HOUSEHOLD WATER TREATMENT AND SAFE STORAGE OPTIONS FOR NORTHERN REGION GHANA: CONSUMER PREFERNCE AND RELATIVE COST

By

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Abstract

A range of household water treatment and safe storage (HWTS) products are available in Northern Region Ghana which have the potential to significantly improve local drinking water quality. However, to date, the region has failed to see significant HWTS product adoption and sustained use. Therefore, this consumer preference study was conducted to give HWTS implementing organizations a method and tool to help stimulate product uptake by tailoring water quality interventions to local preferences and needs. Ultimately, this work highlights a discrete set of HWTS products most likely to have the greatest impact on local drinking water quality, based on product effectiveness, adoption and sustained use. The research methodology included a consumer preference survey and water quality testing in 237 households in four rural and three urban communities around Tamale, Ghana in January 2008. Turbidity testing and total coliforms (TC) and *Escherichia coli (E.coli)* removal were used to assess source water quality. The research confirmed that local purchasing decisions are dominated by a desire for products that offer a major health improvement and have a traditional durable product look, with relatively less importance placed on water taste and look, treatment time and price. The data was used to generate baseline consumer profiles based on a combination of demographic characteristics, source water quality, HWTS product preferences, ability to pay, and purchasing behavior. The consumer profiles reveal that a traditional durable product such as Pure Home Water's *Kosim* ceramic pot filter is a good fit for communities with turbid source water; however, a portfolio HWTS approach will be required to meet the diverse needs of the northern Ghana population. Specifically, there is a cross-segment need for a safe storage product as well as a low-cost chlorine disinfection option. There is an opportunity for revenue generation through a sachet water business targeted to the high-income segment of the urban market. Finally, continued investment in filtration and flocculation technology options will be required to effectively serve rural communities that utilize surfaces waters with average turbidities >200 NTU.

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1. Introduction

The goal of the research described in this thesis is to assess the relative value and cost of household water treatment and safe storage (HWTS) options in Northern Region Ghana. The author will use this analysis to make recommendations about which HWTS products would likely have the greatest impact on local drinking water quality, based on product effectiveness, adoption and sustained use[1].

1.1 Project Background

This project has been a collaborative effort between the Massachusetts Institute of Technology Civil and Environmental Engineering Department, MIT-Sloan School of Management, Pure Home Water (PHW) and PATH "Safe Water Project," to help address the dire drinking water conditions of low- to middle- income communities in northern Ghana.

Ghana is a developing country of 22 million people located along the southern coast of West Africa (Figure 1). Despite recent indications of economic growth, 6% annual GDP growth in 2007 (Central Intelligence Agency, 2008), the country continues to face significant development challenges and remains in the bottom 25% of countries on the United Nations Human Development Index with a ranking of 135 of 177 (2007). Although national income per capita of $2,280[2] is slightly higher than the World Health Organization (WHO) Africa region average, 45% of the population lives below the poverty line, making less than $1 per day (WHO, 2006).

Figure 1: Map of Ghana highlighting location of study site[3]

[1] Adoption is the percentage uptake of a HWTS practice or product after an initial period of training/education and/or marking. Sustained use is the percentage of continued use of a HWTS practice or product after 1 year of ownership.
[2] Purchasing power parity, international dollars
[3] Image from geology.com

The burden of communicable diseases, childhood morbidity and mortality, and lack of access to improved water and sanitation remain significant national development challenges. Ghana's average childhood mortality rate of 112 deaths per 1000 live births is lower than that of African as a whole, 167 deaths per 1000 live births (WHO, 2006); however, there are significant differences between Ghana's northern and southern regions. In fact, the majority of northern Ghana has >155 deaths / 1000 live births (Figure 2). 10-15% of these childhood deaths are caused by diarrheal disease which results, in part, from a lack of access to improved water.

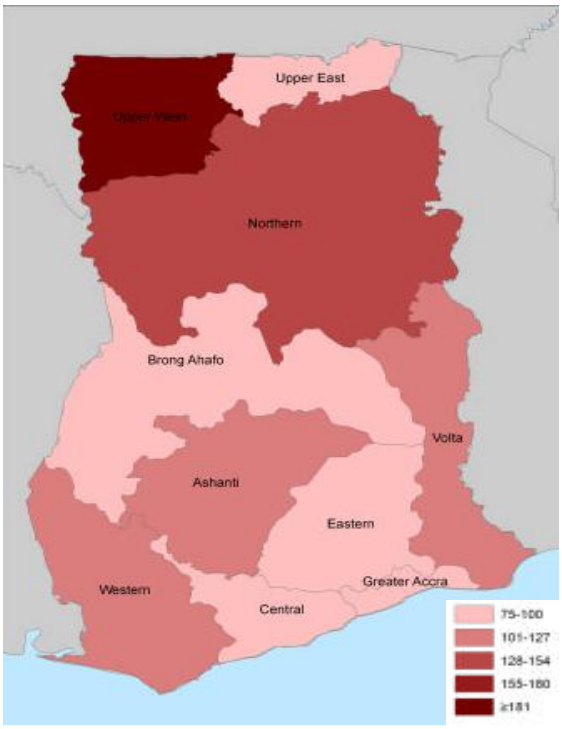


Figure 2: Ghana - Under five mortality per 1000 live births (WHO, 2006)

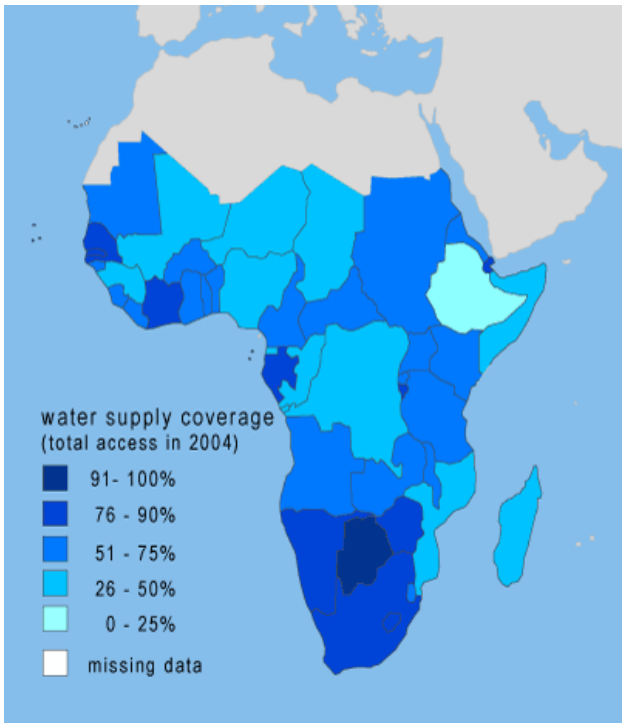


Figure 3: Africa – "Improved" drinking water coverage (WHO 2004)

As shown in Figure 3 Ghana has relatively high national reported access to improved water sources, 93% in urban areas and 68% in rural areas. However, improved water access is defined by the WHO-UNICEF Joint Monitoring Program based on source availability and type of water infrastructure, and does not account for either continuity of flow or effective use.[4] As continuity of supply and recontamination in distribution, transport and storage are key concerns for household water quality management; the percentage of the population drinking contaminated water is likely to be higher than the reported percentage of the population with access to improved sources. In addition, access to improved water

[4] 'Improved sources' are those that are likely to provide 'safe' water including household connections, boreholes, public standpipes, protected dug wells, protected springs and rainwater collection. Unfortunately, the information currently available does not allow WHO & UNICEF to establish the relationship between access to safe water and access to improved sources. Work to demonstrate the relationship between source type and water quality is ongoing (WHO-UNICEF, 2006).

in northern Ghana is lower than the national average as the northern population is predominantly rural.

As the childhood mortality and water access statistics highlight, there is a substantial need for improved water management and water treatment options in northern Ghana. As a result, Pure Home Water (PHW), the local community partner of this research team, chose to focus their work in this region, and thus the Tamale district in northern Ghana was selected as the location for the HWTS consumer research project described in this thesis.

PHW is a non-profit organization based in Tamale in the Northern Region of Ghana. Since its founding in 2005, PHW has worked to demonstrate the viability of HWTS as a complement to borehole drilling and other water supply provision. PHW's goal is to partner with organizations throughout the region to reduce, or eliminate, water-related diseases in northern Ghana initially and later throughout West Africa through the dissemination of HWTS systems. In addition, PHW aims to become financially self-sustaining through a commercial model of product sales that should ultimately allow the organization to at least break-even on expenses (PHW, 2007).[5]

PATH is an international, nonprofit organization that focuses on: "developing sustainable, culturally relevant solutions, enabling communities to break longstanding cycles of poor health." In late 2006 PATH initiated, with the support of The Bill & Melinda Gates Foundation, a five-year "Safe Water Project." The project aims to identify, evaluate, and develop appropriate HWTS products and investment strategies to enable sustainable commercial enterprises to produce, distribute, and sell these products to low-income populations (PATH). PATH's core strategic approach for the Safe Water Project is to work with existing private sector players to determine if commercial markets are a viable mode for selling HWTS products that are appropriate and affordable for middle and lower income households. Currently in the first phase of the project, PATH has focused on developing a market model by identifying, testing, and adapting a family of safe HWTS products; establishing manufacturing and distribution mechanisms; marketing and pricing them appropriately for initial purchase and continued use. The focus of PATH's safe water work to date has been in India. However, they are also exploring opportunities for the commercial approach in other markets, and thus were interested in collaborating in consumer choice research and product testing of available HWTS options in Ghana.

PHW and MIT's experience in Northern Region Ghana placed these organizations in a strong position to collaborate with PATH on this initiative. Specifically, the consumer choice research described in this thesis was supported at MIT by Susan Murcott, the principal investigator for the broader PHW-PATH-MIT project, and in Ghana by PHW personnel, especially Peter Abaazan Adagwine, Shak Ibrahim, and PHW board member Ernest Ansah. The consumer choice element of PHW-PATH-MIT project was developed as a collaborative effort between the author, a MIT Master's of Engineering student, and four

[5] PHW is legally registered in Ghana as a non-profit organization. Additional information provided in Chapter 10.3, Recommendations for Pure Home Water.

business students from MIT Sloan: Matthew Thompson, Gabriel Shapiro, Gaetan Bonhomme, and Avani Kadakia. The work of the business students culminated in a Global Entrepreneurship Lab (G-Lab)[6] report focused on the marketing implications of the consumer choice research, included in Appendix 1.

This thesis provides an overview of the consumer preference research and offers recommendations regarding which HWTS product(s) are most likely to achieve a high adoption rate at commercially viable prices over the long-term, in northern Ghana and also more broadly throughout West Africa. It is our hope that this information will help PHW, PATH and other organizations implementing HWTS solutions to target their efforts to achieve maximum impact and sustainability.

1.2 Research Objectives

Through a consumer survey and water quality testing, the team assessed the comparative value of HWTS products. The objectives of the study were the following:

- Establish baseline household profiles and consumer segments in Northern Region Ghana based on knowledge, preferences, attitudes and motivation for HWTS purchase and use;
- Characterize water quality in the baseline households through total coliform indicator tests and turbidity measurements;
- Understand rural and urban customer preference for HWTS product features through a Choice-based Conjoint (CBC) Analysis methodology;[7]
- Characterize challenges to HWTS product adoption and sustained use.

The consumer survey included two sections. First, through a baseline household profile we gathered information on demographics, purchasing decisions, ability to pay and current water treatment practices and beliefs. Next, we assessed the relative value of HWTS product features through a Conjoint Analysis. Conjoint Analysis is a statistical technique used in marketing to find out how potential customers value certain features in a feature-set that make up a product or products. For the purpose of our work we selected five attributes of HWTS products to test: 1) water look / taste; 2) product type; 3) health impact; 4) treatment time; and 5) price. A detailed description of the baseline survey and conjoint methodology, attribute levels and selection criteria can be found in the Chapter 5 of this thesis.

[6] The MIT-Sloan Global Entrepreneurship Lab (G-Lab) is an academic program that links teams of MBA students with entrepreneurs in emerging nations. The business students share their knowledge, experience, and research with business owners, helping them to design market strategies, rethink practices and priorities, and devise solutions to specific challenges. G-lab MBA students come to global entrepreneurs in teams of four students that work on the project through the fall and then travel to the project site during January (MIT-Sloan, 2008).

[7] Note: Conjoint Analysis work supported by a team of four business students from MIT Sloan. Conjoint Analysis Methodology described in detail in Chapter 4.

The technical component of this research included water quality testing from all households surveyed. We had hoped that this element would allow us to test the effectiveness of HWTS products currently in use; however, as less than 1% of the households sampled were using any type of water treatment product beyond the cloth filter (which does not reduce turbidity or faecal contamination), the water quality element became a way to characterize the baseline water quality in the urban and rural communities surveyed.

1.3 Thesis Outline

The following three chapters provide background and context for this work. Chapter 2 describes the water quality in Ghana, with a particular emphasis on the Northern Region. Chapter 3 describes the range of HWTS product options. Chapter 4 provides an overview of consumer research done to date on HWTS in the developing world, and offers historical context on the marketing methodologies used in this study.

The subsequent five chapters focus specifically on the content of this research. Chapter 5 focuses on the study design and methodology. Chapter 6 offers results of the research conducted to date. Chapter 7 provides and assessment of the relative value and cost of HWTS options available in Northern Region Ghana. Chapter 8 provides an analysis of the market landscape including product feature preferences and consumer profiles seen. Chapter 9 reflects on the efficacy of using a Choice-based Conjoint (CBC) methodology in the developing world and highlights lessons learned. Chapter 10 highlights key findings from the research and draws relevant conclusions for HWTS in Northern Region Ghana, with an emphasis on specific recommendations for PHW.

2. Background: Water Management

Safe water is critical to maintaining the good health of a population. However, water and sanitation remains a significant problem throughout much of the developing world. This section describes both the global water management challenge as well as the specific need for improved water quality in Ghana.

2.1 Global Water Management

The World Health Organization (WHO) estimates that 1.8 million people die each year from diarrheal diseases, 88% of which can be attributed to unsafe water, sanitation and hygiene (WHO, 2004). Globally, diarrheal deaths account for only 3.2% of total deaths; however, the relative disease burden is twice as high in Africa with 6.6% of deaths attributable to diarrheal disease (Nath, Bloomfield, & Jones, 2006). In addition, the waterborne disease burden is even higher than the diarrheal mortality rate suggests, as this statistic excludes the impact of diseases such as guinea worm as well as the detrimental secondary effects of frequent diarrheal episodes in terms of malnutrition and impaired growth.

The importance of investment in increasing access to safe drinking water is highlighted by the selection of this issue as one of the United Nations Millennium Development Goals (MDG). Under the MDG program, the UN aims to decrease by 50% the proportion of people without sustainable access to safe drinking water by 2015. Currently, it is estimated that 1.1 billion people globally still lack access to an "improved" water supply (Nath el. al, 2006). However, the Millennium Development effort does not capture the challenges associated with recontamination in transport from the source or in storage, which also remains a significant problem. Thus, it is likely that the actual number of people who use unsafe water globally is much larger than the UN's estimated 1.1 billion.

2.2 Water and Sanitation in Ghana

Ghana faces significant challenges in meeting the basic water and sanitation needs of its 22 million people. This challenge is magnified in Northern Ghana, particularly the rural communities, where 50% lack access to safe water (Ghana Statistical Service). Piped water is rare an infrequent in flow (personal communication, 2008), with many urban communities only receiving piped water once a week or once every other week. There has been a significant push to expand borehole drilling in the region; however, there remains a significant opportunity for HWTS to improve the livelihoods of the estimated 900,000 people in Northern Ghana that lack access to improved water sources. Furthermore, there is an opportunity to serve urban and peri-urban communities that are faced with unreliable piped water, and thus are forced to store their water for long periods, a practice which has been shown to lead to frequent and extensive recontamination (UNICEF, 2008).

3 Household Water Treatment and Safe Storage Technology Overview

As this research has been designed to help present and future HWTS interventions better target their activities and programs in northern Ghana, it is important to clearly define the range of existing HWTS options under consideration for the region.

3.1 History of Household Water Treatment

Throughout the 1990s, water quality received relatively little attention among interventions to reduce the diarrheal disease burden in the developing world. The lack of investment in water quality generally was significantly influenced by a meta-analysis by Esrey et al. (1991) that concluded that sanitation and hygiene education yielded greater reduction of diarrheal disease than water supply or water quality interventions. However, more recently, a study by Fetwell & Colford (2004) commissioned by the World Bank found that hygiene education and water quality improvements have a greater impact on the incidence of diarrheal disease (42% and 29% respectively), than sanitation and water supply 24% and 23% respectively. Currently, there is evidence to suggest that safe water in the home can reduce diarrheal disease by 6-50%, independent of improved sanitation or hygiene (Nath et. al., 2006). Furthermore a recent review of more than 38 studies covering 53,000 people found that household water quality interventions were nearly twice as

effective in preventing diarrheal disease 47% as community infrastructure such as improved wells and standpipes 27% (Clasen, 2006). The new research on the health benefits of household water treatment has helped draw international attention to HWTS; however, a consensus has not emerged about which treatment option is most effective. Furthermore, for any given community product appropriateness will also depend on site and cultural factors, so technology options must be assessed in the context of the local environment.

This research considers four core HWTS technologies and processes: 1) UV/solar disinfection; 2) chlorine disinfection; 3) particle removal (filtration or flocculation); and 4) combined treatment (particle removal and disinfection). In addition, we chose to consider bagged "sachet" water in this assessment. Although it is not a water treatment method, 'sachet' water provides a safe drinking water option for target, and has emerged as a popular water choice throughout Northern Ghana (Okioga, 2007).

3.2 Overview of HWTS Product Options

This section provides a brief overview of available HWTS options. Additional information on the cost and benefits of these technologies can be found in the fact sheets section offered by HWTS Network Tools (MIT, 2008) and the Wilson Center's "Household Water Treatment and Safe Storage in Developing Countries: A Review of Current Implementation Practices" (Lantagne et. al., 2006). The results of specific HWTS interventions have been consolidated by the International Scientific Forum on Home Hygiene in a report entitled, "Household water storage, handling and point-of-use treatment" (Nath et. al., 2006)

SODIS / UV

Solar disinfection is a simple and cost effective household treatment option in which clear plastic bottles are filled with low-turbidity (<30 NTU) water, shaken vigorously for oxygenation and then left outside, typically for six hours if it is sunny and two days if it is cloudy (EAWAG, 2008). After the set UV disinfection time defined for the local region, the UV radiation will have disinfected the water and it can be safely consumed. At this point, the plastic bottle acts as a safe storage container helping to protect the disinfected water from recontamination. Several recent studies have demonstrated a significant reduction of diarrheal disease using this method, especially among children under five (Conroy et al., 1996). Despite its ease of use and demonstrated effectiveness in other markets, SODIS was not considered in this research as both polyethylene (PET) and SolAqua products (Figure 4) have been shown to be relatively ineffective in Northern Region Ghana given the turbidity of local water sources and reduction of solar radiation due to extremely high atmospheric dust during the harmattan winds, November-March (Foran, 2007; Yazdani, 2007).

Figure 4: SODIS Product Testing, SolAqua in Northern Ghana (Foran, 2006)

Chlorination (disinfection only):

Disinfection through chlorination has been a known water treatment method since at least the early 1900s; however point-of-use chlorination did not emerge as a scalable HWTS option until the 1990s. During this period, the Pan American Health Organization (PAHO) and U.S. Centers for Disease Control (CDC) developed the Safe Water System (SWS) based on chlorination with dilute sodium hypochlorite solution, safe storage and hygiene education.

Effective chlorination requires the user to place the correct dose of the chlorine solution in a storage container (a larger dose is required for turbid water), agitate the water and then wait for 30 minutes before consumption. Chlorination is less effective in highly turbid water (>30 NTU) as the microbial contaminants are somewhat protected by the particulates in the water (Nath et.al. 2006). Across a number of randomized control trials, SWS has been shown to reduce diarrheal disease by as much as 44-84%. Population Service International (PSI) is a NGO that has utilized a social marketing model to implement SWS in a number of developing world countries. For example, in Zambia, PSI branded the chlorine product (Chlorin) and generated demand through behavior change communications such as radio and TV spots and point-of-sale materials (Lantagne et.al., 2006). However, despite some success, PSI has not been able to increase the price to cover full costs.

One alternative to liquid chlorine has been developed by Medentech, an Irish company. In addition to other products, Medentech markets chlorine tablets called Aquatabs[8] that come in a variety of doses including a 20 liter HWTS dose (Figure 5). Aquatabs have recently been introduced in Ghana and may be easier for consumers to transport and use than the liquid chlorine product traditionally used in the Safe Water System, but they are relatively more expensive per liter. In addition they must be used in a 20 liter container, so a product-specific protocol must be developed to stimulate effective and sustained use.

Figure 5: Chlorine disinfection - Sodium hypochlorite (CDC, 2008) and Aquatabs (Medentech)

[8] Aquatabs are effervescent (self-dissolving) tablets which, when added to unsafe drinking water, make the water safe to drink. Aquatabs utilize the active ingredient sodium dichloroisocyanurate (NaDCC), also known as sodium troclosene and sodium dichloro-s-triazine trione. The NaDCC used in Aquatabs is approved by the US EPA and NSF International for routine treatment of drinking water for human consumption (MIT Watsan, 2008)

Particle Removal Options (filtration and flocculation)

Household scale filtration uses inexpensive local materials such as clay or sand to treat water, making it an attractive HWTS option for low income communities. However, filtration products often require some technical expertise to build and maintain, and lack of residual protection remains a key concern. There have been various studies on the efficacy and health impact of household filtration systems, including several researchers have shown positive results including: Peletz, 2006; Johnson, 2007; Brown, 2007, Stauber, 2007; and Kikkawa, 2008.

Four distinct household filtration options have been developed: 1) cloth filter, 2) biosand filter, 3) ceramic pot filter , and 4) candle filter (Figure 6). The first, and simplest, is a cloth filter which does not reduce turbidity or microbial contamination, but is effective in the removal of larger disease vectors such as the cyclops, which is responsible for the transmission of guinea worm disease. The second filtration option is the biosand filter. This slow-sand system was originally developed for centralized treatment at the community scale, but has been modified to provide a HWTS option. Biosand filters are relatively easy to use, and the flow is immediate and substantial enough to provide water not only for drinking but also for cooking and washing. Biosand filters have been shown to reduce bacteria and viruses by as much as 90% (HWTS Network Tools); however, recontamination remains a significant concern. Furthermore, biosand efficacy has not yet been demonstrated in the extremely turbid waters seen in Northern Ghana, although local studies are currently underway (Kikkawa, 2008). Ceramic filters offer a third filtration option. The ceramic products help limit recontamination as they are combined with a safe storage container, but they also have a slow flow rate with a maximum of only 1-4 liters / hour. One of the most well-known and widely distributed ceramic filters is the "Potter's for Peace" model which is shaped like a flowerpot and impregnated with colloidal silver. It has been shown to remove 99.9% of bacteria (Johnson, et.al. 2008), but must be cleaned regularly to ensure a continuous flow. The "Potter's for Peace" style filter provides a safe storage container with a tap, which helps to limit recontamination; however, as there is no residual chlorine protection the user must be trained to clean the ceramic filter element frequently. PHW's primary product, the *Kosim*, is a ceramic pot filter which has been distributed to 10,000 households to date in Northern Ghana. More expensive versions of the ceramic filter are also available on the market (e.g., British Berkefeld; Katadyn). These higher-end models tend to have cylindrical ceramic "candles" sometimes containing colloidal silver or additional media such as activated carbon. Candle filters are primarily used by high-income households and foreign travelers in Ghana, but have not reached a price point where they are an option for wide-spread distribution. Overall, household filtration is an attractive HWTS option; however, there is some variation in efficacy, ease of use, and cost between filter types and designs, so site specific product assessments should be conducted before introduction in a new market.

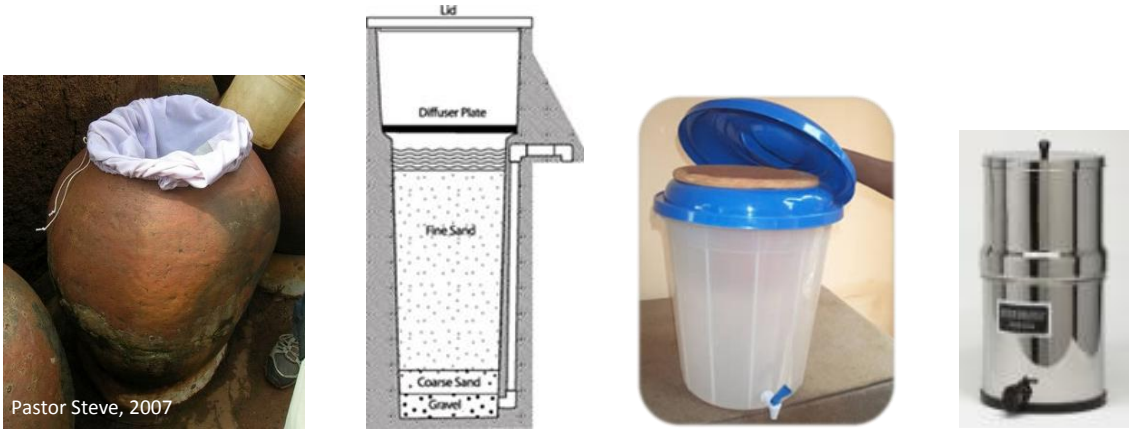


Figure 6: Household filtration options - Cloth, biosand, ceramic pot, and candle filter

Particle removal may also be achieved by using a flocculent such as moringa seed or alum[9]. Such products are locally available in Ghana and have traditionally been used to manage water with very high turbidities. Flocculants are known to effectively remove suspended particles and improve microbial quality. Preliminary research on alum coagulation in Northern Ghana has demonstrated 99.7% removal of total coliforms and 99.4% removal of *E. coli* (Foran, 2006). This removal rate is comparable to that achieved with biosand or ceramic filters. However, as flocculants do not remove all the microbial contaminants during the treatment process, they are not being considered here as a stand-alone HWTS option.

Combined System (Particle Removal + Disinfection) Options

Combined particle removal and disinfection options have recently been developed to more effectively manage the highly-turbid, microbially contaminated surface waters being used as household drinking water sources in many parts of the developing world.

The best-known combined treatment product on the market is PuR™, a single-dose product produced and widely marketed by Proctor and Gamble (P&G) as a part of a collaborative effort with the United States Centers for Disease Control (Figure 7). PuR™ is sold in sachets designed to treat 10 liters of water, and includes a flocculent (ferrous sulfate) as well as chlorine disinfectant (calcium hypochlorite). PuR™ is sold at cost for $0.035 cents per sachet to non-profit organizations, such as PSI, who are currently engaged in product testing and distribution in East Africa. In addition, PuR™ can be bought commercially by retailers and travelers for $0.05-$0.11/sachet. PuR™ has been extensively tested and shown positive health impacts in Pakistan (Luby et.al., 2006), and Kenya (Crump et.al., 2005). However, PuR™ is not currently being considered as an option for Northern Region

[9] Alum is aluminum sulfate (Al2 (SO4)3).H2O which is perhaps the most commonly used coagulant worldwide. A coagulant is a chemical which, when added to water, enables small particles to aggregate into larger flocs. Coagulation is a widely applied process in urban water treatment plants around the world, and is also sometimes applied at a household scale, for example, in India parts of Southeast Asia and China (MIT WatSan, 2008)

Ghana in part because of its relatively high cost but also because it is not currently available in the region.

An alternative option for combined treatment is to use two distinct products in combination such as a *Kosim* ceramic pot filter or alum followed by a chlorine product, such as Aquatabs (Figure 7). Such combinations using two distinct HWTS methods in separate steps have received very limited research to date. However, water quality impacts of combining *Kosim* with Aquatabs has recently been studied in northern Ghana (Swanton, 2007), and a few experiments using alum as a flocculent followed by chlorine have shown the positive impacts on diarrheal outcomes (Reller et.al. 2003). Therefore, such products may offer a locally relevant solution for the low-income communities with highly turbid water seen in Northern Ghana. However, widespread implementation will require the development of an effective model for dosing and effective use.

Figure 7: Combined treatment options - PuR™ sachet or Alum + Chlorine Disinfection

Sachet Water

Finally, sachet water has emerged as a popular choice among urban populations in cities and town throughout the developing world. In Ghana, there are two types of sachet water: hand-tied and factory-produced. These products tend to be produced in bulk in a centralized location, and then sold in individual units in local markets and road-side stands (Figure 8). The sachet product has demonstrated commercial viability in Ghana, and thus it offers an interesting benchmark and microenterprise model. For a detailed description of the production and water quality seen in sachet water in Tamale, Ghana the reader is referred to "Water Quality and Business Aspects of Sachet-Vended Water in Tamale, Ghana" (Okioga, 2007).

Figure 8: Production and sales of hand-tied sachet water in Tamale

HWTS Tradeoffs: Role of Consumer Preference

As highlighted in the high-level product overviews above, efficacy of HWTS interventions varies by geographic region, source water characteristics and community type. HWTS adoption rates and project sustainability depend heavily on the cultural relevance of the HWTS solution selected, the implementation strategy and the local ability and willingness to pay. Therefore, consumer understanding along with assessments of product appropriateness for local conditions and relative cost are needed to determine which products have the greatest potential for long-term sustainable impact in a given region.

4 Background on HWTS Consumer Preference Studies

There are several HWTS product options available in northern Ghana that have the potential to significantly improve the local drinking water quality. However, to date, the region has failed to see significant HWTS product adoption and sustained use. Data collected through consumer preference studies can stimulate product uptake by helping implementing organizations tailor water quality interventions and marketing efforts to local preferences and needs. In this case, the consumer choice study has been designed to assess a range of drivers of HWTS product adoption in both urban and rural communities. In addition, customer segments are identified to characterize relative differences between local populations in terms of product preferences, water treatment needs, and ability to pay.

4.1 HWTS Consumer Choice Research in the Developing World

Water projects in the developing world have suffered from poor performance due, in part, to a lack of consumer adoption of water infrastructure and/or new HWTS products. Consumer understanding is viewed as a key barrier to sustained use of improved water

sources and products, and thus local consumer choice research has emerged as a critical element of successful HWTS interventions.

Clean Water: A Right or Economic Good

The question of whether developing world consumers should be charged for clean water supply and/or household water treatment products has been extensively debated and a consensus has not been reached.

First, access to a regular supply of safe water is widely viewed by the international development community as a basic human right. According to Kofi Annan, United Nations Secretary-General:

> *"Access to safe water is a fundamental human need and, therefore, a basic human right. Contaminated water jeopardizes both the physical and social health of all people. It is an affront to human dignity."*

In 2002 the United Nations Committee on Economic, Social and Cultural Rights officially recognized water an independent right (WHO, 2003). An in-depth discussion on the rights-based approach to development and specifically the evolution of the inclusion of water as a basic human can be found in "*The Right to Water*" published by the World Heath Organization in 2003.

