Pan African University
Institute of Water and Energy Sciences

PAN-AFRICAN UNIVERSITY
INSTITUTE FOR WATER AND ENERGY SCIENCES
(including CLIMATE CHANGE)

Master Dissertation

Submitted in partial fulfillment of the requirements for the Master degree in water policy

Presented by

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TITLE: COMPARATIVE ANALYSIS OF FACTORS THAT INFLUENCE CONSISTENT USE OF HOUSEHOLD WATER TREATMENT AND STORAGE IN NORTHERN KENYA

Defended on 03/09/2018 Before the Following Committee:

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DECLARATION

This research is my original work and has not been presented for award of a degree in any other University.

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DEDICATION

This thesis is dedicated to all victims of effects of consumption of unsafe water all over the world and to my wife and daughter.

ACKNOWLEDGEMENTS

I would first like to thank my thesis advisors Dr. Eng James M. Raude of Jomo Kenyatta University of Agriculture and Technology (JKUAT) Kenya, Dr. Sara Marks and Mrs. Regula Meierhofer of The Swiss Federal Institute of Aquatic Sciences-ETH Zurich (Eawag) for consistently guiding, reviewing, commenting and motivating me throughout the process of this research. I would also like to thank Prof. Eng. Bolaji Fatai Sule whose inputs were instrumental in the initial stages of proposal development.

I would also like to thank The African Union Commission for granting me the scholarship and the opportunity to pursue my masters studies and Pan African University for Water and Energy Sciences (including climate change) for hosting and supporting me throughout my time of the studies.

I would also like to express my gratitude to the Swiss Federal Institute of Aquatic Sciences-ETH Zurich for awarding me the EPP fellowship, which equipped me with intensive skills in data analysis, which were essential in delivering the results of this research. My gratitude also to Dr. Christoph Lüthi and his team who hosted me in the Sandec department and supported me throughout the data analysis and report writing phase of the thesis.

I would also like to acknowledge Dr. Peter Maryna of The Swiss Federal Institute of Aquatic Sciences-ETH Zurich, Ms. Manja Graham, Kenya Country Director, Caritas Switzerland, Mr Fredrick Ochieng, Disaster Risk reduction Expert Caritas Switzerland Kenya office, Ronald O. Amollo Field Based WASH project Manager Laisamis, all staff and enumerators. You played an instrumental role in ensuring that the empirical part of the research was possible.

Finally, I must express my very profound gratitude to my parents and to my wife for providing me with unfailing support and continuous encouragement throughout the study and through the process of research and writing this thesis. This accomplishment would not have been possible without them. Thank you.

ABSTRACT

Economic, technical, behavioral and contextual factors in an emergency context influence the consistent use of household water filters. Use of household water treatment and storage (HWTS) options improves water quality in emergency contexts and consistent use leads to health benefits. However, HWTS options are often designed for the typical household environment, not taking into account unique challenges faced during emergencies. The study aimed at comparatively analyzing factors that influence consistent use of household ceramic water filters in Northern Kenya which was facing prolonged droughts. The study followed both qualitative and quantitative design using structured observations, questionnaires and a focus group discussion. Spearman's correlation analysis and multivariate regression models were used to understand and explain the predictors of consistency of use of household filters. Findings indicate that consistency of use of filters is affected by different factors. Those filters with a two-bucket interface design were mostly affected by design factors such as functional status indicators while those with one-bucket interface design were mostly affected by psychosocial and economic factors such as peer approval and availability of spare parts. The context, i.e. how well these filters fit in the shelters, was a strong determinant of consistency in filter use for both groups. Regression models showed an increase in percentage of consistency of use by 22 points with agreement to good fit in the house. These findings suggest that, WASH actors should take into account these factors during filter-based interventions in emergency contexts. A tradeoff between space occupied by the filter and filter capacity and how they affect fit in the shelters still exists.

RESUME

Économique, des facteurs techniques, comportements et contextuels dans un contexte d'urgence influencent une utilisation uniforme des filtres à eau domestiques. Utilisation des options de stockage (HWTS) et de traitement des eaux ménagères améliore la qualité de l'eau dans des contextes d'urgence et utilisation régulière mène aux prestations de santé. Cependant, les options de HWTS sont souvent conçues pour l'environnement domestique typique, ne tenant pas compte unique défis en cas d'urgence. L'étude visait à analyser comparativement les facteurs qui influencent l'utilisation cohérente des filtres à eau en céramique domestique au nord du Kenya, qui faisait face à des sécheresses prolongées. L'étude a suivi conception qualitative et quantitative à l'aide des observations structurées, questionnaires et un groupe de discussion. Corrélation analyse et multivariée des modèles de régression Spearman ont été utilisés pour comprendre et expliquer les prédicteurs de la cohérence de l'utilisation de filtres domestiques. Résultats indiquent que la cohérence de l'utilisation de filtres est affectée par différents facteurs. Ces filtres avec une conception de l'interface de deux-seau ont été principalement touchés par des facteurs de conception comme indicateurs de l'état fonctionnel tandis que ceux avec la conception de l'interface d'un seau ont été principalement touchés par des facteurs psychosociaux et économiques tels que les pairs approbation et disponibilité des pièces détachées. Le contexte, c'est-à-dire comment bien ces filtres s'intégrer dans les abris, était un fort déterminant de la cohérence dans l'utilisation de filtre pour les deux groupes. Modèles de régression a montré une augmentation du pourcentage de cohérence de l'utilisation de 22 points, avec l'accord de bon rentre dans la maison. Ces résultats suggèrent que, acteurs de lavage devraient prendre en compte ces facteurs lors d'interventions axées sur le filtre dans des contextes d'urgence. Un compromis entre l'espace occupé par le filtre et la capacité de filtration et comment ils affectent l'ajustement dans les abris existe toujours.

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LIST OF ACRONYMS & ABBREVIATIONS

CACH	Caritas Switzerland.
CDW	Co-Design Workshop.
CGoM	County Government of Marsabit.
EAWAG	Swiss Federal Institute of Aquatic Science and Technology.
FGD	Focus Group Discussions.
FHNW	The University of Applied Sciences and Arts of Northwestern Switzerland.
HIF	Humanitarian Innovation Fund.
HWTS	House Hold Water Treatment and Storage.
JKUAT	Jomo Kenyatta University of Agriculture and Technology.
NDMA	National Drought Management Authority
NRDC	Natural Resources Defense Council
ODK	Open Data Kit
PAUWES	Pan African University for Water and Energy Sciences.
RANAS	Risks, Attitudes, Norms, Abilities, and Self-regulation
UNHCR	United Nations High Commission for Refugees
UNICEF	United Nations International Children's Emergency Fund.
WHO	World Health Organization

DEFINITION OF OPERATIONAL TERMS

Behavioral Factors	These are factors that determine behavior as defined by the RANAS model (Mosler, 2012). They include Risks, Attitudes, Norms, Abilities, and Self-regulation.
Consistent use	It takes into account the number of times a user consumes treated water as compared to the number they consume untreated water.
Design factors	Physical features of the HWTS option ease of use, general size and dimensions of the option and ease of assembly, ease of cleaning and maintenance.
Economic factors	Involves availability and accessibility of funds required for the consistent use of a given HWTS. It also factors capital, expenditure costs for the operation, maintenance, and willingness to pay of the HWTS option.
Environmental and contextual factors	Factors such as how the HWTS option fits in household environment, access to safe drinking water, access to new or maintenance products and the state of water at the community.
Household water treatment and storage	Methods for drinking water treatment at household level such as boiling, chlorination, flocculants/disinfectant powder, solar disinfection, and filtration are some of the HWTS options and methods for safe storage. This study will concentrate on household water filters as a HWTS option.
Social and political factors	These mainly involve stakeholder resistance to change and accept new technologies due to interests, ignorance, poor participation or cultural beliefs towards water resources and related treatment technologies.

CHAPTER ONE: INTRODUCTION

1.1 Background

Access to safe drinking water is not a usual occurrence, as it may seem. A 2017 report by WHO/UNICEF indicates that one person in six all over the world is at risk of being infected of diseases related to unsafe water consumption. It is further estimated that 1.8 billion people around the world use a source of drinking water with fecal contamination, which majorly leads to diarrheal diseases (Bain et al., 2014). Further, Boschi-Pinto, Velebit, and Shibuya (2008) indicated that global deaths from diarrhea of children aged less than 5 years were estimated at 1.87 million in 2004, and approximately 19% of these total child deaths were mainly associated with consumption of unsafe water.

Safe drinking water is an immediate priority in most emergencies (The Sphere, 2011). In a study of varied emergency contexts in Nepal, Indonesia, Kenya and Haiti, Lantagne and Clasen (2012) note that HWTS could be effective in reducing the risk due to unsafe drinking water in acute emergency context. In Kenya, Lantagne and Clasen (2012) studied HWTS interventions in a flooding event that led to a cholera epidemic in Turkana, an earthquake in Indonesia and a Cholera outbreak in Nepal. The authors recommended implementers of HWTS interventions to focus on whether interventions actually improve drinking water quality in vulnerable households making "effective use" an important program evaluation metric. The Natural Resources Defense Council (NRDC) forecasted that the number of drought-affected areas is likely to increase, and that one-fifth of the world population could face severe flooding by 2080. This might adversely affect safe drinking water availability since floods can severely affect water quality by flushing large amounts of toxic runoff into drinking water sources, and by damaging water and wastewater management infrastructure (NRDC, 2012).

Water borne diseases such as cholera and diarrhea cases are a common occurrence in Kenya during the rainy seasons suggesting that open defecation is still practiced in the affected areas. Recent studies conducted indicate that the communities residing in major towns in Kenya have high cholera awareness, but cholera prevention knowledge is inadequate, as is access to safe water and appropriate sanitation facilities (Githuka et al., 2016). In some cases, where there is access to safe water at the source, contamination during transport and handling may also occur. Consumption of unsafe water also contributes to absence of children from schools, employees from work and eventual negative effects to economic development. This is because illnesses like diarrhea lead to increased expenditure on healthcare and reduced income due to low productivity (Hutton & Haller, 2004).

With these concerns in mind, household water treatment and storage (HWTS) then has a role to play in providing vulnerable people with a tool to improve their own water safety while they continue to wait for reliable water supplies (Clasen, 2015). In another review Clasen, Roberts, Rabie, Schmidt, and Cairncross (2006) noted that interventions to improve water quality are generally effective in preventing diarrhea. Additionally, Clasen et al. (2015) notes that interventions to improve water quality at the household level are more effective than those at the source. However, other studies have shown that consistency of use of HWTS options is necessary in order to achieve a health impact (Brown & Clasen, 2012a; Enger et al., 2013)

1.2 Problem statement

This study was implemented in Ndikir village, Laisamis Sub-county, Marsabit County in Northern Kenya. Inadequate and unreliable rainfall, poor water management practices, increase in human and animal population are some of the reasons given by County Government of Marsabit for acute water shortage (CGoM, 2014). Water shortage due to drought in the area also informed projects such as REGAL-IR. The project aimed at improving water access through construction of large underground tanks to harvest rain water runoff (ADESO, 2017). A report from the National Drought Management Authority (NDMA) indicated lower precipitation in the month of June 2017 and the authority proceeded to issue early warning signs for Marsabit County (NDMA, 2017). The county's water service providers did not forward any performance assessment data in the county except for Moyale Water and Sanitation Company which showed a coverage of only 22% under its area of jurisdiction (WASREB, 2016) indicating institutional capacity challenges in the area. The area is prone to alternating severe floods and droughts and therefore, requires alternative intervention methods.

The pastoralist villages in Laisamis sub-county, Marsabit County abstract their water from boreholes, water pans, dams, shallow wells and rock catchments. Water scarcity forces men to migrate and look for greener pastures for their livestock. Women and children are left and rely on the scarce unsafe water sources, when available. This eventually leads to water borne diseases such as diarrhea, cholera, typhoid and dysentery since 58% of the population practice open defecation within the County (Njuguna & Muruka, 2017). Due to these diseases mainly caused by consumption of contaminated water, there is need for HWTS interventions to be administered and consistency of consumption emphasized to ensure health benefits.

1.3 Objectives

1.3.1 Main objective

The main objective of this study was to identify factors that influence consistent use of household water filters in Northern Kenya.

1.3.2 Specific objectives

The study addressed the following specific objectives:

i. Characterization of selected HWTS options in use for improving water quality in Ndikir village in Laisamis Sub County, Marsabit County in Northern Kenya
ii. Analysis and comparison of how economic and environmental factors in an emergency context support or impede the consistent use of household water filters.
iii. Analysis and comparison of behavioral and design factors that support the consistent use of household water filters

1.4 Research Questions

The study answered the following questions:

i. What are the characteristics of selected HWTS options in use for improving water quality in selected communities of Laisamis sub-county?
ii. How do the economic and environmental factors in an emergency context support or impede the use of selected household water filters?
iii. Which behavioral and design factors support the consistent use of household water filters in an emergency context?

1.5 Justification of the study

Consistent use of HWTS has been observed to reduce incidences of occurrence and spread of diarrheal diseases by studies such as Enger et al. (2013), Graf et al. (2010), Brown and Clasen (2012b), Moropeng, Budeli, Monyatsi, and Ndombo Benteke Momba (2018) among others. However, most communities do not use HWTS options consistently due to socio-economic, contextual, design and psychological aspects related to the behavior of treating water (Nusrat et al., 2015; Sobsey, Stauber, Casanova, Brown, & Elliott, 2008). Therefore, it is important to understand human behavioral factors that affect the effective and consistent use of HWTS options. This study therefore adds to the efforts to better the understanding and incorporate into improved practice, behavior change, individual and group perceptions and attitudes towards consistent water filtration practice and the socio-cultural drivers that influence HWTS practices of households. Only a few studies have been conducted in relation to this topic in emergency contexts. The findings are beneficial to both filter manufacturers and humanitarian organizations that implement HWTS interventions, specifically ceramic filters. The research features four different models of ceramic filters, since ceramic filters have been observed to be better than other HWTS options in terms of potential of scaling, effectiveness in water quality improvement and socio-economic sustainability (Hunter, 2009; Ren, Colosi, & Smith, 2013).

1.6 Scope and limitations

The study was conducted in the village of Ndikir, which is comprised of 175 households. The village is in Laisamis Sub County, Marsabit County in Northern Kenya. The study examined four filter types within 108 households. The projected 175 households in the proposal could not be achieved since one filter type had not been distributed at the time of the study and some of the household members were not available during the data collection period. The filters in this study only comprised of those that were preselected by emergency organizations. The criteria for the selection was based on logistics and not necessarily in line with a design that is most optimal for use.

CHAPTER TWO: LITERATURE REVIEW

2.1 Introduction

This chapter focuses on the existing recent literature on HWTS. It gives a theoretical review of theories that informed and guided this study. It also reviews recent empirical literature present in the public domain in relation to HWTS devices, their consistent use, attitudes and behavior by the users towards them. This chapter proceeds to give the conceptual framework that guided the study and critique of existing literature and eventually expose research gaps in the existing studies.

2.2 Theoretical review

Consistency of use of any technology is a goal of any behavioral change intervention. Stage and predictive theories have been used as frameworks to understand behaviors of people towards new innovations and ideas. Stage theories focus on the idea that elements in systems move through a pattern of distinct stages over time. These stages can be described based on their distinguishing characteristics. Many stage theories of behavioral change have been enumerated among them the theory of diffusion of innovations (Rogers, 2003). This stage theory explains how, over time, an idea or product gains momentum and diffuses through a specific population or social system. This leads to people being part of the social system adopting a new idea, behavior or product. The theory proposes stages through which a person adopts an innovation to where diffusion is accomplished. Adoption means that a person does something differently from how they did it previously (LaMorte, 2016). According to Rogers (2003) the stages include awareness of the need for an innovation, decision to adopt or reject the innovation, initial use of the innovation to test it, and continued use of the innovation. This theory often forms the basis of WASH studies, an example being Figueroa and Kincaid (2010) who explain social, cultural and behavioral correlates of Household Water Treatment and Storage in their report. Behavior change is affected by household and external factors that are complex in nature. These factors limit stage theories in explaining behavior change since behavior change does not follow the specific stages of stage theories in any given order. Other phenomena also influence adoption rates. For example, path dependence may lock certain technologies from adoption.

