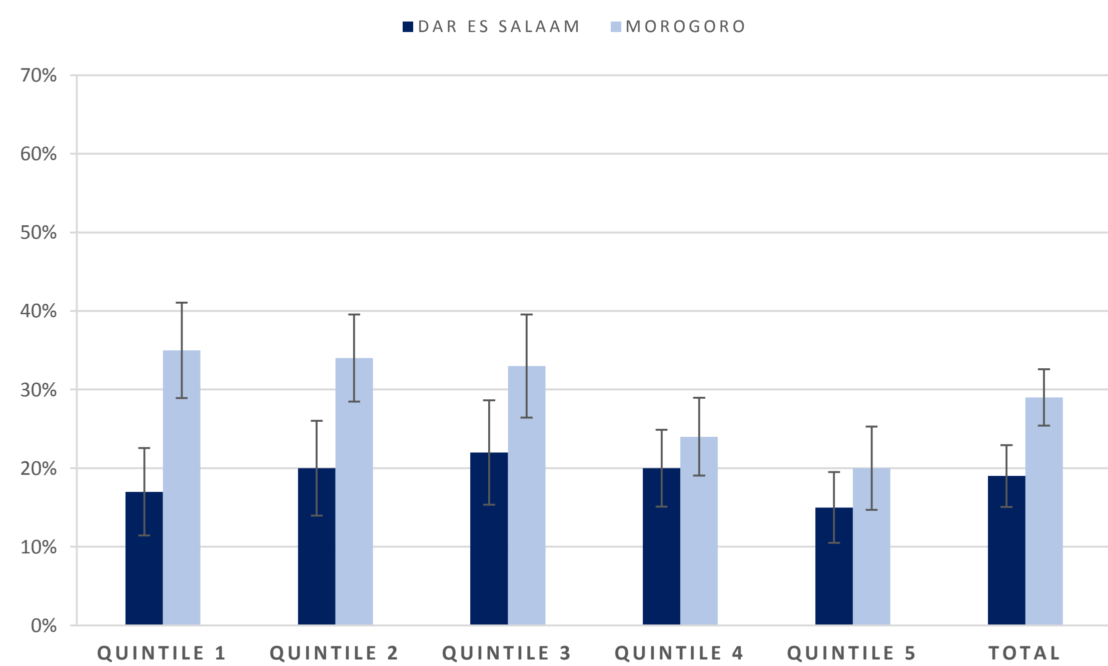


FIGURE 75: WORRIED ABOUT ADEQUATE WATER SUPPLY, LAST 30 DAYS, BY SES

8.14.2 Water shocks and modeled impacts

An acknowledged benefit of access to piped water is that it increases water security. Better security has both instrumental and intrinsic benefits to the household. When water sources become more secure, households can devote fewer resources to "insurance-like" behavior such as storage facilities, carrying containers, and time spent looking for alternative sources of water in the event of a drought or other water-related shock. An obvious intrinsic benefit is the reduced psychic costs borne due to uncertainty about supply sources. The household survey asked a battery of questions about severe shocks experienced by the household in the past two years and, in particular, asked the household to rank these shocks by severity. Using this information, households are classified as water insecure according to two criteria: (i) they rank a water shock among the top three of the shock experiences (*moderately* water insecure); and (ii) they ranked the water shock as the top, or most important, shock they experienced (*severely* water insecure).

The goal of the water shock analysis is to examine the determinants of water insecurity and understand how changes in access to piped water and the reliability of its supply affect water insecurity. The main hypotheses being examined are: (i) more access to piped water decreases water insecurity; and (ii) more reliable piped water sources decreases water insecurity for those households relying on piped water as their main source of drinking water (Table 69). This analysis provides no evidence that access to piped water supplies in the immediate neighborhood is associated with reduced water insecurity. In fact, the probability that a household reports the water shock among the top three shocks it faces increases with the number of taps in the enumeration area.[45] Similar regressions were run including access to piped water as an independent variable and it was not found to be significantly associated with water security. Socio-economic status, adult education and most household structure variables are also not significantly related to water insecurity[46]. The presence of more males in the household is associated with a reduction in water insecurity, but the gender of the head is not related to household water insecurity. Water security is less of an issue in Dar es Salaam as households there are 8% less likely to report being moderately water insecure than households in Morogoro.

The initial regression analysis, thus, does not show a strong association between access to piped water sources and water security. Subsequently, the analysis focused on shortages. As noted elsewhere in this report, those households with piped water into the dwelling or plot responded systematically differently to the queries about shortages than those who rely on other sources of piped water. As a result, the analysis of the relationship between the severity of supply disruptions[47] and water security outcomes is conducted separately for these two groups of households.

Results clearly show that water shortages are significantly associated with water insecurity for households who rely on piped water sources (Table 70). For those households who receive piped water in their dwelling or lot, frequent or lengthy shortages are associated with a 15% higher probability that water shocks rank as the most severe shock they faced and a 22% higher probability that they rank among the top-three shocks (not shown). Households with other piped sources are similar: exposure to frequently or lengthy system-related shortages is associated with a 16% increase in severe water insecurity and a 22% increase in moderate insecurity.

[45] The top 1 shock is not significantly associated with access to piped water.
[46] Separate regressions (not shown) by city of residence were conducted and differences across the cities were not important. Additional regressions were estimated with the full battery of adult education dummy variables included and these also presented similar results and are not shown here.

[47] The *SUPPLY_DAYS* variable is a categorical variable ranging from 0 (no water available through piped system during week) to 8 (water available 24/7). This variable was divided into three indicator variables: *short1* (*SUPPLY_DAYS*<3), *short2* (*SUPPLY_DAYS* = 4, 5, 6) and *short3* (*SUPPLY_DAYS*>=7). The *short3* group, those households with most reliable piped water supplies, was used as the reference group.

Interestingly, once the exposure to shortages is controlled for, socioeconomic status is positively associated with water insecurity for households with piped water in their dwelling or lot.

8.14.2.1 Matching Analysis

To confirm the relationship between access to piped water and supply regularity and water insecurity, an additional analysis was conducted using matching and other treatment effect techniques. These results, which do not rely on the parametric restrictions associated with the regression model, differed slightly from the regression results.[48] When household access to piped water was considered to be the treatment, its impact on moderate water insecurity was consistently negative for the three estimators, with estimates of impact between 4% and 6%. It was, however, significant only for the inverse probability weight (IPW) estimator.

When the treatment was considered to be water shortages, results were consistent with the findings presented above. For households with access in the dwelling or plot, those reporting frequent shortage were 28% more likely to suffer from moderate water insecurity compared to those with the most reliable source of water. For households whose main drinking water comes from other piped sources, the measured effect is a 23% increase in water insecurity. In both cases, the estimated impact was highly significant.

The analysis reveals a weak association between access to piped water and water insecurity, but a strong and highly significant association between service reliability and water insecurity. The latter effect was measured for all households whose main source of drinking water was a piped source, and the measured effects are similar across methods. These findings point to a highly plausible potential positive outcome of the water investments—increases in household perceptions of water security. These improvements are likely to have both instrumental and intrinsic effects.

[48] Alternative estimators used included regression adjustment (RA), inverse probability weight (IPW), and the augmented inverse probability weight (AIPW) methods. Alternative treatment and outcome functional forms were employed. Covariates were similar in each case and included the full battery of variables reflecting household structure and other characteristics, and socioeconomic status.

TABLE 69: MODEL FOR REPORTING WATER SHOCK AS MOST SEVERE OR TOP 3 MOST SEVERE

Among top 3 shocks, last 2 years	Top 3 Severe Shocks (last 2 years)				Most Severe Shock (last 2 years)			
	ME	SE	z	Sig.	ME	SE	z	Sig.
Dependency ratio	-0.02	0.02	-1.07		0.00	0.01	-0.19	
Number of boys ages 6-13	0.02	0.02	1.38		0.02	0.01	1.58	
Number of girls ages 14-18	-0.02	0.02	-1.03		-0.01	0.01	-1.10	
Number of adult females	0.01	0.01	1.00		0.00	0.01	-0.33	
Number of boys ages 6-13	0.01	0.02	0.84		-0.01	0.01	-0.51	
Number of boys ages 14-18	-0.04	0.02	-1.92	*	-0.03	0.01	-1.93	*
Number of adult males	-0.03	0.01	-2.68	***	-0.02	0.01	-2.06	**
Literate household head	0.04	0.05	0.81		0.03	0.04	0.66	
Household head sex	-0.03	0.03	-1.10		0.00	0.02	-0.08	
Number of rooms	0.04	0.01	3.33	***	0.02	0.01	2.43	**
Electricity in the home	0.09	0.02	3.75	****	0.05	0.02	2.60	***
Uses a sanitary toilet	-0.11	0.02	-5.85	****	-0.05	0.01	-3.48	***
Home owned by residents	-0.03	0.02	-1.39		-0.01	0.02	-0.40	
Second socio-economic quintile	-0.03	0.03	-0.83		-0.02	0.02	-0.78	
Third socio-economic quintile	0.02	0.03	0.63		0.01	0.03	0.55	
Fourth socio-economic quintile	0.03	0.04	0.84		0.03	0.03	1.20	
Fifth socio-economic quintile	-0.02	0.04	-0.45		0.04	0.03	1.30	
Number of households w/ piped water	0.01	0.00	4.45	****	0.00	0.00	0.10	
Lives in Dar es Salaam	-0.08	0.02	-4.95	****	-0.06	0.01	-5.48	****
Pseudo R^2	0.05				0.03			
N	4,937				4,937			

Note: Significance levels calculated using p-values and are defined as: *=<.1, **<.05, ***<.01, ****<.001.

