AN ABSTRACT OF THE ESSAY OF

Jaynie L. Whinnery for the degree of Master of Public Policy presented on May 9, 2014.

Title: The Influence of NGO Strategies on the Sustainability of Biosand Water Filters in Cambodia.

Abstract approved: _____

Dr. Sarah L. Henderson

This essay evaluates the effectiveness of NGO strategies to promote program sustainability using a case study of two NGOs that install biosand water filters in Cambodia. While the ownership-focused strategy of cost-sharing is the most commonly used and studied, there is evidence to suggest that certain more neglected strategies can have a greater impact. Drawing from nine months of fieldwork, 457 household surveys and five semi-structured interviews with NGO management personnel, the programmatic details of each program are presented along with other factors that relate to the continued use of biosand filters. Through a mixed methods approach this study finds that labor-sharing and monitoring contribute to a significant 15 percentage point difference in biosand filter continued use between the two NGOs. Meanwhile, the influence of cost-sharing remains elusive. This essay argues that the pervasive sentiment that cost-sharing can effectively promote sustainable outcomes allows NGOs using this policy to have a false sense of sustainability. Consequently, other strategies such as labor-sharing and monitoring that have been found to promote more sustainable outcomes are often neglected. Failure to use evidence-based sustainability strategies results in more program failures and prevents the achievement of desired poverty alleviation outcomes.

The Influence of NGO Strategies on the Sustainability of Biosand Water Filters in Cambodia

by
Jaynie L. Whinnery

AN ESSAY

submitted to

Oregon State University

in partial fulfillment of
the requirements for the
degree of

Master of Public Policy

Presented May 9, 2014
Commencement June 14, 2014

Master of Public Policy essay of Jaynie L. Whinnery presented on May 9, 2014

APPROVED:

Dr. Sarah L. Henderson, representing Political Science

Dr. Sally K. Gallagher, representing Sociology

Dr. Patrick M. Emerson, representing Economics

I understand that my essay will become part of the permanent collection of Oregon State University libraries. My signature below authorizes release of my essay to any reader upon request.

Jaynie L. Whinnery, Author

ACKNOWLEDGEMENTS

I would like to express my sincerest gratitude to everyone that has supported me in this endeavor. First and foremost, I would like to thank the NGOs for willingly participating in this study. This type of work is extremely important, yet it is often a challenge to find organizations that are open to partnering with student researchers on this kind of project. I also want to show my appreciation for each and every community participant, NGO staff member and Khmer language instructor that supported me throughout my time in Cambodia. Next, I would like to thank the faculty of the public policy graduate program for being uncharacteristically supportive of independent graduate student research projects. I want to express particular appreciation for my advisor, Dr. Sarah Henderson, for dedicating so much time and attention to helping me develop and articulate my ideas. Additionally, I want to thank my committee members, Dr. Sally Gallagher and Dr. Patrick Emerson, and Dr. Liz Schroeder for all of their support and advice regarding my research and essay. I would also like to thank Dr. Brent Steel for supporting me throughout my time in the public policy program. Last, and most certainly not least, I must thank my entire family, especially my husband David Whinnery and my parents, for always encouraging me to pursue my dreams to the fullest extent.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1.0 Introduction

What constitutes sustainable development is highly contested. The term 'sustainability' alone has many uses and interpretations (Mog, 2004; Tango International, 2009). This essay addresses sustainability in terms of the continued use of technologies implemented by development programs, considering that even relatively simple lifesaving technologies such as mosquito nets and drinking water systems are frequently reported as misused and nonfunctional (Baumann, 2009; Easterly, 2006; Fogelberg, 2010; Githinji, Herbst, Kistemann & Noor, 2010; Skinner, 2009). To combat such program failures many governments and non-governmental organizations (NGOs) use ownership-focused implementation strategies to promote sustainable development. The importance of establishing a local "sense of ownership" is a common sentiment based on the idea that people do not value something that they have received in exchange for nothing. One of the most popular strategies is cost-sharing, which requires cash contributions from program participants. Other leading strategies include labor-sharing and localized management and decision-making processes. Despite the popularity of these strategies, it is unclear to what extent these forms of participation actually influence the sustainability of program outcomes. Studies have yet to produce evidence that cost-sharing improves sustainability, although it has been found that cost-sharing can counteract program goals by decreasing program participation and exacerbating inequalities (Cohen & Dupas, 2010; Kremer & Miguel, 2007; Nabyonga, Desmet, Karamagi, Kadama, Omaswa & Walker, 2005). At the same time, some evidence suggests that the other more neglected forms of participation of labor-sharing and localize management and decision-making may be more effective at promoting sustainable outcomes.

Water projects are a prominent crosscutting development initiative because addressing the basic human need for water supports several interconnected goals. Beyond reduced mortality, improved health can increase productivity for school and labor-related activities. Furthermore, access to safe water can provide other benefits in the form of

reduced medical expenses, more time for work, study, and leisure (for women and girls in particular), and increased happiness (Devoto, Duflo, Dupas, Pariente & Pons, 2011; Karlan & Appel, 2011; Kremer, Leino, Miguel & Zwane, 2011). It is well understood that drinking, cooking, and washing with contaminated water negatively affects human health and there is widespread consensus regarding the positive impacts that occur when people gain access to safe water. For this reason, countless technologies have been developed to make water safe for consumption. Yet, according to the available global metrics, at least 768 million people still lack access to an improved water source (WHO & UNICEF, 2013). Furthermore, this figure grossly underestimates the problem because it does not account for water quality or water system sustainability. In fact, a more comprehensive analysis estimates that 3.4 billion people, or half of the world's population, do not have access to a *sustainable* source of *safe* water (Payen, 2011).

Access to safe and sustainable water sources is often limited by the socioeconomic and political context, which can restrict the use of readily available technological solutions. In these situations NGOs may provide the assistance needed to implement a water system but fail to ensure that use of this technology continues over time. For example, water wells with hand pumps are one simple but effective technology that NGOs frequently support, but it has been estimated that anywhere from 30% to 50% of hand pumps in Africa are non-functional at any given point in time (Baumann, 2009; Fogelberg, 2010; Harvey & Reed, 2003). In an attempt to understand how to minimize such failures most research on water system sustainability has focused on communal water systems for which local governance is a primary factor. However, household scale water systems are also widely implemented by NGOs, in part as a way to bypass governance limitations (Mintz, Bartram, Lochery & Wegelin, 2001; Liang, Sobsey & Stauber, 2010; Sobsey, Stauber, Casanova, Brown & Elliott, 2008). Yet the factors that influence water system sustainability at the household level have not been thoroughly evaluated. To help address this gap in understanding this essay asks, "how do ownership-focused NGO strategies of cost-sharing and labor-sharing influence the sustainability of household water filters?"

To address the research question the practices of two similar NGOs based in Siem Reap, Cambodia are evaluated. Drawing from nine months of field research, a census survey of 457 households with the oldest biosand filters (BSF), and semi-structured interviews with five NGO management personnel, a significant difference in water filter sustainability is discovered between the NGOs. The BSFs implemented by NGO A are still being used at a rate of 69% and the BSFs implemented by NGO B are still being used at a rate of 84%. Labor-sharing during implementation is found to have a positive influence on BSF continued use but the influence of cost-sharing on sustainability remains elusive. Furthermore, the difference in BSF continued use between the NGOs is also related to other factors beyond the more prominent strategies used during implementation. The findings of this study demonstrate that monitoring frequency and the source of water poured into the BSF are also large and significant factors influencing the continued use of household BSFs. With much of the discussion of sustainable outcomes focused on cost-sharing, more salient factors are being neglected to the detriment of the people that development programs intend to benefit. Effective strategies are overlooked when organizations complacently use cost-sharing based on the unsubstantiated notion that people will value something and continue to use it as long as they are financially invested. This false sense of sustainability slows progress toward achieving universal access to water; consequently there are more children dying unnecessarily and more people needlessly suffering every day.

2.0 The Problem of Sustainability

2.1 Background

Scholars and practitioners disagree over both the determinants of poverty and the solutions for sustainable poverty reduction. When talking about development, many scholars focus on macro-level questions related to the causes of poverty and whether foreign aid can work on a national or global scale. Poverty traps, or problems of low productivity and insufficient resources that work in tandem to keep a population impoverished indefinitely, are often cited as the cause. The list of proposed poverty traps is long, ranging from conflict, natural resources, and geography traps (Collier, 2007; Diamond, 1997; Diamond, 2005) to inadequate infrastructure and low levels of human development (i.e., health, education, reasonable standard of living) (Sachs, 2005) to poor governance and weak institutions (Acemoglu & Robinson, 2012; Collier, 2007). Strategies to resolve these traps at the macro-level have largely divided along ideological lines into all or nothing approaches. For example, Sachs (2005) is the most notable proponent of using foreign aid to break cyclic poverty traps, while Easterly (2006) argues that foreign aid does more harm than good because the average country is not caught in a poverty trap. Others argue that the focus should be on improved democracy, freedom and governance through institution building, international charters, trade reforms and better coordination between nations. Foreign aid can support this solution but alone it is insufficient (Acemoglu & Robinson, 2012; Collier, 2007).

Frustrated by the lack of actionable suggestions provided by the macro-level debates, Banerjee and Duflo (2010) are leading the development community toward a new paradigm where development programs are evaluated at the micro-level. At the micro-level it is possible to more evaluate how different programs influence specific features of poverty (e.g., poor health, low levels of education) for individuals and their families. Banerjee and Duflo (2010) contend that development policies and strategies need to directly address the issues that put poor individuals at a disadvantage. These issues range from being misinformed or lacking information (e.g., regarding the benefits of immunizations) to market failures that prevent poor people from accessing goods and

services that they need at a price they can afford. Following this approach, a network of researchers associated with the Abdul Latif Jameel Poverty Action Lab (J-PAL) used randomized controlled trials to systematically evaluate the extent to which development strategies actually influence desirable behavior changes at the individual level (e.g., providing lentils as way to encourage women to vaccinate their children today rather than putting it off until tomorrow). This reframing of poverty alleviation efforts to the micro-level allows assessment of which concepts work and why, what strategies are more cost effective, and how programs really influence the lives of the poor and their communities. The results of these evaluations can then be translated into specific policy recommendations for better-informed policy decisions and program designs in the future. This essay is situated within this growing micro-level paradigm as it evaluates the influence of specific development program strategies for individual participants.

