Household Water Filter Evaluation

Sustainability Report

Fall 2015

Massachusetts Institute of Technology
Comprehensive Initiative on Technology Evaluation

Acknowledgements

This report is made possible by the generous support of the American people through the United States Agency for International Development (USAID). The contents are the responsibility of the Comprehensive Initiative on Technology Evaluation (CITE) and do not necessarily reflect the views of USAID or the United States Government.

We would like to thank our generous hosts and partners at the Indian Institute of Management-Ahmedabad, as well as the professors, government officials and surveyed households who made our research possible.

Read more about our work and other product evaluations at cite.mit.edu.

Sustainability Team Members

Massachusetts Institute of Technology
Sydney Beasley
Prof. Olivier L. de Weck
Jennifer Green
Maimuna Majumder
Jonars B. Spielberg

Hanken School of Economics (Finland)
Linda Annala

India Field Team
Chinmay Kishor Ajnadkar, Indian Institute of Technology-Gandhinagar
Darshil Chauhan, Indian Institute of Technology-Gandhinagar
Vihar Parikh
Sean Ricks, Tata Center for Technology and Design at MIT
Devina Sarwatay, Gujarat University
Ashish Kumar Sehra, Indian Institute of Technology-Gandhinagar
Paramu Viswanathan

Table of Contents

Acknowledgements 2
Sustainability Team Members 2
List of Acronyms 4
Introduction 5
Sustainability 5
Setting the Context 6
Methodology 8
- Objectives and Scope 8
- Weighted Criteria Matrix and Survey 8
- Field Work, Data Collection and Sampling Plan 12
- Data Cleaning and Analysis 13

Findings 13
- Social 14
- Economic 15
- Perceived Benefits 16
- Usability 17
- Comparative Scoring of Filter Categories 18
- Comparative Scoring of GNE and RO Commercial Brands 19

Summary and Conclusions 22
References 24

List of Acronyms

CITE	Comprehensive Initiative on Technology Evaluation
CPF	Conventional Particle Filter
EWS	Economically Weaker Section
GNE	Gravity Non-Electric
HESN	Higher Education Solutions Network
IIM-A	Indian Institute of Management, Ahmedabad
IIT-GN	Indian Institute of Technology, Gandhinagar
INR	Indian Rupee
KAP	Knowledge, Attitudes and Practices
LIG	Low-Income Group
MIT	Massachusetts Institute of Technology
POU	Point-of-Use
RO	Reverse Osmosis
SI	Sustainability Indicator
USAID	United States Agency for International Development
WASH	Water, Sanitation and Hygiene
WCM	Weighted Criteria Matrix

INTRODUCTION

In summer 2014, a research team from the Comprehensive Initiative on Technology Evaluation (CITE) at MIT evaluated household water filters available on the market in Ahmedabad, India. The team worked closely with students and faculty at local universities to assess water filter products' suitability—do filters perform their intended purpose, scalability—do the filters' supply chain effectively reach consumers, and sustainability—are filters used correctly, consistently, and continuously by users over time. The findings of CITE's sustainability research are presented here.

SUSTAINABILITY

Though technology evaluation is inherently product-centric, the product itself is embedded in a larger socioeconomic system that influences how it is used and the extent to which the local population adopts it. A host of interdependent contextual factors, from the micro- to the mega-level, as shown in Figure 1, determine whether the product will scale successfully.

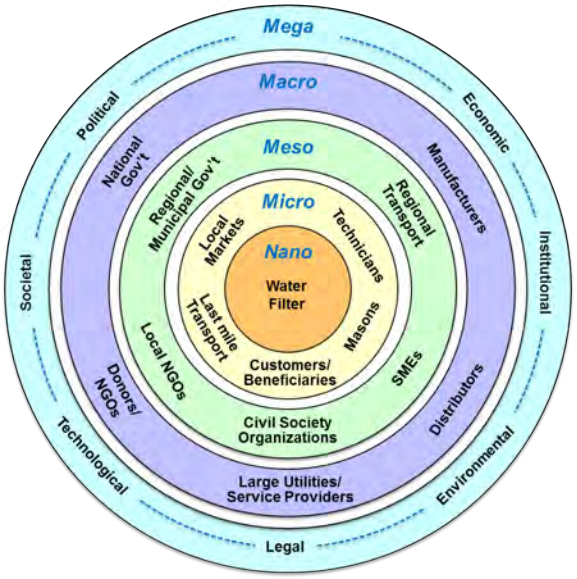

FIGURE 1: SUSTAINABLE SYSTEMS APPROACH

In this evaluation, we have applied the weighted criteria matrix (WCM) methodology—similar to the method used by *Consumer Reports*—to understand the sustainability of different types and models of point-of-use (POU), household water filters with respect to the four macro-criteria of Social, Economic, Perceived Benefits and Usability. The output from this method is a comparative ratings chart.

Social measures how well the technology fits within the social norms of one's surrounding community. Diffusion of innovations theory has shown that if a technology is used and recommended by the family and social network of the potential adopter, they are more likely to adopt the technology themselves (Rogers, 2003).

Economic measures whether the initial cost associated with the technology is within users' willingness and ability to pay. In order to be economically sustainable, product demand must

also be sufficient to achieve scale and profitability for the manufacturers and distributors of the product.

Perceived Benefits measures how well the technology fulfills the users' expectations for meeting their needs. For example, in the case of the water filter evaluation, users were asked to what degree they believed that the water filter improved their health and water quality. While the *perceived* benefit may not be consistent with the *actual* benefit (performance) as tested by the suitability portion of CITE's research,[1] such perceptions are nonetheless important to long-term sustainability.

Usability measures whether the users are confident that they can use the technology correctly in order to achieve the highest benefit, whether there is a structure in place that will teach them how to use and maintain it, and whether they trust that it will continue to operate correctly as long as they expect. Usability is also influenced heavily by perception; however, especially when it comes to dependability of the technology, observation is the strongest driver, especially when users can draw on their own experience or the experience of a friend or family member (for good or bad).

