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Community-Based Management of Handpumps in Rural Ghana: A Quantitative Analysis of What Needs to Change

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B.A., Hamilton College, 2016

Thesis Committee Chair: Matthew Freeman, MPH, PhD

An abstract of
A thesis submitted to the Faculty of the
Rollins School of Public Health of Emory University
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Abstract

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By: Morgan Lane

Background: The image of broken down, unused handpumps littering landscapes in Sub-Saharan Africa is a familiar and disappointing sight for many in the water sector. Around a quarter of the population in Ghana have access to safely managed water, the 'gold standard' service. However, only 7% of the rural population receive water at this service level. Community-based management (CBM) is the main system of water provision in rural Ghana and has often been called into question as an effective management model.

Objective: To investigate some of the factors that contribute to the sustainability of water systems in rural Ghana by examining the relationship between characteristics of the Water and Sanitation Management Teams (WSMT), the community-based management teams, and handpump functionality in rural Ghana.

Methods: Secondary data analysis was conducted using functionality and management data collected by IRC, a water, sanitation, and hygiene focused non-governmental organization, on 11,597 handpumps across six regions in Ghana. Two multivariable logistic regression analyses were conducted to examine the association between the dependent outcomes of interest (handpump functionality and reliability) and the explanatory predictors of interest (management factors).

Results: Handpumps were more likely to be functional when they were managed by WSMTs with younger handpumps, spare parts available within three days, breakdown repair within three days, positive revenue and expenditure balances and no need for repair support from the service authority. They were more likely to be reliable when managed by WSMTs with younger handpumps, initial training of members, spare parts and breakdown repairs within three days and positive revenue and expenditure balance.

Conclusions/Recommendations: Many service providers and authorities in rural Ghana currently lack the capacity to manage handpumps in accordance with national guidelines. In order to promote sustainability of the rural water system, the CBM model in Ghana may require some restructuring. In the effort to provide safely managed water to the entire population in Ghana, the rural water sector may benefit from privatization, professionalization, restructured budget allocations, and/or centralization.

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From the Emory side, I want to thank Dr. Matthew Freeman for his support in developing my project and providing me with guidance throughout the process.

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List of Terms

CBM	Community-Based Management
CWSA	Community Water and Sanitation Agency
DA	District Assembly
GoG	Government of Ghana
GWCL	Ghana Water Company Limited
JMP	Joint Monitoring Programme
PURC	Public Utilities Regulatory Commission
SDG	Sustainable Development Goal
WASH	Water, Sanitation and Hygiene
WATSAN	Water and Sanitation Committees
WRC	Water Resources Commission
WSDB	Water and Sanitation Development Board
WSMT	Water and Sanitation Management Team

Chapter 1: Introduction

Around 30% of handpumps in sub-Saharan Africa break down within a year of installation, and of those that do not, many are left unused or non-functional for a large part of the year (Alexander, 2015; Fisher et al., 2015; Foster, 2013; IRC, 2018). With the lack of sustainability so well known, why are the same methods for service provision continually implemented? The continual use of unsustainable methods in the water sector points to a disconnect between knowledge and action when it comes to the effort to achieve the Sustainable Development Goal (SDG) for safe water. In order to achieve the targets for safe water and sanitation for all, the water sector must implement methods of water delivery that are both effective and sustainable.

Ensuring that water facilities are sustainable requires focusing on many aspects of the service provision system. Key among them are funding—not only for capital costs, but also for operations and maintenance, direct support and indirect support—as well as good governance and management of water systems (Alexander et al., 2015; Cronk & Bartram, 2017; Foster 2013; Whittington et al., 2009). Funding of rural water systems is often provided from both government or non-governmental organizations and the local community. The initial costs for infrastructure are usually paid for by the implementing organization, the national government or other organization, while the costs for operations and maintenance are left to the local community (Foster, 2013). Funding from the local community comes from tariff collection, either at a fixed rate or based upon water use, and those communities with consistent tariff payment show higher functionality rates (Alexander et al., 2015; Cronk & Bartram, 2017; Foster, 2013).