Program sustainability is a crucial aspect of successful poverty alleviation initiatives because anti-malarial bed nets that are not used as designed cannot prevent malaria and broken or unused water filters cannot reduce the incidence of diarrhea. Regardless of the type of program, if the intended benefits do not continue over time then the program cannot have a lasting impact. Development projects often fail because people do not properly use and maintain the technologies implemented. Failed development projects are a problem because they waste limited resources, such as the estimated $215-360 million investment associated with non-functional water points installed since the year 2000 in Africa (Skinner, 2009). Moreover, the time and raw materials expended for these projects can never be replaced. Furthermore, failed projects are an unnecessary disruption in the lives of people who are already struggling to meet their basic needs every day. To avoid destructive consequences the sustainability of development initiatives requires additional attention (Tango International, 2009).

In order to address the problem of sustainability, establishing a "sense of ownership" is one of the most pervasive ideas. Steets, Witte, Heid and Shupe (2006) define ownership as "the capacity, power or influence of stakeholders in development to set and take responsibility for a development agenda and sustain support for it" (p. 58).

The general idea is that ownership can make development programs more sustainable because there is "support, involvement or commitment of interested or affected parties" (Lachapelle, 2008, p. 52). According to Arkes and Blumer, (1985), an investment in money, effort or time can increase the likelihood that people will follow through in what is known as the "sunk cost effect". Evidence has also shown that people tend to place a higher value on things that they own and this "endowment effect" can be instantaneous (Kahneman, Knetsch & Thaler, 1990). However, economic theory does not predict these effects and even they have been observed in some instances, it is unclear how prevalent these effects might be in different situations and across cultural settings (Hoffman and Spitzer, 1993). Nonetheless, organizations continue to emphasize ownership-focused approaches to promote sustainability including cost-sharing, labor-sharing and localized management and decision-making processes. Community participation in general can lead to better development project outcomes but understanding which forms of participation are more effective is an ongoing task (e.g., Isham, Narayan & Pritchett, 1995; Steets et al., 2006). Other widespread strategies that aim to promote sustainable program outcomes are training, education, and monitoring. Table 1 shows the common strategies to promote sustainability by program phase.

Table 1 - NGO strategies to promote sustainability for development initiatives

NGO Strategy		**Before/During Implementation**	**After Implementation**
Ownership-Focused	Cost-Sharing	Cash contributions, in-kind contributions	Paying system fees, buying consumables
	Labor-Sharing	Building the system	Maintaining/repairing the system
	Management & Decision-Making	Managing project	Continuing management
Training & Education		Initial training and education	Retraining and reeducation
Monitoring		Baseline monitoring & evaluation	Follow-up monitoring & evaluation

2.2 Ownership-Focused Strategies

2.2.1 Cost-Sharing

NGOs often require cost-sharing as an implementation strategy to increase sustainability by promoting local ownership, though the effectiveness of this policy is highly contested. Cost-sharing may consist of a cash payment to an NGO, a cash payment into a local community account or the provision of items or materials such as construction supplies. While cost-sharing is a popular strategy, studies have yet to find evidence to support the idea that cost-sharing increases program sustainability (e.g., Cohen & Dupas, 2010; Kremer & Miguel, 2007; Nabyonga et al., 2005). For example, Kremer and Miguel find that cost-sharing negatively influences deworming treatment in Kenya due to lower participation rates. Based on a randomized evaluation, they argue that claims of project sustainability related to local cost-sharing are simply an illusion. Similarly, Cohen and Dupas conclude that requiring cost-sharing for mosquito nets does not increase long-term usage regardless of the amount paid for the nets. Meanwhile, cost-sharing reduces demand and results in fewer people benefiting from mosquito nets overall. Nabyonga et al. also show that cost-sharing decreases program access in their evaluation of healthcare services in Uganda. Their study indicates that cost-sharing not only lowers participation, but it disproportionately excludes the most vulnerable people that have the greatest need for healthcare. In spite of the evidence from these studies many organizations continue to use cost-sharing strategies, claiming that in practice it does promote more sustainable outcomes (e.g., Engineers Without Borders, Water for People).

2.2.2 Labor-Sharing

Labor-sharing is a distinct form of participation, particularly when seasonal incomes are the norm and the time-value of money is not necessarily applicable. This strategy requires program participants to help with construction processes (e.g., digging out the foundation area for a new building) as well as system maintenance and repair. Norton, Mochon and Ariely (2011) provide evidence of what they call the “IKEA effect”, which is the tendency for people to assign a greater value to things that they have built

themselves. This effect even applies to items that do not permit customization (e.g., simple IKEA boxes, Lego sets). The hands-on experience aspect of labor-sharing may also increase the capacity of participants to perform maintenance and repairs. Studies have found that labor-sharing can increase program sustainability but there is a risk of exacerbating inequalities if poorer community members are forced to contribute more labor than their wealthier counterparts (Mansuri & Rao, 2012). Also, if a program relies on labor from an individual for a community-based system without compensation, that individual might be reluctant to prioritize these tasks and over time the system may fall into disrepair. Overall, there is less evidence related to labor-sharing in comparison to cost-sharing, but labor-sharing is also a contested strategy with potential benefits and drawbacks.

2.2.3 Management & Decision-Making

NGOs also use strategies that involve transferring management and decision-making processes to local people or institutions. For example, a local community may be given the authority to set their own development priorities while the NGO acts more like a technical consultant and/or grant-funding source. NGOs may alter the decision-making culture by asking questions, providing information, encouraging alternative forms of knowledge and participation and allowing opportunities for greater interaction throughout the planning, implementation and monitoring processes (Lacapelle, 2008). However, it is still the NGO that decides how much authority is transferred and to whom. One risk is that the benefits of poverty reduction initiatives can be reduced if local elites have a disproportionate amount of control (Mansuri & Rao, 2012). Also, in the case of large infrastructure projects (e.g., bridges, dams), it may be logistically difficult to transfer substantial management and decision-making authority. Mansuri and Rao find that NGO-induced participation in management responsibilities does improve program quality and sustainability for resource management and infrastructure initiatives, as long as the project does not involve novel or overly complex technology. Involvement in highly technical project decisions can be detrimental to infrastructure quality. Overall this strategy has potential benefits and drawbacks. It is less contested than cost-sharing and labor-sharing although literature to verify its effectiveness is limited.

2.3 Training & Education

Training and education can be distinguished from the ownership-focused strategies because this strategy tends focus more on increasing people's capacity. A lack of local capacity, or relevant knowledge and skills, is recognized as one of the biggest limitations to project sustainability for development initiatives (Mansuri & Rao, 2012). Most NGOs address this need by providing technical training and relevant education as an integral part of every program. For example, if a program involves installing water treatment technology, the NGO can provide hygiene and sanitation education along with technical training about how to properly use and maintain the device or system. Emphasizing the importance of training and education, Newman et al. (2002) provide evidence that shows the quality of water provided by new water projects does not improve until after users have been trained in system operation and maintenance. It is also important to revisit participants to provide retraining and reeducation over time. Overall, the development community seems to be in agreement that incorporating training and education into programs is a critical factor for sustainable outcomes (Isham et al., 1995). While this strategy is widely recognized as important it has not been as rigorously evaluated as ownership-focused approaches, particularly cost-sharing.

2.4 Monitoring

Monitoring is also a strategy that NGOs use to promote program sustainability. Before and during implementation monitoring can be used to guide the direction of a program. After implementation monitoring can be used as a way to understand and promote program sustainability. According to Levitt and List (2009) development program monitoring has been associated with the "Hawthorne effect", when the act of being observed makes people behave differently. However, understanding the influence of monitoring is not straightforward. Monitoring can vary from a brief visit to an in-depth evaluation involving technical assessments, surveys and interviews. Assistance with maintenance and repairs may also occur during monitoring visits. In terms of the timeline for monitoring, Breslin (2010) makes a strong argument for ongoing monitoring as long as 10 years after implementation in order to ensure program sustainability. He contends

that this follow-up is critical for accountability between NGOs, beneficiaries and donors. However, with resource constraints, new systems to implement, and donors who are more enthusiastic about paying for implementations, long-term monitoring as recommended by Breslin is uncommon. While monitoring is widely recognized as important, it is a neglected strategy that receives little attention as a way to promote sustainability.

2.5 Summary

The problem of sustainability is a common affliction for development programs. While many scholars and practitioners focus on the role of foreign aid and macro-level interventions, a new micro-level development paradigm is emerging. This new approach aims to illuminate which policies and program features are more effective at reducing specific aspects of poverty, from improving healthcare systems to increasing access to quality education. A micro-level approach can therefore be used to better understand what NGO strategies can effectively combat the problem of sustainability. While cost-sharing is an extremely popular strategy, neither economic theory or empirical evidence suggest that it is an effective strategy for promoting sustainability. Meanwhile, strategies such as labor-sharing and localized management and decision-making have been shown to promote more sustainable outcomes. However, all of these ownership-focused approaches have potential drawbacks, such as lower program participation and exacerbated inequalities between local elites and poorer community members. NGO strategies of training and education as well as monitoring are also very popular. Although evidence shows that these strategies can promote more sustainable outcomes, they are relatively neglected in comparison to the ownership-focused approaches, namely cost-sharing.