Setting the Context

The state of Gujarat is located on the northwestern coast of India. It is bounded by the Arabian Sea to the west and southwest and Pakistan to the north. It has a population of approximately 60.3 million people, about 5% of the Indian population. Gandhinagar is the capital city, while Ahmedabad stands as the commercial capital. Ahmedabad is the most populated district of the 26 districts in the state, with a population of 7.2 million. Though the state has limited natural resources, it has emerged as India's most industrialized state and has developed a reputation for entrepreneurial success (Government of Gujarat, 2014). The demographic characteristics of the 263 households CITE surveyed in its sustainability research are shown in Figure 2.

[1] See "Household Water Filter Evaluation, Suitability—India." CITE, 2015.

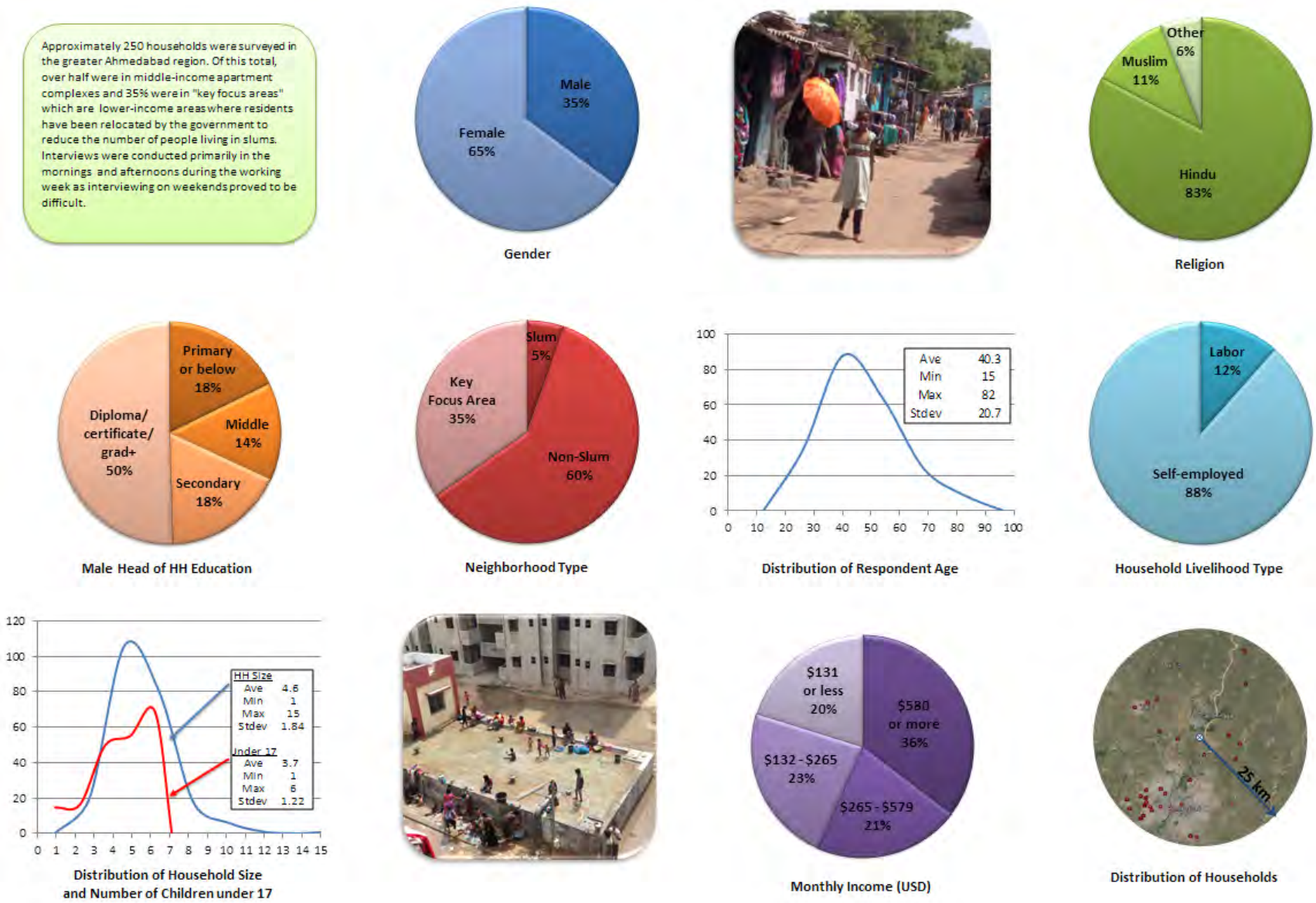

FIGURE 2: DEMOGRAPHICS DASHBOARD

METHODOLOGY

OBJECTIVES AND SCOPE

Three main objectives drove CITE's sustainability research and activities:[2]

- **Objective 1:** Evaluate and compare household water filters from the consumers' perspective.
- **Objective 2:** Understand households' decision-making processes and knowledge about clean water.
- **Objective 3:** Identify the key barriers to scale for the sustainable use of water filters.

CITE sustainability researchers traveled to Ahmedabad, India from June to July 2014 to survey families who used a household water filter, targeting three broad filter user categories: conventional particle filters (CPF), gravity non-electric (GNE) filters, and reverse osmosis (RO) filters. In addition, 34 households who did not use a water filter of any kind were surveyed to inform our understanding of barriers to scale and sustainable use.

CITE sustainability was specifically interested in understanding consumer knowledge, decision-making processes and perceptions of household water filters. In many ways, CITE's sustainability research sheds more light on the *users* of household water filters, rather than the *actual* household water filters themselves. This is important: identifying what people value about a product, and how they relate to and perceive it, is crucial in unpacking the drivers and barriers to sustainable use.

WEIGHTED CRITERIA MATRIX AND SURVEY

In alignment with the sustainability objectives, especially Objective 1, 10 sustainability indicators (SIs) were developed, shown in Table 1. These 10 indicators serve as the basis for computing an overall, integrated sustainability score for each filter category evaluated. To calculate comparative indicators for each filter, we developed a weighted criteria matrix (WCM) that evaluates household water filters according to the 10 SIs, categorized under 4 macro-criteria: social, economic, perceived benefits and usability. Simply put, a WCM is a table that lists out

[2] Though not investigated here, in future reports, environmental sustainability of the technology on the surrounding natural and built environment and local community may be considered. This would be done by identifying known environmental issues associated with the specific technologies (e.g., the fact that the reverse osmosis systems waste a considerable amount of water) and looking at the technology within the larger system shown in Figure 1. Another important factor that was not addressed in this report is the environmental impact of the water filters on the surrounding community. Particularly in the case of the reverse osmosis (RO) filters, which discharge a high percentage of wastewater that is not generally reused at the household level, a systems-level environmental impacts assessment should be performed to assess the environmental sustainability of the water filters.

relevant criteria for a given project or product and assigns a weight to each criteria indicating how important it is to overall success. Cell-by-cell algorithms were developed that allow us to convert end-user survey data into a score for each SI.

