



An Impact Evaluation of Multiple-Use Water Services in Morogoro Region 2016 Tanzania









Tanzania Integrated Water, Sanitation and Hygiene (iWASH) Program

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Executive Summary

Study Background: In the Morogoro region of Tanzania, the Integrated Water, Sanitation and Hygiene Program (iWASH) aims to support sustainable, market-driven water supply, sanitation and hygiene services to improve health and increase economic resiliency of the poor. Multiple-use water services (MUS) is an integrated water service delivery approach that takes into account households' range of needs as a starting point when planning, financing, and managing water services for domestic and productive uses.

The MUS component of iWASH uses a demand-oriented approach to provide rural communities with new or upgraded water services to meet domestic (drinking, cooking, washing and bathing) and productive (e.g., livestock rearing and gardening) needs. Water system configurations include piped networks providing public taps, protected wells equipped with rope pumps, watering troughs for livestock, and irrigation pumps for gardening and agriculture. In addition to upgraded water services, "impact boosting activities" designed to support households' productive activities are offered with the support of local organizations.

Study Approach: The aim of this study is to systematically and rigorously evaluate a range of impacts associated with a higher level of domestic and productive water services within the iWASH program area. Specifically, the study will quantify the influence of MUS on rural households' livelihoods, health, and water service quality as a result of their participation in iWASH. Key outcome measures include: water-based income, livelihoods diversification, water availability in the dry season, nutritional status, food security, drinking water quality, and child health.

Baseline (pre-iWASH) data was not collected for the measures listed above, so it was not possible to directly measure the before and after status among iWASH program participants. Furthermore, as the MUS project is demand-led, it was not possible to randomly assign households into treatment and control groups. Therefore, this study relies on a dual-strategy for estimating the effect of MUS on rural households' lives: (1) strategic sampling with enrollment of a control group, and (2) statistical matching techniques. This report contains the results of the first component, with matching to be undertaken in a subsequent peer-reviewed publication.

Communities that had joined the iWASH program and received a new (or upgraded/rehabilitated) water scheme at least one year prior to the study were eligible for enrollment in the treatment group. Communities located within the program area that could qualify for the iWASH program but had not yet applied for a water scheme were eligible for enrollment as a control. From this eligible pool,

communities were selected purposively with consideration of four key criteria: baseline status, intervention design, demand-led implementation, and accessibility. Thus, control communities were thought to be reasonably similar to iWASH communities' status prior to their joining iWASH, thereby allowing for a reasonable comparison.

Based on field visits and discussions with iWASH field staff prior to data collection, the study team defined and sampled three household typologies using a stratified-randomized strategy. Typologies include households living in iWASH communities who are members of MUS interest groups¹ (interest group members), households living in iWASH communities who are not members of MUS interest groups (non-members), and households in communities not part of the iWASH program (control).

From August - October 2015 the study team conducted over 1,300 household surveys with structured observations across 10 communities: 7 iWASH and 3 adjacent control (non-iWASH) communities. In addition, the team collected drinking water samples across various water point types within a subset of villages to analyze microbial water quality. Interviewer training commenced for one week in mid-August, with interviewer recruitment beginning about 1 month prior. Data collection ran for 8 weeks beginning on September 1, 2015, ending just prior to the Tanzania General Elections.

Key Findings: The results presented in this report focus on direct comparisons of measures of livelihoods, health, and water services across the three typologies defined above. Overall, we find that households in iWASH communities are experiencing greater benefits than households in control communities. Moreover, MUS interest group members (such as food vendors and vegetable gardeners) tend to experience greater benefits than non-members.

In terms of *livelihoods impacts*, the most common productive activities undertaken with water by all households were livestock rearing and gardening, with staple crop farming typically depending on seasonal rainfall. Other water-based activities included water and food vending, brick making, and beer brewing. Relatively fewer households took advantage of the latter, but for those who did the earnings reported were comparatively high. Overall and for virtually every activity, households within iWASH communities (and especially MUS interest group members) were more likely to be undertaking and earning income from activities with water. iWASH households were also able to better diversify their portfolio of water-based productive activities. Finally, a greater share of respondents (67%) in iWASH

¹ MUS interest groups were formed in iWASH communities support "impact boosting" activities. For example, improved poultry and livestock husbandry, market gardens, and other productive uses of water.

communities reported women earning half or more of their household's total income, as compared to control communities (51%).

The *health impacts* analysis examined nutrition, food security, child health, and injuries experienced during water collection. MUS interest group members within iWASH communities were most likely to report being food secure and consuming a wider variety of food types, as compared to control households. MUS interest group members were also more likely to have eaten one or more animal products (meat, milk, or eggs) in the past week, as compared to control households. Within iWASH communities there were fewer incidences of diarrheal disease and respiratory illness among children under age five, as well as injuries due to water fetching among all age groups. While the difference in rate of injury was statistically significant, further research and a larger sample size is needed to better assess impacts of MUS on child health.

The impacts of MUS on *water services* were found to be similarly positive. Three-quarters of improved water sources were categorized as "probably safe" (1-9 CFU *E.coli* per mL) according to WHO standards, as compared to only one-third of unimproved water sources. However, no drinking water samples were found to meet the WHO microbial water quality standard (0 CFU *E.coli*/100 mL) when tested with the Msabi kit. The typical household in iWASH communities spent half the amount of time (15 minutes) on a single round trip as compared to a household in control communities (30 minutes). In terms of reliability of water services, virtually all water points (iWASH and control communities) were functioning at the time of the visit. iWASH households were more likely to report experiencing interruptions in their water service lasting 1 day or more, as compared to control households. Yet when iWASH communities (22 days). These results suggest that whereas iWASH communities' more complex water systems may be more prone to service interruptions, they are better able to respond quickly to such shocks.

Summary: Overall this study finds that the iWASH program's comprehensive MUS package has a large and positive impact on the well-being of rural households in the Morogoro region. Based on a household survey and drinking water sampling, results show that the iWASH program has improved the livelihoods, health, and water service quality for the rural communities it serves. Especially striking were the dramatic benefits experienced by those households participating in an MUS interest group designed to support impact boosting activities with water, such as animal husbandry and market gardens. The results of this report lend strong evidence to ongoing water sector dialogue regarding the role of MUS as a means to alleviate poverty and improve the health and well-being of the rural poor.