The rights-based approach strives to empower local people to use legal systems to achieve basic human rights, such as safe water. Under this model, the principles of freedom from discrimination and equality can be used to rule out exclusion from access based on ability-to-pay (WHO, 2003). Therefore, the declaration of water as a right has bearing on the role of water as an economic good. Since the early 1990s, international development projects have strived to establish sustainability by pricing products slightly above the cost of production. Through a social entrepreneurship approach, NGOs and local entrepreneurs have sought to use the market forces of supply and demand to sustain the project independent of donor funding. The social market-based development paradigm frequently focuses on using social marketing to stimulate demand for health and/or water treatment products, which are concurrently brought into the marketplace to meet the stimulated need. Market-oriented sustainable development is based largely on a capitalist model that suggests that unless people are willing to pay for a product they will be unlikely to value it (Shea, 2007). However, several recent studies have challenged the validity of this paradigm by demonstrating that payment is not closely correlated with product adoption and sustained use. For example, a recent study called the "Illusion of Sustainability," by Kremer & Miguel (2007) found that charging a fee for medications in Kenyan schools reduced adoption from 75% to 19%. Similarly, recent research on adoption of a chlorine treatment product in Zambia found that higher prices do screen out less intensive product users, but do not increase product use among those that do adopt (Ashraf, Berry, & Shapiro 2007).

In contrast, at the community level, pricing water at full supply cost has been shown to have a positive impact on equity, efficiency and sustainability in the water supply (Rogers, Silvia, & Bhatia, 2002). Proponents of full-supply pricing argued that removing water subsidies can in fact serve to enhance equity of access and long-term system sustainability by reducing overall demand and providing funds for expansion of supply into previously underserved communities.

Contingent Valuation: Willingness to Pay Assessment

The international development community has not reached agreement regarding the utility of charging impoverished developing world consumers for clean water and/or HWTS products; however, if a commercial "double-bottom line" approach is desired an assessment of willingness to pay is critical to successful project implementation. The Contingent Valuation approach to assessing relative value and cost of water infrastructure projects emerged in the 1980s following a series of disappointing investments in water supply systems (Whittington & MacRae 1988). Poor project management and lack of funding for maintenance clearly contributed to poor long-term performance of water infrastructure projects; however, a fundamental lack of understanding of the dynamics of local demand for improved water systems also contributed to the decline of water infrastructure investments. As the provision of clean water was viewed as a basic right, the focus was on rapid scale-up of supply, and thus there was limited incentive for governments or international development agencies to incorporate the preferences of local communities into water infrastructure development efforts (Whittington, 1988). Contingent Valuation helps incorporate the consumer perspective by asking consumers to respond to a series of scenarios, provides additional information about the response of consumers to new water supply options.

At the household, it was historically assumed that as long as the cost of the new water service did not exceed 5% of income, consumers would choose to adopt (Whittington, Briscoe, Mu, & Barron 1990). However, the 5% approach failed to capture individual differences in willingness to pay and desired level of service. Consequently, Contingent Valuation bean to be used to assess willingness to pay for water treatment products or improved water supply alternatives. A complete description of the development of Contingent Valuation methodology to assess willingness to pay in developing countries can be found in "Estimating willingness to pay for water services in developing countries: A case study on the use of contingent valuation surveys in southern Haiti" (Whittington, D., 1990).

Further research has utilized Contingent Valuation to more accurately assess what people are willing to pay for access to improved water sources (McPhail, 1993). Here a bidding game was used to demonstrate that low income households may be willing to pay more for improved water access, 8.0-8.2% for households with and without electricity respectively, than the 5% of income typically used for cost calculations. Furthermore, it has been estimated that low income people may already be spending as much as 20% of their budget on water, and thus their willingness to pay will likely be relatively high, particularly if the

service is reliable (Moor & Calamai). In addition, Contingent Valuation research has demonstrated the expected correlation between willingness to pay for improved water services and more concrete variables such as household income, perceived seriousness of water contamination and demographics (Pattanayak, Yang, Whittington & Kumar, 2005), suggesting that the methodology is capable of capturing real differences in consumer perceptions.

Emergence of Micro-Market Models

Contingent Valuation willingness to pay assessment is inherently limited by the bias generated by asking for hypothetical preferences. Therefore, in recent years, micro-market models have been developed that offer a more robust tool for assessing actual willingness to pay (Ashraf, 2007). In the case of HWTS micro-market model, consumers are offered the opportunity to purchase a water treatment product at a randomly chosen discount price, and actual purchasing behavior is assessed. In addition, to willingness to pay micro-market models can be used to test the relative efficacy of various HWTS product marketing scripts and sales channels. However, micro-market studies are poorly suited to a multiproduct assessment as the large number of variables significantly drives up the desired sample size (Glennester, personal communication, October 2007).

4.2 Multi-Feature Consumer Research: Conjoint Analysis Methodology

Conjoint Analysis is a statistical technique used in marketing to test how potential customers value certain features in a feature-set that make up a product or products. The methodology is based on the premise that people cannot reliably express how they weight separate features of any given product, but researchers can assess the relative preference for various features through repeated evaluations of product concepts (Orme, 2006). Conjoint Analysis emerged as a statistically robust tool to improve product design and marketing while avoiding expensive and time-consuming market tests which are inherently limited in the number of features that can be tested simultaneously.

The way in which complex consumer preferences can be incorporated into product development is highlighted in literature from Sawtooth Software[10]

> *"Humans evaluate overall desirability of a complex product alternative based on a function of its separate (yet conjoined) parts."*

A Choice-based Conjoint (CBC) seeks to incorporate these trade-offs into the survey design.

> *"In contrast to answering direct questions about individual product features, conjoint survey respondents cannot simply say that all features are important – they must trade off different*

[10] Sawtooth Software is a privately owned company founded in 1983 located in Sequim, WA. Sawtooth produces software tools for interviewing and data analysis, and supported this research by providing access to their Conjoint Analysis software.

aspects of the product (as in real life), weighing products that have both highly desirable and less desirable qualities (Sawtooth, 2008)."

Therefore, CBC has emerged as the methodology of choice for complex consumer preference studies as it most closely matches a real market scenario where customers simply chose the product they most prefer. Research from Sawtooth Software shows that today, thousands of CBC studies are conducted each year, and organizations throughout the developed world are successfully using the results to design new products and make more profitable pricing decisions. As the HWTS study described here sought to collected data on a number of product features across a large range of HWTS products, CBC was good fit for our research objectives.

Conjoint Analysis in the Developing World

Little experience had been documented to date on multi-feature conjoint analysis in developing world environments. Focus groups using a similar choice task methodology have been utilized to identify HWTS customer segments with some success in rural India (Austin, personal communication, November 2007); however, integrated assessments of product feature preference have typically not been utilized in development work. Through the support of Sawtooth Software, the MIT team was able to use a web-based platform for CBC survey generation and data analysis. As developed for this study, CBC proved a relatively low-cost tool to enhance consumer understanding across a number of critical elements of HWTS product design.

5 Methodology: Consumer Choice Research

The methodology for this research was formulated in conjunction with a team of four Masters of Business Administration students from MIT-Sloan School of Management. From October 2007 to January 2008 the team worked to develop a consumer choice survey instrument and gain approval from PATH, our project sponsor. During the month of January 2008, the team spent four weeks on the ground executing the survey and collecting water quality data. Throughout January, the MIT team worked closely with four Ghanaian surveyors who helped to refine the methodology and execute the research. The field research phase officially ended on January 25th, after which time the author was responsible for the data integration and analysis described in this thesis. The work of the business team culminated in a Global Entrepreneurship Lab (G-Lab) report focused on marketing implications of the research (Appendix 1).

5.1 Survey Design: Tools and Methodologies

During the planning phase, the team sought to develop a consumer research protocol to assess the relative attractiveness of a variety of HTWS options. Initially, the team considered marketing a range of products in the field. This type of micro-market approach has proven to be an effective way to assess consumer willingness to pay and evaluate point-of-use treatment program efficacy (Ashraf, et.al., 2007); however, through

conversations with individuals from The Jameel Poverty Action Lab (JPAL), we learned that a sample size of at least 1000 would be required to use a randomized marketing methodology to test the number of product trade-offs we wished to assess. Undertaking such a large-scale research endeavor was beyond the scope of this research, thus we sought alterative consumer research tools. Ultimately, we decided that a Choice-based Conjoint (CBC) Analysis would be an effective approach for our research scope. Specifically, this methodology is effective for smaller studies because the number of trade-offs made by each individual allow for higher statistical significance with a smaller sample size.

In addition to the product feature trade-offs made in the conjoint, the team wanted to collect baseline data on all households surveyed to assess difference in behaviors and preferences between market segments. Furthermore, as the relative efficacy of different HWTS products depends on the quality of the source water, we hoped to use water quality testing to characterize the water of the sample populations. In addition, we hoped that some individuals would be using HWTS products, and that we could use the water quality testing element to make an initial assessment of the efficacy of the HWTS options currently on the market. However, we did not want to bias our study toward any particular product, and thus we selected communities where there had not been any significant HWTS interventions.

5.2 Survey Elements

Ultimately, the team developed a survey instrument that included four elements:
1) informed consent and confidentiality of participants, 2) a baseline survey, 3) a conjoint assessment, and 4) water quality testing. The survey was designed to allow us to gather the information required to develop customer profiles and to understand interest levels and willingness to pay for specific product features. We hoped to use this information to make recommendations about product choice that would be useful for implementing organizations in Northern Region Ghana. The final version of the informed consent script and survey instrument can be found in Appendix 2.

Informed Consent

The survey instrument started with an informed consent section which gave the respondents background on our research, explained their rights, and gave them the option to accept or decline participation. The complete informed consent script can be found with the survey instrument in Appendix 2.

Baseline Survey / Customer Segmentation

The goal of the customer segmentation section was to gather the information required to develop HWTS customer profiles. The team hoped to use these profiles to identify target customer segments, and assess behavioral differences between the different communities seen in Northern Region Ghana. The customer segmentation section of the survey

included four elements: 1) Household Information, 2) Purchasing Decisions, 3) Ability to Pay, and 4) Current Water Practices.

The researchers hoped to combine this data with the HWTS product feature preference determined through the Choice-based Conjoint (CBC) analysis to assess which products were the best fit for which segments of the target population.

HWTS Feature Preference / Conjoint Analysis

The goal of the CBC element was to determine which HWTS product features are the most desirable to the target customers. To develop the conjoint tool, we initially brainstormed features of HWTS products which we might want to test in the study. These included: water look, water taste, product look, product durability, health impact, ease of transport, treatment time, storage volume and price. We then eliminated features that we could assess through the baseline survey such as demand for large storage volumes and ease of transport. Next, we selected levels to be displayed as trade-offs in conjoint tasks:

- Water Look: clear vs. turbid
- Water Taste: crisp vs. chlorine vs. earthy
- Product Look: traditional vs. modern
- Product Durability: consumable vs. durable
- Health Impact: major impact vs. minor impact
- Treatment Time: less than 30 min vs. more than 30 minutes
- Price: low price vs. high price

We wanted to reduce the number of features to keep from overwhelming the respondents effective trade-offs, but we felt that each attribute was important for the research. We tried to prioritize by focusing on those product features critical to describing differences between source water conditions and potential treatment options for Ghana. Ultimately, we decided to combine features where there was only a select range of options in Ghana (i.e., water look was combined with water taste and product look was combined with product durability). In addition, we had an extended debate about the inclusion of a health impact feature. We felt that this attribute might bias the choice selection toward this feature as customers had been conditioned to believe that point-of-use water treatment products were purchased to improve their health. On the other hand, the team wanted to assess the relative importance of health impact as compared with the other product features.

After selecting the desired feature set, we developed a set of images to help depict the choices to our target audience. We felt that this step was critically important, as the task screens were written in English and thus needed to be displayed to the potentially illiterate Dagbani-speaking respondents in a pictorial way that could easily be understood. The final feature set and images developed is shown below (Figure 9).

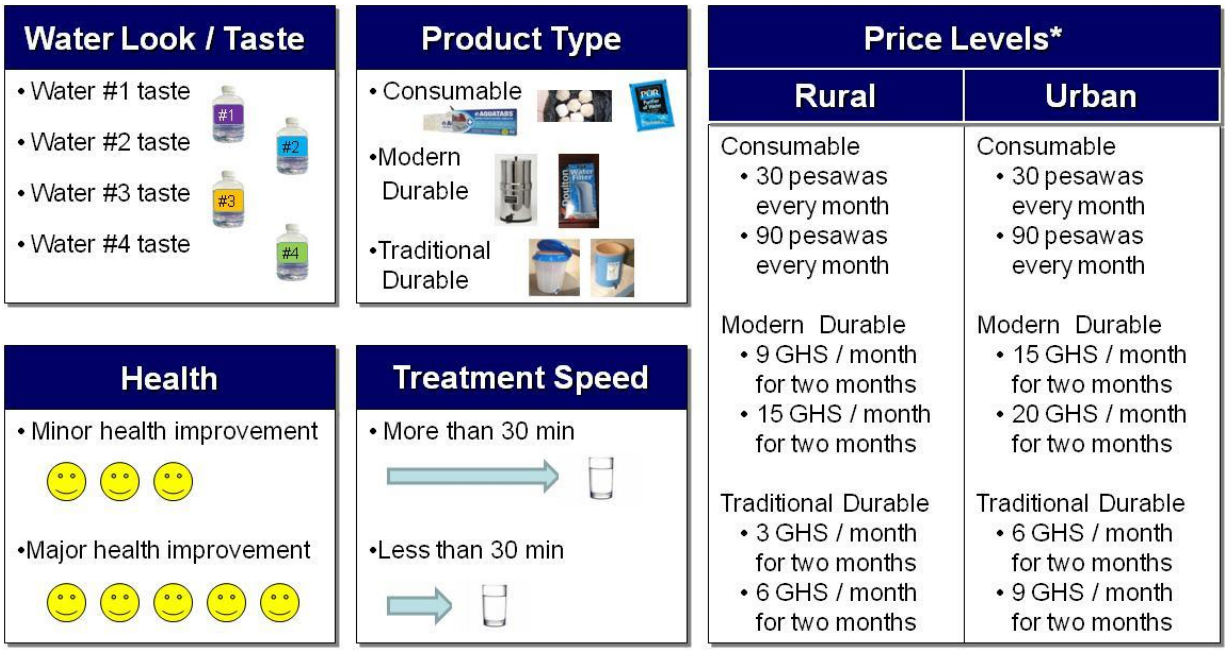


Figure 9: Final Conjoint Analysis Feature Set and Images[11]

The researchers planned to show twelve different task screens per interview (Figure 10). Each participant would be asked to choose between the options shown on each task screen, and by amalgamating all the data the researchers could draw conclusions about the relative importance of HWTS features. Ultimately the number of task screens was reduced to eight based on feedback from PATH as well as enumerators concerns about respondent fatigue.

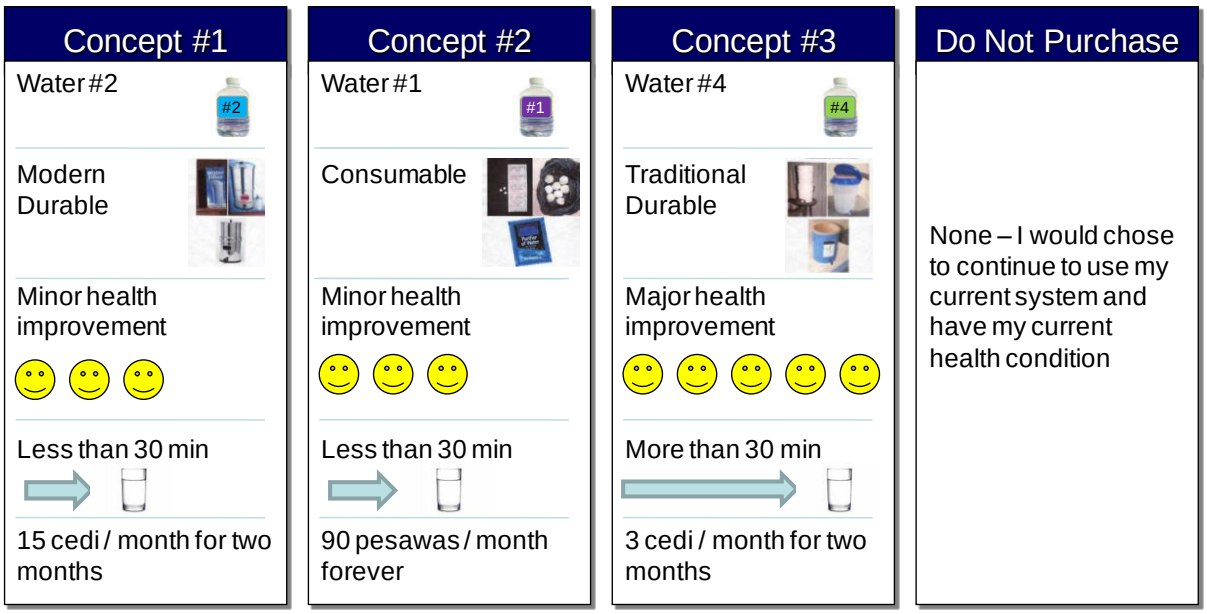


Figure 10: Example Task Screen - Rural Survey

[11] Note: Initial price levels set based on local prices; as originally quoted in new Ghanaian Cedis (GHS)

Following the planning phase, the survey instruments were vetted with our local survey team and a two day pre-test was conducted in a village approximately 10 minutes by car from Tamale. To facilitate effective communication, each task screen was placed in a laminate sheet and bound together for the surveyors use. In addition, the researchers prepared a number of props to help explain the product features shown in the conjoint.

To communicate water look / taste, the team prepared four bottles of water that could be used to demonstrate the different tastes. Water #1 was Voltic[12] bottled water taken straight from the bottle. Water #2 was municipally treated water dosed with Aquatabs[13] to give a chlorine taste. Water #3 was turbid water taken from the Ghanasco dugout in Tamale and boiled for fifteen minutes. Water #4 was Ghanasco dugout water filtered through the *Kosim* filter to give an earthy taste and then boiled for fifteen minutes to ensure safety. Water was served to respondents in disposable plastic cups. The water was changed every day, and the bottles themselves were replaced every two to three days to address contamination risk.

Product type was described using full-size sheets showing the products. The color images[14] were placed in laminate sheets for the surveyors to refer to while describing the differences in product type. In addition, the researchers made sure that the product type images shown were visually linked to those on the task screen. As product type was only one feature of the consumer choice task, the researchers did not want to overemphasize a single product look, so multiple examples were shown for each product type (Figure 11).

Figure 11: Conjoint props product type images

[12] Voltic water is a high-end bottled water product produced in Ghana. It is produced by a Ghanaian company and is among the most expensive and widely distributed bottled water products in the region.
[13] Aquatabs is a chlorine product designed for emergency water treatment, but recently applied in HWTS development applications. It is and sold locally in Tamale. The parent company is Medentech located in Ireland.
[14] All products shown are available in Ghana with the exception of PuR™

To help communicate health challenges associated with waterborne disease the researchers used images that had been prepared by a local artist for PHW. The images show some potential negative effects of poor health, such as diarrhea, tiredness, and expensive hospital visits (Figure 12). Alternatively the healthy images show people engaged in daily activities such as farming, attending school and playing a common board game (Figure 13). The researchers were concerned that this element would place an undue amount of emphasis on health; however, during the pre-test the survey team expressed that they very much liked working with the images, so we chose to continue using them throughout the research.

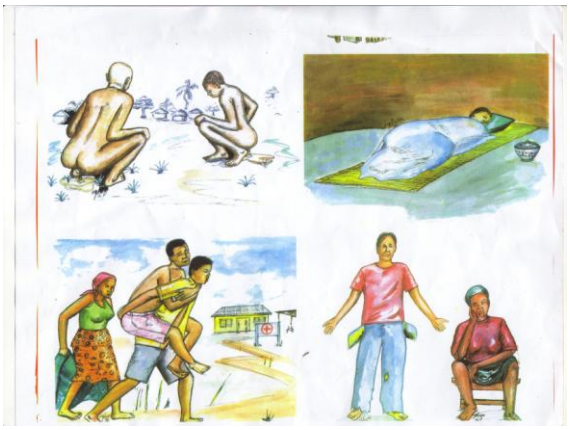


Figure 12: Conjoint props health images (impact of waterborne disease)

Figure 13: Conjoint props health images (benefits of no waterborne disease)

It was ultimately decided that no props were necessary to communicate treatment time and price, although the researchers were aware that this had the potential to introduce a bias towards those features that were described using colorful props.

Following the pre-test a number of wording changes were made to the survey instrument. In particular, the price of the items was converted to old cedis (x10,000 GHS) because the respondents and the surveyors appeared to be much more comfortable with that currency metric which was officially in effect until June, 2007. During the pre-test, the MIT team was pleased to observe that the survey respondents appeared to be able to process the trade-offs between the five features shown. Thus, no features were removed from the conjoint design. Additional details on the design of the conjoint method and delivery are included in Appendix 3.

Water Quality Testing

Water testing was conducted to characterize the water quality conditions in each household surveyed. One water sample was collected from the drinking water supply of each household surveyed[15]. Samples were collected in sterile Whirl-Pack® bags, placed on

[15] Typically samples were collected from a large earthen drinking water vessel, located either in the family's central courtyard or inside the hut.

ice and processed in the afternoon 2-4 hours after the completion of the day's surveys. Specific water quality tests conducted included turbidity and the 3M™ Petrifilm™ test for the enumeration of *E.Coli* and total coliform. Chlorine residual tests were not conducted. The procedures for the two types of water quality tests used are described below.

Turbidity is a physical property of water used to characterize of the amount of suspended particles and molecules in the water sample. It can be measured electronically by a turbidimeter or with a turbidity tube; the later was selected for this research largely because of ease of use in the field. Turbidity tubes are transparent, one inch diameter and one meter long clear plastic tubes closed on the bottom end and open at the top. The closed end has a "bull's eye." The well-mixed representative sample is poured into the tube until the "bull's eye" is no longer visible. The amount of water required for the "bull's eye" to disappear will depend on the turbidity of sample being tested. Turbidity tubes have calibration marks that are spaced in such a way as to give equivalent turbidities in turbidity units (TU).

E.coli and total coliform were used as indicators to assess water quality. Both indicators are described in the 3rd Addition of the WHO Guidelines for Drinking Water Quality (2003), which are summarized below. Escherichia coli (E.coli) is considered the most suitable index of faecal contamination as it occurs in high numbers in human and animal feces and water subject to recent faecal pollution. Thus, E.coli is the first organism of choice in monitoring programs for verification including surveillance of drinking water quality. Total coliform include a wide range of both faecal and environmental bacteria that can survive and grow in water. Therefore, total coliform is not useful as an index of faecal pathogens, but they can be used as an indicator of treatment effectiveness and to assess the cleanliness of distribution systems. However, as a disinfectant indicator, the total coliform test is slower than direct measurement of disinfectant residual.

The 3M™ Petrifilm™ *E.Coli* / total coliform (TC) test uses sample-ready plates for conducting bacterial indicator tests that can identify both *E.coli* and total coliforms concurrently. The plates are coated with Violet Red Bile (VRB) nutrients, a gelling agent, an indicator of glucuronidase activity (which is a characteristic trait in *E.coli*), and an indicator that enables colonies to be counted. A top film on the plate traps gas produced by lactose fermenting coliforms and *E.coli*. One milliliter of sample was applied to each 3M™ Petrifilm™ plate. The samples were incubated for 24 hours at 35°C in a Millipore Portable Single Chamber Incubator Model Number XX631K203 after which time *E.coli* colonies were identifiable as blue colonies with gas bubbles, while Total Coliforms were the sum of red and blue colonies with gas bubbles.[16]

Survey Approval

[16] 3M™ Petrifilm™ E.Coli / TC tests require a 1 milliliter (ml) sample and results are typically expressed as the actual number counted per plate per milliliter. However, because the standard form for reporting *E.Coli* / TC uses a unit of total coli-forming units (CFU) / 100 ml we multiplied both the numerator and denominator by 100 in our presentation of 3M™ Petrifilm™ results in this report.

Prior to initiating field research, the survey instrument and methodology was approved by both MIT Committee On the Use of Humans as Experimental Subjects (COUHES) and PATH Human Subjects Protection Committee (HSPC). It was determined that the research project described in this thesis qualified for exempt review status as defined in the federal regulations, 45 CFR 46.101 (b) (3), and while in Ghana approval to proceed was granted by PATH HSPC (Internal communication, Elizabeth Trias, January, 10 2008).

5.3 Data Collection

Following the completion of the two-day pre-test and the approval of the final survey instrument, the MIT-PHW team worked closely with four Ghanaian survey enumerators over three weeks of research. Respondents were selected at random from seven local communities, for a total of 237 completed surveys. This section describes the methodology used to train the field research team and select communities, households, and respondents for the survey.

Field Research Team

The field research was conducted by four survey teams, including 5 MIT graduate students and 4 Ghanaian surveyors, and supervised by the principal investigator S. Murcott. Prior to the arrival of the MIT team, PHW representatives Ernest Ansah and Peter Abazzan Adagwine had secured a high-quality survey team, based on recommendations provided by S. Murcott and the Center for Disease Control (CDC). The professional team selected had previous experience working with the CDC on HWTS research in 2007, and were able to commit six days per week to this study. Because the local survey enumerators hired had professional experience and were native speakers of the local language, Dagbani, it was not necessary to hire additional local guides or translators to complete our research. Before beginning the actual survey testing in households, the MIT / PHW team spent two days reviewing the survey instrument with the Ghanaian surveyors, and adapting the wording and choices to local norms. The team also reviewed the pictographs to check meaning. During this orientation period, the local survey team was also trained in the delivery of the conjoint.

Survey enumeration is a particularly critical challenge for consumer preference research in the developing world. Whittington (2002) offers a detailed overview of best practices in survey enumeration. In particular, twelve pieces of concrete advice for training of survey enumerators are offered in Table 1A (Whittington, 2002, pp 349-350).

1. *Read every question exactly as written in the questionnaire – do not improvise*
2. *Read questions slowly enough that the respondent can understand*
3. *Wait for the respondent to answer*
4. *If the respondent can't answer repeat the question*
5. *Remain absolutely neutral about the respondent's answers*
6. *Don't act embarrassed about a respondent's answers to sensitive questions*

7. *Never suggest an answer unless the instructions say to read the answers*
8. *Don't repeat the respondent's answers*
9. *Conduct the interview in private*
10. *Do not give advice to respondent's on personal matters*
11. *Answer directly any questions the respondent has about the purpose of the survey*
12. *Listen carefully to the respondent's answer*

The researchers aimed to meet rigorous survey enumeration standards; however, due to short timelines and unexpected local circumstances, the researchers did not provide all copies of the written questionnaires in the local language, Dagbani and did not conduct the interviews in complete privacy. It is recommended that enumerator training be completed over a 4-6 week period (Whittington, 2002). In the case of this study, the researchers had only 3-4 weeks to complete the entire survey. Thus, timelines were condensed which removed the opportunity to abide by the comprehensive set of training tools recommended for consumer preference surveys. However, apart from the limitations described Whittington's advice was followed by the research team. Following the two-day enumerator training, the team conducted a two-day pilot study, during which the researchers determined that each enumerator could conduct four to five high-quality surveys per day. Although this number was lower than we had initially hoped, we felt that data quality was critical for the conjoint so we opted to abide by this limit.

Survey Instrument Translation

All elements of the survey were conducted by the surveyor in the local language, Dagbani. However, as Dagbani is predominantly an oral, not a written language, it was not necessary for the MIT team to provide all of the 269 surveys required for the pre-test and study in Dagbani. Although there was a Dagbani version of the survey instrument available; in practice, each surveyor translated the questions and interpreted the responses independently in the field, and thus were not heavily reliant on the written Dagbani translation.

Prior to starting the study, the MIT team worked to complete a translation and back-translation of the written survey instrument. This task was more complicated than expected for a number of reasons. First, Dagbani is a simple language with only 6,000 documented words (Mahama, I. 2003). Dagbani is mostly a spoken language, and typically not expressed in written form. English is the official national language and it dominates in professional and academic settings. In general, Bible translation facilities appear to have the most developed translation capabilities and are one of the few places that have the ability to type in Dagbani. Therefore, we first spoke with the typist at one such facility. Unfortunately, he was not comfortable doing the English to Dagbani translation, and asked us to provide a hand-written Dagbani version for him to type. Thus, we took the document to a pastor who was able to complete the translation. Subsequently, we followed the same two step process for the back-translation, using a different pastor for the hand-written translation. However, water management seems to be a particularly challenging topic as there are a lot of idiomatic expressions around how people express their water needs and

practices. Therefore the oral translations, by individuals familiar with water management, such as the PHW staff and the survey team, may more accurately express the meaning of the survey questions. As the back-translation task took longer than planned we were not able to utilize the back-translation directly in our research, but it did give us a number of insights about the way water management ideas are communicated in Dagbani. The translated survey can be found in Appendix 4, and the back-translated version of the survey, including comments from the researchers, can be found in Appendix 5.

Sample Size Determination

One of the primary goals of the research was to understand differences in consumer behavior between population segments. Thus, we sought to identify five to six distinct consumer segments. The minimum number of customers that is required to obtain insight in a conjoint analysis is 30. We applied a conservative security coefficient of 1.5x to select a target sample size of 45. Consequently, we anticipated that a sample size of 225-250 would be sufficient to perform our study.

Sample Population: Household Selection

Upon arrival in Ghana in January 2008, the MIT team worked with the PHW staff and the survey team to select a representative set of communities. Ultimately we settled on three urban communities and four rural villages, all of which had no exposure to PHW's products (Figure 14). The team planned to spend two days in each of these seven villages, surveying 40 households per community.

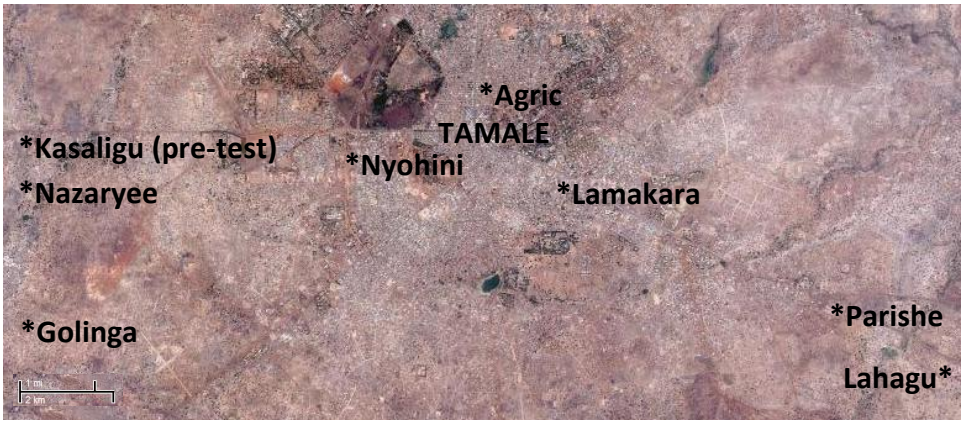


Figure 14: Detailed map of urban and rural research sites surrounding Tamale

For the purpose of this study, modern households were defined as concrete block or brick houses with tin roofs (**Figure 15**), and traditional households were defined as mud-brick houses with thatched roofs (**Figure 16**). In practice, the team found some mixing of household types in both urban and rural communities.

