Norges miljø- og biovitenskapelige universitet

Master's Thesis 2017 30 credits
Faculty of Landscape and Society

The Biosand Filter: A pilot evaluation study to investigate perceived community acceptability and feasibility among Maasai pastoralists in the Ngorongoro Conservation Area, Tanzania.

Tina Paasche
Public Health Science

Acknowledgements

First and foremost, my deepest gratitude to my supervisor Sheri Bastien for guiding me through this process. I am forever grateful for your most excellent constructive feedback, for always being available for questions and support, for the extra miles you walk, and finally for your brilliant sense of humor and tendency to spread joy, laughter and happiness around you. I am truly impressed by your work, and honored beyond words to be a small part of your project.

My gratitude also to the Global Health Field School program hosted by the University of Calgary and the Catholic University of Health and Allied Sciences, and especially to Drs. Karin Orsel and Frank van der Meer. Field school was surely a life-changing experience. Thank you for the opportunity to collect data for my thesis, and for making me feel welcome and included from day one. Special thanks also to Project SHINE team member Lauren Hebert for notetaking, useful discussions and great teamwork in field. Thanks also to PhD-student and team member Elias Nyanza for in-field support and co-supervising. Last but not least, thanks to the community in Endulen, and to all participants for sharing their thoughts and perceptions.

Very special and warm thanks to fellow student Lise Hovden whom I have been ever too lucky to have by my side before, during and after field school. I have previously heard that writing your thesis tends to be a lonely process – I certainly avoided the loneliness solely because of you. I will never forget the ups and downs, the immense amounts of coffee and malt beer shared, and most importantly the unstoppable gales of laughter.

Finally, many thanks to my family and friends who have now dealt with my weariness, absentmindedness, and general absence for an entire year – thank you for your patience. I am especially thankful to my mom for the multiple surprise care packages sent through mail, my dad for keeping me active through monthly running-challenges, my aunt in Belgium for the uplifting emails and Skype calls, and to my best friend Mari Nilsen Skinnes for your engagement and curiosity in my work and for reading through the entire product at the end.

Never has a learning curve been any steeper. I am thankful for all the new knowledge that I have acquired, and I am proud of my own work and commitment. Despite all the good help and support that have been given to me, a few errors and mistakes may still exist in the final product. If so is true, I recognize that they are solely mine.

Tina Paasche

Abstract (English)

Background: Worldwide, 1.8 billion people rely on drinking water sources that are fecally contaminated. In addition to the major burden of lives lost due to diarrheal disease, lack of access to safe water contributes to a multitude of public health issues in terms of equity gaps related to a gender burden when it comes to water collection, and access within and between countries and groups of people. Additionally, lack of access to safe water may have other indirect effects across the lifespan such as school and workplace absenteeism and performance, leading to less economic productivity and development. In contexts where drinking water is unsafe and where resources are scarce, household water treatment and safe storage (HWTS) options such as the Biosand filter (BSF) allows households to directly reduce contamination and increase the quality of their drinking water.

Rationale: The BSF is proven effective in reducing fecal contamination and diarrheal disease. However, considerably less research has been undertaken to understand health behaviors and factors contributing to behavior change related to successful adoption of HWTS technologies. Situated in a rural and resource constrained area, the Ngorongoro Conservation Area (NCA) in Tanzania enables a unique opportunity to study health behavior in a complex community anticipated to be under the influence of a multitude of factors affecting the potential adaption of water, sanitation and hygiene (WASH) interventions, and the present study addresses important knowledge gaps related to the understanding of the local context in which the BSF is implemented, community perceptions regarding the BSF technology and potential barriers and facilitators to adoption of BSF treatment practices.

Objective: This study seeks to develop a deeper understanding of community perceptions and concerns related to water scarcity and water quality among Maasai pastoralists in the NCA, and to understand perceptions related to implementation of the BSF as a low-cost, low-tech option for treating water with respect to perceived acceptability and feasibility of the technology at an early stage of intervention.

Methods: The study applied a qualitative descriptive approach to answer the research questions, while in-depth semi-structured interviews, group discussions and think tanks were used as the primary methods for data collection. The study participants included a wide cross-section of community members, stakeholders and other actors to provide a rich, in-depth description of community perceptions in the NCA. The data were analyzed through thematic analysis.

Results: The main concerns related to water scarcity in the NCA is related to perceived changes in climate resulting in less rain and more disease, an extra burden on women and girls who are responsible for fetching water and managing its use at the household level, disparities within the community related to access to water, shortcomings in the management and leadership of water-

related issues, and a strained relationship between main actors related to water and other members of the community. The main concerns related to water quality in the NCA is related to shared water sources with animals, and the extent of community knowledge around water quality and transmission of water-borne disease. Guided by the Integrated Behavioral Model for Water, Sanitation and Hygiene (IBM-WASH) framework, a range of perceived contextual, technological and psychosocial factors were found to potentially affect the acceptability and feasibility of BSF adoption in the NCA, highlighting the complex relationship that exists among the multiple layers of influences in the setting.

Conclusions: Based on community perceptions at this early pre-implementation phase, the BSF is seemingly an accepted option to treat water within the NCA. There are however considerable barriers, especially in terms of feasibility, that may lower the likelihood of widespread adoption. This study provides a structured overview of potential contextual, technological and psychosocial factors that are present in the community, and which would need to be adequately addressed if the goal were to scale up and reach a high rate of BSF adoption and sustained use in the NCA in the future.

Sammendrag (Norsk)

Bakgrunn: 1,8 milliarder mennesker er på verdensbasis i dag avhengig av forurenset drikkevann. I tillegg til tapte menneskeliv grunnet diaré har mangelen på rent vann store konsekvenser for folkehelsen i form av urettferdige forskjeller og ulikheter. Kvinner opplever en større byrde i form av et større ansvar for henting av vann, og tilgangen til vann er ulik både mellom forskjellige land, og mellom ulike folkegrupper innenfor hvert enkelt land. Mangelen på tilgang til rent vann har også flere indirekte negative konsekvenser som blant annet dårlige prestasjoner og fravær fra jobb og skole, noe som fører til mindre økonomisk produktivitet og utvikling. I situasjoner hvor vannet er av dårlig kvalitet og ressursene er få, kan et vannfilter - Biosand Filter (BSF) - være et godt alternativ da det tillater familier selv å redusere forurensning og øke kvaliteten på sitt eget drikkevann.

Rasjonal: Det er bevist at BSF effektivt reduserer fekal forurensning og diaré. Det har derimot blitt utført langt mindre forskning i form av å forstå helseatferd og faktorer som bidrar til atferdsendring og vellykket opptak av slike teknologier. Ngorongoro Conservation Area (NCA) i Tanzania er et område bestående av unike muligheter til å studere helseatferd. Dette da de her har et samfunn hvor det er antatt å eksistere en mengde faktorer som påvirker mulig adopsjon av intervensjoner og praksis innen vann-, sanitær- og hygienesektoren. Denne studien adresserer et viktig kunnskapshull relatert til det å forstå den lokale konteksten hvor BSF implementeres, det lokale samfunnets oppfatninger av teknologien, og potensielle faktorer som hindrer eller fremmer adopsjon av praksis knyttet til vannrensing med BSF.

Oppgavens formål: Formålet med denne oppgaven har vært å utvikle en grundig forståelse av oppfatninger og bekymringer knyttet til vannmangel og vannkvalitet blant pastorale Maasaier i NCA, og å forstå deres oppfatninger knyttet til implementering av BSF som en billig og enkel mulighet for vannrensing i området. Oppfatninger ble adressert i form av samfunnsaksept av (acceptability) og muligheten for (feasibility) vannfiltrene i et tidlig stadium av intervensjonen.

Metode: Studien tok i bruk en kvalitativ deskriptiv tilnærming for å besvare forskningsspørsmålene, med semi-strukturerte dybdeintervjuer, gruppediskusjoner og tenketanker som metoder for datainnsamling. Deltakerne i studien besto av et bredt spekter av medlemmer fra lokalsamfunnet, interessenter og andre aktører for å gi en rik beskrivelse av de ulike oppfatninger som eksisterer i samfunnet. Dataene ble analysert via tematisk analyse.

Resultat: Hovedsakelig var bekymringene relatert til vannmangel i NCA knyttet til oppfatninger av klimaendringer som resulterer i mindre regn og mere sykdom, en ekstra byrde for kvinner og jenter som er primært ansvarlig for å hente og håndtere vann, manglende forvaltning og lederskap knyttet til vannrelaterte temaer, og et anstrengt forhold mellom hovedaktører relatert til vann og andre

medlemmer i lokalsamfunnet. Bekymringene relatert til vannkvalitet i NCA var knyttet til delte vannkilder med dyr, og graden av generell kunnskap i lokalsamfunnet knyttet til vannkvalitet og overføring av vannbåren sykdom. Guidet av en økologisk modell for helseatferd (The Integrated Behavioural Model for Water, Sanitation and Hygiene [IBM-WASH]) ble det funnet en rekke oppfattede kontekstuelle, teknologiske og psykososiale faktorer som potensielt kan påvirke samfunnsaksept av- og muligheten for adopsjon av BSF i NCA, noe som belyser det komplekse forholdet som eksisterer mellom de mange innflytelsesnivåene i den unike konteksten.

Konklusjon: Basert på lokalsamfunnets oppfatninger ser det ut til at BSF er en akseptert mulighet for vannrensing på husholdsnivå i NCA. Resultatene viser derimot til vesentlige faktorer som potensielt kan hindre utbredt adopsjon av vannfilteret i området. Selv om samfunnsaksepten av vannfilteret i NCA tilsynelatende er høy, viser resultatene derimot til betydelige faktorer som potensielt kan hindre utbredt adopsjon av BSF i NCA. Denne studien gir en strukturert oversikt over potensielle kontekstuelle, teknologiske og psykososiale faktorer som er til stede i lokalsamfunnet, og som må adresseres skulle utbredt adopsjon og bærekraftig bruk av BSF være et mål i NCA i tiden som kommer.

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LIST OF ABBREVIATIONS

AAAQ	Availability, Accessibility, Acceptability & Quality
ACI	Aqua Clara International
BSF	Biosand filter
CAWST	Centre for Affordable Water and Sanitation Technology
CUHAS	Catholic University of Health and Allied Science
CHP	Community health promoter
CHREB	Calgary Conjoint Health Research Ethics Board
DOI	Diffusion of Innovations
E.coli	Escherichia coli
HWT	Household water treatment
HWTS	Household water treatment and safe storage
IBM-WASH	Integrated Behavioral Model for Water, Sanitation, and Hygiene
JMP	Joint Monitoring Programme for Water Supply and Sanitation
NCA	Ngorongoro Conservation Area
NCAA	Ngorongoro Conservation Area Authority
NIMR	National Institute of Medical Research
NOK	Norske kroner
RCT	Randomized controlled trial
SDG	Sustainable development goal
SHINE	Sanitation and Hygiene INnovation in Education
SODIS	Solar water disinfection
SoHIP	Seeds of Hope International Partnerships
TZS	Tanzanian shillings
U of C	University of Calgary
UNICEF	United Nations Children's Fund
VEO	Village executive officer
WASH	Water, sanitation and hygiene
WET	Water Expertise and Training
WHO	World Health Organization

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1 CHAPTER 1: INTRODUCTION

1.1 BACKGROUND

1.1.1 Drinking water and the global context

In 2015 the Millennium Development Goals (MDGs) expired having successfully reached the target of halving the proportion of the population in low- and middle income countries without sustainable access to safe drinking water and basic sanitation (United Nations Children's Fund/World Health Organization [UNICEF/WHO], 2015). However, despite major improvements in the water, sanitation and hygiene (WASH) sector, 663 million people still lack access to improved drinking water sources[1] worldwide. An even larger number, 1.8 billion people, rely on drinking water sources that are fecally contaminated (WHO, 2016). It is now widely acknowledged that access to improved water sources does not necessarily ensure access to safe, sufficient, and affordable water (WHO/UNICEF Joint Monitoring Programme for Water Supply and Sanitation [JMP], 2017) which is supported by a number of studies including a systematic review and meta-analysis conducted by Bain and colleagues (2014). Several reasons as to why improved water sources do not necessarily imply microbiologically safe water have been identified. Water entering pipes and other improved sources may be untreated water originating from already contaminated sources. In addition, people may mix multiple water sources which leads to improved and unimproved water being jointly consumed, or household water storage and hygiene practices may be unsafe leading to recontamination of stored water in the home (Shaheed et al., 2014).

Within the Sustainable Development Goals (SDGs) - which were ratified by 193 countries in 2015 and substituted the previous MDGs - WASH targets have been considerably upgraded and transformed, and the ambitious goal number 6 of the SDGs now aims to "ensure availability and sustainable management of water and sanitation for all", while target 6.1 specifically aims to "by 2030, achieve universal and equitable access to safe and affordable drinking water for all" (WHO/UNICEF JMP, 2017). Table 1 provides an overview of the proposed interpretation of the target language.

[1] An improved drinking water source was until recently defined by the WHO/UNICEF JMP (n.d) as "one that, by the nature of its construction and when properly used, adequately protects the source from outside contamination, particularly faecal matter" and includes piped water into dwelling, yard or plot, public tap or standpipe, tubewell or borehole, protected dug well, protected spring and rainwater collection.

Table 1. How to interpret the language in SDG target 6.1.

By 2030, achieve	***universal***	Implies all exposures and settings including households, schools, health facilities, workplaces, and public spaces
	and ***equitable***	Implies progressive reduction and elimination of inequalities between population subgroups
	access	Implies sufficient water to meet domestic needs is reliably available close to home
	to ***safe***	Safe drinking water is free from pathogens and elevated levels of toxic chemicals at all times
	and ***affordable***	Payment for services does not present a barrier to access or prevent people meeting other basic human needs
	drinking water	Water used for drinking, cooking, food preparation and personal hygiene
	for all	Suitable for use by men, women, girls and boys of all ages including people living with disabilities

The table is retrieved from the report "WASH in the 2030 Agenda: New global indicators for drinking water, sanitation and hygiene" (WHO/UNICEF JMP, 2017).

A safely managed[2] drinking water source now implies a source which is both located on the premises, available when needed, and compliant with fecal and priority chemical standards (WHO/UNICEF JMP, 2017). Even though ensuring universal and equitable access to safe and affordable drinking water for all is the ideal and ultimate goal, such a scenario is likely decades away in many low- and middle income countries (Ojomo, Elliott, Goodyear, Forson, & Bartram, 2015), meaning other temporary solutions are needed to protect populations from water-borne illness.

1.1.2 Household water treatment and safe storage

Lack of access to safe drinking water is one of the major causes of diarrhea, and an estimated 502,000 people die each year globally[3] from diarrhea due to inadequate drinking water alone (Pruss-Ustun et al., 2014). The burden is especially high in low- and middle income countries, where diarrheal diseases are a leading cause of mortality and morbidity in children under five (Galan, Kim, & Graham, 2013). In Tanzania alone, diarrheal diseases caused by poor water and sanitation leads to the death of approximately 4000 children each year (WaterAid Tanzania, n.d). In addition to the major burden of lives lost due to diarrheal disease, other public health issues are closely related to consumption of contaminated drinking water. The Hygiene Improvement Framework, developed by the Environmental Health Project in collaboration with UNICEF among others, identifies other indirect

[2] The previous MDG indicator for safe drinking water that was synonymous with the use of an *improved* source of drinking water has been replaced by the new SDG indicator that is "the percentage of population using *safely managed* [emphasis added] drinking water services (WHO/UNICEF Joint Monitoring Programme for Water Supply and Sanitation, 2017)", and the WASH post-2015 indicator of an improved drinking water source is now divided into three categories; safely managed-, basic- and limited drinking water sources.

[3] Estimated using data from 145 low- and middle income countries (Pruss-Ustun et al., 2014).

effects which place a burden on individuals, families and societies and includes, but is not limited to, cost of hospital treatment, school absenteeism, poor school or workplace performance and less economically productive family members (2004). Additionally, there are differential impacts and substantial equity gaps with respect to gender burden of water collection and access within countries, between rural and urban citizens, rich and poor, and other socioeconomic groups (UNICEF/WHO, 2015).

Treating water at the household level and storing it safely is important in the approach to improve access to safe drinking water and reduce deaths from childhood diarrhea (UNICEF/WHO, 2009). In general, water treatment systems improving microbial quality of water at the point of consumption are proven effective in reducing occurrence of diarrhea (Clasen, Schmidt, Rabie, Roberts, & Cairncross, 2007; Fewtrell et al., 2005). In situations where drinking water sources are unsafe at the point of collection or distant and at risk of recontamination before the point of consumption, household water treatment (HWT) options such as boiling, filtration, adding chlorine or bleach, and solar water disinfection (SODIS) are provisional yet effective options for vulnerable populations to improve their drinking water quality at the household-level (Ojomo et al., 2015; WHO/UNICEF JMP, 2011). The Biosand filter (BSF) is one such option, a simple and low-cost household water treatment and safe storage (HWTS) technology that is proven highly effective in removing both particles and pathogens in the water (Buzunis, 1995; Stauber, Kominek, Liang, Osman, & Sobsey, 2012; Stauber, Printy, McCarty, Liang, & Sobsey, 2012).

Vulnerable and marginalized populations such as the Maasai pastoralists in rural and remote Tanzania are in particular need of HWTS technologies such as the BSF. It is however recognized that effective, simple and low-cost HWTS technologies in itself are not enough to reach the people in need, as use of such technologies requires substantial changes in behavior which may not be easily adopted and maintained (Fiebelkorn et al., 2012; Figueroa & Kincaid, 2010). In addition, interventions often fail to address people's perceptions and factors contributing to widespread adoption and sustained behavior change, making pilot studies such as this important to the development of effective efforts that can be scaled up if found to be both acceptable and feasible to the community.

The remainder of this introductory chapter will present background information describing the focus of this thesis which is a sub-study as part of an ongoing WASH intervention situated in the Ngorongoro Conservation Area (NCA), rural and remote Tanzania.

1.2 STUDY BACKGROUND

1.2.1 The Project SHINE intervention

In May/June 2016, I participated in the annual Global Health Field School in the NCA hosted by the University of Calgary (U of C) and the Catholic University of Health and Allied Science (CUHAS), Tanzania. The Norwegian University of Life Sciences is a new partner involved in the field school and it is an opportunity for Masters of Public Health students there to collect data for their thesis. A transdisciplinary team including faculty and students representing various disciplines including medicine, public health and veterinary medicine have been conducting One Health focused research in the area since 2004 focusing on the interrelationship between humans, animals and the environment (Rock, Buntain, Hatfield, & Hallgrímsson, 2009) in the effort to improve health and well-being of the Maasai pastoralists and their livestock. The present study represents a sub-study within a WASH intervention in the NCA called Project SHINE (Sanitation and Hygiene INnovation in Education) which is a school and community-based intervention and research collaboration between the U of C, CUHAS and communities of Maasai pastoralists that has been ongoing in the NCA since 2014 (Bastien, Hetherington, Hatfield, Kutz, & Manyama, 2015; Hetherington et al., 2017). The primary objective of Project SHINE is to build the capacity of youth and communities to develop and sustain locally relevant strategies to improve sanitation and hygiene in the NCA. The theoretical framework of Project SHINE is based on the Integrated Behavioral Model for Water, Sanitation and Hygiene (IBM-WASH) – which is a socioecological framework developed on the basis of a systematic review of behavior change models and frameworks related to the adoption of WASH behaviors (Dreibelbis et al., 2013b). In accordance with participatory action research[4], the foundation of the Project SHINE approach is not only to provide hardware such as science supplies through the intervention, but also software in terms of education and awareness-raising through the long-standing partnership and engagement with the local community. Project SHINE aims at deepening the understanding of pastoralists needs, norms, and practices that are in turn essential to the development of the intervention (Bastien et al., 2015).

1.2.2 Biosand Filter pilot evaluation study

Formative research conducted as part of Project SHINE identified issues related to water scarcity and water quality to be major concerns by community members in the area, which led to the proposal of a BSF pilot evaluation to investigate acceptability and feasibility of the technology for communities in

[4] Participatory action research "aims to improve health and reduce health inequalities through involving the people, who, in turn, take actions to improve their health" (Baum, MacDougall, & Smith, 2006, p. 854). Power relations and empowerment are two of the main concepts in participatory action research, and participatory action research should even out power differentials between researchers and participants, and lead to community members experiencing increased control over their lives (Baum et al., 2006).

the NCA. An overview and description of the different events conducted throughout the BSF pilot evaluation in May/June 2016 is presented in Table 2 below.

Table 2. Overview of the BSF pilot evaluation study events and their relevance to the present sub-study.

Event	**Description**	**Relevance to present study**
Baseline survey	A total of 30 households from two separate wards in the NCA (Endulen and Nainokanoka) were selected to participate in the BSF pilot evaluation study (15 households in each ward). A member of all participating households answered a questionnaire including questions related to demographics and socioeconomic characteristics. Trained local assistants fluent in *Kimaa* and *Kiswahili* (the local and national languages respectively) administered the questionnaire.	Used in the background chapter to enrich the description of the research setting and the studied population.
Biosand filter workshops	Following completion of the baseline survey, each of the participating households chose one household member to attend three consecutive workshop- and training sessions[5] on BSF use and maintenance which was offered by experts from Aqua Clara International (ACI) Kenya and Seeds of Hope International Partnerships (SoHIP). At the end of the workshop- and training sessions, each household member received either a BSF or BSF materials for household implementation.	The 15 household members who attended the workshop- and training sessions in Endulen were also included as participants in the qualitative data collection.
Ongoing support for study participants	The local assistants also received training on the use and maintenance of the BSF, and served as contact persons that participants could contact at any point during the implementation of the filters. The same is true should the participants experience any later difficulties in maintaining the filter. Additionally, the local assistants conducted follow-up visits in each household addressing questions and concerns.	Not applicable.
Qualitative data collection	Simultaneously with the workshop- and training sessions and the implementation of the BSFs, in-depth semi-structured interviews, group discussions and think tanks with various community members including BSF pilot evaluation participants and other community members (Endulen) such as traditional leaders, heads of households, women's group representatives and other stakeholders were carried out.	Main component in the present study. Serves as the data source used to answer the research questions guiding the study.
Water quality assessment	The Water Expertise and Training (WET) Centre in Zambia and SoHIP performed water quality testing of nine different drinking water sources in the NCA. In line with WHO guidelines for drinking water quality (2017), key indicators for water quality included turbidity, pH and fecal coliform/E.Coli were tested.	Included in the background chapter to describe the current situation regarding water quality in the NCA.
Follow-up survey	Follow-up survey with each household including questions related to the adequacy of training provided, perceptions of BSF effectiveness, ease of use and maintenance, and user perceptions of taste, smell and other properties of the filtered water.	Planned to be conducted in fall, 2017.

[5] The workshop- and training sessions included training of both BSF technicians and Community Health Promoters (CHPs). The BSF technicians were taught how to construct, install, use and maintain the filters (hardware), while the CHPs received training related to basic WASH and health education and how to raise community awareness (software).

1.2.3 Rationale for the study

It is argued that 'frugal technologies' (low-cost technologies) specifically designed for the world's poorest are essential to meet the global health needs in low- and middle-income countries where substantial structural level challenges or barriers exist (Howitt et al., 2012). While several studies evaluate the performance of the BSF in terms of reduction of fecal contamination and diarrheal disease (Buzunis, 1995; Stauber, Kominek, et al., 2012; Stauber, Printy, et al., 2012), considerably less research has been conducted to understand WASH-related factors contributing to sustained behavior change [6] and successful adoption of HWTS technologies, suggesting the field is currently underdeveloped (Dreibelbis et al., 2013b; Fiebelkorn et al., 2012; Figueroa & Kincaid, 2010; Hutton & Chase, 2016).

Effective implementation of WASH-related technologies in resource-poor settings requires several issues to be addressed, including efforts to understand the context in which the technology will be implemented to ensure the technology is acceptable and maintained over time by its users (Dreibelbis et al., 2013b; Howitt et al., 2012). As cultural and social limitations to the use of HWTS technologies may be highly context-specific (World Bank, 2007), formative research before or at the outset of HWTS interventions identifying key barriers and facilitators in the community is the first critical step in understanding HWTS implementation and potential adoption of HWTS practices (Ngai & Fenner, 2008). A focus on the end users and what they need, want and will use is proposed as one of the most important factors affecting sustained use of HWTS technologies[7] (Clasen, 2009). Water treatment interventions should therefore start with gaining an understanding of the end users point of view regarding the technologies and the multi-level factors related to water treatment behavior that are present in their specific context (Figueroa & Kincaid, 2010). To achieve this, communication with the targeted population is needed, and as individual perceptions may vary by factors such as gender, age and socioeconomic status, assessment of a broad range of community perceptions and preferences is essential.