Due to these limitations, predictive theories, which identify and describe social, cognitive and emotional factors as important determinants of behavior, irrespective of time are necessary

(Figueroa & Kincaid, 2010). Studies have shown that predictive theories overcome limitations of stage theories and include other determinants of behavioral changes such as emotion (Zanjonc, 1984).

Models have also been developed and used to assess the social, cognitive and emotional factors. The risk, attitudes, norms, abilities, and self-regulation model (RANAS) of behavioral change developed by Mosler (2012) details the nature of interventions for behaviorial change and the factors they target for a given target population to adopt a new behaviour. These interventions usually target information, persuasion, normative factors, infrastructure, end user ability, planning, intentions and relapse prevention.

2.3 Empirical review

WHO (2011) defines safe drinking water as that which does not represent any significant risk to health over a lifetime of consumption, including different sensitivities that may occur between life stages. Different researchers have enumerated a number of HWTS options to improve the quality of water being consumed especially in developing countries. These options include sedimentation, filtration, boiling, ultraviolet radiation, chemical disinfection, safe storage and a combination of the above (CAWST, 2018; Johnston, n.d).

Boiling is one of the oldest and most commonly used methods of treating water at the household level in most communities. It is generally effective in killing microbial pathogens such as bacteria, protozoa, helminthes and viruses (CAWST, 2018). It is however limited by constraints such as cost, where households recorded using 7% of their income on fuel (Psutka, Peletz, Michelo, Kelly, & Clasen, 2011) in Zambia, as well as lack of residual disinfection. Chlorination is also an effective option for water treatment and storage. It is however limited by turbidity of the raw water and is ineffective for turbidities more than 100 NTU (Mohamed et al., 2015). Graf et al. (2010) presents evidence of health gains from use of solar disinfection (SODIS). However, SODIS is limited by turbidity of raw water with more than 30 NTU (Meierhofer et al., 2002). A review by Hunter (2009) indicates that ceramic filters are more effective in household water treatment as compared to chlorination, biosand filters and coagulant-chlorination. This study therefore focuses on ceramic filters as they have been proven to be the most viable options for emergency contexts. Their design impact on consistency of use is also not well understood.

2.3.1 Role of HWTS on health

A number of studies have been conducted on consistency of use and attitudes towards HWTS and their relationship to diarrheal diseases. Fewtrell et al. (2005) noted that there is a strong consistency in the effectiveness of HWTS interventions in reducing diarrheal and other related water borne diseases. Schmidt and Cairncross (2009) later argue that scaling HWTS may have been done prematurely based on biased evidence. Others have related health benefits with consistent use of HWTS options (Brown & Clasen, 2012a; Enger et al., 2013). More recent studies have documented HWTS success in preventing diarheal diseases (Moropeng et al., 2018).

HWTS plays a significant role in emergency context. This was observed after a study in Nepal (a cholera outbreak in Jajarkot), Indonesia (an earthquake in West Sumatra), Kenya (cholera epidemic in Turkana during a flooding event), and Haiti (the January 2010 earthquake) (Lantagne & Clasen, 2012). The authors conclude that HWTS options are effective in improving water quality of unsafe drinking water. In Haiti sixteen months after the onset of cholera, Patrick et al. (2013) noted that water and sanitation infrastructure investment was very important but HWTS interventions were necessary to improve access to safe water in near term. Despite all this evidence of HWTS options improving water quality, no health benefits can be accrued without their consistent use (Brown & Clasen, 2012b; Enger et al., 2013).

2.3.2 Consistency of use of selected HWTS options

Consistent consumption of treated water is necessary since evidence suggest health benefits may be eroded by even slight inconsistency of use. A risk assessment of diarrheal infection from intermittent treatment by a Ugandan water treatment plant indicated that failure in water treatment for one day per year increased the annual probability of enterotoxigenic *Escherichia coli* (ETEC) infection via drinking water from 0.1% to 1% (Hunter, 2009). Focus on strategies to improve the correct, consistent and sustained use of HWTS among women in self-help groups in rural India was also recommended to increase health gains (Freeman, Trinies, Boisson, Mak, & Clasen, 2012)

In understanding effects of efficacy and compliance or consistence use in HWTS in community level, Enger et al. (2013) noted that effectiveness within actual communities decreases with imperfect consistence in use. Enger et al. (2013) further reported that HWTS can prevent diarhea in developing countries, however it has diminishing returns with consistent usage levels of less or equal to 99%. Incidence ratios of diarrhea in children below two years is affected directly by consistent use or compliance and log removal ratios associated with the filter type. Higher pathogen log removal ratios and high rate of compliance contribute to lower diarrhoea incidences. For a household filter with 99.99% bacterial removal rate, 100% consistent use led to 0.01% diarrheal inceidence ratio. If compliance is reduced from 100% to 95%, the diarrhoea incidence ratio rises to 10%. Further reduction of consistency of use from 95% to 80% for the same filter gives a diarrheal incidence ratio of 31%. Brown and Clasen (2012) also report similar findings concluding that adherence is necessary in water quality interventions to realize health gains. The authors further demonstrate that the efficiency of a treatment option has very low impact in delivering health benefit to the user unless there is 100% consistent and sustained use.

In Zambia, household filter interventions were only effective if they were used correctly and consistently. This was evidenced by a case study of 101 households (Peletz et al., 2013). Peletz et al. (2013) report that there was high potential to maintain high uptake of household filter usage behavior. Filter performance remained acceptable even in the absence of regular household contact by implementers. This was observed a year after the distribution of these filters. In the study, most (90%) of the households that participated in the surveys met the criteria for current users while three quarters had stored water with lower levels of fecal contaminant than that at the source. The filters were still functioning with log removal values greater than 2. In Peru, Rosa, Huaylinos, Gil, Lanata, and Clasen (2014) indicate that surveys of self-reported HWTS use fail to account for inconsistent compliance and use in rural contexts. This was noticed when most (85%) of urban and rural household in their study claimed good HWTS practices but follow up showed that these reports exaggerated actual practices.

Other studies suggest that the effectiveness of a HWTS options is optimizable by ensuring that the method is microbiologically effective, making it accessible to an exposed population and securing their consistent and long term use (Clasen, 2015). Contrary to most studies reviewed, Boisson et al. (2010) acknowledge the ability of water filters to improve water quality. However, the authors concluded that the results of their study provided little evidence that the filter was protective against diarrhea in the context of their study. Boisson et al. (2010) findings indicate that health benefits may not be accrued with inconsistent use.

2.3.3 Factors that affect consistency of use

Effective HWTS promotion and use on the premise of health benefits alone might not lead to consistency of use and consequently the health benefits. This is because consumers often select an HWTS option based on the convenience of the practice and design appeal of the product rather than the efficacy (Figueroa & Kincaid, 2010). It is notable that different communities hold various perceptions, beliefs and attitudes towards drinking water. According to Herbst et al. (2009), there was an indistinct and undeveloped link between water, sanitation, hygiene and health among the peri-urban population in Mekong Delta, Vietnam. Herbst et al. (2009) reported that the population practiced hygiene measures in an untimely manner or applied them in an incorrect way. This is mainly due to misconception of risks and or a lack of background knowledge of cause-effect relationship between consuming contaminated water and diarrheal diseases. Peoples beliefs associated with water quality affect water treatment behavior. Studies in Chad show that the perception of social norms was unfavorable for water treatment behaviors (Lilje, Kessely, & Mosler, 2015). The authors recommended mass radio campaign, using information and normative behavior change techniques. The authors recommend that this should be combined with community meetings focused on targeting abilities and personal commitment to water treatment.

Nusrat et al. (2015) recorded technological, psychosocial and contextual factors as contributing factors to low sustained use of siphon filters in low-income urban communities in Bangladesh. Despite the fact that regular water users had better quality of water after six months as compared to after three months follow up, the study still indicated low percentages (28% and 21%) of regular use in the third and sixth months of follow up respectively. Similar factors were also cited in a more recent study by MacDonald et al. (2017). Considering filter use an additional task, filter breakage and time required for water filtering were some of the major factors cited for restraining consistent siphon filter use. Dreibelbis et al. (2013) state that contextual dimension, psychosocial dimension, and technological dimensions influence adoption and consistent use of technologies. Hulland, Martin, Dreibelbis, Valliant, & Winch (2015) have reported similar results as those of Najnin et al. (2015) on probability of contextual, psychosocial and technological factors influencing consistency of filter use. Hulland et al. (2015) review findings demonstrate that psychosocial factors such as injunctive and descriptive norms and nurture,may be more predictive as motivators to continue behaviours over time.

Ojomo et al. (2015) indicates that presence of chain supply for products related to a HWTS option plays a role in adoption and consistent use. The consumer's ability to adopt and sustain a promoted behavior such as consistent consumption of filtered water depends on the existence and availability of products and technologies, and it is vital to not only consider the availability of supplies, but also the proximity of consumers to the distributors (Cogswell & Jensen, 2008).

Comprehensive Initiative on Technology Evaluation (CITE) (2015) released an evaluation report on household water treatment in Ahmedabad India. The report’s findings reveal that the household filters that were evaluated could be an effective and affordable option for Ahmedabad’s poorer households for water treatment, but would need better financing mechanisms to make their upfront cost feasible for the poorest. The author further reports that all the non-electric filters evaluated did not remove total dissolved solids (TDS). Perceived benefit was identified as the single greatest predictor of participant’s consistency of use of household filters in Chennai’s municipal limits in a non-emergency setting (MacDonald et al., 2017).

2.3.4 Designs of selected filters

There are many upcoming household filter designs in the market, the tabletop design is more preferred to siphon filters due to accessibility, adequate head height and minimal footprint (PATH, 2011). According to PATH, most of the other kinds of designs including wall hang and immersed siphon devices have some advantages but are limited to given settings despite the fact that they have reduced footprints. Table 2.1 in the following page shows some of the common household water filters. Some of these filters are not commonly available in the Kenyan market for purchase because there is more emphasis on access to water as compared to consumption of safe water especially in rural areas among other reasons. It is also a norm for nomadic communities to drink raw water for long durations without immediate negative effects to their health and thus low uptake of household filters. Filter interventions in the country are generally conducted by development agencies.

Table 2.1: Common filters that are in use in most developing countries

Technology	**Filter type/brand**	**Total water production in m^3/unit per lifetime**	**Retail price in USD without subsidies**	**Format design**	**Maintenance**	**Reference**
Ceramic filter	Tulip Siphon Filter		5.69–7.32	Table top	Back washing using syringe with filtered water	(NWP, 2010)
			26.02			(Bleeker, 2013)
	Pot Filter	36.5–54.75	7.5		Scrubbing the ceramic part lightly when flow reduces	(Roberts, 2003)
			10-25			(Akvopedia, 2017)
			5.4–28			(NWP, 2010)
	Water4life		1.87–20.33			(NWP, 2010)
	Candle Filter		25			(Akvopedia, 2017)
	Potters for Peace		15–30			(Akvopedia, 2017)
Biosand filter	Concrete	219	6.99–22.76		Backwashing with filtered water	(CAWST, 2012)
	Plastic	87.6–262.8		On ground		(CAWST, 2012)
	Iron oxide filter		15–36	On ground		(Ahammed & Davra, 2011)
Membrane Filters	LifeStraw® Family	18	25-40	Wall hang	Back flushing using clean water.	(CAWST, 2012)
	Nerox® -02 Drinking Water Filter	91	12-15	Table top with over hang	Back flushing using syringe	(CAWST, 2012)

2.4 Conceptual framework

Figure 2.1 presents the conceptual framework that this study is based on

Independent variable

Factors that influence consistent use:

Economic factor :

(CITE, 2015; Cogswell & Jensen, 2008; Herbst et al., 2009; Hulland et al., 2015; Nusrat et al., 2015; Ojomo, Elliott, Goodyear, Forson, & Bartram, 2015)

- Perceived filter value
- Willingness to pay
- Availability of spares

Environnemental/contextual factor :(Hulland et al., 2015; Nusrat et al., 2015)

- Fit in household environment
- Risk awareness
- Access to information from aid organization
- Access to water.

Psychological and behavioral factor: (Brown & Clasen, 2012a; Hulland et al., 2015; Mosler, 2012; Nusrat et al., 2015))

- General feeling about the filter
- Costs and benefits of treating water.
- Risk awareness
- Attitude
- Norms
- Self efficacy
- Planning and coping
- Commitment
- General vulnerability
- severity

Design factor: (Nusrat et al., 2015; Ojomo et al., 2015)

- Initial setup
- Aesthetics of the treated water
- Product status indicators
- Product format and dimensions
- Platform interface
- Intuition during use
- Product aesthetics

→

Dependent variable

Consistent use of household water filters in emergency context. (Brown & Clasen, 2012a; Clasen, 2015; Enger et al., 2013)

Figure 2.1: Conceptual framework

2.4.1 Operational parameters of the filters

It is evident in the studies reviewed that household filters play an important role in improving the drinking water quality and subsequently reducing occurrence of water borne diseases (Enger et al., 2013; Fewtrell et al., 2005; Freeman et al., 2012; Lantagne & Clasen, 2012; Patrick et al., 2013). For this filters to function effectively, they need the raw water to be at their labelled turbidity levels.

EPA (1999) defines turbidity as an expression of the optical property responsible of scattering and absorption of light by particles and molecules in a water sample. Particles of turbidity form grounds where pathogenic microorganisms form colonies and consequently increase incidences of diarrheal and other water borne diseases (LeChevallier, Evans, & Seidler, 1981). These diseases are deadly to people with vulnerable immune systems such as those with HIV, children or the elderly. LeChevallier, Norton, and Lee (1991) highlighted a strong positive linear correlation between removal of turbidity and removal of giardia. The authors further demonstrated a similar trend for cryptosporidium removal in relation to turbidity. High levels of turbidity also clog the pores of ceramic filters and consequently reduce their efficiency.

2.4.2 Consumer adoption process

The decision making process for end users to buy or adopt and use a new product or innovation is affected by a number of factors. These include economic aspects, psychological factors, social influence and purchase situation. The economic needs include convenience, efficiency in use, and dependability among others. Psychological variables comprise of perception, attitude, trust, learning and motivation among others. Social influence is usually due to family, social class, culture and reference groups while purchase situation encompasses the reason for purchase, time and surroundings (Faraz, n.d). Rogers (2003) defines an innovation as an idea, practice, or object perceived as new by an individual or other unit of adoption.

This research postulated that use of household filters is a new behavior that was adopted and was undergoing diffusion stages within the community. However, factors related to consumer decision making during the adoption of this new behavior were also influencing the diffusion process.

2.5 Critique of the literature

The literature reviewed dwells on relationships between consistent use of household water filters and related beliefs in general but does not delve into the specific filter types currently in the market except for study by Nusrat et al. (2015). Lantagne and Clasen (2012)'s study on HWTS in emergency context does not address consistency in use of HWTS options. Blanton et al. (2014) only focuses on access of HWTS in his study leaving out consistent use, which is equally important in order to acquire full benefit of HWTS. Nusrat et al. (2015) study focuses on a population in a normal home setting without any emergency need. The population in the study also sensitized on importance of filter use, filter assembly and maintanance which takes time and resources. This may not be available in emergency contexts as there are competing needs and financial priorities. The studies with the exception of Boisson et al. (2010) assume a direct correlation between HWTS and diarrheal diseases in the specific communities, which may not always be the case.