Macro-Criteria	SI #	SI Name	SI Description
Social (15% weighting)			
	1	Observability	Prevalence of use and awareness of filters
	2	Social Influence	Impact of peers and the past on filter use
	3	Recommendability	Endorsement of a filter based on personal use
Economic (50% weighting)			
	4	Cost Barrier	Initial purchase cost relative to annual income
Perceived Benefits (15% weighting)			
	5	Health	Health as a value and reason to buy a filter
	6	Convenience	Time and money values and reasons to buy a filter
	7	Water Quality	Water quality as a value and reason to buy a filter
Usability (20% weighting)			
	8	Confidence in Use	Faith in user's own ability to use a filter correctly
	9	Instructions & Training	Type and diversity of support services for a filter
	10	Dependability	The satisfactory performance of a filter over time

TABLE 1: SUSTAINABILITY INDICATORS

To gauge the overall sustainability of each product, the macro-criteria scores were weighted, as shown in Table 1, to: 1) best reflect the priorities and decision-making behaviors of the survey population; and 2) to align with barriers to scale—that is, a larger weighting signifies a more significant barrier to scale. By weighting the macro-criteria, our aim was to incorporate contextual relevance into the matrix. Final scores for each household water filter category were computed using the same criteria, cell-by-cell algorithms and weighting schematic.

The survey and indicators were developed concurrently to ensure that each question or set of questions would provide the raw data necessary to compute one or more of the indicators from our WCM. The indicators and survey are based primarily on documents from USAID, WHO/UNICEF, previous field research done in Gujarat and elsewhere in India, and feedback from water, sanitation, and hygiene (WASH) scholars and evaluation experts in the U.S. and India (Hernandez, 2010) (GRASP Analytique, 2011) (TARA, 2012) (WHO/UNICEF, 2012). The survey was developed over several months, and the team received extensive feedback, covering content, ordering and wording. The survey was translated from English to Gujarati, and piloted for a week to adjust for cultural sensitivities and appropriate questions and response choices. Feedback and input from CITE's suitability and scalability researchers helped to further refine the survey. Data on demographic and knowledge, attitude, and practices (KAP) was collected from participants to understand the contextual elements that drive respondents'

adoption and use of filters. The connection between survey questions and SIs can be seen in Table 2.

Due to their prevalence, and notably their use among poorer populations, households that used cloth and/or *jali*[3] mesh to filter their drinking water were also targeted. In alignment with Objective 3, households who do not use a filter were also interviewed.

[3] *Jali*, in Hindi, means a perforated material (e.g. cloth, stone, metal) or lattice screen.

QUESTION ID	SOCIAL			ECONOMIC	PERCEIVED BENEFITS			USABILITY		
	SI-1	SI-2	SI-3	SI-4	SI-5	SI-6	SI-7	SI-8	SI-9	SI-10
	Observ -ability	Social Influence	Recommend -ability	Cost Barrier	Health	Conven- ience	Water Quality	Confidence in Use	Instructions & Training	Depend -ability
B8A	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
B8B	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
B8C	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
B8CC	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
B8D				✔						✔
B8E				✔						
B8E										
specify				✔						
B8F				✔						
B11				✔						
B12					✔	✔	✔			
B14		✔								
S1		✔								
S1 specify		✔								
S3A			✔							
S3B			✔							
S3C			✔							
S3D			✔							
S4A						✔				
S4B						✔				
S4C					✔					
S4D							✔			
S4E							✔			
S4F							✔			
S4G										✔
S4H										✔
UN1							✔			
UN2A			✔							
UN2B			✔							
UN3A									✔	
UN3B									✔	
UN3C									✔	
UN3D									✔	
UN4A									✔	
UN4B									✔	
UN5A										✔
UN5B										✔
UN6A						✔				
UN6B						✔				
UN6C										✔
UN6D										✔
UN6E										✔
UN6F										✔
UN6G							✔			
UN6H							✔			
UN6I							✔			
UN8A								✔		
UN8B								✔		
UN9A										✔
UN9B										✔
UN9C										✔
UN10A										✔
UN10B										✔
UN10C										✔
UN10D				✔						✔
UN10E										✔
UN10F										✔
B15							✔			
B22A	✔									
B22B	✔									
B23A										✔
B30				✔						

Note: Of the approximately 80 questions on the survey, 61 were used in the calculation of the 10 SIs. The remaining questions were used to assess the knowledge and practices, and to capture demographic data, of respondents.

TABLE 2: RELATIONSHIP BETWEEN SURVEY AND SUSTAINABILITY INDICATORS

Field Work, Data Collection and Sampling Plan

CITE sustainability surveyed 263 households in 12 wards throughout Ahmedabad. The target population was urban and peri-urban households in the Ahmedabad metropolitan region who own a household water filter in one of three categories: conventional particle filters (CPF), gravity non-electric (GNE) filters, and reverse osmosis (RO) filters.