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Table of Contents

Executive Summaryii
List of Tablesvii
List of Figuresvii
List of Photos
Abbreviations and Acronymsviii
1. Introduction
1.1 Study Setting
1.2 Study Objectives
1.3 Research Questions and General Approach 4
2. Methodology 6
2.1 Sampling Strategy
2.2 Data Collection Tools11
2.3 Data Processing and Analysis14
3. Results
3. Results 15 3.1 Water Sources and Household Characteristics 15
 Results
 Results
 Results
 Results
3. Results 15 3.1 Water Sources and Household Characteristics 15 3.2 Comparing MUS and Control Communities: Livelihoods, Health and Environment 16 3.2.1 Livelihoods Activities 16 3.2.2 Income Generation 21 3.2.3 Food Security 22 3.2.4 Nutrition 24
3. Results 15 3.1 Water Sources and Household Characteristics 15 3.2 Comparing MUS and Control Communities: Livelihoods, Health and Environment 16 3.2.1 Livelihoods Activities 16 3.2.2 Income Generation 21 3.2.3 Food Security 22 3.2.4 Nutrition 24 3.2.5 Illness and Injury 26
3. Results153.1 Water Sources and Household Characteristics153.2 Comparing MUS and Control Communities: Livelihoods, Health and Environment163.2.1 Livelihoods Activities163.2.2 Income Generation213.2.3 Food Security223.2.4 Nutrition243.2.5 Illness and Injury263.2.6 Drinking Water Quality27
3. Results153.1 Water Sources and Household Characteristics153.2 Comparing MUS and Control Communities: Livelihoods, Health and Environment163.2.1 Livelihoods Activities163.2.2 Income Generation213.2.3 Food Security223.2.4 Nutrition243.2.5 Illness and Injury263.2.6 Drinking Water Quality273.2.7 Satisfaction with Water Services31
3. Results153.1 Water Sources and Household Characteristics153.2 Comparing MUS and Control Communities: Livelihoods, Health and Environment163.2.1 Livelihoods Activities163.2.2 Income Generation213.2.3 Food Security223.2.4 Nutrition243.2.5 Illness and Injury263.2.6 Drinking Water Quality273.2.7 Satisfaction with Water Services313.2.8 Reliability32
3. Results153.1 Water Sources and Household Characteristics153.2 Comparing MUS and Control Communities: Livelihoods, Health and Environment163.2.1 Livelihoods Activities163.2.2 Income Generation213.2.3 Food Security223.2.4 Nutrition243.2.5 Illness and Injury263.2.6 Drinking Water Quality273.2.7 Satisfaction with Water Services313.2.8 Reliability323.2.9 Fetching Time33
3. Results153.1 Water Sources and Household Characteristics153.2 Comparing MUS and Control Communities: Livelihoods, Health and Environment163.2.1 Livelihoods Activities163.2.2 Income Generation213.2.3 Food Security223.2.4 Nutrition243.2.5 Illness and Injury263.2.6 Drinking Water Quality273.2.7 Satisfaction with Water Services313.2.8 Reliability323.2.9 Fetching Time334. Synthesis and Lessons Learned34
3. Results 15 3.1 Water Sources and Household Characteristics 15 3.2 Comparing MUS and Control Communities: Livelihoods, Health and Environment 16 3.2.1 Livelihoods Activities 16 3.2.2 Income Generation 21 3.2.3 Food Security 22 3.2.4 Nutrition 24 3.2.5 Illness and Injury 26 3.2.6 Drinking Water Quality 27 3.2.7 Satisfaction with Water Services 31 3.2.8 Reliability 32 3.2.9 Fetching Time 33 4. Synthesis and Lessons Learned 34 5. Bibliography. 38

List of Tables

- Table 1: Selected community characteristics
- Table 2: Village and household sample sizes and strategy
- Table 3: Amount of water samples according to the community type and water point type
- Table 4: Empirical contamination scale based proposed for Msabi tests
- Table 5: Share of households using different water sources for drinking and other purposes
- Table 6: Share of households undertaking and generating income with water-based activities
- Table 7: Annual income generated from water-based activities with domestic water supply (USD)
- Table 8: Share of households consuming each food type in the past week and mean number of food types consumed.
- Table 9: Health risk categorization based on World Health Organization Drinking Water Quality Guidelines for E. coli concentrations

Table 10: Health risks associated with drinking water quality according to the type of drinking water sourceTable 11: Total and fecal coliform count in two iWASH communities

List of Figures

Figure 1: The Morogoro region of Tanzania

- Figure 2: Location of study communities iWASH (red) and control (blue)
- Figure 3: Cultivation of vegetables during the warm-dry season in iWASH and control communities
- Figure 4: Median number of water-based productive activities undertaken and median annual income earned using water
- Figure 5: Median seasonal income earned by households within iWASH and Control communities and percentage households with women earning at least half of total income.

Figure 6: Perceived food security among iWASH and Control households

Figure 7: Percentage of households reporting (a) diarrheal disease and (b) respiratory illness incidence among children under age 5, and (c) injury due to water fetching among all age groups.

Figure 8: Health risks associated with drinking water quality among iWASH and control communities

Figure 9: Health risks associated with drinking water quality according to the category of drinking water source

- Figure 10: Self-reported satisfaction with water services among iWASH and control households
- Figure 11: Duration of service interruption among households in iWASH and control communities
- Figure 12: Distribution of time spent fetching water among iWASH and control households

List of Photos

Photo 1: Public tap

- Photo 2: Vegetable garden
- Photo 3: MUS impact boosting activities include improved chicken husbandry, livestock support, and agricultural training.
- Photo 4: In-person interviews conducted using ODK and smartphones
- Photo 5: Drinking water sample collection using Msabi test kit

Abbreviations and Acronyms

CBT	Compartment bag test
EC	Escherichia coli
FIB	Fecal indicator bacteria
iWASH	Integrated Water, Sanitation and Hygiene program
IWRM	Integrated Water Resources Management
MUS	Multiple Use Water Services
ODK	Open Data Kit
ТАНА	Tanzanian Horticultural Association

1. Introduction

In the Morogoro region of Tanzania, the Integrated Water, Sanitation and Hygiene (iWASH) program aims to support sustainable, market-driven water supply, sanitation and hygiene services to improve health and increase economic resiliency of the poor through an integrated water resource management (IWRM) framework. Multiple-use water services (MUS) is an integrated water service



delivery approach that takes into account rural households' range of needs as a starting point when planning, financing, and managing water services for domestic and productive uses. The MUS component of iWASH uses a demand-led approach to provide rural communities with a higher level of water services² for domestic (drinking, cooking, washing, bathing) and productive (e.g., livestock rearing, gardening) purposes.

Photo 1: Public tap

Past studies have shown the powerful benefits of MUS in terms of water-based income generation and women's empowerment (Davis, Hope, & Marks, 2011; Hall, Vance, & van Houweling, 2014; van Houweling, Hall, Diop, & Davis, 2012). Yet little is known about the indirect impacts of MUS at scale, including changes in households' health, resilience during dry months, and service quality attributes.

The aim of this study is to systematically evaluate a range of impacts associated with a higher level of

domestic and productive water services within the iWASH program area. Specifically, the study quantifies the influence of MUS on rural households' livelihoods, health, and water service quality as a direct result of their participation in iWASH. Key outcome measures include: water-based income, livelihoods diversification, water availability in the dry season, nutritional status, food security, drinking water quality, and child health.



Photo 2: Vegetable garden

² A higher level of water services refers to water schemes located on or near the household plot, generally providing more than 20 LPCD.

1.1 Study Setting

Tanzania is an East African country bordered by Kenya, Uganda, Rwanda, Burundi, the Democratic Republic of Congo, Zambia, Malawi and Mozambique. The eastern edge of the country is a coastline along the Indian Ocean (Figure 1). There are nearly 52 million people in Tanzania, with 68% of the population living in rural areas. Water resources are scarce and characterized by significant seasonal variability. According to the WHO/UNICEF Joint Monitoring Programme, 46% and 8% of the rural population enjoys access to an improved water source and adequate sanitation facility, respectively (Joint Monitoring Programme, 2014).



Figure 1: The Morogoro region of Tanzania

In Tanzania, the MUS component of the iWASH program uses a demand-responsive approach to provide rural dwellers with the option of investing in upgraded water services to support their domestic (drinking, cooking, washing, bathing) and productive (e.g., livestock rearing, gardening) activities with water. Water system configurations include piped networks providing public taps, protected wells equipped with rope pumps, watering troughs for livestock, and irrigation pumps for

gardening and agriculture. Water systems installed through iWASH may be new, rehabilitated or upgraded.

In addition to a higher level of water services, "impact boosting activities" designed to support households' productive uses with water are offered with the support of local organizations. These activities include (but aren't limited to) livestock and poultry support with Heifer International, through providing new stock, improved husbandry practices, disease treatment and local brooders (kinengunengu). As another example, the Tanzanian Horticultural Association (TAHA) provides agricultural training on drip irrigation and market gardens.



Photo 3: MUS impact boosting activities include improved chicken husbandry, livestock support, and agricultural training.