2.6 Research gaps

Though there are many studies on HWTS implementation, sustained use and diarrheal diseases and their inter linkage, there are only a few that address HWTS implementation in emergency contexts. Those present do not address sustained and consistent use. The studies also indicate different responses towards HWTS options among different communities in different geographical areas due to cultural beliefs and attitudes towards water treatment and the design of the option. Therefore, there is need for further contextual studies within specific communities using different HWTS options in order to understand the factors explaining sustained and consistent use of HWTS options in different cultural contexts. Nusrat et al. (2015) and Ojomo et al. (2015) studies brings out the technological, psychosocial and contextual factors of concern in sustained use of siphon filters with the component of filter education at point of distribution at normal conditions. Even with extensive sensitization the percentage of sustained use is low (21%) and research on how this percentage would be like in an emergency context would be informative. This study therefore addresses household water filters that are commercially available and the factors affecting their consistent and sustained use in a drought emergency context.

2.7 Summary of the Chapter

The studies reviewed indicate a direct link between quality of drinking water, consistent use of HWTS and diarrheal diseases. The studies further indicate how contextual, technological and socio economic factors bar or promote sustained or consistent use of filters among different communities. There are however few studies covering consistent use and especially in emergency context. No comparative study of household filters in an emergency context was available. This study therefore serves to fill the knowledge gap in this research area.

CHAPTER THREE: MATERIALS AND METHODS

3.1 Introduction

This chapter details the methodology that was used to collect and analyze data for this study. It encompasses the research design that was used, the target population, sample size, sampling frame and data collection instruments that were used to inform the study. It further explains how data was collected, processed and analyzed.

3.1.1 Study site

The following map presents the location of the study site.

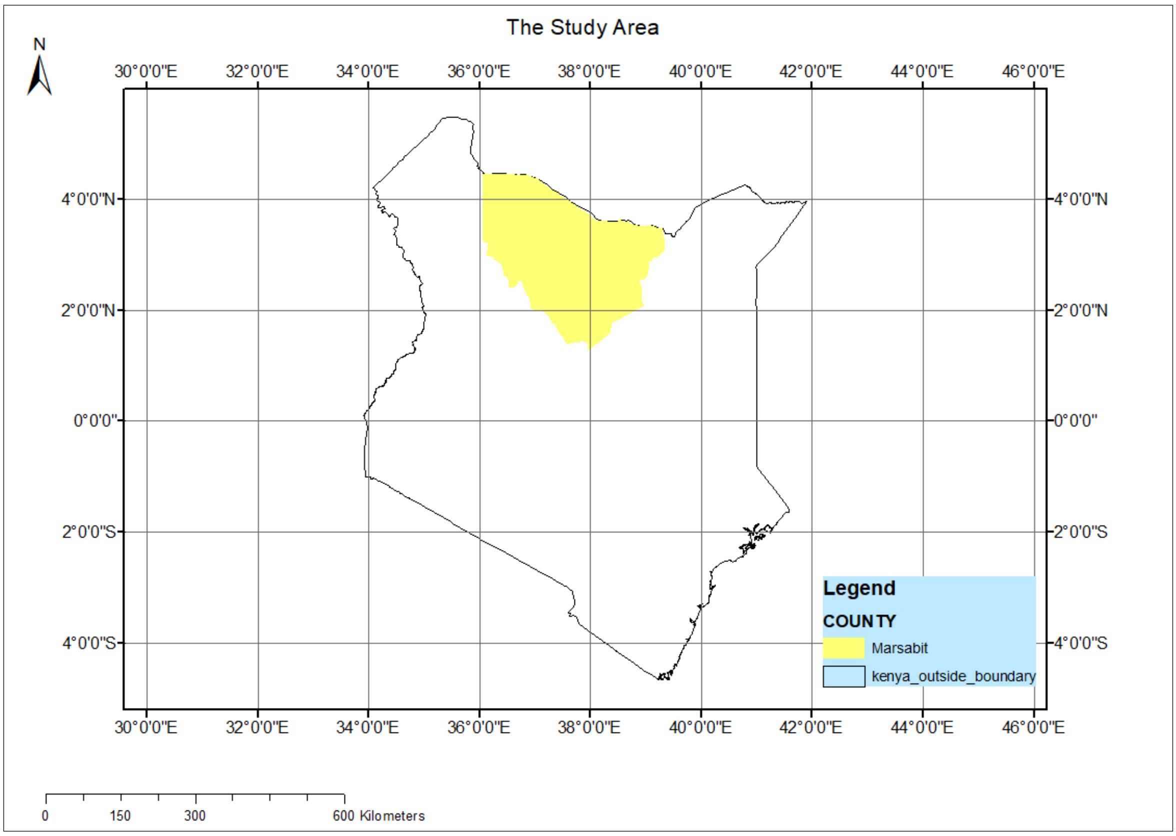

Figure 3.1: Map of Kenya showing the study site

This study was based in Northern Kenya, Marsabit County in Laisamis Sub county, Ndikir village. It was part of an ongoing project by Elrha's Humanitarian Innovation Fund (HIF), The University of Applied Sciences and Arts of Northwestern Switzerland (FHNW) together with the Swiss Federal Institute of Aquatic Science and Technology (Eawag) and Jomo Kenyatta University of Agriculture and Technology as field-testing partners. CESVI and Caritas Switzerland (CACH) were the humanitarian partners. The area mainly comprises of pastoralist communities with a population of 291,166 (ACTED, 2011). The study took place during a protracted drought crisis in Northern Kenya.

Data was collected from four manyattas namely: Lejale, Lekamario, Lorola and lngerledi in Ndikir location, Laisamis Sub County, Marsabit County in Northern Kenya. Figure 3.2 shows an overview of the geographical distribution of locations where the filters are located in Ndikir village.

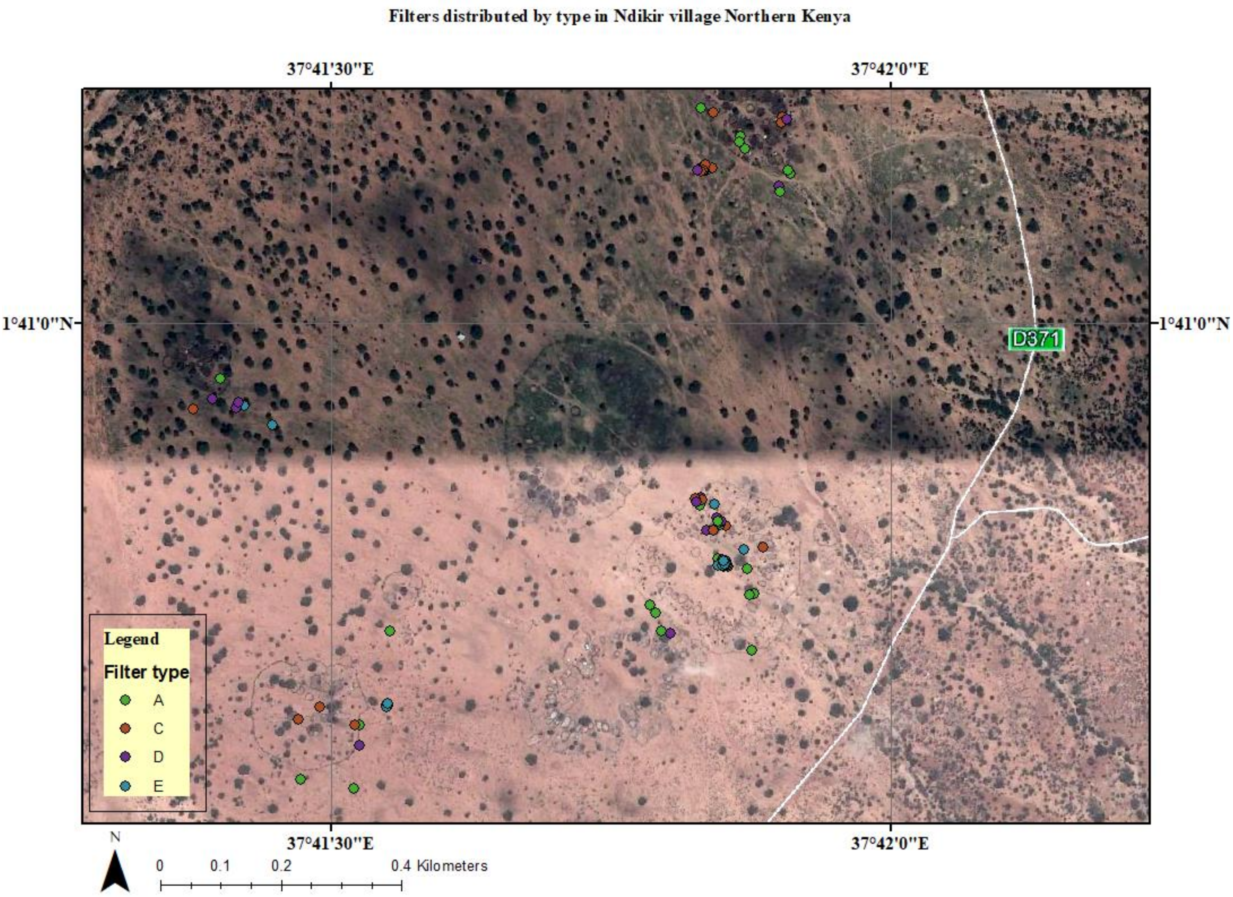

Figure 3.2: Actual geographical distribution of filters in Ndikir

3.1.2 Physiographic characteristics of the research area

Marsabit County receives between 200mm and 1000mm of rainfall per year, with the average precipitation being 254mm. Based on water precipitation and evapotranspiration, the aridity index of the county ranges from 0.026 to 0.12 (Mwenda, Mugambi, & Nyaga, 2016). This makes it one of Kenya's driest counties and consequently, often suffers from drought. Most of the rainfall (rainy season) is received in April and November. The county of Marsabit has more than half (58.6%) of the people practicing open defecation, most (80%) living in poverty. It has a low population density of four people per square kilometer (Njuguna and Muruka, 2017).

The county does not have a full-fledged registered Water Service Provider (commonly known as Water and Sewerage Company). The largest town in the County, Marsabit, relies on Bukuli springs for most of its supply, which is not very reliable during the dry season. Other sources in the County include pans, rock catchments, shallow wells, boreholes, buried tanks and springs. Laisamis Sub-county where this study was carried out is served by 320 Shallow Wells, 27 Boreholes, 36 Pans, 7 Rock Catchments, 8 Buried Tanks and 3 Springs (CGoM, 2014).

Being mainly a nomadic community, the residents use the open water souces for both their consumption as well as drinking by animals. This leads to high turbidity levels at the sources and feacal matter contamination in the water due to high rates of open defecation by both humans and animals. The County estimates that more than half (66%) of these sources have contaminated water and require treatment before drinking (CGoM, 2014). Many of these sources are seasonal due to frequent droughts and therefore, they rarely fulfil the required demand throughout the year.

3.2 Research Design

This study followed a mixed research design applying both quantitative and qualitative methods. The relationship between variables employed the use of Spearman's Correlation. Multivariate linear regression was used to model and understand the factors that inhibit or promote consistency of use of household filters. Qualitative data was also analyzed to give an in-depth understanding of the study questions.

3.2.1 Triangulation

This study employed triangulation. The data that was collected via questionnaires, observation and focus group discussions. The data collected via these three methods was then analyzed and compared to derive an in-depth understanding of the topic of study.

3.3 Method

3.3.1 Quantitative and observational data

The researcher georeferenced the filters and mapped them using Arc Gis. A data collection plan was developed for use by the enumerators. A questionnaire based on an .xml file, which contained all the questions that the enumerator would ask using ODK build software was developed. It was then transferred it to the ODK collect software on the enumerators' mobile phones.

To test the applicability of the questionnaires and the efficiency of the enumerators in the context, the researcher piloted the questionnaire with ten potential respondents while observing and recording required alterations to the original questionnaire. At the end of the piloting exercise, the researcher debriefed the enumerators and amended the questionnaire to fit the context while maintaining the objectivity of the research.

The researcher and the two enumerators then administered the questionnaires to 108 households. This number was arrived at using Cochran's sample size formula (Equation 3.1) considering a population of 48,500 households, 95% confidence interval and 10% margin of error. The sample size required was 96 households. They collected data on the contextual, socio-economic, design and behavioral factors that influence the consistent use of household water treatment and storage in a drought context. A detailed in the questionnaire (Appendix 1) was used for a period of twelve days. The researcher further reviewed the data collection routing plan daily and monitored the collection process using Arc Gis to avoid double collection.

$$n_0 = \frac{Z^2 pq}{e^2} \tag{3.1}$$

Where:

- e is the desired level of precision (i.e. the margin of error),
- p is the (estimated) proportion of the population which has the attribute in question,
- q is 1 – p.

The data collected was spot-checked for accuracy at the end of each day. The enumerators were questioned about any inaccuracies and the data was cleaned. One case was removed since the respondent had indicated that the respondent never used his filter and the observed consistency reported was zero. The researcher further took photos of the contextual setup of the households while the enumerators recorded further structured observation data on the ODK tool kit.

3.3.2 Measures used in the study.

A structured questionnaire was developed. The questionnaire assessed perceptions of economic, psychosocial, contextual and design factors. Together with observations, it also assed consistency of use. These factors were based on previous related studies (Brown & Clasen, 2012b; CITE, 2015; Cogswell & Jensen, 2008; Herbst et al., 2009; Hulland et al., 2015; Mosler, 2012; Nusrat et al., 2015; Ojomo et al., 2015). The following paragraphs describe measures for individual sections of the questionnaire.

Economic factors.

Economic perceptions of the filters were measured by gauging how the users felt about statements in the questionnaire about the perceived value of the filters. The statements sought to assess availability of filter spare parts, the perceived value of the filter and the willingness to pay for a similar filter. A Likert scale ranging from 1=strongly agree to 4=strongly disagree was used for most of these factors.

Behavior and psychosocial factors.

Ranas model was used to assess psychosocial factors as proposed by (Mosler, 2012). This was done in form of statements that sought to find out how the respondents felt about set out behavioral factors. The statements included perceptions on self-efficacy including general norms, cost benefits of filtering water, peer approval, intent to treat water, habit, planning, forgetfulness and severity. A Likert scale ranging from 1=strongly agree to 4=strongly disagree was used for most of these factors.

Environmental and contextual factor.

This factor was composed of the physical conditions in the field that inhibited or promoted consistent use of household filters. This included fit in the house, operation of the filters in low lighting, access of water from the filter by children, time wastage during filter use, acceptability of flow rate, cleaning time needed and cultural prohibition. This was all assessed using a Likert scale ranging from 1=strongly agree to 4=strongly disagree.

Design factors.

This factor was composed of the filters aspects such as initial set up, the filters format and dimensions and whether the filter indicated while working properly. Perceptions about disassembly requirement during cleaning, tap accessibility for all members and filter stability were assessed on a 4-point Likert scale (1=strongly agree to 4=strongly disagree). Indication of proper functioning was assessed on a “yes” and “no” basis.

Consistency of use.

This was the dependent variable of the study. Consistency of use was assessed at the household by the estimation of the total amount of water that the household reported using for drinking in one day as compared to the amount of filtered water that they drank in a day within the previous last thirty days. This ratio was then converted into a percentage. Zero percent implied inconsistent use while one hundred percent implied fully consistent use. The respondents reported these amounts in form of locally available plastic jericans of known capacities. The enumerators further verified whether the filters had water in the raw water compartment or whether it was dump to verify usage.

3.4 Qualitative data

The researcher mobilized for a focus group discussion and invited nine participants.

a. They had been assigned to a given type of filter for more than 30 days.
b. At least two participants must have used one type of the four available filters for the 30 days.