Figure 15: Urban household, Tamale

Figure 16: Rural household, Parishe

Community Engagement

Prior to working in a community, a team member visited the site to obtain permission from the village chief or community leader. In Ghana, particularly in more traditional rural communities, it is a cultural norm to visit the chief for a formal introduction before beginning work in a community. Subsequently, when the entire survey team arrived, the researchers and enumerators met briefly with the community leader to obtain his approval for the work. Following these proceedings, the survey four teams radiated out in four directions, and randomly selected target households to approach. As stated above, the goal for each research day was to achieve twenty complete surveys per day; however, in rural villages travel time to the village and between homes often only allowed for a total of sixteen complete surveys per day (Table 1).

Table 1: Research Sites and Number of Respondents

Community Name	Number of Households	Date Visited (2008)	Community Type
Kasaligu (pre-test)	16	January 08	Rural
	16	January 09	Rural
Nazaryee	16	January 11	Rural
	19	January 12	Rural
Golinga	20	January 14	Rural
	20	January 15	Rural
Agric	20	January 16	Urban
	20	January 17	Urban
Nyohini	20	January 18	Urban
	20	January 19	Urban
Lamakara	20	January 21	Urban
	18	January 22	Urban
Lahagu	16	January 23	Rural
Parishe	12	January 24	Rural
Lahagu	16	January 25	Rural

TOTAL (with pre-test)	**269**	**15 days**
TOTAL (without pre-test)	**237**	**13 days**

Respondent Recruitment

The researchers aimed to include 150 female head of household and 100 male head of household for 45 minute face-to-face interviews. We sought this gender percentage (60% female, 40% male), because we hoped to assess the differences in purchasing behaviours between female and male segments of the population. We achieved a slightly lower target for male respondents because our short timelines did not allow us to control for the higher percentage of men working away from the home during the four-hour window, 8am to 1pm, during which we conducted surveys each day

In developing our research protocol, we planned to limit selection bias by offering to return to the household at a later time if the head of household was not available. However, in practice, we found that the households were typically very large (average of 12-13 individuals). An average of seven adults seen in each household is typical of Northern Region Ghana, as families tend to be polygamous and sons often start their own families within the family compound of their father. Thus, we found that many households included multiple "heads of household". Because each household included a number of adults, we generally were able to find an adult responsible for water management and/or purchasing decisions on the first visit to the household.

In practice, the short timelines for this research made it difficult for the team to avoid bias in selecting survey respondents. As we always surveyed in the morning, we were sometimes unable to speak with the most senior head of household. Furthermore, the interviews were typically given in the central courtyard of the household compound. As the entire family was often eager to voice their opinion, it was sometimes challenging to get only one adult respondent, despite repeated requests by the surveyor. In some cases, we even got combined responses from the male and female head of household. For example, some younger female respondents were unfamiliar with the household finances, and called on their husbands to address these questions. We did not disqualify these responses.

5.4 Survey Execution Critical Success Factor: High-quality Survey Team

Securing highly qualified Ghanaian survey enumerators was critical to our project's success. The MIT researchers found that taking the time to discuss the research goals with the survey team greatly increased the quality of the data collected. This initial communication aligned the goals of the entire team, which increased our efficiency as well as the MIT team's understanding of the translation limitations. The delivery of the conjoint also presented a number of unique challenges, which were largely mitigated by the efforts of the surveyors. Efficacy of conjoint analysis hinges on the respondent's willingness to think carefully and make trade-offs across a number of features. Therefore, successful execution requires effective communication from the surveyor as well as focus from the respondent. Before starting the survey, the team found that it was helpful to carefully explain to the respondent that it was not a test, and that the goal of the research was to better understand what was important to them. The props were also very helpful in communicating the choice options. Each surveyor used the props slightly differently, but

in all cases the images were displayed and used to help the respondent make trade-offs. In addition, having the water tasting early in the survey helped engage the respondents (Figure 17).

Figure 17: Survey delivery and use of props[17]

Respondents that formed a strong opinion very early in the task choice activity also created challenges. For example, some individuals only wanted one product type. Such a strong preference was useful for assessing consumer preference; but, in a few cases respondents got irritated when they were continually asked to make a selection after they had already expressed a definitive preference. In such cases, it was critical for the surveyor to avoid the temptation to move ahead without fully explaining all the options. Overall, the professionalism and dedication of the survey team proved critical to limiting data bias.

6 Consumer Choice Results

This section summarizes the results collected in the field during January 2008. The chapter will report aggregate data for urban (n=118) and rural (n=119) respondents. The data shown will include six sections: 1) demographics of the sample population; 2) water source

[17] Images show each of the four surveyors, clockwise from top-left: Wahab, Jaafar, Al Hassan and Mohammed

type; 3) needs assessment including water quality, health and current water management practices; 4) preferred product type based on conjoint data; 5) ability to pay designed to inform product pricing; 6) an assessment of purchasing behaviours designed to inform future marketing efforts. Data analysis including market segmentation, customer profiles and associated product preference will be reported and discussed in Chapter 8.

6.1 Sample Population Demographics

By design, the sample population was predominantly female in both urban and rural areas. In addition, the sample was 90% Muslim, a slightly larger majority than the 56% seen throughout the Northern Region as a whole (ModernGhana, 2008). The majority of urban respondents lived in modern homes with tin roofs and a slight majority had received some primary or informal education, but only 31% had continued to secondary school. The majority of rural households lived in traditional mud-brick hut compounds with primarily thatched roofs, and only a small percentage had received any primary education, with only 3% continuing to secondary school. The household size and age distribution was consistent across urban and rural areas with an average of twelve and thirteen individuals per household respectively, and two children under five (Table 2).

Table 2: Demographics of Sample Population

Type	Gender (% Female)	Religion (% Muslim)	House Type (Roof)		Education		Average Household Size
			% Tin	% Thatch	Primary	Secondary	
Urban (n=118)	77%	94%	100%	5%	51%	31%	12
Rural (n=119)	70%	86%	15%	97%	19%	3%	13

The similarity in household size across urban and rural areas seen in this research differs from prior results obtained by R. Peletz, 2005 and S. Johnson 2006, which found an average urban household size of six and an average rural household size of twelve. The urban difference might be due to the fact that this survey targeted lower middle class urban households while the prior work targeted wealthier middle class households. Lower middle class urban respondents were chosen for this study because the researchers believe that this group has a greater need for clean water as a result of reduced access to improved water sources.

6.2 Water Source: Type and Access

Water Source Type

Urban and rural communities in Northern Ghana utilized a very different mix of water sources. In addition to rainwater, urban communities primarily used water from private taps, either personal or those of neighbors (Figure 18), while rural communities mostly collected water from surface water sources, dugouts / dams, as well as boreholes (Figure

19). In both community types the majority of respondents were supplementing their water supplies with rainwater collection during the rainy season (June – September).

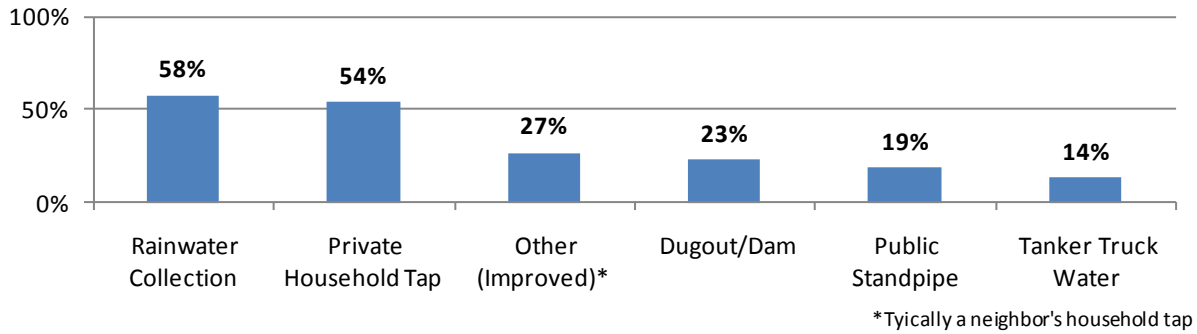


Figure 18: Primary Water Sources - Urban Communities

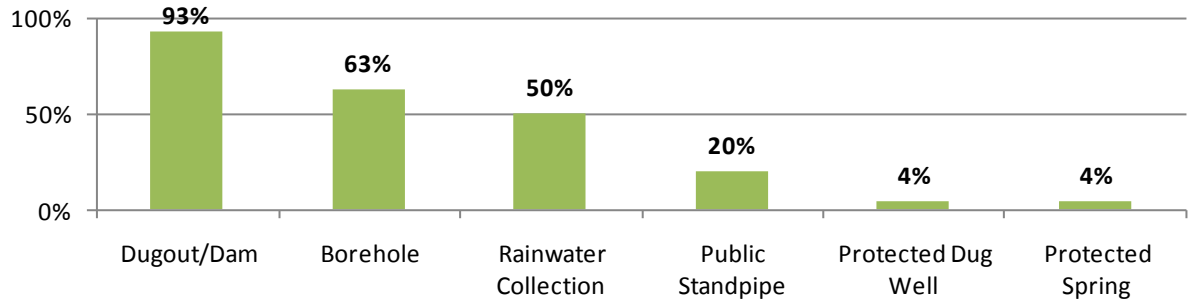


Figure 19: Primary Water Sources - Rural Communities

Water Source Access

Water collection practices also varied substantially among community types. Urban data showed that respondents collected water an average of 5 times per day in both the dry and rainy season; however, this number may not be representative as the municipal water only flowed at most two times per week, and often only a few times per month. On the days when water is available at local taps, residents collect water and transport it to large storage vessels in their homes (Figure 20). If the stored water runs out prior to the next time the municipal water is available, residents may buy from neighbors or seek out tanker truck vended water. Rural households collect water an average of 6-7 times per day in the rainy and dry season respectively. As the majority of rural communities use a local dugout as their primary source of water and a typical trip to the dugout takes longer than thirty minutes, water collection alone requires over three hours per day (Figure 21). In addition, three of the four rural communities surveyed had some access to a borehole, typically located near the dugout. Interestingly, many respondents said they used water from the dugout and the borehole interchangeably, storing and transporting it in the same vessels.

Figure 20: Key Urban Water Management Challenge: Water Quantity and Safe Storage

Figure 21: Key Rural Water Management Challenge: Source Distance and Quality

6.3 Needs Assessment: Demand for Improved Household Water Management

Water Quality

Water quality metrics helped characterize the current drinking water in study populations (Table 3). All urban respondents were drinking non-turbid municipal water[18]; however, microbial contamination seen among urban respondents suggests that recontamination during handling and storage is a critical issue. In rural areas, the dominant drinking water source, dugout water, was highly turbid. However, researchers observed that the water in some households had lower turbidity than the characteristic average from the source due to settling and mixing with borehole water and/or household treatment with alum. High levels of *E.coli* and total coliform were seen throughout the rural sample population. Household and community water quality data can be found in Appendix 6.

Table 3: Water Quality Metrics

Type	Turbidity[19]		Total Coliform (CFU)				E.coli	
	Ave. (TU)	Max. (TU)	% with CFU	% with 100- 1000 (CFU / 100 ml)	% with >1000 (CFU / 100ml)	Ave . (CFU/ 100ml)	% with E.Coli	Ave. (CFU/ 100 ml)
Urban (n=118)	<5	<5	59%	33%	26%	2,500	8%	47
Rural (n=119)	238	1000	89%	7%	82%	18,800	26%[20]	172

[18] Urban respondents generally used dugout water for non-drinking activities such a washing (qualitative responses)
[19] Turbidity tube limit of detection is <5 TU
[20] The percentage of rural households with *E.coli* that is reflected in this data is likely lower than the actual because 1 to 10 ml dilutions were done for 70% of rural households. In these cases, only those samples with *E.coli* concentrations of 1,000 (CFU/100ml) or greater were captured. When samples with dilutions are excluded the percentage of rural households showing *E.coli* in the water increases to 69%.

Health Status

Although health status was not assessed in detail in this study; one question relating to diarrheal incidence was included in the survey. The diarrheal data was collected by asking respondents to self-report incidence of diarrhea in the past week, and the information collected provides an additional metric to help measure need for improved water treatment and health outcomes. Overall, 25% and 32% of urban and rural households respectively reported a diarrheal incident. Children under five saw the highest rate of illness, particularly when considered on a per capita basis (Figure 22).

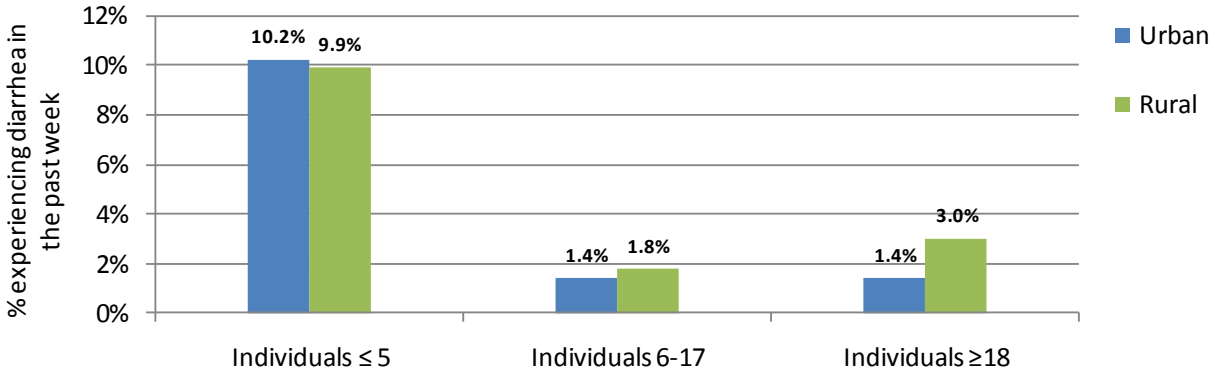


Figure 22: Diarrheal incidents in the past week

Water Management Practices

Differences in source water between urban and rural populations appear to be correlated with differences in household water management. Urban populations tend to rely primarily on the quality of the municipal water from the Ghana Water Company (96%), while the rural respondents typically use a cloth filter (93%) supplemented by settling in a storage vessel and alum treatment (Figure 23).

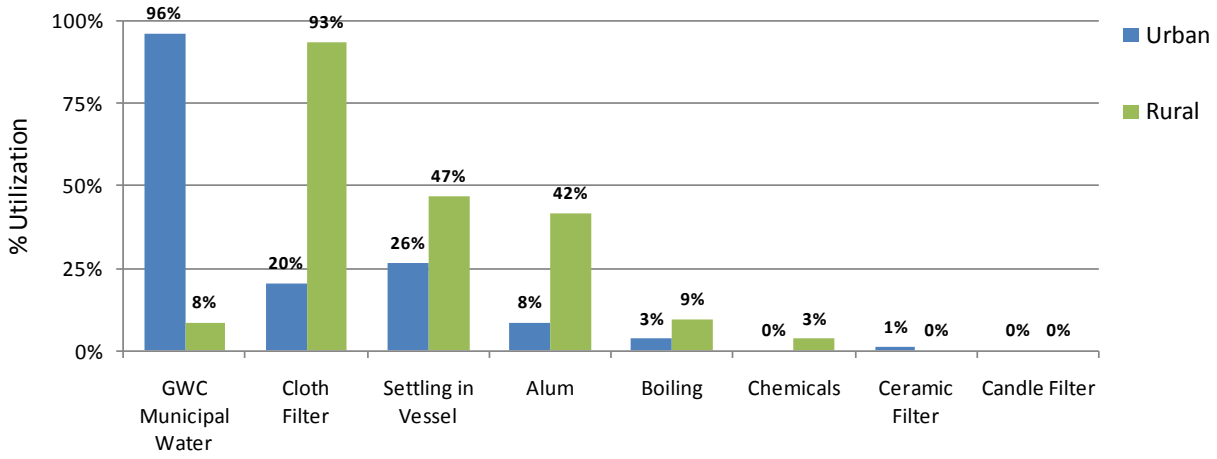


Figure 23: Current water treatment methods

Nearly all rural households engaged in some form of household water treatment; however, less than 10% actively treated microbial contamination either by boiling or with chemical disinfectants. In particular, the cloth filters provided by the Carter Center throughout the region as a part of the Guinea Worm Campaign, appear to have achieved substantial uptake[21]. In addition, alum is used seasonally when turbidity is particularly high. Of the 50 rural respondents that used alum, 90% only used this treatment method when the water was more turbid than usual.

> "*We use alum only when the water becomes very muddy at the end of the dry season"* – Lahagu (rural)

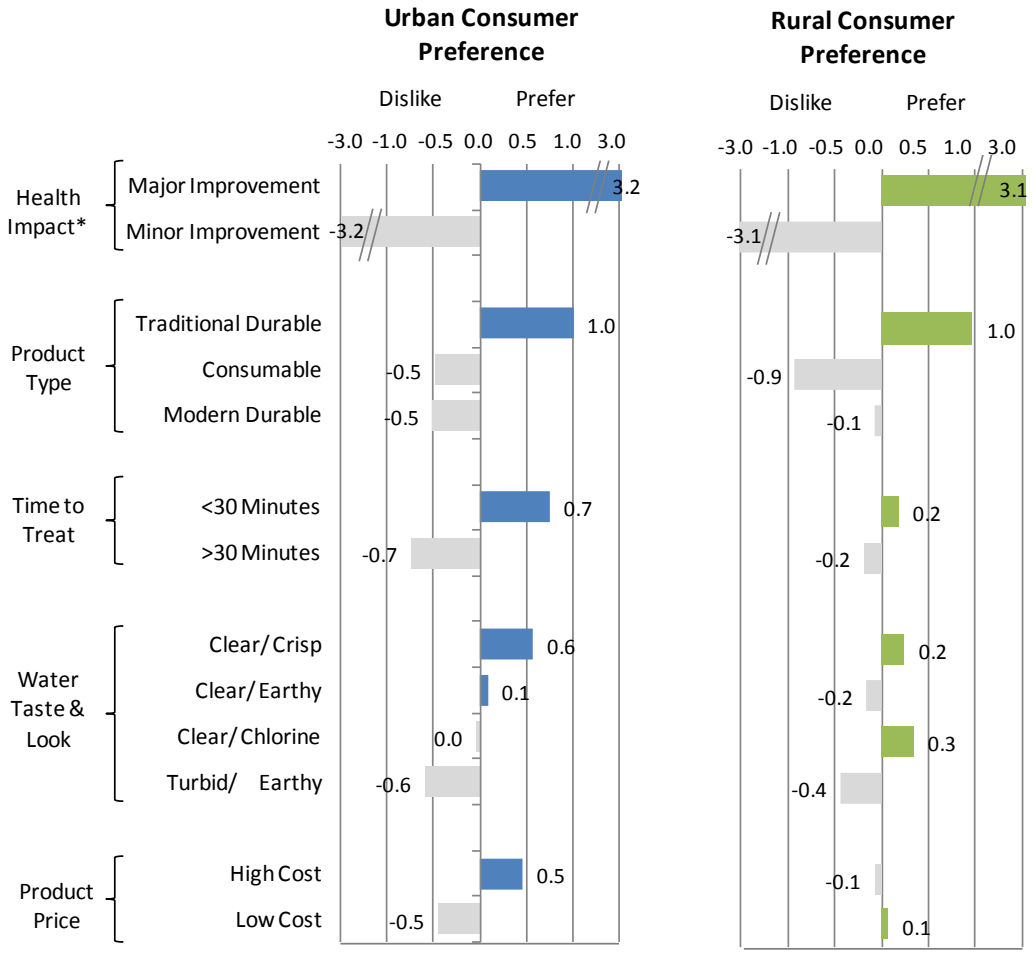
The researchers also collected data on volume of water treated to assess the total volume of water being utilized in the household. The majority of rural respondents treated more than 144 liters per day with the cloth filter, water which was used for washing as well as drinking. Conversely, the majority of the urban respondent did not treat any water because of their confidence in the quality of the municipal piped water supply.

Finally, the team collected qualitative data on respondent happiness with water quality and treatment systems. The responses to these questions suggest a fatalistic attitude about water quality and water management. Although many individuals were unhappy with their water quality, they were accepting of their water management system because it was the only option. In addition, many felt that they were doing a good job of water management by using the cloth filter and covering the vessel; however, they were still interested in further improving their water with additional water treatment products.

[21] Some households also had "pipe filters" which they used to treat water for Guinea Worm when away from home.

6.4 Consumer Choice: HWTS Feature Preference

The conjoint section of the survey is designed to help researchers assess the relative value of different features of HWTS products, with the goal of better matching HWTS product offerings to consumer preferences. We hope this will enhance product adoption and stimulate sustained use. Figure 24 below gives an overview of the relative preference for different product features, with preferred products shown to the right of the middle line for both urban and rural populations.



*Note: For purposes of chart scaling health impact is discontinuous.

Figure 24: Product feature preference in urban and rural communities

Comparing the two preference patterns seen in Figure 24, we see that urban and rural respondents showed similar preference patterns for HWTS product features; however, differences in relative importance of the product features suggests that tailoring the product type, design, educational material and marketing strategy to the preferences of different consumer segments has the potential to increase HWTS adoption.

Health Improvement

Major health improvement proved to be the most significant driver of product choice in both urban and rural markets, with a relative value of at least three times that of all other features. The researchers anticipated that health improvement would be an important driver of purchasing behavior; however, the importance of health relative to other features highlights the need to ensure product quality and brand based on health improvement.

Product Type

The traditional durable product was preferred among both urban and rural populations. Individuals that expressed a preference for the traditional durable product typically highlighted longevity and durability as important to their choice. In addition, some respondents highlighted the attractive look of both the metallic modern durable and the plastic traditional durable.

> "*Things break easily here. I need something that will last.*" – Nazyree (rural)
>
> *"I like the look of the traditional durable and it is cheaper than the modern model."* - Nyohini (urban)

A few respondents favored consumables; however, many were reluctant to invest in a product that required repeat purchase.

> *"I like the consumables because they are easy to use. I can just drop them in and be done. Filters take more time and work"* – Agric (urban)
>
> *"When I buy, I will choose something I can afford. I want something durable because it is easier for me to pay once than to find the money every month."* – Golinga (rural)

If the concern arose because of the difficulty of pulling together the money each month as suggested by the quote above, respondents might prefer to buy a consumable product in bulk and keep the product on hand to use as required. Alternatively, if purchase place is the primary concern, providing a local point of sale could help reduce the burden of repeat trips to market.

Time to Treat

Time required for water treatment was largely ignored by many respondents; however, there were a few respondents that focused exclusively on selecting for short treatment times. In particular, urban respondents were more likely to see long treatment times as arduous and a barrier to use.

> "*Speed of treatment is important to me. I want the water to be ready when the children want to drink it.*" - Golinga (rural)

Water Taste and Look

Although water taste and look was a high-touch element of the survey, respondents did not show a strong preference for this feature. In a number of cases, respondents continued to ignore this feature even when reminded by the surveyor that they were choosing a water option that they had disliked in the initial tasting.

> "*I want the product that gives me the best health, even if the water I have to drink looks turbid*" –Lamakara (urban), when choosing major health paired with water #3 (turbid/earthy)

In addition, the researchers were surprised to discover that there was not an aversion to the chlorine taste and in some cases respondents even preferred it because to them it made the water "taste clean." Overall, the relatively small magnitude of the taste feature reflects the limited importance placed on water taste relative to other product features.

Product Price

Product price had the least impact on overall choice, particularly in rural areas where ability to pay is low. This trend could be due to a strong desire to purchase a water treatment product or an inability to accurately assess relative prices.

> "*Price is not a concern for me as long as the product is durable and it brings me good health.*" – Golinga (rural)

> "*I chose the tablets because there is absolute poverty here and the tablets are cheapest.*" – Nazyree (rural)

Conversely in urban areas, respondents tended to favor higher prices, often because of the belief that a higher price signified a higher quality, longer lasting product. The differences in price sensitivity and perceptions among sample populations highlights the importance of understanding local variations in ability to pay and price perceptions before setting a price for a commercial HWTS product.

> "*I chose the higher price because quality things cost more. I think the higher priced item will last longer.*" – Nyohini (urban)

The differences in price sensitivity and perceptions among sample populations highlights the importance of understanding local variations in ability to pay and price perceptions before setting a price for a commercial HWTS product.

6.5 Ability to Pay for HWTS Products

The team also collected annual household income data to improve estimations of ability to pay. However, in practice this data was very difficult to collect. Thus, many of the urban values were extrapolated from estimates of daily or weekly income while rural values were

calculated based on the number of bags produced in the annual harvest. The calculations show an average annual income of GHS 1,530 per urban household and GHS 619 per rural household. Although these values are not precise, they offer a representative estimate of relative purchasing power of different communities.

Income data can be used to estimate the amount of disposable income available for HWTS product purchases. Assuming that household are willing to allocate a conservative 5% of daily income to water management (McPhail, 1993),[22] urban and rural communities would have GHS 0.21 and GHS 0.08 dollars per household per day respectively to spend on water treatment. However, in rural areas the majority of income is typically earned and spent during the harvest season from November to February. Thus, assuming an average of 50% of annual income is saved through the remaining eight months of the year, the average daily rural income for water management would be reduced to only GHS 0.06 per household day.

"If you are going to bring an expensive filter to this village you need to bring it at the time of year when we have just finished farming" – Golinga (rural)

Information on prevalence of common household goods was collected to supplement the income data (**Figure 25Figure 25**). Willingness to pay for other household purchases reflects the size of investment a household would be able to make in the right HWTS product.

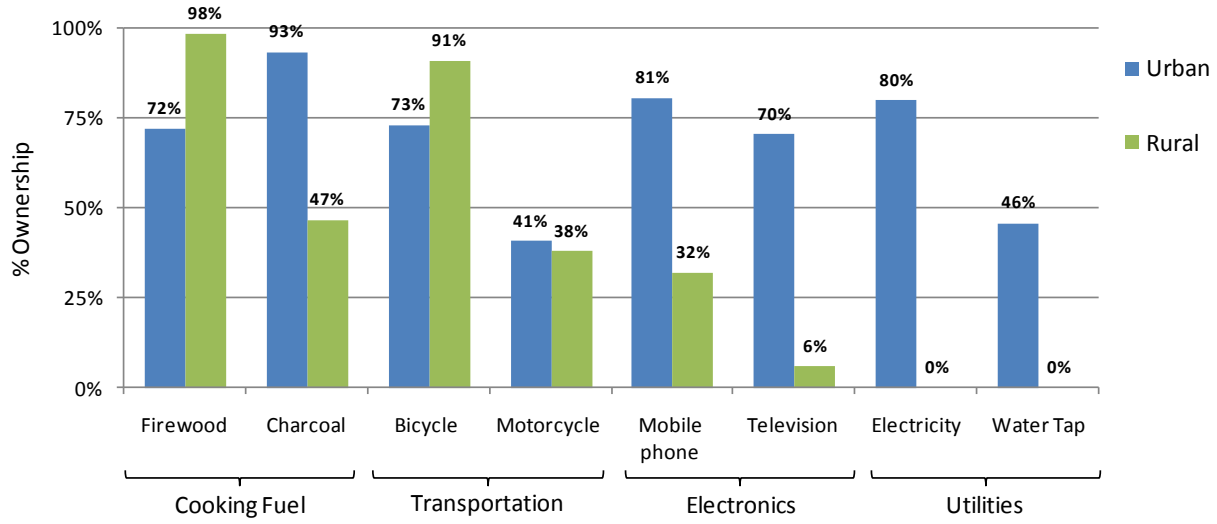


Figure 25: Ability to Pay for Household Goods

[22] Research by McPhail found that households were willing to pay 8% of income for water management activities.

Cooking fuel is seen as a key to livelihood and is purchased (or sometimes collected in the case of firewood) by all households surveyed. Seven percent of urban respondents and fifty-three percent of rural respondents surveyed were unwilling or unable to buy charcoal, and thus depend on collecting firewood to use for cooking. In urban areas eight percent of residents have invested in more expensive gas or electric stoves; however, other high-cost items appear to take precedence over improved cooking facilities. Means of transportation are most frequently purchased even by low income households. A large majority of both urban and rural households own at least one bicycle and nearly half have a motorcycle.

Despite the relatively high one-time cost of mobile phones and televisions, these items appear to be highly valued as they are prevalent in urban areas. Such luxury items are seen less frequently in rural areas; however it is interesting to note that thirty-two percent of rural residents have invested in cell phones despite a lack of access to electricity.

Municipal water and energy services were not seen in any of the rural communities surveyed. In urban areas where utility access is standard, eighty percent of respondents paid for electricity, while only forty-six percent invested in a private water tap. However, those residents that lack taps do not lack access to municipal water as they frequently purchase or collect water from taps in neighboring households or public standpipes.

6.6 Purchasing Decision Drivers and Behaviors

Purchasing decisions questions were designed to help future HWTS marketing efforts focus investment on locations and individuals likely to have the greatest impact on stimulating product sales. Results regarding the primary purchaser, buying decision influencers and purchase location are described below.

Primary Purchaser

In both sample populations, the men are responsible for the majority of household purchases. Women appear to take a more active role in the purchase of large items. It is not clear from the data whether the men give them money and permission before they buy, but this was heard qualitatively from a number of respondents.

> *"For large purchases, like water storage vessels, my husband gives me money to buy the item."* – Rural respondent, Golinga.

The data below shows both the frequency with which different types of items were bought as well as the purchaser for both urban (Figure 26) and rural markets (**Figure 27**).