1.2 Study Objectives

The aim of this impact study is to systematically and rigorously evaluate a range of impacts associated with a higher level of domestic and productive water services within the iWASH program area. The goal

is to answer questions of cause and effect, *i.e.*, quantify changes in beneficiaries' lives as a direct result of their participation in the demand-led MUS component of iWASH, as compared to households who did not have the opportunity to participate. Key outcome measures include: household income, livelihoods diversification, water access in the dry season (resilience), women's empowerment and entrepreneurship, nutrition and food security, and drinking water quality.

1.3 Research Questions and General Approach

The main research questions and measures to be investigated are:

 What is the impact of the iWASH MUS program on the livelihoods of rural households in the Morogoro region of Tanzania?

1.a. Undertaking water-based productive activities for own consumption and sale (e.g., gardening, farming, food vending, etc.)

- 1.b. Income generation
- 2. What is the impact of the iWASH MUS program on the **health and food security** of rural households in the Morogoro region of Tanzania?
 - 2.a. Food security and nutrition
 - 2.b. Diarrheal and respiratory disease
 - 2.c. Injuries experienced while fetching water
- 3. What is the impact of iWASH MUS program on **water services** for rural households in the Morogoro region of Tanzania?
 - 3.a. Microbial water quality
 - 3.b. Reliability of water services
 - 3.c. Household satisfaction with the water service provided
 - 3.d. Time spend fetching water

Baseline (pre-intervention) data was not collected for the measures listed above, so it is not possible to directly measure the before and after situation among iWASH program participants. Furthermore, as the MUS project is demand-led, it was not possible to randomly assign households into the treatment (iWASH) and control (no-iWASH) groups. Therefore, we will use a dual-strategy for estimating the effect of MUS on rural households' lives:

• Strategic Sampling (this report): Through carefully defining and randomly sampling specific household typologies, as well as enrolling communities which were as similar as possible in the

time period prior to initiation of iWASH, a direct comparison of treatment and control can give a reasonable sense of the impacts of the program.

Statistical Matching (not reported here, see follow-on peer review publication): Using propensity score matching (PSM) to estimate the influence of MUS on households' well-being, as compared to households not receiving MUS. PSM is a statistical matching technique which links treatment and control households along covariates known to influence a household's likelihood of participating in the project, such as wealth, education, and proximity to markets. Matching allows treatment and control groups to be as comparable as possible in all ways except whether they received MUS, thus making an unbiased comparison possible. This study was run in parallel to second MUS impact study in rural Burkina Faso, which used a similar methodology.

Household Typologies

The general approach for answering the above questions is to compare households living within and outside of iWASH communities along a variety of outcomes using an unbiased sampling approach. In the Morogoro region of Tanzania, rural communities embody a range of characteristics, from those communities that have demanded and received improved water supply through iWASH (plus additional training/interventions related to MUS), to communities who have applied and are waiting to participate in the iWASH program, to those communities who have chosen not to apply to iWASH or were not aware of the program.

Within iWASH communities, some households may be official members of a "MUS interest group," which provides support and resources for various productive activities with water such as livestock production and gardening. By contrast, iWASH community members may have undertaken productive use of water but chosen not to join their community's MUS interest group. In view of these important distinctions, the study team carefully defined various household typologies and designed a stratified-randomized sampling strategy for each household type, thereby maximizingthe extent to which the final sample was representative of the general population of Morogoro region. Section 2 describes community and household selection/enrolment in detail.

Study Timeline

From August - October, 2015 the study team conducted over 1,300 household surveys with structured observations across 10 communities: 7 iWASH and 3 adjacent "control" (non-iWASH) communities. In

addition, the team collected drinking water samples across various water point types within a subset of villages to analyze microbial water quality.

During July 6-10, 2015 an Eawag project officer visited iWASH headquarters in Morogoro for the purpose of scoping potential study communities, discussing logistics with the field team, and initiating household survey design. Interviewer training commenced for one week in mid-August, with interviewer recruitment beginning about 1 month prior. Data collection ran for 8 weeks beginning on September 1, 2015 and ending just prior to the Tanzania General Elections.

2. Methodology

2.1 Sampling Strategy

Community Eligibility and Selection

The iWASH program was implemented in rural communities in the region of Morogoro. Communities in Morogoro that were visited by the iWASH program and received a new or rehabilitated water scheme³ at least one year prior to the study were eligible for enrollment in the treatment group and are henceforth referred to as **iWASH communities**. Communities located within the program area that could qualify for the iWASH program but had not yet applied for a water scheme were eligible for enrollment as **control** (Figure 2). From this eligible pool, communities were selected purposively through consideration of four key criteria:

- **Baseline status**: The study team sought to balance key characteristics across treatment and control groups known to confound outcomes of interest. These confounding factors include baseline (pre-intervention) population, wealth status, livelihoods activities, distance to town centers, and access to water.
- Intervention design: A wide variety of water infrastructure characteristics were included in the treatment group so that study results could be extended broadly to the greater iWASH program.
- **Demand-led implementation**: Since the iWASH program matured with time and project implementation evolved into a highly demand-responsive approach, the study team prioritized iWASH communities that had actively demanded and applied to receive a new or rehabilitated water scheme.

³ A water scheme refers to any combination of infrastructure delivering water to the community or household level. In the iWASH program options include piped networks and upgraded/new manually drilled wells equipped with rope pumps.

• Accessibility: Finally, to keep study costs within budget it was necessary to prioritize reasonable proximity to other study communities to reduce travel time when choosing among potential study communities.

A total of 7 iWASH communities and 3 control communities were enrolled (Table 1). All communities selected are rural with a population of no more than 10,000 people. Within study communities, *typical* households depended on subsistence farming and/or livestock rearing, were located some distance from a town center, and were largely dependent on unimproved water sources prior to iWASH. The enrolled iWASH communities contained a wide variety of the water supply infrastructure designed to support MUS (enhanced wells equipped with rope pumps, gravity-fed piped schemes, and deep borehole schemes), as well as other pre-existing sources (hand pumps and rivers).

As a result of the above selection process, control communities were thought to be reasonably similar to iWASH communities in the time period prior to the intervention, thereby allowing for both direct comparison as well as a statistical matching analysis. Further, the iWASH communities visited during the study were a good representation of iWASH communities broadly.



Figure 2: Location of study communities - iWASH (red) and control (blue)

Туре	Com. code	Рор.	# of HHs	MUS impact "boosting activities" –OR- interest groups	Start of iWASH project	Hand-over of iWASH project	Water points provided by iWASH	Other improved sources	Unimproved sources
	Τ1	7492	1025	 Chicken production Backyard gardening Pig production Cattle trough Goats, chicken breeding, pigs, goats 	mid 2010	end 2011	Gravity-fed piped schemes (public taps, some household connections), cattle troughs	none	River
	Т2	2817	509	 Gardening Livestock group formation 	beginning 2012	end 2013	Gravity-fed piped schemes (public taps)	none	River
WASH	Т3	6179	1270	 Gardening (commercial) Livestock group formation 	beginning 2012	end 2013	Deep boreholes (public kiosks), Community rope pumps	none	Trad. Wells
	T4	3336	896	 Backyard gardening Chicken production 	course of 2012	end 2013	Community rope pumps	Handpumps	River
	T5	1237	342	 Backyard gardening Chicken production 	course of 2012	end 2013	Community rope pumps	none	River
	Т6	1758	424	 Backyard gardening Chicken production 	course of 2012	end 2013	Community rope pumps	none	River
	Т7	1758	424	1. Backyard gardening 2. Chicken production	course of 2012	end 2013	Community rope pumps	Handpumps	River
l	C1	3025	648					Handpumps	River
ontro	C2	N/A	N/A					none	Trad. Wells River
Ŭ	C3	2317	682					Handpumps	River

Table 1: Selected community characteristics

Household Selection

The Morogoro region is characterized by mountainous terrain, and rural communities are often located long distances from each other over unpaved roads. Due to the challenges associated with reaching communities (and therefore a risk of personal bias among survey team members when choosing households to interview), we used an automated approach to generate a random sample of households.