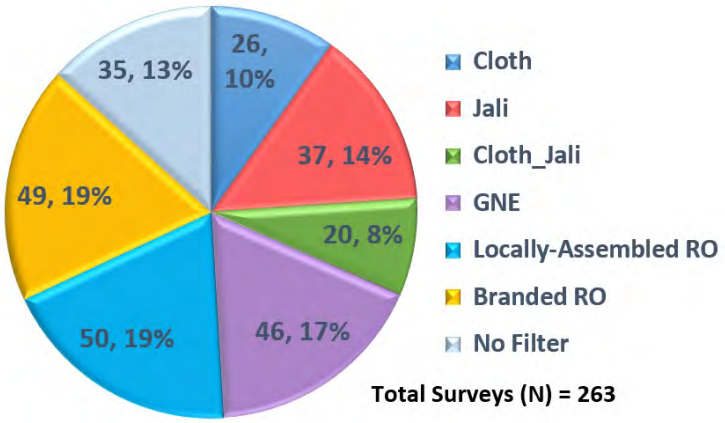

FIGURE 3: DISTRIBUTION OF FILTER TYPE USAGE

Our sampling was purposive, rather than randomized, based on the project's overall objectives, and to make the best use of limited resources. We targeted specific filter category users, and needed to make sure that we found enough respondents from each category while also covering all income groups, from high-income to the economically weaker section (EWS).[4] Our partners from IIM-A and IIT-GN helped us identify specific communities throughout the city where we could find the filter users we sought. Figure 3 and Table 3 show the breakdown of surveyed users by filter category and type.

To facilitate survey administration, local students and professionals were hired as enumerators. Enumerators were briefed about the project and its goals, familiarized with the survey and trained to adhere to standard research guidelines and survey protocols. Before administering surveys independently, CITE researchers accompanied enumerators to ensure proper, consistent and accurate data collection. In addition, every day after enumerators returned from surveying, a CITE researcher reviewed each survey with the enumerator to confirm data integrity.

[4] EWS is the lowest of four income categories used to determine beneficiaries for certain government programs. As of 2012, a household earning an annual income of 100,000 INR (1 lakh) is defined as EWS. Similarly, a household earning an annual income between 100,001 INR and 200,000 INR (1 to 2 lakhs) is defined as Low-Income Group (LIG) (Government of India, 2012). 1 USD is equal to approximately 60 INR.

Filter Category	Filter Type	Sample Size
I. Conventional Particle Filtration (CPF)		**83**
	Cloth	26
	Jali	37
	Cloth and *Jali*	20
II. Gravity Non-Electric (GNE) Filtration		**46**
	Eureka Forbes AquaGuard	27
	Eureka Forbes AquaSure	8
	Hindustan Unilever PureIt	3
	Kent Ultra	2
	Other	6
III. Reverse Osmosis (RO) Filtration		**100**
	Dolphin (Local Assembly) RO	50
	Eureka Forbes RO	21
	Kent RO	14
	Power H2O RO	6
	Zero B RO	5
	Other	4
IV. Other		**34**
	No Filter	34
Total		**263**

TABLE 3: SAMPLE SIZE BY FILTER CATEGORY

Data Cleaning and Analysis

After the fieldwork and data collection were completed, a single data file was compiled from the individual hardcopy surveys from all of the researchers and enumerators. This compilation file was cleaned column by column—that is, question by question— to facilitate analysis and to ensure consistency in notation, units and coding.

Once the master data file was cleaned, indicator algorithms were modified to be consistent with the data collected and weightings were determined. Demographic, knowledge and perception data was also analyzed to identify trends and correlations related to sustainable filter use.

Findings

The approaches and results of CITE's Sustainability team are described below for each of the four macro-criteria (Social, Economic, Perceived Benefits and Usability) and information is also provided on the indicators for each. The comparative evaluation ratings charts are shown for the water filters separated into 3 main categories: conventional particle filters (CPF) (including cloth alone, *jali* alone, cloth and *jali* together), gravity non-electric (GNE) filters, and reverse osmosis (RO) filters (including branded RO filters and locally-assembled RO filters).

SOCIAL

Three indicators were calculated: Observability, Social Influence, and Recommendability.

Observability measures the degree to which water treatment is prevalent among people's peer groups. As the prevalence of a technology among one's peers increases, the easier it is to see in use and, assuming it is a desirable product, the more likely it is to be adopted (Rogers, 2003). Filter users were asked whether their peers took some action to treat their water. We ranked those filter categories with a higher proportion of "All," "Most," or "Some" responses as having greater observability.

Social Influence measures the degree to which those in one's social network influenced a purchase decision, as well as past filter use. We calculated the proportion of those influenced by people in their close (family, friends) and distant (health professionals, advertisements, salesmen) networks, and also the proportion of people using a filter in the past. These two proportions were weighted equally among the GNE and RO filter users, and full weight was given to using a filter in the past for cloth and/or *jali* users, since the purchase decision question is not applicable to this filter user category.

Recommendability measures the degree to which a current filter user has endorsed, or would endorse, his or her product. This score is a combination of responses to two questions: "Have you, or would you, recommend your water filter to your peers?" and "How satisfied are you with your filter?" By filter category, we calculated the proportion of users who have or would recommend their filter, and those who are satisfied or very satisfied with their filter. These two proportions were weighted equally among the filters (branded ROs, locally assembled ROs, and GNE filters and full weight was given to the satisfaction question for users of cloth and/or *jali*, since the question about purchase decision is not applicable to them.

The results from the scores of these criteria and further analysis supports the view that water filter use is highly dependent on one's social context. Filtration use in the past correlates with present use: 72% of those who currently do not use a filter did not use one growing up, while 60% of those who currently use a commercial filter (GNE, branded RO, locally assembled RO) also used one growing up. Additionally, a filter purchase is often based on the recommendations of people in one's close social network: 59% of respondents said a family member (43%), friend (12%), neighbor (10%) or colleague (2%) influenced their purchase decision. By comparison, print, television and radio advertisements influenced only 13% of respondents. This suggests that sustainable filter use would benefit more from improved peer-to-peer knowledge transfer, rather than more conventional, top-down marketing approaches.

ECONOMIC

One indicator was calculated: Cost Barrier to use.