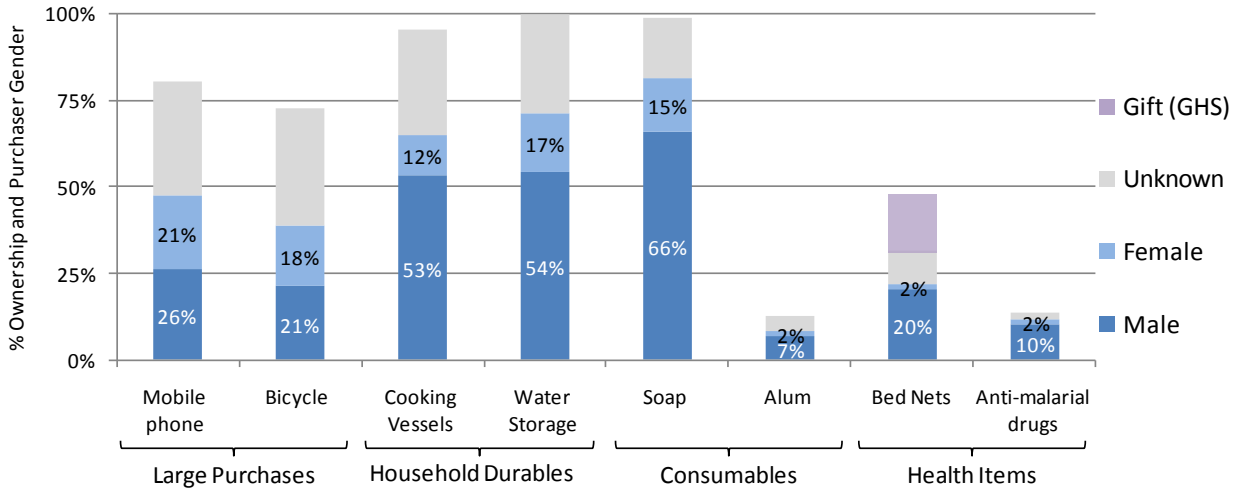


Figure 26: Total Purchase Incidence by Primary Purchaser - Urban Population

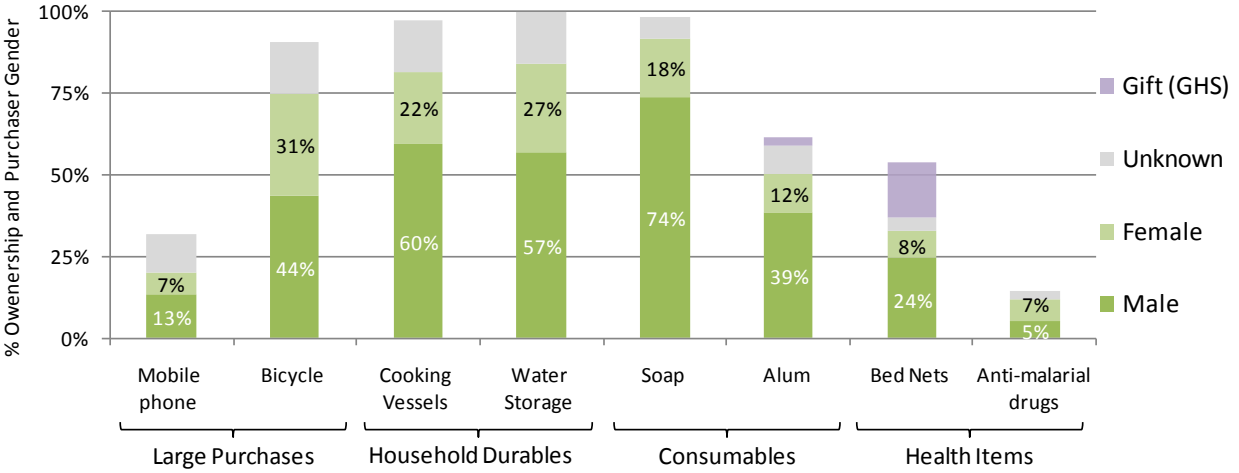


Figure 27: Total Purchase Incidence by Primary Purchaser - Rural Population

Buying Decision Influences

The researchers also collected data on which individuals influence buying decisions for different product types (Figure 28).

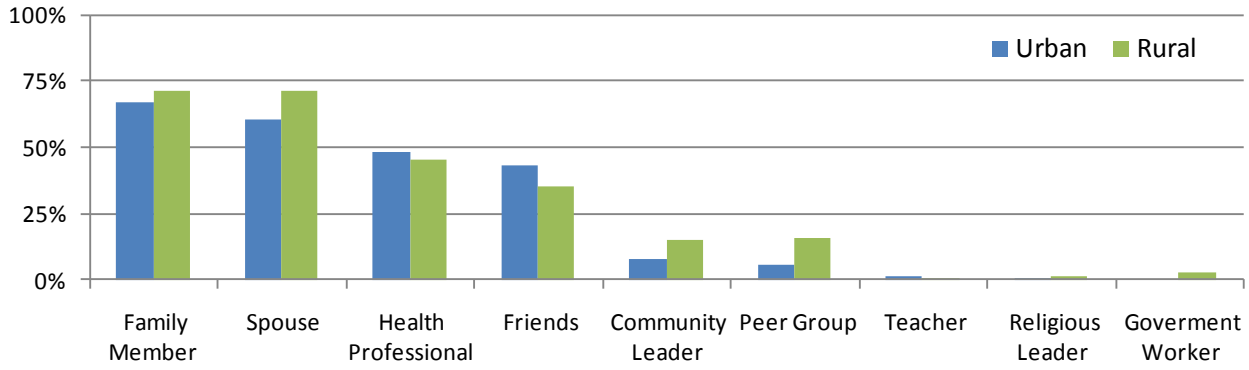


Figure 28: Primary Opinions Considered in Making Purchase Decisions

At an aggregate level, family members had the most influence on household purchasing decisions. In addition, health workers impacted purchasing decisions about health related items. Finally, friends and community networks were seen as a strong driver of purchasing decisions. Notably, the opinions of such social networks are viewed as more important to potential HWTS customers than advice from community leaders or local officials. Although respondents rarely sited religious or community leaders as buying decision influencers, those individuals played an important role in the community's willingness to engage with the researchers which enabled the study to take place at that location, so the social and political influence of the community leaders should not be dismissed.

Purchase Place

Finally, detailed data was collected on typical and preferred place of purchase for various types of goods including: health items, consumables, large purchases and water products. Displayed below is summary data which highlights the differences seen in typical and desired purchasing patterns (Figure 29).

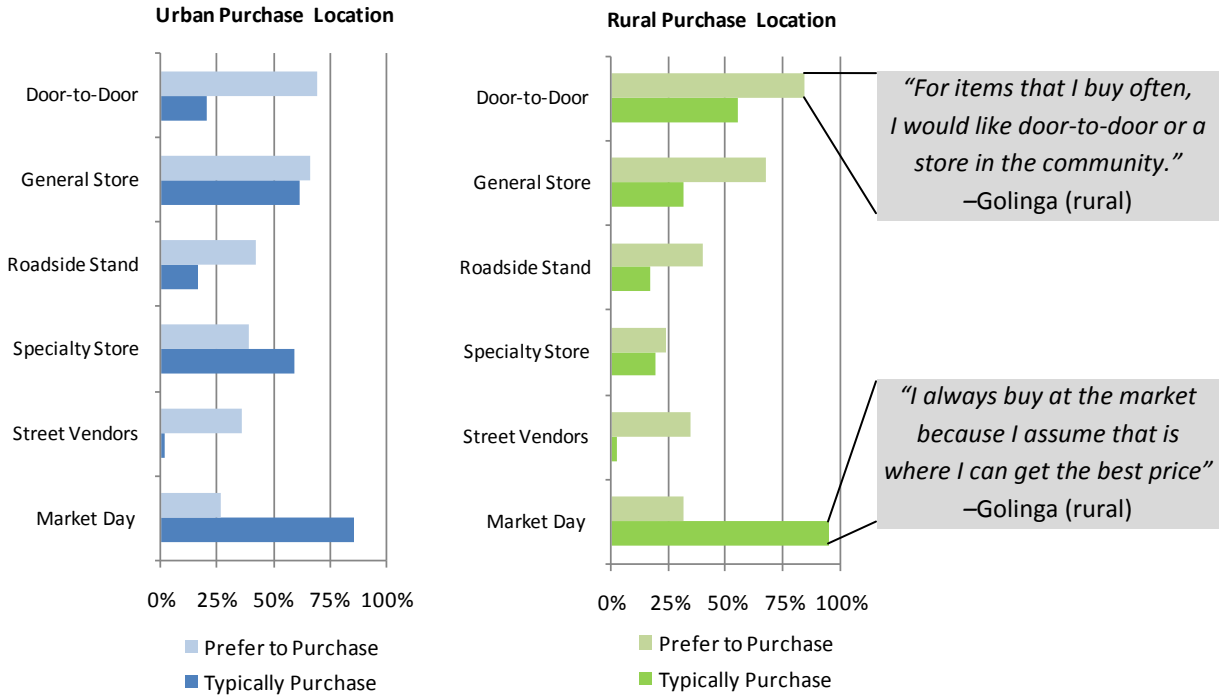


Figure 29: Typical and Preferred Purchasing Location

Both urban and rural residents primarily purchase items at the market. However, all respondents would like to see more local sales through either door-to-door marketing or general stores within their communities. In addition, the data shows a preference for more personalized sales models (door-to-door or roadside stand or street vendors). Such a high-touch model could be particularly effective for HWTS products that required education and follow-up for correct and sustained use.

6.7 Field Observations

On particular challenge faced by the survey team was the high levels of illiteracy and weak numeracy skills seen among respondents. Thus, any task that involved a numeric assessment created challenges. In many cases, the Ghanaian surveyors and MIT team members were asked to help assess age, count the total number of people in the household, and calculate income based on number of bags of produce. Therefore, data quality depended directly on the survey team's persistence in seeking accurate and detailed information.

Second, the frequent desire to transition from one respondent to another based on question type created challenges. In particular, men were often called in to answer questions regarding money and purchasing. Respondent mixing may have impacted the primary purchaser data as often both male and female respondents participated simultaneously during this task, which made it difficult for the survey to record accurate data in the "respondent" or "spouse" selection. In addition, because the survey was always

conducted in a group setting there was an opportunity for the respondent to be biased by the broader household opinion. The researchers wanted household level data, so private interviews were not sought initially, but the group decision mentality could have impacted the results, particularly in the choice tasks.

Lastly, the author observed some interesting behaviors regarding water source preference in rural areas. In many cases, despite the fact that a borehole was available near the dam/dugout, community residents still chose to use the dam/dugout water. Through informal conversations the researchers learned that this was largely because some residents preferred the taste of the dam/dugout water[23], and did not necessarily believe that the borehole water was safer for drinking.

> "*We like to prepare porridge with dam water because it makes the porridge thick. If we use borehole water it tastes watery."* –Lahagu (rural)

Therefore, before moving ahead with a new or modified strategy for HWTS implementation, it will be critical to better understand the local barriers to drinking the borehole water. Furthermore, if the borehole water is found to have similar health outcomes to the dugout water, recontamination could be an explanation due to unhygienic practices and/or the practice of mixing ground water and surface water. If this were the case, chlorine and safe storage could provide an effective solution.

7 HWTS Product Prioritization

The researchers aimed to identify those HWTS products likely to have the greatest impact on water quality and health outcomes in our target communities in Northern Region Ghana in both the short and long term. As intervention efficacy varies by geographic region, water source characteristics, and community type, we considered the HWTS product options described in Chapter 3 in the local context of Northern Ghana. Based on the results of the survey the range of available HWTS products were prioritized based on three screens: 1) efficacy for treatment of source water, 2) local availability 2) product price relative to consumer ability to pay (Table 4). Segment specific HWTS product recommendations are developed based on this analysis and can be found in Chapter 7: Customer Segmentation.

[23] For example, some residents complained that the borehole water tasted salty.

Table 4: Comparative Assessment of HWTS Products in Northern Region, Ghana

Type	Household Water Product		Turbidity Efficacy	Microbial Efficacy	Local Availability	Annual cost (GHC) / family*
Particle Removal	Cloth Filter		Low	Low	High	0.0
	Alum		High	Low-Moderate	High	2.2
	BioSand Filter	Local LDP	High	Moderate	Low	10
		Int. Aid	High	Moderate	Low-Moderate	22
Particle Removal & Safe Storage	Pot Filter (*Kosim*)		High	Moderate	High	10
	Candle Filter	OK	High	Moderate	Moderate	14
		Mission	High	Moderate	Low	50
		Berkefeld	High	Moderate	Moderate	136
Disinfection	SODIS (UV)		Low	Low-Moderate	Moderate	8
	HTH Chlorine		Low	High	Low	0.3
	Liquid Chlorine		Low	High	Low	2 – 5
	Aquatabs (20l)		Low	High	Low-Moderate	13
Coagulation & Disinfection	PuR™ (P&G)		High	High	N /A	45 - 80
Safe Storage	Locally Manufactured		N / A	N / A	Low	1.2
	CDC (SWS)		N / A	N / A	Low	2.4
Sachet Water	Hand-tied (single)		N / A	N / A	High	275
	Factory (wholesale)		N / A	N / A	High	657

Note: Annual cost per family was estimated by calculating using an anticipated average household size of 12 individuals and 2 liters of drinking water per individual per day[24].

[24] Values used for price calculations:
1) cloth filters given by Ghana Health Service;
2) alum cost GHC 0.02 / ball which can treat an estimated 2x40 liters of water;
3) Biosand filter price of GHC 30.00 for locally manufactured LDP (Kikkawa, 2008) and 3 year filter life;
4) Biosand filter price of GHC 65.00 for International Aid product and 3 year filter life;
5) *Kosim* ceramic pot filter price of GHC 15.00, 2 filters per household, and 3 year filter life;
6) OK filter price of GHS 18.90, estimated GHS 1.62 replacement filter (6 months), and 7 year filter life (5 year warranty);
7) Mission filter price of GHS 50.00 and GHS 15.00 for replacement filters and chlorine, 2 filters per household, 5 year filter life;
8) Berkefeld filter price of GHS 42.00 and GHS 32.00 for replacement filters (6 months), 2 filters per household, 5 year filter life;
9) One plastic SODIS container (liter) purchased per person every other month for GHS 0.11;
10) Annual HTH cost estimated at 48x lower than Aquatabs;
11) Liquid chlorine minimum calculated from PSI typical cost of GHS 0.25 / bottle for 1.5 month per household;
12) Aquatabs cost based on Northern Region Ghana distributer price of .03 / 20 liter tablet;
13) PuR™ price of 0.05 / sachet (10 liters) which would likely be the minimum price in Ghana given a $0.035 price to NGOs;

As shown in Table 4, among the low-cost particle removal options, alum and the *Kosim* ceramic pot filter have the most potential in the short term as they effectively remove turbidity as well as microbial contamination and are available in Northern Ghana. In addition, the OK candle filter and the two models of biosand filter (locally manufactured LDP[25] and International Aid) have longer term potential as these products are also reasonably priced. However, as these filters, particularly the biosand, are large durable products and thus are difficult to transport so an appropriate distribution model and/or outreach program would need to be developed to get these products to rural communities.

Among disinfection options, UV has not been shown to be highly effective given local environmental conditions in Northern Ghana (see Chapter 3), and thus chlorine disinfection emerges as the priority alternative. However, chlorine disinfection is less effective in water with turbidities greater than 30 NTU. Therefore, in rural areas where source waters are highly turbid chlorination should be used in conjunction with a particle removal option such as alum or the *Kosim* ceramic pot filter. PuR offers a simple solution as it combines both particle removal and disinfection in a single sachet; however, the relatively high-cost reduces the attractiveness of this option particularly in lower income rural areas where combined treatment is most needed. In addition, as PuR is not currently on the market in Northern Ghana, local scale-up would be required to determine whether PuR is a viable option for the region in the longer term.

Safe storage options have been included because although these products do not provide water treatment, they can be an important component of water quality management. In this case, low-cost safe storage options have the potential to enhance protection from recontamination, particularly if used in conjunction with chlorine disinfection.

The more expensive Mission and Berkefeld candle filters as well as sachet water product should be targeted to upper and middle class consumers. Among the population surveyed in this study, 34% and 9% of the population would be able-to-pay for the Mission and Berkefeld respectively, using the same 5% of income criteria. None of the respondents would be able to pay for hand-tied and factory produced sachet water as their sole source of household drinking water. However, this research targeted lower to middle income urban communities, so it is possibility that upper class communities could afford to utilize sachet water as their primary source of household drinking water. Furthermore, sachet water is typically used as a supplemental source when away from home, and the high demand in urban households suggests that a substantial number of urban households are able to afford sachet as a supplement to their primary household water source.

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14) Locally manufactured safe storage includes GHS 2 jerry can and GHS 1 tap, 2 containers per household, 5 year life;

15) CDC SWS safe storage estimated at GHS 6 in Ghana (price of $5 in USA), 2 containers per household, 5 year life;;

16) Hand tied sachet is priced at 0.02 / 700ml (Okioga, 2007);

17) Factory produced sachet is priced at 0.05 / 500 ml.

[25] Biosand model developed by Kikkawa, 2008

8 Customer Segmentation

The goal of the market segmentation section of this thesis is to depict the HWTS landscape in Northern Region, Ghana in terms that will help future HWTS interventions better target investments and maximize impact.

8.1 Segmentation Methodology

The market segmentation methodology utilized here aims to describe the market landscape in terms that will allow present and future HWTS interventions to take targeted action. By defining market segmentation variables based on observable differences between populations, the author hopes to facilitate the development of interventions and marketing strategies that can be targeted to easily identifiable market segments.

In developing the market segmentation a number of potentially actionable variables were considered -- community type, household size, respondent profession, water source type, accessibility, purchase location -- for those variables that had the most significant differences in product preferences and purchasing behaviors. As a result, consumer segments most appropriate for different HWTS products are highlighted. Furthermore, segment specific customer profiles enhance recommendations about desired market messaging (promotion), pricing and placement.

8.2 HWTS Market Segmentation, Northern Ghana

The consumer segmentation frame developed is displayed to the right (Figure 30). The vertical axis is source water, defined by community location and water quality. These characteristics can be easily observed based on distances from an urban area, and a simple turbidity test of local drinking water. The horizontal axis is respondent profession, which serves as a proxy both for ability to pay and daily activity. Profession is defined by a number of discrete options that describe locally appropriate employment alternatives.

RESPONDENT PROFESSION / SOURCE WATER		Housewife	Agricultural	Production Worker	Sales & Other	Trader	Profess-ional
Urban							
Rural	Clear Water						
	Turbid Water						

Figure 30: HWTS Market Segmentation Frame

Based on the results of the HWTS preferences observed in the conjoint, these eighteen consumer types have been combined into five segments by grouping those populations that show similar product preferences (Figure 31). The five distinct segments identified are: 1) Urban-high income; 2) Urban-worker; 3) Agricultural / clear water; 4) Agricultural / turbid water; and 5) Rural traders and sales people. In order to observe a statistically significant

difference between segments it is desirable to have at least 30 individuals, thus each segment has been chosen such that it includes >30 respondents. Once the segments were defined, priority HWTS products were selected for each segment based on observed differences in source water quality, ability to pay and consumer choice

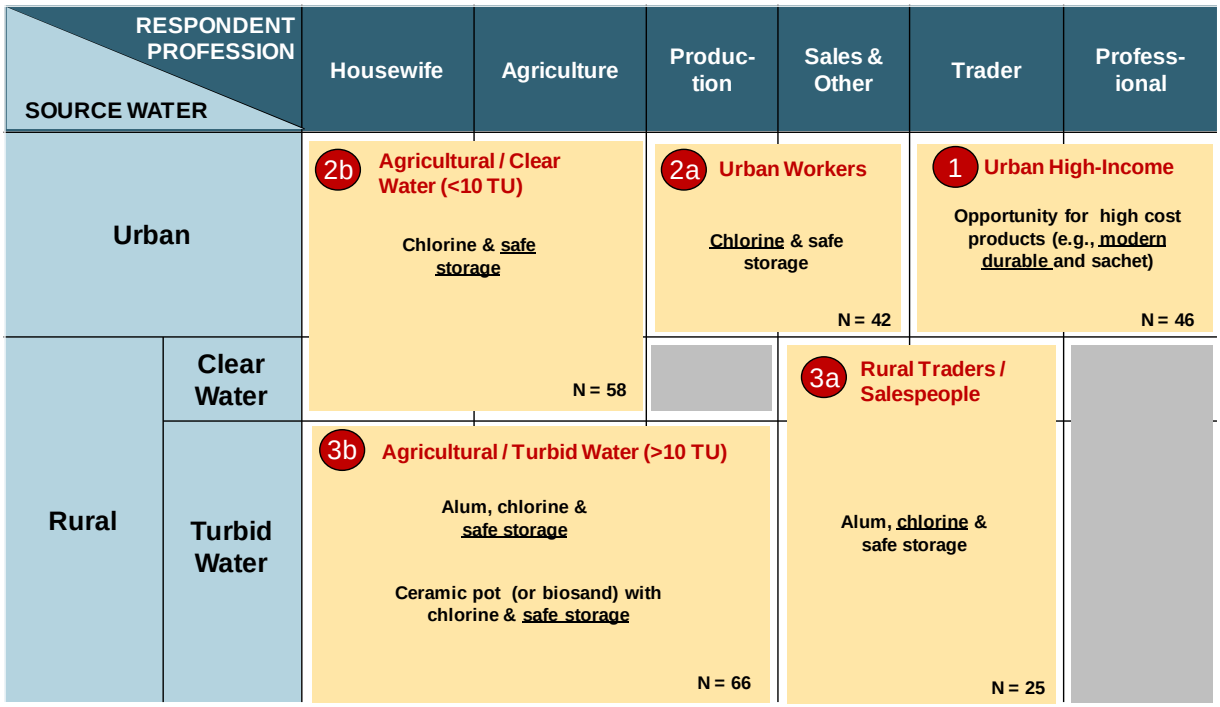


Figure 31: HWTS Market Segments, defined for Northern Region Ghana

Segments 1, 2a, and 2b are defined to include only households with clear water (<10 NTU), and are therefore strong candidates for chlorine disinfection. In addition, as recontamination was observed as a critical challenge among this population, safe storage containers are recommended to further reduce recontamination risk. As Segment 1 showed greater ability to pay and demand for higher cost products (observed in the conjoint) it is also an attractive target for a sachet water business and/or the modern durable filter. Rural households that make more than $700 annually were also considered as a potential target for sachet water. However, urban areas have a higher proportion of high income households, so a sachet water business focused on serving urban markets will likely be more economic and scalable. Interestingly, urban populations with greater abilities to pay showed the strongest preference for more expensive products and fast treatment times. This consumer choice profile is a good fit for sachet water which is significantly higher cost than other water options, but may be immediately consumed upon purchase.

Segments 3a and 3b have turbid water (>10 NTU) and thus require particle removal prior to disinfection. Locally available HWTS options for particle removal include alum, the *Kosim* clay pot filter or the biosand filter. In addition, settling in a storage vessel could also be considered as a viable to reduce turbidity prior to additional treatment. The locally

available *Kosim* pot filer and newly introduced biosand filter offer the capability to reduce microbial contamination and turbidity; however, neither technology provides residual protection against recontamination. The safe storage element of the *Kosim* helps mitigate the recontamination risk; however, the addition of a chlorine product (liquid chlorine, Aquatabs or HTH) has the potential to further improve the final drinking water quality produced by all three of these particle removal products. Thus, the combination of low-cost alum pretreatment with chlorine disinfection and safe storage could be considered as a locally available solution to meet the needs of the lowest income rural populations. In addition, both the *Kosim* and the biosand filters combined with a safe storage element (and ideally chlorine disinfection), provide robust water treatment options for rural populations facing the dual challenges of high turbidity and microbial contamination.

Finally, the broad-based recommendation for dedicated safe storage vessels is supported by the strong preference for traditional durable products observed throughout the survey population. A low-cost plastic safe storage container is a solid match for this observed demand, and thus the appropriate low-cost safe storage product has the opportunity to meet consumer demand and improve drinking water quality across all segments.

8.3 Consumer Profiles

Once the HWTS products are matched to the most appropriate market segments, each segment can be profiled in terms of demographics, health status, and purchasing behavior to facilitate product specific interventions and to target marketing efforts. The differences between the consumer segments are described in the profiles below (Table 5; Table 6). If the scope of the research had allowed for a completely random sample of households in Northern Region, Ghana we would be able to extrapolate segment size from the sample size in each segment population. However, as the study targeted specific populations of interest, the author has estimated the size of each sample population based on tabulated demographic data for Northern Region, Ghana.

Table 5 and Table 6 highlight the findings from the CBC survey that support the segment specific prioritization of the HWTS products described above. In addition, elements of the baseline data including demographics, current water management practices, and desired marketing and pricing strategies are shown for each segment. For segments 1, 2a and 2b the dominant and most desirable purchase place for proved to be door-to-door or a local store (target for consumable products), as well as the general store (target for durables). In addition, these segments showed a greater emphasis on product quality (expressed both through desire for high price, high health impact and durability). Finally, the preference for higher prices among all three of these segments suggested that there is no need to discount products targeted to these consumers. Segments 3a and 3b also preferred a local community sales model, but in this case a model utilizing a local village entrepreneur to provide community level access to HWTS products is recommended. Product durability and health impact are also very important to these segments; however, as lower-prices are preferred among these segments low-cost products are emphasized.

Table 5: Consumer Profiles (Segments 1, 2a, 2b)

Segment	1) Urban High-Income	2a) Urban Workers	2b) Agriculture based / clear water (<10 TU)
Description:	Urban respondents that have clear water and are professionals or traders.	Urban respondents that have clear water and are sales people or workers.	All agricultural workers or housewives with clear water (urban and rural).
Ability to Pay:			
• Average Income:	GHS 2,180 / household yr	GHS 1,228 / household yr	GHS 765 / household yr
• Mobile Phone:	80% Ownership	81% Ownership	48% Ownership
• Motorcycle:	50% Ownership	33% Ownership	41% Ownership
• Private Tap:	41% Ownership	55% Ownership	19% Ownership
Size:	~5% of N. Ghana pop.	~16% of N. Ghana pop.	~7% of N. Ghana pop.
Household Profile:			
• Household size:	13 individuals	13 individuals	13 individuals
• Education:	17% primary school; 24% additional education	19% primary school; 45% additional education	9% primary school; 9% additional education
• Health (diarrhea):	7% (children <5) 2% (individuals >5)	12% (children <5) 3% (individuals >5)	10% (children <5) 4% (individuals >5)
• Water Source:	83% private tap; 22% public standpipe; 70% rainwater; 37% dugout	81% private tap; 17% public standpipe; 45% rainwater; 12% dugout	40% private tap; 12% public standpipe; 41% rainwater; 52% dugout
Water Quality:			
• Ave. turbidity:	• 0 TU	• 0 TU	• 3 TU
• Total coliform:	• 1,800 CFU / 100 ml	• 3,100 CFU / 100 ml	• 8,700 CFU / 100 ml
• % with Ecoli:	• 7% with E.coli	• 10% with E.coli	• 19% with E.coli
Feature Preference:			
• Health	• Average health concern	• Lowest health concern	• <u>High health concern</u>
• Product type	• Traditional durable; some pref. for <u>modern durable</u>	• Traditional durable; some pref. for <u>consumable</u>	• Strong preference for <u>traditional durable</u>
• Treatment time	• Strongest pref. for <u>fast</u>	• Moderate pref. for fast	• Moderate pref. for fast
• Price	• Strongest preference for <u>higher priced</u> products	• Moderate preference for higher priced products	• Slight preference for higher priced products
• Taste	• Slight pref. for "crisp"	• Slight pref. for "crisp"	• Slight pref. for "crisp"
Purchase Location:			
• Typical (top two):	• 91% market day; • 54% general store	• 76% market day; • 74% general store	• 95% market day • 40% door-to-door
• Prefer (top two):	• 67% door-to-door; • 65% general store	• 79% door-to-door; • 74% general store	• 72% door-to-door; • 62% general store
Recommendations:	**Segment 1**	**Segment 2a**	**Segment 2b**
• Product	• Opportunity for higher-cost products (<u>modern durable</u> / sachet water)	• <u>Chlorine</u> & safe storage (pref. for traditional durable & consumable)	• Chlorine & <u>safe storage</u> (strong pref. for traditional durable)
• Channel / Place	• Consumables (sachet or chlorine) door-to-door or local store • Durables (traditional and modern) at the general store		
• Marketing/ Promotion	• Opportunity to utilize mobile phone networks • Focus on product quality and speed of treatment		• Focus on health impact and product durability
• Pricing	• Higher prices preferred; no need to discount for urban and clear water consumers		

Table 6: Consumer Profiles (Segment 3a and 3b)

Segment	3a) Rural traders / salespeople	3b) Agriculture based / turbid Water (>10 TU)
Description:	All rural respondents that work as sales people or traders.	Rural respondents with turbid water (>10 TU) that are housewives or agricultural.
Ability to Pay:		
• Average Income	GHS 831 / household yr	GHS 551 / household yr
• Mobile Phone:	28% Ownership	40% Ownership
• Motorcycle:	36% Ownership	34% Ownership
Segment Size:	~20% of N. Ghana population	~52% of N. Ghana population
Household Profile:		
• Household size:	12 Individuals	11 Individuals
• Education:	8% primary, 11% additional	8% primary, 3% additional
• Health (diarrhea):	12% in children under five 6% in rest of household	10% in children under five 5% in rest of household
• Water Source:	96% dugout / dam; 56% borehole; 52% rainwater; 24% public standpipe	94% dugout / dam; 54% borehole; 58% rainwater; 25% public standpipe
Water Quality:		
• Ave. turbidity:	• 253 TU	• 336 TU
• Total coliform:	• 28,000 CFU / 100 ml	• 16,700 CFU / 100 ml
• % with Ecoli:	• 32% with E.coli	• 23% with E.coli
Relative Product Feature Preference:		
• Health	• Average (relative) health concern	• Highest health concern
• Product type	• Strong preference for traditional durable	• Strong preference for traditional durable, some pref. for modern durable
• Taste	• Slight preference for "chlorine" taste	• Moderate preference for "crisp" taste
• Treatment time	• Limited sensitivity to treatment time	• Limited sensitivity to treatment time
• Price	• Slight pref. for lower priced products	• No price sensitivity
Purchase Location:		
• Typical (top 3):	• 88% market day; 72% door-to-door; 56% general store	• 95% market day; 45% door-to-door; 29% general store
• Preferred:	• 88% door-to-door; 56% general store; 44% roadside stand	• 82% door-to-door; 72% general store; 34% roadside stand
Recommendations:	**Segment 3a**	**Segment 3b**
• Product	• Alum, chlorine & safe storage (pref. for low-cost products and chlorine taste)	• Alum / Kosim filter with safe storage (pref. for traditional durable); chlorine may be added for residual protection
• Channel / Place	• Consumables (alum / chlorine) and durables (safe storage / ceramic pot) sold by village entrepreneur at local store in community; low-touch with door-to-door reach	
• Marketing/ Promotion	• Consider radio and social networks • Focus on product durability and value	• Focus on health impact of water treatment and product durability
• Pricing	• Low price preferred, focus on cost recovery pricing and discounts	• Need for further testing of price sensitivity among rural agricultural

9 Methodology Assessment: Conjoint in the Developing World

As discussed in Section 4.1: HWTS Consumer Choice Research in the Developing World, the HWTS market has primarily been studied through Contingent Valuation and micro-market assessments designed to assess willingness to pay for individual products. However, as micro-market studies are poorly suited to a multiproduct assessment, a Choice-based Conjoint Analysis (CBC) was selected for the consumer preference element of this research. The effectiveness of the CBC in assessing HWTS consumer choice in Northern Region Ghana demonstrates that this methodology has the potential to offer HWTS implementing organizations a relatively low-cost tool to enhance understanding of consumer preference across a range of critical elements of product design. Useful survey modifications, lessons learned and opportunities for further research are highlighted below.

9.1 Useful Survey Modifications

A number of survey instrument modifications were required for effective implementation of the conjoint methodology in the developing world.

Pictorial Representation:

Inclusion of pictorial images proved a useful tool. The ability to engage the respondents on the pictorial images greatly enhanced the execution of the conjoint choice tasks. Here, the use of laminated sheets was a critical success factor. Binding the laminate task screens together allowed the surveyors to actively use them as props while interacting with the respondents. In addition, having larger scale visuals that matched the images shown on the task screen helped some respondents better understand the tradeoffs being presented on the visually stimulating task screens (See Figures 10-13). The text shown on the screens was in English, which was not a concern in this case for the surveyors or respondents as Dagbani is infrequently used as a written language. However, the pictorial screens did prove a critical element of the study, so if this methodology is being considered for other cultural context it could be useful to develop translated versions of these props.