The target number of surveys was a total of 1,200 households, with 600 households in the control communities and 600 in the iWASH communities. Sampling within iWASH communities was evenly split

between two household typologies (300 MUS interest group members and 300 non-members). Target sample sizes for control households were based on the relative sizes of the communities, i.e., 250, 250, and 100 households. Actual sample sizes exceeded target sample sizes (Table 2).

A household was designated as a **MUS interest group member** when at least one member was active within an iWASH interest group (impact boosting activities described earlier). Households living in an iWASH village that do not take part in an MUS interest group will be referred to as **non-members**. Within iWASH communities all interest group members were interviewed, and approximately the same number of non-members were then sampled for comparison. Non-members and control households were randomly sampled in each sub-village, proportionally to the weight of the sub-village total population.

In each village, a list of all households was provided by a key informant. Within iWASH communities, interest group members were removed from the list and the programming tool Matlab function *randperm* was used to randomize sub-villages households' numbers and choose the number desired. An extra 5 households were randomly selected using the same function a second time in each sub-village as a buffer. This method ensured that target sample sizes were met (and eventually exceeded) and that a random selection of households in each village.

Community type	Household type	Sample Size	Sampling strategy
BALACI	Interest group members	322	Census: all households are offered to enroll
(n=7)	Non-members	410	Automatized random sampling: households identified as "non-members" were selected across all sub-villages by a random sampling using a code on Matlab.
Control (n=3)	Control	645	Automatized random sampling: households were selected across all sub-villages by a random sampling using a code on Matlab.
	Total household sample size	1377	

Table 2: Village and household sample sizes and strategy

Drinking Water Samples

Originally, the Compartment Bag Test (CBTs) testing kits were intended to be used to assess the quality of the drinking water across communities. During the study period, the required average temperature over 48 hours was too low to allow a good incubation for this kit.

As a result, the Msabi tests using the H₂S method were used instead. The availability of the Msabi tests was limited as their original purpose was for educational demonstration within communities. Two local interviewers received basic training to handle the test and collected water samples without the supervision of the project officer in the field. They collected information and pictures of the samples and the evaluation of the results was made by the project officer after the sampling. Each sampling campaign was followed by a presentation of the results to the local communities.

In total, 35 water points were tested. Due to the limited available materials, no controls or duplicate samples were taken. Water samples were taken in eight communities (5 iWASH and 3 control), and a variety of water points types was tested (Table 3). One water point was sampled in each sub-village when possible, randomly selected by the local interviewer. In the sub-villages where several types of water points were available, the instruction was to vary the types of water sources and infrastructure tested. For example, rivers were tested in communities where most people use them based on indications from the local populations. Table 3 summarizes the number of water points tested by type.

Community type	Type of water points available in community	Water points sampled
	Community piped water (gravity scheme, iWASH)	14
	Community piped water (deep borehole scheme, iWASH)	6
iWASH	Community rope pumps (iWASH)	4
	Hand pumps (non iWASH)	2
	River	3
	Hand pumps	4
Control	Open well	1
	River	1

Table 3: Amount of water samples according to the community type and water point type

In addition to the H₂S tests, a local laboratory was mandated to test drinking water samples in two iWASH communities. Total and fecal coliforms were enumerated at seven water points using a membrane filtration technique with 24-hours incubation. All water points tested by membrane filtration were community piped water (gravity scheme) installed by iWASH.

2.2 Data Collection Tools

In-Person Interviews

Semi-structured in-person interviews were conducted with each enrolled household, for a total of 1,377 completed surveys. After a household was identified through the sampling procedure described above, a trained enumerator asked to meet with the head of household to describe the study, request an interview, and explain informed consent. If the head of household agreed to participate, the household was enrolled in the study. Interviews lasted about one hour each. Respondents were categorized as either the male head of household, wife of the male head of household, or female head of household. The interview was conducted either with head of household alone or with the male head and his wife.



Photo 4: In-person interviews conducted using ODK and smartphones

The survey instrument was developed using Open Data Kit (ODK) by the Eawag and Winrock research team over several months prior to the start of field work. Questions were organized into modules on the household's characteristics (education, health status, sanitation access, etc.), water sources used, livelihoods activities and income, and food security/nutrition. The survey was written in English and translated by enumerators into the preferred local language of the respondent. Data were collected on Samsung smartphones. Following completion of all interviews, data were aggregated into an excel spreadsheet and converted to SPSS format for analysis.

Structured Observations

Following each in-person interview, enumerators conducted structured observations at the household plot to assess the condition of the home and sanitation facility. In addition, drinking water samples were taken at water sources in a subset of study communities. During sampling, observations were recorded on the water point's condition and the visual appearance of the water sample collected. All data were collected on smartphones loaded with ODK and analyzed in excel and SPSS.

Msabi Water Test

The Msabi water test kit is a simple test that does not require a laboratory set up and necessitates little training. This kit uses the H₂S method, which is widely used mainly because of its low cost and its ease of use. Various studies have been conducted to assess the reliability and accuracy of this method (Wright et al., 2012). The media in the testing kit can vary from a manufacturer to another. In general, the H₂S method is used to estimate the presence of bacteria which may be fecal in origin, with results comparable to traditional approaches for detecting fecal indicator bacteria (FIB). However, false positive results have been frequently reported that can come from a wide number of sources (presence of sulfides of non-biological origin and from the activities of microbes of non-fecal origin) (Sobsey & Pfaender, 2002). The H₂S method is considered as a good tool for educational purposes, and as a useful qualitative screening method for water supply systems, but it is advised that the positive H₂S test are confirmed by a standard bacteriological test.



Photo 5: Drinking water sample collection using Msabi test kit

Trained technicians also conducted laboratory analysis of water quality for seven water points in two iWASH communities. The two sampling campaigns (laboratory and Msabi) are difficult to compare for several reasons:

- The two methods tested samples from the same water points but taken at different times (three weeks apart). The microbiological quality of water can vary significantly over time.
- Msabi tests were conducted by unsupervised local interviewers, whereas laboratory tests were run by trained staff.
- The laboratory tested were limited to total and fecal coliform bacteria, whereas the H₂S test is inclusive of coliforms as well as other classes of microorganisms associated with fecal sources (McMahan, Grunden, Devine, & Sobsey, 2012).

The H_2S test is usually conducted as a presence/absence test (P/A). However, the iWASH program proposes a more detailed contamination scale based on empirical observations. This scale was used to interpret the results (Table 4).

Color and smell indicators	Corresponding associated health risk
Golden clear color and no smell after 48 hours	Low risk/safe
Clear/cloudy/grey color/black deposit and bad smell after 48 hours	Intermediate risk/probably safe
Black color and bad smell after 48 hours	High risk/probably unsafe
Black color and bad smell after 24 hours	Very high risk/unsafe

Table 4: Empirical contamination scale based proposed for Msabi tests

2.3 Data Processing and Analysis

Data Review and Cleaning

Each evening the project officer reviewed the incoming survey data with the aid of an automated script written in Excel. Data which appeared to be inconsistent or unclear were flagged for follow up the next day with respective interviewers. Corrections to the data file were made as needed, with each change recorded in a data review log. The survey file included several open-ended questions which were recorded in Kiswahili. At the end of the field study these responses were translated to English by a member of the field team. All data files were converted from Excel format to SPSS Statistics 22 (© IBM Corp.) for analysis.