3.0 Focusing on Water

When it comes to focusing on specific development initiatives, water projects are very popular. Water is a basic human need, yet at least one out of every nine people in the world does not have access to safe water (WHO & UNICEF, 2013). Water is a common priority for many people living in poverty and a significant correlation has been demonstrated between access to safe water and development (e.g., Shafik, 1994; Sullivan, 2002). In high-income countries people enjoy safe water piped directly into their homes at a relatively low cost. At the same time people in low-income countries often spend a significant portion of their time and money obtaining water that may still not be safe to drink. Diarrhea is usually the consequence of consuming unsafe water and young children are disproportionately affected. Ranked among the top ten causes of death, third in low-income countries and seventh worldwide, diarrhea leads to approximately 1.5 million deaths each year (WHO, 2014). Moreover, the burden of living with diarrheal diseases and time spent collecting water detract from educational opportunities and overall productivity. While remarkable progress has been made toward the relevant Millennium Development Goal to halve the population without access to safe water by 2015, achieving *universal* access to safe water is an ongoing global challenge (United Nations, 2014).

Cost-effective technologies for conveying and treating water are abundant and diverse, but social, economic and political factors often prevent the implementation of effective and sustainable water systems. Even as more people gain access to safe water with assistance from governments, NGOs, and other programs, overall progress is inhibited when existing water systems fail to continue functioning. The importance of sustainability for water systems is acknowledged in the wording of the Millennium Development Goals, as well as many other organizational mission statements. However, aspects of water system sustainability are not actually measured by standard global metrics (United Nations, 2014). Global measurements are based on *improved* water sources at one point in time, not *safe, sustainable* water sources. Examples of 'improved' water sources are piped water, tubewells or boreholes, protected wells or springs, and

rainwater. Examples of 'unimproved' sources are unprotected springs or wells, surface water, and tanker truck or bottled water (WHO & UNICEF, 2014). Improved sources are preferable to unimproved sources because the risk of contamination is lower, but it is still possible for water from improved sources to be unsafe due to the presence of pathogens and other contaminants. For this reason, water treatment systems that improve water after it has been collected from the source are an important component of water access even though water treatment systems are excluded from global metrics and evaluations

In low-income countries, particularly in the rural areas, infrastructure is often inadequate. From water systems to roads to electricity, people struggle to accomplish their daily tasks. When it comes to the improvement of infrastructure in this context, especially water and electrical systems, municipal systems are not always feasible due to spatial and institutional limitations. In rural areas households are typically spread out over great distances, making centralized systems without a complex distribution system impractical. Complex distribution systems typically require substantial oversight and maintenance that local institutions are not prepared to manage. In this situation NGOs often implement household-scale technologies, which are the focus of this essay. Many studies have compared the most common household-scale technologies (e.g., chlorination, solar disinfection, filtration) to identify advantages and disadvantages. However, these studies admittedly evaluate over a limited time span and subsequently call for additional assessment of the factors that influence long-term sustainability (Carter, Tyrrel & Howsam, 1999; Lantagne, Quick & Mintz, 2006; Liang et al., 2008).

There is some evidence that ownership-focused strategies can improve water system sustainability (Kleemeier, 2000) but evaluations have focused primarily on centralized systems managed at the community level. For instance, Marks and Davis (2012) and Marks, Onda and Davis (2013) find that labor-sharing and cost-sharing can increase the sustainability of rural community water systems but only if the contributions are equivalent to at least one month of income. Additionally, transfer of management and decision-making authority from NGOs to local participants can promote the sustainability of community-scale water systems through increased user satisfaction with the design of

the water service (Isham et al., 1995; Isham & Kähkönen, 2002; Newman, Pradhan, Rawlings, Ridder, Coa & Evia, 2002; Sara & Katz, 1997). Meanwhile, household-scale systems are also popular with implementing NGOs, but since these household systems do not necessarily rely on collective action, the influence of ownership-focused strategies on sustainability remains unclear in these situations. While cost-sharing and labor-sharing improve sustainability for community water systems in some cases, the contribution must be large. Typical contributions for household-scale systems are equivalent to only a few dollars, meaning the scenario for decentralized water treatment systems is quite different.

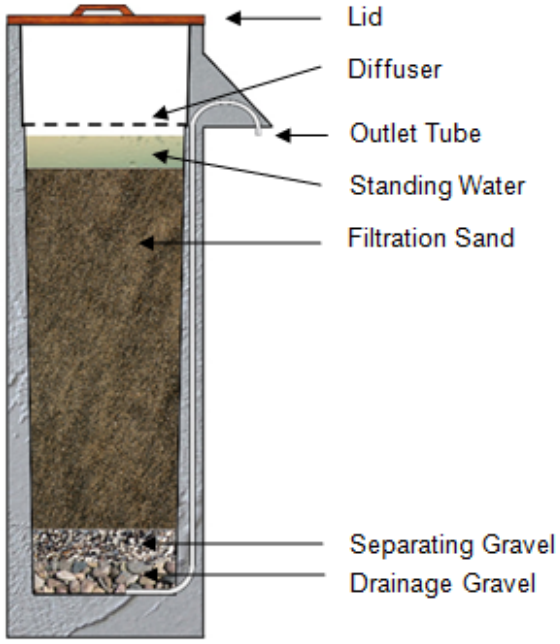

Figure 1 - Cross-sectional diagram of a household-scale BSF (CAWST, 2014)

Biosand filters (BSFs) are one robust water treatment technology that is considered appropriate for many households without access to safe water. The household-scale BSF was developed in the 1990s as a much smaller version of the traditional slow-sand filter that is widely used in municipal water treatment systems around the world. It is estimated that over 430,000 BSFs have been implemented in at least 63 countries around the world (CAWST, 2014). As shown in Figure 1, the standard BSF design is simple, using basic materials including concrete, gravel, sand and a copper pipe. The other major components of a BSF are a diffuser plate that prevents damage to the layer of

microorganisms when water is poured in and a lid that keeps excess debris out of the filter. With regular use, microorganisms grow naturally in the top layer of sand and consume pathogens from the incoming water. The sand and gravel also provide physical mechanisms for water contaminant removal. To use a BSF, water taken from a contaminated source such as a pond or well is poured into the top of the filter. Treatment occurs as the water flows downward and by the time the water reaches the end of the outlet pipe it is considered safe to drink (CAWST, 2014). Maintenance is also straightforward; the flow rate of the BSF naturally decreases over time and once the flow rate becomes unacceptably low the BSF should be cleaned. This cleaning is done by hand and it involves manually swirling the sand and scooping the dirty water from the top of the filter. The frequency of this maintenance procedure varies according to the water source used, from once every few weeks to less than once per year (CAWST, 2014).

BSFs are the only known effective water treatment technology used in a development context that does not have inherent recurring expenses. After initial installation BSFs have no additional costs unless a component is lost or broken. Furthermore, BSFs are easy to use and maintain and have a long lifespan, which is suspected to equal the reliability of the concrete shell (20 years or more). Additionally, the treatment effectiveness and health impacts of BSFs have been thoroughly demonstrated (Sobsey et al., 2008). Yet even with all of the research that has been done on BSFs, the amount of information available on sustainability is minimal. Only three studies have evaluated the continued use of BSFs older than five years and only a portion of the BSFs evaluated are more than five years old. These studies also focus more on the technical functionality of the BSF, training and education and health impacts (CAWST, 2014) and less on institutional and socioeconomic factors. Aside from evidence demonstrating the importance of technical training and hygiene education, it remains unclear how other NGO strategies such as cost-sharing and labor-sharing might influence the sustainability of BSFs. Given the outstanding need for access to water around the world and the ongoing NGO-based efforts to alleviate the problem, it is crucial to understand how NGO strategies influence the sustainability of project outcomes.

4.0 Methodology

To evaluate how NGO strategies influence the sustainability of household-scale water systems, this essay presents a case study of two NGO programs. Both of the NGOs selected have been installing household-scale BSFs for more than six years using different cost-sharing and labor-sharing implementation strategies. Drawing from nine months of field research in Cambodia, the programmatic details for both NGOs are provided along with the rates of continued use of the oldest BSFs implemented six to eight years prior to this study. By comparing the NGOs using a mixed methods approach, it is possible to address the following research question: "How do ownership-focused NGO strategies of cost-sharing and labor-sharing influence the sustainability of household water filters?" The researcher worked as a volunteer technical advisor for both of the NGOs to evaluate the long-term use of BSFs by rural Cambodian households. While initial reports from the NGOs suggest that one NGO requires cost-sharing and the other NGO requires labor-sharing, both NGOs have adopted cost-sharing policies but one NGO additionally requires labor-sharing. Given the situation of this natural experiment it is still possible to consider the continued use of BSFs with cost-sharing and the influence of adding labor-sharing while controlling for other factors.

In this analysis household-level interview and survey data is collected from BSF users and presented alongside interview data from NGO management personnel. Logistic regression models are used to quantitatively evaluate which independent factors are significantly related to a dichotomous dependent variable of BSF continued use. Common barriers to continued BSF use are illuminated by the qualitative data gathered during the household surveys. Likewise qualitative data gathered from interviews with NGO management personnel is necessary to understand the differences in and motivations behind the use of various NGO strategies. Qualitative data also helps illuminate the influences that NGO management personnel perceive in relation to their strategic decisions. Together, these methods provide an explanation of the overall differences that are observed to better inform the resulting policy recommendations.

4.1 Research Setting

Cambodia is an ideal setting to address the issue of project sustainability because of the outstanding need for access to safe water, considerable international involvement in water system development and the installation of a large number of BSFs (CAWST, 2014; Royal Government of Cambodia, 2006). The two NGOs considered in this study are based in Siem Reap Town and work primarily with rural communities in the surrounding districts. According to the World Bank (2012), 80 percent of all Cambodians live in rural areas with limited infrastructure. Despite this reality, through a combination of economic development, government initiatives and NGO involvement, Cambodia has nearly achieved the drinking water portion of the relevant Millennium Development Goal target. Between 1990 and 2010 the number of people with access to an improved water source has increased from 31% to 64%. However, these improvements have occurred predominantly in urban areas, with a discrepancy of 87% access in urban areas versus 58% access in rural areas. The lack of access to safe water in rural Cambodia is an ongoing challenge that many NGOs and government programs are working to address.

