Evaluation of User Preferences for Household Water Treatment Technologies in

Woliso, Ethiopia

Ethiopian Kale Heywot Church
Development Commission

CAWST

D. KEITH MACDONALD FOUNDATION

Contents

Acronyms

BSF	Bio Sand Filter
EKHC	Ethiopian Kale Hewitt Church
HSTP	Health Sector Transformation Plan
HWTS	Household Water Treatment and Safe Storage
RANAS	Risk, Attitude, Norms, Abilities, Self Regulation
SHG	Self-Help Group
WET Centre	Water Expertise and Training Centre
WHO	World Health Organization

1: **Introduction**

Over 40% of the population in Ethiopia does not have access to improved water sources. Of those who do, many still consume contaminated drinking water due to unsafe water collection, handling, and storage practices. *E.coli* in water indicates that human or animal feces are probably present. In Oromia, Ethiopia, 47% of households have drinking water with >100 cfu/100 mL *E.coli*. (Statistical Agency of Ethiopia, 2017). The World Health Organization (WHO) classifies water with >100 cfu/100 mL *E.coli* as being “very high risk” [1].

Household water treatment and safe storage (HWTS) can improve health by removing pathogens from drinking water. The government has set a target under the Health Sector Transformation Plan (HSTP) of reaching 35% coverage of HWTS by 2020 [2]. The current baseline coverage is 6%. The Ministry of Health and the WHO organized a working group to develop guidelines and specifications for HWTS technologies. The overall goal of the regulation is to ensure effective technologies are promoted for public health interventions, and to optimize related health outcomes.

Whether or not HWTS technologies improve health depends on a person’s current pathogen exposure through drinking water, the theoretical performance of the HWTS technology, as well as how the technology is used. To contribute to better health, a technology must be able to perform well in the given setting. It must remove the pathogens and/or chemicals in a particular community that put people at risk of illness. In addition, technologies must be used correctly, consistently, and continuously (the 3 C’s) by those who are at risk. If households do not use them correctly, they are unlikely to perform well. If households do not use them consistently, the household members may still consume pathogens and be at risk of illness. Finally, if households do not use them continuously, health improvements will only be temporary.

The Ethiopian Kale Hewitt Church (EKHC) Development Commission contains a Water, Expertise, and Training (WET) Centre. As a part of their mandate, the WET Centre has been researching HWTS technologies. In Ethiopia, there is currently high interest in the marketability of technologies. The WASH sector is increasingly acknowledging that market-based approaches may improve the sustainability of technologies. However, there is little information available about what works in rural Ethiopia.

To address the knowledge gap, the WET Centre studied different HWTS filters currently available in Ethiopia in a field trial. The study included water quality testing and user interviews after more than one year of use. The study also found the criteria that households have for HWTS, and then evaluated each technology based on these criteria. Households that continued to use their filters consistently after a year were compared to those that did not, to guide future interventions. Finally, we conducted a small market study in the community to estimate the willingness of households to pay for filters.

The study was limited in that it only trialed five of each type of filter. With such a small study the performance of each filter, and the user impressions, cannot be extrapolated to other communities or distribution models. However, even with this limitation, the study highlights some strengths and weaknesses of each of the technologies.

2: **Methodology**

The self-help group (SHG) approach was introduced in Ethiopia in 2002 by Knidernothife and Tearfund in 2002. EKHC Development commission has 249,025 SHGs in Ethiopia. SHGs are groups of 15-20 women or men who self-organize to address individual and communal needs using their own resources. Groups receive training and support over a 3-year period, with the most intensive support being in the first 6 months. Each group creates their own by-laws and record keeping system. They save money on a weekly basis, and borrow from the fund (paying interest) to create small businesses. The savings are not accessible until a member leaves the group. Members address welfare and educational needs at the household level and build their adaptive decision making capacity. SHGs enable members to assume leadership roles (especially women), and enhance the economic capacity of members.

EKHC has self-help group (SHG) programs in eight of the 38 Kebeles in Woliso District. Dere Duleti Kebele was selected for this study because the source waters for households in this Kebele were unprotected springs. In addition, in 2012, nine children died in this Kebele due to an outbreak of acute watery diarrhoea. Dere Duleti has 17 SHGs, each with 10 to 20 members. A lottery method was used to select 35 households from the 17 SHGs.

Seven filters were selected for the study: BSF, Clay pot, Lifestraw, Minch, Sandstorm, Sawyer, and Tulip siphon. These were all locally available and promoted in rural Ethiopia for household use. The Lifestraw filter was the most expensive of these technologies at 1500 birr. Five households tested each type of filter.

The 35 participating households received their filters on March 2, 2017. Representatives from the 35 households participated in a focus group discussion in May 2017. By this time, the households had used their filters for three months. Results from this focus group helped to identify what parameters were of highest importance to the households.

The study team visited the households to test the water quality three times during the study. These visits were in May 2017, September 2017, and April 2018.