Descriptive and Bivariate Analysis

Descriptive statistics are reported in Section 3 to summarize the characteristics typical of households and communities. Next, we examine and compare measures of livelihoods, health, and water services across three groups: households belonging to an MUS interest group in iWASH communities, households not belonging to an MUS interest group in iWASH communities, and control households.

Comparisons depend on bivariate statistical analysis, for example:

- Student's t-test to test whether there is a meaningful difference in average values for each group (i.e., significant at the p<0.05 level).
- Mann-Whitney U test to test whether the there is a meaningful difference in median values for each group (i.e., significant at the p<0.05 level).
- Chi-squared test to test whether the frequency of assignment to categories observed is likely not due to chance (i.e., significant at the p<0.05 level).

3. Results

A total of 1,377 household interviews were completed in 7 weeks of field work. Within 7 iWASH communities, 322 MUS interest group members and 410 non-members were enrolled in the study. Within 3 adjacent control communities a total of 645 households were enrolled. In addition, key informant interviews were conducted in each of the iWASH and control communities. Additionally, 35 water samples were collected by the field survey team and 7 water samples were collected by iWASH laboratory technicians.

3.1 Water Sources and Household Characteristics

Water sources

The study took place in 10 rural communities with a median population of 2,817 people and 648 households. Communities were located (on average) 93.1 km to the nearest paved road, 1.3 km to the nearest river, and 3.5 km to the nearest market. When comparing the main drinking water sources used by households in iWASH and control communities, most iWASH households depended on the piped water schemes (54%), well with rope or handpump (24%) and rivers (21%), whereas control households typically depended on rivers (49%) and handpumps (29%) (Table 5). For productive purposes, households reported accessing river water most frequently, as well as piped schemes (iWASH), rainwater harvesting systems and handpumps (control).

	iWA	ASH	Control		
	Main drinking water source	Water used for other purposes	Main drinking water source	Water used for other purposes	
Piped water scheme	54%	57%	10%	14%	
Public well with rope pump	19%	34%	0%	2%	
Borehole with handpump	5%	14%	29%	35%	
Traditional well	1%	15%	8%	14%	
Water vendor	0%	1%	3%	12%	
River	21%	70%	49%	78%	
Rainwater collection	0%	21%	0%	35%	

Table 5: Share of households using different water sources for drinking and other purposes

Note: More than one source possible for category "water used for other purposes"

Across all communities, the vast majority (84%) of constructed water systems were reported as working at the time of the study. Operation and maintenance of most water supplies was financed through regular contributions by water users. About half of the respondents declared paying for their water, either by monthly fee or per 20-L jerrycan. On average, water fees were \$0.38 per month or \$0.05 per jerrycan. Eight percent of households interviewed also belonged to a water point management group.

Household characteristics

Households were composed of 5 people on average, nearly all (98%) living in a single household units and identifying as either Christians (52%) or Muslims (46%). The typical household was established in the community for 10 years. The typical survey respondent was 35 years old, had completed primary education, and practiced farming, livestock production, and/or gardening as the main occupation. The median weekly expenditure for items such as food and transportation was Tsh 20,000 (USD \$10.00). Only one in ten households were equipped with electricity in the home.

Sanitation and hygiene

The majority of the households (59%) used an unimproved private latrine, while 17% lacked access to any sanitation facility. Most homes were composed of wood or concrete walls, a metal or thatch roof, and mud floors. Respondents typically reported having washed their hands about 5 times the previous day and nearly all declared handwashing as being very important.

Water is not treated at the system level for any of the piped supplies, and only 19% of respondents treat their drinking water at the household level. Among those treating their own water, most (93%) boil, whereas only 8% practice chlorination.

3.2 Comparing MUS and Control Communities: Livelihoods, Health and Environment

3.2.1 Livelihoods Activities

To assess the impacts of MUS on households' water-based livelihoods activities, we examined the following survey questions:

(a) Do you use source X for any of the following activities? (livestock production, gardening, farming, water vending, brick making, food vending, beer brewing, tree nurseries, other water-based enterprises, other)

- (b) How many of each of these animals does your household currently own? (Large stock, small stock, poultry)
- (c) Do you cultivate vegetables in the dry season? How many acres do you cultivate for vegetables in the dry season?
- (d) What is the approximate annual cash income generated by each of the following activities? Small livestock (ducks/chickens), medium livestock (goats/sheep), large livestock (cattle), gardening, farming, water vending, brick making, food vending, beer brewing, tree nurseries. (Answer: Estimate annual income for each water-based activities).

The results show that, among all survey respondents, the most common activities undertaken with the domestic water supply were livestock rearing and gardening (Table 6). Most households undertaking these activities were doing so for sale/income-generating purposes, with between \$20 - \$250 earned annually depending on the activity. Water vending, food vending, brick making, and beer brewing were less commonly practiced by the households interviewed. However, those who did practice these activities did so to generate relatively large amounts of cash. For example, among the eight MUS interest group members undertaking food vending, the average annual income from this activity alone was \$555.

Table 7 reports the average annual income earned by activity and household type. In summary:

- Livestock rearing: MUS members in iWASH communities were more likely than control households to be undertaking livestock rearing for their own consumption and sale purposes.¹ The typical MUS interest group member who raised livestock earned over twice as much income per year from this activity as compared to control households. The strong relationship between membership in a MUS interest group and income generation from livestock may be explained by the influence of Heifer International in iWASH communities, which specializes in enhancing rural livelihoods through animal husbandry.
- **Gardening**: MUS members in iWASH communities were also more likely to be undertaking gardening, as compared to control and non-member households.² When examining the dry season only, households within iWASH communities were significantly more likely to be cultivating vegetables, with 46% of iWASH households cultivating as compared to just 20% of control households. Within iWASH communities only, 63% of MUS interest group members were cultivating vegetables in the dry season, as compared to only 32% of MUS non-members (Figure 3). Chi square tests of independence confirmed the observed differences between

iWASH/control and member/non-member to all be statistically significant at the p<0.001 level (see Appendix for further details). In terms of the area of land being cultivated for vegetables in the dry season, members of MUS interest groups typically cultivated twice as much land (median = 1.00 acres) as compared to non-members and control households (median = 0.50 acres for both).³

- **Farming**: Even though farming was among the top activities for income generation, less than 10% of households reporting using their domestic water supply for farming purposes. This is explained by the fact that most households depended on rainfall for staple crop production.
- Water vending: A modest amount of income (\$38/year on average) was earned from water vending by two households within iWASH communities. Within our control communities there were no cases of households undertaking water vending. (However, water vending had been observed among control households by Winrock staff in the past.)
- Brick making: The domestic water supply in iWASH and control communities was used by only 2-3% of households for brick making. Over half of the households undertaking this activity did so for sale purposes, with an average of \$241 earned per year. There were no meaningful differences in the amount of income earned from brick making when comparing iWASH and control communities.
- Food vending: Across all communities 1% of households used their domestic water supply to support a food vending business. The most successful food vender was an MUS interest group member in an iWASH community who earned \$960 per year, more than twice the earnings of the second-place food vender.
- Beer brewing: Brewing beer for sale was practiced by 3-4% of households in both iWASH and control communities. The median income earned from beer brewing by MUS members was \$150/year, as compared to non-members in iWASH communities (\$35/year) and control communities (\$113/year).
- Diversification: MUS interest group members in iWASH communities were significantly more likely to diversify their water-based productive activities and earn more income per year using water.⁴ Figure 4 shows the median number of activities for each sub-group, as well as the median annual income earned from all water-based productive activities.