With relatively widespread access to sufficient water quantity, the dominant water issue facing most rural populations in Cambodia is poor water quality. Shallow hand dug wells are a common way for people to access water in rural areas, although many households have an improved system such as a deep well with a hand pump. Unfortunately, both improved and unimproved wells in Cambodia often suffer from one or both of the following problems: (1) the well produces water with high mineral content (e.g., iron, manganese) that makes it unpalatable and (2) the well produces unsafe water due to high pathogen content (e.g., bacteria, viruses) because it does not have sufficient well-head protection (RDIC, 2014). For these reasons water treatment systems using biosand and ceramic filtration technology have become popular methods for improving water quality because both issues can be alleviated at a fairly low cost. In terms of BSF technology, Cambodia has the highest reported number of this type of filter in the world with approximately 58,000 BSFs that account for more than 13% of this filter design globally (CAWST, 2014).

4.2 Data Collection & Analysis

The two NGOs participating in this research study have collectively installed about 13,500 BSFs to provide clean water to nearly 100,000 people. Combined, this quantity of BSFs provides more than 10% of Siem Reap Province with access to safe water and accounts for 25% of all BSFs implemented in Cambodia. Both NGOs implement the same BSF design in comparable communities, with some participants living within the same districts and communes. This essay draws from data collected during the following two census surveys of all households associated with the oldest BSFs installed by each NGO: (1) NGO A's 2013 survey of 154 households, 84 of which have BSFs and (2) NGO B's 2013 evaluation of the organization's 400 oldest BSFs, 373 of which could be located. Meetings with program participants were held at their homes and the household member(s) most familiar with the BSF was asked to respond to a set of questions. All participants responded in Khmer (Cambodian language) and most participants were non-literate. For these reasons, local Cambodian staff members from each NGO verbally conducted the informed consent, survey and interview procedures with researcher oversight.

The evaluation of BSF sustainability uses a dichotomous dependent variable that is based on the continued use of BSFs implemented by each NGO. If a BSF is still in-use according to the user and confirmed by a visual verification by the surveyor, the value for this variable is given a value of one. If the BSF is no longer in use, then the value assigned is zero. The main independent variable is also a dichotomous variable used to indicate the NGO, with NGO A used as the reference group. For this analysis, important control variables are presented alongside supporting qualitative evidence to rule out as many competing explanations as possible for the difference in BSF continued between the NGOs. For one control variable, the number of times that a NGO staff member has visited each BSF to conduct monitoring is recorded. Also, the household location by village, commune, and district is noted and a set of variables to control for socioeconomic conditions and the physical condition of the BSF are documented. Table 2 provides the details of these socioeconomic condition and BSF physical condition variables.

Table 2 - Socioeconomic and BSF physical condition variables

Category	Variable	Range of Values
Socioeconomic Conditions	Water Source	(0) Does not have an improved water source[a] (1) Has an improved water source[a]
	Latrine	(0) Does not have a latrine (1) Has a latrine
	Housing Materials	(0) Bamboo, Thatch, Palm (1) Wood, Boards, Iron Sheet (2) Cement, Concrete, Bricks
	Livestock	(0) No pigs or cows/buffalo (1) 1-3 pigs and/or 1-2 cows/buffalo (2) More than 3 pigs and/or 2 cows/buffalo
	Transportation Devices	(0) Less than $500 value (1) $500 to $1000 value (2) More than $1000 value
BSF Physical Condition	Flow Rate	(0) Stopped (0 mL/min) (1) Very Low (<150 mL/min) (2) Low (150-399 mL/min) (3) Within Standard (400-600 mL/min) (4) High (601-900 mL/min) (5) Very High (>900 mL/min)
	Sand Level	(0) Missing a lot of Sand (>10 cm) (1) Missing Some Sand (7-10 cm) (2) Within Standard (4-6 cm) (3) Too Much Sand (<4 cm)
	Concrete Shell	(0) Severe Cracks (1) No Cracks or Minor Cracks
	Lid	(0) Lid is missing (1) Lid is present
	Diffuser Plate	(0) Diffuser plate is broken or missing (1) Diffuser plate is in good condition

[a] According to the WHO & UNICEF (2014) Joint Monitoring Programme (JMP) definitions for water access, which does not include the use of post-treatment devices (e.g., water filters)

For these control variables, participant responses and observable data come from the household area and the BSF. Socioeconomic data is gathered using a subset of indicators from Cambodia's Identification of Poor Households questionnaire for the following asset categories: (1) water source, (2) latrine, (3) housing materials, (4) livestock and (5) transportation devices (Cambodia Ministry of Planning, 2013). Socioeconomic conditions are evaluated using assets because rural Cambodian

households rely mostly on informal markets; cash flows that are present tend to be seasonal and unpredictable. Information is also collected regarding the physical condition of each BSF. However, deficiencies in the condition do not render a BSF unsustainable if it is still effectively producing clean water (according to a random selection of water quality samples). It is important to control for these factors to ascertain how differences in the continued use of BSFs are associated with NGO strategies versus other systematic differences in the participant households or BSFs.

Key NGO management personnel from both organizations were selected for semi-structured interviews regarding their perspectives on biosand water filter program sustainability, impact, and the role of local ownership. The selection of participants for these interviews is based on their role in the management and decision-making processes of the NGOs. All participants provided informed consent prior to the interview, including approval for an audio recording to be taken during the interview. The participants from these interviews include five NGO management personnel, two individuals from NGO A and three individuals from NGO B. From NGO A they are the Executive Director and the Project Director and from NGO B they are the Director, Program Manager, and Monitoring & Evaluation Officer. These NGO management personnel have been selected based on their role in developing and/or managing their NGO's implementation and monitoring strategies. The purpose of the interviews is to capture the perspectives of the NGO leadership and document historical information about the biosand water filter programs.

Data has been recorded and transcribed with assistance from NGO staff members. Quantitative data has been organized, recoded as necessary, and analyzed using a combination of SPSS and STATA statistical software. Cross tabulation analysis and qualitative interview data are used to compare the dependent variable of BSF continued use against each set of control variables by NGO. Then, logistic regression models are used to evaluate the combined effects.

5.0 Findings

In terms of continued use, a significant difference is found for the sustainability of the oldest BSFs implemented by the two NGOs studied. The BSFs evaluated for NGO A have an overall continued usage rate of 69% while NGO B's filters are still used at a significantly higher rate of 84% (Chi-squared=10.842, $p<0.001$). To put these rates in perspective, 69% is a relatively high rate of continued use considering other studies have found rates as low as 10% and 44% (Vanderzwaag, Atwater, Bartlett & Baker, 2009 and Earwaker, 2006, respectively). Meanwhile, 85% is considered to be a very good outcome relative to other studies with BSFs over five years old that have found a maximum rate of 88% (Earwaker, 2006). Either way, the 15 percentage point difference observed in this study means that NGO B has an estimated 1,500 households, or more than 10,000 people, still accessing safe water with their BSFs who might otherwise not be. Conversely, if NGO A could increase the continued use of BSFs implemented by 15 percentage points, it would mean continued access to safe water for approximately 375 additional households, or around 2,600 people. Explaining this difference can provide important policy recommendations for NGOs to consider when implementing household water filters using ownership-focused strategies such as cost-sharing and labor-sharing.

5.1 Cost-Sharing & Labor-Sharing

At the time of installation, from 2005 to 2007, both NGOs had a cost-sharing policy that required a cash contribution from each BSF recipient equivalent to about 5% of the actual cost of the filter, or approximately $3 USD (with overhead, one BSF costs $50-60 USD to produce and install). Only NGO B also had a labor-sharing policy, requiring recipients to help with the BSF construction process in addition to the cost-sharing payment. This scenario allows for evaluation of the base rate of continued use of BSFs with cost-sharing along with any differential effect of labor-sharing by comparing NGO A with NGO B. The management personnel of both NGOs attribute the relatively high rates of BSF continued use to the implementation strategy of cost-sharing. They all share the perspective that cost-sharing promotes a sense of ownership among program participants with respect to their BSFs and this sense of ownership is a key reason why

they continue to use their BSFs. When asked broadly how ownership influences BSF sustainability, the Project Director from NGO A talks specifically about the perceived influence of monetary contributions.

> *"I think there [are] a couple of factors [that make our BSFs sustainable]. I think one of them is [participation in the village-managed payment account] where the villagers have ownership in the filter...I think they take better care of it. They own it...to my knowledge I haven't really had anyone grousing about paying...some of them just don't have very much money, but I think...there's some empowerment there knowing that they've contributed to the social fabric or support mechanism for their village and they're part of that. They're making a contribution, so I think there's a lot of pride in that."*

In this statement participation in the form of cost-sharing appears to be considered synonymous with having ownership, especially because the money is deposited into a locally managed account. The cost-sharing aspect of the program is considered necessary in spite of the fact that most program participants do not have a lot of money. While ability to pay is not the only factor consider, if those who want a filter cannot afford one the program is likely to disproportionately exclude poorer households.