TABLE 70: MODEL FOR WATER SHOCK AS MOST SEVERE ECONOMIC SHOCK, BY PRIMARY DRINKING WATER SOURCE

Most severe shock, last 2 years	Piped into Dwelling				Other Piped Source			
	ME	SE	z	Sig.	ME	SE	z	Sig.
Dependency ratio	-0.01	0.02	-0.6		0.02	0.02	1.15	
Number of boys ages 6-13	-0.01	0.02	-0.33		0.00	0.02	-0.09	
Number of girls ages 14-18	-0.01	0.02	-0.33		0.00	0.03	-0.09	
Number of adult females	-0.01	0.01	-1.06		-0.01	0.01	-0.43	
Number of boys ages 6-13	-0.04	0.02	-1.98		-0.02	0.02	-0.96	
Number of boys ages 14-18	0.03	0.03	1.37		-0.06	0.02	-2.54	**
Number of adult males	-0.03	0.02	-1.66	*	-0.01	0.02	-0.31	
Literate household head	0.16	0.06	2.5	**	-0.05	0.05	-1.01	
Household head sex	-0.02	0.03	-0.59		0.01	0.03	0.33	
Quantity of rooms	0.01	0.01	1.04		0.03	0.01	1.81	*
Electricity in the home	0.06	0.03	1.89	*	0.04	0.03	1.38	
Uses a sanitary toilet	-0.07	0.03	-2.61	***	-0.07	0.03	-2.5	**
Home owned by residents	-0.01	0.03	-0.25		-0.02	0.03	-0.58	
Second socio-economic quintile	0.05	0.05	1.09		-0.08	0.03	-2.28	**
Third socio-economic quintile	0.13	0.05	2.54	**	-0.01	0.04	-0.38	
Fourth socio-economic quintile	0.13	0.05	2.66	***	0.02	0.04	0.6	
Fifth socio-economic quintile	0.16	0.05	3.16	***	-0.03	0.05	-0.56	
Lives in Dar es Salaam	-0.09	0.02	-5.91	****	-0.11	0.02	-6.14	****
Up to 2 supply-days per week	-0.13	0.04	-3.07	***	-0.13	0.05	-2.63	***
Up to 5 supply-days per week	-0.15	0.04	-3.85	****	-0.16	0.04	-4.25	****
Pseudo R^2	0.13				0.06			
N	1,725				1,944			

Note: Significance levels calculated using p-values and are defined as: *=<.1, **<.05, ***<.01, ****<.001.

8.14.3 Water storage

Table 71 shows the proportion of households that store water before drinking, disaggregated by primary water source and SES quintile. With the exception of bottled water, over 80% of households report storing water in the household before drinking, regardless of their primary source of drinking water. This suggests that hygiene and storage conditions could be mediating factor in diarrheal illness within this population, as contamination is generally more likely to occur during transport, storage, or retrieval of water, as opposed to during collection of water from the source.

TABLE 71: WATER STORAGE IN THE HOUSEHOLD, BY PRIMARY DRINKING WATER SOURCE AND SES

	Dar es Salaam			Morogoro		
	%	**SE**	**95% CI**	**%**	**SE**	**95% CI**
Primary drinking water source						
Own tap	92%	(3.23)	[85.62, 98.30]	89%	(1.17)	[87.02, 91.63]
Other piped	83%	(2.20)	[78.90, 87.52]	86%	(1.86)	[82.61, 89.93]
Vendors	89%	(2.53)	[83.69, 93.63]	97%	(1.91)	[93.51, 101.01]
Non-Tap	85%	(2.88)	[79.18, 90.47]	89%	(3.68)	[81.69, 96.16]
Bottled	59%	(6.56)	[45.63, 71.40]	35%	(10.21)	[15.14, 55.25]
Total	85%	(1.36)	[81.94, 87.27]	88%	(1.09)	[85.77, 90.07]
SES quintiles						
1	85%	(2.67)	[79.33, 89.82]	87%	(2.24)	[82.57, 91.36]
2	86%	(2.58)	[80.95, 91.09]	90%	(1.52)	[86.52, 92.51]
3	83%	(3.92)	[75.05, 90.45]	89%	(1.72)	[85.65, 92.42]
4	89%	(1.79)	[85.84, 92.89]	89%	(1.60)	[86.34, 92.60]
5	80%	(2.86)	[74.71, 85.94]	85%	(1.98)	[80.71, 88.49]
Total	85%	(1.36)	[81.94, 87.27]	88%	(1.09)	[85.77, 90.07]

Table 72 shows the proportion of households with access to piped tap that own a storage tank, disaggregated by primary source of drinking water and SES quintile. A consistently positive relationship between the wealth quintile (CE per capita per day) and ownership of a storage tank can be observed, with the wealthier households far more likely to own storage tanks versus the poorer households: 55 vs. 14% in Dar es Salaam and 19% vs. 3% in Morogoro. There is also variation by primary source of drinking water: most households with a storage tank use a non-tap source as their primary source of drinking water, although all households in the sample have piped water access. It could be that the worse the water supply, the more likely a household is to have a tank in order to capture water from the tap whenever it does flow, as well as regularly seek non-tap water for drinking given the insufficient tap supply. However, it is of note that water from storage tanks can be of lower quality depending on its conditions and maintenance, especially if not treated, since bacterial growth and contamination are likely to occur during storage.

TABLE 72: OWNERSHIP OF STORAGE TANK FOR HOUSEHOLDS WITH ACCESS TO OWN TAP

	Dar es Salaam			Morogoro		
	%	SE	95% CI	%	SE	95% CI
Primary drinking water source						
Own tap	38%	(6.36)	[25.20, 50.20]	10%	(1.41)	[6.81, 12.35]
Other piped	14%	(5.81)	[2.10, 24.92]	17%	(12.21)	[-6.58, 41.41]
Vendors	42%	(11.28)	[19.74, 64.09]	25%	(15.64)	[-5.47, 56.01]
Non-Tap	55%	(18.66)	[18.59, 91.96]	72%	(30.59)	[12.36, 132.61]
Bottled	44%	(8.95)	[26.86, 62.02]	10%	(7.84)	[-5.26, 25.57]
Total	37%	(5.03)	[27.49, 47.26]	10%	(1.41)	[7.26, 12.81]
SES Quintile						
1	14%	(7.55)	[-1.07, 28.61]	3%	(1.57)	[-0.25, 5.93]
2	16%	(5.03)	[5.86, 25.62]	3%	(1.12)	[0.37, 4.76]
3	26%	(7.41)	[11.47, 40.58]	8%	(2.26)	[4.04, 12.93]
4	43%	(7.90)	[27.60, 58.66]	11%	(2.36)	[6.19, 15.49]
5	55%	(6.56)	[41.97, 67.76]	19%	(3.33)	[11.98, 25.07]
Total	37%	(5.03)	[27.49, 47.26]	10%	(1.41)	[7.26, 12.81]

8.14.4 Shortage-induced water collection behaviors

The household survey and follow-up phone surveys collected detailed data on the prevalence and extent of water shortages and how such shortages effect behaviors related to water collection and expenditure. During periods of shortage, households reported highly different amounts of time and money necessary to procure water. This variation might be explained in different ways. First, it is possible that the variation is reflective of actual changes in demand for water from specific sources that is induced by a shortage, especially if these shortages are unpredictable and vary in duration and severity. Second, given that the phone survey was conducted in a short span of time (about 10 minutes of airtime), it may be the case that the estimates from the phone survey are naturally going to vary more as there may not be sufficient time for the respondent to ask questions of, or clarify responses with, the interviewer over the phone.

As trends identified through the report would suggest, households in Dar es Salaam with access to their own tap experienced the least amount of variation over the course of the survey period and spent the least amount of time collecting water due to a shortage, with an average of 23 minutes spent hauling water per week due to shortages. Households that source water from other piped sources during a shortage spent an average of 96 minutes per week, however the range from each survey period is between 25 to 159 minutes. There is a pronounced trend in the baseline and third round of the phone survey that indicate the poorest households spend considerably more time collecting water during a shortage. The wealthiest quintile spends an average of 29 minutes per week.

As would be expected, water shortages prompt households to look for water sources outside of their typical source. Data from the household survey on water expenditure reveal that some sources are much more expensive than others, but poorer households typically pay less for water than wealthier households during a shortage. In Dar es Salaam, households that typically obtain water for drinking from a non-tap source consistently pay more than others for water during shortages, with an average of 8,681 TZS at baseline. The data suggest that poorer households spend less for each unit of water than wealthier households; in some cases this contradicts with anecdotes from qualitative interviews suggesting that the poor are likely to pay more for water from other sources – while this may be true in reference to utility water, it appears to be the case the in the event of a shortage, households who can spend more do.

8.14.4.1 Caveats in interpreting responses about shortage behaviors

Since the indicator relates specifically to service through the public distribution network, households with a tap on premises were the primary focus of this indicator. It is important to note, as is demonstrated in the results, that because the indicator uses information from those with access to a piped source, it was not possible to obtain a measure of service continuity from other households without access to a piped source In addition, a caveat in the use of this indicator is that awareness of shortages depends on the attempt to draw water from a given source; the duration of a shortage thus inherently involves a degree of uncertainty since households are unlikely to be continually vigilant of water supply, but rather assume durations based on periodic attempts to draw water from the tap over the course of a day. For these reasons, the results are likely to represent a lower bound for this indicator, as awareness of shortages from a specific source is likely to increase with the number of attempts to draw water from that source. Clearly, any household that does not report access to any of those sources does not have a value for this variable.

8.14.5 Perceptions of rationing

The household survey probed respondents about their perception of rationing of the water supply. The data was disaggregated by the primary source of drinking water but all of the responses are in reference to a tap on premises that the household has access to. Overall, 76% of households who use their own tap as the primary source of drinking water report rarely or never experiencing water rationing in the wet season. Households that experience ration often tend to then seek water from other piped sources for drinking (35%) In the dry season in Dar es Salaam, public utility connections become less reliable, with reported incidence of rationing rising to 42% of households stating rationing occurs often. This result is corroborated by the qualitative findings.

TABLE 73: MINUTES SPENT HAULING WATER IN THE LAST 7 DAYS DUE TO SHORTAGES: DAR ES SALAAM

	Dar es Salaam											
	Main Baseline			Phone 1			Phone 2			Phone 3		
	Mean	SE	95% CI	Mean	SE	95% CI	Mean	SE	95% CI	Mean	SE	95% CI
Primary drinking water source												
Own Tap	23	(8.9)	[5.9, 40.9]	41	(10.5)	[20.0, 61.4]	17	(3.2)	[11.0, 23.6]	10	(1.6)	[6.6, 13.2]
Other Piped	47	(11.6)	[23.8, 69.5]	159	(63.2)	[34.2, 283.7]	25	(4.7)	[15.6, 34.2]	154	(144.8)	[-143.6, 451.8]
Vendors	20	(9.1)	[1.8, 37.9]	65	(19.0)	[27.1, 102.0]	30	(13.8)	[2.3, 56.9]			
Non-Tap	93	(53.7)	[-13.4, 199.2]				5	--				
Bottled	16	(6.8)	[2.3, 29.2]	98	(63.1)	[-26.1, 222.7]				15	--	
SES quintiles												
1	102	(28.6)	[45.4, 158.5]	69	(35.0)	[-0.0, 138.0]	10	(2.0)	[6.0, 13.6]	258	(217.9)	[-189.5, 706.1]
2	51	(22.7)	[5.9, 95.6]	36	(16.7)	[3.6, 69.3]	30			3		
3	36	(10.8)	[14.2, 57.1]	53	(24.1)	[5.9, 101.0]	21	(5.2)	[10.9, 31.6]	3		
4	22	(5.4)	[11.6, 32.9]	62	(18.6)	[25.6, 99.1]	22	(4.8)	[12.8, 31.9]	9	(3.7)	[1.3, 16.6]
5	29	(9.1)	[11.5, 47.4]	61	(43.1)	[-24.5, 145.5]	10	(3.8)	[2.7, 17.8]	23	(8.5)	[5.6, 40.6]
Total	37	(10.3)	[17.0, 57.8]	58	(13.1)	[31.7, 83.3]	19	(2.9)	[13.1, 24.6]	38	(26.96)	[-17.9, 92.9]