Figure 3: Cultivation of vegetables during the warm-dry season in iWASH and control communities



Figure 4: Median number of water-based productive activities undertaken and median annual income earned using water

		small livestock	medium livestock	large livestock	gardening	farming	water vending	brick- making	food vending	beer brewing	other activity
control	Undertaking:	35%	23%	10%	9%	3%	0%	2%	1%	3%	<1%
control	Sale:	19%	13%	6%	7%	2%	0%	2%	1%	3%	<1%
i\\/ASH	Undertaking:	46%	26%	12%	33%	6%	<1%	3%	1%	4%	<1%
Sal	Sale:	36%	17%	9%	28%	5%	<1%	2%	1%	4%	<1%
manabara	Undertaking:	68%	32%	19%	46%	7%	<1%	2%	1%	5%	<1%
members	Sale:	50%	23%	16%	41%	5%	<1%	1%	1%	5%	<1%
non mombors	Undertaking:	41%	21%	7%	89%	6%	<1%	3%	2%	4%	<1%
non-members	Sale:	26%	13%	3%	18%	4%	<1%	2%	1%	4%	<1%
ALL	Undertaking:	45%	24%	11%	21%	5%	<1%	2%	1%	4%	<1%
HOUSEHOLDS	Sale:	28%	15%	7%	18%	3%	<1%	2%	1%	4%	<1%

Table 6: Share of households undertaking and generating income with water-based activities

Table 7: Annual income generated from water-based activities with domestic water supply (USD)

		small livestock	medium livestock	large livestock	gardening	farming	water vending	brick- making	food vending	beer brewing	ALL ACTIVITIES
control	Mean (SD): Median:	21 (31) 10	56 (55) 30	224 (270) 125	198 (244) 128	256 (209) 180	none	241 (148) 200	196 (136) 130	138 (95) 113	105 (182) 30
iWASH	Mean (SD): Median:	44 (55) 25	94 (95) 55	363 (276) 250	483 (1,293) 180	236 (202) 150	38 (18) 38	240 (204) 200	253 (313) 114	225 (343) 88	301 (182) 85
members	Mean (SD): Median:	45 (45) 25	104 (92) 75	313 (294) 270	550 (1,584) 150	251 (168) 218	25*	200 (91) 200	555 (573) 555	293 (266) 150	401 (1,126) 133
non- members	Mean (SD): Median:	42 (68) 25	81 (99) 50	376 (193) 250	359 (360) 250	222 (232) 125	50*	264 (252) 200	152 (151) 77	158 (405) 35	186 (314) 50
ALL HOUSEHOLDS	Mean (SD): Median:	37 (50) 20	79 (83) 50	312 (281) 250	428 (1,173) 150	241 (202) 150	38 (18) 38	241 (174) 200	223 (230) 130	188 (270) 100	225 (685) 58

*Only one household

3.2.2 Income Generation

*Conversion rate: 2,000 Tsh = USD \$1

To assess the impacts of MUS on income generation at the household level, we examined the following survey questions:

- (a) During the RAINY months, about how much total income is earned each month by members of your household, including ALL activities? Repeat question for the DRY months. Help the respondent estimate by thinking through each income-generating activity. (Answer: Number)
- (b) About what share of your household income is earned by women in your household? (Answer: Very little (<10%); less than half; half; more than half; all; don't know/no answer)

The key results regarding income generation and MUS are summarized below:

- Total income earned (seasonal): Across all households the median income earned during the rainy and dry seasons, respectively, was \$100 and \$200. MUS interest group members typically earned the highest income, with \$125 earned during the rainy and \$350 earned during dry seasons. By comparison, households in iWASH communities who did not belong to an MUS interest group earned \$75 during rainy and \$200 during dry seasons. Households within control communities typically earned the lowest seasonal income, with \$80 earned during rainy and \$150 earned during dry seasons (Figure 5). Statistical analysis revealed that the seasonal income was greatest among iWASH villages (as compared to control)⁵ and among MUS interest group members (as compared to nonmembers)⁶.
- Share of income earned by women: Survey respondents were asked about the share of their total household's income that was earned by women in the family. Across all households, one in ten said women earned less than 10% of the total income, and four in ten said women earn half of the total income. Another one in ten reported 100% of the household's income being earned by a woman, in most cases because the female head of household was divorced or widowed. A greater share of respondents (67%) in iWASH communities reported women earning half or more of their household's total income, as

compared to control communities (51%).⁷ Within iWASH communities, women tended to earn a greater share of the income if their household was not a member of an MUS interest group (Figure 4). But this relationship was not found to be statistically significant.⁸



Figure 5: Median seasonal income earned by households within iWASH and Control communities and percentage households with women earning at least half of total income.

3.2.3 Food Security

Food security was assessed using the following question in the household survey:

How would you describe your household's situation with food security in the past year? (Answer choices: Very secure, somewhat secure, insecure, don't know/no answer.)

Interviewers explained the concept of food security in each respondent's native language and helped each respondent to understand the answer choices. Ideally, this perception-based indicator would be combined with additional objective measures, such as household-level food allocation behavior and individual-level child anthropometrics, to provide a more complete picture of the food security across the study area (Pinstrup-Andersen, 2009). However, the research team found this question to be the most straightforward to communicate to study participants, and it was shown to be reliable during pilot tests of the survey instrument.

Preliminary results show:

- Food security is significantly better in iWASH communities as compared to control communities.⁹ Within iWASH communities, 73% of households reported their situation with food over the past year as "very secure," as compared only 53% of households in control communities reporting the same.
- Within iWASH communities, food security is also significantly better among households belonging to an MUS interest group, as compared to households not belonging.¹⁰ Eightyfour percent of MUS interest group members report their food situation as "very secure" over the past year, whereas only 65% of non-members report the same. Figure 6 shows the relative share of households who report "very secure" across each category.



Figure 6: Perceived food security among iWASH and Control households

3.2.4 Nutrition

To assess nutritional status the household survey asked the follow question:

In the past week, did your family consume any of the following types of foods? Answer choices: starchy foods, beans, nuts, dairy, meat, eggs, leafy greens, vegetables, fruits.

This question draws on the FAO's recommended nutrition matrix for assessing nutritional status of women of reproductive age (FAO & FANTA, 2014). We focused on three key outcomes:

- The total number of food types that were consumed within the past week.
- Consumption of **animal products** such as meat, milk, and eggs, which provide iron, calcium, zinc, vitamin A, DHA, and choline (essential nutrients for pregnant women and young children).
- Consumption of **leafy green vegetables** which provide iron and folic acid, common micronutrient deficiencies in rural sub-Saharan Africa, especially among pregnant women.

Table 8 shows the relative share of households consuming each food type and mean number of food types consumed among each group. The typical MUS interest group member consumed 6.4 food types, as compared to 5.7 and 5.4 food types by iWASH non-members and control households, respectively (differences in mean values were significant at the p<0.05 level).¹¹

When examining consumption of leafy green vegetables, the survey revealed relatively high consumption rates (>90%) among households interviewed. A slightly higher share (95%) of iWASH households had consumed leafy green vegetables in the past week, as compared to control households (92%). However, this difference was not statistically significant.

When examining consumption of animal products (meat, milk and eggs), the survey revealed that 91% of MUS interest group members had consumed at least one animal product and 21% had consumed all three in the past week. This is in stark contrast with control households, of which 75% had consumed one animal product and only 6% had consumed all three (differences in rates of consumption of animal products were significant at the p<0.01 level).¹²

Interestingly, more iWASH households consumed every food type as compared to control households, with the single exception being the broad category "vegetables." This finding is surprising considering iWASH households (especially MUS interest group members) were more

likely to be gardening in the dry season and cultivating larger garden plots. Further discussion with study participants is needed to understand why control communities are more likely to be consuming vegetables, contrary to expectations.