The cost barrier indicator measures how expensive a product is relative to the annual income of an EWS household. The average upfront cost for each filter category was calculated, then divided by 100,000 INR (the upper-bound for the annual income of an EWS household) to get a percentage. This percentage was normalized and subtracted from 100 to compute the final score.[5]

The Cost Barrier score reveals clearly that filter use is commensurate with people's income levels, which is corroborated by Figure 4: lower-income households tend to purchase cheaper products (CPFs), while higher-income households tend to purchase more expensive products (GNE and RO filters). In this strictly economic point of view, which ignores important externalities such as public health, market forces are functioning as they should, thereby segmenting the population. Indeed, 50% of those who use cloth and/or *jali* and 67% of those who use no filter cited cost as the main reason they do not use a commercial filter, as shown in Figure 5. The survey data also reveals that locally-assembled RO filters can be procured through most distribution channels, as these small businesses are able to exploit local supply chains and social networks better than larger national or global companies. Such availability, however, is primarily concentrated to urban areas, with limited access in rural areas.[6]

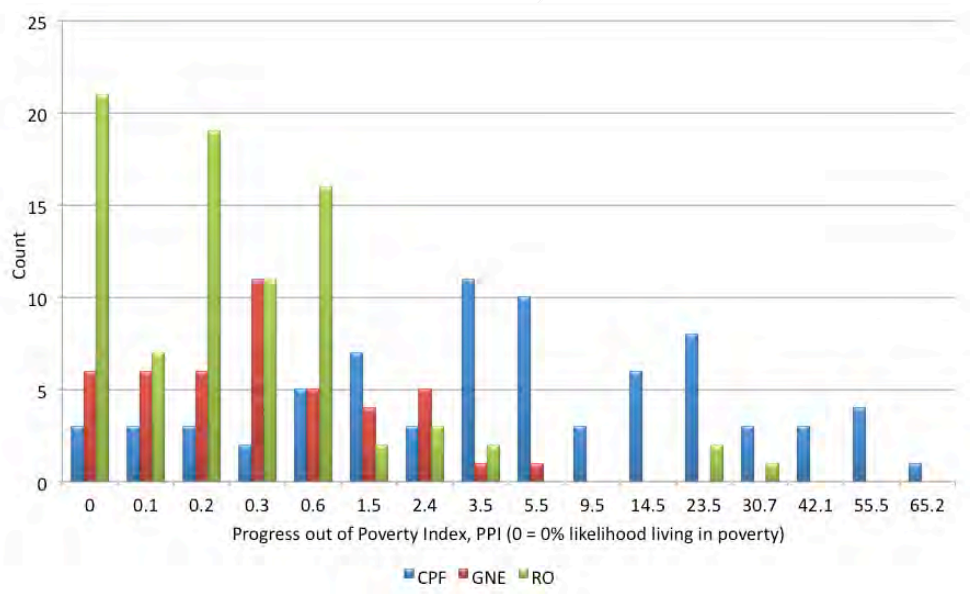

FIGURE 4: FILTER USE AND PPI

---

[5] Ideally, a household would not have to pay anything for water treatment, or a score of 100. Affordability measures vary based on the indicator and threshold (Hutton, 2012). The UNDP defines affordable water as no more than 3% of household income (United Nations, 2010).
[6] "Household Water Filter Evaluation, Scalability." CITE, 2015.

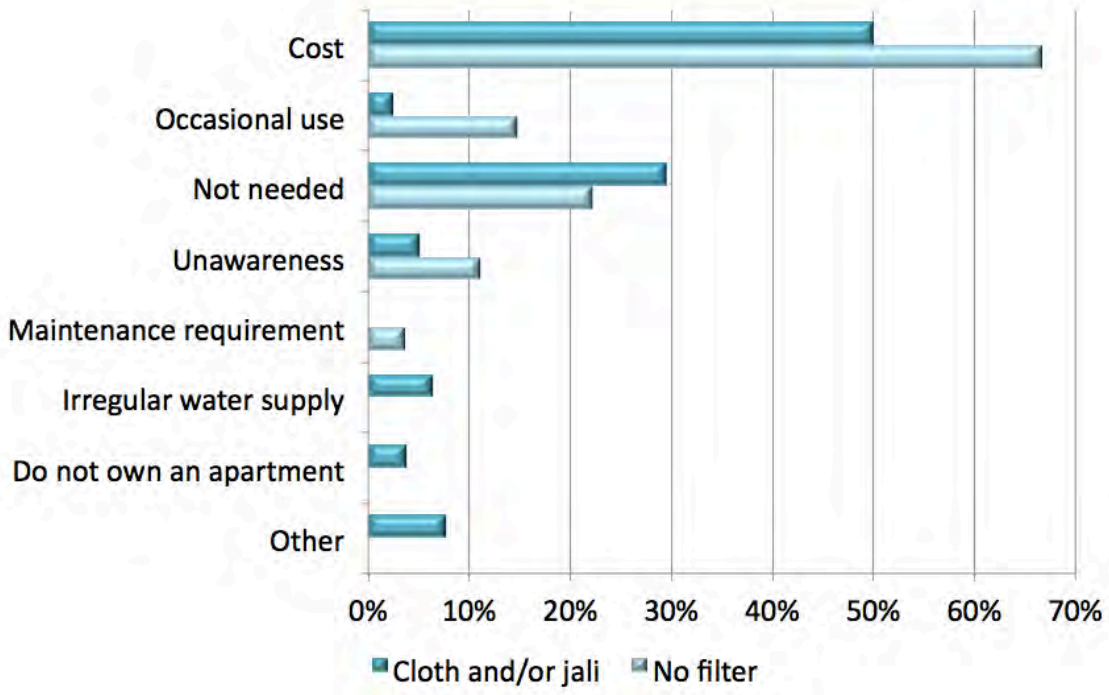

FIGURE 5: REASONS FOR NOT USING A COMMERCIAL FILTER

Perceived Benefits

Three indicators were calculated: Health, Convenience and Water Quality.

Health measures the degree to which health concerns influenced the purchase and use of a filter. Users were asked why they bought their filter and what they value most about their filter. For each question, we calculated the proportion of those who mentioned health as a percentage of all responses. The proportions were added together, with equal weighting given to each question.

Convenience measures the degree to which users believed that their filter affords them savings in time and money. The score draws from four questions: 1) Why did you decide to buy a filter? 2) What are the features you value most about your water filter? 3) Do you agree or disagree with the statement, "My filter filters water quickly?" and 4) Do you agree or disagree with the statement, "My filter has a good storage unit size?" For questions 1 and 2, we calculated the proportion of those who mentioned time and/or money. For questions 3 and 4, we calculated the proportion of those who agreed. All four proportions were added together, with question 1 receiving twice the weight of questions 3 and 4, and four times the weight of question 2.