The researcher and two enumerators met nine participants and conducted focus group discussion with the main aim of gaining in-depth knowledge on the factors that inhibit or promote the use of filters in the drought setting. The participants were assigned numbers from one to nine. The enumerators asked the participants questions in the presence of the researcher as per the prepared discussion guide (Appendix III). Each participant was allowed time to respond in a moderated manner in order to ensure that the discussion did not drift away and lose objectivity. The focus group discussion lasted for half an hour. The enumerators recorded the participants after seeking consent from them using a voice recorder and took short notes. Answers were anonymized in accordance with the number distributed.

3.5 Data analysis

Observational data on characteristics of the filters present was organized and tabulated. Quantitative data analysis was conducted using SPSS v.20. statistical software. The distribution of the dependent variable was tested in order to identify the ideal statistical tests and analysis to conduct. Descriptive statistics were also conducted on the data in order check its structural consistency.

The dependent variable for the study was consistency of household use. In addition to group analysis for all the four filters combined, further analysis was conducted while the filters were grouped in to two i.e. one-bucket and two-bucket filters. One-bucket group represented those filters that had a raw water compartment only while two-bucket represented those that had both a raw water compartment and a filtered water compartment.

A test of the null hypothesis that it is equally likely that a random value from one sample is less than or greater than a random value from a second sample was conducted. This was done in order to check whether the medians of consistencies of use of the two filter groups were similar. Spearman Rho correlation was performed for each individual group to identify items that correlated with the dependent variable. Independent variables that were not significantly correlated at $\alpha=0.05$ with the dependent variable were ignored while identifying items for input in a regression model.

One general multivariate linear regression model was developed for all filters. The type of filter used was integrated into the model as a fixed effect. Only variables that were correlated with the outcome variable of filter use were included in the model. Before putting the variables into the model, they were reverse coded except for the factor assessing culture prohibition on use of such filters, such that greater values corresponded to higher levels of agreement with the question. This reverse coding ensured that higher values from the Likert scale indicated a positive aspect of the questionnaire item. Shapiro Wilk test was used to assess the distribution of the standardized residuals of the regression model.

In addition, two multivariate linear regression models were developed separately for the two groups: the group using one-bucket filters and the group using two-bucket filters. In the first model, similar variables as in the general model were included in the model. A similar procedure of reverse coding was conducted as in the previous model. Shapiro Wilk test was used to assess the normality of the standardized residuals of the regression model.

In the second model, the independent variables that correlated with the outcome of filter use in at least one of the filter groups and whose scores were distributed throughout the Likert scale of the questionnaires were included. This ensured that the model was unbiased in indicating both positive (strongly agree and agree) and negative zones (disagree and strongly disagree) for ease of understanding in policy contexts. The variables were then reverse coded and put into the model with consistency of use as the outcome. This reverse coding also ensured that higher values from the Likert scale indicated a positive aspect of the questionnaire item. The model results for each filter group were recorded. Shapiro Wilk test was also conducted to assess the distribution of the standardized residuals.

Data from focus group discussion was translated and transcribed from the local language to English. The transcript was coded manually and analyzed with the aim to identify aspects of the filter groups that affected consistency of use. A further literature scan on unpublished project reports and other secondary materials was conducted in order to understand the efficiency and some technical characteristics of the filters.

3.6 Filter operational parameters

The filters in each household were inspected to determine whether they were working correctly. Conditions indicating proper operation of the filters were based on the following parameters:

i. The filter was in use at least for a month.
ii. The diffuser was positioned properly and in good working condition.
iii. Water was present at both the raw water and filtered water tanks where it was applicable.

3.7 Ethical considerations

Informed consent from all participants in the surveys was sought before proceeding with the administration of questionnaires. The Eawag Ethical Committee also approved the study protocol for the HIF project as a whole on October 4, 2017.

CHAPTER FOUR: RESULTS

This chapter contains a compilation of results of statistical analysis of the data that was collected in the field. The chapter is divided into structured observations results, quantitative analysis results and qualitative analysis results. Additionally, it shows results of multivariate regression models that were used to analyze for consistency of use.

4.1 Structured observations in the field

Data from observation indicates that most (85%, N=107) of the respondents had water available in their households. When they presented the filters during the data collection exercise, there was water in the raw water tank in more than half (60%, N=107) of the households. In more than half (63%, N=107) of the households, filtered water was not stored in a container outside the filter. The filters were generally clean as evidenced by 73% (N=107) of the households. The respondents concentrated on cleaning the outer casing of the filter and most avoided cleaning the filter element. Containers for storing water were generally clean on the inside in 63% (N=107) of the households. Figure 4.1 to Figure 4.6 summarizes the data above visually.

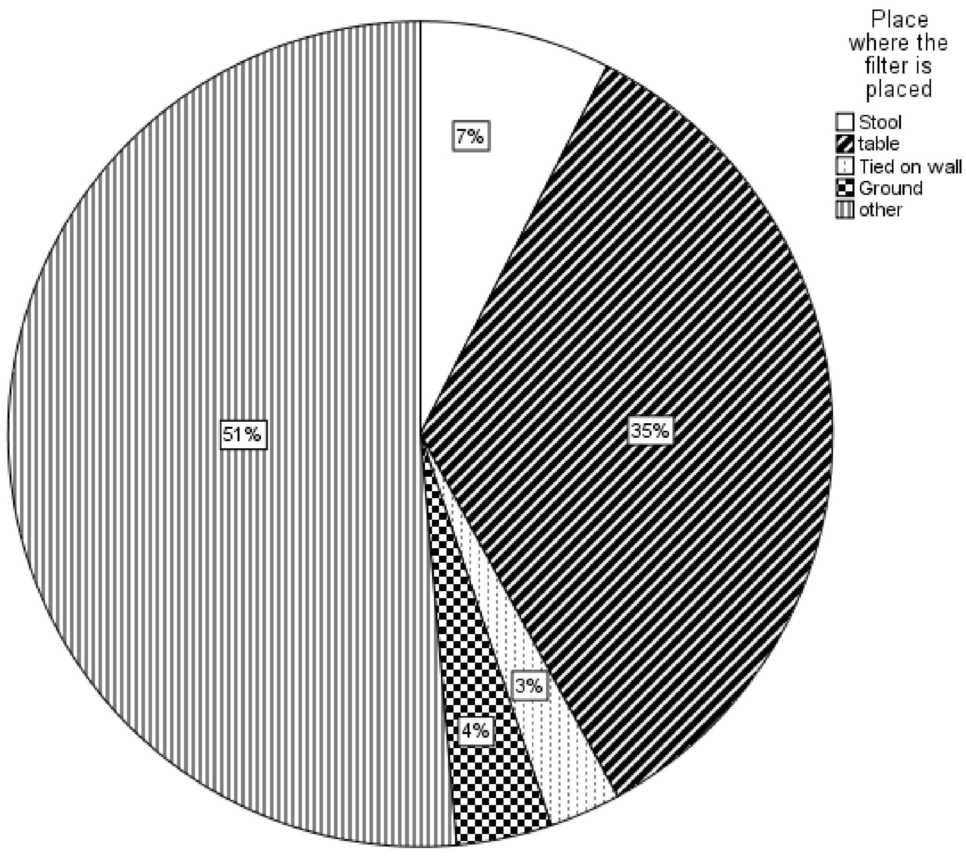

Figure 4.1: Placements of filters within the households.

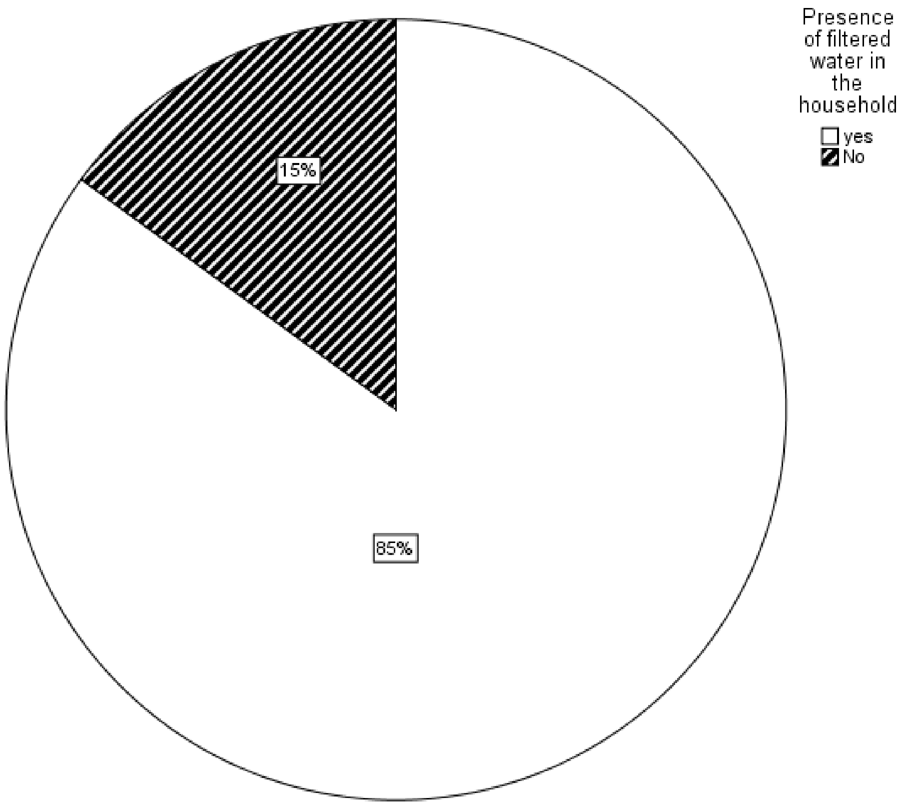

Figure 4.2: Presence of filtered water in the household

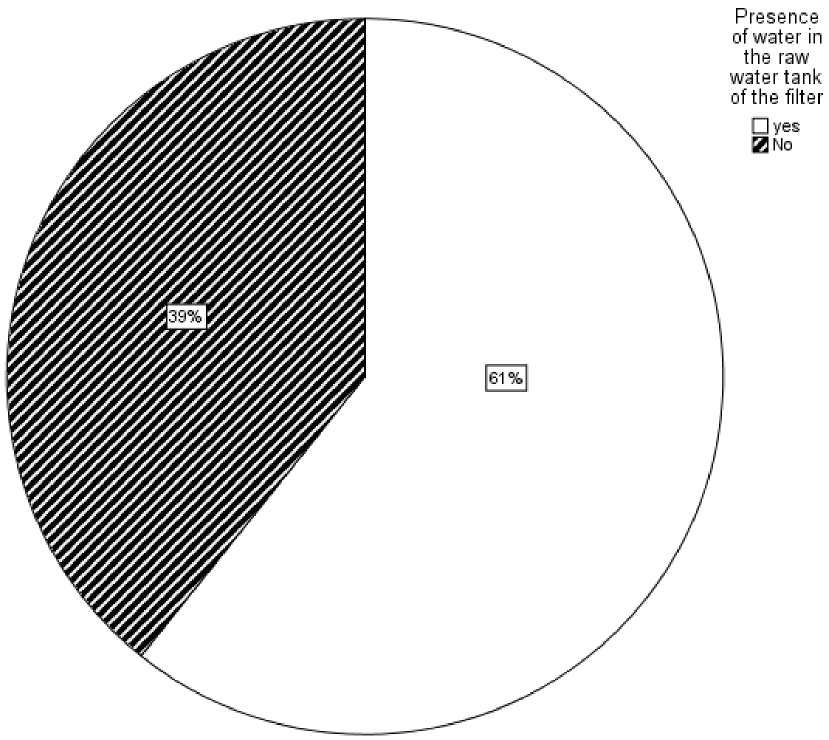

Figure 4.3: Presence of water in the raw water tank of the filter

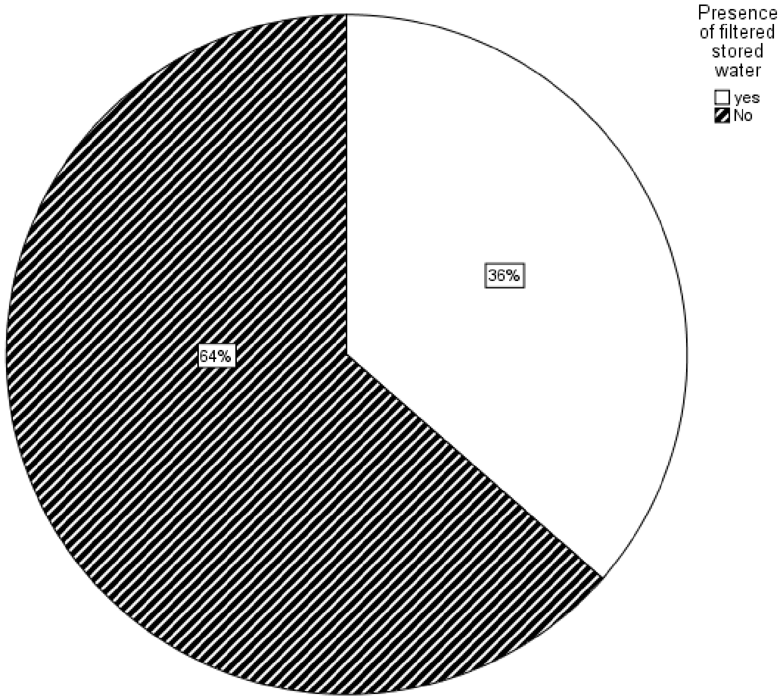

Figure 4.4: Presence of water in the filtered water tank of the filter

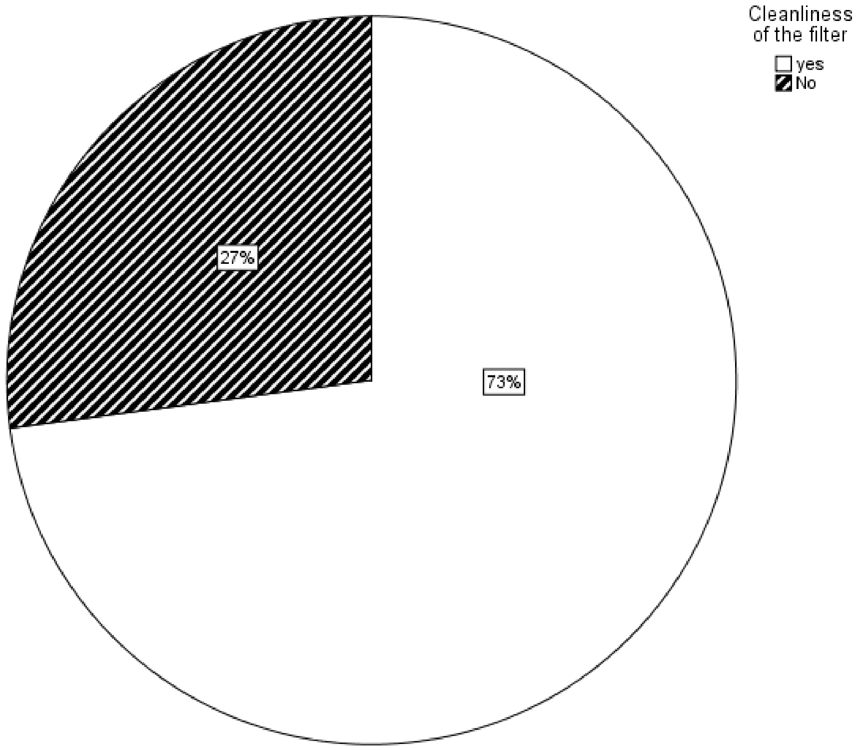

Figure 4.5: Cleanliness of the filter

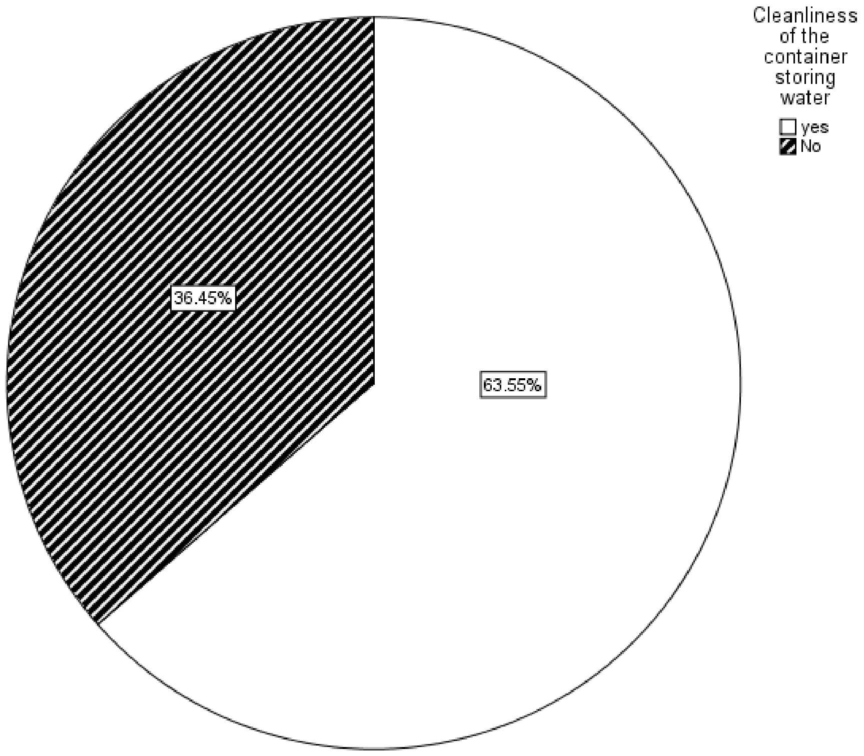

Figure 4.6: Cleanliness of the container storing water

Figure 4.7 shows photographs of the filter types that were included in this study. Filter A and C comprised of the two bucket group while filter D and E comprises the one bucket group.