At the end of the study, in April 2018, a questionnaire was given to 45 households in the community. The 45 households included the 35 households who had tested filters, along with 10 neighbouring households. This survey was in order to test the potential of selling filters in the community. The 35 test households also answered a series of questions about their experiences with the filters over the previous year.

2.1 Study Limitations

There were five major limitations to this study:

1. **Study size:** This study included only five filters of each type. This is too few to make any clear conclusions about the specific technologies.
2. **Non-randomization of filter distribution:** The filter distribution was not random. Rather, households situated near one another were

given the same technology. This was to prevent possible dissatisfaction or jealousy amongst near neighbours. However, it also means that negative experiences from one household would affect the perceptions of the same technology by the other households.

3 **Replacement of some technologies:** Due to a change in the filter's design, Desert Rose Consulting replaced all five of the Minch filters on May 15, 2017. At the time of the first water quality test in May 2017, the new Minch filters had only been in place for four days. By May, one Sandstorm filter had too high a flow rate and three of the Tulip Siphon filters were no longer usable. In one, rats ate through the tubing. Another broke after it was dropped. The third had a very low flow rate. Desert Rose consultancy re-installed the Sandstorm filter in June 2017. Tulip Addis replaced the three tulip siphon filters in July 2017. These replacements meant that some technologies tested had actually been in use for less time than the others. It also means that some filter recipients received more contact and instruction than others.

4 **Frequency of visits:** As well as community visits by the study team for testing, and by manufacturers for filter replacement, there were four additional visits by CAWST during the study period to observe the action research and for the development of promotional materials. These visits occurred in April 2017, August 2017, October 2017, and March 2018. During each of these visits, one household per technology was visited. However, because filter distribution was grouped, the entire study group would have been aware of the visit and would likely have interacted with the foreign visitors. The high number of community visits (3 for the study, plus technology replacement visits, plus 4 additional visits) will have affected user perceptions and rates of continued usage by households as compared to a typical intervention. Biases of the study team and visitors (e.g. due to conclusions from the first report) may also have unintentionally influenced study participants.

5 **Local input:** Due to logistical limitations, some of the study design which should have occurred locally was prepared by the Addis team (discussed further in section 5.2.1). This may have impacted user responses during the market study component of the study.

One additional consideration is that the filters were distributed as they would be in the local market, not necessarily according to manufacturer best practices. For example, Sawyer instructs that its filter be distributed with a safe water storage container with a tap. However, in Ethiopia, the filter re-sellers do not currently provide a safe water storage container when the filter is purchased. Likewise, users received less instruction and follow-up with the Lifestraw filter than is recommended by the manufacturer, as in a market environment there is very little in-person instruction and follow-up.

Given these limitations, this study should not be considered conclusive. Instead, it should be used to identify interesting trends.

Figure 1: A traditional house with a thatch roof, and a modern house with a tin roof

2.2 **Study Location**

The study took place in Kondala Village, Dere Duleti Kebele, Woliso District, Southwest Shoa zone in the Oromia Region. Kondala Village is 12 km away from Woliso town. In Dere Duleti there are 38 SHGs and 1357 households in total. The community's main sources of income are trade, pottery, and some agriculture.

Spring water in the Woliso region is typically of high health risk, with >100 *E.coli* colony forming units per 100mL.[3]

The average size of households in the study was six people, with a range of 2 to 11. Twenty-six of the households, or 74%, included at least one child under age 5. Two families in the study had lost children to diarrhea. Four other respondents mentioned the outbreak of acute watery diarrhoea in which 9 children died. From observation, the water-washed disease trachoma was endemic within the community.

Of the 45 households interviewed in the final survey (35 study participants and 10 neighbours), 38% (17) had only one room in their house. Thirty-one percent of homes were of traditional mud construction with a thatch roof (Figure 1). The median reported monthly salary was 400 ETB ($14.50 USD).

Figure 2: Water collection from the spring

3: **Water quality testing**

The filter performance was measured through water sampling of filters in use after 3, 6, and 13 months.

For filters without a built-in safe storage container (BSF, Sandstorm, Sawyer, and Tulip Siphon), a sample was taken from the untreated water, direct from filter, and from the filtered water storage. For filters with a built-in safe storage (Clay pot, Lifestraw, and Minch) a sample was taken from the untreated water and from the filtered water storage. Samples were collected aseptically in sterile Whirlpak bags, kept cool, and tested within 6 hours. Testing was by the membrane filtration method, using membrane lauryl sulphate broth (MLSB) as a substrate. Samples were incubated at 440C degrees for 18 hours.

The Tulip Siphon filters were not tested at 13 months, as none were still in use at the time of sampling.

For some samples, the *E.coli* levels in the effluent water were below the detection limit of 1 cfu/100 mL. In these cases, the actual removal rate could not be calculated. The removal rate was calculated using the detection limit, with a greater-than sign (>) indicating that the actual removal rate was higher than what is presented.