As for governance and management of water systems, those community-based management teams that have access to spare parts and breakdown repair show higher functionality than those without access (Foster, 2013). Those teams that have regular meetings and better record keeping, as well as the ability to conduct minor repairs also show higher rates of functionality (Alexander et al., 2015; Cronk & Bartram, 2017). These factors have been analyzed in a variety of contexts and have been consistently identified as key factors in determining handpump functionality.

The most common service provision structure for rural water delivery in Sub-Saharan Africa is community-based management (CBM) (Whittington et al., 2009). This management model was developed to improve access to water in communities that had issues with water point breakdowns (Whittington et al., 2009). Underlying this model is the theory of water as an 'economic good' (Sun et al., 2010). This theory holds that because everyone in a community requires access to water, people will be willing to pay for and take care of their water system as long as it is functioning properly (Sun et al., 2010). Community-based management, therefore, relies upon the community's sense of ownership over the system and local political will to pay for and maintain water systems (Whittington, et al., 2009). However, rates of breakdown are still high and access to clean and reliable water is still lagging behind that of urban water. The current challenges with handpump sustainability under this management model bring into question whether the water sector should continue to rely upon community-based management for delivery of water in rural areas.

Statement of the Problem

The United Nation's Sustainable Development Goals (SDG) include a focus on safe water and sanitation. SDG6 is meant to "ensure availability and sustainable management of water and sanitation for all" and includes targets focused on universal and equitable access to safe water and sanitation, protection of water resources and development of the capacity of local communities to improve water and sanitation management (UN, 2018). In the context of functional handpumps, the goal is to achieve target 6.1 for "universal and equitable access to safe and affordable drinking water for all" (UN, 2018). According to data from the Joint Monitoring Programme for Water Supply and Sanitation (JMP), an initiative by the World Health Organization and UNICEF to monitor achievement toward the SDGs, access to safe water in Ghana has been improving since 2000 (JMP, 2018). Currently, an estimated 27% of the population have access to safely managed water, the 'gold standard' service, and only 6% continue to rely on surface water (JMP, 2018). While coverage of top-grade water services has been increasing over this period, there exists a large inequality in the distribution of services among Ghanaians. These inequalities exist across and within regions, as well as between urban and rural populations. Differences in wealth also play a role in the disparity, with the portion of the population in the lowest wealth quintiles falling into the lower rungs of the ladder (GSS, 2014).

Within the JMP figures, there also lies some misrepresentation of the actual percentage of the population covered with water services, due to the relatively high rates of infrastructure non-functionality. According to data collected between 2014-2016 through the joint Community Water and Sanitation Agency (CWSA) and IRC SMARTerWASH monitoring initiative, 26% of handpumps in Ghana were non-functional (Adank et al., 2016). Additionally, many of those that were functional were performing at a sub-optimal level (Adank et al., 2016). The

SMARTerWASH project scored handpumps based on water quality, quantity, reliability, non-crowding and distance. Reliability was scored based on whether the handpump was functional at least 95% of the time. The non-crowding indicator scored the handpump based on whether it served the maximum 300 people per pump, and the distance indictor referred to whether the handpump was no further than the maximum distance of 500m from each household it served (CWSA, 2014). Each indicator was given a dichotomous score of 0 or 1, with a zero indicating that the handpump did not meet the requirements of that indicator and 1 meaning that the indicator was met.

In assessing these indicators across handpumps in six regions, IRC found that the lowest scoring indicator across handpumps was the distance from each water point to the population accessing it (Adank et al., 2016). The low scoring distance indicator highlights the need for more handpumps to be built, because people have to travel further than 500m to reach a handpump. In order to achieve the distance related targets for SDG6, more water points will need to be constructed. Before this infrastructure is built, it is necessary to understand why the existing handpumps have such high non-functionality rates. If more handpumps are constructed without addressing the challenges faced in managing the pumps that are already present, the new water points will risk facing similar breakdown rates and the money invested to build them will be wasted.