TABLE 74: MINUTES SPENT HAULING WATER IN THE LAST 7 DAYS DUE TO SHORTAGES: MOROGORO

	Morogoro											
	Main Baseline			Phone 1			Phone 2			Phone 3		
	Mean	SE	95% CI	Mean	SE	95% CI	Mean	SE	95% CI	Mean	SE	95% CI
Primary drinking water source												
Own Tap	26	(4.2)	[17.6, 34.3]	66	(8.5)	[49.4, 82.7]	40.1	(7.2)	[25.9, 54.3]	18.5	(6.6)	[5.0, 32.0]
Other Piped	41	(8.8)	[23.2, 58.1]	102	(41.2)	[21.1, 183.6]	38.3	(16.0)	[6.6, 69.9]	5	--	
Vendors	46	(16.0)	[14.4, 77.5]	87.9	(29.4)	[29.9, 145.7]	11.2	(1.4)	[8.5, 13.9]			
Non-Tap							30	--				
Bottled	176	(65.8)	[46.1, 306.5]	67	(43.9)	[-19.6, 153.6]	12	(1.8)	[8.4, 15.6]			
SES quintiles												
1	29	(4.5)	[19.8, 37.5]	94	(23.1)	[48.0, 139.2]	43	(12.4)	[18.5, 67.7]	30		
2	36	(6.8)	[22.6, 49.7]	62	(12.1)	[38.2, 86.1]	31	(11.1)	[9.4, 53.3]	11	(7.6)	[-4.3, 26.9]
3	40	(13.2)	[13.7, 65.7]	49	(7.4)	[34.4, 63.7]	69	(18.4)	[32.1, 105.2]	45	(15.2)	[13.3, 75.8]
4	38	(14.4)	[9.3, 66.4]	77	(18.9)	[40.0, 114.4]	23	(3.7)	[15.4, 29.9]	11	(5.7)	[-0.4, 23.0]
5	44	(22.5)	[-0.3, 88.6]	77	(32.3)	[12.8, 140.3]	39	(16.1)	[6.8, 70.8]	12	(4.9)	[2.3, 22.3]
Total	37	(7.7)	[22.0, 52.4]	71	(9.0)	[53.5, 89.1]	39	(6.3)	[26.2, 51.1]	18	(6.27)	[4.9, 30.7]

TABLE 75: SHORTAGE-RELATED WATER EXPENDITURES IN THE LAST 7 DAYS: DAR ES SALAAM

	Dar es Salaam											
	Main Baseline			Phone 1			Phone 2			Phone 3		
	Mean	SE	95% CI	Mean	SE	95% CI	Mean	SE	95% CI	Mean	SE	95% CI
Primary drinking water source												
Own Tap	3,635	(1,213)	[1,236, 6,034]	4,548	(694)	[3,180, 5,916]	2,520	(679)	[1,176, 3,865]	2,321	--	
Other Piped	2,215	(358)	[1,508, 2,922]	4,590	(1,098)	[2,426, 6,755]	3,350	(556)	[2,249, 4,451]	3,379	(168)	[3,034, 3,723]
Vendors	5,132	(2,585)	[19, 10,246]	3,976	(1,010)	[1,984, 5,969]	7,091	(810)	[5,487, 8,695]			
Non-Tap	8,681	(2,369)	[3,994, 13,368]	21,000	--		8,050	(650)	[6,762, 9,338]			
Bottled	7,799	(3,340)	[1,191, 14,407]	5,910	(2,086)	[1,796, 10,024]	2,000	--		4,000	--	
SES quintiles												
1	2,838	(686)	[1,482, 4,194]	3,950	(1,266)	[1,454, 6,446]	2,678	(994)	[710, 4,646]	2,303	(685)	[902, 3,704]
2	2,421	(510)	[1,413, 3,429]	4,560	(1,514)	[1,574, 7,547]	4,073	(1,005)	[2,082, 6,063]	1,500	--	
3	4,344	(1,241)	[1,888, 6,799]	4,290	(751)	[2,810, 5,771]	4,463	(1,324)	[1,842, 7,085]	3,000	--	
4	3,056	(844)	[1,387, 4,726]	4,527	(1,022)	[2,512, 6543]	2,030	(594)	[853, 3,207]	3,889	(1,894)	[15, 7,762]
5	4,503	(1,834)	[876, 8,131]	6,283	(1,827)	[2,681, 9,885]	3,473	(1,585)	[333, 6,612]	2,702	(495)	[1,690, 3,715]
Total	3,531	(645)	[2,255, 4,806]	4,815	(598)	[3,636, 5,993]	3,115	(624)	[1,878, 4,352]	2,818	(438)	[1,923, 3,713]

TABLE 76: SHORTAGE-RELATED WATER EXPENDITURES IN THE LAST 7 DAYS: MOROGORO

	Morogoro											
	Main Baseline			Phone 1			Phone 2			Phone 3		
	Mean	SE	95% CI	Mean	SE	95% CI	Mean	SE	95% CI	Mean	SE	95% CI
Primary drinking water source												
Own Tap	1331	(296)	[745, 1,917]	3224	(698)	[1,848, 4,600]	3490	(683)	[2,137, 4,844]	3,152	(701)	[1,719, 4,586]
Other Piped	2281	(843)	[613, 3,949]	4985	(2,307)	[436, 9,534]	2883	(698)	[1,500, 4,265]	3,000	--	
Vendors	11319	(930)	[9,478, 13,159]	10558	(4,851)	[992, 20,125]	3829	(386)	[3,065, 4,594]			
Non-Tap							1500	--				
Bottled	1436	(376)	[692, 2,180]	8133	(4,628)	[-994, 17,260]	5284	(1101)	[3,103, 7,466]			
SES quintiles												
1	731	(195)	[346, 1,117]	1929	(494)	[954, 2,904]	2617	(1209)	[223, 5,011]	0		
2	1154	(312)	[537, 1,772]	2049	(318)	[1,421, 2,676]	4149	(2100)	[-10, 8,308]	3,027	(1,352)	[262, 5,793]
3	1871	(572)	[739, 3,003]	5635	(1,581)	[2,517, 8,753]	6278	(1683)	[2,945, 9,613]	1,948	(299)	[1,336, 2,560]
4	2281	(1,061)	[183, 4,379]	2726	(722)	[1,302, 4,150]	2239	(412)	[1,426, 3,053]	1,934	(308)	[1,304, 2,564]
5	4154	(1,328)	[1,527, 6,782]	7201	(2,671)	[1,932, 12,469]	2564	(443)	[1,687, 3,440]	4,265	(1,275)	[1,658, 6,872]
Total	2028	(600)	[840, 3,216]	3873	(730)	[2,434, 5,312]	3430	(559)	[2,323, 4,538]	3,145	(668)	[1,778, 4,513]

TABLE 77: PERCEPTIONS OF WATER RATIONING, BY PRIMARY DRINKING WATER SOURCE

	Dar es Salaam														
	Own tap			Other piped			Vendors			Non-Tap			Bottled		
	%	SE	95% CI	%	SE	95% CI	%	SE	95% CI	%	SE	95% CI	%	SE	95% CI
How often do you experience water rationing in the wet season?															
Often	24%	(5.2)	[15.3,35.7]	35%	(10.6)	[17.9,57.6]	15%	(6.9)	[5.6,34.0]	24%	(20.1)	[3.3,73.7]	34%	(15.5)	[11.5,66.7]
Rarely	44%	(6.1)	[32.3,55.8]	19%	(8.3)	[7.5,40.4]	9%	(5.5)	[2.3,27.3]	2%	(2.8)	[0.2,20.9]	35%	(12.3)	[15.8,61.2]
Never	32%	(6.5)	[20.9,46.3]	46%	(12.1)	[24.3,69.0]	77%	(8.8)	[55.5,89.6]	74%	(20.2)	[26.4,95.8]	31%	(12.1)	[12.9,57.8]
How often do you experience rationing in the dry season?															
Often	42%	(6.2)	[30.1,54.2]	41%	(10.44)	[22.9,62.0]	20%	(8.4)	[7.9,41.2]	24%	(20.1)	[3.3,73.7]	39%	(14.8)	[15.8,68.5]
Rarely	35%	(6.6)	[23.6,48.7]	14%	(8.1)	[4.3,38.0]	1%	(1.3)	[0.1,9.8]	2%	(2.8)	[0.2,20.9]	39%	(12.6)	[18.3,64.6]
Never	23%	(7.1)	[12.1,39.9]	45%	(12.2)	[23.5,68.2]	79%	(8.6)	[57.7,91.4]	74%	(20.2)	[26.4,95.8]	22%	(10.5)	[7.8,48.6]
Total	100%			100%			100%			100%			100%		

	Morogoro														
	Own tap			Other piped			Vendors			Non-Tap			Bottled		
	%	SE	95% CI	%	SE	95% CI	%	SE	95% CI	%	SE	95% CI	%	SE	95% CI
How often do you experience water rationing in the wet season?															
Often	21%	(2.0)	[16.9,24.6]	49%	(11.5)	[28.2,70.5]	57%	(18.8)	[22.7,85.6]	72%	(28.4)	[13.8,97.8]	30%	(11.6)	[12.3,55.6]
Rarely	57%	(2.3)	[52.9,61.8]	25%	(8.9)	[11.3,45.5]	5%	(4.4)	[1.0,24.2]	28%	(28.4)	[2.3,86.2]	50%	(11.9)	[28.4,72.0]
Never	22%	(2.0)	[18.5,26.1]	26%	(8.3)	[13.2,45.4]	38%	(18. 3)	[11.6,73.8]	0%			20%	(8.6)	[8.1,41.8]
How often do you experience rationing in the dry season?															
Often	57%	(2.4)	[52.4,61.7]	70%	(9.5)	[48.7,84.7]	57%	(18.8)	[22.7,85.6]	72%	(11.3)	[40.3,82.2]	64%	(0.1)	[0.4,0.8]
Rarely	39%	(2.3)	[34.8,43.8]	16%	(7.6)	[5.6,36.5]	0%			28%	(11.3)	[17.8,59.7]	36%	(0.1)	[0.2,0.6]
Never	4%	(0.7)	[2.6,5.3]	15%	(6.5)	[5.9,32.2]	43%	(18.8)	[14, 77]	0%			0%		
Total	100%			100%			100%			100%			100%		

8.15 Qualitative Insights into WSP Implementation

8.15.1 Implementation challenges

The Tanzania WSP has faced significant delays in both Dar es Salaam and Morogoro, with the completion of works in each city delayed for more than one year past the original estimated completion dates.