The WHO recommends that a technology be able to remove a minimum of 2 log10 *E.coli* colony forming units (cfu). This is equivalent to a 99% removal rate of *E.coli*. The only technology for which the median removal rate met this requirement in the filtered water storage container at all three visits was the Minch.

The BSF, Sandstorm, and Sawyer filters all had recontamination post-treatment.

Table 1: Median performance direct from filter (no built-in safe storage)

Filter	Median *E.coli* Removal		
	3 months	6 months	12 months
BSF	**99%**	90%	**>97%**
Sandstorm	**99%**	**>92%**	**>99%**
Sawyer	**99%**	**>99%**	98%
Tulip siphon	98%	92%	**n/a**

Table 2: Change in quality of drinking water for the end user (from storage container)

Filter	Median *E.coli* Removal		
	3 months	6 months	12 months
BSF	**99%**	75%	96%
Clay pot	86%	**99%**	-20%
Lifestraw	**>99%**	**>99%**	95%
Minch	**>99%**	**>99%**	**>99%**
Sandstorm	97%	87%	64%
Sawyer	93%	87%	-157%
Tulip siphon	**>99%**	55%	**n/a**

4: **User perceptions**

4.1 **User criteria**

In the May focus group, households shared their criteria for a filter. In the end line survey, they rated the filter they were testing against those criteria. Each criterion was graded on a 5-point Likert scale, where a 5 indicated the most positive response and 1 the most negative. Durability was assessed as how many of the original five filters were still functional at the time of the endline survey.

Nearly all respondents, regardless of which filter they had, felt their household's health was "much better" when they used filtered water. Only one respondent said "a little better."

In contrast, no respondent gave a "5" for either volume produced or flow rate for any of the filters.

From the point of view of the household's criteria, the filter that performed best overall, having an average score of at least 4 in all categories other than volume and flow rate, was the BSF.

Table 3: Average user perceptions, by filter

		BSF	Ceramic Pot	Lifestraw Family 2.0	Minch	Sawyer	Sandstorm	Tulip Siphon
Filter	Effort to use	4.4	4.6	5.0*	5.0*	4.2	2.8	2.8
	Effort to maintain	4.6*	4.4	1.8	3.8	3.6	2.8	1.4
	Filter's appearance	4.2	3.4	4.4	5.0*	4.2	3.4	4.2
	Durability	5*	4	2	5*	5*	4	4
	Volume	3.6*	2.8	2.0	3.2	2.6	3.2	2.8
	Flow	3.0	2.8	2.4	2.8	2.4	3.4*	1.6
Finished water	Temperature	5.0*	3.5	3.4	3.6	4.0	4.0	3.8
	Taste	4.8	4.0	4.0	4.6	5.0*	4.6	4.2
	Smell	4.8*	4.0	4.0	4.2	4.4	4.4	4.4
	Appearance (i.e. clarity, colour)	4.6	4.5	4.2	4.6	4.2	5.0*	4.3
Other	Health impact of using filter	5.0*	4.8	5.0*	5.0*	5.0*	5.0*	5.0*
	Overall happiness with filter	4.6	3.2	4.0	4.6	5.0*	5.0*	4.2

A * indicates that the score was the highest in this category

Figure 3: Local children on their way to collect water

4.2 User demonstrated preferences

Households must use their HWTS consistently and continuously in order to realize a sustained health improvement. A substantial time period is required to test whether technologies can successfully be integrated into a family's routine. This study tested continuity by asking whether the household still used their technology, which was confirmed by observations by the study team at 3 months, 6 months, and 13 months after filter distribution. To test for consistency, households that were still using their filter estimated on a 5-point scale what proportion of the water they drink was first treated by their filter (Table 4).

The BSF, Minch, and Sandstorm had all five households still using the filter by the end of the study, with the BSF having the highest number of households reporting consistent use (though the difference between BSF, Minch, and Sandstorm was very small). The Tulip Siphon was no longer in use by any household.

The enumerator then gave the respondent seven picture cards illustrating the filters in the study. It was assumed that the respondent would be familiar with all seven from having participated in the earlier focus group, and from having the other filters be present in the village. The respondent selected which of the seven, if any, they might be interested in. The price of the filters was not discussed at this point. How they responded once the price was revealed is discussed in section 5.2.3.

Table 4: Filter interest

	BSF	Ceramic Pot	Lifestraw Family 2.0	Minch	Sawyer	Sandstorm	Tulip Siphon
Filter still in use	5*	3	1	5*	3	5*	0
User filters "Almost all" of their water	4*	2	1	3	1	3	0
# who expressed interest in the filter (price not considered)	18	1	6	17	10	19*	3

Figure 4: A local home in the study area

4.2.1 Behaviour Change

One of the secondary objectives of this study was to look at psychosocial differences between those who chose to continue to use their filter, as compared to those who had functional filters but did not continue to use them. A rough Risk, Attitude, Norm, Ability, Self-Regulation (RANAS) model was used to identify key differences. Fourteen households said that they treated "almost all" of their drinking water. There were no households from the Tulip Siphon filter who were in this category. There were 17 households who had functioning filters but either did not use them or only treated a portion of their drinking water. There were households from all seven of the treatment groups in this category. The four households with non-functioning filters were excluded from this portion of the analysis.