[6] While several definitions exists, health behavior can be defined as "action purposefully taken by individuals in order to promote, protect or maintain their health" (Naidoo & Wills, 2009, p. 305). An intervention addressing HWTS options and behaviors related to HWTS may address one or more behaviors (Hernández, 2008). The specific behavior most relevant to this study is drinking water treatment practice, although it is recognized that a cluster of other behaviors such as sanitation and hygiene practices (e.g. water storage, open defecation, household hygiene, etc.) are highly interrelated with water treatment practice (Figueroa & Kincaid, 2010) and will therefore not be ignored. However, this study is an exploratory pilot study, and assessment of water-treatment practices per se is therefore not the primary focus of this study.

[7] There are many other identified elements important to HWTS adoption, sustainability and long-term behavior change, such as collaborations and partnerships, engagement of national and regional governments, international leadership, promotion and delivery strategies, community education, involvement, ownership and commitment etc. (Clasen, 2009; Nath, Bloomfield, & Jones, 2006; Ojomo et al., 2015).

Situated in a rural and resource constrained area, the NCA provides a unique opportunity to study community perceptions and WASH-related health behaviors in a complex community where it is anticipated that there are a host of influential barriers and facilitators affecting the potential adoption of HWTS technologies such as the BSF. The present sub-study is at an early stage of intervention, and will therefore contribute to 1) an assessment of the local context in which the BSF is implemented, 2) filling the important knowledge gap related to community perceptions regarding the BSF technology, 3) assess potential barriers and facilitators to adoption of BSF treatment practice within the NCA, and 4) contribute to the evidence base regarding best practices in implementation of the BSF in similar resource constrained settings.

1.2.4 Research questions

The aim of the present study is to develop a deeper understanding of community perceptions and concerns around water scarcity and water quality among Maasai pastoralists, and to understand perceptions related to implementation of the BSF as a low-cost, low-tech option for treating water in the NCA. The specific research questions guiding the study are:

1. *What are the community perspectives and concerns related to water scarcity and water quality in the NCA?*

2. *To what extent is the BSF an acceptable and feasible water treatment option in the NCA?*

It is beyond the scope of the study to evaluate the effectiveness or sustainability of the filter, but the focus here rather is to identify preliminary factors which may influence community acceptability and feasibility of the BSF as a water treatment option in the NCA context.

1.2.5 Thesis structure

This thesis has seven chapters. The current chapter (chapter 1) has described the focus of this thesis as part of an ongoing WASH intervention in the NCA. The following chapter (chapter 2) describes the background necessary to understand the context in which the research is situated, before providing a more detailed description of the BSF technology, while chapter 3 outlines the conceptual framework guiding the study. Chapter 4 presents underlying methodological assumptions, outlines the specific methods used and explains in detail how the study was conducted before discussing ethical considerations. Chapter 5 reports findings from the analysis in relation to the research questions guiding the study. In chapter 6, a discussion of the findings is presented in light of the broader literature including the theoretical framework, followed by a discussion on methodological strengths and limitations of the study. The final chapter (chapter 7) provides concluding remarks and suggestions on further research.

2 CHAPTER 2: BACKGROUND

To set the context, this chapter starts with an overview of the research area with special emphasis on demographic and socioeconomic characteristics of the Maasai population. Following this, a description of water quality tests conducted as part of the broader Project SHINE intervention is provided, and locally available drinking water sources and water-borne disease in the NCA is discussed. This chapter then gives a brief introduction to the technical details and performance of the BSF technology, before ending with a presentation of other studies that have addressed community perceptions regarding the BSF.

2.1 THE NGORONGORO CONSERVATION AREA

Located in the Crater Highlands area in northern Tanzania, the NCA (Figure 1) is a unique and protected area (UNESCO World Heritage site) serving multiple land-uses including wildlife conservation, cultivation, research, and tourism, while also being home to Maasai pastoralists (Galvin, Thornton, Boone, & Knapp, 2008). The area is 8,292 km^2 and stretches from the Serengeti National Park in the north-west to the Rift Valley in the east. According to the Ngorongoro Conservation Area Authority[8] ([NCAA], n.d), the Maasai population in the NCA consists of approximately 42,200 people. The Maasai pastoralists are predominantly semi-nomadic relying heavily on their livestock (Galvin et al., 2008), and depending on season and conditions, the Maasai either reside in permanent *bomas* (traditional houses) or in temporary *bomas* in search for water and pasture for their livestock. Access to natural resources such as water and forage are limited for the Maasai population due to a challenging climate, shared resources with wildlife and tourism. Numerous restrictions are placed on the Maasai by the NCAA, such as rules and regulations for instance on grazing and residence, livelihood strategies such as agriculture which is not permitted even for subsistence, land tenure which is prohibited without special permits, and collection of firewood (the Maasai can only collect fallen wood) (Galvin et al., 2008). The NCA consists of three main ecological zones; the relatively cool and wet highlands (Nainokanoka is located here), the semi-arid lowlands (Endulen is located here), and the transition zone between the two areas which consists of woodlands, bushlands, and grasslands (Galvin et al., 2002, cited in Galvin et al., 2008). Due to vegetation and water sources in the area being accessible at

[8] The NCAA manages the NCA, and is among other functions responsible for tourism, forestry, infrastructure and conservation of natural resources in the NCA, in addition to protection of the needs and interests of the Maasai population (Perkin, 1997, cited in Galvin et al., 2008).

various elevation levels, the Maasai pastoralists have to cover a relatively large area to access all resource types (Hobbs et.al., cited in Galvin et al., 2008).

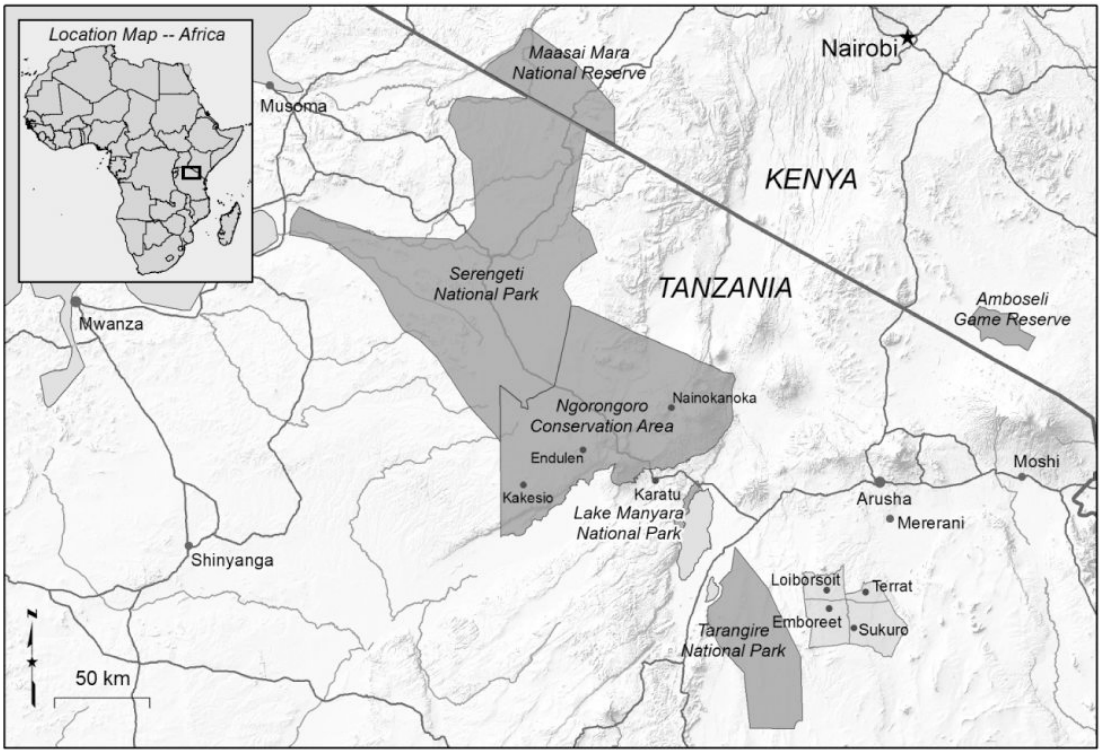

Figure 1. Map showing the location of the NCA. The picture is retrieved from McCabe, Smith, Leslie and Tellingmans article "Livelihood Diversification through Migration among a Pastoral People: Contrasting Case Studies of Maasai in Northern Tanzania" (2014).

2.1.1 Demographics and socioeconomic characteristics of the Maasai population

According to the 2012 population and housing census (National Bureau of Statistics Tanzania, 2013), the two wards of Endulen and Nainokanoka have a total population of 13,537 and 12,971 people respectively, with an average household size of 4.7 and 4.5 household members. As mentioned earlier in the previous chapter (Table 2) the first activity conducted as part of the BSF pilot evaluation study was a baseline survey by all participating BSF households covering questions related to demographics and socioeconomic characteristics. The participating BSF households were selected during a community meeting hosted by the Village Executive Officer (VEO) and were stratified to include households which were situated within the village (urban), at a short distance from the village (peri-urban) and a greater distance from the village (rural), and with an inclusion criteria that the selected households were not semi-nomadic which would pose challenges for filter maintenance. According to the baseline survey, participating households in Endulen has a mean household size of approximately 15 members, compared to participating households in Nainokanoka where the mean household size is 10 people. House types varies between the two wards, with a slightly higher standard in Endulen versus Nainokanoka. Altogether, the two wards are almost evenly distributed with household assets. In Endulen more households are equipped with a radio than in Nainokanoka. Cell phones are common

in both wards, and only one household (in Nainokanoka) was reportedly not in possession of a cell phone. In both wards, only one 1 out of 15 household participants owned a car. Households in Endulen have access to multiple water sources including tap water, tube/borehole wells with a pump, river, and truck supply while households in Nainokanoka mainly rely on tap water or rivers and ponds as their only water source. The frequency of diarrhea is reportedly higher in the baseline sample in Endulen than in Nainokanoka. It is important to note that these assumptions must be interpreted with caution as the questionnaire is based on the 30 participating BSF households only and is thus not representative of the entire population. However, this information does shed light on the demographic characteristics of the communities participating in this pilot study.

2.1.2 Water quality in the Ngorongoro Conservation Area

As mentioned previously, one of the components of the Project SHINE BSF pilot evaluation study is a drinking water quality assessment which was undertaken by staff from the WET Centre in Zambia and SoHIP[9] at various sources throughout the NCA. Key WHO indicators for drinking water quality were tested, including turbidity, pH and E.coli (fecal coliforms)[10].

Figure 2. Petri plates showing high numbers of fecal coliform colonies from one of the sampled water source in the NCA. Photo: Dalla Simasiku, SoHIP.

[9] SoHIP website: http://sohip.org/

[10] Coliforms, or fecal coliforms, are a group of bacteria with characteristics used to identify bacteria that are related to fecal contamination, and Escherichia coli (E. coli) are usually the preferred index of fecal contamination (WHO, 2003). Turbidity is the presence of particles like mud, clay and sand in the water. In addition to affecting acceptability aspects of the water such as taste, odor and appearance (WHO, 2017) pathogens easily attach to particles in the water, meaning turbid water usually increases the chances of disease if consumed (Centre for Affordable Water and Sanitation Technology [CAWST], 2009). Turbidity is further measured by 'nephelometric turbidity units' (NTU), and NTU levels above 4 are usually visible with the naked eye (WHO, 2017).

The water quality tests showed all water sources to be highly contaminated, to the point of 'too numerous to count' in all instances. One of the lab reports with water sampled from the Leshuta Stream is attached in Appendix A.

Figure 3. Example of a highly turbid drinking water source in Endulen. Photo: Tina Paasche.

Based on the findings from the water quality tests, drinking water sources in the NCA are clearly not safe according to the WHO Guidelines for safe drinking water (2017), implying water in the NCA should be treated before consumption.

2.1.3 Water-borne disease and drinking water sources in the Ngorongoro Conservation Area

Water-borne disease is the transmission of disease through ingestion of fecally contaminated drinking water (Landon, 2006). There are four main types of pathogens: bacteria, viruses, protozoa and helminths which can all cause disease. Drinking water quality is closely linked with sanitation and hygiene, and multiple hygiene- and sanitary factors such as unwashed hands, flies and open defecation are all associated with the transmission of disease through drinking water (Landon, 2006).

A formative study conducted in the NCA and which formed the basis for the Project SHINE intervention, reported that infections from helminths and protozoa[11] are among the top diagnoses in the NCA based on reviews of hospital records (Bastien et al., 2015; Henderson et al., 2015). Together with poor hand washing routines, open defecation is found to be a frequent practice in the area, and diarrheal disease particularly affecting infants has been identified as a major public health concern in

[11] Both helminths and protozoa are parasites that can infect humans through the fecal-oral route and cause disease in humans (Centers for Disease Control and Prevention, 2016). Both parasites are associated with diarrheal disease (Genta, 1993; Hashmey, Genta, & White, 1997).

the community (Nyanza et al., in progress). In the same sub-study conducted in the NCA as part of Project SHINE, Nyanza and colleagues found 61.7 % (n=108) of the households included in their study relied on improved drinking water sources[12] throughout the year, and 58.3% (n=102) during rainfall. The study emphasized challenges related to maintaining clean water sources and water points in this setting, suggesting an additional high risk of water contamination from both wild and domestic animals when Maasai pastoralists are in transit searching for pasture and water for livestock.

2.2 The Biosand Filter

The BSF is a HWTS option based on slow sand filtration, developed by Dr. David H. Manz at the University of Calgary in the 1990s[13]. The purpose of the BSF is to remove pathogens and reduce turbidity of the water (Centre for Affordable Water and Sanitation Technology [CAWST], 2012)[14]. It is an intermittently-operated system, meaning the filter is designed to function without the water continuously flowing through the filter as opposed to a continuously-operated filtration system designed to receive a continuous flow of water through the filter (Young-Rojanschi & Madramootoo, 2014). There are several different types of BSFs, with the most evident distinction being usage of either concrete- or plastic housing (CAWST, 2012). In this study, a plastic version of the filter developed by Aqua Clara International (ACI)[15] in collaboration with CAWST is used. Figure 4 illustrates the very basic components of the filter. The key component of the BSF in terms of pathogen removal is the sand, and particularly the top 1-2 cm layer of sand which is called the biolayer (CAWST, 2012). The biolayer consists of microbes from the water that gets poured through the filter. The more water that is poured through the filter, the more microbes accumulate and start living in the top of the sand. These microbes are important because they eat and therefore remove pathogens. For the biolayer to fully grow and function properly, a waiting period of 30 days is required when the filter is new and before the filtered water is safe to drink. During the waiting period, the filtered water needs to be disinfected in order to ensure safe drinking water. Because the biolayer needs nutrients to survive, the filter must be used consistently (preferably 12 L of water run through the system every day) and with a maximum of 48 hours between uses to ensure the biolayer will not dry out and die (CAWST, 2012). Additionally, because the biolayer adapts to the certain type and level of contamination in the water, the same water source should be used every day. If water sources are changed between rainy

[12] Measured with the MDG indicator for safe drinking water

[13] Manz Water Information: http://www.manzwaterinfo.ca/bsf/bsf1.html

[14] Pathogens and dirt are removed in the filter either thorough mechanical trapping (some pathogens and dirt are too big to flow through the sand), predation (the pathogens get eaten by microbes in the biolayer), absorption (pathogens get stuck to the sand) or natural death (the pathogens die because they are deprived of food and air inside the BSF) (CAWST, 2012).

[15] ACI Kenya webpage: http://aquaclara.org/where-we-work/kenya/

and dry season for instance, the filter needs a few days before it is again able to consume all the pathogens in the water, meaning the filtered water needs to be disinfected during the transition phase (CAWST, 2012). For the filter to function properly, correct installation, use and maintenance of the filter is essential. It is beyond the scope of this thesis to lay out a detailed explanation of the technical functions of the filter (i.e. standing water levels, flow rates, pause periods, cleaning of the filter etc.), however the curious reader may retrieve further information elsewhere[16].

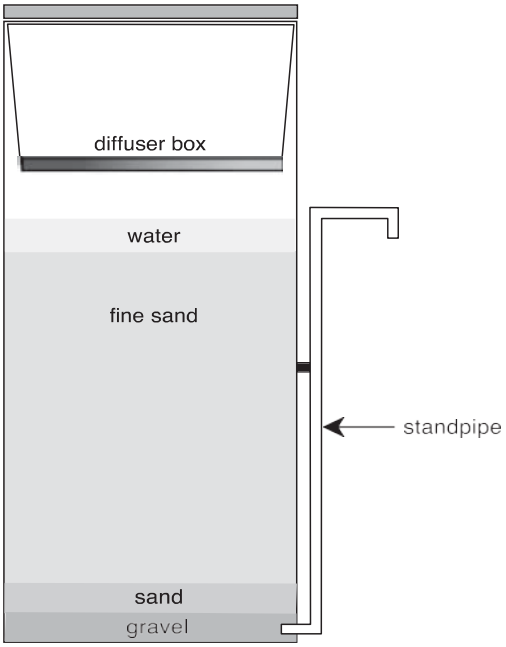

Figure 4. Illustration of a typical plastic house BSF made from locally available plastic barrels. The picture is retrieved from Michael Lea's (2005) article "Biological Sand Filters – Low-Cost Bioremediation Technique for Production of Clean Drinking Water".

2.2.1 Filter performance

There is a relatively large body of evidence on BSF performance both in laboratory- and field conditions, and the following section provides an overview of BSF studies and the implications on BSF performance and health impact of the filter.

Under the supervision of Dr. David Manz, the performance of intermittently-operated slow sand filters was established by Buzunis (1995) in several laboratory tests and field prototypes. Buzunis found the removal rates to vary although consistently remove more than 90 % of fecal coliforms in the water. Turbidity removal was found to average at 95.5 %. In addition to its effectiveness in bacterial removal and turbidity reduction, the BSF efficiently removes protozoa from the water (Palmateer, 1999). BSF performance in terms of virus reduction is however questionable and varies considerably depending on type of virus (Elliott, Stauber, Koksal, DiGiano, & Sobsey, 2008).

[16] BSFs Knowledge Base: http://biosandfilters.info/

More recently, a randomized controlled trial (RCT) of the plastic BSF performance in Cambodia (Stauber, Printy, et al., 2012) showed significantly lower concentrations of E.coli in drinking water in BSF villages compared to control villages (2.9 and 19.7 CPU/100ML respectively, $p < 0.001$) and the BSF group also had lower turbidity in their drinking water compared to the control group (1.6 and 2.5 NTU respectively, $p<0.001$). Additionally, BSF villages had lower diarrheal disease (incidence rate ratio 0.41, 95 % confidence interval: 0.24-0.69) compared to control villages. Another RCT on plastic BSF performance from rural Tamale, Ghana (Stauber, Kominek, et al., 2012) showed similar results reporting a geometric mean reduction of 97 % for E.coli and 67% for turbidity, while also suggesting an overall reduction in diarrheal disease of 60 % (prevalence ratio 0.40, 95 % confidence interval: 0.05, 0.80) for the BSF group compared to the control group. It is important to note that the performance of plastic versions of the BSF has not been as extensively tested as concrete and ceramic versions, and as an example a RCT study in Honduras reported varying filter performance of the Hydraid plastic-housing BSF over the course of their study. In this study the filter did not significantly reduce diarrheal disease (Fabiszewski de Aceituno, Stauber, Walters, Meza Sanchez, & Sobsey, 2012). It is argued however that through interventions with robust study designs such as the RCTs mentioned, ideal environments are created (i.e. home visits, filter monitoring, prompting on operation and maintenance, etc.) which may create bias (Hawthorne effects), and because the filter itself is not the only factor influencing diarrheal disease the authors argue that modest gains from the BSF combined with additional interventions to improve health should be equally recognized (Divelbiss, Boccelli, Succop, & Oerther, 2013). In their study, the same authors found higher household education level and proper use and maintenance of the BSF to indirectly protect against diarrhea.

2.2.2 Sustained filter performance and continued use of the filter

The performance of the BSF in turbidity and fecal coliform removal, and reduction in diarrheal disease is obviously important, however, the filter performance in laboratory settings or in field immediately or shortly after implementation has little value if sustained filter performance and continued use is not achieved over time. Studies assessing sustained filter performance and long-term usage of plastic versions of the BSF was found to be lacking in the literature, and the rest of this section is therefore based on a discussion of studies which focus on concrete-, cement- and ceramic BSFs.

In an assessment of long-term sustainability of household biosand-filtration (Fewster & Wiessent-Brandsma), it was reported that after re-testing of fecal coliform levels in 51 filters implemented in Kenya, the filters were still working as effectively as they did four years earlier, and in general BSFs are proposed to be more sustainable over time than other HWTS technologies (Sisson, Wampler, Rediske, McNair, & Frobish, 2013). In a study from Bolivia, 67% of the ceramic filters that were distributed nine months earlier were still being used regularly, 13 % intermittently, and 21 % were no

longer in use (Clasen, Brown, & Collin, 2006). A broken filter, lack of knowledge on how to use the filter, and the filter being too slow for the family's needs were the most frequently reported reasons to why households did not use the filter regularly. In rural Cambodia, continued use of a ceramic version of the BSF was found to average at approximately two years before disuse, usually due to breakage of the filter (Brown, Proum, & Sobsey, 2009). The main factors contributing to continued filter use were type of water source used, investment in the technology, access to sanitation, and practice of other hygiene behaviors in the household (i.e. handwashing with water and soap, access to a latrine etc.). In another study assessing continued use of a concrete filter in the Dominican Republic, 90 % among 328 households were found to use their BSFs approximately one year after installation, with the main reasons for the remaining 10 % disuse being related to poor perceptions or dislike of the BSF water categorized as either 'not like using the BSF', 'BSF water is of poor quality', 'BSF water has a bad odor', 'too much time is needed to use', or 'it is not necessary to use BSF' (Aiken, Stauber, Ortiz, & Sobsey, 2011). The same study also found E.coli reductions that were higher than previous water quality tests, suggesting the BSF is an effective technology also in a long-term perspective. In a field study of 107 households in Haiti (Duke, Nordin, Baker, & Mazumder, 2006), the *end user* acceptability of a concrete version of the BSF was found to be very high, with all 107 participating households reporting to like their filter because of better quality water (49%), health protection (22%), and because it worked well (7%). The study also reported that participants liked the taste and smell of the water, the ease of use of the filter and that the quantity of water produced was enough for the entire household.

In summary, the plastic version of the BSF is proposed to be a lightweight, low-cost and low-tech water treatment option for household use (CAWST, 2009), and although varying filter performance has been reported in field (Fabiszewski de Aceituno et al., 2012), the filter is found by others through field tests to be effective in removing pathogens and reduce turbidity of the water (Stauber, Kominek, et al., 2012; Stauber, Printy, et al., 2012). The concrete- and ceramic versions of the BSF show promising sustained filter performance in terms of E.coli reductions (Aiken et al., 2011; Fewster & Wiessent-Brandsma, 2004), and while end user acceptability of the concrete version of the BSF is found to be high (Duke et al., 2006) findings on continued use of the filter largely varies between studies (Brown et al., 2009; Clasen et al., 2006; Sisson et al., 2013). The following chapter present this study's conceptual framework which recognizes that a myriad of context-specific factors exists and affects end-user perceptions on acceptability and feasibility of the BSF.

3 CHAPTER 3: CONCEPTUAL FRAMEWORK

3.1 BACKGROUND

As identified in the rationale for this study, innovations addressing water treatment behavior need to be built on an understanding of the perceptions of the end-consumer related to the technology under study, as well as their perceptions on the many factors related to water treatment behavior (Figueroa & Kincaid, 2010). In doing this, various theories for behavior change prove to be useful, and Figueroa and Kincaid propose a combination of stage theories – theories suggesting that adoption of a certain behavior occurs over time as individuals pass through a sequence of stages (DiClemente, Salazar, & Crosby, 2013) - and what they call predictive theories – theories that "identify and describe social, cognitive and emotional factors as important determinants of behavior, irrespective of time" (2010, p. 7).

This study is situated within a socio-ecological approach to health promotion, and applies a framework drawing on the IBM-WASH framework and the Diffusion of Innovations (DOI) theory of behavior change to understand potential facilitators and barriers affecting adoption of BSF drinking water treatment practices. The present chapter begins with presenting the definitions of acceptability and feasibility adopted by this study, before situating the study within the socio-ecological model to health promotion. The chapter concludes with an overview and presentation of the IBM-WASH framework and an extract of the DOI theory relevant to this study.

3.2 DEFINING ACCEPTABILITY AND FEASIBILITY

A broad and simple definition of acceptability is how the targeted population involved in a study reacts to the intervention being studied (Bowen et al., 2009). A more precise definition of acceptability may include focus on to what extent the intervention is perceived as suitable, relevant, satisfying, or attractive to the targeted population (Bowen et al., 2009). However, as emphasized by the authors of the availability, accessibility, acceptability & quality (AAAQ) framework - a generic indicator for acceptability related to water may not be appropriate due to difficulties in determining cultural appropriateness (Jensen, Villumsen, & Døcker Petersen, 2014). The authors further proposed the need to contextualize this criterion because of the many different cultural practices with regards to water. According to Ayala & Elder who focus on qualitative methods for assessing acceptability of interventions, acceptability relates to "how well an intervention will be received by the target population and the extent to which the new intervention or its components might meet the needs of the target population and organizational setting" (2011, p. 1), also recognized by the same authors as 'adoptability' (Green & Kreuter; Steckler & Linnan, cited in Ayala & Elder, 2011).