Water Quality measures the degree to which an improvement in one's water is observed. Such improvement is measured across several dimensions: taste, smell, clarity, and overall satisfaction. Five proportions were added together based on people's responses: 1) those who valued taste, smell and clarity; 2) those who believed their filter improves taste, smell, and clarity; 3) those who were concerned about quality during their purchase; 4) those who believe

that their filtered water is adequate, good, or very good; and 5) the average difference between the perceived water quality of filtered and unfiltered water.

Awareness of health issues related to water appears to be generally high among all filter users, though GNE and RO filter users appear to have a greater ability to articulate specific water-related diseases and conditions. Those who do not use filters cite skin and hair issues, headaches and throat issues in greater proportion than filter users. Most people cited water quality as the reason they bought a filter (71%), followed by health reasons (20%), followed by convenience (7%). Improved health was the most cited feature that customers valued most (45%), followed closely by water quality (40%), then by convenience (12%). GNE and RO filters were more satisfied than cloth and/or *jali* users in the performance of their filters: 65% of GNE and RO filter users were very satisfied, while 41% of cloth and/or *jali* users were very satisfied. Only 1% GNE or RO filter users, but 15% of cloth and/or *jali* users, reported being somewhat or very dissatisfied.

Usability

In the Usability category, three indicators were chosen: Confidence in Use, Instructions & Training and Dependability.

Confidence in Use measures how confident the water filter users are in their ability to use their existing water filter to treat their water. The score is based on the proportion of respondents who said that they were confident in their ability to treat their water compared to the total sample size and the proportion who said that they were "very confident." As shown in Table 4, the majority of users said that they were confident that they could use their filter correctly, but many were only somewhat confident. As a group, the GNE and RO systems scored higher than did the cloth and *jali* filters; however, it is unclear whether this is driven more by the usability of the filters or the education and skill level of the respondents.

Instructions & Training measures whether the seller provides written and verbal instructions on how to use the water filter and the completeness of that material. This indicator was only used for the GNEs, branded RO and locally assembled RO filters, since no formal training or instructions are provided with the cloth and *jali* filters. The score for this indicator is based on the proportion of users who received a written manual, read it and found it helpful, as well as the proportion of users who received verbal instruction and the extensiveness of that instruction. As shown in Table 4, the branded RO customers received the best quality instructions and training on their units, including a helpful manual which most of the users actually read. This result is not surprising given the generally higher socioeconomic status of the branded RO users.

Dependability measures the confidence that the user has in the continued operation of their filter over its lifetime. For the cloth, *jali*, and cloth/*jali* categories, Dependability is a function of four indicators including: the filter ownership period; whether the filter needs replacing each year;

how many replacements are required and whether an additional water treatment method is used. For the other three categories (GNE, branded RO and locally assembled RO), thirteen indicators were used to calculate the score including the four listed above and questions on whether dependability was a desired feature, whether the filter had a warranty,[7] whether users agreed with certain reliability and maintainability criteria and whether an annual maintenance/servicing contract was available and if so, what types of servicing were performed.

Based on these indicators and scores, the cloth and *jali* users did not feel that their filters were particularly dependable, and those that used both cloth and *jali* together found that the combined filter was even less dependable than either cloth or *jali* alone. This was primarily due to the need to replace both pieces frequently. In the case of the GNE and RO filters, approximately 75% thought that the filters were dependable; however, 86% of the GNE filter users and nearly all RO filter users had the units serviced by a technician, with approximately two-thirds of those maintaining an annual service contract. If this kind of professional servicing is not available, which may well be the case outside of major cities, the sustainability of the RO and GNE units would be significantly impacted.

Comparative Scoring of Filter Categories

Table 4**Error! Reference source not found.** shows the score chart comparing the three filter categories (6 filter types/brands). Based on the results of the surveys, the Social criterion was weighted at 15%, Economic at 50%, Perceived Benefits at 15% and Usability at 20%. The weightings at the indicator level were equally distributed and depended on whether the CPF category survey was used or if the GNE/RO survey was used. The surveys differ since all filter purchasing decision questions were not applicable to CPF or Non-filter users. The percent weighting each of the 10 indicators received depended on whether all indicator data was present. If 3/3 indicators have data, then each is assigned a weighting of 33.3%. Similarly, if only 2 of 3 are present, each receives a 50% weighting. To calculate the final weightings, the separate indicator weightings were multiplied by the criteria weightings.

As currently weighted in Table 4, the overall sustainability score for the CPFs (cloth, *jali*, and cloth/*jali*) averaged to be 74/100 points, while the more advanced GNE and RO filters categories scored worse on average, at 52/100 points. The scores for the commercial filters, particularly RO filters, were driven lower by their higher cost. The cloth and *jali* filters performed poorly in the Improvement in Water Quality and Dependability indicators, while the GNE and RO categories had low scores in the Convenience indicator—which measured the degree to which users

[7] In our sample group and in Ahmedabad as a whole, a filter "warranty" is a service contract where the manufacturer or retailor sends a service technician once approximately every 3 months to service the filter. The average warranty lasts between 1-2 years and is included in the price of the filter. After the warranty expires the user must purchase a service agreement or service the filter themselves. Replacement parts may or may not be included.

believed that their filter affords them savings in time and money—a result that is consistent with their higher costs.

			SOCIAL			ECONOMIC	PERCEIVED BENEFITS			USABILITY		
		CPF Weightings	*3.8%*	*3.8%*	*7.5%*	*50.0%*	*0.0%*	*0.0%*	*15.0%*	*6.0%*	*0.0%*	*14.0%*
		GNE/RO Weightings	*3.8%*	*3.8%*	*7.5%*	*50.0%*	*3.0%*	*3.0%*	*9.0%*	*5.0%*	*5.0%*	*10.0%*
Category	**Type/Brand**	**Sustainability Score**	**Observability**	**Social Influence**	**Recommend ability**	**Cost Barrier**	**Health**	**Convenience**	**Water Quality**	**Confidence in Use**	**Instructions & Training**	**Depend-ability**
CPF	Cloth	77	35	38	72	100			43	83		54
CPF	Jali	72	39	46	61	100			29	71		43
CPF	Cloth and Jali	73	60	45	55	100			49	71		25
GNE	Several Brands	62	60	63	91	52	50	42	59	90	72	80
RO	Branded	37	64	69	91	0	43	38	75	85	86	79
RO	Local Assembly	57	62	63	95	41	40	37	73	87	70	74