Reduced Number of Tasks:

Based on feedback from our surveyors and concerns about survey length expressed by experts at PATH during the pre-test, we decided to reduce the number of tasks from twelve to eight. This modification gave us slightly less data, but the team felt that eight tasks per-respondent would be sufficient given the relatively large sample size[26]. Throughout this study the researchers typically observed respondent fatigue around task screen 3-4. Observable elements of respondent fatigue included distraction, focus on a single feature (at the complete exclusion of others), and frustration with the repetitive descriptions of the surveyor. However, as respondents moved into screens 5-8, the majority of respondents

[26] Conjoint analysis only requires 30 respondents to achieve statistically significant results (See Section 5.3, Sample Size Determination)

went through the options more quickly, showing learned task behaviors. The observation of learning behavior suggests that the respondents did understand the task and were able to make trade-offs at higher speeds, once they understood the range of potential options.

Number of Survey Variations:

The use of paper surveys necessitated a reduction in number of survey variations from that which would be used with an online tool. Ideally a different randomly selected set of product options would be shown to each respondent. In our case, four different surveys were produced for each population (urban and rural), and the same four sets were used throughout the research. The reduction in survey length reduced the volume of data collected; however, it did appear to enhance the quality of the results.

9.2 Conjoint Analysis Lessons Learned

In reviewing the work, there are a number of elements of the study that the author would like to highlight as areas for improvement. First, data analysis could have been expanded by utilizing the same survey instrument for both rural and urban populations. A similar conjoint tool was chosen for the two populations, but higher prices were shown in the urban survey. The change was made as a result of anticipated differences in urban and rural ability to pay. However, the urban and rural populations actually had somewhat similar ability to pay, and using a single conjoint tool would have facilitated a comparative analysis of urban and rural data.

Second, the CBC approach may have been equally effective with smaller target sample size, and a greater emphasis on in-depth translation and discussion. A number of the greatest insights gathered in this research came from patterns observed in commentary and discussion. Thus, a more detailed approach with a smaller sample could have offered greater understanding of the local preferences, politics, beliefs and traditions that govern water management behaviors. In addition, qualitative approaches based in anthropological research methodologies could be explored.

Finally, limiting the baseline household section of the survey has the potential to enhance the CBC element. The survey instrument utilized in this study provided high levels of detail in the baseline assessment. Ultimately, the variables highlighted on the segment profiles (Tables 5-6) proved most helpful to this work. Reducing the number of variables could help focus attention on quality of responses, and allow for time to ask open-ended follow-up questions for key variables. Furthermore, as effective market segmentation requires that each respondent fall in a unique location on the segmentation frame. Therefore, questions that did not provide a unique answer for each respondent (e.g., check all that apply) were not as helpful for the segmentation element of this work. To help address this challenge, questions relating to market segmentation variables could be framed either to require a discrete answer or where multiple responses are desired force ranking could be utilized.

9.3 Comments on Product Feature Selection

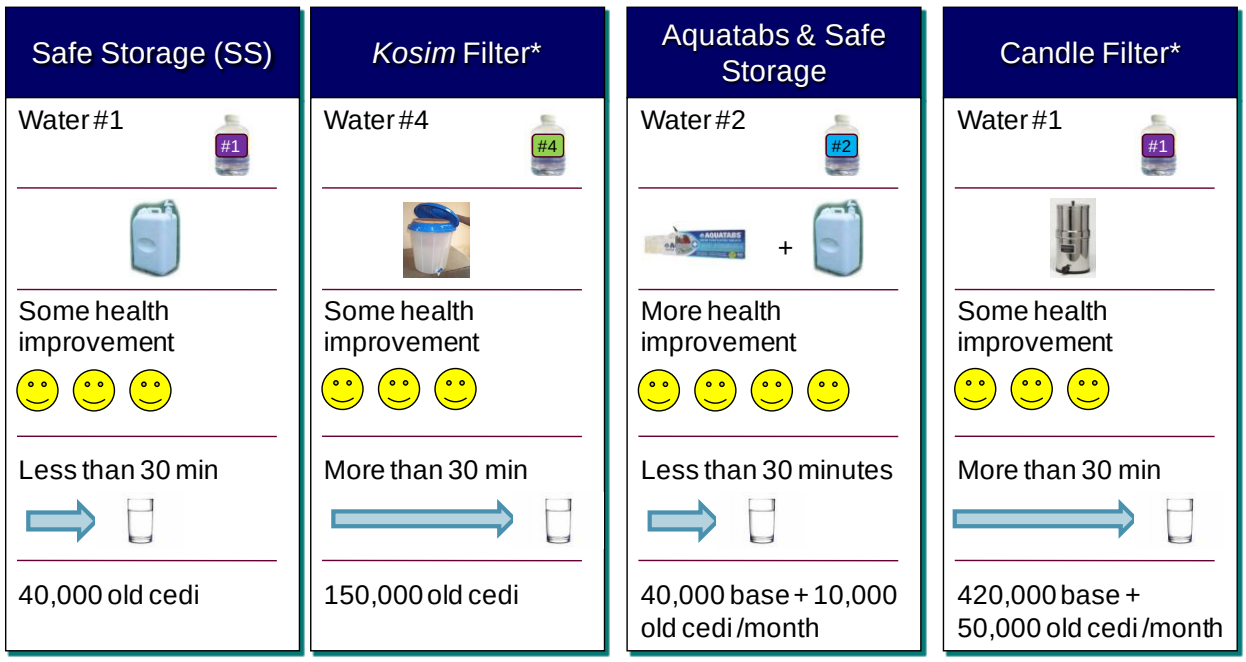
Prior to commencement of the survey the merits of including a health impact variable were extensively discussed. Inclusion facilitated assessment of the relative importance of health in HWTS purchasing decisions. Conversely, strong selection for this variable had the potential to mask preference for other features. Furthermore, as health impact of a single product cannot be easily quantified, the health variable might not have been the most effective way to describe HWTS products. To help offset the strength of the health variable a "fixed" task screen was included where the product options were matched to real products, with major health impact displayed in all three options. Despite the fixed task, the health attribute ultimately overshadowed all the other features. Thus, if the research were replicated in a different context it might be better to assume major health improvement is the most important driver of HWTS product purchase and either exclude the health attribute or set it at "major health improvement" throughout the study.

In addition, the decision was made in this research to co-vary price with product type to more accurately replicate the existing market landscape. The co-variance was useful in that it ensured that the product prices matched the product type; however, it made it difficult to clearly distinguish the relative in importance of price versus product type.

9.4 Opportunities for Further Research

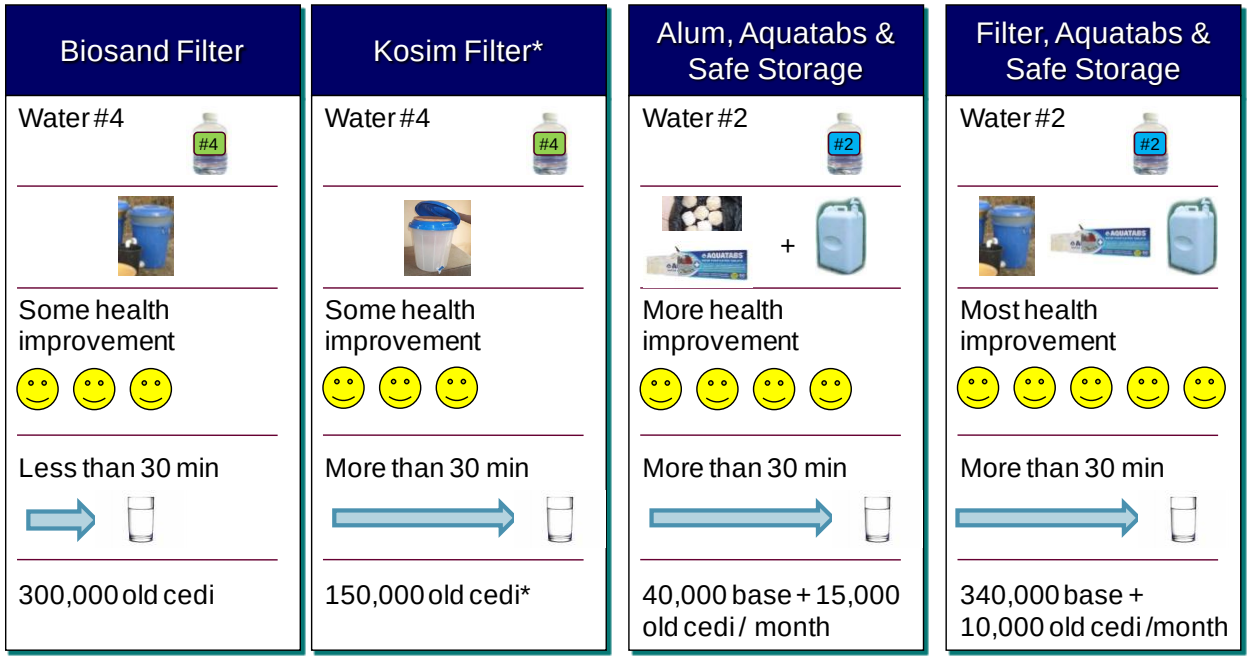
The initial conjoint assessment conducted in this research clearly demonstrated the potential for the conjoint tool for developing world consumer choice contexts. The ability of the surveyors to communicate and the respondents to accomplish the choice task is a critical step in proving the viability of the methodology for developing world consumer research. Additional work is needed to assess correlations between conjoint preferences and actual purchasing behaviors in the market segments identified. The test would be most effective if similar attribute sets to those used in the CBC analysis were used to describe the most appropriate HWTS products for each segment in the micro-market study. Task screens could be developed for each market segment modeled on the priority products identified. For example, for urban communities with clear water high-quality durable products and chlorine disinfectant options could be shown (Figure 32)[27], and for rural communities with turbid water filtration product such as the *Kosim* as well as combined treatment options could be shown (Figure 33).

[27] Sachet water has been excluded from the micro-market analysis because it is typically purchased in smaller volumes to supplement drinking water used in the home.



*Note: Only provides enough water for 6 individuals/day (if used correctly), thus two filters may be desired.

Figure 32: Conjoint Testing - Example HWTS Product Description Materials for Segments 1, 2a & 2b



*Note: Only provides enough water for 6 individuals/day (if used correctly), thus two filters may be desired.

Figure 33: Conjoint Testing - Example Product Description Materials for Segments 3a & 3b

Although relative importance of price in purchasing decisions was assessed using the CBC methodology, price was only one of five variables so the researchers were not able to develop a price to demand curve. Therefore, to learn more about willingness to pay for

HWTS in Northern Ghana, two options should be considered. First, a conjoint could be developed based on one or two of the product descriptions above that used price as the only variable. Alternatively, price variations could be incorporated into the micro-market model; however, given the large number of products being assessed, the later approach would require a large sample size to achieve any statistical significance.

Given local purchasing patterns seen in Northern Ghana, the author would recommend that any micro-market follow-up attempted be conducted in December-February, post the harvest season when respondents are most likely to have enough excess cash on hand to invest in a larger household purchase.

9.5 Conjoint Methodology Conclusion

Overall, the conjoint methodology proved a useful tool to assess product feature preference in Northern Ghana. As a result of this study, the researchers learned which features of a household water treatment product are most important to the local communities in urban and rural Northern Region, Ghana. However, further micro-market research would be useful to assess whether the conjoint methodology was effective in capturing actual purchasing behaviors.

10 Recommendations & Conclusions

In this section the author highlights the key learnings from the HWTS consumer preference research conducted in northern Ghana, and makes recommendations for organizations seeking to implement household water treatment interventions in the region. An emphasis is placed on recommendations for Pure Home Water (PHW).

10.1 Recommendations for HWTS Products in Northern Ghana

In this study, consumer preference research is used to identify strategies to enhance HWTS product adoption and sustained use. The results indicate that a portfolio approach is needed; however, it is our hope that local organizations seeking to implement point-of-use water treatment interventions can use these recommendations to target their efforts towards those interventions and HWTS products that are the best fit for the local consumers, and thus most likely to improve local drinking water quality in the long-term.

<u>Region-wide Recommendations</u>

- **Low-Cost Safe Storage**: The data show a significant short-term need for a low-cost plastic safe storage product throughout both urban and rural communities. A strong consumer preference for the traditional durable product type and high levels of recontamination in both urban and rural areas support this recommendation. Ability to pay and product cost estimates suggest that a commercial market would exist for this product.

- **Household Chlorine Product:** Opportunity for local manufacturing and/or promotion of a low-cost HWTS chlorine product (e.g., liquid chlorine). Our surveys showed substantial numbers of people with clear, microbially contaminated drinking water, and slight preference for a chlorine taste. In urban communities, chlorine treatment shortly prior to use could reduce recontamination risk. Due to the high turbidity of the sources waters of rural communities, household chlorine treatment scale-up in rural areas will likely require a clear dosing protocol (due to the need for a multi-step treatment process that includes particle removal prior to disinfection).

Urban / High-Income Communities (Segment 1)

- **Targeted Sachet Water Business:** Opportunity for sachet water vendors focused on urban traders and professionals. The recommendation is supported by segment preference for high price, short treatment times and clear crisp water taste. Opportunity for brand differentiation through product look.

- **High-End Modern Durable:** Limited market for modern durable filters among urban upper class. The recommendation is supported by Segment 1 consumer preference for high price and most interest in modern durable look (could be seen as a status symbol). Sales at the general store as well as social marketing should be emphasized to stimulate demand.

Clear Water / Working and Agricultural Class (Segment 2a & 2b)

- **Chlorine Disinfection & Safe Storage**: The initial target market for the combined chlorine and safe storage product. This segment is a good point of entry as it is a large market, that is relatively easy to reach, and has enough income to pay commercial prices for chlorine and safe storage containers. Recommendation supported by preference for traditional durable (which could be a safe storage container), with relatively less concern about a consumable product. Additionally, significant microbial contamination observed despite clean source water support the recommendation for improved residual protection and safe storage. Success depends on the development and communication of a clear chlorine treatment dosing protocol, specifically treating within twenty four hours of consumption to maintain residual protection. Preference for door-to-door purchasing suggests that a local sales model (vendors or local store) would likely be most effective for marketing a consumable product to these segments.

Rural Traders / Turbid Water (3b)

- **Alum, Chlorine Disinfection & Safe Storage**: Initial target market for a combined treatment system including alum, chlorine and safe storage. Opportunities for low-cost combined treatment products (e.g., alum / ceramic pot + chlorine disinfection) only exist in communities with turbid source water. The trader segment offers a good point

of entry for the consumable alum and chlorine products as this group had the greatest demand for a low cost solution, and behavioral change will not be required for product acquisition. Furthermore, a preference for chlorine taste suggests that these individuals will like using the chlorine product. The recommendation for including a safe storage element is supported by a preference for traditional durable and potential to improve treatment system by limiting recontamination. Success depends on the development and communication of a clear dosing protocol at the household or community level.

Rural Agricultural / Turbid Water (3a)

- **Alum, Chlorine Disinfection & Safe Storage**: A large, secondary market for the low-cost combined treatment system recommended for Segment 3b. The low income nature of the rural agricultural population creates a potential concern about ability to pay for a consumable product year-round (e.g., outside of harvest season). However, the levels of microbial contamination and turbidity in this segment suggest a high-level of need, and product preferences showed a strong demand for a traditional durable product (met by the safe storage container). Thus, a low-cost combined treatment method could be a great fit for this large segment of the population, as long as the appropriate promotional mechanisms could be developed to stimulate adoption and sustained (and effective use).

- **Target for Traditional Durable *(Kosim* Ceramic Pot Filter):** Rural agricultural is a large market, with clear need for turbidity removal and strong preference for the traditional durable product look, thus the locally available *Kosim* pot filter is a solid fit. In addition, biosand filters could also be considered for this market, but difficulty of transport could be a concern as there is a strong preference for a local sales model among rural agricultural respondents.

10.2 Considerations for Implementation of HWTS Interventions

Understanding local needs and clearly communicating product value in terms that are relevant for the local communities is critically important for successful implementation. In addition, education about importance of correct and sustained use should be highlighted for each community and potentially incorporated through marketing materials or product bundling (e.g., dedicated cup for water, products for cleaning, maintenance). Furthermore, where behavioral change is required, it will be important to continue to seek mechanisms of reinforcing correct use.

A community level sales model is desired; however, door-to-door marketing is challenging from a commercial perspective as a substantial number of resources are required to make house calls for limited total sales. One way to address this challenge, particularly for consumable products, could be providing inventory on a local level and restocking from a centralized distributor. From a sales and marketing perspective, timing is also critical, particularly in rural areas where income is cyclical. If households are only able to make

large purchases during the winter months following the harvest, then sales cycles should be matched to this schedule. Additional research on savings and day-to-day utilization of money could be useful to understanding ability to pay through out the remainder of the calendar year.

Local purchasing behaviors must also be considered in developing a successful implementation strategy, particularly if commercial sustainability is desired. In Northern Ghana, as is frequently seen in the developing world, males make the majority of the purchasing decisions while women handle water management. Thus, successful marketing will require a two pronged approach. Women must want to use the product and men must want to buy the product to improve the quality of life or health of the household. Social networks are powerful at the community level; however, community leaders and local chiefs appear to have relatively limited influence on purchasing behavior

10.3 Northern Ghana Water Quality: Lessons Learned

Urban and rural communities in Northern Ghana utilized a very different mix of water sources. In addition to rainwater, urban communities primarily used water from private (or neighborhood) taps, while rural communities mostly collected water from surface water sources, dugouts / dams, as well as boreholes. In both community types the majority of respondents were supplementing their water supplies with rainwater collection during the rainy season (June – September). Water source access remains a significant challenge for both urban and rural communities. Urban data showed that the primary challenges are water quantity and safe storage. Respondents often highlighted the lack of availability of municipal water (2-8 times per month). Therefore, on the days when water is available residents transport it to large storage vessels in their homes, where recontamination can be a critical issue as highlighted by the water quality data. In rural areas, distance to the water source and source water quality were the primary challenges. As the majority of rural communities use highly turbid local dugout as their primary source of water and a typical trip takes longer than thirty minutes, water collection alone requires over three hours per day.

10.4 Recommendations for Pure Home Water

PHW is a social enterprise and legally registered non-profit organization (as of March 2007) located in the Northern Region of Ghana. PHW was founded in June 2005, and since that time has sought to work with other regional HWTS organizations to demonstrate the viability of HWTS as a complement to borehole drilling and other water supply provision, sanitation interventions and hygiene interventions in Northern Region, Ghana (Alhassan, Senanu, Salifu, Wood, & Murcott, 2007).

Pure Home Water's two primary goals are to:

(1) Provide safe water to people in Northern Ghana through the dissemination of household drinking water treatment and safe storage systems in order to reduce/eliminate water related diseases (diarrhea, guinea worm, other), and to focus efforts especially on low-income households.

(2) Become financially self-sustaining through our sales (i.e. to break even, initially with our "Cost of Goods Sold" and ultimately with our "Total Expenses."

Based on local HWTS product research (Peletz, 2006; Johnson, 2007; Foran, 2007) as well as recommendations from previous teams of MIT- Sloan business students PHW has focused primarily on the sales and distribution of the *Kosim* ceramic pot filter. Currently, the *Kosim* product is manufactured by Ceramica Tamakloe Ltd (C.T.). in Accra; however, PHW has been exploring opportunities to reduce *Kosim* cost through development of a manufacturing facility in Tamale. In the past year, PHW has expanded rapidly due in part to a 5000 *Kosim* filter order from UNICEF for distribution to flood victims in the Upper East and Upper West, as well as though expansion of *Kosim* sales in the districts surrounding Tamale.

Continued growth in core product / sales monitoring

To date, PHW has seen substantial growth built around a focus on a single product, the locally-produced *Kosim*, ceramic pot filter. Going forward Pure Home Water should maintain focus on *Kosim* sales to rural consumers with turbid source water (Segment 3b), and continue to enhance education and monitoring to promote sustained use. Furthermore, as PHW is now approaching the three year filter replacement time for initial customers, follow-up procedures should be developed and options to replace only the pot filter element of the *Kosim* should be explored.

The recommendation for continued expansion in core markets is supported by the *Kosim's* appropriateness given preference for traditional durable and low product cost. In addition, as recontamination still poses a potential challenge to the *Kosim* product, PHW should continue to explore models for developing a combined treatment products (e.g., *Kosim* and chlorine disinfection). PHW has had success both in high volume sales supporting emergency relief efforts, as well as in communities where PHW has built relationships with influential individuals within the community. Where *Kosim* sales people and volunteers are passionate about the mission of PHW as well as the well-being of the community, they may be more likely to invest time and energy in promoting correct and sustained use. Finally, there may be an opportunity for PHW to increase adoption and sustained use by emphasizing health impact; however, successful implementation of this strategy will require emphasis on training and regular follow-up to ensure that customers are using the product correctly and satisfied with the result. Furthermore, such an effort would likely further enhance sales as happy customers are most likely to recommend the product to their friends and family and/or purchase again in the future.

Opportunities for revenue generation:

To stimulate further revenue there may be an opportunity for PHW to explore high-margin sachet water business or modern durable filter sales, focused on the urban upper and middle class. Furthermore, given the strong demand for traditional durable products PHW may want to consider opportunities to develop manufacturing capabilities for a low-cost dedicated safe storage product.

Implementation Strategy

The rapid adoption of the *Kosim* filter throughout the region highlights PHW's success in implementation; however, the results of the survey highlight a few areas for continued focus and development. First, PHW should utilize the information on the ways in which the *Kosim* filter effectively serves local needs (desire for traditional durable and low price), to clearly communicate product value in terms that are understood by the target community. In addition, customer satisfaction is critical to successful social marketing, and thus PHW should continue to focus on ensuring that human resources are available on a regular basis to speak with customers about product concerns and to assist with product maintenance. Finally, PHW should seek opportunities to incentivize local water volunteers (e.g., quarterly training sessions, sell five get one free, branded tee-shirts), as the dedication of these individuals is critical to the long-term success of PHW's implementation efforts.

10.5 Conclusion

Although household water treatment efforts in northern Ghana have expanded steadily towards the goal of reaching the 900,000 people in the region that lack access to an "improved" supply drinking water, a substantial number of households remain underserved. Through the consumer preference research described above, the project team gained a solid understanding of which features of HWTS products are most important to local consumers, and which consumer segments within northern Ghana are best suited for each of the priority HWTS product options. In addition, this work offers insight on the HWTS consumer landscape including assessments of: 1) existing water management practices, 2) need for improved water treatment based on health status and water quality, 3) HWTS product feature preference (strong demand for health improvements and traditional durable products with little sensitivity to water taste and price), 4) purchasing power and ability to pay, and 5) purchasing behavior and priority distribution channels. Therefore, it is our hope that this work can be used as a reference for organizations of the relative value and cost of HWTS interventions in Ghana, and throughout West Africa.

Organizations seeking to scale-up HWTS interventions are being asked to serve a diverse set of community needs; however an emphasis on matching appropriate products with target communities has the potential to substantially enhance product uptake and sustained use. Furthermore, continued emphasis on improving product distribution and monitoring, as well as engaging community leaders and local entrepreneurs will be critical to further scale-up of HWTS at the regional level. Today, a range of HWTS products are

available in Northern Ghana that are both appropriate for the local water quality needs, and are within the economic means of households in both urban and rural areas. Therefore, an opportunity exists to extend the reach of HWTS throughout the region by focusing on distribution and/or commercial sale of a discrete set of priority products to the most appropriate consumer segment(s). In addition, by seeking to expand local availability of supporting products such as safe storage and cheaper chlorine disinfection, the range of locally available HWTS options can be expanded to include a broader set of HWTS options that are a good match for the household water treatment needs of each community in the region.

11 References

Alhassan, H., Senanu, B., Salifu, W., Wood, L., Murcott, S. (2007). *Pure Home Water Year Two: Annual Report and Summary.* Submitted to the Conrad N. Hilton Foundation, July, 2007.

Ashraf, N., James, B., & Shapiro, J. (2007). Can higher prices stimulate product use? Evidence from a field experiment in Zambia. *Abdul Latif Jameel Poverty Action Lab*, 41.

Brown, J.M. (2007). *Effectiveness of ceramic filtration for drinking water treatment in Cambodia.* University of North Carolina at Chapel Hill.

Central Intelligence Agency. (2008). *The world factbook: Ghana.* Retrieved May 9, 2008 from https://www.cia.gov/library/publications/the-world-factbook/geos/gh.html

Clasen T, Roberts I, Rabie T, Cairncross S (2006). *Interventions to improve water quality for preventing infectious diarrhoea.* A Cochrane Review.

Conroy R.M., Elmore-Meegan M., Joyce T, McGuigan K.G., Barnes J. (1996). *Solar disinfection of drinking water and diarrhoea in Maasai children: a controlled field trial.* Lancet. 348: 1695–97.

Crump, J. Otieno, P., Slutsker, L., Keswick, B., Rosen, D., Hoekstra, R.M, Vulule, J.M., Luby, S. (2005) *"Household based treatment of drinking water with flocculant-disinfectant for preventing diarrhea in areas with turbid source water in rural western Kenya: cluster randomized controlled trial."* BMJ, doi:10.1136/bmj.38512.618681.E0.

Department of Health and Human Services: Centers for Disease Control and Prevention (2008). *Safe Water Systems (SWS)*. Retrieved May 9, 2008 from http://www.cdc.gov/safewater/index.htm

Esrey, S., Feachem, R., & Hughes, R. (1985). *Interventions for the control of diarrheal diseases among young children: improving water supplies and excreta disposall facilities.* Bulletin of the World Health Organization 63 (4): 757-772.

EAWAG, Swiss Federal Institute for Environmental Science and Technology. (2008). *Solar Water Disinfection*. Dübendorf, Switzerland. Retrieved May 18, 2008 from http://www.sodis.ch/

Fewtrell, L, & Colford, J.M. (2004). *Water, sanitation and hygiene: Interventions and diarrhoea: A systemic review and meta-analysis.* Health, Nutrition, and Population Discussion Paper. Washington, DC: World Bank.

Foran, M. (2007). *An analysis of the time to disinfection and the source water and environmental challenges to implementing a solar disinfection technology (SolAgua).* Harvard School of Public Health.

Ghana Statistical Services. Retrieved May 8 from http://www.statsghana.gov.gh/

Geology.com. (n.d.) *Ghana map: Ghana satellite image.* Retrieved May 9, 2008 from http://geology.com/world/ghana-satellite-image.shtml.

HWTS Network Tools (2008). *"Fact Sheets."* Retrieved May 1 from http://stellar.mit.edu/S/project/hwts-network/materials.html#topic3/

Johnson, S. M. (2007). *Health and water quality monitoring of Pure Home Water's ceramic filter dissemination in the Northern Region of Ghana.* Massachusetts Institute of Technology. Cambridge, MA.

Johnson S., Peletz R., & Murcott, S. *(2008). Results from Household Ceramic Filter Evaluation in Northern Ghana.* 33rd WEDC International Conference. Access to Sanitation and Safe Water: Global Partnerships and Local Actions. Accra, Ghana, 2008

Kremer, M., & Miguel, E. (2007). *The illusion of sustainability*. President and Fellows of Harvard College and the Massachusetts Institute of Technology. The Quarterly Journal of Economics, August.

Kikkawa, I. (2008). Modification of a Biosand Filter in the Northern Region of Ghana. Massachusetts Institute of Technology. Cambridge, MA.

Kols, Adriene (2008). *Commercial approaches to providing safe water in India: A literature review* (eds. Michele Burns). PATH Safe Water Project. Retrieved May 9, 2008 from http://www.path.org/files/TS_safe_water_brief1.pdf

Lantagne, D.S., Quick, R., & Mintz, E.D. (2006) Household water treatment and safe storage options in developing countries: A review of current implementation practices. In Parker, M., Williams, A., & Youngblood, C (Eds.), *Water stories: Expanding Opportunities in Small-scale water and sanitation projects* (17-38). Woodrow Wilson International Center for Scholars: Environmental Change and Security Program. Retrieved February 10, 2008 from http://www.wilsoncenter.org/topics/pubs/WaterStoriesComplete.pdf

Luby, S., Agboatwalla M., Painter, J., Altaf, A., Billhimer, W., Keswick, B. Hoekstrar, R.H. (2006). *"Combining drinking water treatment and hand washing for diarrhea prevention, a cluster randomized controlled trial."* Tropical Medicine and International Health. Vol. 11(4): 479-489. doi:10.1111/j.1365-3156.2006.01592.

MacRae, D.,Jr., & Whittington, D. (1988). Assessing preferences in cost-benefit analysis: Reflections on rural water supply evaluation in Haiti. *Journal of Policy Analysis and Management, 7*(2), 246-263.

McPhail, A. (1993). The "five percent rule" for improved water service: Can households afford more? [Electronic version]. *World Development*, 21 (6), 963-973.

Medentech, Aquatabs. (2008). *Household point-of-use.* Retrieved May 9, 2008 from http://www.aquatabs.com/index.cfm?area=content&action=contentselect&menuid=221

MIT-Sloan School of Management. *Global Entrepreneurship Lab.* Retrieved May 12 from http://mitsloan.mit.edu/globalmitsloan/global-e-lab.php

Moor, A., & Calamai, P. (n.d.). Stalking the elusive subsidy: Subsidizing unsustainable development: Undermining the earth with public funds. Retrieved April 30 from http://stellar.mit.edu/S/course/11/sp08/11.479J/materials.html

ModernGhana (n.d.). *"References: Northern Region."* Retrieved May 12 from http://www.modernghana.com/GhanaHome/regions/northern.asp?menu_id=6&menu_id2=14&sub_menu_id=135&gender

Murcott, S. (2007). *Pure Home Water Annual Report.* (internal document).

Nath, K.J., Bloomfield, S., Jones, M. (2006). *Household water storage, handling and point-of-use treatment.* International Scientific Forum on Home Hygiene.

Shea, C. (2007, November 11). A handout, not a hand up: A popular approach to sustainable development doesn't work, critics say. *Boston Globe*, pp E1, E4.

Lougheed, T. A clear solution for dirty water. *Environmental Health Perspectives,* 114 (7): A424-A427.

Okioga, T. (2007). *Water quality and business aspects of sachet-vended water in Tamale, Ghana.* Massachusetts Institute of Technology.

Orme, B. (2006). Managerial Overview of Conjoint Analysis. *Getting started with conjoint analysis: strategies for product design and pricing research* [reprinted by Sawtooth Software]. Madison, WI: Research Publishers, LCC.

Pastor Steve's public gallery. *Ghana 2007.* Retrieved May 9, 2008 from http://picasaweb.google.com/newsongpastor/Ghana2007/photo#5119350040620695858

PATH Safe Water Project. (n.d.). *Partnerships for Commercialization of Household Water Treatment and Storage Product.* Retrieved May 9, 2008 from http://www.path.org/files/TS_safe_water_fs.pdf

PATH Safe Water Project. (2008). *Commercial Approaches to Providing Safe Water in India: A literature review .* Retrieved May 9, 2008 from http://www.path.org/files/TS_safe_water_brief1.pdf

Pattanayk, S.K., Yang, J.C., Whittington, D., & Bal Kumar, K.C. (2005). Coping with unreliable water supplies: Averting expenditures by households in Kathmandu, Nepal. *Water Resources Research,* 41, W02012.

Peletz, R. (2006). *Cross-Sectional Epidemiological Study on Water and Sanitation Practices in the Northern Region of Ghana.* Massachusetts Institute of Technology. Cambridge, MA.