Meanwhile, the Executive Director of NGO A leader speaks more broadly about participation, stating that any effort on the part of the BSF program participants, either paying money or doing something else, can promote ownership and therefore increase continued use of the filters. In responding to the same question about ownership and sustainability, the Executive Director of NGO A argues,

> *"You've got to have the buy-in; I think people have to be vested in it. If they're just given stuff, I don't think they take as much care...if they've got to put some effort into it, whether it's monetarily or just participatory, they've got to have that ownership. I think that's key and central to sustainability...I think once they have the buy-in and then they're using it properly, and it's just obvious, the impacts of no more diarrhea...I think they'll use it and use it properly and for [the] long-term and one thing kind of begets the next because once they have the clean water, they feel better and their whole lives begin to improve and so they keep using it because they see [and] they are physically experiencing the benefits of it."*

In the development community cost-sharing strategies are pervasive due to the perception that without it projects fail. This concern is alluded to in the comment, "*If they're just given stuff, I don't think they take as much care."* This sentiment is so pervasive that this all three interviewees from NGO B also emphasize the suspected link between cost-sharing, feelings of ownership and program sustainability. They articulate a shared concern that people do not continue to use their BSFs if they do not contribute some money. The NGO B Program Manager expresses this concern in the following statement:

> *"You find that if people receive something for free, they don't have a sense of ownership. They don't feel the need to value this particular thing. So, the fact that the biosand filters are not given for free to the people, somebody pays for the biosand filter but somehow the villagers make a certain contribution...once they spend money like this on something for them, that's their thing, they own it, they have bought it and that creates a sense of valuing this particular product because [they] have paid for it...when people feel [they] own something then they have a tendency to take care of it and they will maintain it."*

The Monitoring & Evaluation Officer from NGO B echoes this concern and also explains that people will always take a BSF if it is free, perhaps even if they do not really want one.

> *"If there is no ownership...they just take from us without paying...we don't know if they will be using [the BSF] or not. If everything is free, most people will take all together but [maybe] they won't use [it] because they do not own [it]..."*

Perhaps cost-sharing functions as a selection mechanism so that only households that really need or want as BSF receive one. Without cost-sharing the NGO management personnel have little confidence that BSFs will continue to be used. The selection process is conceived as part of the sense of ownership that the cost-sharing strategy aims to promote. The NGO B Director elaborates on this point by stating,

> *"...because we are selling the filters we avoid people requesting the filters without deciding to get a filter, without understanding the benefit of having a filter. So we avoid the risk of people getting filters and not feeling any ownership."*

The Director's statement argues that when people are required to contribute money, they engage in a distinct decision process that is markedly different from a more simple decision to accept a free BSF. This argument suggests that participants who pay money are more motivated to understand the benefits of a BSF before acquiring one, hence making continued use more likely. However, it is not clear that people receiving a free BSF could not also understand the benefits and want to use a BSF to the same extent as those who contribute money.

Cost-sharing as an implementation strategy has clearly been embraced by these NGO managers as a way to promote ownership and sustainable outcomes, but currently there is mainly rhetoric rather than evidence to support the use of this strategy for this purpose. In this study, since the cost-sharing policies are comparable for the BSFs evaluated for both NGOs, the 15 percentage point difference observed is a significant finding that suggests there are other factors that must be instrumental in the continued use of BSFs. The main difference in implementation strategies between NGO A and NGO B is the additional participation required by NGO B in the form of labor-sharing. The labor-sharing is also thought to promote BSF continued use by increasing the sense of ownership among the program participants. As the Director of NGO B contends,

> *"Maybe because they build their own filters they have a stronger feeling of ownership, but [there is also the long-life and] the impact. Ownership is a part but also the long lifespan of the filter and if the filters are damaged because they were not properly built then you lose the benefit of the strong ownership feeling...if in order to strengthen the ownership you decrease the lifespan of the filter, then you lose."*

It is possible that labor-sharing has an influence with respect to the continued use of BSFs according to the IKEA effect (Norton et al., 2012) and the fact that participants gain hands-on experience with their BSFs when they help with the construction. The NGO B Director suggests that increased ownership and familiarity with the filters can be achieved through the hands-on experience that labor-sharing provides, although this benefit might be offset by compromised construction quality. Also, according to the Monitoring & Evaluation Officer, program participants are frequently too busy with other tasks (e.g., working in their rice fields) to participate in labor-sharing activities. While the

BSFs from NGO B evaluated in this study had all been implemented with labor-sharing, NGO B to discontinued its labor-sharing strategy after the first year of the program. Beginning in 2008 the implementation strategy changed to cash-only contributions of $7 USD per BSF (approximately 12.5% of production and installation costs). In summary, while this research suggests that labor-sharing can promote continued use of BSFs, it can be a difficult strategy to employ.

Aside from cost-sharing and labor-sharing many other factors could be influencing the observed difference in BSF continued use between NGO A and NGO B. The potential sources of variation, aside from the difference in implementation strategies, could also be influencing the continued use of BSFs. First, there could be differences in the socioeconomic conditions of the households that the NGOs partner with to install BSFs. Perhaps the households that NGO A works with are poorer and therefore have a harder time maintaining the BSFs. Second, there could be other physical or practical differences related to the design, construction, and implementation of the BSFs, aside from the difference in labor-sharing. For example, there could be a critical difference in the materials used for construction that has led to the difference in sustainability. Third, there could be differences between the NGOs in terms of monitoring practices. It is possible that one NGO conducts monitoring differently. These three potential sources of variation must be addressed to assess the influence of NGO B's labor-sharing strategy on the continued use of BSFs.

5.2 Household Socioeconomic Conditions

Socioeconomic discrepancies, such as differences in housing conditions and systematic differences in other water, sanitation, and hygiene (WASH) factors might influence continued use of the filters. All of the oldest BSFs implemented by each NGO are located in similar communities within Siem Reap Province. For NGO A all of these filters are in Puok District and for NGO B these filters are in Puok, Prasat Bakong, and Banteay Srey Districts. These are all rural districts with similar socioeconomic characteristics that directly border the more urban Siem Reap District. Table 3 shows measurements of central tendency by NGO for the five factors of socioeconomic

conditions measured. Relatively speaking, households associated with NGO A have more latrines and slightly better housing materials but less valuable livestock, less valuable transportation devices and fewer improved water sources (according to WHO & UNICEF JMP definitions). While these small differences exist between the households associated with the different NGOs, it does not appear that these factors alone can account for such a large difference in the continued use of BSFs. Neither NGO works with households with consistently lower or higher socioeconomic conditions.

Table 3 - Household socioeconomic conditions by NGO partner

Socioeconomic Variables	Statistic	NGO A (N=84)	NGO B (N=373)	Chi-Squared
Water Source	Mean	0.55	0.60	0.88
	Median	1.00	1.00	
	St. Dev.	*0.50*	*0.49*	
Latrine	Mean	0.75	0.48	20.47***
	Median	1.00	0.00	
	St. Dev.	*0.44*	*0.50*	
Housing Materials	Mean	1.10	1.03	57.27***
	Median	1.00	1.00	
	St. Dev.	*0.30*	*0.74*	
Livestock	Mean	0.69	0.80	19.42***
	Median	1.00	1.00	
	St. Dev.	*0.58*	*0.79*	
Transport Devices	Mean	0.71	0.86	18.98***
	Median	0.00	1.00	
	St. Dev.	*0.87*	*0.75*	

Significance Indicators: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

5.3 Other Factors of Design, Construction & Implementation

The difference in continued use of BSFs does not appear to be related to other factors of design, construction, and implementation. Both NGOs use the procedures and materials recommended by the Center for Affordable Water & Sanitation Technology (CAWST) to the extent possible. Observations of BSF construction, installation, and end user training confirm minimal procedural differences between NGO A and NGO B. The physical design of the BSFs is the same from how the concrete shells are formed using standardized steel molds to the construction of the diffuser plates and lids. One exception is the source of sand used, with NGO A using river sand because it is less expensive and

NGO B sticking to a more costly CAWST-recommended sand made from crushed rock. However, both NGOs have conducted water testing demonstrating the effectiveness of BSFs with both sand types and there is no indication that the sand type influences sustainability. Another difference noted is the scale of BSF production. NGO B produces between five to 10 times more BSFs than NGO A in any given week. It is possible that this difference in scale could influence the quality of BSF construction in positively or negatively, but it is unlikely according to the data on common BSF failure mechanisms. BSFs from both NGOs have comparable failures in terms of low sand levels, broken concrete shells, broken diffuser plates and stopped flow rates. Furthermore, WASH training, including how to use and maintain the filter and hygiene education about general sanitation and hand washing, are integral parts of the BSF program and based on CAWST's model for both NGOs. Overall, other factors of design, construction, and implementation are remarkably similar and nothing indicates that the minor differences observed relate to the 15 percentage point difference in BSF continued use.

5.4 Monitoring

Finally, a difference in monitoring practices helps to explain much of the difference in BSF sustainability. Since recommended methods for monitoring are also provided by CAWST, the differences between the NGOs in terms of monitoring for the old BSFs studied is unexpected. While the substance of the monitoring visits is comparable between the NGOs there are notable differences between the NGOs in the timing and frequency of these monitoring visits. Following CAWST protocol, monitoring visits conducted by both NGOs include checking the functionality of the BSF, noting issues and providing retraining if necessary, taking water samples to be tested for a random subset of the filters, recording basic information about the household and addressing questions and concerns raised by the BSF users. Retraining and maintenance are fairly common during the monitoring visits conducted by both NGOs. In terms of timing and frequency, the oldest BSFs installed by NGO A are all reported as being monitored once, approximately two to three years after installation. Meanwhile, NGO B's monitoring practices are more complex, with a maintenance follow-up for all BSFs about

one month after installation, a monitoring survey and water sample evaluation for a 30% random sample of BSFs approximately six months after installation, and other random visits as needed for targeted evaluations. Due to this threefold approach, households with BSFs installed by NGO B report varying frequencies of monitoring visits, ranging from zero to "four or more".