As identified by Bowen and colleagues (2009), the selection of focus areas and designs for feasibility studies is wide. Among several different definitions, one definition of feasibility is to what extent an intervention can be "successfully delivered to the intended participants in a defined but not fully controlled context" (p. 454). Another definition of feasibility by the same authors is how the intervention can be carried out using "existing means, resources and circumstances and without outside intervention" (Bowen et al., 2009, p. 454).

In this study, community perceptions were assessed pre-implementation, and the adopted definitions are therefore narrower than in the literature to be relevant for the purpose of this study. Acceptability in this study is therefore defined to include initial reactions to the introduction of the BSF filter, including perceptions such as expected advantages or disadvantages of the filter and perceptions related to filter cost. Feasibility is defined to include whether the BSF technology can be implemented, and correctly used and maintained, using locally available resources, logistics and labor. The proposed acceptability and feasibility is assessed based on a balance between potential facilitators and barriers for the BSF to meet the needs of the local community in its unique setting.

3.3 SOCIO-ECOLOGICAL APPROACH TO HEALTH PROMOTION

The socio-ecological approach to health promotion[17] demonstrates how health behavior theories can be applied to a number of environmental levels influencing individual behavior, and that human behavior must be viewed together with and as a part of an integrated ecological system (DiClemente et al., 2013). The various factors comprising the different levels in the socio-ecological model and influencing health behavior (e.g. adoption of health-protective behavior such as drinking water treatment practice) are widely known as health determinants (DiClemente et al., 2013). As explained by Sallis, Owen and Fisher (2008, p. 466): "the core concept of an ecological model is that behavior has multiple levels of influences, often including intrapersonal (biological, psychological), interpersonal (social, cultural), organizational, community, physical environmental, and policy". Evidence shows that multi-level public health and health promotion interventions targeting health determinants at all levels of influence are likely to be more effective than single-level interventions in changing behavior (Glanz & Bishop, 2010; Sallis et al., 2008). A substantial advantage of utilizing an ecological approach to HWTS promotion is the inclusion of both individual behavior (behavioral approach) and the role of pathogens as cause of disease (microbial approach) together with an

[17] Health promotion is "the process of enabling people to increase control over, and to improve, their health. It moves beyond a focus on individual behavior towards a wide range of social and environmental interventions (WHO, n.d)".

emphasis on the surrounding context in which the targeted population exist (Figueroa & Kincaid, 2010).

3.4 The Integrated Behavioural Model for Water, Sanitation, and Hygiene (IBM-WASH)

An ecological approach to health promotion suggest that multiple theories are necessary to understand health behavior within and across the multiple levels of health behavior influences (DiClemente et al., 2013). The adoption of WASH technologies and related behaviors are influenced by a number of health determinants (Dreibelbis et al., 2013b), and there are a range of WASH-related theories and models that have been applied by studies. In a systematic review conducted by Dreibelbis and colleagues (2013b) evaluating behavior change models and frameworks related to factors affecting the adoption of household-level WASH behaviors, it was found that existing models largely focused on individual-level determinants to behavior change. Contextual (i.e. socioeconomic status, gender, household structure, availability of resources) and technological factors (potential favors and constraints of the technology itself and people's responses to the technology) were found to be largely overlooked (Dreibelbis et al., 2013a). Emphasizing the absence of multiple levels of influence in existing models, the authors proposed the multi-level behavior change framework, IBM-WASH, to advance the understanding of sustained adoption of WASH technologies and practices. Formative research was also done to validate the application of the framework to specific technology-supported behavioral outcomes, and the framework was for instance used to guide the thematic coding of qualitative data which contextualized feasibility and acceptability of various handwashing station designs in rural and urban Bangladesh (Hulland et al., 2013).

Indicated as both a conceptual and a practical tool, the IMB-WASH model contains three intersecting dimensions proposed to influence WASH-behaviors; the contextual, psychosocial and technological dimensions with five collective levels under each dimension; societal/structural, community, interpersonal/household, individual and habitual (Dreibelbis et al., 2013b). The full model is presented in Table 5. The model is proposed to serve multiple purposes such as; identification of factors to investigate in qualitative research that describes the reasons for WASH behaviors, design of interventions to promote WASH behaviors, and design of data collection instruments to measure the effect of interventions on determinants of WASH behaviors (Dreibelbis et al., 2013a). As with the theoretical framework guiding Project SHINE, the IBM-WASH is used in this study as an underlying framework guiding the analysis and discussion and serves as a framework directing the interpretation of the research findings.

Table 3. The Integrated Behavioural Model for Water, Sanitation, and Hygiene (IBM-WASH).

Levels	Contextual factors	Psychosocial factors	Technology factors
Societal/Structural	Policy and regulations, climate and geography	Leadership/advocacy, cultural identity	Manufacturing, financing, and distribution of the product; current and past national policies and promotion of products
Community	Access to markets, access to resources, built and physical environment	Shared values, collective efficacy, social integration, stigma	Location, access, availability, individual vs. collective ownership/access, and maintenance of the product
Interpersonal/Household	Roles and responsibilities, household structure, division of labour, available space	Injunctive norms, descriptive norms, aspirations, shame, nurture	Sharing of access to product, modelling/ demonstration of use of product
Individual	Wealth, age, education, gender, livelihoods/employment	Self-efficacy, knowledge, disgust, perceived threat	Perceived cost, value, convenience, and other strengths and weaknesses of the product
Habitual	Favourable environment for habit formation, opportunity for and barriers to repetition of behaviour	Existing water and sanitation habits, outcome expectations	Ease/Effectiveness of routine use of product

The table is retrieved from the article "The Integrated Behavioural Model for Water, Sanitation and Hygiene: a systematic review of behavioural models and framework for designing and evaluating behavior change interventions in infrastructure-restricted settings" (Dreibelbis et al., 2013b).

3.5 DIFFUSION OF INNOVATIONS THEORY

DOI – also known as diffusion theory - is a health behavior theory focused on how people develop perceptions about an innovation and how they make decisions about adopting or rejecting it (Rogers, 2003). Together with other more comprehensive theories of behavior change (predictive theories) such as the IBM-WASH framework, stage theories such as DOI are proposed by Figueroa and Kincaid (2010) as one important foundation in innovations aiming at changing water treatment behavior because it highlights the importance of "knowing the audience" and the process in which adoption of innovations occur.

3.5.1 The four elements of diffusion

Diffusion is within DOI defined as "the process by which an innovation is communicated through certain channels over time among members of a social system" (Rogers, 2003, p. 5). Based on this definition, DOI consists of four main elements; 1. innovation, 2. communication channels, 3. time and 4. a social system. In a social system, all members share a common goal of solving a collective problem, and each social system has its own unique characteristics (i.e. social norms, social structure, etc.) which define and affect diffusion (Rogers, 2003). The aim of this section is not to provide a full description of all four elements of the DOI theory, but rather introduce the aspects of the theory that are relevant to the focus of this study.

3.5.1.1 Innovation

Innovation is within DOI defined as "an idea, practice, or object that is perceived as new by an individual or other unit of adoption" (Rogers, 2003, p. 12). Viewed through the lens of DOI theory, the attributes of an innovation as perceived by individuals within a social system is what determines its rate of adoption. For an innovation to be quickly adopted, high relative advantage, compatibility, trialability and observability is needed, accompanied by low complexity. Table 6 presents the key attributes of innovations as proposed by Roger's DOI theory. For illustrative purposes, the right column of the table presents variables that were derived from DOI theory and used in a field study examining factors affecting the diffusion of SODIS in Bolivia (Heri & Mosler, 2008).

Table 4. Five key attributes of innovations determining its rate of adoption.

Attributes of innovations	**Definitions**	**Illustrative example (SODIS-study)**
Relative advantage	To what degree the innovation is perceived as better than what it replaces, or to what degree members of the social system perceives the innovation as advantageous measured in factors such as economic-, social- and personal benefits.	Cost savings, taste of water, greater safety of the water
Compatibility	To what degree the innovation is perceived as consistent with existing values and needs of potential adopters.	Daily tasks and habits (day-to-day routine), perceived vulnerability to contract diarrhea, severity of diarrhea, Affective beliefs (technology regarded as enjoyable), cognitive beliefs (confidence in the technology)
Complexity	To what degree the innovation is perceived as difficult to understand and use.	Perceived difficulty
Trialability	To what degree the innovation can be experimented with or tried prior to a potential final decision of adopting it.	Availability of enough sunny surface, clear water and transparent bottles
Observability	To what degree the results of the innovation are visible to others.	Experience of reduction in diarrheal diseases

3.5.1.2 Communication channels

A *communication channel* is "the means by which messages get from one individual to another" (Rogers, 2003, p. 18). Mass media channels (e.g. radio, television, newspapers) are identified by DOI theory to be the most efficient way of informing many potential adopters about the existence of an innovation (awareness-knowledge which is explained later). However, interpersonal communication (face-to-face communication) is the main communication channel in DOI theory as "most people depend mainly upon a subjective evaluation of an innovation that is conveyed to them from other

individuals like themselves who have already adopted the innovation" (Rogers, 2003, p. 18). In a study from Malawi assessing factors that motivate women to adopt and sustain chlorine home water treatment (WaterGuard), interpersonal communication was found as especially important to affect adoption of household water treatment (Wood, Foster, & Kols, 2012), and it is also found to have great importance in continued WASH practices (Hulland, Martin, Dreibelbis, Valliat, & Winch, 2015). Further, the extent to which individuals are *homophilous*, or similar in characteristics such as socioeconomic status, beliefs or meanings, also affects how efficient interpersonal communication is and *heterophily,* the opposite of homophily, is one of the major barriers to diffusion because it leads to individuals 'not speaking the same language' (Rogers, 2003). The degree of homophily between *change agents* – "those who actively attempt to promote adoption of an innovation" (DiClemente et al., 2013, p. 216) – and the members of the social system will therefore affect the diffusion of the innovation. *Opinion leaders* who usually are well-respected and influential members of the social system may serve as effective change agents due to their high degree of homophily between themselves and other members of the social system (DiClemente et al., 2013).

3.5.1.3 Time

DOI theory describes three ways in which time is involved in diffusion; through 'innovativeness', 'an innovation's rate of adoption' and 'the innovation-diffusion process' (Rogers, 2003). Only the innovation-diffusion process is further described in this study.

Adoption of an innovation is typically not an impulse decision, but rather a process that occurs over time (Rogers, 2003). This process as described by Rogers consists of five stages affecting an individual's decision about an innovation; 1. knowledge, 2. persuasion, 3. decision, 4. implementation and 5. confirmation. As the individual moves through the five steps – there are no clear distinctions between the beginning and end of each stage, and exceptions to the time-sequence may occur - information is acquired and processed affecting the individual's uncertainty about the innovation which again affects the decision of adopting or rejecting the innovation. A brief introduction to the five stages is presented next.

3.5.1.3.1 Knowledge

According to Rogers (2003) the innovation-decision process begins with a 'knowledge-stage' in which individuals are exposed to an innovation and obtains an understanding of how it works. There are three types of knowledge about an innovation; awareness-knowledge, how-to knowledge and principles knowledge. Awareness-knowledge is simply knowledge about the existence of an innovation. How-to knowledge is knowledge about how the innovation works and how to use it correctly, and the more complex the innovation the greater the amount of how-to knowledge is needed for adoption (Rogers, 2003). Principles knowledge is knowledge on the fundamental principles

underlying how the innovation works, such as the germ theory which underlies how water treatment works to remove pathogens in the water (Rogers, 2003).

3.5.1.3.2 Persuasion

At the persuasion stage, individuals form their attitudes, or feelings, towards the innovation through actively seeking out information and develop a general perception of the innovation (Rogers, 2003). The perceived attitudes explained earlier are central in the development of a general perception of the innovation, and peer influence through interpersonal communication is identified as crucial in influencing and forming attitudes.

3.5.1.3.3 Decision

At the decision stage, the individuals make the decision to either adopt or reject the innovation (Rogers, 2004). It is at this stage that trialability may be advantageous, as the individual may learn during this process that the innovation has a relative advantage affecting the decision to adopt. In some cases, instead of the individual personally trying out the innovation, change agents demonstrating the innovation for the individual may help speed up the decision process, this is especially true if the change agent is an opinion leader (Rogers, 2003).

3.5.1.3.4 Implementation and confirmation

At the implementation stage, thinking and deciding is replaced by action as the individuals adopt the innovation and put it to use, meaning this is where the actual behavior change happens (Rogers, 2003). How to use the innovation and how to solve problems related to use and maintenance are likely questions at this stage, and the role of change agents at this point is mainly to provide technical assistance. The initial adoption of an innovation however does not necessarily imply a long-term commitment and continued use of the innovation (DiClemente et al., 2013), and at the final stage of the innovation-decision process the individual seeks reinforcement for their use of the innovation and may either reverse the decision of adoption, or make a long-term commitment (DiClemente et al., 2013; Rogers, 2003).

This study is situated at an early stage of implementation and is therefore at the very beginning of the innovation-diffusion process. The power of DOI theory to predict future adoption of innovation has been critiqued, specifically due to its lack of insights into the complexity and inter-relation between factors affecting the adoption of HWTS options (i.e. local context) (Ngai & Fenner, 2008). However, together with the IBM-WASH framework and the multi-level approach to behavior change, the DOI theory is viewed as a beneficial tool in this study to enrich the discussion related to facilitators and barriers potentially affecting adoption of BSF water-treatment practice in the NCA. Having presented the underlying conceptual framework, the study methodology is presented in the following chapter.

4 CHAPTER 4: METHODOLOGY

The primary aim of this chapter is to account for the methodological approach used in this study. First, background information is presented through a reflection of the philosophical assumptions and standpoints framing the study and a description of how the study was designed based on these foundations. The research methods used in the study are explained detailing the process of participant sampling, data collection and data analysis. Thereafter, ethical considerations relevant to the study are presented, before the chapter ends with a discussion on methodological strengths and limitations.

4.1 BACKGROUND

Briefly returning to the research questions guiding this study, the aims are to investigate community perceptions and concerns around water scarcity and water quality in the NCA and to what extent the BSF is an acceptable and feasible water treatment option in the area. Based on this, the study is positioned within a naturalistic inquiry, taking account of the nature of social experience (Guba & Lincoln, 1982). The study used a qualitative descriptive approach which fits within the naturalistic and interpretative paradigm (Denzin & Lincoln, cited in Stanley, 2014). The philosophical assumptions of the ontology – the nature of reality (Creswell, 2013) - and the epistemology – the relationship between the researcher and that being researched (Creswell, 2007, cited in Lincoln, Guba, & Lynham, 2011) are presented in more detail next.

4.1.1 Philosophical assumptions

As presented by Sandelowski (2000), basic or fundamental qualitative description differs from other qualitative descriptions such as phenomenology and grounded theory in that the approach is not guided by a pre-existing conceptual, philosophical or highly abstract framework. Sandelowski argues that the approach is therefore less interpretative than other qualitative descriptions as deeply abstract interpretations of the data is not necessarily required. It is important to emphasize that Sandelowski in her outline of the approach however does not claim that basic qualitative description is purely descriptive and not interpretative (Stanley, 2014), as “all inquiry entails description, and all description entails interpretation” (Sandelowski, 2000, p. 335). Further, even though the approach is not committed to a specific theory or philosophy, basic qualitative descriptive studies may be influenced by, or as Sandelowski puts it, have the “look, sound or feel of other approaches” (p. 337).

The ontological foundation of this study was built on a relativistic view, which is a position implying that social phenomena and their meanings should be considered social constructs in a constant process produced through human perceptions and actions, as opposed to objectivism where social phenomena and their meanings are viewed as external facts independent of human perception and

action and thus something beyond their control (Bryman, 2016). As discussed by Guba and Lincoln (1982), social phenomena addressed in social/behavioral sciences has no reality in the physical sense (as they cannot be touched, seen, tasted, smelled or heard), and tangible objects (or events and processes) that has no reality outside people's minds can only mediate behavior through the meaning and interpretation people make of them (Guba & Lincoln, 1982). Multiple realities thus exist, and these realities are constructed within the individual who constructs knowledge through lived experiences and interactions with others (Lincoln et al., 2011). It naturally follows then, that the epistemological foundation of this study builds on a subjectivist view where findings, or knowledge, are created in the process of interaction between the researcher itself and the people being studied (Guba, 1990, cited in Lincoln et al., 2011). In this process, as social scientists interpret human behavior through the eyes of the people being studied (Bryman, 2016), the researcher becomes the primary instrument of data collection and analysis (Merriam & Tisdell, 2016). With the researcher itself being central in the data collection and analysis, the researchers background, personal experiences, beliefs and feelings will inevitably determine what can be seen and thus limit objectivity and affect the way in which a study is framed and executed (Bryman, 2016; Malterud, 2001). Recognizing that qualitative research cannot be value free is therefore essential, and an identification of preconceptions brought into this study and other self-reflections is therefore presented next.

4.1.2 Positionality

As I hold a bachelor degree in human movement science, my professional background prior to enrollment at the Norwegian University of Life Sciences as a master student of public health is based on subjects mostly outside of public health, and especially global health. I consider myself novice both in relation to global health issues and also to qualitative research, meaning I came to the project with little relevant academic background. The relevant knowledge and qualifications that I have acquired stems from existing literature read in the few months before implementation of the data collection, and during field work and writing up of the present thesis. My interest in global health, and water-related issues particularly has therefore gradually evolved together with my involvement in the project, and my beliefs and feelings around the topic are largely shaped by experiences in field and the references cited in this thesis exclusively. I additionally had little to no past experience or knowledge of marginalized communities around the globe, and my perception of poverty and a life in resource constrained settings was mainly based on news from various Norwegian media channels. The interpretations, findings and conclusions in this study may therefore have been shaped by my pre-existing (or the lack there of) understanding of these issues in low- and middle income countries. Further, researchers might develop an affection or sympathy for the people being studied (Bryman, 2016). Although we did not spend much time together with the participants - as would be more the

case if observations were used for data collection – we did spend four weeks in field which I believe may have shaped my understanding of the context to the point where I developed a sympathy for the Maasai people who are in a much less privileged position than me, facing challenges that I previously barely knew existed.

Depending on the setting in which research is performed, the researcher may have the position of an insider, an outsider, or someplace between the two[18] (Hellawell, 2006). There are several personal attributes about me as a researcher that may likely have had implications for my position on the insider-outsider continuum throughout the research. Objectivity in terms of a pure outsider perspective is neither feasible nor necessarily desirable in qualitative research, and even though I differed substantially on a range of characteristics compared to the study participants (i.e. gender, age, ethnicity, privilege etc.) and therefore largely had the position of an outsider, there were some elements driving my position from a pure outsider and closer towards that of an insider. Being a part of an already well-established and accepted project within the community, and therefore benefitting from previously acquired knowledge and mutual respect in the community, is one factor which likely contributed to my position on the insider-outsider continuum. The researcher having both an outsider and an insider position simultaneously is argued to be both possible, and advantageous (Hellawell, 2006). In this study, my position as an outsider helped me retain a certain distance between myself and the participants, while a more insider position was advantageous in terms of being accepted by the participants, gaining trust, and keeping the power imbalance to a minimum. Power imbalance between the researcher and those being researched is a feature that is constantly present in most qualitative research interviews, largely due to the researcher being in position of the scientific qualifications and therefore also controlling the theme, course and execution of the interview (Kvale & Brinkmann, 2015). In the present study, the power imbalance may have been further affected by the great differences in characteristics between me as a researcher and the participants as residents in the NCA. For instance, I am both white and privileged which are all potentially alienating characteristics about me that may have deterred the participant's confidence in sharing their perceptions and stories. However, being a part of an already respected project in the current setting presumably helped equalize the power imbalance between me and the participants. Gender- and age dimensions are other issues that may determine the extent of 'insiderness' that is present in an interview (Hellawell, 2006), I did for instance experience different levels of "distance" between me

[18] An insider can be defined as "an individual who possesses *a priori* [emphasis in the original] intimate knowledge of the community and its members" (Merton, 1972, cited in Hellawell, 2006, p. 484) and therefore implies that the researcher does not necessarily need to be a member of the community to access intimate knowledge (Hellawell, 2006). An outsider implies the opposite, namely a researcher who has no *a priori* knowledge of the research setting and the target population.

and the various participants, and also between the participants themselves. As an example, in the group discussion with BSF pilot evaluation participants from "urban" households in Endulen (post-workshop), all participants and Project SHINE team members that were present were female (except from the translator), which may have helped create a more open atmosphere and environment where all participants felt comfortable and more likely to speak up and share their views, as compared to situations where male participants were also present.

4.1.3 Case study

The BSF pilot evaluation study was as previously mentioned based in the NCA, and took place in the two rural wards (administrative units) of Endulen and Nainokanoka. In a qualitative case study the interest of the researcher commonly is to reveal the unique features of a case, which usually refers to a community or an organization (Bryman, 2016). Another definition of a case study is that it is "an in-depth description and analysis of a bounded system" (Merriam & Tisdell, 2016, p. 37). To give in-depth descriptions of community perceptions in the NCA, this sub-study focused on the Endulen community as the unit of analysis (qualitative data was not collected in Nainokanoka due to logistical reasons). A limitation of case study research relates to the lack of generalizability, meaning the findings are not representative to apply beyond the specific research context (Bryman, 2016). Generalizability, or transferability, and other methodological strengths and limitations are discussed in more detail in chapter 6.

4.2 METHODS

All data for this sub-study were generated through in-depth semi-structured interviews (henceforth also referred to as 'in-depth interviews'), group discussions and think tanks over a three-week period in May/June 2016. Multiple data collection methods were used to ensure inclusion of perspectives from a variety of sources and angles (triangulation[19]), and multiple sessions were conducted to ensure equity in voice. The purpose of triangulation is that the understanding of social phenomenon is assessed through various representations of people's lives, and the more methods used to study them the more rigor, breadth and depth are added to the obtained knowledge (Flick, cited in Denzin & Lincoln, 2003). A further discussion on the study rigor is included in chapter 6. Although additional in-depth interviews, group discussions and think tanks were conducted as part of the study, only nine

[19] There are several types of triangulation, and the term is perhaps most often associated with *methodological triangulation,* which refers to "the use of more than one method for gathering data" (Denzin, 1970, cited in Bryman, 2004). This type of triangulation often implies the use of both qualitative and quantitative research methods combined. In this study however, *data triangulation* was used, which refers to collecting data "through several sampling strategies, so that slices of data at different times and social situations, as well as on a variety of people, are gathered" (Denzin, 1970, cited in Bryman, 2004).

sessions were included in the analysis for this thesis due to its scope and focus. An overview of the data used in this thesis is presented in Table 7.

4.2.1 In-depth interviews and group discussions

Kvale og Brinkmann (2015) states the qualitative research interview gives the researcher access to the life world of the interviewee, and seeks to understand the participants' knowledge, experiences and meanings of a topic through the eyes of the participants being interviewed. Both in-depth interviews and group discussions are essential to engage with and understand the target population's points of view, and additionally helps generate a sense of ownership and local commitment to a project or intervention (Skovdal & A Cornish, 2015). With in-depth-interviews and group discussions, the researcher also has the opportunity to probe relevant topics further as they emerge throughout the discussion, which generally results in a deeper understanding of underlying factors that can potentially deter or favor an intended implementation (Ayala & Elder, 2011). In-depth interviews are beneficial to explore individual thoughts and feelings, ensures that individual voices are heard, and are important in contexts where all groups are not necessarily comfortable about sharing their views with a larger group of people (Skovdal & A Cornish, 2015). Group discussions on the other hand have a focus on collective experiences and are advantageous in providing insight into socially accepted norms, and common knowledge, opinions and frictions within the community (Skovdal & A Cornish, 2015). The ultimate goal of the group discussion is not to agree on or introduce a specific solution to the questions being discussed, but rather explore the various viewpoints covering a theme (Kvale & Brinkmann, 2015).