	Control (n = 645)	iWASH MUS non- members (n = 408)	iWASH MUS members (n = 324)
Starchy foods	99%	100%	100%
Beans	92%	93%	97%
Nuts	25%	29%	35%
Dairy	29%	37%	57%
Meat	68%	75%	84%
Eggs	18%	25%	34%
Leafy Greens	92%	94%	95%
Vegetables	81%	69%	67%
Fruits	47%	52%	71%
Mean number food types consumed	5.5	5.7	6.4

Table 8: Share of households consuming each food type in the past week and mean number offood types consumed.

3.2.5 Illness and Injury

It is expected that water supply schemes within the iWASH program improved drinking water quality, reduced rates of waterborne and water-related illnesses (especially among young children), and reduced risks associated with fetching water from distant sources. To assess the impacts of MUS on rates of diarrheal disease, respiratory illness, and injuries experienced during water collection, we included the following survey questions:

- (a) (Among families with at least one child under the age of 5): Has your child(ren) been sick with diarrheal or respiratory illness within the past week? (Answer choices: Yes, no, don't know)
- (b) If yes, how many? (Answer: Number)
- (c) In the past year, has anyone of any age in your home been hurt while collecting water, either along the path or at the water point? (Answer choices: Yes, no, don't know)

The graph below shows that among iWASH communities, there are fewer incidences of diarrhea, respiratory illness, and injuries due to water fetching, as compared to control communities (Figure 7). Statistical comparisons reveal a significant difference in the rate of injuries related to water fetching between control and iWASH communities.¹³ However, the study was not powered to detect differences in diarrheal disease and respiratory illness incidence among children under five with statistical significance.



	Control	iWASH
diarrhea (<5 yrs)	10%	5%
respiratory illness (<5 yrs)	10%	7%
injury (all HHs)	12%	3%



3.2.6 Drinking Water Quality

In order to estimate the quality of drinking water across communities, two samples were collected across study communities. First, 36 water points were tested using the Msabi H_2S test

and 7 water points were tested for total and fecal coliforms by a local laboratory. Results are interpreted based on the WHO health risk categorizations shown in Table 9. As mentioned in section 2.3, because of the small sample size and the absence of daily control measures, the results presented here are descriptive and need to be interpreted with care.

Health risk category	CFU/100mL		
Low risk/safe	0		
Intermediate risk/probably safe	1 - 9		
High risk/Probably Unsafe	10 – 99		
Very High risk/unsafe	>100		

 Table 9: Health risk categorization based on World Health Organization Drinking Water Quality

 Guidelines for E. coli concentrations

Msabi H₂S Test Results

The graphs below present the relative proportion of samples categorized as low, intermediate, high, and very high risk, divided by community and water point type. There is no obvious difference in water quality when comparing iWASH to control communities, although small sample sizes make interpretation difficult. In terms of water point type, we categorized water points as "improved" or "unimproved" according to the WHO/UNICEF Joint Monitoring Program (JMP) definitions (Joint Monitoring Programme, 2014). The Msabi test showed a clear difference of water quality between improved and unimproved drinking water sources (Figure 9). The majority of water samples taken from improved sources were categorized as "intermediate risk/probably safe," as compared to only 17% of unimproved water sources. Further, "very high risk/unsafe" water represented 14% of the improved water sources and 67% of the unimproved water sources.¹⁴



Figure 8: Health risks associated with drinking water quality among iWASH and control communities



Figure 9: Health risks associated with drinking water quality according to the category of drinking water source

Table 10 presents the health risk associated with each type of water point tested according to the Msabi test results. Piped water schemes and handpumps delivered safer water at the point of collection as compared to unimproved drinking water sources.¹⁵ However, no water samples were categorized as low risk/safe (free from microbial contamination).

		Low risk/ safe	Intermediate risk/ probably safe	High risk/ probably unsafe	Very high risk/ unsafe
Improved drinking water source	Piped water community tap (n=20)	0%	80%	10%	10%
	Community handpump (n=5)	0%	100%	0%	0%
	Community rope pump (n=4)	0%	25%	25%	50%
Unimproved drinking water source	Traditional well (n=1)	0%	0%	0%	100%
	River (n=5)	0%	20%	20%	60%

Table 10: Health risks associated with drinking water quality according tothe type of drinking water source

Laboratory results

Laboratory analyses detected no presence of fecal coliform on all water points tested. However, the concentration of total coliforms varies within the same community (Table 11). Both communities tested by the laboratory are equipped with a piped water supply system with a unique source tank.

	Coliform count (Total / Fecal)				
Community	0	1 - 9	10 - 99	>100	
Pemba (n=5)	40% / 100 %	60% / 0%	0% / 0%	0% / 0%	
Msolokelo (n=20)	0% / 100%	50% / 0%	50% / 0%	0% / 0%	

3.2.7 Satisfaction with Water Services

The satisfaction with the water services was evaluated with the following question in the survey:

Overall, how satisfied would you say you are with your water supply situation? (Answer choices: Very satisfied, somewhat satisfied/dissatisfied, dissatisfied, don't know/no answer).

Results show:

- Satisfaction is significantly better in iWASH communities as compared to control communities.¹⁶ In iWASH communities, 49% of households declare to be "very satisfied" with their water supply system, whereas in control communities 24% declare the same. Households "not satisfied at all" represent 24% in iWASH communities and 55% in control communities.
- Within iWASH communities, the proportion of "very satisfied" households is higher among members of an MUS interest group compared to non-members (57% and 44% respectively).¹⁷ By contrast, the proportion of "dissatisfied" households is relatively similar across these groups (22 and 26% respectively) (Figure 10).



Figure 10: Self-reported satisfaction with water services among iWASH and control households

3.2.8 Reliability

To assess the reliability of drinking water schemes, we probed (a) the current functionality status of households' main drinking water source, and (b) the duration of any recent major interruption in water service. The relevant household survey questions are:

- (a) Is your main drinking water source functioning now? (Answer choices: yes, functioning well; yes, functioning but not well; no, not functioning; don't know/no answer).
- (b) In the last 6 months, were there any times when water from your main drinking water source was not available for more than one day? (Answer choices: yes; no; don't know/no answer).
- (c) How many days did the last interruption in service last? (Answer: number).

Results show that:

- The vast majority of drinking water points (99.5%) were functioning at the time of the survey, although about one in six water points were not functioning well.
- There was no meaningful difference between drinking water points' functionality status across iWASH and control communities. In both cases, the vast majority (84%) were functioning well, 16% were functioning but not well, and less than 1% were not functioning at all.
- In the past 6 months, households in iWASH communities were more likely to have experienced a day-long interruption in their water service as compared to households in control communities¹⁸, with 52% and 24% of households reporting an interruption, respectively.
- Despite experiencing more frequent interruptions, the typical duration of the interruption in iWASH communities (9.2 days on average) was significantly less than the duration in control communities (21.5 days on average).¹⁹ Within control communities, 10% of households had waited one month or more for water service to resume, as compared to only 3.5% of households in iWASH communities (Figure 11).

3.2.9 Fetching Time

The study team assessed the time spent fetching water by asking about the typical time needed to make a round trip (including walking to source, queuing, and returning home) to the household's main drinking water source at the time of the visit.

Results show:

- Across the entire sample of households (n=1,377) there is a wide range in collection times, with 10% reporting their round trip walk time being less than 5 minutes, and on the other hand, 10% reporting 3 hours or more needed to make a single round trip.
- The typical (median) walk time among households in iWASH communities is half the typical walk time among households in control communities (15 minutes versus 30 minutes, respectively).
- Within iWASH communities, 25% of households spend over 30 minutes on a round trip to the source, as compared to 50% of households in control communities.