			SOCIAL			ECONOMIC	PERCEIVED BENEFITS			USABILITY		
		CPF Weightings	*3.8%*	*3.8%*	*7.5%*	*50.0%*	*0.0%*	*0.0%*	*15.0%*	*6.0%*	*0.0%*	*14.0%*
		GNE/RO Weightings	*3.8%*	*3.8%*	*7.5%*	*50.0%*	*3.0%*	*3.0%*	*9.0%*	*5.0%*	*5.0%*	*10.0%*
Category	**Type/Brand**	**Sustainability Score**	**Observability**	**Social Influence**	**Recommend-ability**	**Cost Barrier**	**Health**	**Convenience**	**Water Quality**	**Confidence in Use**	**Instructions & Training**	**Depend-ability**
CPF	Cloth	77	◔	◔	◕	●	*N/A*	*N/A*	◑	●	*N/A*	◑
CPF	Jali	72	◔	◑	◕	●	*N/A*	*N/A*	◔	◕	*N/A*	◑
CPF	Cloth and Jali	73	◕	◑	◑	●	*N/A*	*N/A*	◑	◕	*N/A*	◔
GNE	Several	62	◕	◕	●	◑	◑	◑	◑	●	◕	◕
RO	Branded	37	◕	◕	●	○	◑	◔	◕	●	●	◕
RO	Local Assembly	57	◕	◕	●	◑	◔	◔	◕	●	◕	◕

TABLE 4: SUSTAINABILITY RATINGS CHART

Comparative Scoring of GNE and RO Commercial Brands

In addition to evaluating filter categories, we evaluated the six GNE and RO filter brands best represented in our sample, as shown in Figure 6. The method (WCM) and equations (cell-by-cell algorithms) remained the same as for categories.

Ratings by brand are generally consistent with those by category. RO Filters scored 45/100 points on average, while GNE filters scored an average of 63/100 points. RO filters, especially those that are branded, were more expensive than GNE filters, though RO filters scored higher in perceived improvement in water quality and dependability. GNE filters, however, scored better than RO filters in perceived health and convenience benefits. Social and Usability SIs remain high for across all brands.

Figure 7 and Figure 8 show word clouds of the top 10 most frequent responses to the prompt, “There are many companies that make water filters, and many models of water filters. Which, if any, can you name?” In asking this, we sought to gauge brand recognition, which seems to be relatively consistent with market share: Eureka Forbes’ AquaGuard line of filters is most recognized, followed by the company Kent. A notable difference between all filter users and those who use cloth and/or *jali*, or no filter, is the absence of “Dolphin” recognition among the latter population.

SUSTAINABILITY (BY BRAND)		INTEGRATED SUSTAIN-ABILITY SCORE	SOCIAL				COST BARRIER[1]	PERCEIVED BENEFITS				USABILITY			
Weightings			15%	25%	25%	50%	50%	15%	20%	20%	60%	20%	25%	25%	50%
Category	Name		SCORE	Observ-ability	Social Influence	Recommend-ability	SCORE	SCORE	Health	Conven-ience	Water Quality	SCORE	Confidence in Use	Instructions & Training	Depend-ability
1	Eureka Forbes AquaGuard	61	81	◕	◕	●	◑	55	◑	◑	◕	80	●	◕	●
2	Eureka Forbes AquaSure	63	82	◑	◕	●	◑	51	◑	◑	◑	78	●	●	◕
3	Hindustan Unilever PureIt	64	63	◔	◑	●	◕	47	◑	◔	◑	70	●	◕	◑
4	Local Assembly RO Filter	58	79	◕	◕	●	◑	59	◔	◔	◕	76	●	◕	◕
5	Eureka Forbes RO Filter	37	80	◕	◕	●	○	61	◔	◑	◕	77	◕	●	◕
6	Kent RO Rilter	39	74	◑	◕	●	○	60	◑	◔	◕	88	●	●	●