Several factors have contributed to the delays in project completion. First, due diligence was not adequately conducted on the selected program activities before funding decisions were made. According to several members of the project teams, plans for each of the works were in rudimentary stages at the beginning of the Compact. Designs that were originally thought to be "shovel-ready", turned out to be only preliminary designs or concepts that required considerable additional time for preparation of detailed designs and, in some cases, redesign.

To address this challenge, the designs for most of the plant upgrades were entirely reworked through new design contracts. Delays have been further exacerbated by the challenges inherent in coordinating multiple stakeholders from different countries (funders, implementers, contractors) each without a comprehensive working knowledge of the others' systems, processes, and approaches. A few stakeholders also cited the delays resulting from the import of certain hardware components and construction parts from other countries. In Dar es Salaam, project stakeholders identified problems with electricity supply to the pipe manufacturer as a reason for additional delays, in addition to the protracted start-up time of the contractor.

Furthermore, there was not sufficient consideration at the outset of the project about the ability of the existing transmission main to handle the increase in water supply. After inspection of the existing pipe by the firm contracted to rework the design of the plant, it was concluded that the existing pipe infrastructure would not be able to support the doubling of supply from Lower Ruvu. As a result, another transmission main would need to be installed to support the increased water supply. The initial assumption that other international agencies would finance the transmission main from the Lower Ruvu plant to Dar es Salaam did not materialize, and the Government had to eventually step in to provide funding for the transmission main, resulting in significant delays in preparation of bid documents, tendering, and construction and consequently the realization of project benefits. In Morogoro, delays arose as a result of the contractor responsible for building one of the plants lacking adequate management capabilities and the capacity to fully complete the designs for the project, particularly in terms of the electric and mechanical components of the design. This challenge has since been addressed by bringing another sub-contractor on board to help complete those components.

8.15.2 Cancellation of the non-revenue water component

Initially, the WSP was slated to include a component to address Non-Revenue Water (NRW) in Dar es Salaam. The International Water Association defines NRW as water that has been produced and but is "lost" before it reaches the customer (e.g., caused by leaking and burst pipes, illegal connections and metering inaccuracies). However, the NRW component originally selected for investment was ultimately canceled completely. At the time that this activity was selected for inclusion in the Tanzania WSP, no actionable plans had been developed by the local implementing partners. In addition, at that time, MCC had not coordinated with the World Bank, which had existing programs directed at replacing and repairing water network infrastructure in the city. After the Compact was signed, MCC decided to eliminate this redundancy, especially given the lack of implementation plans for the WSP, and to coordinate efforts with the World Bank where possible. A firm was contracted to complete a pilot study highlighting the main drivers of water loss through production in Dar es Salaam, providing better context for NRW project planning. As of the end of 2013, MCC was working to secure a grant to initiate activities acting on the recommendations of that study through DAWASCO, with the technical assistance of the Public-Private Infrastructure Advisory Facility (PPIAF) at the World Bank.

NRW remains a significant problem. The estimated NRW in Dar es Salaam has increased from 49% to 54% from 2011-12 to 2012-13, according to respondents from DAWASA. NRW appears to be a lesser problem in Morogoro, but according to one key informant from MORUWASA, the estimated figure was 29% unaccounted for water, even though there is no meter now at the production sources to obtain an exact figure. NRW has also affected the tariff structure in Dar es Salaam. The utility was applying for a higher tariff in mid-2013, to account for the real NRW figures to recover costs. Originally, the utility had applied for a tariff that used the assumption of 35% NRW when in fact, because of the lack of investment in this area, the figure has now reached an estimated 54% and the tariff is not covering the utility's operating costs in Dar es Salaam, and the utility is behind in arrears. Further, DAWASCO does not yet have an accurate customer database; a customer mapping exercise undertaken in 2012-2013 is yet to be completed. This affects the utility's ability to plan and monitor water use and NRW and limits its ability to improve its billing and collection efficiency.

Further, the cancelation of the NRW component may curb, to some degree, the estimated impacts of increased water supply in Dar es Salaam. Respondents are not optimistic that the full impacts of the investments can be realized without also addressing NRW and weaknesses in the distribution network infrastructure. This concern was consistently expressed among key stakeholders. The main transmission pipe in Dar es Salaam has burst several times in the last two years and water outages in the city have been increasing. This has escalated the issue of NRW to the level of a political priority, and the cause has been taken up by top government officials who are, in turn, putting additional pressure on the water utility to address the issue.

In addition, at end-line it may be important to pay attention to sewage or drainage issues, which are likely to arise in specific areas where increased volume of water expected to flow due to WSP improvements, particularly in low-lying and relatively flat areas in Dar es Salaam with high population densities. The scaling back or curtailment of the Non-Revenue Water (NRW) component of the WSP can be expected to have an effect on the overall impact of the Project, as increased pressure may, at least at first, increase NRW, and leakages and other infrastructure weaknesses could result in more standing bodies of water that present health threats to nearby residents.

There are nascent plans among stakeholders in the water sector toward establishing a performance-based contract with an outside firm, which would be responsible for conducting specific activities to reduce NRW, and be compensated based on achieving specific NRW reduction targets. Some of the TWSP staff was heavily involved in initial studies to determine causes of NRW in certain areas, and the resulting report was the basis for the recommendation to establish such mechanisms. However, this long process could not be undertaken by MCA-T due to Compact closure, and will be transferred to the utility.

8.15.3 Unavailability of bulk flow meters

Bulk flow meters were not available for measurements of water supply in either city at the time of baseline data collection, although at the time the IE design report was prepared it had been expected that the meters would be available for an objective measure of water supply.

Instead, bulk flow meters were not available for exogenous measures of water supply entering supply zones in either city at baseline. In Dar es Salaam, respondents reported that many meters were either dysfunctional or were measuring water to outdated zone boundaries and thus did not reflect the current zones as delineated by the public utility. In Morogoro, 14-15 bulk meters were purchased by the WSP and installations were scheduled to begin at the end of the baseline data collection period. It is expected that the flow meters will be available for measurements during end-line data collection.

8.15.4 Anticipated effects on vulnerable populations

Unfortunately, the needs of low-income areas or informal settlements were not explicitly considered in the project plans. According to respondents, poorer households or those in informal settlements are less likely to have access to a tap on premises, and therefore rely on other sources or vendors for water. However, according to the key informants, no assessment related to the specific needs of lower-income households was carried out before implementation of the Tanzania WSP began.

As a result, the specific challenges faced by low-income households may not be addressed effectively by the activities of the Tanzania WSP. Within the communities, there was a sense that low-income residents may start paying more for water as a result of this project, while those who are well-off find ways to subvert payment systems (such as meters). One respondent recounted an anecdote that in some cases wealthier households have meters installed inside fenced and gated spaces since meters can otherwise get stolen; but then the access gates will be locked and the DAWASCO employees will not be allowed to enter to read the meters for billing purposes. The utility is interested in exploring pre-paid meter solutions with vending stations. There are a small number of pilot areas in which this approach will be tested, and the utility has already procured the devices for these efforts.

A related impact on low-income populations is that there has been some relocation of populations to enable the construction of the new transmission main, which was necessitated to accommodate the WSP interventions. The government is responsible for handling the resettlement and compensation, but since the new transmission main runs parallel to the existing one, respondents indicated that the populations being relocated may already have encroached into areas in which they were not allowed to legally reside.

Finally, in Dar es Salaam, the utility operator and the regulatory agency are working together to establish a registration system for water tankers to regulate prices and water quality from these sources, as well as the areas in which they are licensed to operate. This process is only starting to develop however, and there seem to be no widely established, formal regulation systems in place yet. Currently, in some areas tankers buy water at the government price (when they pump from official network pumping stations) – for 20 thousand liters they pay only 7500 TZS to DAWASCO. They can sell the same amount for 35 thousand TZS, or up to 40 thousand TZS.

In Morogoro, there are also concerted efforts to reach areas that typically have received lower levels of service, but in some cases there are limits to the amount of supply that can be directed to these areas. These areas typically have a much lower water supply, especially in areas that do not have pumping capacity and rely on gravity sources, like Mambogo, although there is a water tower being specifically built for high elevations. Areas that do not have connections will not benefit from the project unless the connections are put in place there. In addition, some areas have pipes of very small diameters (4-inch or 8-inch), and in these areas, there is a limit to the amount of water that can be pumped.

8.15.5 Other implementation challenges

The controversial issue of water theft and illegal connections arose during the baseline data collection. There are two main types of illegal connections: (1) unmetered connections made by individuals or businesses that are not known to the utility, (2) metered and unmetered connections that are known to and allowed by utility staff such as meter readers in return for a consideration. Water theft can also occur at night when a portable generator and pump set are attached to the utility's pipeline, often resulting in damage to the pipeline and increased leakage and loss to the utility. Construction sites were cited during KIIs as often engaging in this practice. Illegal connections or siphoning from the network could threaten the impact of the program, if water were to be siphoned off in large enough quantities so as to prevent most residents from obtaining supply.

In addition, it should be noted that all the water produced at the Lower Ruvu plant will not necessarily be fully available to Dar es Salaam, as there will be a number of off-takes from the transmission main between Lower Ruvu and the city and its reservoirs, including rapidly growing peri-urban areas north of Dar es Salaam extending to Bagamoyo.

8.15.6 Public profile of the Tanzania WSP

According to MCA-T water sector staff, the Tanzanian Minister of Water has visited the Lower Ruvu site, along with Tanzania's Vice President, partly in response to the political pressure to increase the water supply in the city. It is also salient in public opinion and receives frequent media attention. The Vice President had also accompanied the Minister of Water to the Lower Ruvu plant. According to some respondents, the government's willingness to pay for the transmission main needed to accommodate the increased water supply showed a strong political will to make this project work for the long term. It is expected that the President of Tanzania will attend the project's inauguration. This is a highly visible project in both cities.