Figure 12 shows the distribution of round trip walk times in iWASH (MUS group members and non-members) and control communities.

Figure 12: Distribution of time spent fetching water among iWASH and control households

4. Synthesis and Lessons Learned

This goal of this study was to systematically investigate how rural households in the Morogoro region were impacted by the iWASH program in terms of livelihoods, health, and water service outcomes. In the absence of baseline data which would have allowed for a direct comparison of the before/after situation of each program participant, we instead made use of a control group and a strategic sampling approach targeting various household typologies.

Study Limitations

Due to the limitations inherent to any study of this design, the results reported here are likely conservative estimates of the impacts of MUS on livelihood, health, and water services. The most obvious limitation is the possibility that control communities are not actually similar to iWASH communities' pre-enrolment status. For example, it is possible that control communities (despite

not participating in the program directly) benefited indirectly from the MUS project in neighboring communities. Such "spill over" benefits could be explained by control households traveling to neighboring communities to use an iWASH water point, or through iWASH improving the selection of food and other products at local markets. In the event of control households benefiting from iWASH indirectly, the comparisons between iWASH and control would be less pronounced than reality.

An additional limitation of the study includes that it depends heavily on survey data collection and is therefore prone to certain types of bias, such as survey respondents' desire to give affirmative answers after participating in a water supply program. To control this issue the survey instrument made use of as many objective measures as possible. Also the data analysis team periodically discussed results with the iWASH field staff as a "reality check." Finally, it is important to note the research team visited study communities only two to five years after the iWASH project began. While this follow up period is enough to capture early benefits of the project, ideally a follow up study would take place five or more years later to understand the longer-term benefits of MUS.

Key Findings

The results presented in this report focus on directly comparing measures of livelihoods, health, and water services across iWASH and control communities, with iWASH being divided into those households belonging and not belonging to an MUS interest group.⁴ *Overall, we find that households in iWASH communities are experiencing greater benefits than households in control communities. Moreover, MUS interest group members tend to be experiencing greater benefits than non-members.* Certain isolated exceptions to this general rule were found, for example in terms of greater vegetable consumption and less frequent water service interruptions within control communities.⁵ In summary:

Livelihoods. The most common activities undertaken with the domestic water supply were livestock rearing and gardening, with staple crop farming more commonly supported by seasonal rains. The typical annual income earned from these activities ranged from \$20-250, depending on the activity and community. Other activities undertaken with domestic water supplies included water and food vending, brick making, and beer brewing. Relatively fewer households undertook

⁴ A follow-on peer reviewed publication will use statistical matching to control for factors known to influence participation in rural water supply programs.

⁵ Less frequent water service interruptions is likely explained by control communities depending more heavily on unimproved water sources.

these activities, but for those who did the earnings reported were relatively high. For example, among those MUS interest group members selling food, the average annual income from this activity alone was \$555. Overall and for virtually every activity, households within iWASH communities (and especially MUS interest group members) were more likely to be undertaking and earning more income from activities with water. iWASH households were also able to better diversify their portfolio of water-based activities, with MUS members undertaking twice as many activities, on average, as compared to other households.

Income. Total income earned was higher in the dry season than in the rainy season. Seasonal income was highest among iWASH households belonging to an MUS interest group, with \$125 and \$350 earned in the rainy and dry season, respectively. This is nearly twice the income earned in control communities (\$80 and \$150 in rainy and dry, respectively). Finally, a greater share of respondents (67%) in iWASH communities reported women earning half or more of their household's total income, as compared to control communities (51%).

Food security. Households within iWASH communities were more likely to report being food secure, with three quarters of households reporting "very secure" as compared to about half of households answering the same in control communities. MUS interest group members fared best, with 84% reporting "very secure."

Nutrition. iWASH households consume a wider variety of food types as compared to control households, with MUS interest group members consuming the greatest number of food types on average (6.4). In contrast to a past studies, consumption of leafy green vegetables was very high overall among all survey respondents (>90%). However, MUS interest group members were much more likely to have eaten one or more animal products (meat, milk, or eggs) in the past week, as compared to control households.

Illness and injury. Within iWASH communities there were fewer incidences of diarrhea disease and respiratory illness among children under age five, as well as injuries due to water fetching among all age groups. While the difference in rate of injury was statistically significant, further research and a larger sample size is needed to better assess impacts of MUS on child health.

Drinking water quality: Water quality analysis was limited by a small sample size and the use of two different test kits. Msabi field test kits revealed no meaningful difference between the quality

of drinking water in iWASH and control communities. However, when categorizing water points based on the WHO-UNICEF Joint Monitoring Programme, we found that three-quarters of improved water sources were "probably safe" (1-9 CFU *E.coli* perml) versus only one-third of unimproved water sources meeting the same standard. No drinking water samples were free of fecal indicator bacteria when tested with the Msabi test kit.

Reliability: Virtually all water points (iWASH and control communities) were functioning at the time of the visit. iWASH households were more likely to report experiencing interruptions in their water service lasting 1 day or more, as compared to control households. However, when control communities did have an interruption in service, its duration was typically twice as long (9 days versus 22 days in iWASH and control, respectively). Despite iWASH water schemes breaking down more frequently (probably explained by their relative complexity), they are more resilient to such "shocks" and resume water service more quickly than in control communities.

Time spent fetching water: The typical household in iWASH communities spent half the amount of time (15 minutes) on a single round trip as compared to a household in control communities (30 minutes). However, within iWASH communities some households were still spending many hours collecting water. Especially for those households not belonging to an MUS interest group, 1 in 5 spent more than one hour on a single round trip to their main water source.

Conclusion

This study finds an overall large and positive impact of a comprehensive MUS project on rural households' well-being. Based on a large household survey and water quality analysis, results show that the iWASH program has improved the livelihoods, health, and water services for rural communities throughout the Morogoro region. Especially striking were the dramatic benefits experienced by those households participating in an MUS interest group designed to support impact boosting activities with water, such as animal husbandry and market gardens. The results of this report lend strong evidence to ongoing water sector dialogue regarding the role of MUS as a means to alleviate poverty and improve the health and well-being of the rural poor.

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6. Appendix

Statistical test results (Section 3):

¹ Chi-squared test: $X^{2}(2, N = 1,377) = 114, p < 0.001$ ² Chi-squared test : $X^{2}(2, N = 1,377) = 181, p<0.001$ ³ Mann-Whitney test: U = 10.48, p<0.01 ⁴ Mann-Whitney test: *U* = 49-119, p<0.001 ⁵ Mann-Whitney test: *U* = 42.80, p<0.001 ⁶ Mann-Whitney test: *U* = 24.14, p<0.001, *U* = 36.86, p<0.001 ⁷ Chi-squared test: $X^{2}(4, N = 1,202) = 43.79, p<0.001$ ⁸ Chi-squared test: $X^{2}(1, N = 666) = 3.46, p=.07$ ⁹ Chi-squared test: X^2 (2) = 65.57, p<0.0001 ¹⁰ Chi-squared test: X^2 (2) = 33.97, p<0.0001 ¹¹ Student's t-test for independent samples ¹² Chi-squared test of independence ¹³ Chi-squared test: X²(1, N = 1,377) = 42.57, p<0.001 ¹⁴ Chi-squared test: X^2 (2) = 8.905, p=0.012 ¹⁵ Chi-squared test: X^2 (8) = 15.959, p=0.043 ¹⁶ Chi-squared test: X^2 (1) = 95.79, p<0.0001 ¹⁷ Chi-squared test: X^2 (1) = 12.308, p<0.0001 ¹⁸ Chi-squared test: X^2 (1) = 109.33, p<0.001 ¹⁹ Mann-Whitney test: U = 21,817, p < 0.01

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