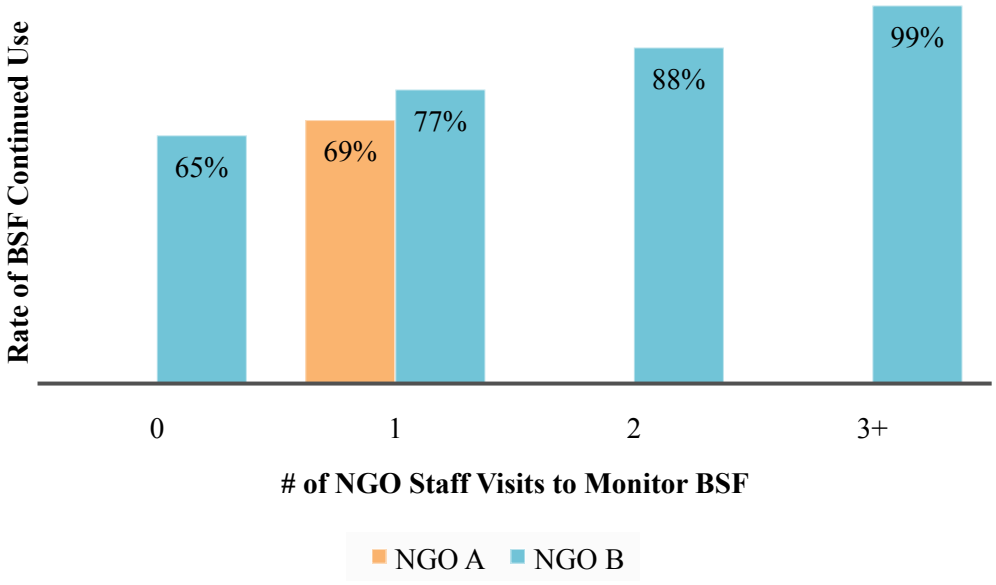

Figure 2 - BSF Continued Use by NGO and Monitoring Frequency

Overall, the differences in monitoring that exist between these NGOs helps explain the differences in BSF continued use. For the most part, the NGOs emulate the program design and follow the implementation recommendations provided by CAWST. However, each NGO has developed a distinct strategy with respect to the frequency of monitoring visits. Shown in Figure 2, the number of reported NGO staff visits is significantly correlated with BSF continued use for NGO B ($r=0.243$, $p<0.001$), with each visit increasing the rate by around 11 percentage points. The average monitoring frequency of NGO A is one visit while the average monitoring frequency of NGO B is approximately two and this difference is significant (Chi-squared=102.47, $p<0.001$). By the third visit, continued use reaches 99% for a more than 50% increase in comparison to zero visits. This data suggests that a large portion of the disparity in continued use of BSFs between the two NGOs is related to the difference in monitoring frequency. NGO

B tends to revisit previously installed filters more often, with more than half of the filters having been visited at least two times. Note that for BSFs with one monitoring visit the rate of 77% continued use for NGO B filters is higher than 69% for NGO A filters, but this difference is not significantly significant.

The interviews with the NGO management personnel elucidate their perceptions on how monitoring visits support BSF sustainability. The Program Manager of NGO B describes the importance of the monitoring visits for the continued use of BSFs,

> *"Through quality control we are able to help people with blocked [BSFs] and observe whether there are any broken parts of the [BSF] which need to be fixed [and] whether the levels of sand are as they are supposed to be. So, I think it's very important for us to actually monitor...to make sure that the [BSF] is working very well."*

NBO B's Monitoring & Evaluation Officer expands on this point by describing the type of feedback obtained during monitoring visits and how this information can be used to improve the program,

> *"For me the main factor is...we can find the main problem from the villager and we can collect more information combined with the good information and bad information from the villager. Like, some villagers, they [talk] about [problems] like, "no people came to check my filter," or "my filter cannot remove iron," or, "the filter water smells bad, I don't like the taste..." So like that, we can take all [of the] information...and discuss [to] find solutions about that. So this is how we find the bad information and we can change...our project."*

It is clear that the monitoring visits are a valuable opportunity for the NGO staff visiting the BSF to address issues and make repairs. Common issues can be identified and the NGO can use these reports to improve future work related to the program. Beyond using monitoring as an opportunity to help with BSF maintenance and repairs, the Program Manager of NGO B also contends that regular monitoring visits encourage people to continue using the BSFs,

> *"I think [maintaining] close contact with the communities is actually what is helping the program to become successful and I think it would be great if we could do it [more]. But this component of quality control which I have talked about, the person who's doing it, he's going back not just to the new filters but also he comes across old filters and then people realize that this is something that people are into...it's working and people who installed it are still coming back to make sure that we are still using it. So I think that's what makes [our program] sustainable...it's unique in a way because you come across many NGOs [that] are doing things but at the same time they don't go back to see...whether people are still continuing [the program], but [our NGO] has a way of going back to these communities and making sure that the [BSFs] are still working."*

Meanwhile, the directors from NGO A, which monitors less frequently, also describe the importance of monitoring, however they perceive that there is less funding support for monitoring activities. In their experience, donors are more apt to contribute funds for the implementation of a program than they are for the monitoring aspect. NGO A relies heavily on personal donations and contributions from individuals, although they also received foundation and grant funding on a regular basis. NGO A's Project Director talks about struggling to find funds to support monitoring activities,

> "*We do the best we can with our [Monitoring & Evaluation] program... return follow-ups are critical...one of the problems is we try to build [Monitoring & Evaluation] cost into the filter but it's always not enough. It's easy to sell bricks and mortar, it's easy to sell a water filter, but trying to [get] capacity building money, the [Monitoring & Evaluation] money, to get people to donate just for filling out a survey form, is really difficult. We do get general funds that we can use, but I'd say a good 80% of our money we get is designated funding. They want a pump well or they want a water filter, and the rest of the money goes for just logistical support, things like that. So that's been a problem for years and I think it's probably one of the components that help determine the sustainability of the project. There's just never enough money available for that, but there's more and more awareness of it I've seen [recently and] I've been doing this 10 years."*

The Project Director of NGO A also notes that the emphasis on Monitoring & Evaluation has improved over the last 10 years but the amount of funding currently available is still insufficient,

> *"I think the money available to support the existing programs is too little. If there was a sustainability factor built in, with the Monitoring & Evaluation monies, I wouldn't have [job applicants] come, and they've been working on big huge grants and the grants run out and their salaries are gone but the project's finished. It doesn't continue on, it's just finished...I mean, the worst case scenario is to just implement a project and walk away from it, and I can take you to any number of sites and show you wells in varying degrees of decay, or water filters, or whatever, where there's no follow-up. And one of the reasons I think a lot of our programs work, and we're still undermanned...we can do a lot more, is that we're in the field and we're available."*

NGO A's Project Director clearly recognizes the importance of monitoring on the continued use of BSFs, arguing that more Monitoring & Evaluation designated money could result in more sustainable program outcomes.

In contrast NGO B perceives that there is strong financial support from its donors to conduct monitoring activities as needed. The donor resources for NGO B include foundation funding, grants and personal donations. However, NGO B relies less on personal donations than NGO A does. Perhaps due to this difference, the Program Manager for NGO B explains that there are no major restrictions on monitoring activities,

> *"If our monitoring and evaluation person needs to go out to do whatever activities are planned, I think there are no restrictions to say, "no you can't go...there are not enough resources," and I think it's mainly because we have a very good institutional donor who is willing to cover almost every expense that we take. So, resource distribution...I would say it's fair for all components, both this monitoring and also the implementation of the actual activities of the project. So far I don't see any limitations to any of the two."*

However, the Monitoring & Evaluation Officer for NGO B expresses concern about the fate of implemented BSFs if NGO B discontinues its BSF program at some point in the future,

> *"[If our NGO] must stop everything, we don't know how many people can continue using biosand filters...we spend [a lot of] time per one village or per one household, but after we leave the villager [does] not remember... they cannot fix [the BSF] by themselves, [they] still have many problems."*

In this statement, the Monitoring & Evaluation Officer explains that despite the best efforts of NGO staff to provide appropriate training and education, monitoring is necessary to prevent many BSFs from falling into disrepair. During monitoring visits it is often necessary to remind people about how to use and maintain their BSFs and to address problems that the program participants cannot repair by themselves. In summary, management personnel from both NGOs perceive monitoring as a key factor for BSF sustainability and the results of this study confirm that increasing the frequency of monitoring visits does increase the continued use of BSFs.

5.5 Combined Effects: Logistic Regression Models

To further understand the influence of the various proposed independent effects, Table 4 presents logistic regression models that predict the probability of continued use of BSFs. The first three models show that monitoring frequency and water source variables have the biggest impact on BSF continued use. While NGO B has a higher probability of continued BSF usage overall, this difference is largely related to the higher average monitoring frequency of NGO B. For each additional monitoring visit a household is more than twice as likely to still be using the BSF. Independently, the water source poured into the BSF also has a large and significant effect on BSF continued use. Households with an improved water source are five times as likely to still be using the BSF. Pouring water that is presumably more contaminated into a BSF can make it more challenging for people to keep their BSFs in good working condition. For example, with greater sediment levels in the influent water people need to perform BSF maintenance procedures more often. Therefore, the fourth model incorporates five additional variables related to BSF physical condition (flow rate, sand level, concrete shell, filter lid, diffuser plate), three of which are found to be significantly related to BSF continued use (flow rate, sand level, and filter lid).

Table 4 - Logistic regression models of BSF continued use

Category	Variable	Model 1	Model 2	Model 3	Model 4
NGO Factors	NGO[a]	2.435***	1.571	2.237	0.247*
	Monitoring Frequency		2.451***	2.282***	1.871*
Socioeconomic Conditions	Water Source			5.010***	3.386***
	Latrine			0.531	0.560
	Housing Materials			0.896	0.652
	Livestock			0.897	0.719
	Transport Devices			0.808	0.846
Location	Prasat Bakong District[b]			0.572	2.747
	Banteay Srey District[b]			2.723	7.797
BSF Physical Condition	Flow Rate				3.898***
	Sand Level				0.684*
	Concrete Shell				2.291
	Filter Lid				5.910**
	Diffuser Plate				0.632
	Constant	2.231***	0.910	1.053	0.146
	Pseudo R^2	0.022	0.085	0.187	0.514
	N	457	457	457	457

Notes: [a] NGO A is the reference group; [b]Puok District is the reference group
Significance Indicators: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Unfortunately, all of the BSF physical condition variables are likely endogenous in the regression of the probability of continued use. Data limitations are such that methods to address the endogeneity are unavailable. People are more likely to continue using BSFs in good physical condition, but it is also possible for the physical condition of BSFs to decline if the filter is not being properly used and maintained for other reasons. Keeping in mind the possible overestimation of these factors, the addition of these BSF

physical condition variables influences the effects of the other key variables in the model. Most notably, the effect of the NGO variable reverses to indicate a higher probability of BSF continued use for NGO A. Also, the effect of monitoring frequency and water source is reduced. The results of this final model suggests that the strategies that NGO B uses, both frequent monitoring and labor-sharing, lead to better BSF physical condition over time. First, the relationship between monitoring frequency and BSF physical condition is mutually reinforcing. Monitoring visits can promote both BSF physical condition and continued use, as NGO staff members assist with repairs and provide retraining, and continued use is more likely for BSFs that are in a better physical condition. The importance of ongoing program monitoring is really highlighted by the fact that this variable remains significant even after controlling for factors of BSF physical condition.