8.15.7 Achievements and lessons learned to date

Respondents of the key informant interviews expect that the intervention will, indeed, achieve the stated objectives of increasing water supply to the intended target levels in each city, and improve water quality in Morogoro. However, most respondents offered that the process as a whole could have been more efficient with adequate due diligence, and with better coordination with other actors in the sector from the beginning. If the appropriate scope and approach had been established earlier in the life of the Compact at least some of the delays could have been avoided. While interviews at end-line, after the intervention is complete, will supplement findings from baseline, respondents already had several recommendations regarding ways that the intervention implementation could have been improved. For example, it would be beneficial to carry out gap analyses with plant staff and management to understand the areas related to the management of specific plant technologies that may need to be addressed – in order to inform the design of the intervention itself, to select appropriate technologies, and/or to supplement the intervention implementation with relevant training for the staff maintaining and operating the plant. Some respondents noted the overall lack of staff training accompanying the project, though several mentioned instances of project staff traveling internationally to receive specific training on the new technologies and equipment. Other sector-specific project assessment tools cited by respondents could be implemented to help project planners understand how to best customize the intervention to suit stakeholders' needs appropriately. Several respondents also mentioned that the process of developing management and communication plans for all stakeholders, including the implementing entities, could have been improved, especially in terms of clear delineation of reporting responsibilities, communication of delays and challenges, and supervision of contractors. One respondent felt that the MCA-T M&E team was understaffed, especially with respect to specific sector guidance. One respondent cautioned: *"…if you are doing M&E for water, the M&E team must have specialization in water. If you are doing energy, make sure you have someone energy. [sic] It doesn't matter who is the chief, but you need someone who will advise you."* There were also concerns voiced about the motivation and overall conditions of the workers at the Lower Ruvu plant, which is removed from the main city and located in an area where there are few facilities and accommodations for the plant workers and their families.

9 CONCLUSION

This report examined a variety of outcomes including water-related demand for water and volume consumed, water expenditures, water hauling, stakeholder perceptions of water security and other issues, impacts on health, and effects on schooling and labor force participation. Although the IE is still in progress, this report's preliminary analysis based on baseline data suggests that the variability in water supply and quality does have an impact on some of these main outcomes of interest. These impacts also differ by socioeconomic status, suggesting that the poorest households bear the greatest burden of the challenges in access to clean water.

The next step of this IE is to conduct follow-up data collection to gather post-intervention data. The main approach of this IE is to take advantage of natural variability in the intensity of treatment, where the treatment is conceived as access to and quality of water. In the next stage of this IE, a continuous treatment approach will be operationalized using a generalized propensity score matching (GPSM) approach combined with the use of instrumental variables (IV) to control for potential sources of selection bias. The full IE analysis of the impacts of water access on these outcomes will shed light on whether the WSP intervention has achieved its goals of increasing investment in human and physical capital and reducing the prevalence of water-related disease.

The population of both of the Morogoro and the Dar es Salaam urban centers is continually increasing, putting substantial pressure on the system as a whole in the long-term. The latest national Census of Population and Housing conducted in 2012 revealed an annual population growth rate of almost 6% in Dar es Salaam and 3.4% in Morogoro. Dar es Salaam is one of the fastest growing cities in sub-Saharan Africa, with a population expected to exceed 5 million by 2020, much of which will be in unplanned settlements that are not served by the public distribution network. This rapid growth can provide both opportunities and threats to urban development. While urban migration offers opportunities for additional customers to increase revenues in the system, development throughout the city simultaneously increases demand for reliable and safe sources of water. The extent to which the WSP may alleviate some of the pressure on the system will be explored in the full IE analysis, after end-line data collection is completed in 2016.

10 LIST OF ANNEXES

A. Documentation of Methods and Data
1. Technical Annex: Documentation of Modeling Methodology
2. Selected Visual Data (Part 1 and Part 2)

B. Final Data Collection Instruments
1. Mini Baseline Questionnaire
2. Full Baseline Questionnaire
3. Phone Follow-Up Questionnaire
4. Spot Check Revisit Form
5. Qualitative Tools (FGD and SSI guides)
6. SI Qualitative Data Quality Assurance Field Guides (2)
7. SI Qualitative Area Selection Matrix

C. EDI Documentation
1. EDI Field Implementation Manual
2. EDI Listing and Sampling Manual
3. EDI Interviewer Manual
4. EDI Supervisor Manual
5. EDI Water Quality Testing Protocol
6. EDI Data Quality Assurance Report - 1
7. EDI Data Quality Assurance Report - 2
8. EDI Data Quality Assurance Report - 3
9. EDI Baseline Data Collection Basic Information Document
10. EDI Baseline Data Collection Completion Report

D. SI Baseline Data Quality Report

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12 APPENDIX: DATA TABLES

TABLE 78: HIGHEST EDUCATIONAL ATTAINMENT AMONG HOUSEHOLD HEADS, BY GENDER

	Dar es Salaam				
	None	Primary/ Pre-Primary/ Adult-Vocational	Complete Primary/ Some secondary	Complete Secondary	Some/Complete University
Male	3%	6%	59%	24%	8%
SE	(0.78)	(0.83)	(2.13)	(1.65)	(1.18)
95% CI	[1.44, 4.66]	[5.04, 8.34]	[54.43, 62.77]	[21.32, 27.81]	[5.78, 10.49]
Female	13%	9%	51%	22%	4%
SE	(2.92)	(2.41)	(3.48)	(3.01)	(1.14)
95% CI	[8.60, 20.24]	[5.19, 14.93]	[44.61, 58.21]	[16.67, 28.51]	[2.48, 7.13]
Total	5%	7%	57%	24%	7%
SE	(0.85)	(0.92)	(1.83)	(1.42)	(0.98)
95% CI	[3.47, 6.88]	[5.40, 9.06]	[53.48, 60.69]	[21.22, 26.82]	[5.36, 9.23]

	Morogoro				
	None	Primary/ Pre-Primary/ Adult-Vocational	Complete Primary/ Some secondary	Complete Secondary	Some/Complete University
Male	3%	8%	59%	22%	8%
SE	(0.44)	(0.70)	(1.43)	(1.13)	(0.91)
95% CI	[2.27, 4.02]	[6.56, 9.34]	[56.35, 61.98]	[19.91, 24.34]	[6.30, 9.88]
Female	14%	14%	53%	15%	3%
SE	(1.68)	(1.66)	(2.39)	(1.63)	(0.99)
95% CI	[11.11, 17.74]	[11.42, 17.99]	[48.61, 57.97]	[11.90, 18.34]	[1.87, 5.94]
Total	6%	9%	58%	20%	7%
SE	(0.56)	(0.69)	(1.27)	(0.95)	(0.77)
95% CI	[4.65, 6.87]	[8.12, 10.85]	[55.28, 60.27]	[18.53, 22.25]	[5.45, 8.51]

TABLE 79: ACCESS TO OWN TAP CONNECTED TO PUBLIC NETWORK, BY SES

SES quintile	Dar es Salaam			Morogoro		
	%	SE	95% CI	%	SE	95% CI
1	3%	(0.78)	[1.43, 4.50]	31%	(2.87)	[25.60, 36.86]
2	8%	(1.39)	[5.58, 11.03]	48%	(2.72)	[42.22, 52.91]
3	14%	(2.49)	[8.99, 18.76]	54%	(3.02)	[47.59, 59.44]
4	20%	(3.20)	[13.34, 25.91]	66%	(2.71)	[60.54, 71.18]
5	24%	(3.72)	[17.13, 31.74]	70%	(2.75)	[64.95, 75.76]
Total	14%	(1.74)	[10.43, 17.25]	54%	(1.80)	[50.16, 57.23]