Table 5: RANAS results

What non-users think about filters compared to users	What we want the target individuals to think in the future	Behaviour change techniques (taken from the RANAS manual)
Risk factors ■ There was little difference between users and non-users	n/a	n/a
Attitude factors ■ Non-users were less likely to be happy with their filter	Filtering water is a positive, pleasant behaviour.	Describe feelings about performing and about consequences of the behavior: present the performance and the consequences of a healthy behavior as pleasant and joyful and its omission or an unhealthy behavior as unpleasant and aversive.
Norm factors ■ Non-users gave a lower rating as to how they believed that their neighbours perceived their filter	Neighbours would like to have a filter too.	Inform about others' behavior: point out that a desired behavior has already been adopted by other persons.
Ability factors ■ Non-users perceived both using and maintaining the filters much more difficult than users did	Using and maintaining a filter is easy	Prompt guided practice: ■ train participants in behaviour enactment by giving instructions, ■ demonstrate the behaviour, ■ *and then let him/her practice.* ■ Give feedback about the correctness of the performance.
Self-regulation factors ■ There was little difference between users and non-users	n/a	n/a

The biggest difference between households that used filters after 13 months and those that did not was in their perceptions about how difficult the filter was to use.

The results of this analysis need to be interpreted with caution and in context. For example, it is likely that how happy a household was with its filter and how much they believed that their neighbour liked it were correlated. It is not straightforward to determine which of the two was more important. Likewise, a household may have been unhappy with their filter because they perceived it as difficult. To ensure correct, consistent, and continued use of the technologies, more attention needs to be given to building the confidence in users that they are capable of using and maintaining the technology.

Figure 5: The study team discusses the findings

5: **Market study**

5.1 Interest in Alternative Payment Options

For most of the participants in this study, the cost of the filters was equivalent to several months' income. As such, a filter purchase would be a major household expense and require some strategy for payment. Respondents were asked to rate their level of interest in several alternative payment options.

- More than half of respondents expressed that they would "definitely" be interested in an installment payment scheme if a filter were too expensive for them.
- Respondents were less interested in joining family or neighbours to purchase a filter (though more than half would still be "likely" to be interested). The main reason given for this was that the filters were to too slow and produced too little for a single family.
- Most respondents would not want to use their savings plan to pay for a filter. The common reason given for this was that their savings were specifically for income-generating activities.

Figure 6: Openness to alternative payment schemes

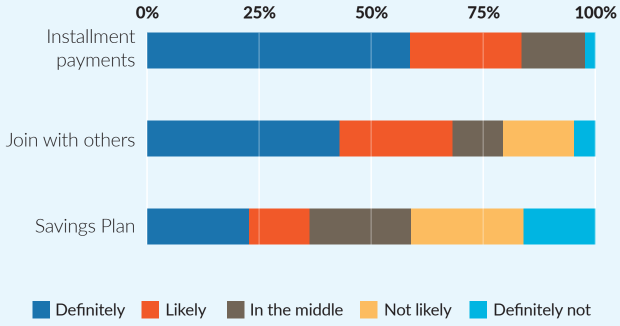


Figure 7: Respondent ranking the value of a filter compared to other objects

5.2 Setting a price

5.2.1 Relative value of a filter as compared to other objects

Respondents ordered six picture cards (a sheep, a mobile phone, a kitchen shelf, a jacket, a table with stools, and a filter) from what they believed was the lowest priced object to the highest priced object. An attempt was made to select objects that would be familiar to respondents and worth about 300, 600, 900, 1200, and 1500 ETB, encompassing the range of actual prices of the filters. The filter image for each household was the filter that they had been testing, or, in the case of neighbours, the closest filter to the household.

The responses to this question had some variability due to the difference in interpretation

Figure 8: A local home with thatched roof

by respondents as to the quality of each of the items depicted, and thus the price. Ideally objects would be chosen in a focus group so that they would be specific to the community, and would be depicted clearly enough for there to be less room for interpretation. This was not possible in the current study due to logistical and time constraints, so the study team in Addis selected the objects. Despite this uncertainty, the results are informative.

Respondents perceived the cost of a filter as being between above that of a mobile phone, and similar to that of a kitchen shelf. For context, 67% (30/45) households interviewed owned a mobile phone, while only 13% (6/45) had a kitchen shelf.

5.2.2 **Price range for filters**

In the focus group three months into the study, participants gave the acceptable price range for a filter as being 150 to 300 birr, with a price of > 300 ETB being unacceptable and a price < 150 ETB being ideal.