Reller J, Lopez B, Mejia MA, Mendoza C, Luby S, (2003)/ *A novel technology to improve drinking water quality: a microbiological evaluation of in-home flocculation and chlorination in rural Guatemala.* Journal of Water Health (1): 15–22.

Rogers, P. Silvia, R., & Bhatia, R. (2002). Water is an economic good: How to use prices to promote equity, efficiency and sustainability [Electronic version]. *Water Policy,* 4, 1-17.

Swanton, A. (2008). *Combined Kosim Filter and Aquatabs Treatment System in Northern Region, Ghana.* Massachusetts Institute of Technology. Cambridge, MA.

Sawtooth Software. (2007). *Technical paper series: The CBC system for choice-based conjoint analysis.* Sequim, WA. Sawtooth Software Inc.

Stauber, C. (2008). *The microbiological and health impact of the biosand filter in the Dominican Republic: A randomized controlled trial in Bonao.* University of North Carolina at Chapel Hill.

UNICEF. (2008). *"Promotion of household water treatment and safe storage in UNICEF wash programmes,"* Retrieved May 12 from HWTS Network Tools Website http://stellar.mit.edu/S/project/hwts-network/materials.html#topic2/

Whittington, D., Briscoe, J., Mu, X., & Barron, W. (1990). Estimating the willingness to pay for water services in developing countries: A case study of the use of contingent valuation surveys in southern Haiti. *Economic Development and Cultural Change, 38*(2), 293-311.

Whittington, D. (2002). Improving the performance of contingent valuation studies in developing countries. *Environmental and Resource Economics,* 22. 323-367.

World Health Organization. (2006). *Country cooperation strategy, Ghana.* Retrieved May 9, 2008 from http://www.who.int/countryfocus/cooperation_strategy/ccsbrief_gha_en.pdf

World Health Organization. (2006). *Country health system fact sheet, Ghana.* Retrieved May 9, 2008 from http://www.afro.who.int/home/countries/fact_sheets/ghana.pdf

World Health Organization. (2004). *Water, sanitation and hygiene links to health*. Retrieved May 9, 2008 from http://www.who.int/water_sanitation_health/facts2004/en/

World Health Organization. (2004) *Guidelines for drinking water quality: Third edition.* Geneva, Switzerland.
World Health Organization. (2003). *The Right to Water.* Health and human rights publication series (3). Retrieved May 18, 2008 from http://www.who.int/water_sanitation_health/rtw1.pdf
WHO-UNICEF joint monitoring programme for water supply and sanitation. (2006*). Sub-Saharan Africa: water supply data.* Retrieved May 9, 2008 from http://www.wssinfo.org/en/233_wat_africaS.html
Yazdani, I. (2007) *High Density Polyethylene (HDPE) Containers as an Alternative to Polyethylene Terephthalate (PET) Bottles for Solar Disinfection of Drinking Water in Northern Region, Ghana*. Massachusetts Institute of Technology.
Zwane, A.P., Kremer, M. (2007) *What works in fighting diarrheal disease in developing countries? A critical review.* Cambridge, MA: National Bureau of Economic Research.

Appendix 1: Global Entrepreneurship Lab Final Report

PURE HOME WATER CONSUMER CHOICE STUDY RESULTS AND RECOMMENDATIONS

Gaetan Bonhomme, Avani Kadakia, Gabriel Shapiro & Matt Thomson

Summary of Findings

- Conjoint study shows that the **most important attributes**, in order, for the **Urban** communities are: major health improvement, traditional durable product type, clear & crisp tasting water, fast treatment speed and high price
- Conjoint study shows that the **most important attributes**, in order, for the **Rural** communities are: major health improvement, traditional durable product type, clear & chlorine tasting water, fast treatment speed and low price
- Based on these findings, we recommend that PHW focus on the following **New Product Offerings:**
  - Safe Storage: Urban communities experience significant contamination from storage systems
  - Biosand: This filter offers many of the most important attributes to respondents
  - Larger Kosim: For rural communities, a larger Kosim would better serve their daily water requirements
- …And focus on the following **Marketing Efforts:**
  - Brand based on health
  - Higher price to communicate better quality
  - Door-to-door distribution plus retail space in the market to advertise

Background & Objective

- Pure Home Water's (PHW) mission is to provide home water treatment systems to the residents of Northern Ghana who lack consistent access to clean water.
- Current strategy is to sell the Kosim filtration system, a ceramic filter combined with a plastic safe storage container to resellers in urban areas and directly to rural villagers.
- While PHW has experienced some success selling the Kosim, a lack of strong demand and widespread adoption led them to question whether they should continue offering only the Kosim filter to their potential customers. This led them to develop a project to better understand their opportunities.
- This project was supported by PATH's Safe Water Project, which seeks to demonstrate the commercial viability of household drinking water treatment and safe storage (HWTS) systems scale-up in India and several other countries around the world. Our MIT team sought to assist PATH to better understand the consumer market for HWTS in Ghana.
- In addition, our team worked to help Pure Home Water determine which home water treatment system or systems would gain widespread adoption in the rural and urban areas of Northern Ghana by interviewing potential customers.

Methodology

- In order to determine which product or products Pure Home Water should be offering to which populations, our team conducted a household consumer choice study consisting of two pieces:
  - Market Segmentation to determine
    - Demographics and household profile (household size, ages, adult/child breakdown)
    - Questions that tease out ability to pay
    - Decision maker/purchaser identification
    - Technological adoption traits
    - Current water, treatment, hygiene, sanitation and health practices
  - Conjoint Analysis is to determine which features of a water treatment system are the most appealing. The features of HWTS that we will test in our conjoint analysis are:
    - Water Look & Taste
    - Water Taste
    - Price
    - Product Appearance
    - Health Benefits
- We conducted the survey in both rural and urban neighborhoods in and around the city of Tamale in Northern Ghana.

Sources

- To familiarized ourselves with Pure Home Water and the water treatment industry landscape generally and in Northern Ghana we consulted:
  - Theses of current and former students of Pure Home Water Founder Susan Murcott including:
    - Water Source Options in Tamale, Ghana, S Johnson, 2007
    - The Cost of Water in Ghana, K Doyle, 2007
  - Academic papers:
    - Cost recovery of community-managed piped water systems in Ashanti region, Ghana, K. B. Nyarko, S. Oduro-Kwarteng & I. Adama
    - Privatisation of water: Public-private partnerships: do they deliver to the poor?, The Norwegian Forum for Environment and Development
  - Company Collateral and Presentations
- To inform the design of our consumer choice survey we consulted:
  - MIT Sloan professors who are experts in the field
    - John Hauser, PHD
    - Other Sloan Professors
  - Water quality surveys conducted elsewhere in the developing world.
  - PATH, a non-governmental organization that was supporting Pure Home Water's work in the field and has a wealth of experience conducting surveys in the developing world.

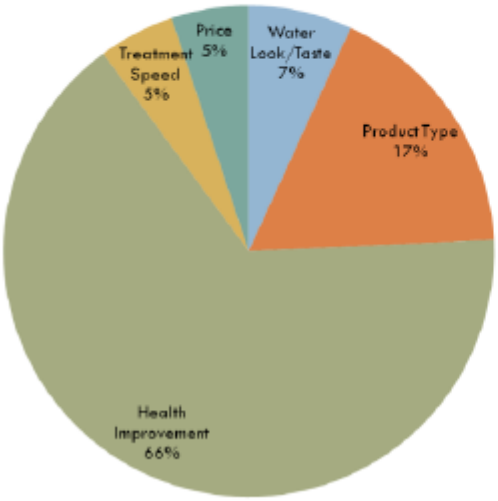
Rural Summary

- Rural was defined as communities with the following characteristics:
  - Insular communities separated from urban sprawl of Tamale, each with their chief.
  - PHW had not previously visited the community.
- 4 Rural communities were visited (Kasaligu, Golinga, Nyarizee, East Gonja)
- Both Muslim and Christian communities were selected to minimize biases.
- Overall, ~120 rural households were visited with a household defined as "people sharing from the same pot of food."
- To obtain a random sample, each village was divided in quadrants and households were selected using the random walk method.

Rural Demographic Findings

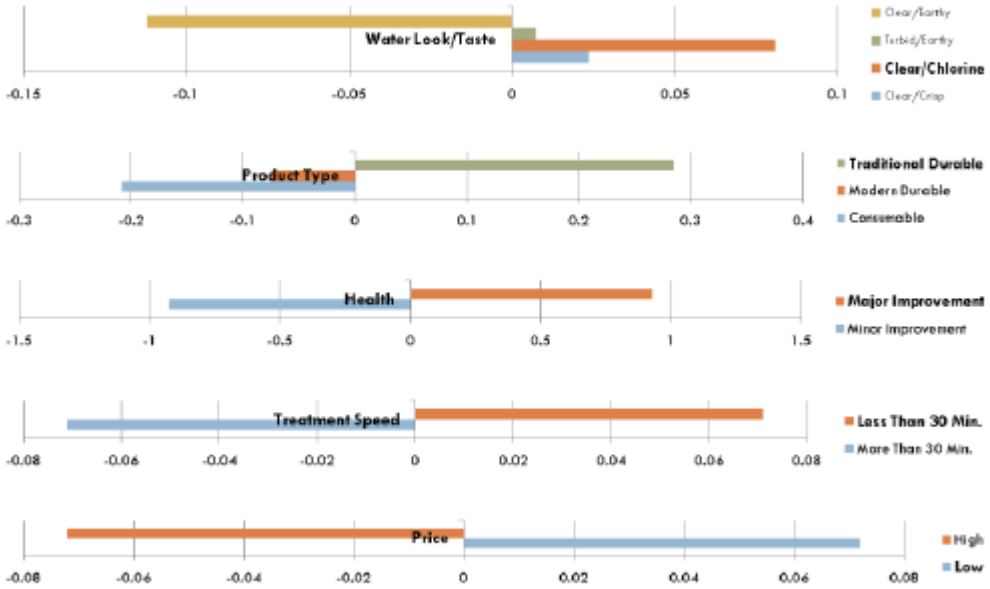
- 13% of rural households we surveyed have tin roofs while 95% have thatched roofs
- <1% have electricity connections while 30% have motorcycles and cell phones and 93% have bicycles
- 30% of respondents purchase health items through a door to door marketer while 70% purchase items at market day in Tamale
- 60% prefer to buy health items through a door to door salesperson while 20% prefer going to a specialty store or market day
- 42% of respondents are happy with their drinking water
  - Quotes from happy respondents:
    - "We don't experience guinea worm in our village"
    - "We filter the water…[using guinea worm cloth filter - widely available in Northern Ghana through free distribution by the Guinea Worm Eradication Campaign]…before drinking but we still need more filters to improve our health"
    - "We fetch water from the borehole"
  - Quotes from unhappy respondents:
    - "We share our water source with the animals"
    - "It is not very good unless you apply alum"
    - "Because we have no treatment measures or filters"
- 80% of people who treat their water do so because of guinea worm larvae, 70% do so because the water is turbid and 30% because people get sick
- Over 80% of households treat more than 4 jerry cans of water per day
- About 50% of households surveyed have turbidity results over 100 turbidity units (TU)

Rural Conjoint Findings > Attribute Importance



Attribute Importance quantifies the effect that each attribute has on a respondent's preferences for products.

Rural Conjoint Findings > Level Winners and Losers



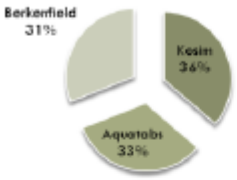
The Perfect Product for Rural

- The perfect product is a *Traditional Durable* sold for a *lower* price that offers *major* health improvement and filters water at a *faster* treatment speed while turning out water that is *clear and chlorine*y.
- In addition, that product can treat *46* liters of water per day and will come with a storage container that has a tap.
  - 46 liters meets the water requirements per day of 75% of rural households surveyed.

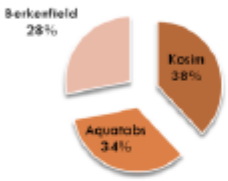
Rural Market Simulation Results

Expected Outcome of Current Competition

Share of Market with Kosim @ Low Price Point

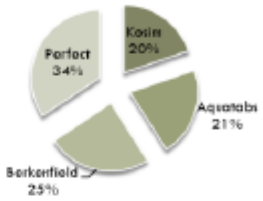


Share of Market with Kosim @ High Price Point

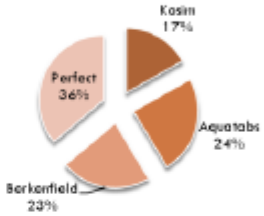


Current Products Against the Perfect Product

Share of Market @ Low Price Point



Share of Market @ High Price Point



The Kosim Filter in the Rural Market

- The Kosim filter exhibits the top two of the attributes that are desired in the rural markets and it is clear why Pure Home Water chose to enter with this product.
  - The Kosim boasts 99% effectiveness in filtering bacteria, which is consistent with the major health improvement that was the most important attribute to the rural participants
  - The second most important attribute to the rural customers was the product type and the Kosim's traditional durable product type was strongly preferred.
- However some features of the Kosim provide an explanation for its slow adoption
  - While the conventional wisdom was that rural villagers would prefer water that tasted "earthy" like the water they currently drink, respondents strongly preferred the two non-earthy tasting waters, with the Kosim water being the least desired water type by a wide margin
  - While it was only the fourth most important attribute, respondents prefer a fast filter time. In addition, with filter times of 1.0 liter per hour (assuming highly turbid water) it is clear that one Kosim filter could not satisfy the drinking needs of nearly 50% of the households that we surveyed.

Recommendations for Rural

- Raise Price to signal high quality of product
  - Bulk discounts for families that would require more than one Kosim
- Continue Research on Biosand Filter
  - Faster filtration speed will better satisfy volume without sacrificing attributes that are important to rural communities
- Marketing efforts focused on PHW product being "the healthiest"

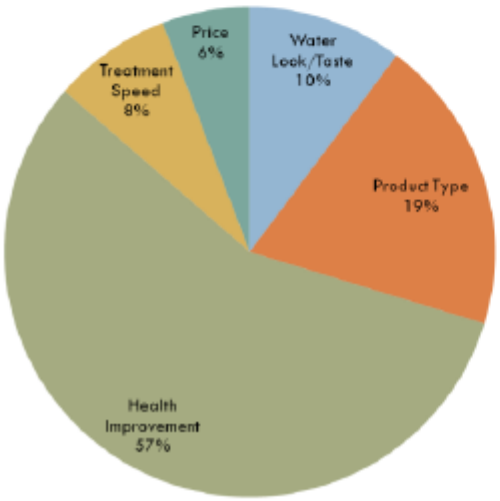
Urban Overview

- Urban was defined as communities surrounding the center of Tamale with the following characteristics:
  - Communities located within the urban sprawl of Tamale, with community leaders as opposed to chiefs.
  - PHW had not previously visited the community.
- 4 Urban communities were visited
- Communities with differing economic situations were selected to minimize biases
- Overall, ~120 urban households were visited
- To obtain a random sample, each community was divided in quadrants and households were selected using the random walk method

Urban Demographic Findings

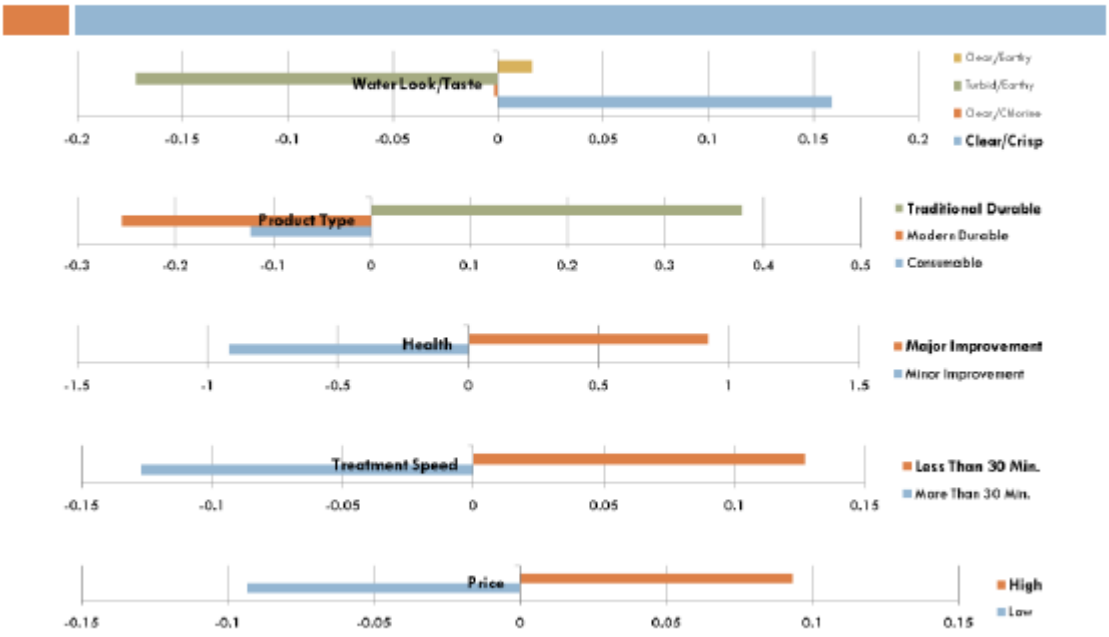
- 100% of urban households we surveyed have tin roofs while only 5% have thatched roofs
- 80% had electricity and owned a cell phone while 70% had a bicycle and 40% had a motorcycle
- The majority of our respondents typically make health related purchases at specialty stores and in the market. About 30% prefer to make health related purchases from a door to door marketer
- 82% claim that they are happy with their drinking water
  - Quotes noted:
    - "Because I believe that they treat the water before they supply it"
    - "It is clean and tastes normal"
    - "Good taste and clarity"
    - "It is treated by Ghana Water Company before distribution"
- 20% of respondents who treat their water do so because of turbidity while 15% do so because of microbial contamination
- 80% are happy with their current water treatment system
  - Quotes noted:
    - "Because we always wash the storage vessels daily"
    - "The water is always treated"
    - "We cover the water and protect our indoor water with a cover"
- 100% of our respondents had water turbidity results <= 5 TU.

Urban Conjoint Findings > Attribute Importance



Attribute Importance quantifies the effect that each attribute has on a respondent's preferences for products.

Urban Conjoint Findings > Level Winners and Losers



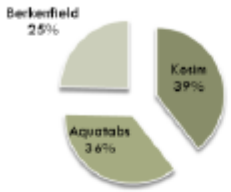
The Perfect Product for Urban

- The perfect product is a *Traditional Durable* sold for a *higher* price that offers *major* health improvement and filters water at a *faster* treatment speed while turning out water that is *clear and crisp*.
- In addition, that product can treat *45* liters of water per day and will come with a storage container that has a tap.
  - 45 liters meets the water requirements per day of 75% of urban households surveyed.

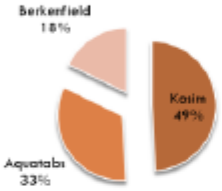
Urban Market Simulation Results

Expected Outcome of Current Competition

Share of Market with Kosim @ Low Price Point

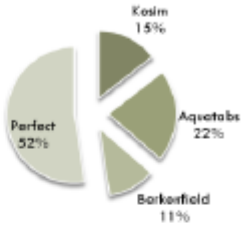


Share of Market with Kosim @ High Price Point

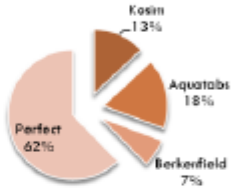


Current Products Against the Perfect Product

Share of Market @ Low Price Point



Share of Market @ High Price Point



The Kosim Filter in the Urban Market

- The urban market had the same top two attributes as the rural market making Kosim a good fit.
  - The Kosim boasts 99% effectiveness in filtering bacteria, which is consistent with the major health improvement that was the most important attribute to the urban participants
  - The second most important attribute to the rural customers was the product type and the Kosim's traditional durable product type was strongly preferred.
- However some features of the Kosim provide an explanantion for its slow adoption
  - While the urban respondents did not have as an adverse reaction to the Kosim treated water as the rural respondents, they strongly preferred the clear and crisp water over all others
  - While it was only the fourth most important attribute, respondents strongly prefer a fast filter time. Though household sizes were similar to those of the rural areas, faster filter times with tap water would minimize the need for multiple filters
  - One of the most surprising results of the survey was a fairly string preference for a higher price with all other attributes being equal

Recommendations for Urban

- Raise Price to signal high quality of product
- Continue Research on Biosand Filter
  - Faster filtration speed will better satisfy volume without sacrificing attributes that are important to rural communities
- Marketing efforts focused on PHW product being "the healthiest"
- Focus on selling safe storage systems in the urban communities given that piped water is relatively clean and the bulk of contamination occurs during storage

Product and Marketing Next Steps

- Take into account seasonality:
  - Sell Rural from November to March, after the beginning of harvest and a few months after
    - Rural channels: community presentation, door-to-door, specialty store and market
  - Switch to Urban and potentially other products (like Pure and Aquatabs) during the rest of the year
    - Urban channels: Specialty store and door-to-door
- Revise pricing guidelines:
  - The price discrimination strategy is fine (i.e. charging more in Urban than rural), but since customers do not seem to be as price sensitive as expected more flexibility in terms of exact price setting needs to be introduced
  - Sales people should be responsible to sell as high as they think they can, especially if their incentives are linked to sales amounts
  - Try to sell at no loss even in Rural
- Build PHW brand around "most healthy" home water treatment.
- Product focus?:
  - Sell branded safe storage containers.
  - Investigate Biosand (PHW R&D?)
  - Supersize the Kosim

Ad Hoc Recommendations for PHW

- Complete structure in Ghana
  - Managing director most needed:
    - Based in Tamale
    - Ability to speak the languages
    - 100% of his or her time shaping the organization
    - Think about some of our surveyors
  - Formalize contracts with Sales People and community liaisons:
    - Community liaisons should have the same contracts/incentives:
      - Same "salary" rule (flat fee for 100 filter sold OR fee per filter)
    - Salary and commission not totally as % of sales but also tied to % of profits generated
  - Clarify the duties and responsibilities of the Board of Advisors in order to create synergy with Managing Director's leadership
- Delay factory plans for at least another harvest season
  - Evaluate impact on profits based on new pricing and incentive policy

Appendix 2: Consumer Research Survey Instrument

Consumer Choice Marketing Study of Household Drinking Water Treatment and Safe Storage Products in Northern Region Ghana

Susan Murcott murcott@mit.edu
Senior Lecturer, Civil and Environmental Engineering Dept.

Hello, my name is _____, and I am a researcher working with a team from Pure Home Water in Savelugu, Ghana and Massachusetts Institute of Technology, in the United States. The study is being funded by PATH, an international public health organization based in the United States. We are conducting a research survey on household water management, treatment and safe storage systems. We are talking with people in your community to learn what water products are best suited for households in urban and rural Ghana. All information we collect will be kept confidential, which means that we will not reveal the information you give to us with others. The data will be kept only as a collection of the responses given by all survey participants.

We would like to talk with the main person in your household who is in charge of managing water in the home for about 1 hour. We are planning to ask questions about your household profile, income, health status, and water management practices. You may find some of the questions sensitive. In this case, you may choose to not answer any or all of the questions, and, if you wish, you may end the interview before it is finished. At the end of the survey we would also like to collect a water sample to test the water turbidity and quality.

For additional information about this research survey you may contact the local non-profit Pure Home Water at 027-364-3034.

Participation is completely voluntary. Are you willing to participate in this study?

Yes	
No	

If no, thank you for your time and we will end here. If yes, do you have any questions about the survey or may we begin now?

Interview background

Surveyor	
District name	
Community name	

Date	
Start Time	
End Time	
GPS mark number	
GPS coordinates	

Note: Page 1 of the survey, with the head of household identifying information, will be kept confidential. It has been formatted as a separate page (pages 1), which can be separated from the rest of the survey, once each survey is numbered.

1. Consumer HTWS Product Feature Preferences (Conjoint Analysis)

We are going to ask you some specific questions about what YOU want in a household water treatment system. We are interested in learning what type of product YOU would be most interested in buying.

5.1 Attribute Explanations

EXPLANATIONS SHOULD BE GIVEN BEFORE THE CONJOINT AND MADE AVAILABLE LATER, IF NECESSARY, TO HELP PARTICIPANT MAKE SOLID JUDGEMENTS.

First we would like to familiarize you with the potential features of household water treatment products that we will be asking you to consider.

Water Taste / Look – We have with us four bottles of different types of treated water. You will be asked to make decisions based on which type of water you would prefer, if it would be helpful to your decision you can taste these samples of water at any time.

Product Type / Lifespan – You will be asked to choose among three different product types, the first type is consumable which means that it is used immediately after buying. It can only be used to treat a certain amount of water and then you must buy more (SHOW CONSUMABLE IMAGE). The second type is modern durable which means that it is made outside Ghana and lasts for 3-5 years (SHOW MODERN DURABLE IMAGE). The last type is traditional durable which also lasts for 3-5 years, but is made in Ghana (SHOW TRADITIONAL DURABLE).

Health / Germ Removal – Drinking water is one source of waterborne disease in Ghana. Typical symptoms of waterborne disease include diarrhea, worms and need for trips to the hospital (see images). All types of water treatment will remove things from the water that make you sick which improves your health; however different water treatment systems may have different levels of impact. For the purpose of this survey we will ask you to consider minor health improvement shown by 🙂🙂🙂 and major health improvement shown by 🙂🙂🙂🙂🙂. Minor health improvement means that some organisms are removed from the water making you / your family healthy more of the time and major health improvement means all organisms are removed from the water making you / your family is healthy most of the time.

Treatment Speed - Treatment speed means time required to clean the water. For the purposes of this survey we will ask you to choose between relatively rapid treatment (less than 30 minutes) and longer treatment (more than 30 minutes).

Price – Finally, prices will be shown for each product. For products that are purchased on a weekly basis the price will be shown in pesawas / month , and for products that last for multiple years the price will be shown as two equal payments made in the first two months the product is owned.

1.1 Feature Set Choices

Now that you are familiar with the product features, we are going to show you 8 images of water treatment products and we would like you to choose the one that you would most like to buy. If you

would not purchase any of the products shown you should select the "Do not purchase option." Each product set may look very much alike. However, all are slightly different.

INTRODUCE **ALL FIVE PARTS OF EACH PRODUCT** – EXAMPLE BELOW.

- Product A has the taste and look of #X. Do you remember what that tastes like? If not, you can taste again.
- You will buy a product that looks like this to clean the water (SHOW IMAGE).
- It will make a major health improvement or it will make a minor health improvement.
- It will take more than 30 minutes to filter or it will take less than 30 minutes to filter.
- It costs XXX Ghanaian cedis or pesewas.

REPEAT FOR **PRODUCT A, B AND C** ON EVERY SHEET

MAKE SURE TO MENTION THAT IF THEY WOULD NOT BUY ANY OF THE PRODUCTS THEY SHOULD SELECT "OPTION D."

Data Collection Template (SELECT ONLY ONE OPTION PER ROW):

	A	B	C	D	Why (only when applicable)
Task 1					
Task 2					
Task 3					
Task 4					
Task 5					
Task 6					
Task 7					
Task 8					

2. Household Information Questions

2.1 Background TO BE COMPLETED BY SURVEYOR.

Survey Number			
Surveyor			
Respondent language used			
Respondent gender			
Respondent religion			
Respondent roof type(s)	Tin	Ceramic	Thatch
Community type	Urban	Rural	
MIT monitor present?	Yes	No	

2.2 What is your present marital status?

Married	
Consensual Union	
Divorced	
Never Married	
Other	

If other please specify_____

2.3 How many people live in your household? What are their ages?

Total Number in household	
Respondent's Age	
Respondent's Spouses Age	

Age	Number of Members (including respondent)
≤ 5 years old	
6-17 years old	
≥18 years old	

2.4 What is your highest level of education completed?

Primary School	
Secondary School	
University	
Advanced Degree	

3. Purchasing Decision Questions

3.1 Have you bought any of the following? If so, who bought these items (i.e., respondent, respondent's spouse, chief, chief's secretary, relative (family), other)? CIRCLE YES OR NO.

		Purchaser
Electricity connection	Yes / No	
Water Storage Vessel(s)	Yes / No	
Water Tap – private	Yes / No	
Soap	Yes / No	
Alum or other water treatment products (WTP)	Yes / No	
Television	Yes / No	
Cell (mobile) phone	Yes / No	
Bicycle	Yes / No	
Motorcycle	Yes / No	
Cooking vessels	Yes / No	
Bed nets	Yes / No	
Anti-malarial drugs	Yes / No	

3.2 Where do you TYPICALLY purchase these types of items? TICK ALL THAT APPLY.

	General Store	Specialty Store	Roadside Stand	Door-to-Door	Roaming Street Vendors	Market Day Market	Other
Health items (i.e., medicine, bed nets, water storage vessel)							
Consumable items (i.e., food, alum, aquatabs)							
Large household purchases (i.e., bicycle, TV, cell phone)							
Durable water treatment products (i.e., filters)							

If other please specify_____

3.3. Where would you PREFER to purchase these types of items? TICK ALL THAT APPLY

	General Store	Specialty Store	Roadside Stand	Door-to-Door	Roaming Street Vendors	Market Day Market	Other
Health items (i.e., medicine, bed nets, water storage vessel)							
Consumable items (i.e., food, alum, aquatabs)							

Large household purchases (i.e., bicycle, TV, cell phone)							
Durable water treatment products (i.e., filters)							

If other please specify_____

3.4. Whose opinion do you consider before purchasing these types of items? PLEASE TICK ALL THAT APPLY.

	Friends	Peer Group	Spouse	Family Member	Health profes-sional	Comm-unity Leader	Teacher	Govern-ment Worker	Religious Leader	Other
Health items (i.e., medicine, bed nets, water storage vessel)										
Consumable items (i.e., food, alum, aquatabs)										
Large household purchases (i.e., bicycle, TV, cell phone)										
Durable water treatment products (i.e., filters)										

If other please specify_____

4. Ability to Pay Questions

4.1 What kind of work have you done for most of your life? Your spouse (if yes to question 1.4)? Your father?

	Respondent	Spouse	Father
Agricultural / Farmer			
Professional			
Administrative / Office Worker			
Sales			
Trade			
Production / Worker			
Housewife			
Day Laborer			
Other			

If other please specify_____

4.2 What is the amount in Ghanaian Cedi you receive for your work? The other members of your household (if yes to question 1.4)? COMPLETE RELEVANT ROWS.

	Respondent	Other Household Members
Ghanaian cedi / day		
Ghanaian cedi / week		
Ghanaian cedi / year		
Annual harvest (bags)		

4.3 What type of toilet facility do you most often use at home? Is this facility public or private?

	Public	Private
Flush toilet/WC		
KVIP Latrine		
Pit/Pan latrine		
Free range		
Other		

If other please specify_____

4.4 What fuel do you typically use to cook? Do you cook with firewood, charcoal or gas? Who collects and / or purchases these items?

	Tick	Who collects / purchases
Firewood		
Charcoal		
Gas (Propane / Kerosine)		
Electric		

5. Current Water and Sanitation Practices Questions

5.1 Household Health

5.1.1 Has anyone in the household had diarrhea in the last week? How many individuals have had diarrhea? How old are these individuals?