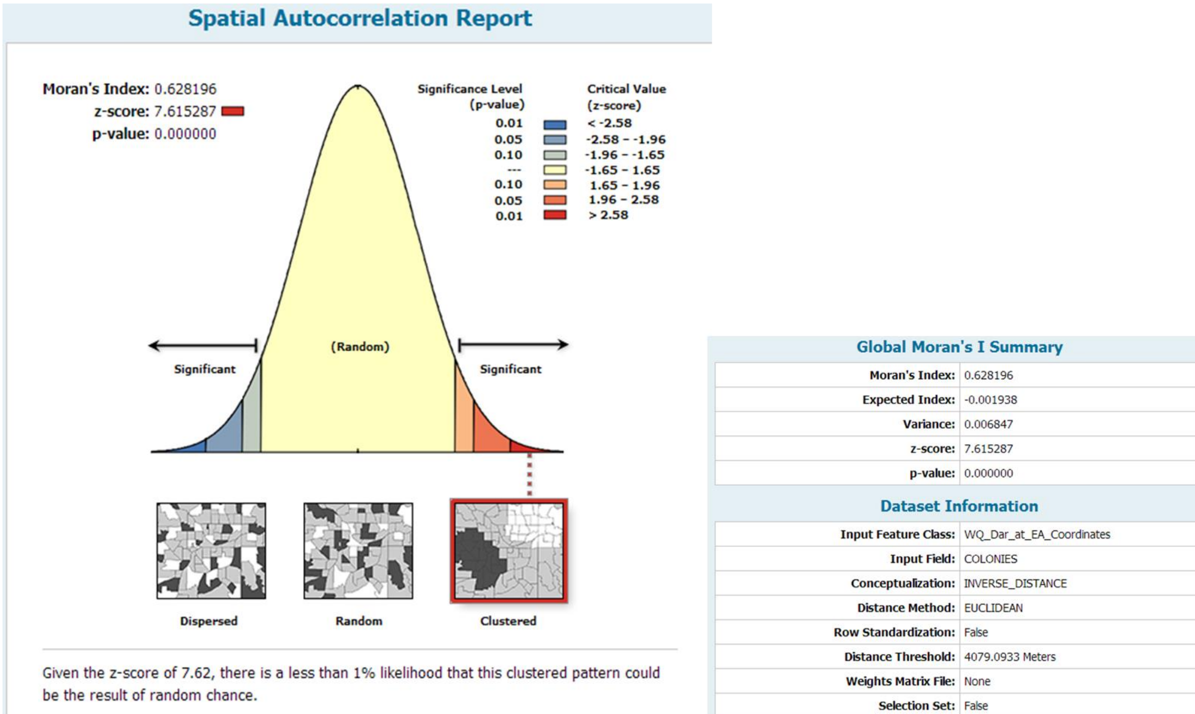

FIGURE 76: SPATIAL AUTO-CORRELATION RESULTS FOR FECAL BACTERIA: DAR ES SALAAM

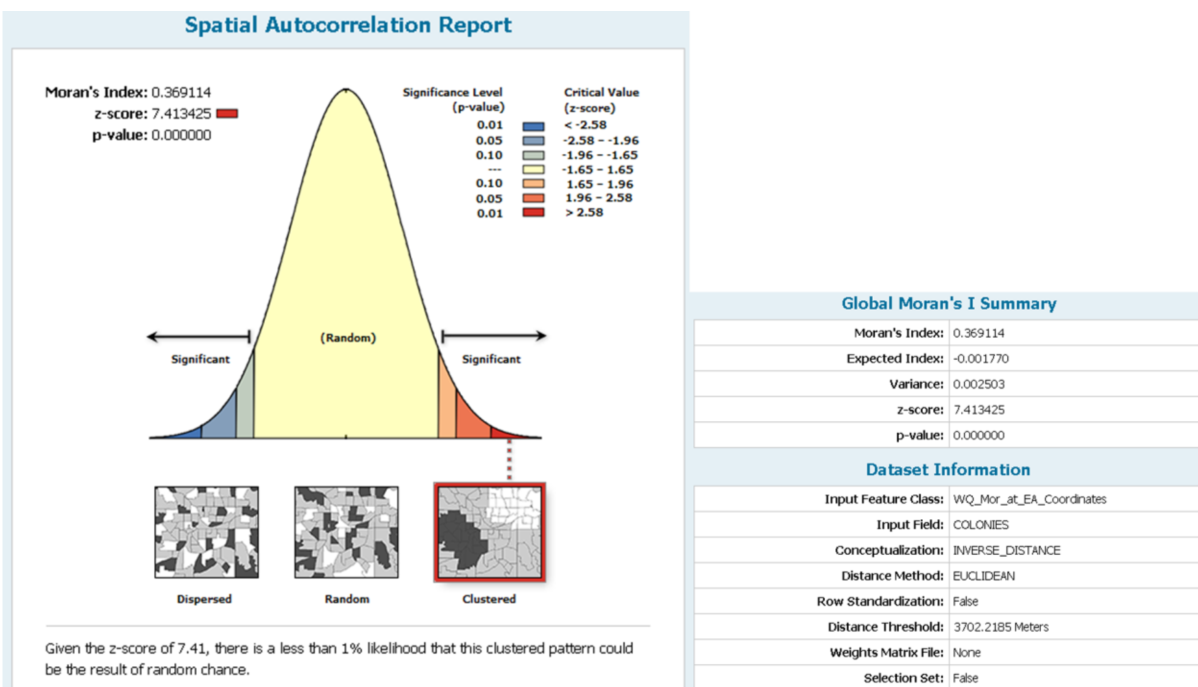

FIGURE 77: SPATIAL AUTO-CORRELATION RESULTS FOR FECAL BACTERIA: DAR ES SALAAM

TABLE 80: WATER TREATMENT PRACTICES, BY PRIMARY DRINKING WATER SOURCE

	Dar es Salaam					
Primary drinking water source	**Boil**	**Disinfect**	**Filter**	**Let stand and settle**	**None**	**Total**
Own tap	76%	1%	1%	2%	20%	100%
SE	(3.94)	(0.52)	(0.58)	(0.91)	(3.64)	
95% CI	[67.68, 83.16]	[0.22, 2.84]	[0.50, 3.09]	[0.84, 4.86]	[13.45, 27.77]	
Other piped	38%	2%	1%	7%	51%	100%
SE	(3.02)	(0.52)	(0.46)	(1.35)	(3.59)	
95% CI	[32.76, 44.58]	[1.17, 3.28]	[0.71, 2.65]	[4.91, 10.30]	[43.99, 58.01]	
Vendors	47%	1%	1%	5%	47%	100%
SE	(4.38)	(0.87)	(0.40)	(1.94)	(4.13)	
95% CI	[38.48, 55.56]	[0.39, 4.68]	[0.20, 2.16]	[1.90, 10.27]	[38.58, 54.69]	
Non-Tap	30%	0%	0%	3%	67%	100%
SE	(3.56)	0.00	(0.20)	(0.80)	(3.74)	
95% CI	[23.93, 37.89]		[0.14, 1.04]	[1.34, 4.65]	[58.94, 73.55]	
Total	41%	1%	1%	4%	53%	100%
SE	(1.83)	(0.27)	(0.21)	(0.70)	(1.92)	
95% CI	[37.43, 44.64]	[0.69, 1.79]	[0.57, 1.43]	[3.29, 6.08]	[48.74, 56.26]	

	Morogoro					
Primary drinking water source	**Boil**	**Disinfect**	**Filter**	**Let stand and settle**	**None**	**Total**
Own tap	51%	4%	5%	16%	24%	100%
SE	(1.86)	(0.70)	(0.69)	(1.30)	(1.71)	
95% CI	[47.51, 54.82]	[2.86, 5.64]	[4.21, 6.96]	[13.11, 18.24]	[20.68, 27.39]	
Other piped	25%	3%	6%	18%	48%	100%
SE	(1.74)	(0.74)	(1.01)	(1.72)	(2.35)	
95% CI	[21.47, 28.32]	[2.22, 5.21]	[4.68, 8.71]	[14.57, 21.35]	[43.15, 52.35]	
Vendors	48%	2%	10%	8%	31%	100%
SE	(6.36)	(1.47)	(3.86)	(3.36)	(5.79)	
95% CI	[36.27, 60.79]	[0.50, 8.09]	[4.79, 20.69]	[3.39, 17.59]	[21.12, 43.59]	
Non-Tap	17%	3%	6%	28%	46%	100%
SE	(4.24)	(1.28)	(2.29)	(6.02)	(6.77)	
95% CI	[10.18, 26.99]	[1.00, 6.75]	[3.01, 12.59]	[17.63, 41.04]	[33.51, 59.53]	
Total	39%	4%	6%	16%	35%	100%
SE	(1.41)	(0.47)	(0.60)	(1.09)	(1.53)	
95% CI	[36.13, 41.68]	[2.786, 4.651]	[4.91, 7.28]	[14.41, 18.71]	[32.15, 38.15]	

Note: The water treatment method variable presented had been separated into the following water treatment methods listed representing appropriate categories from the household survey: Boil (“boil”); Disinfect (“water guard, bleach, chlorine”; “solar disinfection”*); Filter (“filter through a cloth”, “water filter”); Other (“let stand and settle”; “aluminium sulfate”*); None (“none”). *Note that starred categories were not mentioned by any households from either city. Therefore, the category “other” in the case of our data represents only “let stand and settle”, and therefore we present the data in this way.

TABLE 81: SUPPLY DAYS, AVERAGE BY PRIMARY DRINKING WATER SOURCE IN EACH CITY

	Dar es Salaam			
Primary drinking water source	**Main Baseline**	**Phone Rd. 1**	**Phone Rd. 2**	**Phone Rd. 3**
Own tap	5.71	4.12	5.28	5.52
SE	(0.27)	(0.41)	(0.29)	(0.22)
95% CI	[5.19,6.24]	[3.32,4.92]	[4.72,5.84]	[5.10,5.94]
Other piped	5.82	3.65	4.15	5.57
SE	(0.60)	(0.68)	(0.59)	(0.53)
95% CI	[4.64,7.00]	[2.32,4.98]	[2.98,5.31]	[4.54,6.60]
Vendors	5.86	3.71	4.72	5.6
SE	(0.62)	(0.98)	(0.87)	(0.53)
95% CI	[4.64,7.07]	[1.79,5.63]	[3.01,6.42]	[4.55,6.64]
Non-Tap	5.35	4.64	3.09	6.48
SE	(1.38)	(1.02)	(2.62)	(0.38)
95% CI	[2.64,8.06]	[2.65,6.64]	[-2.06,8.23]	[5.74,7.22]
Bottled	4.11	5.17	5.69	5.72
SE	(0.97)	(0.46)	(0.56)	(0.35)
95% CI	[2.21,6.01]	[4.26,6.07]	[4.60,6.78]	[5.03,6.41]
Total	5.58	4.19	5.17	5.56
SE	(0.29)	(0.33)	(0.26)	(0.19)
95% CI	[5.01,6.15]	[3.54,4.83]	[4.66,5.69]	[5.20,5.93]

	Morogoro			
Primary drinking water source	**Main Baseline**	**Phone Rd. 1**	**Phone Rd. 2**	**Phone Rd. 3**
Own tap	6.26	5.06	5.21	5.16
SE	(0.06)	(0.08)	(0.08)	(0.08)
95% CI	[6.15,6.37]	[4.89,5.22]	[5.05,5.38]	[5.01,5.30]
Other piped	4.49	4.14	4.19	4.74
SE	(0.98)	(0.53)	(0.49)	(0.27)
95% CI	[2.57,6.41]	[3.10,5.18]	[3.22,5.15]	[4.22,5.27]
Vendors	5.42	1.1	4.19	5.65
SE	(1.21)	(0.76)	(1.34)	(0.65)
95% CI	[3.03,7.80]	[-0.39,2.59]	[1.57,6.82]	[4.36,6.93]
Non-Tap	7	7	4.42	5.52
SE	--	--	(2.47)	(1.41)
95% CI	--	--	[-0.44,9.27]	[2.75,8.30]
Bottled	5.82	4.41	5	4.58
SE	(0.35)	(0.93)	(0.51)	(0.32)
95% CI	[5.13,6.50]	[2.58,6.25]	[3.99,6.00]	[3.96,5.20]
Total	6.2	4.96	5.14	5.13
SE	(0.07)	(0.09)	(0.09)	(0.07)
95% CI	[6.06,6.34]	[4.77,5.14]	[4.97,5.32]	[4.98,5.27]

TABLE 82: WATER SUPPLY FROM OWN TAP BY CITY AND SES

	Dar es Salaam			
SES quintiles	Main Baseline	Phone Rd. 1	Phone Rd. 2	Phone Rd. 3
1	6.48	4.67	5.44	5.41
SE	(0.25)	(0.57)	(0.52)	(0.37)
95% CI	[5.98, 6.98]	[3.56, 5.79]	[4.42, 6.46]	[4.69, 6.13]
2	5.88	4.15	5.55	6
SE	(0.30)	(0.49)	(0.26)	(0.38)
95% CI	[5.28, 6.47]	[3.19, 5.12]	[5.04, 6.06]	[5.26, 6.74]
3	5.55	3.03	4.72	5.15
SE	(0.41)	(0.52)	(0.61)	(0.31)
95% CI	[4.74, 6.36]	[2.01, 4.05]	[3.53, 5.92]	[4.53, 5.76]
4	5.42	4.16	5.12	5.63
SE	(0.37)	(0.52)	(0.28)	(0.19)
95% CI	[4.69, 6.16]	[3.13, 5.19]	[4.57, 5.68]	[5.26, 6.01]
5	5.4	4.72	5.25	5.57
SE	(0.40)	(0.41)	(0.42)	(0.27)
95% CI	[4.62, 6.17]	[3.91, 5.53]	[4.42, 6.07]	[5.04, 6.11]
Total	5.58	4.19	5.17	5.56
SE	(0.29)	(0.33)	(0.26)	(0.19)
95% CI	[5.01, 6.15]	[3.54, 4.83]	[4.66, 5.69]	[5.20, 5.93]