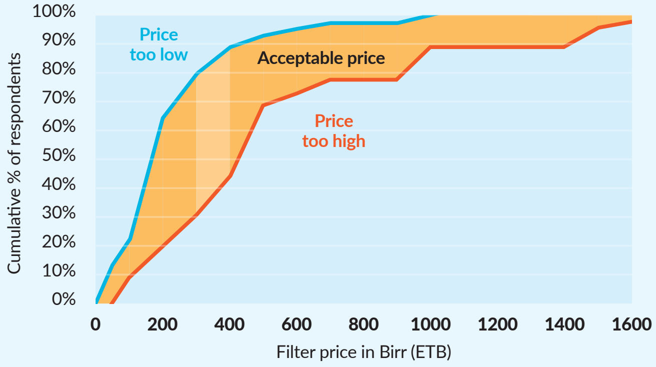
This range shifted during the final survey. Respondents were asked if they saw a filter in the market, at what low price they would begin to question its quality and ability to clean water. The median low price given was 200 ETB.

Respondents were then asked if they saw a filter at the market, at what high price they would think that the seller was crazy, or out-of-touch. The median high price given was 500 ETB.

There was a large range in the responses to this question, with some listing 50 birr as an acceptable low-end price, and some listing 1500 birr as an acceptable high-end price. Several respondents noted that the exercise was difficult for them, since they had never seen a filter on the market and so did not know what the price should be.

In Figure 9, the red line indicates the cumulative percent of respondents (y-axis) for whom the given price (x-axis) was too large. A respondent who stated that 500 birr was too expensive would also find any price greater than 500 birr to be too expensive. For example, at 500 birr, 69% of respondents had stated either that 500 birr was too expensive, or that a number below 500 birr was too expensive. In contrast, the blue line represents the minimum price given by respondents. The yellow space indicates the proportion of respondents who find each price acceptable. At 500 birr, 93% of respondents had listed a price lower than 500 birr as not being too low. The percent of respondents for who 500 birr would be an acceptable price is the space between the two lines, 93% - 69% = 24%. It follows that the size of the potential market in this community for a filter costing 500 birr would be about 24% of households.

Figure 9: Minimum and maximum prices for a filter



Overall, the price that the highest number of respondents found acceptable (neither too low nor too high) was 300 birr, which corresponded with the results of the focus group. Even at this price, however, only 49% of respondents would consider the purchase.

5.2.3 Interest in filters after knowing their price

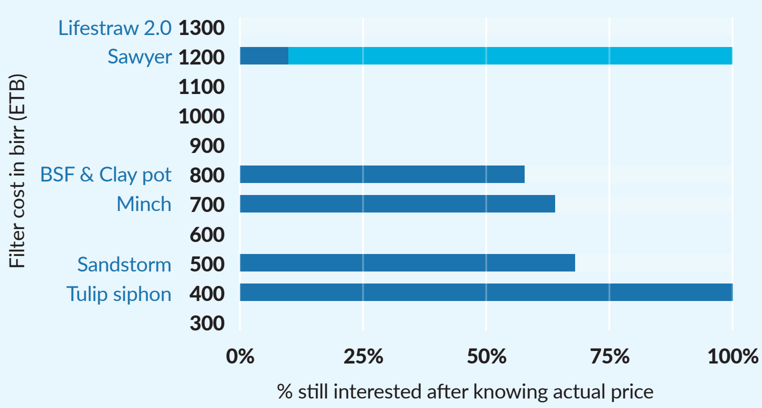
Towards the end of the final survey, respondents were shown picture cards of the seven filters in the study and asked if they found any of them interesting for purchase. They were then told the actual prices for the filters that they had selected as interesting and asked whether, knowing this real price, they would still be interested in purchasing the filter.

As with Figure 10, these results suggest a step-change in willingness to pay between 400 and 500 birr, and an additional step change between 800 and 1200 birr. However, the percent of respondents expressing a willingness to pay at these points was higher than would have been predicted by the earlier questions.

Comparing the individual results of the two exercises, 68% of responses were consistent with the price range that they had previously given, accepting filters within their range and rejecting filters outside of their range. Twenty-seven percent retained interest in a filter although it was above their earlier range, while 5% lost interest upon knowing the price, although the filter was within their earlier range.

One entrepreneur had recently approached households the community and successfully sold several BSFs at 400 ETB. At the time of the final survey, the entrepreneur had returned and was attempting to sell them at 700 ETB.

Figure 10: Interest in filter after knowing the price



6: **Conclusions**

This study trialed seven different HWTS technologies in five households each within Kondala village, Ethiopia, for one year. This was followed by a market study within the community to estimate the willingness of households to pay for such technologies. The study was small, with only five households per filter, so the results must be interpreted with caution.