Figure 4.7 (A-E): Photographs of filters that were distributed

Characteristics of filters were also assessed as shown in Table 4.1and Table 4.2. Ease of use and ease of assembly were assessed on a Likert scale ranging from very easy (1) to very hard (4).

Table 4.1: Characterization of filters that were distributed

Filter code	Filter type	C1 Common Interface compliance (PATH, 2011)	Filtering mechanism	Pre-filter presence	Ease of assembly	Ease of use	Labeled flowrate (L/h)
A	Ceramic	Compliant	Gravity	None	Easy	Easy	6
C	Ceramic	Compliant	Gravity	None	Easy	Easy	8
D	Ceramic	Partially	Siphoning then gravity	Available and in use	Easy	Easy	4-5
E	Ceramic	Partially	Gravity but requires higher elevation.	Available but not in use	Easy	Easy	30

Note: Filter A and C comprises the two bucket group while filter D and E comprises the one bucket group.

4.2 Technical characterization of filters

Data on microbiological tests, flow rate and turbidity conducted during integrity tests before filter distribution indicated filters A and C removed the levels of the contaminants to some extent as detailed in Table 4.3 (CACH, 2018). However, average turbidity levels in filtered water (8.00 NTU) for filter D were higher as compared to the average turbidity levels for raw water (5.67 NTU) used for the same filter. Data for filtered water samples for filter E was not available.

Table 4.2: Technical characterization of filters that were distributed based on laboratory pretests at the field

Filter code		N	Range	Minimum	Maximum	Mean	Std. Deviation	KEBS Standards
A	Turbidity for raw water	35	16.00	1.60	17.60	5.86	3.84	<5
	Turbidity for filtered water	35	7.50	0.00	7.50	1.10	1.63	
	ETC test raw water	35	297.00	4.00	301.00	233.89	115.47	0
	ETC test for filtered water	35	301.00	0.00	301.00	71.11	103.98	
C	Turbidity for raw water	18	10.85	0.00	10.85	4.56	2.68	<5
	Turbidity for filtered water	18	47.00	0.00	47.00	3.57	10.90	
	ETC test raw water	18	301.00	0.00	301.00	178.11	142.92	0
	ETC test for filtered water	18	301.00	0.00	301.00	79.94	110.33	
D	Turbidity for raw water	19	12.69	1.40	14.09	5.67	3.54	<5
	Turbidity for filtered water	19	23.24	0.40	23.64	8.00	8.03	
	ETC test raw water	19	296.00	5.00	301.00	215.84	119.13	0
	ETC test for filtered water	19	298.00	3.00	301.00	142.26	125.63	
E	Turbidity for raw water	5	0.16	0.00	0.16	0.08	0.07	<5
	Turbidity for filtered water	*						
	ETC test raw water	5	295.00	6.00	301.00	110.80	133.02	0
	ETC test for filtered water	*						

Note: * These values were not available

4.3 Quantitative analysis of factors affecting consistency of use of household filters

4.3.1 Descriptive statistics

Table 4.3: Descriptive statistics for questionnaire items on households' perceptions of their filter

Questionnaire item	N	Mean	*SD*	Median	Mode	Min	Max
How do you feel about the following statements:							
I would buy this filter for my friend as a gift	107	2.03	0.56	2.00	2	1	4
I would buy another filter if this one broke down.	107	1.91	0.45	2.00	2	1	4
I would find spare parts to repair the filter easily	107	2.65	0.66	3.00	3	1	4
I dislike drinking filtered water	107	2.93	0.59	3.00	3	2	4
Filtering drinking water is worthwhile	107	1.56	0.55	2.00	2	1	4
People who are important to me disapprove if I filter my drinking water.	107	2.71	0.61	3.00	3	1	4
I am sure that I can always filter my water before drinking, even if this may be difficult sometimes	107	1.87	0.41	2.00	2	1	3
I intend to always filter my water before drinking.	107	1.83	0.38	2.00	2	1	2
Filtering my drinking water is something I do automatically	107	1.70	0.48	2.00	2	1	3
It is possible to install this filter anywhere in my house.	107	3.28	0.47	3.00	3	2	4
It is difficult to operate the filter in low lighting	107	2.25	0.57	2.00	2	1	4
Children in the house can access water from the filter easily.	107	2.18	0.60	2.00	2	1	3
I easily fill and operate this filter.	107	1.85	0.43	2.00	2	1	3
I help my neighbor clean their filter	107	1.92	0.50	2.00	2	1	4
I waste time using this filter	107	3.02	0.55	3.00	3	1	4
The filtered water flows at an acceptable rate while dispensing.	107	2.04	0.55	2.00	2	1	3

Table 4.3: continued from previous page

Questionnaire item	**N**	**Mean**	***SD***	**Median**	**Mode**	**Min.**	**Max.**
Cleaning time needed is equivalent to that of most household utensils	107	2.34	0.57	2.00	2	1	3
I am happy to own this filter	107	1.31	0.46	1.00	1	1	2
My culture prohibits the use of filters	107	3.38	0.64	3.00	3	1	4
The fitting parts can be incorrectly fitted	107	2.64	0.61	3.00	3	1	4
It is difficult to set up this filter even with the help of a manual	107	3.07	0.28	3.00	3	2	4
The filter stands by itself in a stable manner	107	1.93	0.47	2.00	2	1	3
The tap height allows for easy use by all family members	107	2.04	0.36	2.00	2	1	4
Parts of the filter require dis assembly during cleaning	107	2.05	0.56	2.00	2	1	4

Note: Values 1=strongly agree, 2=Agree, 3=disagree and 4=strongly disagree on the Likert scale

Table 4.4: Descriptive statistics for questionnaire items that assessed filter use and experience

Questionnaire item	N	Mean	*SD*	Median	Mode	Min.	Max.
Direct Questions:							
In the last seven days, how often did it happen that you wanted to drink water, but you forgot to filter it in time? (1=0, 2=0-5, 3=6-10, 4=more than 10)	107	1.48	0.66	1.00	1	1	4
Have you made a detailed plan how to overcome difficulties to water filtering? (1=yes, 2=No)	107	1.82	0.38	2.00	2	1	2
How important is it for you to filter your water before drinking? (1=Very important, 2=important, 3=not important, 4=Not very important)	107	1.52	0.50	2.00	2	1	2
How high or low are the chances that your children get sick if they drink unfiltered water? (1=Very high, 2=high, 3=Low, 4=Very low)	107	1.83	0.49	2.00	2	1	4
How many times have you repaired the filter in the last 7 days? (1=none, 2=1, 3=More than 1, 4=I don't know)	107	1.75	0.99	1.00	1	1	4
How many days in the last 7 days have you forgotten to drink filtered water from your filter? (Number of days)	107	1.36	2.02	0.00	0	0	12
How much water does your household use for drinking in one day? measured in Litres)	107	18.64	8.00	20.00	20	5	40
How much filtered water does your household drink in one? (measured in Litres)	107	9.33	4.46	10.00	10	0	20
How easy or hard was it to assemble your filter? (1=very easy, 2= easy, 3=hard, 4=very hard)	107	1.93	0.69	2.00	2	1	4
How easy or hard is it to use your filter from day to day? (1=very easy, 2= easy, 3=hard, 4=very hard)	107	1.85	0.47	2.00	2	1	3
Do you like the colour of your filter? (1=yes, 2=no)	107	1.00	0.00	1.00	1	1	1

Figure 4.8 details comparisons of consistencies for the individual filters. For all the filters, consistency for most households was observed to have a median of 50%. Filter A and E did not have any person reporting low consistency (0 to 20%). Most of the users of Filter E had consistency of use ranging between 50 to 70%.

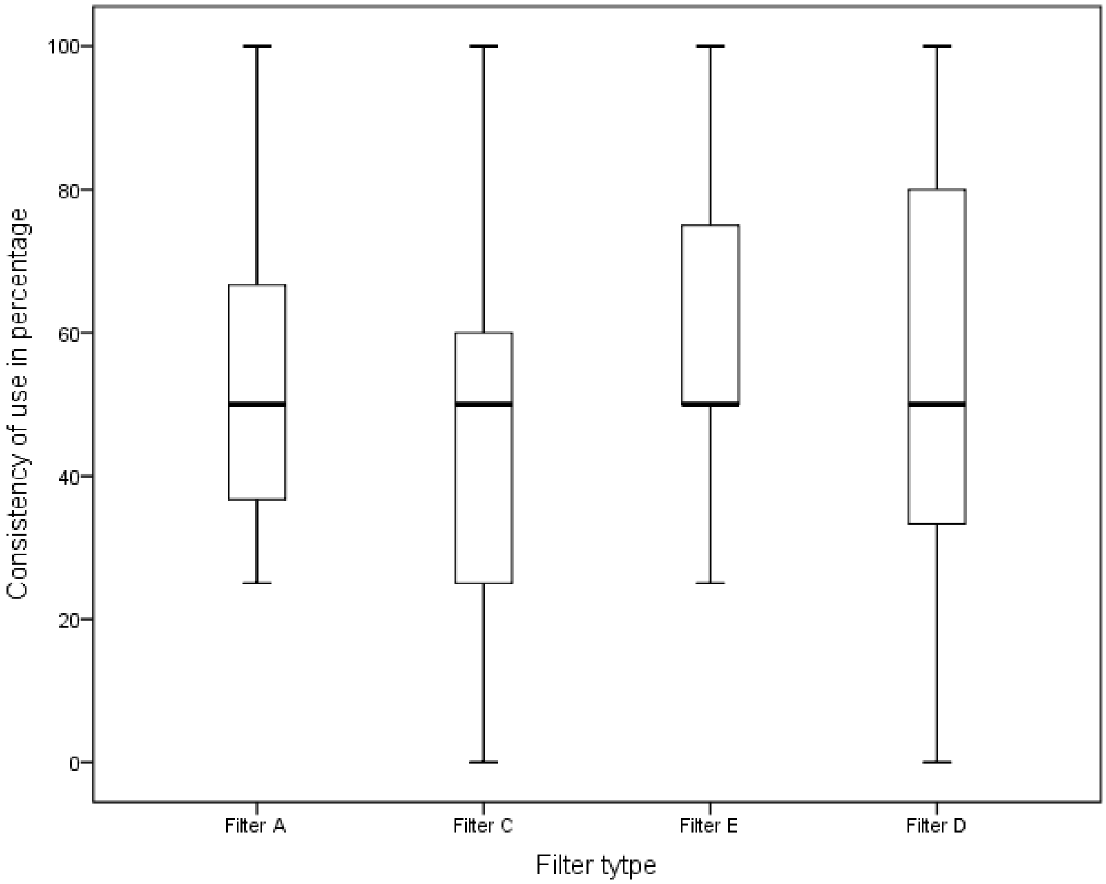

Figure 4.8: Distribution of consistency of use for each study filter, with 100% consistency indicating constant filter use over 30 days

The median consistency of use for both two and one-bucket filters was 50%. The distribution of the consistency of use variable, was significantly different from a normal distribution according to Shapiro-Wilk tests ($p<0.001$). According to a Mann-Whitney U test, the hypothesis that there was no significant difference in the distribution of consistency of use for the two filter groups ($U=1570$, $p=.448$) was retained.

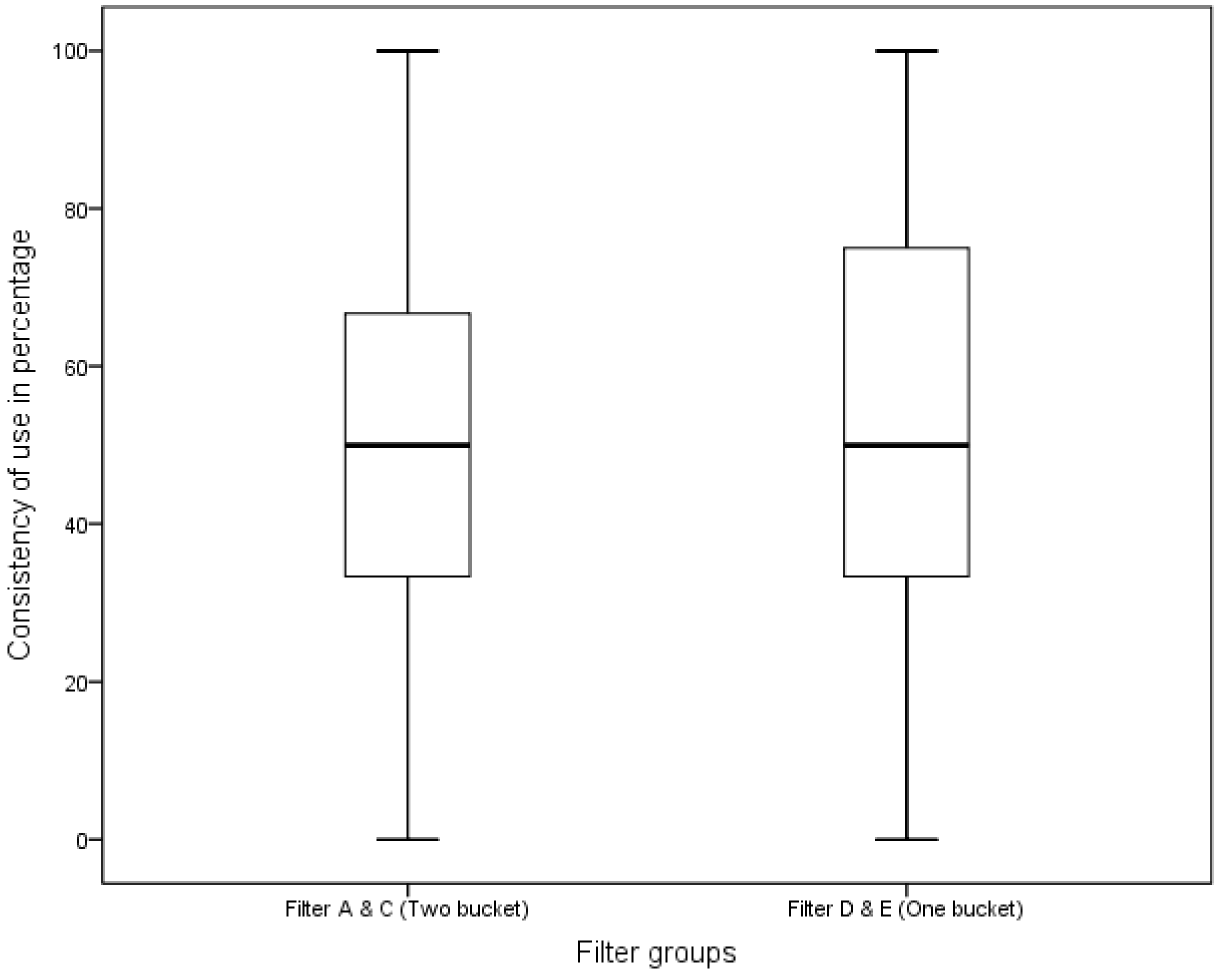

Figure 4.9: Distribution of consistency of use for each study filter, with 100% consistency indicating constant filter use over 30 days

Flow rates of the individual filters were acceptable for the users. However, for the dual bucket group, the users did not consider the actual flowrate but rather the fact that filtered water was always present in the filtered compartment. This is detailed in Figure 4.10. It was however notable that 36% and 13% of the respondents using filter D and E respectively did not consider their flow rates to be acceptable.