	Morogoro			
SES quintiles	Main Baseline	Phone Rd. 1	Phone Rd. 2	Phone Rd. 3
1	6.25	4.68	5.12	5.25
SE	(0.13)	(0.26)	(0.20)	(0.20)
95% CI	[6.00, 6.50]	[4.16, 5.19]	[4.72, 5.52]	[4.85, 5.65]
2	6.13	4.87	5.37	5.12
SE	(0.11)	(0.14)	(0.13)	(0.15)
95% CI	[5.92, 6.34]	[4.60, 5.14]	[5.11, 5.64]	[4.84, 5.41]
3	6.1	4.95	5.01	5.18
SE	(0.12)	(0.15)	(0.17)	(0.12)
95% CI	[5.88, 6.33]	[4.65, 5.25]	[4.69, 5.34]	[4.95, 5.41]
4	6.32	4.95	5.28	5.09
SE	(0.09)	(0.16)	(0.14)	(0.12)
95% CI	[6.15, 6.50]	[4.63, 5.26]	[5.00, 5.55]	[4.86, 5.31]
5	6.19	5.16	4.95	5.08
SE	(0.14)	(0.19)	(0.18)	(0.12)
95% CI	[5.92, 6.46]	[4.78, 5.54]	[4.59, 5.31]	[4.84, 5.33]
Total	6.20	4.96	5.14	5.13
SE	(0.07)	(0.09)	(0.09)	(0.07)
95% CI	[6.06, 6.34]	[4.77, 5.14]	[4.97, 5.32]	[4.98, 5.27]

TABLE 83: WATER CONSUMPTION (L/PC/DAY), BY PRIMARY DRINKING WATER AND SES

	Volume of water consumption per capita per day (Liters)			
	DAR ES SALAAM		MOROGORO	
Primary drinking water source	*Rainy Season*	*Dry Season*	*Rainy Season*	*Dry Season*
Own tap	123	129	108	115
SE	(7.09)	(6.78)	(3.59)	(3.71)
95% CI	[109, 137]	[116, 143]	[101, 115]	[108, 123]
Other piped	48	52	35	41
SE	(3.38)	(3.38)	(2.21)	(2.31)
95% CI	[41, 54]	[45, 58]	[31, 40]	[36, 45]
Vendors	44	49	50	54
SE	(4.71)	(5.36)	(7.64)	(6.65)
95% CI	[35, 53]	[39, 60]	[35, 65]	[40, 67]
Non-Tap	46	51	42	40
SE	(7.85)	(7.67)	(8.23)	(7.43)
95% CI	[30, 61]	[36, 66]	[26, 58]	[25, 54]
Bottled	78	86	84	96
SE	(11.80)	(13.56)	(10.72)	(11.70)
95% CI	[55, 102]	[59, 113]	[63, 105]	[73, 119]
Total	57	62	74	80
SE	(3.31)	(3.39)	(2.56)	(2.66)
95% CI	[50, 63]	[55, 69]	[69, 79]	[75, 85]
SES quintile	*Rainy Season*	*Dry Season*	*Rainy Season*	*Dry Season*
1	39	43	44	47
SE	(4.21)	(4.25)	(3.58)	(3.69)
95% CI	[30, 47]	[35, 51]	[37, 51]	[40, 55]
2	43	49	55	60
SE	(3.74)	(3.56)	(3.39)	(3.44)
95% CI	[36, 51]	[42, 56]	[48, 61]	[53, 67]
3	51	56	64	70
SE	(4.30)	(4.44)	(3.15)	(3.38)
95% CI	[43, 60]	[48, 65]	[58, 71]	[63, 76]
4	66	70	91	97
SE	(5.43)	(5.77)	(4.94)	(4.99)
95% CI	[55, 76]	[59, 82]	[82, 101]	[87, 107]
5	88	93	119	129
SE	(6.70)	(6.54)	(5.87)	(6.02)
95% CI	[75, 101]	[80, 106]	[107, 130]	[117, 141]
Total	57	62	74	80
SE	(3.31)	(3.39)	(2.56)	(2.66)
95% CI	[50, 63]	[55, 69]	[69, 79]	[75, 85]

TABLE 84: WATER EXPENDITURES (TZS/PC/WEEK) BY PRIMARY SOURCE OF DRINKING WATER AND SES

	Water Expenditures per capita per week (TZS)			
	DAR ES SALAAM		MOROGORO	
Primary drinking water source	*Rainy Season*	*Dry Season*	*Rainy Season*	*Dry Season*
Own tap	1845	2306	846	1112
SE	(208.88)	(267.36)	(51.86)	(66.93)
95% CI	[1435, 2255]	[1781, 2831]	[744, 947]	[981, 1244]
Other piped	1830	2196	1018	1332
SE	(150.30)	(183.05)	(94.44)	(124.75)
95% CI	[1535, 2126]	[1837, 2556]	[833, 1204]	[1087, 1577]
Vendors	2546	3078	3941	4043
SE	(380.89)	(429.58)	(620.70)	(499.44)
95% CI	[1798, 3294]	[2234, 3921]	[2722, 5160]	[3063, 5024]
Non-Tap	1095	1213	320	547
SE	(218.96)	(229.03)	(103.64)	(180.10)
95% CI	[665, 1525]	[763, 1663]	[116, 523]	[193, 901]
Bottled	7765	8500	6548	10138
SE	(722.06)	(767.29)	(911.56)	(1568.64)
95% CI	[6347, 9183]	[6994, 10007]	[4758, 8338]	[7057, 13218]
Total	2056	2411	1073	1386
SE	(133.51)	(153.05)	(64.04)	(79.88)
95% CI	[1793, 2318]	[2111, 2712]	[948, 1199]	[1229, 1543]
SES quintile	*Rainy Season*	*Dry Season*	*Rainy Season*	*Dry Season*
1	1008	1238	648	801
SE	(127.23)	(149.56)	(60.17)	(83.94)
95% CI	[758, 1258]	[944, 1532]	[530, 766]	[636, 966]
2	1426	1659	699	868
SE	(130.35)	(134.15)	(65.88)	(69.63)
95% CI	[1170, 1682]	[1395, 1922]	[570, 829]	[731, 1004]
3	1694	2153	995	1375
SE	(192.98)	(236.28)	(103.59)	(156.67)
95% CI	[1315, 2073]	[1689, 2617]	[791, 1198]	[1068, 1683]
4	2363	2717	1167	1390
SE	(195.80)	(230.94)	(137.26)	(132.36)
95% CI	[1979, 2748]	[2264, 3171]	[897, 1436]	[1130, 1650]
5	3836	4331	1837	2472
SE	(360.08)	(375.43)	(160.78)	(209.62)
95% CI	[3129, 4543]	[3594, 5068]	[1521, 2153]	[2061, 2884]
Total	2056	2411	1073	1386
SE	(133.51)	(153.05)	(64.04)	(79.88)
95% CI	[1793, 2318]	[2111, 2712]	[948, 1199]	[1229, 1543]

TABLE 85: DIARRHEA PREVALENCE, BY AGE AND PRIMARY DRINKING WATER SOURCE

Diarrhea in last 14 days	Dar es Salaam			Morogoro		
	%	SE	95% CI	%	SE	95% CI
Ages <5						
Own tap	7%	(2.80)	[3.26, 15.03]	15%	(1.65)	[11.72, 18.24]
Other piped	7%	(1.37)	[4.84, 10.33]	12%	(1.75)	[8.49, 15.42]
Vendors	7%	(2.07)	[3.85, 12.32]	13%	(4.57)	[6.01, 24.64]
Non-Tap	7%	(2.62)	[2.99, 14.05]	6%	(2.71)	[2.46, 14.15]
Bottled	7%	(5.25)	[1.48, 26.95]			
Total	7%	(1.09)	[5.08, 9.43]	13%	(1.12)	[10.75, 15.18]
Ages 5-18						
Own tap	1%	(0.47)	[0.47, 2.54]	4%	(0.64)	[3.26, 5.80]
Other piped	2%	(0.64)	[0.93, 3.65]	4%	(0.73)	[3.07, 5.97]
Vendors	1%	(0.30)	[0.30, 1.64]	5%	(1.82)	[2.58, 10.17]
Non-Tap	3%	(1.09)	[1.20, 5.92]	7%	(3.77)	[2.28, 19.05]
Bottled	2%	(1.54)	[0.51, 8.52]			
Total	2%	(0.42)	[1.10, 2.80]	5%	(0.52)	[3.575, 5.62]
All children < 18						
Own tap	3%	(0.87)	[1.55, 5.18]	7%	(0.71)	[6.04, 8.85]
Other piped	3%	(0.65)	[2.31, 4.93]	6%	(0.79)	[4.92, 8.03]
Vendors	2%	(0.66)	[1.36, 4.07]	7%	(2.09)	[4.12, 12.63]
Non-Tap	4%	(0.95)	[2.41, 6.25]	7%	(2.72)	[2.90, 14.43]
Bottled	4%	(2.10)	[1.12, 10.93]			
Total	3%	(0.45)	[2.48, 4.28]	7%	(0.52)	[5.91, 7.95]

TABLE 86: DIARRHEA PREVALENCE, BY AGE AND MAIN SANITATION FACILITY

Diarrhea in last 14 days	Dar es Salaam			Morogoro		
	%	SE	95% CI	%	SE	95% CI
Ages <5						
Flush toilet (to sewer, tank, pit)	7%	(1.33)	[4.84, 10.14]	15%	(1.51)	[11.77, 17.74]
Pit latrine (VIP/slab)	7%	(1.73)	[3.98, 10.99]	11%	(1.65)	[8.03, 14.58]
Flush to elsewhere	9%	(10.13)	[0.75, 54.21]	0%		
Open pit latrine	14%	(10.57)	[2.59, 48.06]	5%	(4.83)	[0.76, 27.67]
No facilities	0%			63%	(33.41)	[9.16, 96.50]
Total	7%	(1.09)	[5.08, 9.43]	13%	(1.12)	[10.75, 15.18]
Ages 5-18						
Flush toilet (to sewer, tank, pit)	2%	(0.53)	[0.80, 3.02]	5%	(0.63)	[3.47, 5.97]
Pit latrine (VIP/slab)	2%	(0.69)	[0.97, 3.90]	4%	(0.83)	[2.84, 6.19]
Flush to elsewhere	12%	(6.22)	[4.03, 30.27]	12%	(4.64)	[5.82, 24.75]
Open pit latrine	0%			4%	(2.54)	[0.88, 13.62]
No facilities	0%			24%	(7.82)	[12.18, 42.53]
Total	2%	(0.42)	[1.10, 2.80]	4%	(0.52)	[3.58, 5.62]
All children <18						
Flush toilet (to sewer, tank, pit)	3%	(0.60)	[2.17, 4.59]	7%	(0.65)	[6.19, 8.74]
Pit latrine (VIP/slab)	3%	(0.75)	[2.11, 5.13]	6%	(0.84)	[4.65, 7.98]
Flush to elsewhere	11%	(6.05)	[3.32, 29.41]	8%	(3.56)	[2.90, 18.23]
Open pit latrine	6%	(5.93)	[0.94, 32.58]	4%	(2.05)	[1.54, 10.65]
No facilities	0%	0.00		31%	(7.31)	[18.21, 46.40]
Total	3%	(0.45)	[2.48, 4.28]	7%	(0.52)	[5.91, 7.95]