- Only the **Minch** filter removed > 2 log *E.coli* (>99% *E.coli*) at the point of consumption at all three water quality tests.
- Drinking water quality degrades in filters without a built-in safe water storage container (BSF, Sandstorm, Sawyer, Tulip Siphon). **Water is re-contaminated post-filtration.**
- The average ratings of **user-defined** filter criteria was overall highest for the **BSF.**
- The **BSF, Minch, and Sandstorm** filters had the **highest continuous use.**
- The **BSF** had the **highest consistent use,** followed closely by the Minch and Sandstorm.
- Respondents expressed the **highest interest** in the **Sandstorm** filter, followed closely by the BSF and Minch.
- Households expressed interest in paying for filters using **installment payments**. They were much less interested in using savings programs.
- Households believed that the value of a filter was **greater than a mobile phone.**
- The price at which the largest percent of respondents expressed a willingness to pay for filters was **300 birr.** Even at this price, however, only slightly less than half found this an acceptable price.
- A potential market exists at higher price points, with step changes in acceptability before 500 birr and 1000 birr. There were 11% of respondents who found a price between 1000 and 1500 birr to be reasonable. **Higher priced products would still have potential buyers.**
- The biggest difference between households that treated "almost all" of their drinking water, and those that did not, was **the perception of how easy the technology was to use.** This was true regardless of which technology the household was trialing, and so was not a function of the technology itself.

7: **Acknowledgements and References**

The team who participated in this project included:

From EKHC:

- Martha Gebeyehu –WET Centre Coordinator
- Ruhama Bereket –WET Centre WASH officer
- Dawit Dalga – EKHCDC Water Quality Analyst
- Tsegahun Yaecob – EKHCDC, CED Health Promoter
- Aster Ayele –EKHCDC, CED Health Promoter
- Gilinesh Oljera- EKHCDC, CED Health Promoter
- Behailu Shewakan- EKHCDC, CED Coordinator
- Daniel Awedew – Driver

The team received some support from CAWST:

- Tal Woolsey – International Technical Advisor
- Candice Young-Rojanschi – Knowledge and Research Advisor
- Kelly James – Knowledge and Research Advisor
- Mike Grant – Graphic Design

Funding for the project was provided by: CAWST and DKM

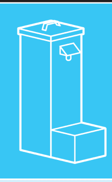
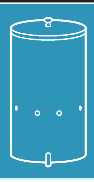
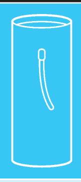
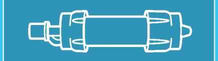
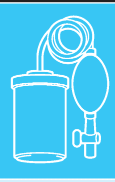
References

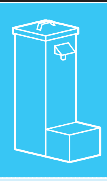
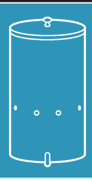
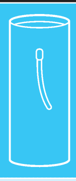
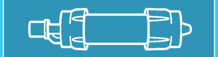
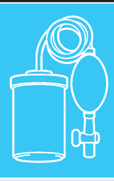
1 World Health Organization. Guidelines for drinking-water quality: fourth edition incorporating the first addendum. [Internet]. 2017 [cited 2017 Mar 1]. Available from: http://apps.who.int/iris/handle/10665/43428

2 Health Sector Transformation Plan [Internet]. Government of the Federal Democratic Republic of Ethiopia Ministry of Health; 2015 Oct [cited 2018 Sep 25]. Available from: https://www.globalfinancingfacility.org/sites/gff_new/files/Ethiopia-health-system-transformation-plan.pdf

3 Smith A. Woliso Source Water Baseline. Desert Rose; 2018 Apr.

Appendix 1: **Overview of Filters used in Study**

	Filter	Biosand Filter (BSF)	Ceramic Pot	Lifestraw Family 2.0	Minch	Sandstorm	Sawyer	Tulip Siphon
Overview								
Overview	Description	BSFs are columns of finely crushed rock (sand) on which microorganisms are living. Water is poured into the top of the column and spends a period of time in contact with the sand. This allows the microorganisms living in the sand to remove pathogens from the water. When a new batch of water is poured in, water added earlier flows out.	Water is poured into a porous ceramic filter pot and is collected in another container after it passes through the ceramic pot. This system also provides safe storage until the water is used. Ceramic pot filters are usually made from clay mixed with a combustible material like sawdust, rice husks, or coffee husks.	The LifeStraw Family 2.0 is a membrane ultrafiltration system manufactured by Vestergaard that uses gravity to move water through it. It uses a 0.02 micron membrane filtration cartridge but is designed to sit on a tabletop and provide safe storage after filtration. The untreated water is poured into a container at the top. The filtered water collects in a safe storage container (5 L) that also serves as the base.	Minch is a newly developed filter by Desert Rose consultancy in Ethiopia. It is a granular media filter which is smaller and lighter than a BSF or Sandstorm, is not biologically active and so does not require a ripening period or to be "fed", and includes a built-in safe water storage reservoir.	Sandstorm is a slow sand filter adapted for use in people's homes. The container can be made out of cylindrical galvanized iron sheet, and is filled with specially selected and prepared sand and gravel. The filter removes pathogens and suspended particles helped by the biolayer that is produced in the top layer of the sand.	The Sawyer PointONE filter is produced by the US-based company Sawyer Products. It is a gravity-driven hollow fiber membrane filter with a pore size of 0.1 microns.	The Tulip Siphon Filter is a ceramic candle filter for household use that is produced by Basic Water Needs. The siphon filter relies on gravity to draw water through a silver-impregnated Tulip ceramic candle element, housed in plastic, which is placed into a container of untreated source water.
Overview	Supplier	EKHC Development Commission BSF Project	SMS Ceramic Filter	Setema Limited PLC	Desert Rose Consultancy	Desert Rose Consultancy	Gemeshat PLC	Tulip Addis
Overview	Cost	800 ETB	800 ETB	1500 ETB	700 ETB	500 ETB	1200 ETB	400 ETB
Performance	Median % E.coli removal from collection bucket to stored water after > 1 year	96%	-20%	95%	>99%*	64%	-157%	n/a
Performance	Median % E.coli removal from collection bucket to direct from filter after > 1 year	>97%*	-20%	95%	>99%*	>99%*	98%	n/a
Performance	Durability (# of functional filters after > 1 year)	5*	4	2	5*	5*	5*	4