Table 5 - BSF physical condition by NGO partner

Variable	NGO A	NGO B	Chi-Squared
Flow Rate	1.19	2.74	153.66***
Sand Level	1.44	1.71	11.64**
Concrete Shell	0.87	0.90	0.32
Filter Lid	0.79	0.79	0.61
Diffuser Plate	0.99	0.98	0.03

Significance Indicators: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

The labor-sharing strategy of NGO B also appears to have significantly contributed to better BSF physical condition and continued use in the long-run. Table 5 shows that BSFs implemented by NGO B are generally in better physical condition compared to those implemented by NGO A, especially in terms of flow rate and sand level. The concrete shell is the exception to this trend, and concrete reliability is one of the major concerns related to labor-sharing, but this difference is not significant. Flow rate is the most influential variable in the model that is significantly different between NGO A and NGO B, indicating that people are more likely to continue using their BSFs if the flow rate is higher. Meanwhile, sand level is negatively correlated with continued use, which probably represents higher usage leading to a loss of sand over time. Overall, it appears that the labor-sharing strategy did increase continued functionality of BSFs. From this study it is not possible to ascertain whether this effect is because labor-sharing

promotes a sense of ownership or because it increases people's capacities to properly use and maintain their filters. However, what is most important is that this NGO strategy does positively influence BSF sustainability.

Overall, considering the combined effects evaluated in this section, monitoring frequency, labor-sharing and water source emerge as the most influential factors for the continued use of BSFs. These factors are all within the scope of NGO program design. NGOs can control the monitoring frequency, the use of labor-sharing during implementation and ensuring installation of improved water sources such as protected wells prior to the implementation of BSFs. The interviews with the NGO management personnel emphasize cost-sharing, labor-sharing, and monitoring for BSF continued use. The influence of cost-sharing remains elusive in this case, but labor-sharing and monitoring are both related to increased BSF continued use. Labor-sharing and monitoring both support the continued functionality of BSFs in terms of the physical condition factors. These are the primary differences between NGO A and NGO B that are driving the 15 percentage point difference in BSF continued use.

6.0 Policy Recommendations

This study demonstrates that for two NGOs using comparable cost-sharing strategies, the additional strategies of labor-sharing and monitoring significantly influence the continued use of BSFs. This study also suggests that BSFs paired with an improved water source are more sustainable. One policy recommendation based on the findings of this study is for development initiatives to put less emphasis on cost-sharing as a way to establish a sense of ownership and therefore promote project sustainability. This unfounded claim distracts from other strategies that have been shown to actually increase program sustainability. There is more evidence to support monitoring and non-monetary forms of participation (i.e., labor-sharing and management and decision-making) for the purpose of improving program sustainability. Meanwhile, cost-sharing evaluations, including this one, have repeatedly failed to find any influence on sustainability. Moreover, some evaluations of cost-sharing have found evidence of pitfalls such as exacerbating inequalities and counterproductively reducing program participation rates, although these aspects are not evaluated in this study. As organizations continue to dedicate resources to and design programs around cost-sharing policies, other strategies that are more likely to promote sustainability are either neglected entirely or given a lower priority. If sustainability is the goal organizations should reprioritize the implementation and monitoring strategies used.

Even though cost-sharing does not appear to influence the sustainability of BSFs, cost-sharing policies seem to be useful for promoting more self-sustaining *organizations*. Notwithstanding the risk of the associated pitfalls, cost-sharing can have positive implications if the money collected is used for other productive purposes. For example, NGO B uses the cost-sharing money collected to install more than 150 additional BSFs each year, providing safe water to more than 1,000 more people annually. Alternatively, NGO A diverts the cost-sharing money into locally managed financial accounts from which community members can take microloans. Evidence shows that this use of the cost-sharing money has benefited the local community. The indirect influence of using cost-sharing allows each NGO to stretch each dollar received a little further. Overall, this

policy makes the NGOs, which must otherwise rely entirely on external grants and donations, more financially sustainable as organizations. Rather than labeling cost-sharing as a strategy to promote ownership, it could be reframed as a strategy for more defensible purposes.

Based on the results of this study, labor-sharing during BSF implementation does positively influence the continued use of BSFs, although it is impossible to decipher the reason for this relationship with any level of certainty. It could also be the case that other unobserved differences between the NGOs contribute to the effect associated with this variable. Assuming these unobservable effects are minimal, labor-sharing could either be promoting the continued use of BSF through increased feelings of ownership akin to the IKEA effect. Or this sense of ownership could be irrelevant and the effect could be related to increased familiarity participants have regarding how to use and maintain the BSF because they have had hands-on construction experience with the filters. Since NGO B stopped using a labor-sharing policy at the end of 2007 and increased the cost-sharing payment required it could be very informative to conduct a similar analysis of BSFs implemented in 2008. This assessment would confirm whether the change in implementation strategy has resulted in a lower rate of BSF continued use, as this essay suggests. Additionally, this information could be compared with that of NGO A to assess differences in continued use based on different levels of cost sharing (i.e., 5% versus 10%).

The next policy recommendation that emerges from this study is for development initiatives to pay more attention to monitoring as strategy to promote project sustainability. Monitoring is found to have a large and significant positive impact on BSF continued use. The emphasis on monitoring and evaluation (especially randomized control trials) to demonstrate program impact continues to increase. This type of analysis is critical to understanding what works and what does not, but it is also important to ensure the program impacts continue to accrue. Monitoring visits should focus first on addressing issues and providing retraining and reeducation. Then, a secondary goal can be gathering information for evaluation and reporting purposes. Ideally, both of these

valuable aspects of monitoring can be executed at the same time to conserve resources and simultaneously increase project sustainability and demonstrate impact. Alternatively, local implementers could focus on the policy recommendations of impact evaluations done by scholars and research labs without constantly having to demonstrate impact to grantors and donors. If programs could receive support by using previously demonstrated best practices and focus more on effective implementation and monitoring strategies, rather than evaluation, sustainable outcomes could be more achievable.

Finally, the type of water source that is poured into a BSF also has a large and significant impact on its continued use. Household BSFs can be an effective water treatment technology but the water must be collected from a source before it can be treated. Although assessments typically show that those without access to an improved water source have a greater need for a BSF, the filters will be more sustainable if implemented at households that already have an improved water source such as a protected well rather than an unimproved source such as an open well or pond. Therefore, to provide sustainable access to safe water in this context the first step should be the installation of an improved source such as a tubewell. Then, the second step should be the installation of a BSF. Sometimes this sequence is followed, but often it is not. This essay recommends more deliberate pairing of improved water sources and BSFs. To follow this recommendation, development initiatives could implement an improved water source either before or at the same time as the BSF is installed. In the case of NGO A, the breadth of programs has expanded in the past few years to include a well drilling program. Now, new wells are often installed before or at the same time as new BSFs. However, much of the choice between wells and/or BSFs is left up to the community leaders and individual participants. On the other hand, NGO B does not have a well drilling program and therefore must partner with other organizations to follow the recommended sequence of installing a well prior to installing a new BSF.

7.0 Conclusion

Cost-sharing and labor-sharing to promote a sense of ownership are among the most pervasive strategies that aim to increase the sustainability of program outcomes. However, the actual influence of these ownership-focused approaches is highly contested. At the same time, program evaluation is receiving increasing prominence for demonstrating impacts while the influence of monitoring on program sustainability is relatively neglected. This study demonstrates that NGO strategies of labor-sharing and monitoring can positively influence program sustainability, but the influence of cost-sharing remains unclear. For BSFs in Cambodia, the inclusion of labor-sharing during implementation combined with a greater frequency of monitoring visits contribute to a 22% increase in continued use of the filters. These findings illuminate a systemic problem in the way organizations select and describe the strategies used to promote sustainable outcomes.

Given the problem of sustainability that repeatedly impairs the progress of development initiatives, it is essential to understand how different strategies can be used to reduce the incidence of failed projects. As many development programs continue to tout the unproven sustainability benefits of cost-sharing, alternative strategies that could have a substantial influence are overlooked. When organizations assume that cost-sharing fulfills the need to address the problem of sustainability for development programs, it is the beneficiaries of the program that suffer the most. Gaining access to safe water only to lose it again is much more than a huge disappointment; people's health and the lives of their children are endangered once again. Moreover, organizations may lose the trust of those who are benefiting from the program and those who are contributing resources to support the program. Overall, maintaining a false sense of sustainability is detrimental to everyone involved in development initiatives. Considering the challenges that different socioeconomic and political contexts often present when it comes to poverty alleviation, this study is instructive. Strategies easily within the control of NGOs can have a large and significant influence on sustainable outcomes.

8.0 References

Arkes, H. R. & Blumer, C. (1985). The psychology of sunk cost. *Organizational behavior and human decision processes*, *35*(1), 124-140.

Banerjee, A. V. & Duflo, E. (2008). *The experimental approach to development economics* (No. w14467). National Bureau of Economic Research.