Yes	
No	

	Number that have had diarrhea
≤ 5 years old	
5-17 years old	
≥ 18 years old	

5.2 Water Source / Collection

5.2.1 Where do you get your drinking water during the DRY season? Where do you get your drinking water during the WET season? TICK ALL THAT APPLY

Improved Source	Dry	Wet	**Unimproved Source**	Dry	Wet
Household tap			Dugout or Dam		
Public standpipe			Surface (lake/river)		
Protected dug well			Unprotected dug well		
Protected spring			Unprotected spring		
Borehole			Tanker truck water		
Rainwater collection			Water vendor: Sachet		
Other			Other		

If other (improved) please specify_____

If other (unimproved) please specify_____

IF WATER IS FROM A TAP INSIDE THE HOME SKIP QUESTION 5.2.2.

5.2.2 How many times each day does your household collect water? How long does it take to collect water, including going, filling, and returning?

	Number of Times	Under 30 min	Over 30 min
Dry season			
Wet season			

5.2.3 When not at home, from what source do you drink?

Source	Primary	Additional
Surface (lake/river/dugout)		
Unprotected well / spring		
Protected well/ spring		
Water carried from home		
Sachet water (hand-tied = "bagged water")		
Sachet water (factory produced = "pure water")		
Other		

If other please specify_____

5.3 Water Quality Perception

5.3.1 Are you happy with the water you currently drink?

Yes	
No	

Why?_____

5.3.2 What do you use to obtain, treat and store your water? What if water is turbid at collection? What if family members are sick?

	Always	When water is turbid	When family member is sick
Settling in Storage Vessel			
Boil			
Alum			
Chemicals –chlorine (tablets/liquid)			
Filter - Ceramic			
Filter - Candle			
Filter - Cloth			
Municipal water provided by the Ghana Water Company			
Other (specify)			

If other please specify_____

If filter, who in the family decided to purchase_____

Are there any other circumstances when you might choose a distinct treatment option for your water?_____

5.3.3 What are the most important reasons you treat your water?

DO NOT READ LIST – TICK ALL THAT APPLY

Dirty/turbid	
Microbial contamination	
Larvae/worms	
Causes malaria	
People get sick	
Other	

If other, please specify_____

5.3.4 Why did you select the water treatment method your currently use? Please state the importance of the following product features. TICK ONE PER ROW.

	Very Important	Important	Not Important
Water Taste			
Water Clarity			
Water Health Impact			
Product - Ease of use			
Product - Ease of Transport			
Product - Volume of Storage			
Product - Speed of treatment			
Product – Price			
Other (if applicable)			

If other, please specify_____

5.3.5 How much water (volume) does your household treat daily? ONE CAN IS 36 LITERS.

Less than 1 can	
1- 2 cans	
3- 4 cans	
More than 4 cans	

5.3.6 Are you happy with your current household water management and/or treatment system (i.e., the way you collect, treat and store water)?

Yes	
No	

Why?_____

This completes the formal portion of our questionnaire.

Do you have any additional questions or relevant water treatment information that you would like to share with the survey team?

Before we leave, could you provide us with a sample from your household's water source?

RESPONDENTS SHOULD PROVIDE THE WATER SAMPLE IN THE WAY THAT THEY WOULD NORMALLY PROVIDE WATER TO THEIR FAMILY. THE SURVEYOR SHOULD THEN POUR THE FIRST SAMPLE INTO A LABELED WHIRLPACK BAG. A SECOND SAMPLE SHOULD THEN BE OBTAINED IN THE SAME WAY AND TESTED FOR TURBIDITY USING THE TURBIDITY TUBE.

Turbidity Results	TU
Household water quality test #	

Thank you very much for taking the time to answer our questions. The information you have provided will be very useful to us.

SURVEYOR ADDITIONAL COMMENTS / QUESTIONS

REMEMBER

Mark end time
Water sample
GPS coordinates

MIT USE ONLY

E.coli	
Total Coliform	

Appendix 3: Choice-based Conjoint Delivery Preparation

We prioritized four product attributes to test and each attribute is divided into 2-4 levels.

Water Look / Taste	Product Type / Lifespan	Price Levels*	
		Rural	Urban
• #1 -- Water #1 taste • #2 -- Water #2 taste • #3 -- Water #3 taste • #4 -- Water #4 taste	• Consumable •Modern durable •Traditional durable	Low and high rural price levels have been selected for each product type	Low and high urban price levels have been selected for each product type

Health / Germ Removal	Treatment Speed
• Minor health improvement •Major health improvement	• More than 30 min • Less than 30 min

Water Taste / Look – Team will carry vessels of each water type labeled with a NUMBER and color. Respondents will be able to taste the water at any time during the conjoint. All potentially contaminated water will have been boiled to eliminate risk of contamination.

- #1 Clear / crisp taste – Bottled voltic water.
- #2 Clear / chlorine taste – Municipal water correctly dosed with Aquatabs
- #3 Clear / earthy taste – Treated with the Kosim (ceramic pot filter)and boiled
- #4 Turbid / earthy taste - Boiled dugout water

Product Type / Lifespan – Team will carry pictures of each product type.

Consumable

Modern Durable

Traditional Durable

Health / Germ Removal – Team will carry educational pictures of symptoms associated with typical Ghanaian waterborne diseases. As water is only one of many sources of disease, we selected not to use an icon showing a sick person for the tasks because we felt that this might bias decision-making among non-literate respondents.

Treatment Speed – No props required. A time to clear water image is shown on the conjoint screen. surveyor may explain the period of 30 minutes to the respondent in relevant terms (e.g., amount of time required to walk to the dugout).

Price – Prices will co-vary with product type. A low and a high price point have been selected for each product type based on what is currently available in the market. Prices will be shown in terms of realistic payment plans (e.g., in perpetuity for consumables and two payments for durables). Due to rural / urban differences in product price and ability to pay, different prices will be offered to the urban and rural survey populations.

Rural
Consumable • 30 pesawas every month • 90 pesawas every month Modern Durable • 9 GHS / month for two months • 15 GHS / month for two months Traditional Durable • 3 GHS / month for two months • 6 GHS / month for two months

Urban
Consumable • 30 pesawas every month • 90 pesawas every month Modern Durable • 15 GHS / month for two months • 20 GHS / month for two months Traditional Durable • 6 GHS / month for two months • 9 GHS / month for two months

Feature Set Choices

The respondent will be shown 8 task screens. Each task will be printed in color on a separate page to avoid confusion. The respondent should select one box from each task. The number of concepts per screen has been set at three since showing more product concepts per screen increases the information content of each task. Recent research has shown that respondents are quite efficient at processing information about many concepts. It takes respondents considerably less than twice as long to answer choice tasks with four concepts as with two concepts.

The MIT team plans to use four printed versions of the conjoint task screens for each market to increase the number of potential pairings.

Appendix 4: Dagbani Survey Translation

The translation was also conducted in two pieces. First, the original survey instrument was translated and then the edits were translated following the pre-test.[28]

<u>Part 1: Baseline Survey Translation</u>

PURE HOME WATER

Bɛndiriba Suhuyurilim Daabiligu Bubhambu Zan Chaŋ ti Dun-donani Konyurima Sapta kpaŋsibu Ti Tudu Poloŋɔna .

Pure Home Water, Tamale Ghana.

Gaafara, N yuli m boondi _____, kan nyɛ vehira n tumdi ni tuun shɛli bini boondi Pure Home Water la ka dibe Savelugu, ti Ghana tingbaŋ ni ka bi zaŋ bi kpa lan zuya gbun tuun shɛli din be United States ka di yuliboondi Mosachusetts Institute of Technology. Ti yi mi na ni ti chaŋ kpe ya ni n vihi nyɛ ti ni gbe bi ti ko nyurima, n nindilikasi ka zan di li sham ka tidi yu ni ti mini yili yidana bee yili yidaan paɣa di toɣsi ka man hawa yini lasabu. Ka ani toi labisi bohasi ŋu shɛŋa bee di zaa. Ka a ni toi nai bee n gbai toɣasigu maa saha shɛlli a suhu ni bora. Lahabali shɛŋa zaa tini die, ti yan zaŋ li mi gbɛbi ni ashilli. Di wuhi ya ni tiku zaŋ a yuli bee ani titi lahabali shɛlli maa wuhu sɔ. Ka ŋɔ nyɛ la suhu yurilim. A nyɛ la ninvuɣ sɔ ŋɔn saɣi nibi bota bohasi ŋɔ?

iin		(Diyi nyɛ aayi din puhimo ka naayi)
aayi		

Vihigu Soli		
Vihugu kalinli		
Vihira		
Labsira maŋmaŋ yuli		
Labsira daŋ yuli		
Labsira paŋu bee doo		
Labsira adiini		
Talim a daka		
Yili Pɛllibu (Taha bee Mori)		
Yaɣdini		
Foŋ yuli		
Foŋ bo		
	Foŋ	Tinkpaŋa
	iin	aayi
	iin	aayi

[28] Pages slightly cropped at bottom (< 1 inch) as Ghanaian print paper is longer than the scanner used to upload.

Dabsilidim	
Piligu Saha	
Nanbu Saha	
Yilimo ko nyuri suŋ	
GPS Kalinli	
GPS zonzon gili korachinima	
Photo Kalinli	

1. YIŊ PUUNI LAHABALI BOHASI

1.1 A YULI

Daŋli	Dinbahandi

1.2 ALAANBA AMILIYA LAHABALI?

Bimiŋ Amiliya	
Bi Chetab	
Bi Chetaba	
Din Pahi	

SHAHIYILAN PAHI NYIN YƐLLI _____

1.3 NIRIBA ALA N LEE BƐ A YIŊA? BI YUMA?

Yilima zaa niriba kalin li	
Ŋun labsiri bohasimaa yuma	
Ŋun labsiribohasi maa yidana / paɣa yuma	
YUMA	NIRIBA KANLINLI N PAHI
Yuma anu zan shea na	
Yuma yobu hal ni yuma piani	
Yun pinaa-yobu zaŋ du	

2.1 A mali binyahari ŋɔ shaŋa? Diyin yɛ iin, ŋun n lee da li (Labsira, Labsiriba, Yidaka bee yili yidan paɣa, Naa, Naa gbaŋ ŋbara, Daŋni so bee shalbolo nira)?

	IIN / AAYI	DORA / BƐN DARA
Bugum gbaabu		
Ko lɔri		
Pompi-Foŋ maadini		
Alɔ bee ti shaŋa di paha kati mali niŋ I ti ko ma ni		
Lahabali Shuɣu		
TV		
Nucheni Fongali		
Cheche		
Cheche Bugum		
Jiransawle		
Kpaɣu shaɣ tima		
Yo sura		
Ti sha ŋa dinpahi		

2.2 Ti yipayan boha la bohasi zaŋ kpa a bindara maa polo. A ni dali shalli po lo: DNucheni Tangali 2) Alɔ bee kom ti sha ŋa din pahi 3) Jiransawle 4) Kpaɣ shaɣu taɣbu Tima 5) yosura 6) Tishaŋa din pahi.

2.2.1 Ya kaa daa lee ku jandi d bin yara ŋɔ?

	Shito kara	Shito bihi	Ban zi pala zufu	Din doli ni Dindoli	Dabi gindiba	Daadali daa	Din gahi
Nucheni tangali							
Alɔ bee ti shali din pahi							
Jiransawle							
Kpaɣ shaɣu tima							
Yo sura							
Ti shaŋa din pahi							

Shali yilan pahi nyin yɛlli

	Shitoɣi Karlini	Shitoɣ bilni	Pala Zuɣu Atenima	Bu kohiri Kperi Yehi	Ban Ko-hiri doli pala	Daa dibu jali	Dia pahi
Mɔbile fon							
Alum / Dinlan pahi							
Jiran solo							
Kpaɣ zoɣu tima							
Condomniwa							
Ti shoŋa dim pahi							

2.2.2 Zuɣu dini ka a lee yu ni a di jimboyo niŋa?

Wulimi dini pahi _____

2.2.3. Ŋuni ka a lee maani shawora poi ka naan yi da dimboŋo niŋa

	Doɣira / Mabia	Alafee Korachi	Tiŋ Toon-dana	Kariŋba	Ŋomnanti tumbumda	A diini toondana/ Kpema	Ŋin pahi
Mobile fɔn							
Alurini din pahi							
Jirangolo							
Kpaɣzeɣu tima							
Condomnima							
Din pahi yaha							

Wuhimi ti shaŋa dim pahi maa _____

4. KƆM MINI SABTA YƐLA BOHIRI

4.1 Yiŋ duŋdoŋ puuni a laafee

4.1.1 Yilŋɔ so daa sa bin saa bakoi din gari ŋɔ puuni? Niribi a la?

Bɛ yuma nyɛla wula?

Eey	
Aayi	

	Niribi a la
0 - 5 Yuuma	
5 - 15 Yuuma	
16 + Yuuma	

PAƴABA KO:
Bɔhi labsiri yi nyɛla doo, chem. 4.2

4.1.2. A doƴya / a na min dɔƴi? Bihi a la mba bi nyɛvili nio?

	Bihi ala	Ala nibɛ bi nyeviliri
Bi puƴinsi		
Bi sibsi		

4.2 KƆM NYƐSU SOYA

4.2.1. Wuuni saha, ya ka a lee nyɛri kɔni? Shɛƴuni, ya ka a lee nyɛri kɔm? Dim bɔŋo dia nyaŋa, ya ka a lee la hinyɛra kɔm?

Soya din Viɛla	Wuuni	Sheƴuhi	Din pahi	Soŋu dinbiriɛk	Wuuni	Sheƴuhi	Din pahi
Yiŋ pɔmpi				Moƴli dim bi viɛla			
Salo Pɔmpi				Kɔ zorim kulga			
Kobil' suŋ				Kobilga bim bi viɛla			
Moƴ suŋ				Moƴli dim bi viɛla			
Awaana				Tanker kɔm			
Saa kɔm				Kɔ kohiri			
Din pahi				Din pahi			

Wuhini din pahi (soya din veɛla)_____

Wuhini din pahi (soya din bi viɛla _____

3. YƆBU KPAŋMAŋ BOHISI

3.1 Tuum bɔ ka a lee tuma nyɛvili zaa puuni? Paɣa bee yi dana (1.4 saɣbu yi nŋela eeŋ)?

	Bohi labsira	Yisana / paɣa	Ba
Pukprigu			
Nuuni bayda			
Office kaɣachi			
Daa bilim			
Buŋyera malibu			
Yinlandoo / Yiŋpara			
Lebra			
Din pahi			

Wuhima din lahi pahi maa _____
Ni nyɛ shelis

3.2 A yɔri lee nyɛla a la ? A yidan / a paɣa (Bɔhugu: 1.4 saɣibu yi nyɛlu eeŋ? Ni a ba?

	Bohi labsira	Yidan / Paɣa	Ba'
GHS / YR			

3.3 Bangida bo ka a lee moli a yiŋa? Di nyla salozaa din bee a dini bee?

	Chek	Salo / A dini
Flush / Kɔm dini		
KVIP		
Yiŋ boɣli gbibu		
Yɔ ɣuni		
Din pahi		

3.4 Bɔ kaa' lee mali duɣi bindirigu? Dari bee, sala, bee gay?

	eeŋ / aayi	ŋun lee bɔri / dari ŋa na
Dari		
Sala		

4.2.2 Bula ka a lee tooiri kom dab' sili puuni? Saha wula ka a lee mali tooiri kom, a chandi ni a lab'buno n-ti pahi a lɔri palibu.

	Kanli bula	Minti Pihita	Ganiti minti pihita
Wuuni			
Shaɣ' ni			

4.2.3 Ayi ti ka yiŋa, luɣ' dini ka a le nyuri kam?

Kol noli	Saha kam	Saha Saha
Kulibuŋni bee beinni		
Kobilgo din kom bi viɛla		
Kobilga din kan viɛla		
Kom din zo yi yigna		
Sacheti kan / nuu lɔbu bee mashini		
Sacheti kam / Tuma duzuɣu pincuerta		
Dinpahi		

Tahigi yɛlli dii nig ka ko no-shɛga beni? _____

4.3 Tiɛhi shɛbi o-ni mali zaŋ kpa kom polo.

4.3.1 A mali suhupiɛlli ni ko shɛli a ni nyuri saha ŋɔ?

lin	
Aayi	

4.3.2 Bɔ ka a lee mali guri ka taɣ'ri a kom? Ka dii nig ka ko noli maa bi viɛla? Ka dii niŋ ka a yiŋ nima gbahiri doro?

	Baha kam	Di yi ni niŋ Ka kom bi viɛla	Diyi ni tɛ yiŋnim biɛɣa
Kom lubu ko duɣ ni			
Duɣibu / tambu			
Alom			
Chenica - Cloriin ti-kpela			
Biih tɛirigu			
Yaɣ' tɛɛrigu			

Chinchini / Tani Tɛɛrigu			
Ko shali Ghana Kom tuma			
du-zuɣu nim nni bɔ n-tinya			
Dinpahi			
Dinpahi			

Kahigi yɛli din niŋ ka shaŋa beni _____

Di yi niŋ ka yi tɛɛra. ŋuni yi doŋ maani n-lee dari _____

4.3.3 Bo zuɣu ka a lee tɛɛri a kom.

Ko daɣiri	
Germs ni be ko shɛli ni	
Nyarifunima	
Di tiri maleria	
Iriba gbahiri dɔriti	

4.3.4 Bɔ zuɣu ka lee pii so shɛli a ni mali m-gura ka taɣ' ri a ko nyurim maa? Pahimi suɣ' lo ko pii bin shaŋa din do gbini g' n-doli diro kpa ni din bi kpa.

Kom viɛlim	
Zaŋ tum tumani be shɛm	
Aleefee	
Di ʒin tahi yiŋa	
Kom golisim	
Gu ka taɣi soya valim	
Laɣ' si baniiya	
Din pahipahi	

Di yi nigka a ni pii shahi bela tuuli diba ata la nyin kahig, yɛli _____

4.3.5. Kom galsim wula ka a lee tɛri bee n-guri ka taɣ'ri dati sili puuni.

Lɔɣ zaɣ' yini	
Lɔri dibaayi	
Diyi gariti lɔri ayi	

4.3.6. A suhupiɛlli so shɛga zuɣu a ni mali n-guri ka taɣri a kom a yiŋ dundoŋni?

mmm	

Part 2: Conjoint Survey

1. NIRA YIŋ TUMA ZAŋ CHAŋ KOM POLO

Ti yɛm bɔhila bɔhi shɛŋa zaŋ chaŋ a ni bɔri zaŋ ti ko nuuri suŋ tuma. Ti bɔri mi ni ti bɔhim m-baŋ dagu shɛli a ni bɔri dabu venɛlanga.

KAHIGU WUHI TI PɔL KA TI LAGIBU ŋɔ NAAM DI LAGGU JINA TɔBU NI.

Tuuli ti yuyabaŋsa ko nyuri suŋ tibbu yili puuni jin nyɛ ti ni kpaŋsida tumbu.
Kom nyagsim: Ti malla lugiligu diba anahi din nyɛ konkoba din mall ko suŋ. Ti yam chɛ ka a pii di ko shɛli a bɔra, ka di ni mali sɔŋsim zaŋ jamdi a piibu maa ka a lamdi kom suŋ maa saha shɛli kam.

Daguya Ballibu / Di yuubu: Ti yam bɔhami ka a pii daguya ballibu buta zuayu, tuuli din maa nyɛla din dira ka di wuhiri nidi yɛn dirimi di da na.. Di ni tooi mali tibiiri kom shɛli ka di simdi taam dabu (wuttim dibu bɛttgu) Din pahi ayi maa nyɛla tindua ni daguya din yura kappa Ghana dini ka ni tooi zani paaigi yuma ata ni anu (WUHUMI DIBU BɛHIGU)

Alaafee bɔbu / Binniɛma Yihibu:
Kom nyubu tahiri kom doro na Ghana. Di shɛŋa nyɛ dinsaa, kpari yuri ka di simdi ashibiti tibbu (nyɛn biɛhigunima).

Kom tibbu soya ŋɔ ni yihi dɔriti ti ni ka kpaysi ti jaalaafee, dinzugu soya balibu pam bɔbu tu ti bɔ zaŋti koma tibbu ka di mali sɔŋsim. Vihugu ŋɔ daliri zigu ti kpaŋsira ni a kpaŋsim.

Sohihi bɔbu din kpaŋsiri alaafee din wuhiri la alaafee so kara kpaŋsibu o o o . Alaafee sobihi kpaŋsibu wuhirila biŋnɛma kom ni yibu zaŋ ti a mini a yiŋnima alaafee zooibu saha kam, ka alaafee so kara gba kpaŋaŋsibu mi wuhiri kom ni binniɛma yibu zaŋ ti nira mini o yiŋnima a laafee zooiri saha kam zaa.

TIBBU SAHA:
Tibbu saha wuhiri la saha zaŋ ti kom mallibu. Vihugu ŋɔ daliri zugu ti kpaŋsira mi ni a pii tibbu yomyom bɔbu (Kamani timti pihita zugu pɔi) Ka di yi yuugi minti pihita garibu zugu). Ka di yi yuu gi (himdi pihita garibu zugu)

Ligiri yobu:
Di kpalinkpaal kolivaai. Ligiri yobu ni wuhi zaŋ ti daguli kam Dagu shɛŋa din dari dakulo ni di ligiri yobu ni wuhila pɛsuwanim ni kobo ni l goli ni ka daguya din dari yuuni puli ni di ligiri yobu ni wuhila yobu bugi yobu zugu ka tuuli goli buyi puuni dayuli maa lee o dini.

1.1. KAMANIM PIIBU
Punpɔŋa a ni yi pa baŋ daguli maa kamanim ŋɔ, ti yɛn wuhila kom tibbu dahili soya bunii zugu ka ti ni yu nia pii di zag. Yini shɛli a ni y8uri dabu. Ka a yi ku da dagu shɛŋa ti ni zaŋ wuhla ŋɔ shɛli yini piimi. Di da shɛli yagli Daguli kam dini beni maa ŋmani la taba. Amaa di-laa mali wɔligism blɛla.

YAGA BALIBU BUMU ZAŋ WUHI KAMANIMA

Tuuli daguli a nyagisimi ka nya #X. A tooi tee nyagisim kotomsi? Ka a yi bi tooitee laguli din nyɛ. Din nŋa ŋmani kom wosi ŋɔ (WUHINU BIƐHIGU)

Di ni chɛ ka a daalafee vooi pam bee biɛla.

Dini zaŋ minti ɜtli bee din bi pɛai mindi ɜo n tɛli.

Di di XXX Ghana be pɛsuwal kɔbɔ

DAGULI BOLI DOLI A, B, AND C, BELA GBAŊ KAM NI.

KPAŊMI A MAŊA KA A YƐLI BE YI KU DA DI DAGU SHƐLI. YI PIIMI YAGLI DIN NYƐ d.

Lahibaya gbahibu tuma (PIIMI ZAŊ YINI TI YAGLIKAM)

	A	B	C	D	Wula / Di yi ti luhi / kpa
Tuuli 1					
Tuma 2					
Tuma 3					
Tuma 4					
Tuma 5					
Tuma 6					
Tuma 7					
Tuma 8					

Part 3: Survey Edits

PURE HOME WATER

Ti malila bohigunima ni to boha zaŋ kpa a yiŋ, a lagin' nyabu a laa fee, ni, a kom gubbu tuma. A ni tooi nya yam bohisi maa labi sibu ni. Ka lala zugu a ni tooi pii n zagisi di dhɛli labsbu bee n zagisi di zaa ha labibu, ka a yi bora a ni tooi naai di labibu poi ka di naayi taa labsi. Ka tuma ŋo ti naaigi, ti yuya ni to ti a kom shɛli n-zahi di nya gsim mini di vlɛllim n-nya.

Ka pahigu yi beni zay chaŋ ŋo polo a ni tooi boli ko nyuri suŋ yilituma duu 027-364 3034.

2.4. Ka karim baŋsim karim naaiyi tariga?

Primary Shikuru	
Secondary Shikuru	
University Shikuru	
University Karim gari Shahira gbaŋ	

3. CHIBO

3.1 A YULI

Alaafee nɛma (Kaman tima jirasabir, ko yuya	mmm	aayi	
Dibu nɛma (Kaman Bindirigu, alum, aquatabs)	mmm	aayi	
Yili puuni nɛma (Kaman chɛchɛi, TV, nuchɛbaŋa	mmm	aayi	
Kom tibbu nɛma din yuura (Kaman ko tɛvisi)	mmm	aayi	

4. KƆHIBU / DABILIGU

4.2 Ghananim Cide

Ghananim Cidi / Dabslli		
Ghananim Cidi / Dakulo		
Ghananim Cidi / yuuni		
Yuuni Putuma (Kpalansi)		

5.3.2 Daliri shɛŋa zugu ni tooi chɛ ka a tagi soli kom tibbu so shɛli?

5.3.4 Viɛlli pam Viɛla Bi Viɛla

Ti bɔhigunim maa bahigu
A mali bɔhisi shɛŋa bee kom tibbu so shɛli lahibali ni a zaŋ pahi ti vihigu tuma ŋɔ?

Pɔi ka ti chaŋ, a ni tooi ti ti a yiŋ kom tuma soŋa?

So din ni ma, ka yan doli ka yiŋ nim ye kom. Karokaro tu no chɛ ka kom din daŋ toni uiɛla, ka din pahi naa dola

Kom Zahambu	
Yiŋ Kom Viɛla yɛbu	

Ti puhiya ka paŋ yi kpaŋ yimaŋ n lopsi lahabali sili maa. Di yɛ la di yɛn chɛ ka ti tu ma chɛŋ too ni

Niŋmi dibahadi yɛŋa	
Kom di yewuhi	
GPS Zonzongli	

Kpam be sihi	
E. Koli	
Labukoli Gbaŋ	

Appendix 5: Survey Back-Translation (with researcher comments)

The back-translation was also conducted in two pieces. First, the original survey instrument was back-translated and then the edits were back-translated following the pre-test.

Choice of Food Business Education Encouraging Water Hygiene at Home in Northern Region, Ghana.

(Back-translated from Dagbani into English by John Sidsaya Issifu)

Excuse, my name is ……., I am a researcher and works with Pure Home Water which cited at Savelugu in this part of Ghana. It is the Ghanaian counterparts who have agreed with their colleagues in United States of America call Mosachusetts Institute of Technology. We would go with you into houses to find out about our drinking water, either it is kept clean or not. _____missing sentence_____
All the information that we gather from you will be treated as confidential. This means that we would not release the information you would provide to anybody or show.

We wish we could talk with the husband and wife for about an hour. We have questions to ask concerning your home, health at meetings grounds and how you handle water. _____missing sentence_____ You may get new ideas or knowledge out of this questions. Because of that you may decided not to answer a particular questions or refuse answering any at all. You may choose to answer the questions before an answer is given to you. Before the finishing of this work, we would be please to supply you water to test the interest and taste.

If you have suggestions you could call Pure Home Water on 027-364-3034.

This is person interest. Are you willing to agree and answer the following questions?

Yes	
No	

If it is no, you thank him and finish up. _____missing sentence_____

Methodology	
Number Interviewed	
Reseracher	
Town Location	
Name of Area	

Date	
Time Started	
Finished Time	
GPS Number	
GPS Coordinator/Supervisor	

Comment [v1]: Translation for consumer choice marketing. The word "food" has been included because it is associated with consumer concept.

Comment [v2]: Translation for study

Comment [v3]: Translation for water treatment and safe storage. The positive spin on the phrase likely reflects local perceptions of water treatment activities.

Comment [v4]: Combines two sentances to express the concept of speaking with someone from the household about water management. In practice there was a strong tendancy for the Ghanaian surveyors to try to explain the survey in terms of health when doing introductions. The MIT researchers, one accompanying each Ghanaian survey team, asked that the surveyors to instead focus on water as we did not want to bias the answers toward an overemphasis on health.

Comment [v5]: Where gaps in flow occur, as in this missing sentence, they are usually the result of the need to make edits to the translation following the pre-test.

Comment [v6]: Suggests that some questions may be sensative. In practice, we worked with the surveyors to determine which questions would be most sensative and highlighted that the surveyors should give the respondent the option not to answer.

Comment [v7]: Mis-translated. The survey team understood that they should offer the respondent the opportunity to not answer any of the questions.

Comment [v8]: Should be "your." This sentence refers to the water sample needed at the end.

Comment [v9]: Translation for participation. Voluntary is difficult to translate, but each surveyor clearly conveyed this idea and left the household if the respondent seemed at all uncomfortable.

Comment [v10]: Word order – this means "interveiw number"

Comment [v11]: Name of district collected

Comment [v12]: GPS coordinates was translated. This word was likely unclear to the back-translator.

1. WHAT TO DO WITH WATER AT HOME

We want to ask about what portable or pure water. We wish to know the kind of business item you like buying?

1.1 Missing word Explaination

[ANSWER TO PAUL NOW AND IN THE MEETING [WE, the survey team] WILL LATER DISCUSS IT]

Initially, we would like you to know that we are promoting portable water jobs.

The sweetness of water: We have some four bottles and each of them has clean water. We would allow you to choose the one you like out of the four and that would be helpful to your choice, hence you would continue to sip it often.

Different Jobs / Duration: We want to ask you to choose a three types of business. The first one has to do with edables/consumables….. It could be boiled and used for treating water. The second has to do with a business that is transacted by foreigners in your country and this type of business would not expire after three to five years (SHOW THIS KIND OF EDIBLE-CONSUMEABLE).

Seeking Good Health / Controlling Insects:
In Ghana the drinking water cause illness. Some of the deases are diahorea, ring worm which has to be treated at the hospital. Treated water will safe us from many diceases and promote good health; for that matter there are new ways to learn to treat water for our good. For this research, we entreat to encourage others about it. The ways that encourages and teach about health are important to you. Means of teaching good health is encouraging the teaching of treating insects in water. This safes you and family and promotes good health in our community all the time. Important teaching about health concerns the way to treat insects in water and how to eliminate them in your home.

Time for Treating:
Treatment time refers to a time for water management. The reason for this reasearch is to encourage you to look for treatment quickly (about 30 minutes before). And if it past 30 minutes (passes thirty minutes.)

Period for Payment:
In summary, payment of money will show how every trade rate or demand based on weekly income that will indicate how every penny is collected and so to monthly. This applies to annual sales and the amount of money saved towards the payment for. Then after the first two months payment, the item becomes yours.

Comment [v13]: The entire conjoint element relied heavily on the images used to show the different features. These images were provided to the surveyors during the training and pre-test. They were intentionally NOT provided to the back-translator. The translations for the words on the task screens are shown below; however, the English versions were used in conjunction with the images to conduct the surveys and the surveyors worked together with the MIT researchers to ensure consistancy in the way they were describing each image in Dagbani. This was rigorously communicated and understood by the surveyors, but not well-translated by the back-translator.

Comment [v14]: Communicated as something you can move to your home which can be used to make water clean.

Comment [v15]: Translation for product. Word business appears because the sentence suggests that the item is bought and sold.

Comment [v16]: "Attribute" not easily translated. Surveyors understood and explained this concept as elements or features of the product.

Comment [v17]: Again the confusion with the words "attribute" and "conjoint." The surveyors were initally very confused with these words as well and the MIT team spent a long time talking about the purpose of this piece to ensure effective execution.

Comment [v18]: Surveyors knew to give respondents the option to review the different feature elements throughout the task screen activity.