	Filter	Biosand Filter (BSF)	Ceramic Pot	Lifestraw Family 2.0	Minch	Sandstorm	Sawyer	Tulip Siphon
								
User long-term interest	# of households that filtered "almost all" of their water after > 1 year (out of 5)	4*	2	1	3	3	1	0
	# of filters still in use for any water after >1 year (out of 5)	5*	3	1	5*	5*	3	0
	# of respondents that expressed interest in buying the filter (price not considered)	18	1	6	17	19*	10	3
	# of households purchasing the filter	5	~2	0	5	4	~1	0
Perceptions of filter	overall happiness with filter	4.6	3.2	4.0	4.6	5.0*	5.0*	4.2
	health impact of using filter	5.0*	4.8	5.0*	5.0*	5.0*	5.0*	5.0*
	effort to use	4.4	4.6	5.0*	5.0*	2.8	4.2	2.8
	effort to maintain	4.6	4.4	1.8	3.8	2.8	3.6	1.4
	filter's appearance	4.2	3.4	4.4	5.0*	3.4	4.2	4.2
	volume	3.6*	2.8	2.0	3.2	3.2	2.6	2.8
	flow	3.0	2.8	2.4	2.8	3.4*	2.4	1.6
Perceptions of finished water	temperature	5.0*	3.5	3.4	3.6	4.0	4.0	3.8
	taste	4.8	4.0	4.0	4.6	4.6	5.0*	4.2
	smell	4.8*	4.0	4.0	4.2	4.4	4.4	4.4
	appearance (i.e. clarity, colour)	4.6	4.5	4.2	4.6	5.0*	4.2	4.3

Appendix 2: **User comments about specific technologies**

1 BSF

1.1 Biggest Strength

- Provide clean water, the food I cooked with filter water is very delicious
- Provide clean and cool water
- Provide Clean water
- It provides me clean water. No diseases.
- Even if it gives me not enough water the water is clean

1.2 Improvements

- I have only one jerrican. I use the same jerrican for transport and storage.
- She has only one jerrican. Using both for transport and storage
- The flow rate is too low.

1.3 Why did you stop using the filter?

- n/a

2 Ceramic Pot Filter

2.1 Biggest Strength

- It removes many dirts
- Provide clear water
- Give me clean water.
- Less amount of water
- The filter provide clean water

2.2 Improvements

- It is smaller I want to have the bigger one
- It is not durable
- Flow rate
- The filter doesn't give colder water. The filter appearance is not attractive

2.3 Why did you stop using the filter?

- Because it has cracks
- Less amount of water

3 Lifestraw Family 2.0

3.1 Biggest Strength

- To make water clean. A type of fetching like tap water. Attractive to see
- the appearance and it gives clean water, but it is sophisticated to damage
- the appearance, to give clean water
- it able to filter the dirty water and we have bring clean water

3.2 Improvements

- It very small ,so it gives small water, must be improved the size of the filter and speed,
- size, more durable,
- the tube easily eaten by rats,
- it should be improve as fit with rural community
- She doesn't like the filter because it is physically small

3.3 **Why did you stop using the filter?**

- it already damaged and the family use tap water
- it is already eat by rat
- the plastic tube eat by rat
- I don't like the filter. It is small

4 Minch

4.1 **Biggest Strength**

- It is shiny and the filtered water taste good
- The size of the filter and the treated water taste are good
- It is easy to maintained
- All the family's have got clean water, we safe from diarrheal disease, attractive to see
- It is very attractive to see and give us a clean water