Banerjee, A. V. & Duflo, E. (2011). *Poor Economics: A Radical Rethinking of the Way to Fight Global Poverty*. Public Affairs: Kindle Edition. Available from http://www.amazon.com/.

Baumann, E. (2009). May-day! May-day! Our handpumps are not working! *RWSN Perspective No 1*. Retrieved from http://www.rural-watersupply.net/en/resources/details/206.

Breslin, E. D. (2010). Rethinking hydrophilanthropy: Smart money for transformative impact. Retrieved from http://www.waterforpeople.org/assets/pdfs/rethinking-hydrophilantropy.pdf.

Cambodia Ministry of Planning. (2013). Identification of Poor Households Programme (IDPoor). Accessed at http://www.mop.gov.kh/Projects/IDPoor/tabid/154/Default.aspx.

Carter, R. C., Tyrrel, S. F. & Howsam, P. (1999). Impact and sustainability of community water supply and sanitation programmes in developing countries. *Journal of the Chartered Institution of Water and Environmental Management, 13*(4), 292-296.

Center for Affordable Water and Sanitation Technology (CAWST). (2014). Biosand filter. Accessed at http://www.cawst.org/en/resources/biosand-filter.

Cohen, J. & Dupas, P. (2010). Free distribution or cost-sharing? Evidence from a randomized malaria prevention experiment. *The Quarterly Journal of Economics, CXXVI*(1), 1-45.

Collier, P. (2008). *The bottom billion: Why the poorest countries are failing and what can be done about it*. Oxford University Press.

Devoto, F., Duflo, E., Dupas, P., Pariente, W. & Pons, V. (2011). *Happiness on tap: piped water adoption in urban Morocco* (No. w16933). National Bureau of Economic Research.

Dittmar, H. (1992). *The social psychology of material possessions: To have is to be*. Hemel Hempstead: Harvester Wheatsheaf.

Duflo, E., Glennerster, R. & Kremer, M. (2007). *Handbook of development economics Vol. 4.* Chapter 61: Using randomization in development economics research: A toolkit, p. 3895-3962.

Earwaker, P. (2006). Cranfield University, Silsoe Institute of Water and Environment.

Easterly, W. (2006). *The White Man's Burden: Why the West's Efforts to Aid the Rest Have Done So Much Ill and So Little Good*. Penguin Books: London.

Easterly, W. (2013). The big aid debate is over. *Reason Foundation.* Accessed at http://reason.com/archives/2013/10/04/the-big-aid-debate-is-over

Fogelberg, K. (2010). Filling the knowledge gap: Monitoring post-construction water and sanitation sustainability. *Waterlines*, *29*(3), 220-235.

Githinji, S., Herbst, S., Kistemann, T. & Noor, A. M. (2010). Mosquito nets in a rural area of Western Kenya: ownership, use and quality. *Malaria journal*, *9*(1), 250.

Harvey, P. A. & Reed, R. A. (2003). Sustainable rural water supply in Africa: rhetoric and reality. Retrieved from https://dspace.lboro.ac.uk/dspace-jspui/handle/2134/2108.

Hoffman, E. & Spitzer, M. L. (1993). Willingness to pay vs. willingness to accept: legal and economic implications. *Wash. ULQ*, *71*, 59.

Isham, J. & Kähkönen, S. (2002). Institutional determinants of the impact of community-based water services: Evidence from Sri Lanka and India. *Economic Development and Cultural Change, 50*(3), 667-691.

Isham, J., Narayan, D. & Pritchett, L. (1995). Does participation improve performance? Establishing causality with subjective data. *The World Bank Economic Review*, *9*(2), 175-200.

Kahneman, D., Knetsch, J. L. & Thaler, R. H. (1990). Experimental tests of the endowment effect and the Coase theorem. *Journal of Political Economy*, 1325-1348.

Karlan, D. S. & Appel, J. (2011). *More than good intentions*. New York: Dutton.

Khandker, S. R., Koolwal, G. B. & Samad, H. A. (2012). *Handbook on impact evaluation: Quantitative methods and practices*. World Bank Training Series. Kindle Edition: World Bank Publications. Available from http://www.amazon.com.

Kleemeier, E. (2000). The impact of participation on sustainability: An analysis of the Malawi rural piped scheme program. *World Development, 28*(5), 929-944.

Kremer, M., Leino, J., Miguel, E. & Zwane, A. P. (2011). Spring Cleaning: Rural Water Impacts, Valuation, and Property Rights Institutions. *The Quarterly Journal of Economics*, *126*(1), 145-205.

Kremer, M. & Miguel, E. (2007). The illusion of sustainability. *The Quarterly Journal of Economics*, *122*(3), 1007-1065.

Lachapelle, P. (2008). A sense of ownership in community development: Understanding the potential for participation in community planning efforts. *Journal of the Community Development Society, 39*(2), 52-59.

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. *Wilson Quarterly, Woodrow Wilson International Center for Scholars Environmental Change and Security Program*, *99*(11).

Liang, K., Sobsey, M. & Stauber, C. (2010). Improving household drinking water quality: Use of biosand filters in Cambodia. *World Bank Water and Sanitation Program May 2010 Field Note*. Retrieved from http://www.wsp.org/wsp/sites/wsp.org/files/publications/WSP_biosand_cambodia.pdf.

Mansuri, G. & Rao, V. (2012). *Localizing development: does participation work?*. World Bank Publications.

Marks, S. J. & Davis, J. (2012). Does user participation lead to sense of ownership for rural water systems? Evidence from Kenya. *World Development, 40*(8), 1569-1576.

Marks, S. J., Onda, K. & Davis, J. (2013). Does sense of ownership matter for rural water system sustainability? Evidence from Kenya. *Journal of Water, Sanitation and Hygiene for Development*, *3*(2), 122-133.

Mintz, E., Bartram, J., Lochery, P. & Wegelin, M. (2001). Not just a drop in the bucket: expanding access to point-of-use water treatment systems. *American Journal of Public Health*, *91*(10).

Mog, J. M. (2004). Struggling with sustainability—a comparative framework for evaluating sustainable development programs. *World Development*, *32*(12), 2139-2160.

Nabyonga, J., Desmet, M., Karamagi, H., Kadama, P. Y., Omaswa, F. G. & Walker, O. (2005). Abolition of cost-sharing is pro-poor: evidence from Uganda. Health policy and planning, 20(2), 100-108.

Newman, J., Pradhan, M., Rawlings, L. B., Ridder, G., Coa, R. & Evia, J. L. (2002). An impact evaluation of education, health, and water supply investments by the

Bolivian Social Investment Fund. *The World Bank Economic Review*, *16*(2), 241-274.

Norton, M. I., Mochon, D. & Ariely, D. (2012). The IKEA effect: When labor leads to love. *Journal of Consumer Psychology*, *22*, 453-460.

Payen, G. (2011). Worldwide needs for safe drinking water are underestimated: billions of people are impacted. *Originally published as: Le Droit à l'eau potable et à l'assainissement, Sa mise en œuvre en Europe, Académie de l'Eau, Smets et al*, 45-63.

Resource Development International - Cambodia (RDIC). (2014). Ground water quality survey. Accessed at http://www.rdic.org/ground-water-quality-survey.php.

Royal Government of Cambodia. (2006). National Strategic Development Plan: 2006-2010. Retrieved from http://www.cdc-crdb.gov.kh/cdc/aid_management/nsdp.pdf.

Sachs, J. (2005). *The End of Poverty: Economic Possibilities of Our Time*. Penguin Books: London.

Sara, J. & Katz, T. (1997). *Making the rural water supply sustainable: Report on the impact of project rules*. UNDP-World Bank Water and Sanitation Program.

Shafik, N. (1994). Economic development and environmental quality: an econometric analysis. *Oxford Economic Papers*, 757-773.

Skinner, J. (2009). Where every drop counts: tackling rural Africa's water crisis. *IIED Briefing. London: International Institute for Environment and Development* Retrieved from http://pubs.iied.org/pdfs/17055IIED.pdf.

Sobsey, M. D., Stauber, C. E., Casanova, L. M., Brown, J. M. & Elliott, M. A. (2008). Point of use household water filtration: A practical, effective solution for providing sustained access to safe drinking water in the developing world. *Environmental Science & Technology, 42*(12), 4261-4267.

Steets, J., Witte, J., Heid, E. & Shupe, C. (2006). Partnerships for sustainable development: On the road to implementation. The Seed Initiative Partnership Report 2006. Retrieved from http://www.gppi.net/fileadmin/media/pub/2006/ Steets_2006_SEED_report.pdf.

Sullivan, C. (2002). Calculating a water poverty index. *World Development, 30*(7), 1195-1210.

Tango International. (2009). Sustainability of rural development projects: Best practices and lessons learned by IFAD in Asia. Retrived from http://www.ifad.org/operations/projects/ regions/pi/paper/8.pdf.

United Nations. (2014). Millennium development goals and beyond 2015. Accessed at http://www.un.org/millenniumgoals/.

Vanderzwaag, J. C., Atwater, J. W., Bartlett, K. H. & Baker, D. (2009). Field Evaluation of Long-Term Performance and Use of Biosand Filters in Posoltega, Nicaragua. *Water Quality Research Journal of Canada*, *44*(2).

World Bank. (2013). Data. Accessed from http://data.worldbank.org/.

World Health Organization (WHO) & UNICEF. (2013). Progress on sanitation and drinking-water-2013 update. Retrieved from http://www.wssinfo.org/fileadmin/ user_upload/resources/ JMPreport2013.pdf.

World Health Organization (WHO). (2014). Top ten causes of death. Accessed at http://www.who.int/mediacentre/factsheets/fs310/en/.

World Health Organization (WHO) & UNICEF. (2014). Joint Monitoring Programme (JMP) for water supply and sanitation: Types of drinking-water sources and sanitation. Accessed at http://www.wssinfo.org/definitions-methods/watsan-categories/.