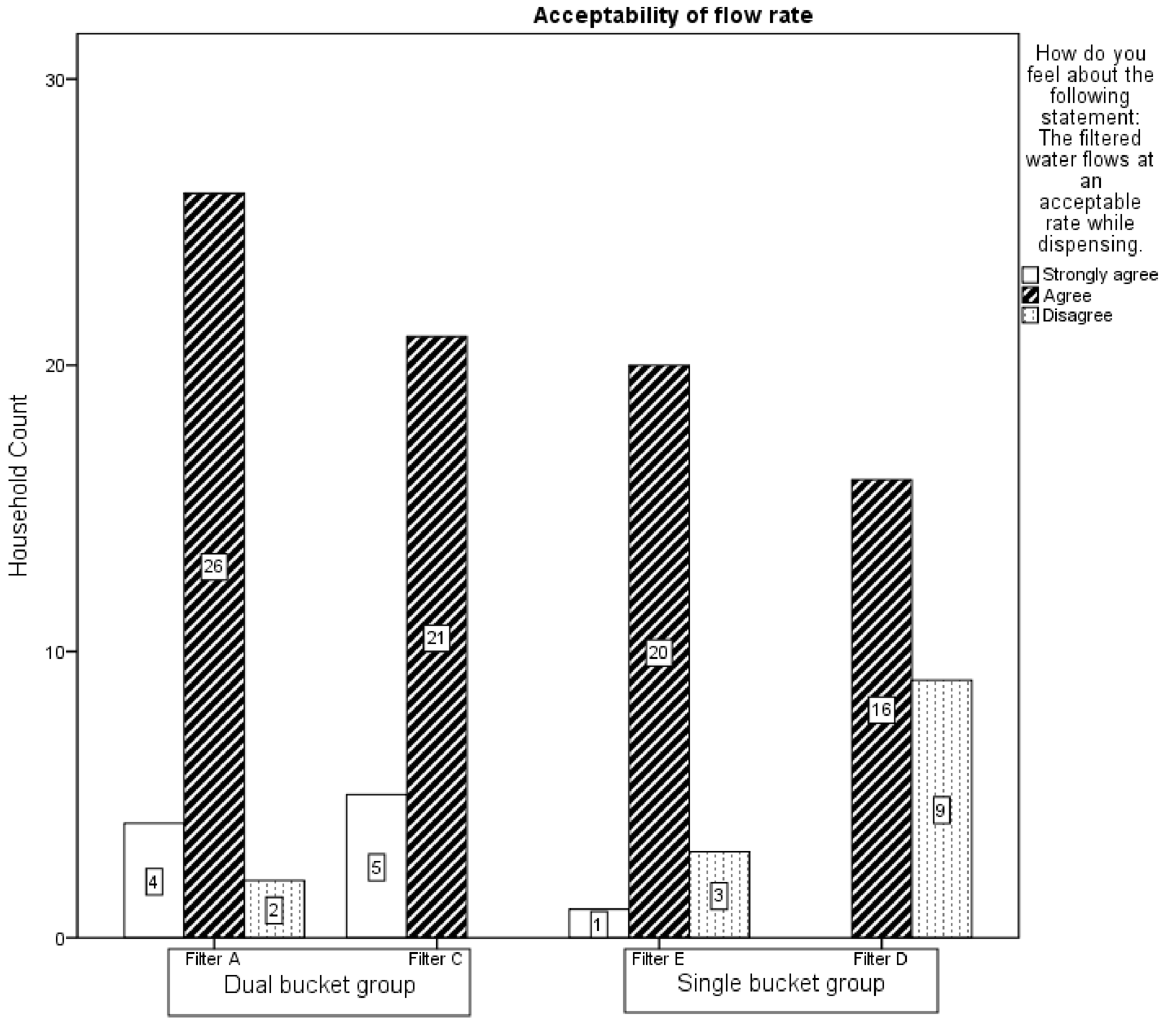

Figure 4.10: Comparison of flow rates acceptability for the individual filters in their filter groups

4.3.2 Correlation tests results for independent variables and consistency of use

Tests of correlation indicated that there were economic factors that had influence on consistency of use. For all the filters combined, the majority of the respondents (70%) were willing to pay above KES. 1000 ($10) for a similar filter as the one, they owned (Figure 4.11).

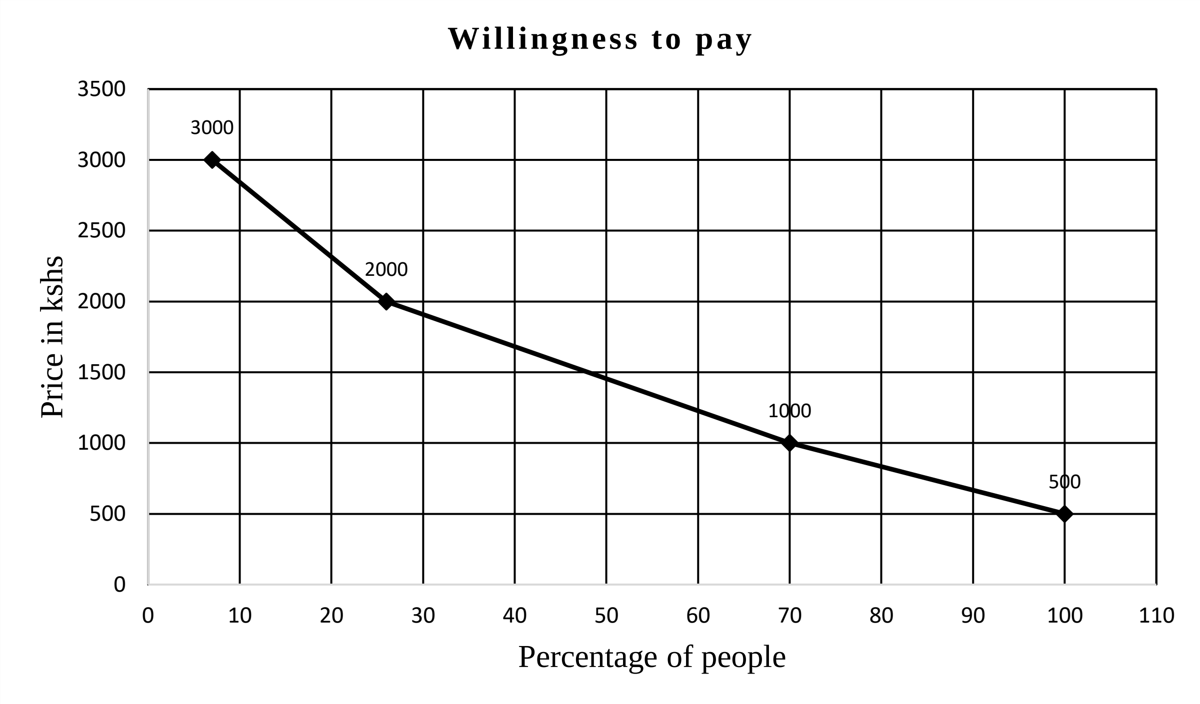

Figure 4.11: Willingness to pay curve for all filters

Among households using two-bucket filters, there was a weak positive and negative significant correlation with consistency of use. This was for the two questionnaire items that assessed intent to buy a similar filter as a gift for a friend and for themselves if the one they owned broke down ($r(56)=0.276$, $p=0.049$ and $r(56)=-0.260$, $p=0.49$), respectively (Table 4.2). The respondents answered either "strongly agree" or "agree" for these two questionnaire items. This implied that overall the respondents valued these filters (Table 4.6).

For the one-bucket group, there was a negative moderate correlation, $r(48)=-0.523$, $p<0.01$ between availability of spare parts for the filter and consistency of use. This implied that the more the respondents perceived that they could not find spare parts for the filter; the less consistently they used the filter. A very weak negative correlation which was approaching significance between spare part availability and consistency of use was also observed for the two-bucket group $r(56)=-0.24$, $p=0.069$. This was the only economic factor among those assessed that showed correlation with consistency of use for the one-bucket group of filters.

Generally, design factors and habit correlated significantly with consistency of use for two-bucket group while behavior correlated with consistency of use for the one-bucket group. Contextual factors affected the filters in almost equal magnitude for both filter groups (Table 4.6).

Table 4.5: Spearman's rho correlation coefficients between economic, behavioral, contextual and design factors with constituency of use as the outcome.

Spearman's Rho correlation		**Two Bucket filters (N=58)**	**One bucket filters (N=49)**
		Dependent variable: Consistency of use (0%=non consistent, 100%=fully consistent)	
Factor	**Questionnaire item**	Correlation Coefficient	Correlation Coefficient
Economic (1=strongly agree → 4=strongly disagree)	I would find spare parts to repair the filter easily	-0.241	**-0.582****
	I would buy this filter for my friend as a gift	**0.276***	-0.077
	I would buy another filter if this one broke down.	**0.260***	-0.037
Behavior (1=strongly agree → 4=strongly disagree)	Filtering my drinking water is something I do automatically	**0.421****	0.253
	I dislike drinking filtered water	0.195	**0.333***
	Filtering drinking water is worthwhile	0.223	**0.579****
	People who are important to me disapprove if I filter my drinking water.	0.182	**0.373***
	I intend to always filter my water before drinking.	0.209	**0.331***
	In the last seven days, how often did it happen that you wanted to drink water, but you forgot to filter it in time?	0.017	**-0.311***
Contextual/ Environmental (1=strongly agree → 4=strongly disagree)	It is possible to install this filter anywhere in my house.	**-0.533****	**-0.476****
	Children in the house can access water from the filter easily.	**0.360****	**0.298***
	I help my neighbor clean their filter	**0.285***	0.254
	I waste time using this filter	**-0.263***	-0.279
	Cleaning time needed is equivalent to that of most household utensils	**0.516****	0.276
	I am happy to own this filter	**0.382****	**0.500****
	My culture prohibits the use of filters	**-0.398****	**-0.360***
	The tap height allows for easy use by all family members	0.189	**-0.299***
Design	How many times have you repaired the filter in the last 7 days? (1=none 2=once 3=more than once 4=I don't know)	**-0.365****	**-0.305***
	Does the product indicate when it is not filtering water properly?(1=Yes, 0=No)	**-0.465****	-0.216
	How easy or hard was it to assemble your filter? (1=Very easy→4=Very hard)	**0.334***	**0.468****
	The fitting parts can be incorrectly fitted (1=strongly agree → 4=strongly disagree)	**0.351****	0.193
	How easy or hard is it to use your filter from day to day? (1=Very easy→4=Very hard)	**0.434****	0.247

Note: * $p \leq 0.05$, ** $p \leq 0.01$, *** $p \leq 0.001$

4.3.3 Regression models for predictors of consistency of use of household filters

Multiple linear regression (ordinary least squares, or OLS) was used to model the predictors of consistency of use for all the filters combined. Two more OLS models were used to analyze the data separated based on filter groups, i.e., two-bucket filter and one-bucket filter groups.

For all filters combined, the results indicated that the seven predictors included in the model explained 44% of the variance (R^2=0.44, $F(7, 99)$ =11.14, p<0.001) for all filter groups. Fit to household environment significantly predicted consistency of use of the household water filters (β=15.73, $p<0.001$), while the feeling of happiness due to ownership of the filter significantly predicted consistency of use (β=-11.192, $p=0.015$). This implied that if all other predictors are held constant, for every unit of agreement to the question about the filter's fit in the house, there is a 15-point increase in its consistency of use. Table 4.7 shows the independent variables that were included in the model. Shapiro Wilk test for the general model indicated evidence that the residuals of the regression models were normally distributed for all the filter groups combined, p=0.232.

Table 4.6: Ordinary least regression coefficients for the general model for factors that affect consistency of use of all household filters in emergency contexts.

All filters groups combined		
Predictors	**B**	***P* value**
I am happy to own this filter	-11.192*(4.53)	0.015
It is possible to install this filter anywhere in the house	15.734***(4.29)	0.000
Children in the house can access water from the filter easily	-2.362(3.51)	0.503
How easy or hard was it to assemble your filter (1=Very hard, 2=hard, 3=easy, 4=very easy)	-4.614(2.99)	0.126
My culture prohibits the use of filters (1=Strongly agree, 2=Agree, 3=Disagree, 4=Strongly disagree)	-8.912*(3.04)	0.004
Does the product indicate when it is not filtering water properly? (1=Yes, 0=No)	-6.855(5.59)	0.223
Filter group (dummy: 1=One-bucket, 0=Two-bucket)	-4.711(3.78)	0.215
Constant	121.14(21.8)	<0.01
R^2	0.44	
Observations	107	

Notes: Model standard errors in parenthesis, * $p \leq 0.05$, ** $p \leq 0.01$, *** $p \leq 0.001$. All variables are coded as 1=Strongly disagree, 2=Disagree, 3=agree, 4=Strongly agree unless otherwise specified

Two separate models of the two filter groups i.e. two-bucket and one-bucket were also developed and labeled model 1 and model 2. Table 4.8 indicates the factors that were included in the models. Shapiro Wilk test for Model 1 indicated evidence that the residuals of the regression models were normally distributed for the dual and one bucket group, p=0.078 and p=0.786 respectively.

The results of model 2 indicated that the six predictors explained 37% of the variance (R^2=0.37, F (6, 51) =5.02, p<0.001) and 55% of the variance (R^2=0.55, F (6, 42) =8.56, p<0.001) for two-bucket and one-bucket groups respectively (Table 4.8). This model points out that if all other predictors are held constant, for every unit of agreement to the question on fit of the two bucket group filters in the house; there is a 22-point increase in its consistency of use. None of the filters in the field had an indicator to show whether they were working or not. Those who perceived that the filters had an indicator exhibited 19 points decrease in consistency of use as compared to those who were confident that there was no indicator.

On the other hand, access to spare parts for the filter, fit in the house, and incorrect fitting of filter parts significantly predicted consistency of use for the one bucket group (β=22.64, $p<0$.001), (β=21.12, p=0.003) and (β=13.20, $p=0$.019) respectively. This result shows that the perception of existing chain supply of filter spares exhibited increased consistency of use of one-bucket filters by 23 points if all the other predictors were held constant. The effect of fit in the houses of the respondents for the one bucket was similar to that of two bucket group. Approval from peers also predicted consistency of use (β=-11.09, $p=0$.027) (Table 4.8). Where peer approval of filter use increased by one unit, consistency improved by 11 points when all other factors are held constant.