4.2 **Improvements**

- The flow rate is slow
- It will be improve to give long service
- No

4.3 **Why did you stop using the filter?**

- n/a

5 Sandstorm

5.1 **Biggest Strength**

- Provide me clean water. The water is cooler
- The filter makes my water clear
- Provide us clean and enough water
- I like the filter because it has sand in it. Sand removes many dirts
- It provides me enough and cold water

5.2 **Improvements**

- The filter has no lid and heavy to lift up 20 litre jerrican
- Nothing
- It has no lid at the top of the filter. It is heavy to lift the 20 litre jerrican
- To lift the 20 liter jerrican is some how difficult. Sometimes it is difficult to remove the diffuser to do maintenance

5.3 **Why did you stop using the filter?**

- n/a

6 Sawyer

6.1 **Biggest Strength**

- After they got the filter they bring clean water, the health of the family improved
- He bring a clean water
- The water is very clean and tasty
- They like the filtered water but it is not enough for their family consumption

- To obtain clean and safe water, the appearance of water, taste

6.2 **Improvements**

- The bucket is small and filter also give small yield
- Weak bucket, slow flow rate
- No replacement of the tube and the filter possible
- Speed, improve the speed
- No problem

6.3 **Why did you stop using the filter?**

- It has some leakage in the bucket
- The bucket is broken, the filter element disconnected from the tube

7 Tulip Siphon

7.1 **Biggest Strength**

- It give clean water, type of filter is attractive
- It is attractive to see
- It gives us clean water
- It is good to filter the contaminated water, we are free from diarrhoeal disease
- To able to give clean water, the physical appearance of the filter

7.2 **Improvements**

- The speed
- The speed, quantity
- It has its own jerrican
- It improved the speed, it has its own jerrican
- It is difficult to maintain and also increase the yield

7.3 **Why did you stop using the filter?**

- It is not give sufficient water, speed and quantity
- They get a tap water now but some times they use it

Appendix 3: **Comments from manufacturers**

Sawyer

“I … would like to comment on the safe storage issue you mentioned in the preliminary report.

As I told you before we normally sell our HWT technology with two food grade buckets: one for the raw water and the other one for clean water storage. The bucket designated for clean water storage has got a proper cover and a spigot/faucet attached to it in order to avoid any possible recontamination. Users directly drink from their spigot instead of dipping their glass into their filtered water which is the main cause of recontamination. As it is clearly shown in the product catalogue that I sent you before, our technology is designed for a bucket to bucket filtration system or faucet to jar filtration system. Because of that safe storage is not a problem as far as Sawyer is concerned.

Hope your final report will capture this advice.”

Lifestraw

“We would like to note the following on your Report

1. **Flow Rate:** we assume that the follow rate that is mentioned in your report is regarding the clean water coming out of the LifeStraw Family 2.0 (LSF 2.0) of the clean water storage container. If this is the case we do not know how you evaluate flow rate and also compare rates of the different technology filters. However, LSF 2.0 has a flow rate of one liter per 14 seconds. This means a flow rate of more than 4 liters per minutes. Compared to the other filters, this LSF 2.0 flow rate is very high for a households filter that removes bacteria, virus, parasites, and turbidity to the highest degree (99.9%). Though you looked at bacteria removal only. We wonder if a rural households needs more than 4 liters of clean drinking water per minutes. Other Filters that don’t have in built clean filtered water storage may have better flow rate but recontamination in whatever the households uses as a storage container is the danger as confirmed by your own evaluation.

2. **Recontamination:** as your study confirmed contamination was confirmed in filtered water collected by glasses or other containers found in the households. Obviously the used glasses, cups or other containers are not free from bacteria. In other words, the contamination is not from the filtration devises. Regarding LSF 2.0 since the filtered water is stored in the inbuilt clean water storage tank there can’t be any contamination.

3 **Leakage:** LSF 2.0 is produced in a modern technology factory. Accordingly, every filter unit passes strict quality control inspection, including leakage proof procedure. They are alleged leakage at two households may have only be caused by improper assembly. We suspect that the clean water storage tank lid was not properly fitted until it clicks in to place.

4 **Certification:** LSF 2.0 does not claim any certification that is doesn't possess. For your information LSF 2.0 has evaluation report from UNWHO, Ethiopian Conformity Assessment Enterprise, the Ethiopian Ministry of Water Energy & Irrigation and the Oromia Water Bureau and a lot of other certifications from other countries. We can provide you such documentations if you so require.

5 **Damage Risks:** you have mentioned that households were afraid of LSF 2.0 filter can be damaged by children and rates but this is not a filtering devise problem many other items in a household can be damaged similarly so the household should place their filters in a safe place where there are not exposed to such damage. We believe households know better how to keep their valuables safe.

6 **Perception:** we believe most of the comments by the households are just perceptions rather than reality. A better or further training and demonstration will clear away on such perceptions or non-realistic concerns. Our company will support you in such efforts.

Hence, we would like to kindly request you to consider the above matters for your upcoming final evaluation report. Please fill free to request us for any further information, discussion and/or demonstration if you so require."