The in-depth interviews were semi-structured and were based on an interview guide (Appendix B) covering a series of relevant topics and questions related to water-related issues in the NCA and the BSF in particular. To develop a deeper understanding of community perceptions and concerns around water scarcity and water quality, general themes and sub-themes included but were not limited to 1) both historical and current perceptions of water-related issues in the NCA (e.g. main challenges, management, etc.), 2) stakeholders engaged in water-related issues in the NCA (e.g. main actors and their roles, current efforts, collaboration between the various actors, etc.) and 3) current strategies to address water scarcity and water quality (e.g. human and animal use and needs, knowledge of the linkage between water and health, commonly used water treatment options, available drinking water sources, seasonality, equality/inequality, gender roles and responsibilities, etc.). With the aim of understanding perceptions related to implementation of the BSF as a low-cost, low-tech option for treating water in the NCA general themes and sub-themes included but were not limited to 1) awareness, knowledge and perceptions of the BSF, 2) perceptions regarding community feasibility of the BSF (e.g. whether the filter could be an option for cleaning water in the NCA, main challenges such

as logistics of and permission to get materials in the NCA, cost, options for water storage, etc.) and 3) perceptions regarding community acceptability of the BSF (e.g. main challenges to widespread community acceptance and adoption such as perceptions of effectiveness, cost, effort required, preference for other methods, maintenance, knowledge, skills, etc.). In case of any additional information, the participants were asked at the end of each interview if there was anything that we had not mentioned or asked about the issued that they would like to elaborate on. As is expected in semi-structured interviews (Kvale & Brinkmann, 2015) the questions were flexible and adjustable and the interviewer was free to skip, add and change the predetermined questions as the interview proceeded. In conformity with the in-depth interviews, the group discussions (which followed the same interview guide as the in-depth interviews) were open with respect to the topics being discussed, but differed as the interviewer had the role of a moderator with the purpose of raising a discussion and inviting all participants to share and discuss their views and opinions.

4.2.2 Think tanks

A think tank is a form of semi-structured group discussion much like focus group discussions, however it has a very specific purpose. The think tank is intended as a tool to engage the community in dialogue to explicitly identify community concerns or worries around a topic and to identify mitigation strategies to minimize potential unintended harm or consequences, and has been used successfully within Project SHINE previously (Friebe, 2016; Hetherington et al., 2017). Through open-ended questions posed by a moderator, the think tanks in this sub-study were conducted to engage in brainstorming and sharing of ideas to identify community concerns and strategies to minimize potential unintended harms associated with efforts to implement the BSF at the household level in the NCA. Although not the main focus of this thesis, the concept of unintended harm as proposed by Allen-Scott and colleagues (Allen-Scott, Hatfield, & McIntyre, 2014) highlights the importance of not only focusing on the positive benefits of public health interventions, but also identifying potential unintended harm and working to minimize potential harm to the community. In addition to providing a platform to address potential unintended harms to the community (which is the focus of another concurrent sub-study and thesis), the think tanks included questions related to water-related issues in the NCA and therefore served as an additional source of information both to assess community concerns around water scarcity and water quality and perceptions related to implementation of the BSF. The discussion guide used in the think tank sessions is found in Appendix C.

4.2.3 Participant sampling

The participants sampled for the in-depth interviews, group discussions and think tanks included a wide cross-section of community members, stakeholders and other actors in order to gain a broader understanding of community perspectives. All participants in this sub-study were recruited from the

Endulen ward, and were selected either through purposive or convenience sampling. As explained by Bryman (2016), when selecting participants through purposive sampling the research questions guiding the study gives a strategic indication of which participants need to be sampled to allow the questions to be answered with a sufficient variation in the sample (Bryman, 2016). The purposive sampling in this study was for instance based on occupation (i.e. employee of the Water Committee, Aqua Clara representative) or their specific role in the community (i.e. traditional leaders, BSF pilot evaluation participants, stakeholders with knowledge of the policy perspective), or through convenience sampling based on logistics and general availability of community members. An overview of study participants and how they were recruited is summarized in Table 7.

Project SHINE has been an ongoing study in the NCA since 2014, and as such has built up community relationships with the hospital, schools and the wider community. The research team used local project coordinators and their knowledge of cultural norms and values as the linkage between the project and the community, and in close collaboration with VEOs from the Endulen ward, the local project coordinators lead the process of recruiting participants, with instructions of selecting a sample of varied participants differing from each other in terms of key characteristics (i.e. gender, occupation, role in community).

A limitation of purposive sampling relates to the limited possibility to generalize the findings to another population (Bryman, 2016). Another limitation of the sampling strategy applied in this study is related to data saturation. Although theoretical saturation – which is when new data no longer give new theoretical insights (Bryman, 2016) – was not a criterion in this study, general data saturation which can be described as "the number of interviews needed to get a reliable sense of thematic exhaustion and variability within [the] data set" (Guest et al. 2006, p. 65, cited in Bryman, 2016, p. 417) was intended. There are many factors contributing to when general data saturation is reached, including the research domain, the quality of the data and the homogeneity of the sample (Guest, Bunce, & Johnson, 2006). When the goal is to describe common perceptions, beliefs and behavior in a relatively homogenous group, rather than comparing how two groups differ for instance, a smaller sample size of six to twelve interviews is proposed to be sufficient (Guest et al., 2006). In this study, the participants were sampled to give an adequate variation in the sample, and the participants differed in terms of gender, occupations, role in community and to some extent socioeconomic status. The sample was however relatively homogenous, in the sense that the majority of the participants were middle-aged members of the same community. In the analysis, the similarities in the views of the participants seemed to be sufficient to reach general data saturation, as few new codes were developed at the end of the analysis. It is however recognized that the sample size is relatively small and other community perceptions may have emerged through a larger sample size.

4.2.4 Data collection process

The in-depth interviews, group discussions and think tanks took place at various locations in Endulen. All sessions were conducted outdoors. A total number of five researchers took turns leading the sessions, and in addition to note-taking by a minimum of one student, all sessions were audio-recorded with permission to allow for more complete documentation of the interaction during the session. The in-depth interviews, group discussions and think tanks ranged in length from 30 minutes to approximately two hours depending on the number of questions asked, the amount of probing and how talkative the respondents were. The think tanks lasted the longest given that the project had to be presented in detail, before shifting the discussion to focus on dialogue and the ranking of concerns and identification of mitigation strategies. In most cases, the participants either spoke the local language *Kimaa* or the national language *Kiswahili*, while the interviewers in all except one session (various community members think tank lead by a research member fluent in all three languages) spoke English. Two local translators employed by the project were otherwise used. Some of the participants, the traditional leaders and the employee for the Water Committee, attended more than one session as they were present in the think tanks in addition to their individual interviews. Some of the participants were also present in multiple think tanks. The potential implications that this may have on the study rigor is discussed at the end of chapter 6.

Table 5. List of selected in-depth interviews, group discussions and think tanks.

Source type	**Participant sampling**	**Composition of participants (number of participants disaggregated by sex)**	
In-depth interview	Purposive	Traditional leaders	2 males
In-depth interview	Purposive	Employee, Water Committee	1 male
In-depth interview	Purposive	Representative from Aqua Clara Kenya	1 male
Group discussion	Purposive	BSF pilot evaluation participants from “urban” households in Endulen	3 females, 2 males
Group discussion	Purposive	BSF pilot evaluation participants from “rural” households in Endulen	2 females, 3 males
Group discussion	Convenience	BSF pilot evaluation participants from “urban” households in Endulen, post-workshop	4 females
Think tank	Purposive	Various community members	4 females, 6 males
Think tank	Convenience	Women’s group representatives	9 females
Think tank	Purposive	Community members with special knowledge of the policy perspective in the NCA	6 males

4.2.5 Data analyses

4.2.5.1 Thematic analysis

Although not as clearly defined and acknowledged as long-established approaches such as discourse analysis or grounded theory, thematic analysis is one of the more frequently used strategies in

qualitative data analysis (Bryman, 2016). The method is suitable for identifying and analyzing patterns (themes) within the data set, and is compatible across a range of theoretical and epistemological positions (Braun & Clarke, 2006). Because of its flexibility, and because the outcome of this study was aimed at a rich description of the data rather than theory generation, thematic analysis was deemed appropriate to allow the right amount of interpretation within the qualitative descriptive methodology used in this study (Stanley, 2014). Ryan and Bernard's (2003) techniques to identify themes were used as support in the process of discovering themes and sub-themes in the text. To manage the analysis and extraction of themes, NVivo version 11 was used.

4.2.5.2 Analysis process

The data analysis process was iterative and began in field, through the process of field notes, debriefs, identification of emerging themes and suggestions on further probing after each session. Debriefs were conducted immediately or as soon as possible after data collection to ensure minimal memory loss. The questions guiding the debriefs are included in Appendix D. The process of transcribing the audio recordings was carried out in January 2017, eight months after return from field-work. Transcribing was done verbatim and was viewed as an active phase in the process of getting familiarized with the data and start identifying ideas of potential patterns, reflecting phase number one in Braun and Clarke's step-by-step guide to thematic analysis (2006).

As discussed by Ryan and Bernard (2003) although there are multiple elements of information to look for and ways of coding texts, it does not mean all techniques are effective and appropriate to all researchers and all kinds of data. In this study, repetitions or "topics that occur and reoccur" (Bogdan and Taylor, cited in Ryan & Bernard, 2003, p. 89) and similarities and differences across statements and data items were the main techniques used to discover initial codes. The 'cutting and sorting' technique was then used to discover overarching themes by organizing all initial codes into higher level folders containing codes representing the same theme (Ryan & Bernard, 2003). Given my own language competence and the general linguistic challenge in this study (discussed in more detail later in chapter 6), techniques depending on metaphors and analogies and linguistic connectors were not used. Looking for transitions (i.e. pauses, changes in voice tone or the presence of particular phrases (Ryan & Bernard, 2003)) emanated from the analysis process due to the use of translators, and the search for missing data (what is not mentioned) was decided to be inappropriate due to relatively short responses and the likelihood of finding themes that were only a result of how the interviews were conducted or merely a result of what the researcher was looking for, rather than actual missing data (Ryan & Bernard, 2003). During the analysis process, a journal was kept with the purpose of tracking the major decisions made and the reason behind them, this as a strategy to add rigor to the study (Stanley, 2014).

Due to the underlying IBM-WASH framework in this study - and especially the second research question regarding acceptability and feasibility of the BSF - the analysis of the data must be viewed as being somewhere between inductive (data driven) and deductive (theory driven). Research question number one regarding community perceptions and concerns around water scarcity and water quality was coded completely without trying to fit the analysis into a pre-existing coding frame (Braun & Clarke, 2006), and was therefore more inductive in nature. Research question number two regarding perceived acceptability and feasibility of the BSF was however driven by the IBM-WASH framework to a greater extent. As proposed by the authors of the IBM-WASH framework (Dreibelbis et al., 2013b), and confirmed by Hulland et.al (2013), the structure of the model is suitable as a codebook guiding the analysis of qualitative data. Even though the framework was not used directly as a codebook in this study, the themes and sub-themes that were developed through the analysis were inevitably affected by pre-existing knowledge of the framework and the relevant literature. Although the analysis was kept open for emerging themes outside of the IBM-WASH framework, the final thematic map of themes and sub-themes were consistent with the framework and were therefore structured within the three dimensions (contextual, psychosocial and technology) and their associated levels.

4.3 ETHICAL CONSIDERATIONS

The data material in this study contained sensitive information and the ethical principles stated in the Declaration of Helsinki (World Medical Association, 2013) was therefore maintained throughout the study. The study protocol was approved by the University of Calgary Conjoint Health Research Ethics Board (CHREB), Canada, the Tanzania National Institute for Medical Research (NIMR) and Norsk senter for forskningsdata (NSD). See Appendix E for the NSD approval. Additionally, the project was approved by authorities at regional, district and village levels in Tanzania. In accordance with the principles of the Helsinki declaration and NSD requirements, participants received verbal information about the project before giving their informed consent to participation and audio taping. Informed consent was also acquired prior to photographing of participants. The confidentiality of the participants was maintained throughout the study. Given that sensitive data was stored on a personal computer, password protection and other precautions were necessary to ensure data was adequately encrypted.

5 CHAPTER 5: RESULTS

This chapter presents the results and main themes that emerged through analyses of the in-depth interviews, group discussions and think tanks. In the analysis, two thematic maps were developed covering each of the two research questions guiding the study. The respective thematic maps and findings are presented separately.

5.1 COMMUNITY PERCEPTIONS AND CONCERNS RELATED TO WATER SCARCITY AND WATER QUALITY

As highlighted in the background chapter, the NCA is a remote and resource constrained setting, where the Maasai way of life consists of daily activities that are largely situated around water which is a scarce resource. Additionally, drinking water sources in the NCA are highly contaminated, and diarrheal disease are among the top diagnoses for the Maasai in the region each month. In this section, the identified themes and sub-themes related to community perspectives and concerns around water scarcity and water quality are presented. Six main themes were developed in the analysis of the data and the following sub-sections presents the findings covering each theme and their sub-themes as they are ordered in Table 8.

Table 6. Themes and sub-themes related to community perceptions and concerns around water scarcity and water quality.

Themes	Sub-themes
"The changes of years"	*Water scarcity* • Harsher conditions now than in the past
Burden on women and girls	*Water scarcity* • Gender roles and responsibilities • Risks associated with collection of water
Disparities related to access to water	*Water scarcity* • Based on residency • Based on socioeconomic status (SES)
Knowledge related to water quality	*Water quality* • Overall knowledge level in the community • Water with low turbidity perceived as safe water
Shared water sources with animals	*Water scarcity* • Insufficient amounts of water to meet the needs of both humans and animals *Water quality* • Sharing water sources with animals as the leading cause to water-borne disease
Management of water related issues	*Water scarcity* • Perceived shortcomings concerning management and leadership • Strained relationship between main actors and the community

5.1.1 "The changes of years"

This theme was developed *in vivo* from the interview with the traditional leaders. When asked about climatic conditions now as compared to conditions in the past, the *Kimaa* word to describe the changes that in English are described as 'climate change' was identified as '*ingibelekenyat oo larin'*, which means 'the changes of years' in English.

5.1.1.1 Harsher conditions now than in the past

The past - which was formulated as more than 10 years ago in the interview guide – was according to the participants associated with more rain and green grass, greater availability of water, and less disease than present years. Drawing conclusions about trends in climate changes such as annual rainfall on the African continent is difficult because of insufficient observational data (Niang et al., 2014). However, data from the past century shows "*very likely* [emphasis in original] increases over parts of eastern and southern Africa" (Niang et al., 2014, p. 1209). That being said, Lyon and DeWitt (2012) cited in (Niang et al., 2014) has reported a *decrease* in rainfall in the March-May season in eastern Africa, which concurs with the perception of one of the participants who claimed that the scope of water scarcity in the area has increased extensively starting in 1974, and compared to the past when the rain started in October and went on until June, it now sometimes only rains for 2 consecutive months.

> *And then there is even some years which is we can just get rain maybe two months only. For a long time the rain can just start October up to June raining. And then nowadays the rain can just start on January, I mean December, and then there is no rain and then up to February/March rain a little bit and then it will be the end (male participant, traditional leaders interview).*

In one of the group discussions, one participant who also specified the 'good' years to be from 1980-98, explained how the availability of water has decreased in recent years[20].

> *For a long time ago when we were small, young kid, there is really availability of water, there are some streams which are dry now, but by that time it was flowing water throughout of the year, but now they are dry. And also for that time there is more raining compared to now (female participant, urban BSF group discussion).*

According to the traditional leaders, the changes that are happening on the earth surprise and concern the Maasai. They acknowledge that of course there has always been death, but they described the

[20] Periods of 'good' and 'bad' years in terms of rainfall and temperature changes are well-known by scientists, and on the African continent three major climate phenomena (the movement of the Intertropical Convergence Zone, the El Niño-Southern Oscillation and the annual alteration of the Monsoons) are known to drive the highly variably African climate (Conway, 2009). As an example, years of El Niño are associated with more rain in the December and February months in eastern Africa, while the opposite phenomenon of La Niña brings drier weather (Conway, 2009). In 1998, El Niño resulted in an estimated five-fold increase in rainfall (Galvin et.al, 2001, cited in Galvin et al., 2008), while 1997 and 1999 were severe drought years (World Food Program [WFP], 2000, cited in Galvin et al., 2008).

past as a time where people were generally healthier. The changes in rainfall and duration and extent of the dry season is something perceived to be new that reportedly influences how the Maasai currently view disease and death in their community.

> *They are just surprised; what is happening, what is going on? Because if they take the history, the long back history there's nothing like this. A long time ago, death yes, there is death, but people are healthy, they have a lot of cattle, they have a lot of rain (male participant, traditional leaders interview).*

> *…now, because there is, there is a shortage of water or no water at all and that's why it is different. Because by that time there is no many diseases but now there is lot of diseases because of people they can just get a little bit water there, but they share with animal (male participant, traditional leaders interview).*

Current challenges related to water scarcity is an issue that poses challenges to the community. Less rainfall and therefore available water in the community is perceived as being a potential cause of increased levels of disease, presumably related to an increased probability of having to share water sources with animals. In another rural and water-limited area of Tanzania (the Ruaha region), a study which applied a One Health approach to address emerging zoonotic diseases in pastoralist communities reported increased water scarcity as central in zoonotic disease transmission, as it forces humans and animals closer together and leads to shared water sources and increased risk of zoonotic diseases such as rabies, Rift Valley fever, tuberculosis, brucellosis and diarrhea (Mazet et al., 2009). Findings related to shared water sources with animals are further elaborated on in a later sub-section.

5.1.2 Burden on women and girls

5.1.2.1 Gender roles and responsibilities

> *When we talk about water issues, we talk about women issues. So, when we talk about water issues, there are really like women issues (female participant, community members think tank).*

The above statement illustrates the importance of water to the everyday reality of a Maasai women. While men were identified as the decision-makers both in the community and in the households, Maasai women and girls were, in accordance with most other women in low-income countries around the globe (Sorenson, Morssink, & Campos, 2011), identified as the ones responsible for most of the practical water-related activities throughout the course of the day .

> *They are the one responsible for fetching, they are the one responsible for ensuring that the families are getting access to adequate amount of water (female participant, women's group think tank).*

In their daily activities related to water, the women explained how they prefer to go together in a group, and they confirmed that collecting water is perceived as a social activity. When down by the water, the women share stories, talk about their family and gossip about other people.

> *They ask them self about your family this morning, children that are fine. And make different stories. They say they talk about different things like yesterday I saw a snake, maybe someone yesterday do something that make that kind of story. They say they sing, and sometimes they make gossip other people, like men, the second wife, and the first one (female participant, women's group think tank).*

Another dimension related to women and water, and which highlights their important role in the community, is how Maasai women are spiritually responsible of handling concerns around water scarcity. In periods when rain is absent but expected, participants described specific Maasai rituals that are traditionally performed by women to bring rain. The women gather to sing and walk to the rivers or the mountains, where a pregnant woman about to give birth will lay down on her back. This act is believed as a prayer, and when God recognizes their need for water he will give them rain.

> *…when the women walking, singing and pray for God, they can just take one of the pregnant women who is really about to give birth and then they find that place on the plainland, and then they can just tell her to lay down there at the middle of that place, laying down on her back, just to show the God her pregnant, and then the women just singing around, just pray for God and then the God can just really listen their prayer and give rain (male participant, traditional leaders interview).*

5.1.2.2 Risks associated with collection of water

Statistics shows the distribution of the water collection burden to fall heavily on both women and girls compared to men and boys in sub-Saharan Africa (UNICEF/WHO, 2012). In a context of water scarcity, many women and girls face long walks to fetch water every day, with the average distance of six kilometers each day for women in Africa and Asia (United Nations Human Rights and WHO, 2010). In Tanzania, women and children typically spends from two hours every day collecting water, to as much as seven hours in remote areas (WaterAid Tanzania, n.d).

Carrying heavy loads of water takes a toll on the body, for instance in terms of caloric expenditure, injuries to the back, neck or joints, risks of falling, and assault and attack risks (i.e. rape or attacks by wild animals) (Sorenson et al., 2011). A donkey, which was referred to as *"the woman's car" (female participant, woman's think tank),* was identified as a potential aid for carrying the heavy buckets of water, but only a few women in the NCA are fortunate enough to own a donkey to help them carry the water (Figure 5). In cases where water is collected in deep wells, women and girls risk falling into the well, which was identified as especially problematic for pregnant women. Water sources are often shared with animals, and the women and girls especially face the risk of running into wild animals such as elephants, buffaloes and snakes both on their way to and around water sources.

Figure 5. A local woman and her donkey – "the woman's car". Photo: Tina Paasche.

In addition to physical stress related to collection of water, the women who have the longest walks and who spend the entire day looking for water were identified as having little or no time for other family-related activities, meaning the burden on certain women is affecting not only the women themselves but also the opportunity for the women to take care of and develop their family.

> *…woman will take the entire day looking for water and that means they have no other time for development or family development issues and that means they are wasting a lot of time search for water (Employee, Water Committee).*

For girls and young women, time spent assisting their mothers in water-related activities is time that may otherwise have been spent in school (Sorenson et al., 2011), and in Tanzania among other countries, improved access to water has been shown to increase school attendance by up to 15 % (UNICEF, 2006).

5.1.3 Disparities related to access to water

A recurring theme that emerged from the analysis of the data relates to a shared concern among the participants towards the most marginalized in their community. In addition to women and girls being disproportionally affected by water collection, disparities related to access to drinking water between urban and rural residents of the NCA, and between those with high- and low SES[21] were identified.

[21] Up to this date, no validated measure of SES among Maasai pastoralists exists, but livestock ownership is proposed to serve as a proxy measure for SES in the NCA context (Hetherington et al., 2017).

5.1.3.1 Based on residency

A higher burden of water-related issues was identified with the more rural population due to longer walks to collect water. Because the water pipes supported by the World Bank reaches only 16 kilometers in radius[22], a large proportion of the Endulen population is left without piped water and depending on drinking water sources that are few and far between. In the more urban areas of Endulen, in the area around *Madukani* (town), a smaller proportion of people have access to piped water, and for this reason water scarcity is likely not as big of a concern to the more urban population compared to the rural population.

> *Water scarcity is not a problem especially in Endulen community that which is close to the town but if you go beyond that, is a problem…but for even Endulen now where scarcity is not a problem the quality is an issue. But for the peripherals both like availability and the quality is an issue (Employee, Water Committee).*

In summary, those participants who identified the amount of water as their biggest concern were mostly community members living in rural parts of Endulen, while more urban members of the community identified safe water as their main challenge, implying that water scarcity is a greater challenge to the marginalized rural population than the more urban population.

5.1.3.2 Based on socioeconomic status (SES)

Often in coherence with where people reside, the access to drinking water was identified as being related to a person's SES and with the main concern revolving around how only a few people can afford to buy water. People who cannot afford to buy water are also usually those who collects water from drinking water sources that are located far away from their home, and a car or donkey to help carry the heavy loads is another privilege out of their reach.

One example of a water-related service that is accessible only to those who can afford it is a water truck belonging to a manager of the pastoralist council [PC]. The truck is filled with water at the NCAA headquarters or from the river, and then brought to the homes of those who can pay.

> *He's a PC manager, and then that is his own truck. And then he can just take the water to his boma by using his car, and then he can just make a business, just take water to cultural bomas and then sell to them…but it is not limit, if you, anybody who want, and then you can just pay and then they can just bring you (male participant, traditional leaders interview).*

The cultural bomas are traditional Maasai bomas made for tourists to experience the Maasai way of living (Galvin et al., 2008). The cultural bomas are used as an initiative to help the poorest people in the community, by letting them stay there and engage in business-related activities with the tourists.

[22] The exact words of the participant were "total pipe distance", but it is assumed that he meant a *radius* of 16 kilometers.

However, especially during the dry season and because the water pump that was once there is broken, the people living in the cultural bomas are left without access to water resulting in all their income spent on buying water from the NCAA or cars like the water truck mentioned above.

> *…and then those cultural bomas we put there for the purpose of poverty people to go to stay there and make business with the tourist, but for them they have really difficult life there because they don't get water especially during the dry season. So during the dry season they depend water from, they buy, water from NCAA or they just pay any car to bring them water, so instead of finding money there they using money for the other use. But if they could have water there, then they can just get good money for they kid to school or whatever (male participant, traditional leaders interview).*

The cultural bomas, and the tourism industry in general, are known from other literature as having little benefit in terms of profit for the local residents in the NCA, and the pastoralist council only receives 10 % of the earnings (Charnley, 2005, cited in Galvin et al., 2008). The tourism industry, in form of hotels and safari lodges, are also competing over the same drinking water sources as the Maasai (Galvin et al., 2008), and because they can pay they succeed in receiving enough water for their tourists.

> *…lodges are getting water, and the Maasai are not getting water. Because the Maasai know that people from lodges are going to buy their water and then bring to their lodges, the Maasai are not thinking about quarrelling with them (male participant, traditional leaders interview).*

Although the Maasai are aware of the situation of safari lodges accessing water in an area of water scarcity, the participants showed no hard feelings towards this, which was explained by the traditional leaders to be related to a general perception of water as a source that is more readily available to those who can pay.

5.1.4 Knowledge related to water quality

With respect to water - and water quality in particular - the general level of knowledge in Endulen seems to vary widely, ranging from what the participant described as "lack of education" in the community, which was interpreted as a lack of knowledge regarding water quality and transmission of water-borne disease, to a broader, more comprehensive understanding of water as an issue largely affecting both human and animal health expressed by the participants themselves.

> *…when you talk about health-related issues, it's all about water (female participant, various community members think tank*).

5.1.4.1 Overall knowledge level in the community

The majority of the participants seemed to have a general awareness of water quality as a potential threat to health and an issue in the NCA.

There's a big challenge of water in the NCA. For example, we do have river where there is water here but it is not good for human use (male participant, traditional leaders interview).