Shapiro Wilk test for Model 2 indicated evidence that the residuals of the regression models were normally distributed for the two and one bucket group, p=0.050 and p=0.455 respectively. This was upheld by the Lilliefors corrected Kolmogorov–Smirnov test, p=0.076 and p=0.200 respectively.

Table 4.7: Ordinary least regression results for model 1 and 2 for both filter groups

	Predictors	Model 1		Model 2	
		B	*p*-value	B	*p*-value
Filter A & C (Two-bucket)	I would find spare parts to repair the filter easily			0.839(4.23)	0.844
	It is possible to install this filter anywhere in my house.	13.951*(5.31)	0.011	21.554**(6.22)	0.001
	In the last seven days, how often did it happen that you wanted to drink water, but you forgot to filter it in time? (1=0, 2=0-5, 3=6-10, 4=more than 10)			-5.531(4.76)	0.250
	The fitting parts can be incorrectly fitted			2.309(5.21)	0.660
	People who are important to me disapprove if I filter my drinking water.			-0.610(4.67)	0.896
	Does the product indicate when it is not filtering water properly? (1=Yes, 0=No)	-12.4208 (6.8)	0.073	-19.151* (7.27)	0.011
	I am happy to own this filter	-6.115 (6.11)	0.322		
	Children in the house can access water from the house easily	-7.751(4.53)	0.093		
	How easy or hard was it to assemble your filter? (1=Very hard, 2=hard, 3=easy, 4=very easy)	1.101(3.95)	0.782		
	My culture prohibits the use of filters. (1=Strongly agree, 2=Agree, 3=Disagree, 4=Strongly disagree)	-11.702**(4.2)	0.008		
	Constant	112.51(31.87)		5.318 (26.27)	
	R^2	0.48		0.37	
	Observations	58		58	
Filter D & E (one-bucket)	I would find spare parts to repair the filter easily			22.644***(4.79)	0.000
	It is possible to install this filter anywhere in my house.	18.903** (6.95)	0.009	21.118**(6.61)	0.003
	In the last seven days, how often did it happen that you wanted to drink water, but you forgot to filter it in time?			-3.652 (3.88)	0.352
	The fitting parts can be fitted incorrectly			13.192*(5.41)	0.019
	People who are important to me disapprove if I filter my drinking water.			-11.092* (4.84)	0.027
	Does the product indicate when it is not filtering water properly?	5.083(9.02)	0.576	-1.247 (8.57)	0.885
	I am happy to own this filter	-21.223* (6.61)	0.003		
	Children in the house can access water from the house easily	6.209 (5.43)	0.260		
	How easy or hard was it to assemble your filter?	-12.379**(4.23)	0.007		
	My culture prohibits the use of filters	-7.297 (4.28)	0.095		
	Constant	138.67 (29.45)		-36.17	
	R^2	0.52		0.55	
	Observations	49		49	

Notes: Model standard errors in parenthesis, * $p \leq 0.05$, ** $p \leq 0.01$, *** $p \leq 0.001$. All variables are coded as 1=strongly disagree, 2=Disagree, 3=agree, 4=strongly agree unless otherwise specified

4.4 Qualitative data for assessment of factors affecting consistency of use of filters

A focus group discussion was conducted with nine participants who were currently using the filters. For both one and two-bucket filter groups, a third of the participants reported previous experience with water treatment technologies deduced from statements such as "I have been boiling my water before drinking", "I used to filter my water using a sieve to remove aquatic animals" and "I used to decant before using my water to separate the dirt and the water". This showed knowledge of previous treatment methods and effects of consumption of untreated water or dislike towards drinking contaminated water.

About half of the respondents concurred and appreciated the importance of filtering water before drinking. This was indicated by statements such as "It is good because it removes impurities such as soils and germs", "It removes small aquatic animals" and "It makes one not get sick". These statements indicated the respondent's awareness of the importance of the filters in improving the quality of raw water and their connection to health.

Those with one bucket filters reported that they would stop using the filter if it broke down, when they did not have water and when they are away from home. Respondents' description of taste, colour and odour of filtered water stated that the water was "cool", "clear and odorless" and "tasted sweet" for filter A and E. However there was no response from respondents of filter C whereas the respondent having filter D said that the water had some "odour". There was no logical explanation for presence of odour as reported by the last respondent.

The discussion further indicated that users of filter A and C found their filters "beautiful and stable and if set in a good space, they did not disturb". Those who had filter types D and E did not answer this question. It had been observed that filter D dispensed dark coloured filtered water and the users did not like this. All the respondents concurred that, "at first, it was difficult to use the filters because it was not familiar" to them. This changed after they were instructed later on how to use them. While using the filter, one of the respondents with filter C reported that the filter elements "colour changed from white to brown and despite thorough cleaning, it remained stained". This was only observed with the very few who were curious to clean the filter elements. Another with filter E claimed that the filter needed a considerable elevation for it to function properly. While all the filters were easy to clean as reported by the respondents, they noted that they feared dis-assembling filter C as they feared they would damage it.

Statements such as “It is easy to clean even though disassembling its elements creates fear in us therefore, we fear to disassemble the filter for thorough cleaning” and “The filters are easy to clean except type C.” indicates the need for less parts for filters to make reassembly easier and training in the early stages of interventions.

The ability of the filters to remove physical impurities was the characteristic most of the respondents liked about the filter. On the contrary, for filter C, one respondent reported that the “fear of breaking the filter during disassembly and cleaning was what she did not like about her filter”. All the respondents reported that they had been given prior but very brief information on filter use meaning that the users had been sensitized before.

CHAPTER FIVE: DISCUSSION

This study sought to understand the factors that influence consistency of use in household filters in an emergency context. It further hypothesized that different filter designs had different factors that affected their consistency in use. Zones of answers from the Likert scales were defined as either positive or negative zones. The positive zones comprised of responses "Agree" and "Strongly Agree" while the negative zone comprised of "Strongly disagree" and "Disagree".

The population in the study all came from one community served by similar water sources, had similar cultural beliefs and were all women. This is a limitation due to lack of variety in terms of culture, religion and gender.While this is one of the limitations of this study, it is also part of its strength since it allowed comparison of the filter groups on a relatively stable comparative framework. The studies findings are also analogous to other global studies with similar contexts and as such is can be generalized.

The literature review revealed that only the mean field measured flow rate (4.48 L/s) for filter D matched its manufacturer's labelled flow rate (4-5 L/s). All the other filters recorded lower flow rates. Higher levels of turbidity for filter D in the filtered water were recorded (CACH, 2018). This was attributed to dark particles of activated granular carbon in the filtered water from the filter.

5.1 Consistency of use

The average consistency of use for both the two-bucket group and the one-bucket group was observed as 51% (*SD*=22.52) and 55% (*SD*=26.18) respectively. These values were relatively higher than 21% and 31% as reported by Najnin, et al. (2015) and Brown and Sobsey,(2006) in a non-emergency setting in Bangladesh for filters similar to those in one bucket group. This discrepancy could be due to contextual backgrounds differences in terms of culture and relationship between the implementers and end users. The protracted emergency situation could have also prompted the increased consistency.

5.2 Structured observations

About 63 percent of the households did not have filtered water stored in an outside container. This high percentage could be attributed to the fact that most of those who owned the dual bucket filters prefered to consume most of their filtered water directly from the filtered water compartment and they did not find further reason to store because they had sufficient supply throughout.

Relatively lower acceptability of filtration rates observed in one-bucket filters is analogous with results of Nusrat et al. (2015) which linked low filtration rate among other factors as a hindrance to sustained use of siphon filters. In contrast, the same assessment showed zero percent dissatisfaction for those with filter C and six percent for those with filter A. This was attributed to the fact that the two-bucket filters had the storage component that allowed the filter to continue filtration even when the filtered water was not required.

All the filters' elements were ceramic. Their mode of operation was generally gravity driven except for type D which used siphon action. Their labelled filtration rates ranged from 6 L/h to 30 L/h (Table 4.2). All of them recorded improved water quality in terms of turbidity and bacterial removal .

5.3 Economic factors that affect consistency of use

A number of economic factors are linked to consistency of use of HWTS options in emergency context as evidenced from Spearman's correlation analysis (Table 4.6). For the two-bucket group, these factors include willingness to buy a similar filter as the one the respondent had, for a friend and intent to buy another filter if what the respondents had broken down. This showed that the respondents perceived the filters to be valuable within their households. As indicated by the willingness to pay curve, 70% of the respondents were willing to pay KES. 1,000 (10 USD) for similar filters as the ones they owned. Nusrat et al. (2015) also recorded similar findings for willingness to pay for ceramic filters in Bangladesh. These two factors were positively correlated indicating that as the strength of agreement decreased on the Likert scale, the consistency decreased. This is contrary to the expectations. However, all of the respondents were in the positive zone and this could mean increasing perception of value of the filters in this filter group might not necessarily translate to higher consistency. Those who valued the filters highly were less likely to use them heavily as they would have wished to preserve it as long as possible.

In contrast, easy availability of spare parts was the only economic factor that indicated evidence of association with consistency of use for one-bucket filter group. Half of the respondents reported that they could not get spare parts for this group's filters. The more the respondents perceived that the spares would be available, the more consistently they used the filter. This was due to the respondents feeling that the filters' use was limited to the lifetime of the filter since if it broke down, they would not find spare parts. This contrasted with dual filter group whose parts especially the tap were easily available in hardware shops. Those who thought they would find spare parts for the one-bucket filter exhibited consistency, which was 23 percentage points higher as compared to those who thought they would not find the spare parts, assuming that all other factors were held constant. Filter breakage and lack of supply chain have been linked to termination of use of ceramic filters in previous studies (Sobsey et al., 2008).

5.4 Behavioral factors that affect consistency of use

For the two-bucket group, filtering drinking water was habitual to them. This showed a positive correlation, which was logically unexpected. However, most of the responses to the associated questionnaire lied in the positive zone of the habit of filtering water. This represents a person's perceived ability to continue to practise a behavior, which includes the person's confidence in being able to deal with barriers that arise (Mosler, 2012). This item shows that for the two-bucket group, the respondents easily adopted and consistently used the filters with confidence. Other filters with a similar interface as that of those in two-bucket group had been previously distributed by humanitarian organizations and therefore, this product's familiarity contributed to self-efficacy in consistently filtering water. Bandura (1998) further explains this rapid uptake of behavior to be because of familiarity of previous use or ability of peers to use a technology or adopt a behavior. The author further acknowledges that people's beliefs in their collective efficacy to accomplish social change plays a key role in the policy and public health approach to health promotion and disease prevention.

The one-bucket filter group's consistency of use is associated with more behavioral factors as compared with the two-bucket group. These factors include the general feeling of liking filtered water, cost benefit of filtering water, intent to filter water, forgetfulness and peer approval of filtering drinking water.

The general feeling of liking filtered water by the respondents (74%) reflected to their knowledge of link between contaminated water consumption and diarrheal diseases. Further assessment of cost-benefits of filtering water revealed that the respondents consider it worthwhile to filter water because it made them not get sick. There exists knowledge in the community of the link between consumption of contaminated water and disease. The more the respondents forgot to treat their water, the more the consistency reduced. While more than half (53%) of the respondents did not forget to treat their water, the rest forgot at some point. This still poses a health threat as a single instance of contaminated water consumption can cause an infection (Enger et al., 2013).

Peer, relatives, family and friends' approval of filtering drinking water mattered. More than half (63%) of the respondents were in the negative zone with the statement "People who are important to me disapprove if I filter my drinking water" and the further they disagreed the more consistent they were in using the one-bucket group. Rogers (2003) explains this as a collective innovation-decision where the decision of using the filters consistently was to an extent directly influenced by immediate peers. Injunctive norm factors represent the perceived social pressure towards a behavior (Mosler, 2012). Those respondents whose peers, relatives, family and friends approve their use of filters show 11 points increase in consistency of use for this filter group as compared to those who did not perceive the approval. This concurs with Freeman et al. (2012) who acknowledges peer influence and recommends group approach in HWTS sensitization campaigns in order to enhance maximum health gains from HWTS options. This finding is also analogous to Hulland et al. (2015). Trinies, Freeman, Hennink, and Clasen (2011) while assessing the role of social networks in HWTS uptake recommends promoters to not only ensure product availability and financing, but also encourage platforms for discussion; recognize the socio-economic norms that develop around who adopts new technologies.

5.5 Contextual/environmental factors that affect consistency of use

Among the factors assessed, fit to house environment, happy feeling of ownership, culture prohibition and access of the filter by children are associated to consistency of use for both one-bucket and two-bucket filters. Time consideration while using the filter, cleaning time needed and the will to help immediate neighbours clean their filters in relation to consistency of use mattered for the two-bucket filter. On the other hand, tap height and access affected the consistency of use of the one-bucket filter.

The better a filter fits in the house, the more people consistently use it. The two-bucket filter group takes a larger space relative to all other household items in the respondents' shelters. This therefore contributes to lower levels of consistency in use since the respondents felt that it was taking up too much space in the shelters. On the other hand the one bucket group requires a higher elevation for the flow rate to be acceptable by the respondents. This proved to be a challenge to most of the shelters visited in the study since most were shorter than one and a half meters. For the two-bucket group, a move from the negative to the positive zone translated to a 22-unit increase in consistency of use, while a similar move on the one bucket group predicts a 21-units increase when all other factors are kept constant. The nature of the respondents' shelters could have majorly contributed to this due to larger volume occupied by the two-bucket group and the need for a higher elevation for use for the one-bucket group. This finding agrees with PATH (2012) finding on limitation of siphon filters, such as those in one-bucket group in some contexts despite their minimal footprint. It also shows that two-bucket group filters are also affected by the context and mainly due to their large volume. Therefore, there exists a tradeoff between space occupied by the filter, filter capacity and how they affect fit in the houses of the beneficiaries. While one-bucket filters may be more preferred by humanitarian organizations due to their small volume that facilitates easy logistics, the context they will be operated in needs to be checked due to their need for elevation.

Filtering water was not considered as an additional task. For the two-bucket group, most (76%) of the respondents concurred that the practice of filtering water was not a waste of their time and this was associated with consistency of use. Consideration of filtering water as an additional task that wastes users time has been linked to irregular use of household filters by Nusrat et al. (2015) in non emergency settings. The dire need of clean water in emergency settings and where there is low access led to development of coping mechanisms for the low flow rates. Women left the water filtering overnight or when they went to do other chores during the day and stored it so as to ensure sufficient supply.

Almost all (99%) of the respondents were happy to own the filters they had in the two-bucket filter group. There was a feeling of aspiration associated with those who owned the filters. This was similarly reflected in the one bucket group. Happy feeling due to ownership of the filter significantly predicted consistency of use in the one bucket group within the positive zone as evidenced in Model 1 (Table 4.8). This factor however showed that consistency might decrease with excessive sensitization, as the respondents tend to be skeptic due to change in attitude and perceptions. Culture did not prohibit the use of any filters in in both groups.

5.6 Design factors that affect consistency of use

From the design factors assessed, frequency of repair and ease of assembly affected consistency of use for both filter groups. The perception of product functionality status indication, day-to-day use of filter and probability of incorrectly fitting the parts during assembly and consequent re-assembly show a relationship with consistency of use for the one-bucket group only.

About a quarter (N=49) concurred that the fitting parts could be fitted incorrectly for the one-bucket group. Presence of many parts to fit while assembling it showed evidence of association with consistency of use. The more confident the respondents were in fitting the filter, the more consistently they used it. Those who perceived that the parts could be incorrectly fitted predicted 13-units more in consistency of use of the filter when all other factors were kept constant. This could be attributed to the fact that they had already gone through the challenge of fitting them and did not fear in case the parts were accidently disassembled. This consequently improved perceived self-efficacy. This can be explained by Bandura (1998) who states that mastery experiences, seeing people similar to oneself manage task demands successfully among other factors is a source of influence for people to believe in their own self-efficacy. Incorrect fitting may lead to incorrect use of the filter. Ojomo et al. (2015) states that users may believe products are ineffective if they continue to get sick, even if the reason they are getting sick is incorrect use.