Comment [v19]: Again we see the translation of household water product to portable (something that can be taken home) and the idea of business / jobs associated with the word product. Nothing about jobs was communicated to the respondents as the surveyors knew the idea of employment had nothing to do with the survey being conducted.

Comment [v20]: Translation for taste

Comment [v21]: Surveyors very clearly explained to respondents that the water was clean, the respondent could taste the water to help in their choice (and could taste the water again at any point during the survey). At times there was hesitation or the respondent wanted the surveyor or MIT researcher to aslo taste the water to make sure it was good. The team was more than willing to do this and did so on some occasions, and in the rare (1-2 cases) where the respondent felt uncomfortable the taste element was skipped.

Comment [v22]: The product option is very confusing in translation because of the associations between the words "consumable" and "food" as well as "product" and "business." In praactice, this element was explained using images of the different product types. The survyor would show the picture and expain the product life element to communicate the idea of consumable and durable.

Comment [v23]: Poor translation for germs. Survey team translated this concept as things in the water that make you sick or give you guinea worm.

Comment [v24]: Prices were shown on the conjoint sceens and the respondent was told that the price was the amount that they would have to pay to buy the product in question. The weak translation of this section may reflect differences in perception of money.

1.2 About Choice:

Now that you know the means and ways about the business, we will now now teach on the treatment of water in eight ways. We will like you to choose the method you like. If you happen to buy one of the products we have shown to you, there will be a reduction of one of the lot. The product has some similarities but still has some differences.

Comment [v25]: Again poor translation for product. As a note, the surveyors often explained this concept based on specific items as well as the images of items provided in the survey packets.

FOLLOWING **FIVE SECTIONS** - SHOW THAT

- Initially, which of the products that you enjoy #X? Can you remember or describe your excitement? Can you remember the product?
- Describe the water look (SHOW CHARACTER)
- Do not allow your health to deteriorate or even a little.
- Do not take a dirty cloth to clean the product.
- Don't spend funds of XXX Ghana.

Comment [v26]: This was explained while showing the first task screen. The surveyor described each option in detail and then asked the respondent to select one. In some cases, where the respondent was confused, the surveyor showed the second screen to help the respondent understand how the task activity worked. In general, "Option D" or none was stated, but slighly de-emphasized, because there was no accompanying graphics. On subsequent screens, the surveyor was able to go through each feature more rapidly as the respondent was somewhat familiar with the task and had started to form preferences. In particular, "major health improvement" often drove choice.

PRODUCT "CALL & FOLLOW" A, B, AND C IS PART OF EVERY LEAFLET

MAKE SURE TO MENTION WHEN A PRODUCT IS NOT SOLD. CHOOSE THE PART D.

	A	B	C	D	
First Work (1)					
Work 2					
Work 3					
Work 4					
Work 5					
Work 6					
Work 7					
Work 8					

2.0 **QUESTION ASKED AT HOME**

2.1 Background

Number Interviewed		
Reseracher		
Sex		
Language		
Gender		
Religion (omitted)		
House roof (Zinc or Thatch)		
Area	Area	Village
MIT	Yes	No

Comment [v27]: Surveyor use only. Gives researchers the option to assess impact of the presence of a "white face" on expressed preference.

2.2 FAMILY MARRIAGE BACKGROUND

Comment [v28]: Options not given to respondent. Surveyor asked question and made selection.

Marriage	
Consensual union (omitted)	
Divorce	
Not Divorce	
Any other	

IF THERE ARE OTHER THINGS TO ADD_____

2.3 Number of people living in your home? Their names?

Comment [v29]: This is a mistranslation for "age" Not clear why it was translated as "name." However, names were not asked to protect confidentiality.

Total number of people are	

AGE	NUMBER OF ADDITIONAL PEOPLE
Five Years below	
Six to 17 years	
18 and above	

2.4 Educational Status/Background:

Primary School	
Secondary School	
University	
Degree	

3. Buying

3.1 Do you owe some of the following items? Who bought them (Respondant (s), Husband, Wife, Chief, Secretart ti chief, Family spokeperson or translator)?

	YES / NO	EXTRACTER / TRADER
Handling of Fire		
Water pot		
Area Pipe Mechanic		
Ilion* or other for treating water		
Soap		
Television		
Cell Phone		
Bicycle		
Motor cycle		
Cooking vessels (omitted)		
Mosquitor Net		
Malaria Drugs		

* What is Ilion(?)

Comment [v30]: Mistranslation of "electricity connection." This question was only asked where electric power was available. Surveyor typically asked about whether the household had lights, as that is what people typically use electricity for at the most basic level.

Comment [v31]: Survyor asked about access to piped water. Then asked if access was in the home. Then asked if the pipe was turned on.

Comment [v32]: Surveyors knew how to translate the word Alum. The word came up poorly in the translation because it is not a common biblical word.

3.2. Where did you get these items to buy?

Comment [v33]: Surveyors gave examples of specific items, asked where those items were purchased and checked the appropriate box.

	Big Shop	Small shop	By the wayside	House to House	Salesmen who go round	Market Days	Other
Health Item (e.g. medecine for water containers)							
Items for feed (e.g. food, illium, aquatabs)							
Household items (e.g. Bicycle, TV, Cell Phone)							
Items for treating water (e.g. 'Tevis'*)							

Comment [v34]: Poor translation for cloth filter. Again the survey team was more effective at communicating this idea because they are familiar with water treatment where as the translator was mostly familiar with biblical terminology.

If there are other necessary you could add_____

3.3 What type of the item do you like fixed for you?

Comment [v35]: Poor translation. The surveyors communicated the idea of where would you prefer to buy using the same product examples as above.

	Big Shop	Small shop	By the wayside	House to House	Salesmen who go round	Market Days	Other
Health Item (e.g. medecine for water containers)							
Items for feed (e.g. food, illium, aquatabs)							
Household items (e.g. Bicycle, TV, Cell Phone)							
Items for treating water (e.g. 'Tevis')							

If there are other necessary you could add_____

3.4 Who do you often consult before buying these items?

	Peer	Relative/ Siblin	Husband/Wife	Health Worker	Opinion Leader	Teacher	Government	Religious Leader	Others
Health Item (e.g. medecine for water containers)									
Items for feed (e.g. food, illium, aquatabs)									
Household items (e.g. Bicycle, TV, Cell Phone)									
Items for treating water (e.g. 'Tevis')									

If there are other necessary you could add_____

4. INCOME VENTURE

4.1 What job are you doing throughout your life? Wife or husband (Answer yes or no)?

Comment [v36]: Surveyors asked as a general question in Dagbani and selected the appropriate English option from the list. Surveyors added a few options to this question given their knoweldge of the local communities.

	Answer/Respondant	Husband/Wife	Father
Farmer			
Craftman			
Officer			
Sales			

Market Trader			
Hand-crafts			
Housewife			
Labourer			
Others			

Include other jobs here_____

4.2 How much is your monthly salary? Your wife / husband?

Ghana Cedi / Date		
Ghana Cedi / Week		
Ghana Cedi / Year		
Annual Harvest (Bags)		

4.3 What type of toilet facility do you have in your home? It is to all the community or you alone?

	Check	Community / Individual
Flush / Water type		
KVIP		
Locally dug hole		
Free range		
Any other		

4.4 What do you use in cooking? Fuelwood, charcoal, or gas?

	Yes or No	Who looks for the fuel
Wood		
Charcoal		
Gas		
Electric (omitted)		

5. WATER AND HYGIENE

5.1 Health at home

5.1.1 Has some poeple ran diahorea within the past week in your home? How many? How old are they?

Yes	
No	

	How many people
0 – 5 years	
5 – 15 years	
16 + above	

5.2 SOURCE OF WATER

5.2.1 During dry season, where do you get water? Wet season, where do you get water? Apart from these where do you get water?

Comment [v37]: This was asked as a general question in Dagbani , the respondent described their source and the surveyors made the correct selection in English. The use of "good and bad" reflects local perceptions of the terms "imrpoved and unimproved."

Good ways	Dry season	Wet season	Wrong ways	Dry season	Wet season

Home pipe			Bad river source		
Community pipe			Running water		
Good Well			Bad well		
Good river			Bad Dam		
Borehole			Water Tanker		
Rainy water			Water Sales person		
Others			Others		

Comment [v38]: Where confusion arose around the difference between the English words "river" and "spring" the researchers went to observe the source to make the correct selection.

Indicate other (good ways)_____

Indicate other (bad ways)_____

5.2.2 How many times to you go for water in a day? How much time spent looking for, going and coming until all pots gets full.

	How many times	Thirty minutes	Over thirty minutes
Dry season			
Wet Season			

5.2.3 When not at home, where do you drink water?

Comment [v39]: This was asked as a general question in Dagbani , the respondent described their water practices when away from home and the surveyors made the correct selection(s) in English.

	always	Some times
Edges of farm field / A brook		
Bad well		
Clean well water		
Running water		
Sachet water/tied by hand		
Sachet water distiller		
Others		

Indicate if there are other sources of getting water_____

5.3 Thoughts About Water

5.3.1 Are you happy with your drinking source?

Yes	
No	

_____
_

5.3.2 What do you use to cover and collecting water? Supposing the the water source is not good? What if your household is often sick?

Comment [v40]: Asked as a general question in Dagbani , the respondent described their water practices in the home and the surveyors made the correct selection(s) in English.

	Everyday	If the water is not good	If your household falls sick
Water pour/falls			

straight to pot			
Boils water			
Alium			
Chemical – Clorin			
Beer sheaver (siever)			
Pot sheaver (seiver)			
Cloth/material			
Water treated by Ghana Water Company			
Others			

Comment [v42]: Survey team was very comfortable with the idea of a water filter, but this concept may been more challenging for the translator as "filter" is not a biblical term.

Indicate if there are others_____

If you sieve water. Who buys that for the family consumption_____

What are the reasons that will make you change your way of water treatment?

_____

5.3.3 Why do you seef water

Dirty water	
Water that has germs in it	
Gyneaworm	
It give malaria	
People falling sick	
Others	

5.3.4 Why do you choose this method to protect drinking water? Be patient and allow him/her to choose the following indicating important of illness or not.

	Very Clean	Clean	Not Clean
Good water			
?			
Used for work			
Health			
Carrying it home			
Respect for water			
The quick ways of prevention			
Gather ideas			
Others			

Comment [v43]: Poor translation. This ideas was communicated as important by surveyors.

Comment [v44]: Each option in this question was described by the surveyor relative to the water treament products and choices given in the conjoint element of the survey.

Comment [v45]: Communicated as water look.

Comment [v46]: Typically, most difficult for respondent to understand. Described using examples and references to known products.

Comment [v47]: Communicated as amount / size.

Comment [v48]: Communicated as cost.

If your choice falls within the first three, then indicate

5.3.5. How much water content the you treat and protect.

One Pot	
Two pots	
Always more than two pots	

5.3.6 The exciting ways you use to proctect and cover your water at home?

Yes	
No	

Conclusion on Questions:

Do you have any question or other method of treating water that you want us to know or include in our research?

Before you leave, can you tell us the ways you handle water in your home?

HOW DO YOU SOURCE WATER FOR YOUR FAMILY? YOUR SUPERVISOR NEED MAKE SURE THAT THE FIRST WATER IS PORTABLE FOR USE AND THE FOLLOWING:

Examination of Water	
Clean water for home	

We thank you for answering these questions. This will help improve our work.

Conclusion	
Water sample	
GPS	

Comment [v49]: Unit size based on 36 liter cans that were common in the households and used to collect water.

Comment [v50]: Excited may be confused with happy in Dagbani. Surveyors made sure to always ask this as a question. Response was frequently "yes we are happy because it is all we have," which may refelct local attitudes on happiness.

Comment [v51]: Asked as: "Can you get us a sample of water from your household drinking source?"

Comment [v52]: Not communicated to respondents. Only included to remind surveyors not to create contamination risk by getting the water themselves. Respondents always brought a sample in the cup that they would use to drink and it was poured into the turbidity tube and the Whirlpak csample bag.

Comment [v53]: For internal use only. Technical terms (turbidity and microbial) that would likely not be understood by the bible translators.

Appendix 6: Household and Community Level Water Quality Data

#	Turb-idity	Ecoli Results (CFU / 100 ml)	TC Results (CFU / 100 ml)	Dilution Ratio	Are you happy with the water you currently drink?	Why or why not happy with the water?	Notes
1	250	0	20,000	10	Yes	Because it is the only source of water they have.	
2	200	0	4,000	10	No	We want a better water source.	
3	300	0	28,000	10	Yes	Because it is the only source we have.	
4	600	0	13,000	10	No	The water source is not good.	
5	50	3000	68,000	10	No	The treatment is not enough to improve health.	
6	75	0	58,000	10	No	The treatment doesn't make the water all that clear.	
7	80	0	9,000	10	No	When it rains, the water carries all the dirt we cause into the dugout causing contamination.	
8	75	0	1,000	10	No	I'm not happy because we suspect some dirt even though we treat before we drink.	
9	650	4000	204,000	10	No	No, open to humans and animals.	**Too numerous (>200)
10	65	0	2,000	10	No	No, not convinced about the quality.	
11	58	0	30,000	10	No	No, the turbidity level is high and it has a bad odor.	
12	450	0	40,000	10	No	No, it is turbid.	
13	240	0	200,000	10	No	It is good for our health (???)	**Too numerous (>200)
14		0	-				*Respondent left early
15	325	0	9,000	10	No	It is not very healthy	
16	180	0	10,000	10	No	The water is not adequate for us	
17	500	1000	34,000	10	Yes	Because it is good and tastes good	
18	50	0	27,000	10	No	No, the water is too turbid.	
19	40	1000	48,000	10	Yes	Yes, because with the cloth filter there is no problem with the water.	
20	900	1000	6,000	10	Yes	Yes, because we have no other choice.	
21	700	0	24,000	10	Yes	Yes, because last year at this time the dam had dried up.	
22	700	0	3,000	10	Yes	Yes, because we have no other choice.	
23		0	-				*Respondent left early
24	0	-	-	-	No	As compared to the water from the tap, you can see that there is still something in the water.	*No water in household
25	47	0	8,000	10	No	Still turbid after treatment.	
26	8	0	25,000	10	No	Turbidity is too high.	
27	75	0	7,000	10	No	There are still things that we cannot see in the water.	
28	500	0	10,000	10	No	It's very turbid.	
29	300	0	8,000	10	No	The color is unattractive. The water is very turbid	
30	48	0	-	10	No	Rain washes dirt into water source.	
31	250	0	4,000	10	No	It is turbid and cloth filters make little difference	
32	230	0	23,000	10	No	Its very turbid	
33	410	0	3,000	10	No	It is good for our health and also it is not adequate	
34	320	0	1,000	10	No	Because it is not good for our health	
35	310	0	7,000	10	No	Because the water is not good	
36	0	0	2,000	10	No	It is not good for our health	
37	400	0	10,000	10	No	It is not good and it has diseases	
38		0	-				
39	12	300	3,300	1	Yes	Yes, it is ok as compared to other villages.	
40	5	0	400	1	Yes		
41	10	100	11,300	1	Yes	Yes, our water situation is better than in other villages so we are mostly happy.	
42	0	0	24,000	10	Yes	But we'd like if you could give us quality water source which is better than what we are using	

#	Turb-idity	Ecoli Results (CFU / 100 ml)	TC Results (CFU / 100 ml)	Dilution Ratio	Are you happy with the water you currently drink?	Why or why not happy with the water?	Notes
43	7	0	28,000	10	Yes	But if you could get a better source we will be happy	
44	8	400	12,500	1	Yes	Yes, it is the only thing available for drinking.	
45	7	1000	10,000	10	Yes	Because we do not pass the water anymore because of the borehole	
46	5	0	50,000	10	No	We want cleaner water than what we have right now.	
47	6	0	26,000	10	Yes	Because it has no negative health impact	
48	0	200	3,900	1	Yes	Yes, water is clean and clear.	
49	11	800	7,000	1	Yes	I believe borehole water is pure	
50	10	0	10,200	1	Yes	Because our water comes from underground, it is clean	
51	12	100	400,100	1	No	The water is not very clean even after it is filtered	** Too numerous (estimated)
52	8	0	5,000	10	Yes	It is underground water	
53	7	0	2,000	10	Yes	No Guinea Worm disease	
54	7	0	2,700	1	Yes	It is clean because it is from underground sources	
55	15	0	15,000	10	Yes	It is always filtered	
56	8	0	3,000	10	Yes	I don't feel sick frequently	
57	7	0	3,000	10	Yes	It's clear	
58	25	1600	7,900	1	Yes	I believe it is clean	
59	15	200	10,400	1	No	We wish we could get tap water.	
60	7	1000	5,000	1	Yes		
61	7	200	28,200	1	Yes	Because that is the only source of water that we have.	** Too numerous (estimated)
62	7	400	4,600	1	Yes	Because it is the only source of water that we have.	
63	8	100	3,700	1	Yes	Because that is the only place that we can get water.	
64	0	0	61,000	10	Yes	Yes, the water is good.	
65	8	0	3,000	10	Yes	Yes, it is good and clean.	
66	8	0	47,000	10	Yes	Yes, it is clean	
67	5	0	1,000	10	Yes	Yes, it is safe for drinking.	
68	8	0	15,000	10	Yes	Yes, it is clean and tastes good.	
69	8	0	11,000	10	No	We drink from the same source as animals, so it is not good	
70	10	0	1,000	10	No	Because we have no treatment measures or filters	
71		0	-				**No sample taken*
72	11	0	28,000	10	No		
73	0	0	40,000	10	Yes	We fetch water the borehole and treat it before drinking	
74	7	100	4,400	1	Yes	I think it is good	
75	18	500	20,500	1	Yes	It is covered, so dirt does not enter	**Too numerous (>200)
76	17	300	8,100	1	Yes	It is healthy	
77	8	0	8,600	1	Yes	It is good for health	
78	9	1000	21,000	1	Yes	It is good for health	**Too numerous (>200)
79	0	0	47,000	10	Yes	Because we fetch our water from the borehole, which is underground	
80	0	0	-	1	Yes	We fetch direct from the tap.	
81	0	0	-	1	Yes	"We don't have any problems with our drinking water."	
82	0	100	3,200	1	Yes	Because we fetch from the tap.	
83	0	0	-	1	No	The water company over treats the water sometimes. And, at other times, the water is kind of green.	
84		0	-		Yes		
85	0	0	-	1	Yes	Because our water is far better than Dam water	

#	Turb-idity	Ecoli Results (CFU / 100 ml)	TC Results (CFU / 100 ml)	Dilution Ratio	Are you happy with the water you currently drink?	Why or why not happy with the water?	Notes
86	0	0	200	1	No	Because the tap does not flow everyday	
87	0	300	1,600	1	Yes	Because it gives us health	
88	0	0	-	1	No	Because the tap water is not available very regularly	
89	0	200	1,000	1	Yes	Because this is the only water we have	
90	0	0	-	1	Yes	Yes, we don't fall sick from the water.	
91	0	0	24,000	1	Yes	Yes, it is treated from the source.	** Too numerous (estimated)
92	0	0	-	1	Yes	Yes, we have no water related disease.	
93	0	100	600	1	No	No, new methods of treatment are welcome.	
94	0	0	100	1	Yes	Yes, the water and the vessels are always clean.	
95	0	0	600	1	Yes	It is safe drinking water	
96	0	0	-	1	Yes	It is safe for drinking.	
97	0	0	-	1	Yes	It is safe for drinking	
98	0	0	-	1	Yes	Believes it is safe for drinking	
99	0	0	-	1	Yes	Because pipe water is safe to drink	
100	0	200	1,500	1	Yes	It is safe for drinking	
101	0	0	-	1	Yes	The water is now well treated by the water company	
102	0	0	2,500	1	Yes	I take good care of my drinking water	
103	0	0	-	1	Yes	For now it is the best we can get as compared to other places with other sources of water	
104	0	0	-	1	Yes	I believe our water is good for us so I can't complain	
105	0	0	9,300	1	Yes	Because we fetch from the tap and practice cleanliness.	
106	0	0	-	1	Yes	It's clean	
107	0	0	-	1	Yes	It's clean	
108	0	0	200	1	Yes	It is hygienic	
109	0	0	-	1	Yes	It is pipe borne and treated well	
110	0	0	100	1	Yes	It Is treated at source	
111	0	0	-	1	Yes	Is safe for drinking	
112	0	0	4,400	1	Yes	I think it is safe for drinking	
113	0	0	28,000	1	Yes	Is safe for drinking	** Too numerous (estimated)
114	0	0	2,900	1	Yes	it is healthy and safe for drinking	
115	0	0	-	1	Yes	Because it is pure and clean	
116	0	0	-	1	No	Because the water is not flowing regularly	
117	0	0	300	1	No		
118	0	0	-	1	Yes	Because the water is very clean	
119	0	0	-	1	No	Because we don't have water flowing regularly	
120	0	0	700	1	Yes	We use cloth filters	
121	0	0	-	1	Yes	pipe borne water	
122	0	0	-	1	Yes	We are healthy	
123	0	0	600	1	Yes	It is clean and we don't fall sick frequently	
124	0	0	300	1	Yes	It is treated and clear	
125	0	0	2,600	1	No	no answer	
126	0	0	9,900	1	Yes	Because we fetch direct from the tap but sometimes the color is bad	
127	0	0	1,000	1	Yes	very well treated and good taste	
128	0	0	-	1	Yes	There is clarity and good taste	

#	Turb-idity	Ecoli Results (CFU / 100 ml)	TC Results (CFU / 100 ml)	Dilution Ratio	Are you happy with the water you currently drink?	Why or why not happy with the water?	Notes
129	0	300	2,500	1	Yes	It is well treated	
130	0	0	1,000	1	Yes	Because it is piped water	
131	0	0	500	1	Yes	It is from GWC source	
132	0	0	1,900	1	Yes	It is hygienic	
133	0	0	100	1	Yes	Its hygienic, clean and tastes good	
134	0	0	5,700	1	Yes	It is hygienic and clean	
135	0	0	900	1	Yes	I am happy but it doesn't open regularly	
136	0	0	5,800	1	Yes	Because that is the only water we have	
137	0	0	200	1	No	Because we open the top once in a week	
138	0	200	8,700	1	Yes	Because it is the only source we can get drinking water	
139	0	0	1,200	1	Yes	Because that is the only source	
140	0	0	3,600	1	Yes	Yes, there is good taste and clarity.	
141	0	0	-	1	Yes	Yes, it is clear and tastes good.	
142	0	0	600	1	Yes	Yes, because we drink from the tap and the water has a good taste.	
143	0	0	100	1	Yes	Yes, the water is clear and it tastes good.	
144	0	0	200	1	Yes	It is clear and has good taste.	
145	0	0	-	1	Yes	Yes, I think it is clean and it tastes good.	
146	0	0	1,600	1	Yes	Yes, it is clean.	
147	0	0	4,300	1	Yes	Yes, because we buy piped water and I think they treat it.	
148	0	200	700	1	Yes	Yes, because it is clean and it tastes good.	
149	0	0	1,200	1	Yes	Yes, the water is safe.	
150	0	0	800	1	Yes	Yes, it is filtered.	
151	0	0	1,100	1	Yes	No, water can be contaminated by the storage container in the house.	
152	0	0	300	1	Yes	Yes, stored in a clean reservoir.	
153	0	0	-	1	Yes	Yes, it is pipe born water.	
154	0	0	-	1	Yes	Yes, it is treated by Ghana Water Company before distribution.	
155	0	0	200	1	No	No, because the piped water does not flow regularly.	
156	0	0	800	1	No	No, because the taps are not flowing.	
157	0	0	300	1	Yes	Yes, because we buy the water from the tanker trucks.	
158	0	0	40,000	1	No	No, because the taps are not flowing.	** Too numerous (estimated)
159	0	0	200	1	No	No, because the water does not flow.	
160	0	0	200	1	Yes	Yes, very clear and tastes good.	
161	0	0	-	1	Yes	Yes, the taste is good and the water is clean.	
162	0	0	-	1	No	No, because we drink a mixture of both dugout and tap water.	
163	0	0	100	1	Yes	Yes, tap water from the Ghana Water Company is the only water available.	
164	0	0	1,400	1	Yes	Yes, because we drink piped water.	

#	Turb-idity	Ecoli Results (CFU / 100 ml)	TC Results (CFU / 100 ml)	Dilution Ratio	Are you happy with the water you currently drink?	Why or why not happy with the water?	Notes
165	0	0	44,000	1	Yes	Yes, it appears clean.	** Too numerous (estimated)
166	0	0	-	1	No	No, it has a bad odor and is turbid.	
167	0	0	-	1	No	It is turbid from the beginning and bad odor when stored	
168	0	0	-	1	Yes	It is cleaner than dugout water	
169	0	0	2,600	1	Yes	Yes, it is well treated.	
170	0	0	1,000	1	Yes	Clean from the taps	
171	0	0	400	1	Yes		
172	0	3800	33,800	1	Yes	GWC	** Too numerous (estimated)
173		0	-				*Survey not given*
174		0	-				*Survey not given*
175	0	0	300	1	Yes	because we believe tap water is very clean	
176	0	0	400	1	Yes	The water is clear and there is no dirt in it	
177	0	100	5,100	1	Yes	the water is very clean	
178	0	0	400	1	Yes	Tap water is good for our health	
179	0	0	-	1	Yes	because it has already been purified	
180	0	0	-	-	Yes	Because the tap opens once a week	*No sample taken
181	0	0	-	1	No	Because we want the tap to flow regularly	
182	0	0	-	1	Yes	Because we are drinking tap water	
183	0	0	-	1	Yes	Because we are not experiencing water	
184	0	0	-	1	Yes	Because some process then do not get tap water	
185	0	0	-	1	Yes	We assume that the water company treats the water before sale to us	
186	0	0	-	1	No		
187	0	0	-	1	No	Because it is not as filtered as it used to be.	
188	0	0	-	1	No	I would be happy to drink tap, but not dugout	
189	0	0	10,700	1	Yes	Yes, good taste and clarity.	
190	0	0	200	1	Yes	Pipe born and clean	
191	0	0	700	1	Yes	it is clean	
192	0	0	4,800	1	Yes	it's clean and it tastes good	
193	0	0	200	1	Yes	it is clean and tastes normal	
194	0	0	800	1	No	The tap water is turbid for a while before clean water flows	
195	0	0	-	1	Yes	It is clean	
196	0	0	3,900	1	Yes	Because I believe that they treat the water before they supply it	
197	0	0	-	1	Yes	It is clean	
198	0	0	-	1	Yes	Because it is clean	
199	0	0	300	1	Yes	Because I think it is safe for drinking since it is from GWC	
200	500	0	3,400	1	No	It is not potable for drinking an also too turbid these days	
201	600	0	-	10	Yes		Dilution water +20-30 total coliform / liter
202	680	0	-	10	No	No good for drinking. Don't like the taste of the borehole water.	Dilution water +20-30 total coliform / liter
203	650	0	-	10	No	Not clean.	Dilution water +20-30 total coliform / liter
204	700	0	-	10	No	Because we have to use alum and cloth filters before we can drink the water.	Dilution water +20-30 total coliform / liter

#	Turb-idity	Ecoli Results (CFU / 100 ml)	TC Results (CFU / 100 ml)	Dilution Ratio	Are you happy with the water you currently drink?	Why or why not happy with the water?	Notes
205	600	0	26,000	10	No	We still think that we get sick when we drink from the source.	Dilution water +2 total coliform / liter
206	700	0	11,000	10	Yes		Dilution water +2 total coliform / liter
207	700	0	-	-	No	we have to treat it with alum and cloth filter before drinking	*Sample not taken
208	800	0	14,000	10	No	It's not like tap water; it's turbid.	Dilution water +2 total coliform / liter
209	500	0	37,000	10	No	After treatment, water still looks the same but a with a better taste.	Dilution water +2 total coliform / liter
210	550	100	1,400	1	Yes	it's filtered through and is still turbid	
211	1000	0	5,000	10	No	No, because currently the dugout is too turbid. We are not happy, but we can't do anything but drink the water.	Dilution water +2 total coliform / liter
212	24	0	500	1	Yes	Yes, because of the cloth filter we are happy.	
213	300	0	15,000	10	No	No, because the water we are drinking currently is not good. We share it with cattle.	Dilution water +2 total coliform / liter
214	110	0	8,000	10	Yes	Yes, because the borehole water is very clean and we treat it before drinking.	Dilution water +2 total coliform / liter
215	450	0	700	1	No	because we share the water with the animals	
216	700	0	-	10	Yes	When we filter it, it has no guinea worm.	Dilution water +20-30 total coliform / liter
217	600	0	-	10	No	Is turbid and has the scent of animal urine.	Dilution water +20-30 total coliform / liter
218	600	0	-	10	No	Cattle make the water muddy.	Dilution water +20-30 total coliform / liter
219	450	0	-	10	No	The water is turbid and we compete with cattle.	Dilution water +20-30 total coliform / liter
220	600	100	2,000	1	Yes		
221	500	100	2,400	1	Yes	It is not very good unless you apply alum	
222	80	0	12,000	10	No	No, because we still need portable drinking water.	
223	65	0	4,000	10	No	No, because it is not very safe for drinking.	
224	60	0	15,000	10	No	No, because it is not very safe for our health as compared to piped water.	
225	300	0	2,000	1	Yes	we share our water source with the animals	
226	500	300	2,200	1	No	we share it with the animals and most of us are suffering from guinea worm	
227	150	0	2,000	10	Yes	Yes, because it is the only source of water that we have. If we could get another improved source we would want it.	
228	190	0	-	10	Yes	Yes, because the water is clean	
229	90	0	2,000	10	Yes	Yes, because the water is clean.	
230	750	100	2,700	1	No	animals contaminate water	
231	700	100	9,700	1	No	very turbid and animals urinate into the dugout	
232	44	0	42,000	10	No	it is very clean (note from Gaetan: yet resp. is not happy!)	
233	950	0	4,000	10	No	compete for water with cattle	
234	100	0	8,000	10	Yes	from underground and clean	
235	450	400	3,900	1	No	because we share our water source with the cattle.	

#	Turb-idity	Ecoli Results (CFU / 100 ml)	TC Results (CFU / 100 ml)	Dilution Ratio	Are you happy with the water you currently drink?	Why or why not happy with the water?	Notes
236	5	0	300	1	No	because the water is too turbid	
237	0	0	10,000	10	Yes	we filter the water before drinking but we still need more filters to improve our health	
238	75	0	4,000	10	No		
239	75	0	7,000	10	Yes	we don't experience guinea worm in our village	
240	10	200	30,200	1	No	It is not very pure taste for drinking	** Too numerous (estimated)
241	800	100	1,500	1	No	very turbid and compete with animals for water	
242		0	-	1	No	our water is not good	
243	900	700	8,800	1	No	because we wish we could get tap water or any improved water source	

Summary Results				% Happy	Population Size
Nyarizee	268	286	27,029	20%	35
Golinga	8	208	24,845	85%	40
Agric	-	23	2,013	83%	40
Lamashagu	-	108	3,834	82%	38
Nyohini	-	13	1,630	83%	40
Parishe	189	47	7,760	40%	15
Lahagu	544	52	6,252	31%	29
Urban	-	47	2,469	82%	118
Rural	238	172	18,803	47%	119