Several water-borne diseases and methods to treat water were identified by the participants. Typhoid, skin- and eye diseases and diarrhea were among the identified diseases believed to be caused by consumption or hygiene use of untreated water, and many of the common sources for drinking water, especially the river, was perceived as potential sources for illness and were often believed to be caused by 'small and bigger bacteria in the water' (male participant, rural BSF group discussion). Boiling, cloth filtration, sedimentation and use of WaterGuard (locally available chlorination) were among the identified strategies. The relationship between contaminated water and water-borne diseases seemed familiar to many of the participants, however boiling was perceived by most participants as not common. There are several potential reasons why the Maasai people do not boil their water, including the need for large amounts of firewood, the NCA restriction on chopping wood, and because it changes the taste of the water. Formative research conducted as part of Project SHINE also suggest few people in the NCA boil their water, while cloth filtration generally is performed only when the water is turbid (Henderson et al., 2015).

While expressing a general awareness of water quality and transmission of water-borne disease, the participants however repeatedly raised concerns about the overall knowledge levels in the community. In the group discussion including urban households selected to receive a filter, one woman described how only a few people in the community have the knowledge of how to keep their water safe.

These are the few people who know. But if you go to interview the Maasai (in their) bomas they don't know something like that. Just take water, drink. Without thinking about this (female participant, urban BSF group discussion).

In the group discussion with rural households selected to receive a filter, it became clear that one of the respondents perceived his drinking water as clean enough for consumption, and after two of the other respondents had expressed their concerns about bacteria in the water leading to diseases such as typhoid his comment was this:

The bigger problem is enough water not the quality because we, near there we find the source of water where we can find the clean water (BSF pilot evaluation participant, rural household).

The above statement indicates that this participant perceives his water as safe, even though the participants had just discussed the presence of bacteria in the water. Other than the mentioning of 'bacteria', viruses, and other microorganisms were also not directly expressed by any of the participants, and as further elaborated on in the next section, *visible* microorganisms in the water was

described as the most common perception of dirty water in the community, implying that an understanding of low turbid water as safe water is common in the community.

5.1.4.2 Water with low turbidity perceived as safe water

The main concern around community knowledge of water quality and transmission of water-borne disease is related to what people view as safe water. More specifically, participants often pointed to how many people in the community have the perception of *clear* water as being equivalent to *safe* water.

> *For example, people are taking water from the river down there. And then others take from the tap and then, because it looks clean, or clear, then they can just say it´s safe water (BSF pilot evaluation participant, urban household).*

A more detailed view on community perceptions of water with low turbidity being equivalent with safe water was illustrated in another interview where the participant explained that only water with a high turbidity, for instance such as water from flowing rivers or dams, are viewed as not clean in addition to water where moving microorganisms are possible to spot. Other than this, water is considered safe.

> *So, one of the perceptions from the community, people that have been using water from rivers, flowing river, from dams right, so and it has a very high turbidity, it has a lot of microbes sometimes then we can see them by naked eyes, so for them when it comes now to water quality, so safe and clean water for them (is) if it lacks, it's not turbid…but also if they don't see also like moving microbes, or moving maybe worms or something which they can see by naked eye, they see that there is nothing moving like creatures moving, that one is safe (Employee, Water Committee).*

Interestingly, when asked about his personal view on safe water, the same participant explained how he, even though he is aware of the risks associated with untreated water, still in practice has a view of clear water as safe water.

> *He understands that for him, like you mentioned earlier, the water is clear. And no movement of living organisms, that water is clean and safe. However, from the media like radio, television they have been hearing that in order for the water to be safe it must be treated. So, that kind of perceptions is coming up. However, for them, it's hundred % that (if the) water is clear and it lacks moving living things, it should be safe (Employee, World Committee).*

Another interesting issue to highlight in his statement relates to how perceptions regarding water quality are emerging in the community and being shaped and influenced due to information spread through media. This can be interpreted as a potential positive change in awareness around drinking water and its significance to health, at least in parts of the community where assets like radio and

television are common[23]. However, media campaigns are seemingly not enough to change the general perception in the community of low turbidity water as equivalent to safe water.

5.1.5 Shared water sources with animals

Situated within a One Health paradigm, where the broader ecosystem and animal and human connections are understood as deeply interrelated (Rock et al., 2009), water is perceived by the Maasai as being synonymous with life itself.

> *We understand that humans are need of so many things, however water, water is life. Water is life for the animals, water is life for the human being. So, you can have everything but if you don't have water, then there's no life (Employee, Water Committee).*

Related to shared water sources with animals, the amount of water available was perceived as a huge challenge to the coexistence of human and animals within the NCA. Additionally, although education was perceived as highly needed in the community at large, the participants – who themselves as previously mentioned were generally well aware of water quality and the transmission of water-borne disease - repeatedly brought up the challenge of sharing water sources with animals as the leading cause for water-borne disease.

5.1.5.1 Insufficient amounts of water to meet the needs of both humans and animals

The lack of sufficient amounts of water to provide the needs of both humans, livestock and wild animals was a repeated concern across the data set. The human population in the NCA has largely increased between the 1960's and now (Galvin et al., 2008), and so has the wildlife population. The increase in human-, livestock- and wild animal populations was described as one of the main reasons to the insufficient amounts of water in the area, in addition to changes in climate.

> *…people nowadays they have a lot of cattle and the population of people is high also that's why…and then high population with animals like elephant they share the same water that's why nowadays there's not enough (male participants, traditional leaders interview).*

With water sources that are scarce, another issue that was brought up was the conflicting interests of Maasai pastoralists and their livestock, and wildlife conservation given the fact that the NCA is a UNESCO World Heritage Site that is a substantial source of revenue for Tanzania through tourism. With parts of the NCA being controlled from human use to prevent harm on the wildlife population, the Maasai are denied access to much needed water sources.

> *…they can just get enough water when they dig there from the ground…but people are not allowed to get their cattle there. Because it is a sensitive place for the wild animal they used to*

[23] In the NCA context, battery operated radios are relatively common, while only a minority of people have TV's as a household asset.

stay there during the dry season, so if the Maasai moved to that area then the wild animals can just go away (male participant, traditional leaders interview).

As already discussed in relation to the perceived changes in climate in the NCA, the Maasai being forced even closer together with their livestock in terms of shared water sources may have implications on zoonotic disease transmission.

5.1.5.2 Shared water sources with animals as the leading cause of water-borne disease

In most cases where water quality was discussed, sharing water sources with animals were perceived as being a potential threat to human health, as illustrated by one of many similar responses to water-related challenges in the NCA.

The other challenge is that because they have the same rivers with the cattle, the cattle drink at the same time people they go fetch water there so they may find sick when they drink that water and like they get amoeba (unidentified participant, rural BSF group discussion).

In addition to cattle and livestock, wild animals are another concern for the Maasai, with one possible scenario being wild animals dying close to drinking water sources.

…even though they dug those well it is not safe water or good water for human use because wild animal can just die there and cattle share with the people so it will be not really good water for the human health (male participant, traditional leaders interview).

As pastoralists, the Maasai are however accustomed to living in close proximity to livestock and wild animals, and the participants identified a number of common practices to manage human, livestock and wild animal use of water sources. As an example, several respondents explained how the river is separated into places for fetching drinking water and places for washing clothes. Further, there are designated areas where people can let their livestock drink water. In some places, a guard is present to help control the various uses of the river, and a scarecrow is sometimes used to scare the wild animals away. The most common strategy to keep both livestock and wild animals away from the water is by building a fence around the water source.

…at the source of the river they can just make a fence…and then they can say from here, people can just take water for drink here. And then for washing clothes from here to here, you are allowed to wash your clothes here. And then cattle are allowed to drink water from here, or not (male participant, traditional leaders interview).

One respondent also explained how people risk a payment fee of 50,000 Tanzanian shillings (TZS), equivalent to 200 Norske kroner (NOK), if the rules are broken.

…if they find someone washing places, the place for fetching for coming home, they give him a punishment, and then they have to pay money (female participant, women's group think tank).

Although building fences was explained as a commonly used strategy to keep animals away from drinking water sources, the strategy was subject to concerns. Wild animals such as elephants and buffalos are not likely to be deterred by fences, and monkeys and baboons who can climb trees (and fences) was another concern.

5.1.6 Management of water-related issues

In 1959, the Maasai lost their rights to access all permanent water sources in the Serengeti National Park (Galvin et al., 2008), with a promise from the Tanzanian government of new water supplies that would replace the old. However, numbers from 1998 showed that out of 29 water systems that were made to compensate the Maasai for their loss, only two of the systems were operative and available for the Maasai population (Galvin et al., 2008). In the interview with the traditional leaders, the participants animatedly explained how the NCAA have failed to deliver their promise to the Maasai of bringing water from the protected areas to another area where there would be no conflicting interests with wildlife conservation.

> *During that time the communities tried to sit with the NCAA, because of that area, then the NCAA promised them that they can just go and sit and make a budget to bring water from that area to the area where there is no wild animal where they can just allow people to stay there and get the water for their own use and their own animal, but up to today nothing is done (male participant, traditional leaders interview).*

This excerpt illustrates perceived shortcomings concerning management and leadership related to water in the NCA, and introduces a potentially existing conflict between main actors engaged in water-related issues in the NCA and the members of the local community.

5.1.6.1 Perceived shortcomings concerning management and leadership

Although water issues were expressed as having a high priority in the community - with special emphasis on future plans to assure equality in access of water – participants identified several issues that can be interpreted as perceptions of shortcomings concerning management and leadership related to water in the NCA. Main actors and other stakeholders not working efficiently together was one of the main issues brought up as potential reasons to why projects are not successfully achieving their intended goals.

> *It seems like these people are not working together…an example is the World Bank, World Bank Water. The government supported for give the community water, but they dug the water from near to the hospital but it is like useless, people are not really benefit with that water just a few people are getting (male participant, traditional leaders interview).*

Another issue brought up was the perception that instead of putting collective effort into one large and effective project, many small and reportedly inefficient projects are present in the community. Instead of spending time constantly drilling new wells in multiple locations, working together on one

main source with pipes for supplying different areas with water was proposed as a better solution than already existing solutions. One participant indicated an especially strong opinion on the issue:

> *…it is a kind of game which people is just playing with money but are not supporting people because all that work they could just put in one site (male participant, traditional leader interview).*

In addition to poor collaboration and executive decisions that fail to engage all stakeholders in the community, both poor quality of the actual work being done and the quality of the materials used were identified as concerns related to the efficiency of water projects in the area. The pipes provided by the World Bank that are supposed to lead water from a pump to the Endulen community tend to burst and frequently leak, reportedly because of poor quality of the plastic used in the pipes.

> *…so the construction however they had the big challenge that the water pipes from the pump to the community, they tend to burst every now and then, probably they suspect maybe the quality of the PVC pipes…because like they just explode, and then water now is in the environment…(Employee, Water Committee).*

5.1.6.2 Strained relationship between main actors and the local community

Perceptions of a strained relationship between main actors concerning water-related issues and other members of the community also emerged as a sub-theme through the analysis. In one of the think tanks, a female participant pointed out an imbalance in power between executives managing the projects and members in the community.

> *…so the project is managed by the executives, so if they fail, who are we to question them? (female respondent, various community members think tank).*

The participant went on to explain how a World Bank project was supposed to provide her village with a supply of water, but because of poor management the village ended up with no supply of water and the members of the community lost their chances to be involved in the project. After this, the village seemed to develop a lack of trust in the project.

> *Now, that they are doing the handling of the project, this part of the village didn't want to accept the project, because it´s not the way we are told on the beginning (female respondent, various community members think tank).*

Another perception which points to a strained relationship between actors and community members was portrayed by the employee for the Water Committee in Endulen when he explained how project managers sometimes face challenges of people intentionally spearing pipes and later showing resistance to pay for the damage.

> *…and people when they are grassing the animals and they see oh this is the water pipe and they will just spear it and then, the next village will not get water because someone intentionally*

speared the pipe and then it become broken… and if they track and find out who did that then the person refuse to pay and say oh well that one is funded by the NCAA so it's not your money so why are you asking me? (Employee, Water Committee).

However, it is worth mentioning how the employee of the Water Committee also identified conflicts as *"a normal thing in any community project, and not really a conflict in the setting here".* While some members of the community indicated a power imbalance between project managers and other community members, contrasting views were also found. This was illustrated by the employee of the Water Committee after he had explained how the World Bank wanted people in the community to contribute with 50 TZS (less than 1NOK) per household as an effort to ensure future sustainability of their projects in case the NCAA decides to stop the support of diesel to their pumps.

And now the conflict is that people are not ready to pay that, they say well this is supported by the NCAA, so why do we contribute for that? So, so that's kind of an antagonistic relationship how they use us and the managers (Employee, Water Committee).

In summary, this section has presented the identified themes and sub-themes related to community perspectives and concerns around water scarcity and water quality in the NCA. The perceptions and concerns that emerged through the analysis of the data largely concurs with previous knowledge of the NCA as a remote and resource constrained setting posing huge challenges for the Maasai population. It highlights major concerns especially related to water scarcity in the area, while also demonstrating how the Maasai perceive their coexistence with animals as a potential threat to human health, in terms of a general awareness of the linkage between shared water with animals and contaminated water leading to disease.

5.2 Perceived acceptability and feasibility of the Biosand Filter technology

In this section, the identified themes related to perceived acceptability and feasibility of the BSF technology are presented. The findings are presented as key factors associated with the contextual, technological and psychosocial dimensions of the IBM-WASH framework. Table 9, 10 and 11 provide an overview of the identified themes and sub-themes consistent with the IBM-WASH framework. The three dimensions and their associated levels are inextricably linked to each other, meaning the factors are indeed naturally overlapping and it could be argued that the themes and sub-themes may be classified in more than one dimension and level.

It is important to note that the majority of the participants had no awareness or knowledge of the BSF prior to the interviews and group discussions, and only two participants recalled having seen or heard about the BSF (when visiting districts outside of the NCA). Given that the participants had no prior knowledge of the filter and how it works, the findings presented must be considered as preliminary

and also reflects the rationale for adopting definitions of acceptability and feasibility (presented in chapter 3) to ensure they were appropriate for pre-implementation assessment.

5.2.1 Contextual factors

The contextual dimension of the IBM-WASH framework focuses on background characteristics and determinants related to the environment, setting and/or individual thought to influence behavior change and adoption of new technologies (Dreibelbis et al., 2013b). Table 9 gives an overview of the identified themes and sub-themes in the contextual dimension which are presented next.

Table 7. Identified themes and sub-themes consistent with the contextual dimension of the IBM-WASH.

Level	**Contextual factors**	
	Themes	**Sub-themes**
Societal/ structural	Climate and geography	*Feasibility* • Water scarcity • Water source availability • Long distances between households
Interpersonal/ household	Gender roles and responsibilities	*Acceptability/feasibility* • Women responsible for use and maintenance of the BSF
Individual	Socioeconomic factors	*Acceptability* • Poverty

5.2.1.1 Contextual dimension at the societal/structural level

At the societal/structural level - which refers to the broad organizational, instructional and cultural factors that influence behaviors (Dreibelbis et al., 2013b) – three factors related to the climate and geography in the NCA were identified as potential barriers to BSF feasibility. As highlighted previously, water is a limited resource in the NCA (Galvin et al., 2008), and as already illustrated in the previous sub-chapter, water scarcity was found to be a major concern expressed by participants in this study. Water scarcity is related to feasibility of the BSF as an option to treat water in the NCA because maintenance of the filter requires a minimum of 12 L of water to be run through the system every day; going more than two days without pouring water through the filter will deprive the biological layer of oxygen and nutrients and the layer will eventually dry out and die (CAWST, 2012).

Closely linked to water scarcity are differences in water source availability, both between rainy and dry season and within seasons. During the dry season, households are likely to collect water from any source available at the time. As these sources may be under high pressure from large numbers of both local households, pastoralists traveling from afar, livestock, and wildlife, the chances of contamination is likely to be very high. In the rainy season, households often alternate between various drinking water sources, making them more able to manage sources for different purposes such as washing,

drinking and water for livestock. In several interviews, the use of multiple water sources was identified, especially during the rainy season or during times when the pipes supplied by the World Bank are leaking.

> *So, there are two opportunities during the rainy season, they can just collect from the roof, the rain water and then they can just take from the tap water (female participant, urban BSF group discussion, post-workshop).*

> *…community can be lacking water for week, or two weeks, or three weeks before it is fixed. That means you are supplying clean water for today and then there is a couple of days without water…but if it's raining there is different source of water after all they are being use different source of water when there is no piped water by that time (Employee, Water Committee).*

Given that feeding the BSF with water from more than one source is not recommended (CAWST, 2012) the practice of using multiple water sources due to contextual factors such as water scarcity and water source availability is likely to act as a barrier to proper maintenance of the filter and therefore potentially affecting feasibility of the BSF. Alternating water sources between seasons is feasible as long as the filtered water is disinfected for a few days after (CAWST, 2012), however, frequently switching between sources will affect the efficacy of the filter in removing pathogens and is therefore not recommended.

Another contextual factor that was identified related to climate and geography that may potentially affect feasibility of the BSF is the size of the NCA and its unfavorable geography for widespread community knowledge. The long distances between households was identified as challenging both related to logistics and the effort of spreading the knowledge of the technology far and wide. One participant described how a vast area such as the NCA is unfavorable to small-scale implementation because people need to be exposed to the technology for it to become well known.

> *Out of these members, if they are not part of the 15 [BSF pilot households], where are they going to learn? Because this one here is a very big area…if they don´t see it, they might not, it won´t like stick into their mind (male participant, various community members think tank).*

5.2.1.2 Contextual dimension at the interpersonal/household level

At the interpersonal/household level, factors related to interactions between individuals and the people they associate with (household members, friends, neighbors) are represented (Dreibelbis et al., 2013b).

At the interpersonal/household level, gender roles and responsibilities were found to be important in determining expected use and maintenance of the BSF. As explained in greater detail in the previous sub-chapter, women and girls were identified as being responsible for water-related issues in the home. Women were also identified as the ones primarily responsible for treating water and therefore

also use and maintenance of the BSF. Men however were identified as more likely to be in charge of initially constructing the filter, and were also identified as being the decision-makers in the household.

> *…collect the water is a work of women, so she has to know that; I´m told about this, then I have to do this in my house. My husband can just come and enjoy the safe water, which is already prepared by me (female participant, urban BSF group discussion).*

The identification of women as more likely than men to be in contact with water for household chores and primarily responsible for maintenance of WASH technologies is among others consistent with a study assessing acceptability and feasibility of various handwashing stations in rural Bangladesh, reporting women as primarily responsible for maintenance of handwashing stations (Hulland et al., 2013).

5.2.1.3 Contextual dimension on the individual level

At the individual level – which refers to sociodemographic factors (Dreibelbis et al., 2013b) – poverty was found to potentially affect acceptability of the BSF. In the rural BSF group discussion, one of the participants explained how lack of money is a major concern.

> *As we are Maasai in the Ngorongoro we are living in a hard life because we don't have enough money to make water clean so they ask help, to help us people that become sick like children because of that water, so they still ask help from you because they don't want to drink that water but due to lack of money, enough money, they have to drink (unidentified participant, rural BSF group discussion).*

In East-Africa, pastoralists are considered to be amongst the poorest of populations (Little, Smith, Cellarius, Coppock, & Barrett, 2001), and in Tanzania, rural poverty is associated with lack of land and livestock ownership (Ellis & Mdoe, 2003). Livestock numbers in the NCA are typically small, and livestock mortality rates are found to be proportionally higher the smaller the herd size, meaning the Maasai are caught in a vicious circle suffering from the high mortality rates among their already small livestock herd (Galvin et al., 2008).

In this study, we estimated the total cost of a BSF (including safe storage container) within the NCA context to be approximately 120,000 TZS (480 NOK). This price was identified through the interviews and group discussions to be equivalent to the price of a cow or a large goat in the NCA context, and for the most marginalized people in the community livestock ownership was identified as very low, meaning poverty in some cases can act as an absolute barrier for households in the community to afford a BSF without outside funding.

> *There are individuals in these communities who are really, really, extremely poor. So someone maybe own only one cow or one goat, so those kind of families it will be very very difficult…for the technology which actually cost more then what they have (Employee, Water Committee).*

Although poverty was found as a potential barrier to the implementation of the BSF, various views on cost of the filter were identified and is presented later under the psychosocial dimension.

5.2.2 Technological factors

Moving from the contextual dimension, the technology dimension of the IBM-WASH framework which addresses the specific attributes of a technology that influence its adoption and sustained use (Dreibelbis et al., 2013b) are presented next. Table 10 gives an overview of the identified themes and sub-themes in the technology dimension.

Table 8. Identified themes and sub-themes consistent with the technology dimension of the IBM-WASH framework.

Level	**Technological factors**	
	Themes	**Sub-themes**
Community	Access to materials (hardware)	*Feasibility* • Availability of tanks, sand and gravel • Inter-ward tensions • Getting materials into the NCA
Individual	Initial reactions to the introduction of the filter Expected strengths and weaknesses of the technology	*Acceptability and feasibility* • Reactions on filter appearance • Context friendly materials • Filter size and weight • Safe water storage container
Habitual	Expected ease of installation, maintenance and use of the filter	*Acceptability* • Education and training needed • Continued support from local technicians and CHPs needed

5.2.2.1 Technology dimension at the community level

The community level of the IBM-WASH framework refers to formal and informal institutions that shape individual experiences, in addition to the physical and social environment in which individuals reside (Dreibelbis et al., 2013b).

At the community level, the three most significant technology factors related to the access to materials potentially affecting feasibility of the BSF was the availability of tanks, sand and gravel, and the challenge of getting materials into the NCA. The Aqua Clara representative explained how the required type of sand was a challenge because it is not readily found in Endulen.

> *One of the challenges I see is getting the sand. It's a big problem because we don't have a specific place where we can say that the sand we need can be found there (Aqua Clara representative).*

With the appropriate sand and gravel not being easily available all through Endulen (the sand and gravel were only found in specific places), multiple potential barriers arise. One challenge was raised by a participant who linked the lack of closely available sand with challenges related to money.

> *You have to go far away a little bit to get sand. And then it cannot come alone here. You have to pay the car which can just go and bring the sand here. Also, the people who can just collect the sand. They have to be paid (female participant, urban BSF group discussion).*

Aside from the limited availability and proximity of the required sand and gravel and the potential extra cost it may bring, the project ran into political challenges (inter-ward tensions) when collecting sand and gravel in other communities than Endulen and Nainokanoka where the project was based. Negotiations with neighboring wards proved challenging as getting approval from all the involved parts were difficult. Village chairmen would question permits given by the water council, and questions were raised about how people in the communities where the sand and gravel was located would benefit from giving away resources to other communities. This challenge was eventually solved by having people from the local communities helping with the collection of sand and gravel, so that the payment would end up benefitting the respective communities.

In addition to challenges related to sand and gravel, tanks for the BSF had to be purchased in Arusha or Karatu, which are located outside of the NCA (approximately 200km and 63km in distance), which adds to the logistical challenge of obtaining the required materials. A permit is also technically needed to get materials through the NCA gate: "*She said you have to ask the permit" (female participant, urban BSF group discussion).* However, as explained by a participant at the policy think tank, the potential barrier of getting materials into the NCA is not necessarily an issue. As long as the NCAA is informed about the project, and a collaboration with them is established, getting a permit to bring materials through the NCA gate was perceived as feasible.

> *When the project is now known within NCAA, then it is easier to bring the materials from outside, because we draft the letter from the village office. Then they just write and tell everything there, they go and show there the main gate, that we are going to collect the materials for this. I mean, then there will be no question for that (male participant, policy think tank).*

Although a permit was identified by some participants as a potential barrier for getting materials into the NCA, the project did not experience that a permit was necessary to bring the materials for the BSFs through the NCA gate, which implies a potential barrier of getting materials into the NCA may not be as challenging as the participants anticipated.

5.2.2.2 Technology dimension at the individual level

In all interviews and group discussions, the initial reactions from the participants when introduced to the BSF (they were shown a picture of the filter and received a short explanation of the practical

functions of the technology) were positive (i.e. participants smiling, nodding, showing appreciation towards the filter etc.) and the BSF appearance was therefore identified as a potential facilitator to acceptability of the filter. Throughout the conversations and discussions several other potential facilitators and barriers were found to operate in the technology dimension at the individual level, all related to anticipated strengths and weaknesses of the BSF technology.

A water treatment option that requires materials which are not "destroying the land" (interpreted as compared to boiling of water which requires firewood), was identified as appreciated and a favorable property about the BSF.