A considerable percentage (37%) of those who had the two-bucket group had repaired their filters more than one time within the previous seven days. This is in contrast with 12% in the one bucket group. The more the number of repairs, the less the consistency in use was for the two-bucket group. Major repairs cited were leakages from taps and breakage of filter elements. Filter breakage has been linked to termination of use of ceramic filters in previous studies (Mellor, Abebe, Ehdaie, Dillingham, & Smith, 2014; Sobsey et al., 2008)

It was easy to assemble all the filters. However, the participants in the focus group discussions indicated that “at first it was hard to assemble” all the filter groups until they were later instructed how to assemble. This implies that there is need for initial training to ensure effective and consistent use. (Ojomo et al., 2015) emphasizes importance of these trainings even when implementers view a particular HWTS technology or product as easy or intuitive to use.

Placement and accessibility of the diffuser (tap) in the one bucket group had considerable effect on consistency of use. Where the respondents felt that the tap was complicated to use or not easily accessible in terms of dispensing water, their consistency of use decreased. This was mainly in the agreement zone indicating that the respondents thought the diffusers were generally well placed within the design of the filter. Observations in the field showed that diffuser designs that were uncommon like those of two-bucket group required new training to use and were less preferred as compared to those in the two-bucket filter group.

Indication of correct working status by the filters was a point of concern for filters in the two-bucket group. No filter had any indicator to show when they were working properly or not. Those respondents who perceived that the filter had an indicator were likely to use the filters with consistency 19 units less as compared to those who knew there was no indicator, all other factors held constant. This signals that filter manufacturers could put an indicator to show the functioning status of the filters as it has a significant effect on the filter’s consistency of use. This further indicates that a noticeable percentage (16%) of the respondents did not understand how the filters worked furthering the need for training on effective use.

Sickness and removal of physical impurities were the main reasons that motivated the respondents to filter water. Filter breakdown, lack of water and being away from home were the main reasons for the respondents not to use the filters. Similar barriers have been cited by Nusrat et al. (2015). Change in the colour of the filter element, relatively large footprint and need for elevation posed as challenges to filter use to some of the respondents. Fear to dis-assemble the filters was also cited and was a concern for filter C and an inhibiting factor to filter use. Table 5.1 presents a summary of statistically significant predictors of consistency of use for the two filter groups. There was no theoritical basis for presence of interactions in the predictors within the models.

Table 5.1: Summary of statistically significant predictors of consistency of use

Predictors	Nature	Filter Groups	
		Two bucket	One bucket
It is possible to install this filter anywhere in my house.	Context	✓	✓
My culture prohibits the use of filters	Context	✓	✓
I am happy to own this filter	Psychosocial	✓	✓
The fitting parts can be incorrectly fitted	Design	×	✓
I would find spare parts to repair the filter easily	Economic	×	✓
People who are important to me disapprove if I filter my drinking water.	Behavior	×	✓
Does the product indicate when it is not filtering water properly?	Design	✓	×

Note:

- ✓ *Significant predictor for the group*
- × *Not significant predictor for the group*

5.7 Summary of the chapter

It is clear that different filters have different factors that affect their consistency of use in households in emergency contexts. Presence of a storage component for dual bucket filters gave the respondents the perception that their flow rate was higher than that of the one bucket filters since water was always available in enough quantities at most time of needs. Contextually, the ability to place or install a filter anywhere within a shelter matters for all filters. The cultural beliefs and attitude towards filter ownership also plays a significant role in defining whether the filter is consistently used or not.

For two-bucket filters, the knowledge by respondents of the ability of the filter to indicate its functionality status defined how consistently the users used this kind of filters. Those who knew that there was no indicator to show functionality status recorded higher consistencies. Perceived social pressure due to other peoples' approval or disapproval of use of the filter, availability of spare parts and probability of incorrectly fitting of parts during assembly and reassembly of the filters influenced consistency of use for one-bucket filter.

Consistency of use for two-bucket group majorly relied on the design factor: whether the product indicated while working properly. On the other hand, that of the one bucket majorly relied on behavior factor: approval or disapproval by other people and economic factor: availability of spare parts. The context factor affected all the filters in a similar manner and the more the filter fitted in a shelter; the more it was consistently used. Respondents perceived the filters as valuable products in their homes and were willing to pay 10USD for each.

The community was aware of the risks of consuming untreated water. The main reasons given for filtering water included avoiding sickness and removing physical impurities. Reasons for inconsistency in use included filter breakdown, lack of available water to filter and absence from home. Fear of breaking the filter during disassembly was a point of concern for those who owned filter type C. Two-bucket filters were liked more and their owners considered them "beautiful and stable." They however insisted that the filters required space. There is need for a short initial training of filter beneficiaries before distribution since most of the respondents could only assemble the filters after training.

CHAPTER SIX: CONCLUSION

This study drew the following conclusions:

i. The filters present in Ndikir village were comprised of ceramic made elements for filtration. They were effective in improving drinking water quality in terms of bacteria and turbidity removal. They comprised of two groups, those that had both the filtered and raw water containers (two-bucket filters) and those that only had the raw water container (one-bucket filter). They were all fully gravity driven except for filter D that additionally used siphon action.

ii. The contextual factors in which the filters were in affects the consistency of use of all the filters. These factors include fit of the filter inside the house and local cultural beliefs. The more the filter fits spatially in the house and while in use, the more it is consistently used. For improved consistency, local culture should not prohibit use of the HWTS intervention intended to be administered.

   Perception of availability of spare parts determines whether people consistently use the one-bucket filters but not the two-bucket filter. The more available the spare parts are perceived to be, the higher the consistency of use.

iii. Societal influence and approval by peers determines whether people will consistently use one-bucket filter. The more they approve, the more consistency increases. For all the filters assessed, happy feeling of ownership increases consistency in use.

   Users' understanding of whether a filter works or not and how to fit parts of a filter plays a role in determining whether users will consistently use the filter or not. Users who familiarize with the physical features of filters portray higher consistencies of use specifically for two-bucket filters.

RECOMMENDATIONS

1. Humanitarian organizations, which distribute one bucket group filters in emergency settings, should emphasize trainings of implementing officials on behavior and psychosocial perceptions towards the filters during initial stages of such interventions. They should emphasize on group trainings for beneficiaries to allow buy in of consistency of use since injunctive norms play a pivotal role.
2. Trainings of beneficiaries on assembly and correct use at initial stages of interventions are also necessary to ensure consistency of use as it was observed that most people could not assemble the filters initially by themselves.
3. For sustainability of interventions, humanitarian organizations need to establish a supply chain mainly for the one bucket filters and ensure spare parts are readily available.
4. The manufacturers may improve filter designs by fitting a functioning status indicator on filters and ensuring that the filters have the least number of assembling parts. Specifically for type C filter, reducing the number of reassembly parts could lead to better self-efficacy and consequently consistent use.
5. There lies a dilemma between lower space requirement and high storage capacity needs for two-bucket filters in both households and shipping logistics. This area therefore requires further research.
6. One-bucket filters are as effective as two-bucket filters; they however have the potential to become more popular as communities familiarize more with them. The manufacturers need to do more marketing to both end users and humanitarian organizations to improve product familiarity since the one-bucket group is relatively new in the market as compared to the two-bucket filters. Alternatively, humanitarian organizations could concentrate on using two-bucket due to its familiarity.
7. Manufacturers of one-bucket needs to improve the filtration rate of this filter as informed by this study.

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APPENDICES

Appendix I

1. **Oral consent script:**

Hello. My name is __________ and I am working with Caritas Switzerland on a study on comparative analysis of household filters. Are you a **head of household** for this family? [*If individual is not a head of household, ask to speak to a head of household and begin introduction again*.]

We have selected all households from this community, which is why you have been chosen for this interview. We would thus like to ask you to participate in this study. The information you will give us will be kept **completely anonymous**; your individual privacy will be maintained in all written materials produced from the study. We will use the information we collect from households here to understand what kind of filters are best suited for this region.

Today we would like to speak to the **person who usually manages water treatment** for your family. We will ask that person some questions and mark the answers down on this survey. This survey will take about an **hour and a half**.

There are **no risks** associated with any of these activities. Participants in the study **will not be paid**. Potential **benefits** of participation are that this study's results may help to improve water treatment tendencies in communities throughout Marsabit County.

Again, we would like for you to participate in this survey, but participation in the study is **completely voluntary**. Even if you begin to participate in the interview now, you are **free to stop participating at any time**, for any reason.

We have spoken with your **community leader**, and he is available to speak with you about this study at any time. In addition, if you ever have any **questions, concerns or complaints** about this research study, its procedures, risks and benefits, you can contact the Program officer Mr. Fredrick Ochieng.

Do you have any **questions** about the purpose of, or the activities involved in, this study? [*Make note of, and answer, any questions asked*.]

Can you tell me if you would be **willing to participate** in our study?

____ Yes

____ No [THANK respondent and proceed to next household]

Appendix II: Questionnaire used for collecting data.

1. General Information:

Date	
Name of respondent	
Gender	
Contact	
Location	
Number of the household	
Filter type	
Filter code and number	

Section II:

	1. Economic factors				
	Perceived filter value. How do you feel about the following statements?	**1.Strongly agree**	**2.Agree**	**3.Disagree**	**5.Strongly disagree**
1	I would buy this filter for my friend as a gift.				
2	I would buy another filter like this one if this one broke down.				
3	I would find spare parts to repair the filter easily				
4	My filter is safe from rodents				
		Less than 500	**1000**	**2000**	**More than 3000**
5	How much money can you buy a filter like the one you are currently using for?				
	2. Psychological and behavioral factors				
	How do you feel about the following statements:	**1.Strongly agree**	**2.agree**	**3.Disagree**	**4.Strongly disagree**
6	I dislike drinking filtered water				
7	Treating drinking water is worthwhile				

8	People who are important to me disapprove if I treat my drinking water.				
9	I am sure that I can always treat my water before drinking, even if this may be difficult sometimes				
10	I intend to always filter my water before drinking.				
11	Filtering my drinking water is something I do automatically.				
12	In the last seven days, how often did it happen that you wanted to drink water, but you forgot to filter it in time?				
13	Have you made a detailed plan how to overcome difficulties to water filtering (e.g. when your filter breaks down, you have no time etc.)?	**yes**		**No**	
14	How important is it for you to treat your water before drinking?	1.Very important	2. Important	3.Not important	4.Not very important
15	How high or low are the chances that you or your children get sick if you drink unfiltered water?	Very High	High	low	Very low
16	How does filtering water help your children?				
	3. Environmental and contextual factors				
	How do you feel about the following statements:	**1.Strongly agree**	**2.agree**	**3.Disagree**	**4.Strongly disagree**
17	It is possible to install this filter anywhere in my house.				
18	It is difficult to operate the filter in low lighting				
19.	Children in the house can access water from the filter easily.				
20.	I easily fill and operate this filter.				
21.	I help my neighbor clean their filter	**1.Strongly agree**	**2.agree**	**3.Disagree**	**4.Strongly disagree**

22	I waste time using this filter				
23	The filtered water flows at an acceptable rate while dispensing.				
24	Cleaning time needed is equivalent to that of most household utensils				
25	I am happy to own this filter				
26	How often in a year does the rainy season occur?	Once	Twice	Sometimes never	
27	My culture prohibits the use of filters				
	4. Design factors				
	Initial setup	**1.Strongly agree**	**2.Agree**	**3.Disagree**	**4.Strongly disagree**
28	The fitting parts can be incorrectly fitted				
29	It is difficult to set up this filter even with the help of a manual				
30	How many times have you repaired the filter in the last 7 days?	**None**	**1**	**More than 1**	**I don't Know**
	Product format and dimensions	**1.Strongly agree**	**2.Agree**	**3.Disagree**	**4.Strongly disagree**
31	The filter stands by itself in a stable manner				
32	The tap height allows for easy use by all family members				
33	Parts of the filter require dis assembly during cleaning				
	Product status indicators				
34	Does the product indicate when it is not filtering water properly?	**yes**	**no**		

35	35. How many days in the last 7 days have you forgotten to drink filtered water from your filter?				
36	How much water does your household drink in one day?				
37	How much filtered water does your household drink in one day?				
38	How easy or hard was it to assemble your filter?	Very easy	Easy	Hard	Very hard
39	How easy or hard is it to use your filter from day to day?				
40	Do you like the colour of your filter?	yes		No	
	If No, which colour would you prefer?				
	Photo				
	Comment				

Observational data capture list

Direct observations by the enumerator	
Is there drinking water (treated or not treated) in the household?	
Does raw water tank have water inside?	
Does clean water tank have water inside?	
Is treated water stored in a container outside the filter?	
Is the filter visibly clean?	
Is container for storing water visibly clean?	
What is the filter placed on?	

Appendix III: Focus group discussions guide:

Introduction:

My name is George Kiambuthi Wainaina; a student at Pan African University, Institute for Water and Energy Sciences. I am conducting a research to find out how house hold water filters compare with relation to consistence in use. Welcome to this focus group discussion.

This discussion will take 90 minutes of your time.

Probe questions:

1) Have you been filtering water before the introduction of filters in your community? How?
2) Is it good to filter water before drinking? Why?
3) How would you describe the filters that you have been using?
4) What would make you stop using the filter?

Follow-up questions:

1) How much would you be willing to pay for the filter?
2) How would you comment on the filtered water, how does it taste, smell and does its colour change?
3) How does the filter fit in your houses?
4) What sources of water would you not recommend for use with the filters?
5) Could you set up the filter by yourself without any help? (suggest those who can to raise their hands)
6) How easy or hard is it to use the filter for water filtration?
7) What are the challenges you face while using this filters?
8) How easy or hard is it to clean the filter?
9) What exactly do you like about this filter?
10) What exactly do you not like about this filter?
11) How often do you use this filter?
12) Do members of your family sometimes also drink water from other sources, for example when they are out of the house?
13) How do you know the filter is working?
14) Did you receive any information on how to use this filter?
15) Was the information you received useful? Can you explain it?

Expenses report

Thesis project: Comparative analysis of factors that influence consistent use of household water treatment and storage in Northern Kenya

Name: George Kiambuthi Wainaina

MSc Water Policy

16) Item	Description	Unit	Quantity	Unit cost	Amount
1	**A. Supplies/Expenses**				
2	Cell phone usage charges (Calls) (for 3 people)	Monthly	2	$ 31.58	$63.16
3	Cost for monthly internet use	Monthly	3	$ 31.58	$94.74
4	16gb flashdisk and trascend harddisk	item	1	$ 116.84	$116.84
5	Paper, pens and notebooks	Sum	1	$ 31.58	$31.58
	Category Total:				**$306.32**
	B. Travel				
6	Return Air-ticket (Tlemcen to Kenya)	Item	1	$ 890.85	$890.85
7	Local travel costs (Nairobi-Marsabit)	sum	1	$ 141.58	$141.58
8	Lodging during field period	Daily	60	$ 5.26	$315.79
9	Lunch meals during field work for enumerators/translators	Daily	30	$ 15.79	$473.68
10	SPSS consultation	Daily	30	$ 5.26	$157.89
	Category Total:				**$1,979.80**
	C. Personnel				
11	Translators/mobilizer	Monthly	2	$ 236.84	$473.68
	Category Total:				**$473.68**
	D. Publication and dissemination				
13	Printing and binding of thesis	Item	1	$ 47.37	$47.37
	Category Total:				**$47.37**
14	Algeria -Kenya bank transfer including foreign exchange rates to Kenya shillings	**Item**	**1**	$ 195.47	**$195.47**
	GRAND TOTAL				**$3,002.64**