FIGURE 6: COMPARATIVE RATINGS CHART BY FILTER BRAND

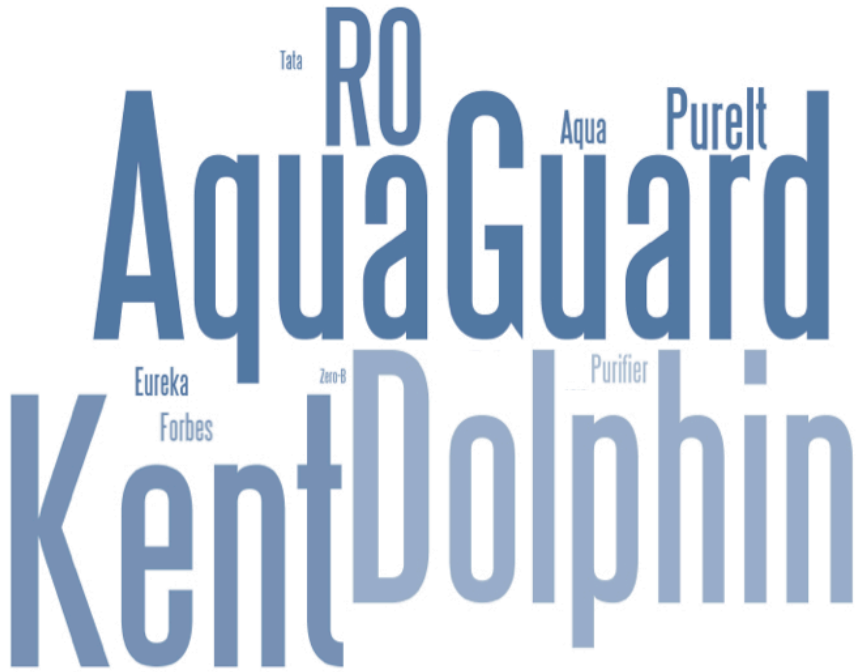

FIGURE 7: BRAND RECOGNITION—ALL FILTER CATEGORY USERS

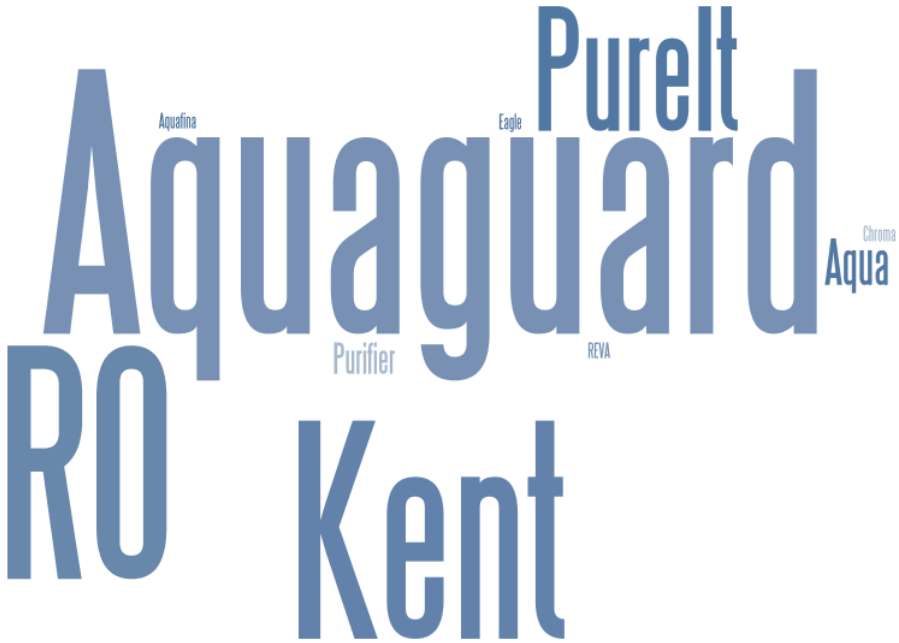

FIGURE 8: BRAND RECOGNITION—CLOTH, *JALI* AND NO FILTER USERS

Summary and Conclusions

As currently weighted, the overall sustainability score for the CPFs (cloth, *jali*, and cloth/*jali*) averaged 74/100 points, while the GNE and RO filters categories scored worse on average, at 52/100 points. Higher costs of GNE and RO filters are largely responsible for their lower scores. The cloth and *jali* filters performed well in terms of cost, though poorly in the Improvement in Water Quality and Dependability indicators, while the GNE and RO categories had low scores in the Convenience indicator—which measured the degree to which users believed that their filter affords them savings in time and money—a result that is consistent with their higher costs.

By brand, RO Filters scored 45/100 points on average, while GNE filters scored an average of 63/100 points. RO filters were more expensive than GNE filters, though RO filters scored higher in perceived improvement in water quality and dependability. GNE filters, however, scored better than RO filters in perceived health and convenience benefits.

Apart from the evaluation itself, supporting analysis points to the strong influence of the socioeconomic systems surrounding household water filters. A significant determinant of water filter use seems to be the influence of social norms regarding water treatment practices during childhood and in one's immediate social network (family, peers, neighborhood). Seventy-two percent of those who do not use a filter also did not use a filter growing up. Similarly, of the 13% of respondents who said that their peers did not use filtration of any kind, 45% did not use a filter themselves and 26% used cloth and/or *jali*. This suggests that behavior is deeply rooted and may be difficult to change without strong incentives, and the buy-in of those in one's social sphere.

This is complicated further by a general heightened awareness of water issues among the residents of Ahmedabad. Because they also have a good water source (Narmada Canal) and a good municipal water system, at least relative to the standards of other Indian cities, many residents feel that they do not need to filter their water (see Figure 5). A more realistic understanding of water quality—perceptions of water quality are generally inflated—may be important in convincing people of the need to filter their water.

Cost is another key barrier to scale among poorer populations: 50% of those who use cloth and *jali* and 67% of those who use no filter cited cost as a reason they do not use a commercial filter. While Locally-assembled RO filters are generally cheaper than branded RO filters—though satisfaction, on average, is higher for branded ROs—both still remain outside of the self-reported willingness and ability to pay for poorer households. While there is space for technological and materials innovation that would reduce manufacturing costs without inordinately sacrificing performance, the considerable cost barrier at the household level speaks to the importance of financial innovations in the diffusion of technologies to lower-income consumers.

Additionally, while consumers in lower- and higher-income markets are not identical, they do share similarities. In response to the question, "Are there any factors that would improve your

filter?” the top two responses were improved design and improved performance for commercial filter users *and* cloth and *jali* users. The underlying lesson is evident, but worth noting explicitly: Understanding the consumer—their needs, values, knowledge, perceptions and context—is paramount to sustainable product use.

REFERENCES

Government of Gujarat. (2014). *Gujarat*. Retrieved August 24, 2014, from State Profile: http://www.gujaratindia.com/state-profile/state-profile.htm

Government of India. (2012, November 14). *Office Memorandum.* Retrieved June 23, 2014, from Revision of Income Ceilings for Economically Weaker Section (EWS) and Low Income Group: http://mhupa.gov.in/W_new/EWS_OFFICE_MEMORUNDUM_14_11_2012.pdf

GRASP Analytique. (2011). *Market Potential Analysis for Water Purifiers Using Nanotechnology for the Bottom of the Pyramid.* Project Jal. Delhi: Development Alternatives.

Hernandez, O. (2010). *Access and Behavioral Outcome Indicators for Water, Sanitation and Hygiene.* Hygiene Improvement Project, Academy for Educational Development. Washington, DC: USAID.

Hutton, G. (2012). *Monitoring "Affordability" of water and sanitation services after 2015: Review of global indicator options.* United Nations Office of the High Commission for Human Rights.

Rogers, E. (2003). *Diffusion of Innovations* (5th ed.). Free Press.

TARA. (2012). *Access to Safe Water for the Bottom of Pyramid : Strategies for Disseminating Technology Research Benefits* . TARA. London: DFID.

United Nations. (2010). *The Right to Water: Fact Sheet No. 35.* United Nations Office of the High Commissioner for Human Rights.

WHO/UNICEF. (2012). *A Toolkit for Monitoring and Evaluating Household Water Treatment and Safe Storage Programs.* Geneva: WHO.