> *I don't see any problem because the material which are going to be used are not going to destroy the land, I mean, making the land look bad so we can just, people can just collect gravels and the sand without destroy anything (female participant, urban BSF group discussion, post-workshop).*

The use of chlorine as a treatment option was perceived as unfavorable, and the BSF was perceived as a more attractive option fitting the NCA context likely due to the treatment process being chemical free. From previous Project SHINE data, it is known that people in Endulen are worried about getting the quantity of chlorine wrong and possible killing someone, and concerns about the taste of the water after chlorination have been brought up. Concerns regarding the taste and odor of chlorinated water is commonly reported in many studies looking into perceptions of chlorination as a HWT option, for instance in a study from Kenya where taste of the water was reported as an important behavioral barrier to use of Klorin (a chlorine disinfectant solution) (Freeman, Quick, Abbott, Ogutu, & Rheingans, 2009), and in a study from rural Madagascar where the taste of chlorinated water was reported as a potential barrier to sustained use of the Sûr'Eau water disinfectant (a diluted chlorine solution) (Ram et al., 2007).

> *He was worried when we started the meeting that maybe you were going to use some chlorine or something like that to treat the water. But he realized that just natural things are going to be used, then he say, oh, no problem (male participant, policy think tank).*

The appreciation of materials that are context friendly is likely related to the Maasai being used to live in harmony with their environment, in addition to the many rules and restrictions related to deforestation, cultivation and agriculture protecting the area (Galvin et al., 2008). By using context friendly materials (here interpreted as avoiding firewood and being chemical-free) the Maasai avoids potentially conflicting interests with other land uses in the NCA, and can treat their water without causing harm to their surrounding environment.

Another technological factor that was found challenging during the workshops and installation of the

30 pilot filters was the size of the filter in relation to the dimensions of the Maasai bomas. The size of the container used in this study was 100 L, however any size between 70-100 L containers are common. The representative from Aqua Clara explained how the 100 L containers were hard to fit or cramped inside some bomas.

> *Another challenge is that their structures, some of those boma structures at times if you put a filter inside it's not even fitting or there's a lot of things around it (Aqua Clara representative).*

Although some challenges were found with fitting the filter inside the bomas, when the issue was raised in other interviews and group discussions, most participants expressed that they thought the size of the filter was possible to fit within most bomas, and the *size* of the filter is therefore not likely to affect community acceptability of the BSF. On the other hand, a BSF when fully assembled is heavy, and the *weight* of the filter was identified as a concern potentially affecting feasibility and acceptability because parts of the Maasai population are semi-nomadic and often shift bomas in the dry season when there is no grass to graze the cattle (Galvin et al., 2008). The filter was perceived as too heavy to move around and likely to stay within the permanent bomas, posing a major challenge when people are in transition between primary and temporary bomas. Adding to this concern is the fact that once installed, the BSF should not be moved at all, as moving the filter will disturb the biological layer and sand and gravel may block the outlet tube, meaning the filter would no longer function properly and the filter would have to be reinstalled (CAWST, 2012). Recall that reinstallation of the filter would require another 30 days waiting period before the filter is ready to use.

> *…if they move, how, what will they do with it? Will they take everything out first, and then to carrying, and then to go and start again? He is worried about that for the other people who is leaving. So that's why he just from the beginning had an idea about the small, which is taking like forty liters (male participant, policy think tank).*

This statement clearly illustrates the challenge for those leaving the primary bomas for longer periods of time, as advantages of safe water in the home provides no protection against water-borne pathogens at times spent away from the boma. Another potential barrier related to the Maasai being in transition between primary and temporary bomas is the fact that the BSF needs a daily flow of water through the system. However, as one participant pointed out, women, children and educated people usually stay behind while men are out taking the livestock to pasture, and maintenance of the filter was according to her not a problem.

> *She said that, only cattle, goats and men are the one that move. But women and children remain behind. And educated people they are not moving. They take only, there are some people that take their cattle, but they remain behind, so that will not be a problem (female participant, women's group think tank).*

Although women and children were described by some participants as likely to stay behind in the primary bomas while men and boys are out grazing the cattle, this might not always be the case. One example that came up through discussion was the children's need for milk. When all livestock are moved to temporary bomas for longer periods of time, women and small children will follow when the child depends on milk for nutrition. In situations where the primary boma is left by all members of the household, no one is present to maintain the filter. The weight of the filter, as well as its requirement of daily maintenance, is therefore a potential barrier to feasibility and acceptability of the BSF. The need for two filters per household was brought up, with the requirement of a second filter substantially smaller and lighter than the 100 L version of the BSF.

Besides being problematic in relation to the use of primary and temporary bomas, the heavy weight of the filter also creates logistical challenges related to the installation of the filter. As explained by the Aqua Clara representative - who trained the local technicians and community health promoters (CHP) and assisted the implementation of the filters in the 30 BSF pilot evaluation households – together with long distances and rugged terrain, the weight of the filter implies that a vehicle is needed.

> *One of the challenges is the transport. Those materials are very heavy actually so one packet you cannot even carry one packet and we are using five and a half packet and there's ballast and the container so the materials are heavy so somebody must use a vehicle that's one of the challenges (Aqua Clara representative).*

As no vehicle is available to the project outside field school, follow-ups and further installations of more filters are faced with a large logistical challenge of transporting the sand and gravel for the filters and implement the heavy filters in bomas that are spread far and wide.

Moving on from the size and weight of the filter, the last identified technological factor at the individual level potentially affecting acceptability was related to the design of the filter and the presence of a separate safe water storage container storing the water after filtration. A design with a separate container storing the water was perceived by the employee of the water committee in Endulen as unfavorable compared to a filter design where the main container also acts as a reservoir itself.

> *They are motivated to have less containers of one big container for filtration as a reservoir. If it's only a system of passing through water, so you put water and it doesn't stay there, as long as you put water you need to catch it, and keep in another container, that way might be not seen as a usable source (Employee, Water Committee).*

The reason why a second container may act as a barrier to BSF acceptability may be related to the size of the bomas as already mentioned earlier, but is also likely due to the perception of an increased cost of a water treatment design with two separate containers.

> *…really like excited to see it happen, and then provided if it acts as a storage because otherwise it will be very expensive to have two containers at home (Employee, Water Committee).*

The second storage container was further perceived by the employee of the water committee as increasing the chances of recontamination of the water, which again was linked to contextual factors such as the lack of defecation places and psychosocial factors such as poor hygiene habits.

> *…because, now if again the water is going into a second container, which probably is not clean, you are contaminating the same water. And then you are coming up with something and then you dip into this particular device maybe was there a kid playing with it, there are fecal matter because lack of defecation places and then you bring that [when] you come and again fetch water. So that will be no point of doing the filtration (Employee, Water Committee).*

The identification of potential recontamination of stored water is important. As an example, in a study from Nicaragua evaluating the use and performance of the BSF, high rates of water recontamination in the storage containers were found, decreasing the overall median bacterial removal efficacy of the filter from 80% to 48% (Fiore, Minnings, & Fiore, 2010). However, the second container which the employee of the water committee is referring to is a safe water storage container[24], which in theory should work as a protection against recontamination. All HWTS methods are to some extent susceptible to recontamination of treated water (World Bank, 2007), and proper hygiene behaviors and handling of the safe storage container (i.e. keeping the lid on to avoid animals and insects to enter the water, properly cleaning of the container, avoiding dirty hands and devices touching the water, etc.) will therefore always be essential to avoid recontamination.

5.2.2.3 Technology dimension at the habitual level

The habitual level is ingrained within the individual and refers to the multiple processes or events that are necessary for the WASH-related behavior to be repeated over the course of the day (Dreibelbis et al., 2013b).

At the habitual level, technological factors related to the expected ease of installation, maintenance and use of the filter were identified. The need for education related to safe water and BSF use and

[24] Six months after the BSF pilot evaluation was initiated (November 2016), a total number of 110 households in Endulen and Nainokanoka (this number includes the 30 pilot evaluation households) received a BSF together with a safe water storage container.

maintenance was acknowledged by the Aqua Clara representative, and was confirmed by one of the urban BSF pilot evaluation participants.

> *…the Maasai community need to be educated, to get the education in a, not in a fast just slowly, slowly, to understand. Then if they will understand you then they will just receive easily (female participant, urban BSF group discussion).*

This perception highlights how the installation, maintenance and use of the BSF are perceived as a challenge and potential barrier for people in the community, and reflects the need for sufficient education before the BSF can be viewed as an acceptable treatment that the community can repeatedly and confidently practice. Building on the need for education, the Aqua Clara representative further illustrated the need for continued support by locally trained technicians and CHPs.

> *…that's why we recommend that we have to have some people who can be following up like a CHP who can know, who can [recording not clear] training now and then so that they can know exactly what they are supposed to do (Aqua Clara representative).*

Local technicians and CHPs who are adequately trained and who are confident in educating other community members can therefore serve as a potential facilitator to BSF acceptability, as it may even out the barriers related to perceived challenges related to installation, maintenance and use of the BSF.

> *…if people are trained, oriented, educated on how to use this system, it can be of vital use in the future (Employee, Water Committee).*

The identification of the need for substantial community education and support on proper use of the technology is yet another crucial point that is also recognized and repeatedly brought up in the broader literature. In the comprehensive evaluation of the Samaritan's Purse BSF projects, a direct relationship between user education and BSF performance (meaning that community members with a higher general education also maintained their BSF to a larger degree) was found (Kaiser, Liang, Maertens, & Snyder, 2002). Samaritan's Purse reports that *"the BSF must be complemented with an intensive and extensive education program"* (Kaiser et al., 2002, p. 55), and a greater emphasis on culturally appropriate and country specific education on the relationship between water quality and transmission of water-borne disease and BSF use and maintenance is recommended.

5.2.3 Psychosocial factors

The psychosocial dimension of the IBM-WASH framework consists of behavioral, social, and psychological determinants that affect behavioral outcomes and technology adoption (Dreibelbis et al., 2013b). Table 11 gives an overview of the themes and sub-themes identified in the psychosocial dimension presented next.

Table 9. Identified themes and sub-themes consistent with the psychosocial dimension of the IBM-WASH framework.

Level	**Psychosocial factors**	
	Themes	**Sub-themes**
Societal/Structural	Pastoralism	*Acceptability* • Daily tasks and priorities
Community	Social and cultural norms	*Feasibility* • Culture of per diems
Individual	Knowledge and perceived threat of disease Perceptions on filter cost Sense of commitment	*Acceptability* • Existing knowledge on water quality and transmission of water-borne disease • BSF perceived as expensive vs inexpensive • 'BSF champions'
Habitual	Outcome expectations from BSF use; perceived benefits	*Acceptability* • Safe water and less water-borne disease • Natural taste of the water • Time-saver for women and girls

5.2.3.1 Psychosocial dimension at the societal/structural level

At the societal/structural level, the daily tasks and priorities of Maasai pastoralists were identified as potential barriers to the acceptability of the BSF. In delivering the workshops provided to the local BSF technicians and the CHPs (explained in chapter 1), the representative from Aqua Clara experienced challenges with workshop attendance and people missing days of the workshop, which he himself explained to be caused by issues related to people's priorities to look after their livestock[25].

> *So, the challenge I saw, these people mostly they are cattle keepers sometimes even keeping time or sometimes there's a lot of issues with those cows, but they tried to come (Aqua Clara representative).*

Since the Maasai way of living revolves around pastoralism (Galvin et al., 2008), much time is spent taking care of livestock. Therefore, water treatment options such as the BSF which require considerable time for education around building, maintenance and use of the technology might have lower acceptability in the community compared to other methods because of the required time for education. However, the Aqua Clara representative further explained that even though the Maasai community may need more time than other communities to become self-contained, once the local

[25] As it is normal for Maasai men to send the young boys to herd the cattle, missing days of the workshop due to priorities of looking after the cattle is a factor that is likely a priority rather than an absolute barrier to workshop attendance.

technicians and CHPs are successfully trained, he believes in widespread adoption and sustainability of the filter.

> *…if we can just have a group which has already known what it's supposed to do, they can train the others eventually I think the whole community will be enlightened (Aqua Clara representative).*

5.2.3.2 Psychosocial dimension at the community level

At the community level in the psychosocial dimension, one potential barrier to BSF feasibility was identified. When asked about perceptions regarding the main challenges in spreading knowledge about the BSF, one participant brought up the culture of 'sitting allowances', or per diems as they are more widely known (Søreide, Tostensen, & Aagedal, 2012). Per diems are cash incentives that individuals receive when attending seminars, excursions and training workshops (Søreide et al., 2012), and it is a frequent practice in Tanzania both within the government, NGOs, donors and research (Premji, 2017).

As illustrated by one participant, spreading knowledge within the community is due to the culture of per diems one of the main perceived challenges in widespread community knowledge about the BSF.

> *The challenge is about money only, because they can just invite meeting and then people can just say oh who can attend that meeting where there is no payment, so they may not even get group of people who can just sit and listen to them because they know that there is no payment (female participant, urban BSF group discussion, post-workshop).*

The challenge concerning the provision of per diems was further explained as being closely related to poverty in the community, with payments from meetings and training workshops serving a way of generating income. Formative studies conducted by Project SHINE has also found that when trainings are offered by the district authorities, people in the NCA usually receive approximately 45,000 TZS per day (depending on location and type of level of education), which is approximately 180NOK.

> *In our area, maybe poverty can just be one of the challenge that if people ask are they going to pay people there, and then if they say if they heard that you are not going to pay them, then they can just disappear go to do other things to get money (female participant, urban BSF group discussion, post-workshop).*

The potential barriers associated with the culture of per diems are two-fold; pilot projects such as Project SHINE that do not have a budget to cover the expenses of per diems might be challenged in getting participants to attend training workshops, and potential change agents may be further challenged by expectations of payments hindering communication and widespread knowledge of the technology.

5.2.3.3 Psychosocial dimension at the individual level

At the individual level in the psychosocial dimension, several factors were found to potentially affect BSF acceptability. As already presented in the previous sub-chapter regarding community perceptions and concerns around water scarcity and quality, existing knowledge related to water quality and the transmission of water-borne disease seemed to vary in the community. While the participants themselves had a relatively broad understanding of drinking water as a potential threat to human and animal health, lack of knowledge throughout the community was repeatedly brought up as a concern. Existing knowledge of pathogens and contaminated drinking water as a leading cause of water-borne disease is likely to be a potential facilitator to BSF acceptability, while the opposite applies to situations where lack of this type of knowledge may imply a low perceived threat towards consumption of untreated water and thus a low perceived need for the technology. In a systematic review examining factors affecting sustained adoption of HWST technologies, knowledge of disease transmission is listed as a factor frequently reported to motivate sustained use of HWTS technologies (Hulland et al., 2015). In a case study from western Kenya evaluating a project on social marketing of chlorination, illiteracy was found as a significant barrier to awareness and adoption of the product, which the authors argue is *"likely to reflect a poor understanding of the relationship between diarrhea and unsafe water"* (Freeman et al., 2009, p. 532).

Perceptions regarding filter cost was another factor found to affect BSF acceptability. As already mentioned, poverty was perceived as a potential contextual barrier to the feasibility and acceptability of the BSF. However, perceptions on filter cost varied between participants. Interestingly, the participants in the urban BSF group discussion all perceived the BSF as an inexpensive technology, while participants in the rural BSF group discussion perceived the technology as expensive.

> *I can just bring my friends to my house and then just explain to them it is not expensive (female participant, urban BSF group discussion).*
>
> *We can see it's good but it's expensive (male participant, rural BSF group discussion).*

As mentioned earlier the BSF is estimated to cost approximately 120,000 TZS in the NCA context (480NOK). During the interviews and group discussions, views on an acceptable filter cost varied widely. While in the rural BSF group discussion the filter was perceived as too expensive, participants in the urban BSF group discussion and the policy think tank agreed on 120,000 TZS as being an acceptable price, whereas in the interview with the employee of the Water Committee in Endulen, the price of a goat (approximately 50.000 TZS/200NOK) was suggested. The varying views on an acceptable filter price can be interpreted as an indication of disparities in SES in the community, and the estimated price of 120,000 TZS for a filter is interpreted as a potential barrier to BSF widespread acceptability within all socioeconomic levels in the community.

Because of the nature of our community is that people are really afraid and scared in investing something which is very expensive. So they are ready to drink unclean or unsafe water because of the investment…if it's expensive (Employee, Water Committee).

Another interesting finding from the analysis was a growing positive attitude within the urban BSF group in the post-workshop interview. The group seemed excited about having received a filter, and motivated by the newly received knowledge.

Many people nowadays expect to be paid for the workshop, so they have been just asking are you going to be payed and then she answered that the knowledge which I got from there is the payment already, so, I don't need to be paid (female participant, urban BSF group discussion, post-workshop).

The group further stressed the importance of education on safe water and BSF use and maintenance to long term success of BSF adoption and sustainability in the community, and showed a dedicated sense of commitment to share the knowledge and take on responsibility and ownership of the project.

…even though if you are not around here, your eye and ear remain here with them, which is me the translator, and then whenever you come back, you´ll come to see the result. House, people, with all this knowledge (female participant, urban BSF group discussion, post-workshop).

So, the seed you plant. You´ll come to see how it's growing. Ok? This is a seed you plant (female participant, urban BSF group discussion, post-workshop).

The group also revealed how they immediately after BSF installation in their homes had experienced curious neighbors visiting their households with questions about the BSF. The identified sense of commitment within the urban BSF pilot evaluation group to share their newly acquired knowledge may serve as an important facilitator to BSF acceptability within this community. The potential of these 'BSF champions' to serve as change agents affecting BSF adoption in the community will be discussed further in the next chapter (chapter 6).

5.2.3.4 Psychosocial dimension at the habitual level

At the habitual level, three different outcome expectations from BSF use were found as potential facilitators affecting the perceived need for the BSF technology and thus BSF acceptability. While also demonstrating an understanding of contaminated water as a leading cause to diarrheal disease, one participant from the women's group think tank explained how she expects the BSF to contribute to safe water and less water-borne disease.

They hope that you may bring them the clean water trough that filter. So they [are] happy because they can go away with the diarrhea and the vomiting (female participant, women's group think tank).

Further, the perception and appreciation of naturally tasting water from BSF use was brought up by one of the participants who had been through the BSF workshop. It is likely that the participant refers

to the taste of water as "natural" comparing it to the taste of water treated with chlorine as already discussed, or water after boiling, as the result of boiling leaves water tasting flat and distasteful.

> *…the water which we are going to drink from the Biosand filter is like natural, nothing can be removed from the nature of the water, just the parasite and others, I mean, things which can just bring diseases. But the water, the taste of the water will just remain natural (female participant, urban BSF group discussion, post-workshop).*

Finally, the last identified outcome expectation found to potentially affect acceptability of the BSF was the perception of the BSF as being a time-saver for women and girls. Instead of spending time collecting firewood for boiling[26], time can be spent on other purposes which have already been discussed such as family development and school attendance for girls.

> *…we are looking on the positive side of the project, is going to help women save a lot of time on collecting firewood's, so now, instead of boiling water, can be used for other purposive (female participant, various community members think tank).*

Taken together, the outcome expectations of safe water and less water-borne disease, natural taste of the water and saved time for women and girls were interpreted as perceived benefits for practicing BSF treatment, and therefore potential factors affecting BSF acceptance.

This chapter has presented the results and main themes that emerged through analyses of the in-depth interviews, group discussions and think tanks. A discussion around these findings is presented next.

[26] As mentioned previously, due to NCAA restrictions, Maasai women are not allowed to cut down trees to collect firewood, but they can collect fallen branches.

6 CHAPTER 6: DISCUSSION

The findings that emerged from the analysis of the data were presented in two separate sections in the results chapter, in relation to the two main research questions guiding this study. This chapter follows the same structure, with community perceptions and concerns around water scarcity and water quality being the focus of the first sub-section. While also being a research question on its own, the community perceptions and concerns around water scarcity and water quality are thought of as providing an overarching contextual backdrop to highlight the uniqueness of the setting in which the BSF pilot study is being implemented. The main purpose of the first research question is therefore to set the stage for the following and main discussion around perceived acceptability and feasibility of the BSF as a low-cost, low tech water treatment option in the NCA. The discussion around perceived acceptability and feasibility of the BSF and potential adoption of the technology is informed by the IBM-WASH framework, the DOI theory, and previous research done on various HWTS technologies, as well as the relevant findings on community perceptions and concerns around water scarcity and water quality that emerged through this study.

6.1 COMMUNITY PERCEPTIONS AND CONCERNS AROUND WATER SCARCITY AND WATER QUALITY

In the following discussion, community perceptions and concerns around water scarcity are first discussed, followed by perceptions and concerns around water quality. Concerns are discussed in relation to their potential contextual importance to BSF implementation in the NCA.

6.1.1 Main community concerns related to water scarcity

With respect to water scarcity, the main concerns that emerged through the analysis of the data relate to a changing climate in the NCA (harsher conditions now than in the past), an extra burden on women and girls related to risks associated with the collection of water, disparities in the community related to access to safe water, insufficient amounts of water to meet the needs of both humans and animals, shortcomings concerning management and leadership of water related issues, and a strained relationship between main actors of water related issues and the community.

The change in climate in the NCA was associated with perceived greater challenges to the community in terms of less rainfall and therefore less available water, leading to an increased probability of having to share water sources with animals, which again increases the level of water-borne disease in the community. The amounts of water available was also perceived as insufficient to meet the needs of both humans, livestock, and wild animals, and in addition to changes in climate, an increase in human-, livestock- and wild animal populations was perceived as one of the main reasons to the insufficient amounts of water in the area. As zoonotic disease transmission increases when humans and animals

are forced closer together depending on the same water sources (Mazet et al., 2009), a scenario of increased water scarcity is indeed likely to cause increased levels of water-borne disease. As it is difficult to draw conclusions about local trends in rainfall on the African continent (Niang et al., 2014), and both an increase and a decrease in rainfall over the past century has been reported in eastern Africa, a discussion around the perceived decrease in rainfall is equally challenging. However, it is worth briefly noting that the year of 1974, as was identified by one of the traditional leaders as the year where the weather started changing and water scarcity became an increased problem, is also the year when the NCA crater area was declared illegal for Maasai pastoralists to live permanently or graze their livestock (Thomson, 1997, cited in Galvin et al., 2008). Whether it is changes in rainfall, changes in natural drinking water sources legally available for the Maasai population to use, a mix between the two, or other reasons not identified in this study that cause concerns around water scarcity in the NCA is after all not essential to the present discussion, as the community concerns are just as real whatever the cause. What is important however, is to take into consideration these identified community concerns around decreased amounts of rainfall and available drinking water leading to water-borne disease, as they may have implications on the perceived need for water treatment options such as the BSF. In a study from India, the perceived need for water treatment is listed as one of several factors affecting the willingness to pay and thus the demand for the BSF technology (Ngai & Fenner, 2014). In relation to the DOI theory, the five key attributes of innovation that are proposed to determine a technology's rate of diffusion are relative advantage, compatibility, complexity, trialability and observability (Rogers, 2003). With perceptions of less rain, less available drinking water and more water-borne disease in the community now compared to the past, water treatment options such as the BSF are more likely to be perceived as advantageous in the community (high relative advantage), as treated drinking water comes with the benefit of greater safety of the water and therefore less likelihood of water-borne disease.

Closely related to the issue of water scarcity, was the identified concern around the extra burden and associated risks related to collection of water that especially falls on women and girls. With natural sources such as rivers and ponds being common sources for water collection, the women and girls face major challenges in terms of physical stress from long distances to collect water, risks of running into wild animals, and risks of falling into deep wells. In addition to physical stress related to water collection, the women who have the longest walks were perceived as having minimal time to take care of and develop their family. In terms of water scarcity and the associated risks to women and girls, a potential adoption of the BSF in households in the NCA is not likely to reduce the extra burden on women and girls, as HWTS options does not increase access to water and water availability will continue to pose an issue whether or not a household has a BSF to treat their water. However,

compared to the present scenario, a situation where the BSF is integrated as a part of the women's everyday life may reduce the time women spend collecting firewood to boil water (Kaiser et al., 2002). The perception of the BSF as a potential time-saver for women and girls is discussed in more detail later under perceived acceptability of the BSF. Another important observation that will be discussed in greater detail later, is the distribution of water-related tasks between genders and how it reflects the importance of including women as well as men in water-related projects.

In addition to concerns around women and girls being disproportionally affected by risks associated with the collection of water, concerns around disparities in terms of access to drinking water between the rural and the more urban residents, and between residents of various SES in the NCA were also identified. The community concerns around disparities among residents in the community related to access to water, and also the potentially uneven distribution of water in the NCA between tourism and the Maasai population (although not expressed as a concern by the participants), raises questions such as what sort of additional disparities that may arise in the community if the BSFs were to be implemented on a larger scale. Potential unintended harms such as creation of inequalities related to potential large-scale implementation of the BSF is however outside the scope of this thesis as it is covered by another concurrent sub-study within the BSF pilot evaluation study. Potential differences in acceptability of the filter between rural and more urban residents, is another highly relevant question that arises from the identification of concerns related to variation in access to water between the two groups. As was mentioned in the results chapter, the more urban participants identified safe water as their main challenge, compared to the more rural participants who stated that water scarcity and access to water was their main concern. Based on this information, it is likely that the rural population will perceive the BSF as less needed than the more urban population who are concerned about the safety of their water to a much greater extent. According to the DOI theory, the perceived relative advantage of the BSF is therefore likely to be higher in the more urban population than the rural population, which again has implications on the potential rate of adoption within the various population segments (Rogers, 2003). Potential of widespread adoption within the most marginalized in the community is discussed in more detail later in relation to poverty as a contextual factor potentially affecting acceptability of the BSF, and in relation to the feasibility of interpersonal-communication and sharing of knowledge in the community.