TABLE 87: EXPENDITURES FOR DIARRHEAL ILLNESS AMONG CHILDREN <5, LAST 14 DAYS (TZS)

Mean TZS in the last 14 days - per child under 5 in the household	Dar es Salaam			Morogoro		
	Mean	SE	95% CI	Mean	SE	95% CI
Primary drinking water source						
Own tap	596	(270)	[66, 1127]	870	(160)	[557, 1,184]
Other piped	594	(161)	[277, 911]	697	(159)	[384, 1,009]
Vendors	739	(363)	[26, 1,451]	471	(286)	[-91, 1,032]
Non-Tap	465	(216)	[42, 888]	213	(152)	[-85, 511]
Bottled	735	(742)	[-720, 2,190]	0	0.00	[0, 0]
SES quintiles						
1	432	(202)	[36, 828]	693	(201)	[297, 1,088]
2	650	(189)	[278, 1,022]	850	(164)	[528, 1,171]
3	889	(356)	[190, 1,587]	558	(132)	[300, 816]
4	473	(217)	[46, 900]	406	(126)	[159, 653]
5	290	(208)	[-118, 699]	1832	(822)	[217, 3,446]
Sanitation facility						
Flush toilet (sewer/septic tank/pit latrine)	641	(161)	[325, 957]	881	(161)	[564, 1198]
Pit latrine (VIP or with slab)	513	(161)	[198, 828]	588	(116)	[360, 816]
Flush to elsewhere	1424	(1,671)	[-1,858, 4,706]	0	0.00	[0, 0]
Open pit latrine	274	(247)	[-211, 760]	402	(375)	[-335, 1,139]
No facilities	0	0.00	[0, 0]	0	0.00	[0, 0]
Total	589	(119)	[355, 824]	748	(103)	[545, 951]

TABLE 88: HAULING TIME (MIN/WEEK) BY PRIMARY SOURCE OF DRINKING WATER, BY SEASON

	HAULING TIME PER WEEK (MINUTES)			
	Dar es Salaam		Morogoro	
Primary drinking water	*Rainy Season*	*Dry Season*	*Rainy Season*	*Dry Season*
Own tap	112	154	89	254
SE	(24)	(27)	(10.98)	(19.18)
95% CI	[65, 158]	[102, 207]	[67, 110]	[216, 292]
Other piped	311	341	324	398
SE	(24)	(25)	(18.51)	(21.01)
95% CI	[265, 357]	[292, 390]	[288, 360]	[357, 439]
Vendors	234	267	355	373
SE	(28)	(25)	(54.45)	(62.49)
95% CI	[180, 289]	[218, 316]	[248, 462]	[250, 495]
Non-Tap	198	233	514	589
SE	(23)	(25)	(59.66)	(66.25)
95% CI	[153, 243]	[183, 282]	[397, 631]	[459, 719]
Bottled	152	171	188	135
SE	(22)	(25)	(122.34)	(36.52)
95% CI	[109, 196]	[122, 220]	[-52, 428]	[63, 207]
Total	243	275	247	351
SE	(13)	(14)	(14)	(15)
95% CI	[218, 269]	[248, 303]	[220, 274]	[322, 381]
SES quintile	*Rainy Season*	*Dry Season*	*Rainy Season*	*Dry Season*
1	254	293	339	401
SE	(23)	(27)	(23)	(24)
95% CI	[208, 300]	[241, 345]	[294, 385]	[353, 448]
2	241	306	280	372
SE	(18)	(24)	(25)	(29)
95% CI	[206, 276]	[259, 353]	[231, 328]	[315, 429]
3	295	316	257	384
SE	(30)	(31)	(26.87)	(33.01)
95% CI	[237, 354]	[255, 378]	[204, 310]	[319, 449]
4	254	277	186	320
SE	(19)	(21)	(20)	(25)
95% CI	[216, 292]	[236, 319]	[147, 226]	[272, 369]
5	171	181	151	266
SE	(16)	(15)	(23)	(27)
95% CI	[141, 202]	[151, 211]	[106, 196]	[213, 318]
Total	243	275	247	351
SE	(13)	(14)	(14)	(15)
95% CI	[218, 269]	[248, 303]	[220, 274]	[322, 381]

TABLE 89: VOLUME HAULED (L/PC/WEEK) BY PRIMARY DRINKING WATER SOURCE, BY SEASON

	VOLUME HAULED (LITERS/CAPITA), WEEKLY			
	Dar es Salaam		Morogoro	
Primary drinking water source	*Rainy Season*	*Dry Season*	*Rainy Season*	*Dry Season*
Own tap	62	92	43	91
SE	(11.37)	(16.92)	(5.51)	(7.49)
95% CI	[40, 84]	[59, 125]	[32, 54]	[76, 106]
Other piped	279	312	210	249
SE	(17.31)	(18.36)	(10.64)	(11.86)
95% CI	[245, 313]	[276, 348]	[189, 231]	[225, 272]
Vendors	240	284	256	299
SE	(18.33)	(28.73)	(27.67)	(34.04)
95% CI	[204, 276]	[228, 341]	[202, 311]	[233, 366]
Non-Tap	259	305	243	244
SE	(28.71)	(31.16)	(42.01)	(39.55)
95% CI	[203, 316]	[244, 366]	[161, 326]	[166, 322]
Bottled	254	298	61	145
SE	(34.66)	(45.73)	(19.48)	(38.39)
95% CI	[186, 322]	[208, 388]	[22, 99]	[70, 221]
Total	240	277	141	171
SE	(11.97)	(14.15)	(7.58)	(7.94)
95% CI	[217, 264]	[250, 305]	[126, 156]	[155, 186]
SES quintile	*Rainy Season*	*Dry Season*	*Rainy Season*	*Dry Season*
1	202	230	142	161
SE	(20.84)	(23.84)	(12.19)	(13.84)
95% CI	[161, 243]	[184, 277]	[118, 165]	[134, 188]
2	224	266	139	160
SE	(16.87)	(16.63)	(11.43)	(12.07)
95% CI	[191, 257]	[233, 299]	[116, 161]	[137, 184]
3	231	270	153	169
SE	(14.82)	(17.74)	(14.20)	(13.15)
95% CI	[201, 260]	[236, 305]	[125, 181]	[143, 195]
4	256	297	129	162
SE	(17.71)	(20.96)	(12.63)	(12.70)
95% CI	[221, 291]	[256, 338]	[104, 154]	[137, 187]
5	293	326	141	203
SE	(26.66)	(28.96)	(14.50)	(15.79)
95% CI	[241, 345]	[269, 383]	[113, 170]	[172, 234]
Total	240	277	141	171
SE	(11.97)	(14.15)	(7.58)	(7.94)
95% CI	[217, 264]	[250, 305]	[126, 156]	[155, 186]

TABLE 90: AVERAGE HOURS WORKED LAST WEEK, PER WORKING ADULT

	Mean	SE	95% CI
Dar es Salaam			
Quintile 1	49	(1.26)	[46.78, 51.72]
Quintile 2	57	(1.27)	[54.19, 59.17]
Quintile 3	56	(1.53)	[53.06, 59.06]
Quintile 4	59	(0.89)	[57.00, 60.50]
Quintile 5	59	(1.04)	[57.13, 61.21]
Total	56	(0.68)	[54.63, 57.28]
Morogoro			
Quintile 1	51	(0.86)	[48.99, 52.37]
Quintile 2	53	(0.87)	[50.85, 54.26]
Quintile 3	56	(0.93)	[54.15, 57.79]
Quintile 4	59	(0.96)	[57.41, 61.17]
Quintile 5	58	(1.04)	[56.41, 60.50]
Total	55	(0.50)	[54.40, 56.36]

TABLE 91: AVERAGE HOURS WORKED LAST WEEK, PER ABLE ADULT

	Mean	SE	95% CI
Dar es Salaam			
Quintile 1	50	(1.70)	[46.27, 52.95]
Quintile 2	56	(1.71)	[52.36, 59.08]
Quintile 3	54	(1.58)	[50.69, 56.90]
Quintile 4	55	(1.19)	[52.88, 57.57]
Quintile 5	56	(1.22)	[53.73, 58.54]
Total	54	(0.70)	[52.72, 55.48]
Morogoro			
Quintile 1	54	(1.24)	[51.56, 56.41]
Quintile 2	54	(1.22)	[51.13, 55.93]
Quintile 3	55	(1.33)	[52.63, 57.86]
Quintile 4	57	(1.23)	[54.96, 59.81]
Quintile 5	56	(1.43)	[53.40, 59.01]
Total	55	(0.65)	[54.00, 56.55]

TABLE 92: RESPONDENTS REPORTING WORRY ABOUT ADEQUATE WATER SUPPLY

	Dar es Salaam			Morogoro		
	%	SE	95% CI	%	SE	95% CI
Primary drinking water source						
Own tap	21%	(5.71)	[9.31, 31.74]	22%	(1.93)	[18.31, 25.87]
Other piped	26%	(2.74)	[20.73, 31.51]	36%	(2.70)	[31.02, 41.64]
Vendors	21%	(5.23)	[11.04, 31.58]	44%	(6.97)	[30.26, 57.63]
Non-Tap	4%	(1.20)	[2.07, 6.78]	42%	(6.40)	[29.62, 54.75]
Bottled	19%	(4.48)	[10.12, 27.72]	31%	(10.43)	[10.69, 51.64]
SES quintile						
1	17%	(2.84)	[11.26, 22.39]	35%	(3.10)	[29.12, 41.31]
2	20%	(3.07)	[14.08, 26.14]	34%	(2.83)	[28.79, 39.92]
3	22%	(3.39)	[14.97, 28.29]	33%	(3.34)	[26.78, 39.88]
4	20%	(2.49)	[14.98, 24.74]	24%	(2.53)	[19.26, 29.21]
5	15%	(2.30)	[10.12, 19.14]	20%	(2.70)	[15.02, 25.62]
Total	19%	(2.01)	[14.66, 22.56]	29%	(1.82)	[25.92, 33.06]