The final concerns that emerged through the analysis of the data which relates to water scarcity were challenges concerning the management of water-related issues in the NCA. Even though water issues and especially access to water were expressed by the employee of the Water Committee as having a high priority in the community, present projects and efforts to increase access to water were perceived as inefficient largely due to main actors and other stakeholders not working efficiently

together. Additionally, a strained relationship between the main actors and the community was identified, both in terms of a seemingly lack of trust in certain water projects because of poor management and leadership, and in terms of the contrasting view of managers facing challenges with resistance from the community in terms of spearing of water pipes and a low willingness in the community to contribute money to ensure sustainability of the projects. The identification of a potentially strained relationship between main actors concerned with water related issues and the community in the NCA may have important implications affecting the potential for BSF adoption in the community. For widespread adoption to take place, the DOI theory emphasizes the importance of change agents to engage in interpersonal communication with individuals in the community (Rogers, 2003). This type of communication influences and form attitudes that are central for the general perception of the innovation (persuasion stage), and help increase the perception of the innovation's relative advantage in the form of demonstrating the innovation for other individuals (decision stage). Opinion leaders may be especially important as they are highly homophilous with the other members of the community which is proposed to facilitate diffusion (Rogers, 2003). Collaboration with community members who can later bring the project forward is important to ensure sustainability of HWTS projects, and partnering with various leaders in the community is proposed as essential because they are well-respected and other community members tend to follow their lead (Ojomo et al., 2015). In terms of a potential widespread adoption of the BSFs, the main questions then relate to who the right change agents and opinion leaders are in the community, and what the ideal scenario is in terms of collaboration between the project, its main actors, and the community members. If a strained relationship already exists between leaders and main actors engaged in water-related issues and other members of the community, it may likely result in challenges in terms of the engagement of change agents. If a change agent is a main actor, based on the perceptions that emerged through the analysis, he or she may suffer from the already existing lack of trust in executives and leaders. Similarly, if the change agent is regular member of the community he or she may suffer from a power imbalance in terms of lack of support and exclusion from executives and leaders.

6.1.2 Main community concerns related to water quality

Shifting from community concerns related to water scarcity in the NCA, the main concerns with respect to water quality that emerged through the analysis of the data were concerns around the overall knowledge level in the community regarding water quality in the area, and concerns related to shared water sources with livestock and wild animals.

While the participants themselves expressed a general awareness of water quality and potential transmission of water-borne disease, concerns about the overall knowledge level regarding water quality and transmission of water-borne disease in the community at large were raised repeatedly

throughout the interviews, with the most common perception of water quality in the community being described as an understanding of water with a low turbidity as equivalent to safe water. Interestingly, promotion of water treatment through media channels such as the radio was identified as present in the community. However, even though promotion of water quality, water treatment and its significance to health may be present in the community, the general perception in the community was still described as being in support of the understanding that water with a low turbidity is equivalent to safe water. According to the DOI theory, mass media channels are indeed identified as the most efficient way of spreading awareness-knowledge (in this case awareness of the existence of various water treatment options). Based on the community perceptions however, one can argue that awareness-knowledge spread through media alone is likely insufficient to change the community perceptions of the need to treat low turbidity water, supporting the importance of interpersonal communication and peer influence in addition to media channels to actively promote the need for water treatment options such as the BSF to treat water in the NCA. Peer influence spread through word of mouth is identified as one of several factors affecting the willingness to pay and thus the demand of the BSF technology (Ngai & Fenner, 2014). An additional remark here is the contrasting note that if low turbidity water is perceived as safe, it is natural to believe that highly turbid water is perceived as the opposite and therefore *not* safe. If so, the fact that most surface water in the NCA is highly turbid may indeed facilitate the acceptance of the BSF even without an existing awareness of invisible bacteria and viruses in the water, as the drinking water will look *clear* after BSF filtration. This special feature of the technology has previously been reported as an important factor driving user demand of BSFs in Tanzania (Ojomo et al., 2015). Viewed through the lens of the DOI theory, this particular quality of the BSF to reduce turbidity of the water in addition to bacterial removal is therefore a factor contributing to its degree of compatibility as the technology is consistent with existing beliefs and needs of potential adopters. Compared to other water treatment options such as boiling, which was mentioned as a water treatment practice that is used by some in the community, the BSF also has a higher relative advantage to the members of the community due to its quality of reducing the turbidity of the drinking water.

Closely related to and relevant to the discussion around the overall community knowledge regarding water quality and transmission of water-borne disease is also the identified concern in the community of having to share water sources with livestock and wild-animals due to its potential threat to human health. Even though the Maasai are accustomed to their close proximity to both livestock and wild animals, and strategies such as guards, fences, scarecrows and designated areas for various uses of the river are common to keep animals away from the water, separating drinking water from the presence of animals were explained as challenging and not always feasible. As already discussed in

the beginning of this chapter, community concerns around shared water sources with animals and the presence and risk of zoonotic diseases have implications on the potential adoption of the BSF in terms of relative advantage (greater safety of the water and therefore less likelihood of water-borne disease). Additionally, from a One Health perspective the relationship between the Maasai, their livestock and the surrounding wild animals may have deeper implications which relates back to the discussion of the overall knowledge level in the community concerning water quality and transmission of water-borne disease. The argument is simply that even though the Maasai may not express their awareness through words such as 'bacteria', 'virus', 'pathogens', 'contamination' or 'water-borne disease', the average Maasai do nevertheless have a fairly high awareness of contaminated drinking water as a potential cause to disease, as they would likely never go through the trouble of managing their water sources and separating human and animal use of the river if they had no awareness of their water being a leading cause to water-borne disease. Put differently, the Maasai may not have a great understanding of germ-theory (disease caused by microorganisms) and its relation to water treatment options such as the BSF (principle-knowledge in DOI theory), but through their coexistence with livestock and wild animals they are still likely to hold a relatively high awareness of health hazards present in their surrounding environment. Based on this argument, it becomes highly important to approach health-related issues such as transmission of water-borne disease in the NCA with a One Health perspective, and recognizing the importance of Maasai traditions, experiences and inherent knowledge when addressing topics such as acceptability and feasibility of the BSF.

As a brief summary, the discussion around community perceptions around water scarcity and water quality has several implications for large scale BSF implementation in the NCA. Perceptions of less rain and less available water leading to more water-borne disease now than in the past, is a potential factor leading to a higher relative advantage of the BSF. Adoption of the BSFs is however not likely to reduce the extra burden on women and girls in the community as water availability will continue as a challenging issue related to gender disparities (one exception is the potential time saved on collection of firewood). The more urban population is more likely to perceive the BSF as needed because they view safe water as their main challenge, compared to the rural population who mainly struggles with water scarcity. The perceived relative advantage is therefore likely to be higher in the more urban population compared to the rural population. A strained relationship between leaders and main actors engaged in water-related issues and the community members may act as a potential challenge in terms of engagement of change agents and collaboration between the various stakeholders. With respect to water quality, community perceptions related to water with a low turbidity being perceived as equivalent to safe water have potential implications to BSF implementation. First of all, inter-personal communication and peer influence is likely needed in addition to promotion through media

channels such as the radio to actively promote the importance of water quality, water treatment and its significance to health. Secondly, these perceptions may work in favor of BSF acceptance as most surface water in the NCA is highly turbid, and one of the advantages of BSF water filtration is the reduced turbidity of the treated water. The degree of compatibility is therefore high as the technology is consistent with existing beliefs and needs of potential adopters, and it also implies a higher relative advantage compared to other water treatment options such as boiling, chlorination or SODIS. Lastly, this discussion confirms the importance of addressing water treatment practices and safe-water interventions through an ecological and multi-level approach way beyond the sole focus of germ theory and messages of killing pathogens and preventing disease (Figueroa & Kincaid, 2010). The range of potential contextual, technological, and psychosocial facilitators and barriers to BSF implementation and adoption that emerged through the analysis of the data are discussed next.

6.2 Perceived acceptability and feasibility of the Biosand Filter technology

The findings from this study are preliminary and assessed pre-implementation, and the following discussion is therefore not meant as an assessment of long-term behavior change and sustainability of the BSF, but rather as a discussion on potential contextual, technological and psychosocial factors that are present in the community and which may affect the extent of acceptability and feasibility of the BSF, offering a valuable foundation and knowledge base for further research in the community. The identified perspectives related to community acceptability are discussed first, followed by a focus on perceptions related to feasibility.

6.2.1 Community perspectives on acceptability of the Biosand Filter

The perceived factors that were found to potentially affect the acceptability of the BSF and which will be discussed next were initial reactions to the introduction of the filter in terms of reactions on filter appearance, expected strengths and weaknesses of the technology, outcome expectations in terms of perceived benefits from BSF use, existing knowledge on water quality and transmission of water-borne disease, perceptions on filter cost and the identification of potential 'BSF champions'.

Physical characteristics of HWTS hardware may influence behavioral outcomes (Dreibelbis et al., 2013b), and the aesthetics of both the hardware itself, and the attractiveness of the treated water has been identified as important drivers of adoption (Ojomo et al., 2015). Individual reactions in terms of attractiveness and appearance was for instance found to contribute to the acceptability of a handwashing station technology in Bangladesh (Hulland et al., 2013). Serving as a potential facilitator to BSF acceptance is therefore the positive reactions that were observed in all participants when first introduced to the BSF. Initial reactions to a picture of the BSF and a short explanation of the practical functions of the technology is however a weak predication for potential acceptability, but building on

the individual reactions to the BSF appearance, several perceived strengths and weaknesses of the technology and outcome expectations in terms of perceived benefits from BSF use were also identified. The benefit of the BSF to clarify turbid water has already been discussed. Another favorable aspect about the BSF that was quickly identified and which may have strong influence on BSF acceptability was the absence of chemicals such as chlorine. The odor and taste of the water is frequently reported as factors affecting user acceptance of HWTS technologies (Hulland et al., 2015; Ojomo et al., 2015), and because chlorine changes the natural taste of the water, and because of concerns related to chlorine potentially being life threatening if handled wrong, the BSF was perceived as a substantially better option to treat water. According to the DOI theory, the BSF therefore has a higher relative advantage to the members in the community than the option of chlorination, and the same is true compared to boiling as already discussed in the previous sub-chapter. Another perceived benefit from BSF use was how the BSF may act as a potential time-saver for women and girls. Looking back at the results chapter, water collection is associated with a heavy physical burden, but also deprivation of women's time for family-related activities or school attendance for girls. When compared to the option of boiling which requires time for collection of firewood in addition to fetching of water, BSF practice requires one less time-consuming activity and may therefore save time and thus increase acceptability of the BSF. The tremendous time and effort saved for women and girls due to the BSF significantly reducing the need for firewood is reported by the Samaritan's Purse as one of the main advantages of the BSF, as the decreased workload on women and girls may potentially increase time for other activities such as operating small businesses and markets which again influences economies in low- and middle income countries (Kaiser et al., 2002). It is however worth bearing in mind that the positive impact of saved time for women and girls may be limited in this case, as water availability is likely the bigger issue.

One factor that may negatively affect the acceptance of the BSF is the perceived weakness of the design in terms of the separate safe water storage container. This perceived weakness may potentially be related to the shortage of space in Maasai bomas, or due to perceptions of an increased cost associated with a technology that consists of two separate components. Additionally, the safe storage container was identified as a potential high-risk site for recontamination of treated water. Perceptions on the cost of the technology was found to vary, and there were contrasting perceptions between rural and more urban participants. The price of the filter of 120,000 TZS (480NOK) was perceived by some as an unacceptable price, which is in line with other studies reporting product cost as one of the largest challenges related to household demand and practice of HWTS technologies (Hulland et al., 2015; Ojomo et al., 2015). Ensuring affordability of the technology is therefore necessary. Interestingly, it is proposed by an international NGO in Tanzania that giving away BSFs for free

decreases use of the filters, which is likely a result from a lack of user investment (Blanton et. al, 2014, cited in Ojomo et al., 2015). This statement is supported by other studies (Brown et al., 2009). In terms of ensuring affordability of the BSF within the NCA, which again affects acceptability of the filter, the possibility of an absolute barrier to BSF affordability in terms of extreme poverty must however be taken into consideration. In another study from the NCA, the SES among residents in Endulen and Nainokanoka was characterized as 'moderate' for the majority of the included participants (50.9 %), while 35.4% of the participants were found to have a 'low' SES (Nyanza et al., in progress). Outside funding may therefore be necessary to reach the most marginalized in the community, as the filter cost may be prohibitively high within the poorest of households. In such cases, having the consumers assist in the required labor (i.e. assist in transport or installation of the filter) may compensate for the lack of user investment that is associated with low sustained use of HWTS products (Ojomo et al., 2015).

Circling back to the perception of the safe storage container as a potential high-risk site for recontamination of treated water, although recontamination of stored water obviously is a critical issue that needs to be addressed, the concern is based on the view of only one higher educated community member (employee of the Water Committee). The likelihood of the safe storage container being a barrier to BSF acceptability due to concerns around recontamination of the water is likely low, but concurrently supports the identified need for substantial education and support in the community. If water storage practice is not done properly, recontamination of the stored water may indeed result in water that is even higher in contamination than water from the original source (Ojomo et al., 2015), and BSF filters has been found more likely to be used by households that already has some knowledge of safe household health and hygiene practices (Brown et al., 2009). In addition to safe storage, user education about water-borne disease and general operation and maintenance of the BSF is frequently reported as crucial for sustained BSF performance (Duke et al., 2006; Ojomo et al., 2015; World Bank, 2007). The knowledge of households to properly use and maintain the BSF is also associated with delayed observable benefits of the technology[27], which are found to be the main factors determining word of mouth and the willingness to pay for the BSF technology (Ngai & Fenner, 2014). Effective educational methods are further highly dependent on factors such as culture, geography and socioeconomic level of the end user (Kaiser et al., 2002). While some participants did identify safe water and less water-borne disease as a potential benefit of BSF use, the previous discussion around the existing knowledge of water quality and transmission of water-borne disease in the community revealed that knowledge around water quality among the Maasai may likely revolve

[27] Observable benefits are not always realized immediately by households (Ngai & Fenner, 2014). As an example, it may take time for a household to experience a reduction in diarrheal disease.

around more practical knowledge from having to share water sources with animals rather than precise knowledge of germ-theory, which supports the recommendations of education that is tailored to fit the specific context in which the BSF is being implemented (Kaiser et al., 2002).

Although the BSF is promoted as a low-tech option for treating water, education on installation, operation and maintenance of the BSF was perceived as information that the Maasai community needs time to acquire and understand. This may suggest that what the DOI theory refers to as 'degree of complexity', or perceived difficulty**,** of the technology is high among Maasai pastoralists, which again may imply that a greater amount of how-to knowledge is needed before the individuals may sufficiently eliminate their uncertainty towards the technology and decide to adopt it (Rogers, 2003). While lack of education may act as a barrier to BSF acceptability, proper education is important to facilitate acceptability, and the need for local technicians and CHPs who are adequately trained and confident in providing continued education and support to other community members is recommended (Kaiser et al., 2002). This issue was also brought up by the Aqua Clara representative as highly important in the NCA context. The local technicians and CHPs may also serve as important change agents as they may spread both how-to knowledge and principles knowledge through face-to-face communication in the community (persuasion stage within DOI theory), help speeding up the decision process through demonstrations of their own BSFs (decision stage within DOI theory), and attend to emerging problems and provide technical assistance (implementation and confirmation stage within DOI theory) (Rogers, 2003). Additionally, change agents may have an increased interest in delivering verbal reminders and discussion which is believed helpful in creating habit and sustained adoption (Hulland et al., 2015). An interesting discovery that emerged through the analysis of the data and which relates to potential change agents was how the urban BSF group showed a considerable growth in motivation and positive attitude after participation in the training and workshops provided by Aqua Clara. In a study from Nicaragua, both intention to use and actual use of SODIS were found to relate to an overall positive attitude, and actual use was further related to knowledge about the technology (Altherr, Mosler, Tobias, & Butera, 2006). The authors further emphasize the importance of promoters who are able to create positive attitudes and inspire confidence in the technology. The four female participants in our case expressed a dedicated sense of commitment to share knowledge and take on responsibility and ownership of the project, and combined with the identified curiosity from neighboring bomas community members such as these four 'BSF champions' are assumed to positively affect BSF acceptability and potential adoption of the technology within the NCA.

As a brief summary, the community perceptions indicate a predominance of facilitators over barriers to BSF acceptability. In addition to the potential facilitators to BSF acceptability that were identified in the previous section (a seemingly high relative advantage compared to boiling, chlorination and

SODIS, and a potential perceived benefit of the BSF to clarify turbid water), the main perceived facilitators to BSF acceptability and adoption in the community that have been discussed in this sub-section are the positive reactions that were observed in all participants when first introduced to the BSF (filter attractiveness), the absence of chemicals such as chlorine in the treated water, potential time saved for women and girls, and the dedicated sense of commitment to share knowledge and take on responsibility and ownership of the project that were identified within 'BSF champions'. Some potential barriers to BSF acceptability were also discussed, including the perceived weakness of the design in terms of the separate water storage container (related to a potential shortage of space in Maasai bomas, and perceptions of an increased cost associated with two separate filter components), the lack of affordability of the filter in the most marginalized households, and finally lack of education and a potential high perceived difficulty of the technology among Maasai pastoralists, which may imply a high uncertainty and thus act as a barrier to the decision of adopting the BSF.

6.2.2 Community perspectives on feasibility of the Biosand Filter

The perceived factors that were found to potentially affect the feasibility of the BSF in the NCA and which lays the foundation of the following discussion were water scarcity and water source availability, long distances between households, the availability of tanks, sand and gravel, inter-ward tensions related to access to sand and gravel, logistics of getting materials into the NCA, the heavy weight of the filter, and the culture of per diems.

The impact of water scarcity, in terms of the likely scenario expressed by participants of households having to go for days without access to water, serves as a potential barrier to BSF feasibility in the NCA. As the filter requires 12 L of water to be run through the system every day (CAWST, 2012), the BSF may have considerable disadvantages in largely water deprived areas. Compared to other water treatment options such as SODIS or chlorination which are not negatively affected by consecutive days without access to water, the relative advantage of the BSF is in this case lower than other water treatment options.

Other water treatment studies have also found that individual treatment practice may be under the influence of seasonal water availability (Hulland et al., 2015). For instance, even though water-borne disease is a year-round problem, a study from Malawi reported community perceptions of greater health risks during the rainy season which lead users to treat their water only during the rainy season (Wood et al., 2012). Such perceptions were not expressed by the participants in this study, however differences in water source availability and use may act as a barrier to BSF feasibility in the NCA because the practice of alternating between water sources may potentially affect the efficiency of the BSF to remove pathogens in the water (CAWST, 2012). However, as discussed in the previous sub-

chapter it is recognized that substantial education and support is required for successful BSF implementation in a community, and because households should remain to one stable water source at least within seasons, the use of multiple water sources and its implications on BSF efficiency should be covered by training and workshop sessions (Kaiser et al., 2002). Alternating water sources between seasons is feasible, although the water then requires disinfection for a few days after feeding the biological layer with an unfamiliar water source (CAWST, 2012). As previously argued, chlorination is viewed by many in the community as unacceptable, and boiling of water is also not widely practiced. Although not necessarily acting as a potential barrier to implementation feasibility, shifting of water sources between seasons may pose challenges to the efficiency of the BSF and is therefore important to acknowledge.

One factor that emerged through the analysis of the data, and which may serve as a barrier to BSF feasibility, is the challenge in terms of logistics during collection of sand and gravel, and during BSF installation in the bomas. As the required sand and gravel is both heavy and not easily found in Endulen, a car is needed both during collection of the sand and gravel and during the actual installation of the filter. As the use of a car requires money, the challenging logistics around BSF installation serves as an important barrier to feasibility in this case. If compared to other treatment options such as SODIS or chlorination, the logistical challenges that are tied to BSF installation implies a much greater dependability on outside support in terms of the extra cost and challenges the need for a car may bring. Besides the logistical challenges already mentioned, inter-ward tensions related to the collection of sand and gravel, tanks that needs to be purchased in Arusha or Karatu which are located far away from Endulen, and potential challenges in terms of a permit that is technically needed to get materials through the NCA gate, all adds to the total logistical challenge and feasibility of BSF installation. Briefly worth mentioning in the discussion around logistics is also the potential need for replacement parts in case of filter breakage which is reported as one of the main reasons for filter disuse (Brown et al., 2009; Ngai & Fenner, 2014). Although BSFs are argued by some to have no parts prone to breakage (Sobsey, Stauber, Casanova, Brown, & Elliott, 2008), filter breakage is indeed frequently reported for ceramic- and concrete filters (Clasen et al., 2006; World Bank, 2007). The plastic version of the BSF is proposed by some as likely more vulnerable to breakage than concrete filters as it is more light-weight (Stauber, Printy, et al., 2012). Based on this, the potential barrier of both affording and getting replacement filter parts may deem challenging not only during BSF installation but also in terms of long-term maintenance of the filters.

In addition to challenges related to installation logistics, the size of the NCA and the long distances between households serves as another challenge and potential barrier to BSF feasibility in terms of reaching out to the entire population and spread the knowledge far and wide. As the success of local

technicians, CHPs, BSF champions or other potential change agents in sharing knowledge and positively influencing attitudes in the community heavily depends on inter-personal communication, a widespread community with long distances between households, in combination with few people owning cars or donkeys for personal transport, is likely to act as a barrier to widespread community knowledge forming the basis of individual decisions to either adopt or reject the BSF technology. An important side note to this discussion is how the more rural population living in the periphery are likely to be disproportionally affected, with the potential of creating even larger disparities between population segments. According to the DOI theory, observability, or the degree to which the results of an innovation are visible to others, is another important attribute determining the feasibility of change agents to influence attitudes in the community for individuals to reach a decision of adoption or rejection of the BSF. As mentioned in the results, one of the participants emphasized how the BSFs "won't stick into their mind" if people are not exposed to it. For instance, an ideal form of observability in this case would be people in the community observing how the BSF clarifies turbidity of the water, as is it proposed through the earlier discussion to facilitate BSF acceptability. However, compared to SODIS for instance which is dependent on direct sunlight and therefore often visible on household rooftops, BSFs are not easily observable as they are kept inside the house. People observing results such as turbidity reduction is therefore dependent on invitations to neighboring bomas or other forms of BSF demonstrations, meaning the size of the NCA and the long distances between household in the community may likely act as an added barrier to BSF observability as well as inter-personal communication. Yet another potential barrier hindering communication and thus widespread knowledge about the BSFs that were brought up by participants is the culture of per diems, as it may affect the willingness of community members to show up at meetings organized by BSF champions or other change agents to share their knowledge. The culture of per diems may also serve as an additional factor creating disparities between members of the community, as it was brought up by participants that the poorer people in the community are more likely to be absent from meetings where incentives in the form of money are not included. Reaching the most marginalized in the society and leaving no one behind is essential to ensure human development for all (United Nations Development Programme, 2016), and addressing potential barriers to reach the more rural population and the poorer members of the community is important to ensure that the potential benefits from BSF treatment can reach everyone, and to avoid creation of added disparities through BSF implementation.

With respect to the heavy weight of the filters, besides acting as a barrier to BSF installation, the heavy weight was perceived by the participants as a technological weakness because it means the filter is not suitable to carry between permanent and temporary bomas. The participants were not aware of

the fact that the BSFs are not portable and should not be moved from the position where it was first installed. To be exact, the identified perception of the BSF as being too heavy to carry is more of an issue related to the fact that a portion of the Maasai population are semi-nomadic, rather than an issue of the actual weight of the filter. A non-portable water treatment option such as the BSF is therefore likely not the ideal option to treat water for many of the residents in the NCA, as it poses problems to those who are semi-nomadic. This is true both in terms of maintenance of the filter because of the required daily flow of water that needs to go through the system, and because water treatment practice needs to take place on a daily basis for the BSF to efficiently protect against water-borne disease:

> Going a day without safe water means being at risk. Practicing POU [point of use] water treatment and safe storage should be like practicing safe sex and brushing your teeth: they need to be done at all times in order to minimize or prevent health risks (Sobsey et al., 2008, p. 4266).

According to the DOI theory, the compatibility of the BSF is therefore likely to be low within the portion of the population who are semi-nomadic, as the technology is not easily combined with their daily life and needs (Rogers, 2003). The need for two filters per household was also brought up through the interviews, with the requirement of the second filter to be smaller and lighter to carry. As the BSFs are not portable, the suggestion of a second and smaller BSF in addition to the main filter is also not a feasible solution to the problem, but it does raise the question if additional water treatment options such as SODIS or chlorination may be required in the NCA context.

The final identified factor deserving a discussion is related to BSF implementation and who is actually trained for use and maintenance of the technology. Because roles and responsibilities related to the BSF were perceived as divided between genders, acknowledging and engaging both women and men in the project were identified as important factors potentially affecting feasibility and also acceptability of the BSF. As men were identified as the decision-makers in the households and the community, they are obviously important agents of change in the NCA. However, the water-related responsibilities that mostly fall on women may imply that women are the better target for this type of education. The importance of not only involving women is all aspects of HWTS projects, but *specifically* focus on the women within the community is identified by the Samaritan's Purse as essential, based on in their comprehensive evaluation of multiple conducted BSF projects in six different countries (Kaiser et al., 2002).

The perceived barriers to BSF feasibility that have been discussed in this sub-chapter relate to both implementation, operation and maintenance of the filter, compatibility with daily life and needs of

the semi-nomadic portion of the population, and the challenge of reaching out to the entire population to spread the knowledge far and wide. It is however worth briefly mentioning that with sufficient support in terms of education and money, community engagement and involvement of women, BSF champions, and other change agents, some of the perceived barriers to BSF feasibility may be largely moderated.

"It has been well established that the BSF is not a "parachute" technology that can be dropped into a community with the expectation that health will improve" (Kaiser et al., 2002, p. 59). In accordance with the rationale of this study which highlighted the need to understand the context in which WASH technologies will be implemented, and gain an understanding of the end users point of view regarding the technologies, the previous sections in this chapter have discussed the community perceptions around water scarcity and water quality in relation to their potential contextual importance to BSF implementation in the NCA, and discussed further the perceived contextual, technological, and psychosocial facilitators and barriers to BSF implementation and adoption in the area. An important strength of this study is the utilization of a holistic approach in identifying perceptions in the community guided by the IBM-WASH framework, which resulted in the identification of a wide spectrum of multi-level factors potentially affecting the acceptability and feasibility of BSF implementation in the NCA. The next section lays out the methodological strengths and limitations of the study in terms of a quality assessment and discussion on study rigor, before the last chapter consists of a conclusion and clarification on suggestions for further research.

6.3 METHODOLOGICAL STRENGTHS AND LIMITATIONS

6.3.1 Discussion on study rigor

As previously mentioned (chapter 4), qualitative research is unavoidably subjective and dependent on the specific researcher whom is central in the data collection and analysis (Merriam & Tisdell, 2016). Compared to quantitative research where subjectivity is associated with a threat to the quality of the study, qualitative research embraces this subjectivity and acknowledge that the findings are never objective truths (Skovdal & A Cornish, 2015). Based on this explicit difference between the two methods, common criteria to determine quality in quantitative research (validity, reliability and generalizability) are argued by many researchers as relevant to quantitative research exclusively and are rarely adequate or appropriate in qualitative inquiry (Bryman, 2016). Alternative positions and criteria to determine study rigor and scientific value are therefore more commonly used in qualitative research (Bryman, 2016). Although critiqued by some scholars as not being fully examined or proven to successfully achieve more rigorous studies (Morse, 2015), trustworthiness is universally acknowledged as essential in determining the rigor of qualitative studies. Trustworthiness consists of

the terms credibility, confirmability, transferability and dependability, and replaces the quantitative terms of internal validity, objectivity, external validity/generalizability and reliability respectively (Lincoln and Guba, 1985, and Guba and Lincoln, 1994, cited in Bryman, 2016). Serving as an aid to assess and determine the rigor of this study, relevant factors to the trustworthiness of this study are discussed next.

6.3.1.1 Credibility and confirmability

Credibility is concerned with how appropriate the multiple realities of human experience have been presented, or how 'believable' the researcher's analysis, formulations and interpretations of these realities are in the minds of those being studied (Guba & Lincoln, 1982), or to people who share the same experience (Thomas & Magilvy, 2011). To ensure confirmability, "it should be apparent that he or she [the researcher] has not overtly allowed personal values or theoretical inclinations to sway the conduct of the research and the findings deriving from it" (Bryman, 2016, p. 386). In the interests of informing the reader and clarify some of the complexity and many obscurities that are inherent in field work, it has been a general goal throughout this thesis to establish credibility and confirmability through maintaining a transparent[28] and reflexive[29] methodology. Some of the other steps taken that may affect the credibility of this study have already been identified earlier throughout the thesis. One strategy that strengthens the credibility of a study is prolonged engagement and increased trust, which is likely to result in thick and rich data (Morse, 2015; Thomas & Magilvy, 2011). Since there have been conducted research in the NCA for many years through the annual Global Health Field School, trust and mutual respect has been established with the NCA community. Triangulation is another strategy to strengthen the credibility of a study (Guba and Lincoln, 1994, cited in Bryman, 2016). In this study, data triangulation was used in terms of multiple data collection methods. Given that the various methods each have their strengths and weaknesses (explained in chapter 4), each method likely resulted in unique information that the other methods may not have provided, and thus added more breadth and depth to the study than what may have been the case if only one data collection method was used. Sample size and its implications for data saturation were also discussed in chapter 4, and because few new codes were developed at the end of the data analysis it was argued that the sample size in this study may have been sufficient to arrive at general data saturation. However, a great variety of individual perceptions are likely to exist within the community, and a potential limitation to the credibility in terms of a small sample size, and thus the likelihood of lack of variation and depth throughout the findings, must therefore be acknowledged (Morse, 2015). In terms of

[28] Being transparent requires the researcher to be open and provide detailed descriptions of how the study was carried out, and how interpretations of the data lead to the results and conclusions (Skovdal & A Cornish, 2015).

[29] Reflexivity is concerned with how the researcher may shape the study (Skovdal & A Cornish, 2015).

credibility, it is also worth briefly noting that a potential limitation of information being held back by participants exists in this study. The rationale behind this statement is that in some instances, and in the women's think tank in particular, many of the answers given by the participants were short (i.e. "no", "yes" and "maybe"). In the women's think tank, the participants also clapped and praised the project frequently throughout the discussion. One potential explanation for the short answers may be that the participants were afraid of what implications negative responses or critique can have on the future of the project. As the community has previously experienced other projects coming and going without benefitting the community, the questions may have felt sensitive to the participants. Sensitive questions often result in what Bryman (2016) refers to as social desirability bias in terms of refusal to answer these particular questions. Another explanation regarding potentially limited responses to certain questions relates to the researcher's novice interviewing skills, as it may have led to failure of effectively making use of the opportunity to probe on relevant topics that came up during discussion. Another issue that may potentially affect the credibility in this study, is that some of the participants attended more than one interview or discussion. As it cannot be omitted that their partaking in earlier session may have increased their knowledge about water-related issues, the fact that they were present in multiple sessions may therefore have resulted in an incorrect increased richness of the data. The final identified potential threat to the credibility in this study is related to linguistic challenges. It is reasonable to believe that a combination between the researchers own language competence and the use of local translators may have introduced possibilities of misunderstandings, or information not being retained in the translation. Ideally, translation or transcription of the data should have been performed by a person fluent in both languages to avoid potential misinterpretation or loss of data.

6.3.1.2 Transferability

Generalizability is concerned with "the degree to which findings can be generalized across social settings" (Bryman, 2016, p. 384), and as already mentioned case study research and qualitative research in general, is associated with lack of generalizability beyond the specific research context (Bryman, 2016). However, the aim in qualitative research is usually not to generalize the findings to the wider population, but rather within the specific setting (Malterud, 2001). When thoroughly exploring a specific phenomenon through the eyes of those being studied, qualitative researchers may build on the deep understanding acquired and gain further knowledge within that specific context (Thomas & Magilvy, 2011). Guba and Lincoln also argue that with a thick description, or extensive information about a context, the findings may potentially have some transfer value in terms of providing other researchers with a database for judgements about the extent of transferability of findings to other similar contexts (Lincoln and Guba, 1994, cited in Bryman, 2016). The aim of this

study has not been to generalize the findings to a universal or wider population. Other researchers do however have the ability to personally make judgements about the applicability of the findings in terms of information that can help build their interventions and understandings (Thomas & Magilvy, 2011). Based on the contextual background that has been provided, and the transparency that has been endeavored throughout this study, it is believed that the findings and implications from this study are suitable for contributing to the evidence base regarding best practices in implementation of the BSF in similar rural and resource constrained settings.

This chapter has discussed the perceived acceptability and feasibility of the BSF as a low-cost, low tech water treatment option in the NCA, in light of the IBM-WASH framework, the DOI theory, and previous research done on various HWTS technologies, as well as the relevant findings on community perceptions and concerns around water scarcity and water quality that emerged through this study. The chapter has also presented relevant factors to the trustworthiness of the study, with the aim of providing the reader with a foundation to determine the study rigor. The following and final chapter is a conclusion including suggestions for future research.

7 CHAPTER 7: CONCLUSION AND IMPLICATIONS FOR FUTURE RESEARCH

This pilot study has helped develop a deeper understanding of community perceptions and concerns around water scarcity and water quality amongst Maasai pastoralists in the NCA. Through community perceptions, this study has also identified a host of context-specific factors potentially affecting acceptability and feasibility of BSF implementation and adoption in the NCA. Although the acceptability of the BSF as an option to treat water within the NCA is seemingly high, there are substantial barriers especially in terms of feasibility that may potentially reduce the enthusiasm and lower the likelihood of widespread adoption. The identified need for extensive education and support in proper use and maintenance of the filter further illustrates a high community reliance on outside support if the goal is to reach a high rate of adoption and sustained use in the future.

As the findings are preliminary and assessed pre-implementation, they are not meant as an assessment of long-term behavior change and sustainability of the BSF technology. The structured overview of potential contextual, technological and psychosocial factors present in the community however offers a valuable foundation and knowledge base for further research in the community. The identified barriers to acceptability and feasibility need to be adequately addressed if scale up and widespread adoption were to take place. The study findings may also provide implications regarding best practices in implementation of the BSF outside the NCA, in similar rural and resource constrained settings.

Future research in the NCA is recommended to integrate both quantitative and qualitative research strategies. In addition to continued education and support on filter usage and maintenance, as well as safe water storage practices, a follow-up assessment of facilitators and barriers to BSF acceptability and feasibility (post-implementation), and an assessment of actual water treatment behavior and BSF uptake is needed in the community. Future research should also include an evaluation of BSF effectiveness in terms of fecal coliform removal, turbidity reductions, and efficiency to reduce diarrheal disease in the NCA setting. Other research methods such as observations may also help to further strengthen the understanding of BSF water treatment practice in the NCA context. To increase the likelihood of widespread adoption and sustained use of the filter, efforts to involve the identified 'BSF champions' and other change agents in the community is recommended. Finally, even though concerns around water quality are present in the community, concerns around water scarcity are seemingly more prominent among Maasai pastoralists in the NCA, and even though HWST options such as the BSF has the potential of reducing diarrheal disease in the area, addressing water quality only is not sufficient and projects addressing both water scarcity and water quality simultaneously in the NCA is needed.

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APPENDIX

Appendix A – Water quality testing results from the Leshuta Stream

SEEDS OF HOPE
INTERNATIONAL PARTNERSHIPS

Reversing Poverty. Creating healthy homes in Africa.

SoHIP WATER LAB ANALYSIS REPORT

Client: Project SHINE
Location: Leshuta Stream, Ngorngoro Conservation Area.
Sample Description: Stream

Date Sampled: **31/06/2016**

Date Tested: **31/06/2016 – 01/06/2016**

Parameter	Unit	Results	**WHO Guideline** (ZS 190: 2010)
***E.Coli* (Faecal Coliforms)**	CFU/100mL	800*	0
General Coliform	CFU/100mL	TNTC*	20
pH		7.89	6.5 – 8.0
Turbidity	NTU	14.0*	5
Fluoride	mg/L	1.04	1.5

iforms.

'*' = Above Recommended Limit
TNTC = Too Numerous To Count (≥200CFU/ 100mL)
Notes:

- The water tested quality positive for faecal and general col
- Turbidity levels were higher than the recommended limit.
- The water must be treated to improve potability.
- Regular monitoring of the water quality is recommended.

Date: 10/06/2016

Dalla Simasiku
Laboratory Manager
Cc Program Manager SHIP-WETC

Appendix B – The interview guide

Introduction

We would like to thank you for participating in this group discussion. This discussion is part of ongoing research cooperation between the University of Calgary, Canada, the Catholic University of Health and Allied Sciences (Mwanza) and the communities that live in the Ngorongoro Conservation Area. The research project aims at understanding water availability and quality in the NCA, as well as perceptions of water treatment options. The reason for this group discussion is to get a better understanding of opinions and experiences of various people in the community so that future programs can be better designed to suit your needs.

The discussion will take about one hour. If you feel that there are related issues that are relevant and important, you are most welcome to raise these issues. With your permission, the discussion will be audio recorded, but we will not use your name in any project publications. Do you agree to allow us to record this conversation? We will share a summary of our findings with the ward counsellor and the village executive officer at the end of the project, but we will not report specifically what you have said.

General themes

1. Perceptions of water-related issues in the Ngorongoro Conservation Area (both historical and current)
2. Stakeholders engaged in water-related issues in the NCA
3. Current strategies to address water scarcity and quality
4. Awareness, knowledge and perceptions of the biosand water filter
5. Perceptions regarding community feasibility of the biosand water filter
6. Perceptions regarding community acceptability of the biosand water filter

Perceptions of water-related issues in the Ngorongoro Conservation Area

a) What are the main challenges related to water in the Ngorongoro Conservation Area? (probes: water scarcity, quality, management/conflict ect)
b) Are the current challenges any different from challenges faced by communities in the Ngorongoro in the past? (probe: 5 years, 10 years)

Stakeholders engaged in water-related issues in the NCA

a) Who are the main actors involved in water-related issues in the NCA and what are their roles? (Probes: NCAA, World Bank, NGOs, church, ect)
b) How, if at all, do these actors coordinate their efforts?
c) What are the past efforts/activities from each of these actors related to water in the NCA? What are the current efforts/activities from each of the actors?
d) Are you aware of any gaps or challenges with the projects that are currently working to address water-related issues in the NCA?

Current strategies to address water scarcity

a) Is there enough water to address the needs of people living in the NCA? Can you elaborate? (Probes: seasonality, climate change, water management, ect)
b) How does it rank in relation to other challenges in the area?
c) If this is a concern, how are pastoralists living in the area adapting to this challenge? What supports, if any, are available to them in this regard?
d) Does water scarcity affect men, women and children equally and in the same way?

e) Do people in the NCA have to pay for water? How do people generally feel about this?

Current strategies to address water quality

a) Is water quality a concern in the NCA? Can you elaborate? (Probes: health/social/economic impacts, seasonality, water management including human and animal use and needs ect)
b) How does it rank in relation to other challenges in the area?
c) How do people in the NCA understand the link between water and health? What kinds of health problems can unsafe water cause?
d) If this is a concern, how are pastoralists living in the area adapting to this challenge? What strategies are most commonly used in the area to improve the quality of water? (Probes: SODIS, chlorination, sedimentation, cloth filtration, ect).
e) Do water treatment strategies vary by season?
f) What supports, if any, are available to them in this regard?
g) Does water quality affect men, women and children equally and in the same way?

Awareness, knowledge and perceptions of the biosand water filter

a) Have you ever heard of the biosand water filter? If yes, what have you heard? If yes, do you know how the filter works to clean water?
b) Have you ever seen a biosand water filter (show picture)? Please elaborate on where you saw it and what you learned about it.

Perceptions regarding community feasibility of the biosand water filter

a) Do you think the biosand water filter could be an option for cleaning water in the NCA? Why or why not?
b) What do you think would be the main challenges to household use of the biosand water filter in the NCA? (Probes: logistics of and permission to get materials in the NCA, cost, options for water storage, ect)
c) What, if anything, do you think could be done to overcome these challenges?

Perceptions regarding community acceptability of the biosand water filter

a) What method do you think communities in the NCA would prefer to treat their water?
b) Do you think the community would support the use of biosand water filters to treat their water?
c) What do you think would be the main challenges to widespread community acceptance and adoption of biosand water filters? (Probes: perceptions of effectiveness, perceived value, cost, ease of use, effort required, preference for other methods, taste/smell/appearance of water after treatment, maintenance, knowledge, skills, ect)
d) Is there anything that we haven't mentioned or asked you about these issues that you would like to tell us about?

Thank you for your participation. Please let us know if you have any questions.

Appendix C – BSF evaluation unintended harm - Think tank discussion guide

Introduction for Participants

Have participants introduce themselves (round table introduction)

Thank you for being a part of this group meeting that aims to promote open discussion for the sanitation and hygiene project (SHINE) in the Ngorongoro Conservation Area (NCA) of Tanzania. This meeting will facilitate a conversation to identify benefits and minimize potential unintended harms associated with Project SHINE (*we don't want to hurt the community). Specifically, we would like to discuss a pilot evaluation of the biosand water filter as a low cost option to provide safe water to the community. This is a sub-study as part of Project SHINE that came about as a result of our research and dialogue with the community which shows that while there are projects and efforts to address water scarcity in the area, such as drilling wells, there is little or nothing being done to address water quality. In this study, we want to understand community perspectives on the biosand water filter and if it is a good option for communities in the NCA as a means to clean their water so that it is safe to drink and to reduce water borne illness.

The biosand water filter has been shown to work very well in other areas around the world, but we need to carefully examine local challenges to using the filter in the NCA given the uniqueness of the context. This will allow us to plan for success.

We anticipate the discussion will take a maximum of 2 hours.

Why are we holding this discussion? If we begin with a discussion of both the beneficial and harmful outcomes of trying to implement the biosand water filter at the household level in the NCA and work backwards to examine how the local context may influence its use, we may be able to minimize any harm to the community.

Ground rules: We want to promote equal voices, a spirit of openness and respect for one another. We will be having discussions as a group and also dividing into smaller groups for discussion.

Any Questions?

Introduce Sheri (Project Leader)

Describe the Proposed BSF evaluation

1. ***What social change do you hope to achieve (Why)?***
2. ***Who is currently involved in the project (Who and Where)?***
3. ***What are the key activities to get the BSF set up and maintained (What and How)?***

Step #1: Brainstorm potential worries

Ask the question: What worries you after hearing about introducing the BSF in the NCA?

1. As a large group identify and prioritize unintended harm according to their perceived likelihood, importance and ability to act.
    a. At the end – get the group to decide the top 3 worries that they would focus on.

Sheri - What worries you about this project?

- Competition, power dynamics, inequity, push back from NCAA, sustainability and access to soap making materials, access to clean water to make soap
- Not achieving our goal (underachievement)
- Trade-offs in other social problems (malnutrition as a neglected area – the problem may get worse)
- Does this project reflect the actual needs on the ground?
- Integrating upstream solutions (water, economic growth)

Step #2: Discuss the role of the underlying factors and archetypes: when we are trying to generate social change we need to know a lot of information about: what works and why, the community and environment and priorities and needs of the community. If we do not know enough about these areas it may lead to harm in the community.

1. Examine how the introduction of the BSF in the NCA may be influenced by the underlying factors and archetype considerations. Below are questions that will guide this process (10-15 minutes per factor):

Unintended Harm Underlying Factors	**Questions to Consider**	**BSF implementation Unintended Consequence Archetypes**
Limited Knowledge (what works and why?)	*Ask the project leader:* • How has the BSF worked in other areas to improve health? *Ask the group:* • What can be learned from previous water based interventions in the area? • What has worked well? • What were some of the challenges?	**Mixture of Archetypes** *Understanding of the complex social problems is often gained progressively and required constant evaluation and re-evaluation of action, outcomes and choices to constantly assess what is working and what is not*

Unintended Harm Underlying Factors	**Questions to Consider**	**BSF implementation Unintended Consequence Archetypes**
Ignoring Context AND "One Size Fits All Fallacy" (unique aspects of the community and environment)	*Ask the project leader:* • What are some of the unique characteristics that need to be considered for implementation of the BSF in the NCAA? o Social, physical, political, economic and cultural context *Ask the group:* • What unique characteristics of your community (and surrounding influences) are important to consider? o Other social problems • Who are the important collaborating parties? • What are the potential challenges between collaborating parties (NGO, non-profit, private, government)?	**Underachievement Archetype** *This section serves to examine the system boundaries and influences that lay within and outside.* *Factors outside of the perceived boundary system may lead to underachievement of goals to improve health*
Basic Values AND Boomerang Effects (priorities and needs of the community)	*Ask the project leader:* • Why do you think implementing BSF's in the NCA is a good idea at this time? o Discuss needs and priorities as understood *Ask the group:* • Are the other areas that could be focused on instead of the BSF? • Where does water quality and diarrheal disease fit in your priorities? OR: Conduct pile-sort analysis to understand priority area. Poverty Hunger/Malnutrition Education Diarrhea Typhoid Syphilis	**Relative Achievement Archetype** *Choosing one decision over the other can also be a result of our inability to recognize the relative importance and priority of problems. It could also be the result of resource constraints or simply our inability to devise alternative solutions. Hence, the action oriented towards one outcome is fulfilled at the expense of an alternative outcome. The consequence is that the favored outcome improves while the neglected outcome worsens.* **Relative Control Archetype** *We see such an archetype in practice in many international programs addressing social problems because the solutions to problems are based on the NPO's or development agency's interpretation of the community needs without knowledge of their actual needs*

Unintended Harm Underlying Factors	Questions to Consider	BSF implementation Unintended Consequence Archetypes
Immediate Interest (will the short-term benefits be sustainable?)	*Ask the project leader:* • What are the potential long-term benefits of implementing the BSF? • What will need to be done to ensure long-term change is achieved? *Ask the group:* • What will need to be done to ensure long-term change is achieved? • What are the larger influences which needs to be addressed to see long-term change?	**Out of Control Archetype** *There is always a tension between devising a symptomatic solution to visible problems versus devising a long-term fundamental solution that requires deeper understanding of the structures that produce the pattern of behavior in the first place. Fundamental solutions require deeper understanding, more time, greater commitment, more resources and greater patience.*

Step #3 – Adapting and Redesigning

Ask the question: how can we minimize the prioritized potential harm to the community?

1. As a group, discuss potential actions that could be implemented to minimize the top 3 worries.

Step #4 - Aspirational Conclusion

What are my hopes for my community? And what is my role in helping my community?

Appendix D – Interview/group discussion debrief

Recording number:

Name of moderator/interviewer:

Name of note taker:

Date:

Location:

Number of participants:

Number of females/males:

Main themes that emerged during discussion:

Did any information contradict information from other interviews/group discussions?

Did participants say anything that was unclear or confusing?

What did you observe that would not have been obvious from reading a transcript of the discussion? (i.e. body language, group dynamic etc.)

What problems were encountered? (Logistical, behavior of participants, questions etc.)

What issues need to be followed up on in future discussions?

Appendix E – NSD Approval

Sheri Bastien

Institutt for landskapsplanlegging Norges miljø- og biovitenskapelige universitet

1430 ÅS

Vår dato: 02.09.2016 Vår ref: 49452 / 3 / STM Deres dato: Deres ref:

TILBAKEMELDING PÅ MELDING OM BEHANDLING AV PERSONOPPLYSNINGER

Vi viser til melding om behandling av personopplysninger, mottatt 15.08.2016. Meldingen gjelder prosjektet:

49452 Neglected Voices, Neglected Diseases: Igniting Youth Driven Innovation in Sanitation Solutions for Maasai Pastoralists in the Ngorongoro Conservation Area, Tanzania

Behandlingsansvarlig *Norges miljø- og biovitenskapelige universitet, ved institusjonens øverste leder*

Daglig ansvarlig *Sheri Bastien*

Student *Tina Paasche*

Personvernombudet har vurdert prosjektet, og finner at behandlingen av personopplysninger vil være regulert av § 7-27 i personopplysningsforskriften. Personvernombudet tilrår at prosjektet gjennomføres.

Personvernombudets tilråding forutsetter at prosjektet gjennomføres i tråd med opplysningene gitt i meldeskjemaet, korrespondanse med ombudet, ombudets kommentarer samt personopplysningsloven og helseregisterloven med forskrifter. Behandlingen av personopplysninger kan settes i gang.

Det gjøres oppmerksom på at det skal gis ny melding dersom behandlingen endres i forhold til de opplysninger som ligger til grunn for personvernombudets vurdering. Endringsmeldinger gis via et eget skjema, http://www.nsd.uib.no/personvern/meldeplikt/skjema.html. Det skal også gis melding etter tre år dersom prosjektet fortsatt pågår. Meldinger skal skje skriftlig til ombudet.

Personvernombudet har lagt ut opplysninger om prosjektet i en offentlig database, http://pvo.nsd.no/prosjekt.

Personvernombudet vil ved prosjektets avslutning, 23.02.2017, rette en henvendelse angående status for behandlingen av personopplysninger.

Vennlig hilsen Katrine Utaaker Segadal Siri Tenden Myklebust

Dokumentet er elektronisk produsert og godkjent ved NSDs rutiner for elektronisk godkjenning.

Norges miljø- og biovitenskapelig universitet
Noregs miljø- og biovitskapelege universitet
Norwegian University of Life Sciences

Postboks 5003
NO-1432 Ås
Norway