There is an urgent need to deal with the high rate of breakdown among handpumps in sub-Saharan Africa in order to provide safe water for all. Without focusing on the sustainability of water systems, the global goal SDG 6.1 will not be achieved (UN, 2018). The purpose of this case study on rural Ghana is to examine which factors related to handpump management and characteristics are associated with the sustainability of handpumps. This analysis will provide further detail on which aspects of the community-based management system appear to be working well in rural Ghana, and which factors may need to be addressed to improve access to water and help Ghana in achieving SDG 6.1. By comparing results of this study with those of similar analyses that have been conducted in other country contexts, recommendations are then provided on possible paths forward for the water delivery system in rural Ghana.

Chapter 2: Literature Review

Enteric illnesses are the third leading cause of death in children under the age of five globally (IHME, 2017). In this population in 2017, diarrheal diseases accounted for 9.9% of deaths globally and 11.9% of deaths in Sub-Saharan Africa (IHME, 2017). These illnesses are also responsible for a significant percentage of DALY's lost among all age groups and they disproportionately affect vulnerable populations (IHME, 2017). A large contributor to the increased incidence of diarrheal disease in vulnerable populations is a lack sustainable access to safe water. Without access to safe water, sanitation and hygiene (WASH), communities face barriers in achieving improvements in health and the economy (Montgomery et al., 2009).

The global health and development communities have focused a great deal of attention to filling this gap in access through different implementation methods. These include working with local and national governments to increase access to water, installing water points in areas without access and training local community members on managing water systems (UN, 2019). Upholding the belief that access to water is a human right, the United Nations included "access to safe and affordable drinking water for all" as a target in Sustainable Development Goal 6 (SDG6). Given the global agreement on the importance of providing safe water to all, the water sector must focus on methods for reaching this target that are sustainable and will offer lasting access.

According to the Sustainable Development Goal Progress Report for 2018, three in ten people globally still lack access to safe drinking water (UN, 2018). Not only does a large percentage of the population still require access to drinking water, funding commitments to the water sector decreased by over 25% between the years of 2012 and 2016, resulting in 80% of countries reporting insufficient funding to meet the SDG6 targets in 2017 (UN, 2018). This reduction in funding highlights the necessity for sustainable systems that will prevent new water points from having to be constantly installed. If the systems that are built keep breaking down, the cost will be higher overall, and we will never achieve universal access to water.

The African continent represents the greatest portion of the population without access to at least basic services, defined by the JMP as "drinking water from an improved source, provided collection time is no more than 30 minutes for a roundtrip including queuing" (JMP, 2018). While there has been a large focus on increasing access to clean water, one-third of handpumps in Sub-Saharan Africa break down within a year of installation, and of those that don't, many are left unused or non-functional for most of the year (Alexander, 2015; Foster, 2013; IRC, 2018). Many of those water points that are non-functional are found in rural communities where the systems are often managed differently from those in urban areas and where there are often alternative options for accessing unsafe water (JMP, 2018).

Community-Based Management

Management of and access to water in rural and urban areas often differs because rural water delivery presents challenges that are not necessarily faced in the urban environment. According to Sun et al. (2010), both market and government failures are at play in rural areas when it comes to ensuring sustainable access to safe water. The private sector often does not have sufficient incentives to invest in rural water because of the high cost of infrastructure development for a lower population density, and the challenges that are faced in collecting user fees (Sun et al., 2010). Given the common ease of access to alternative sources of water, rural communities may not be willing to pay for water services, especially if the education is not in place to make them aware of the importance of safe drinking water. On the government failure side, it can be difficult for governments to foot the bill for water infrastructure and maintenance leaving them to rely on communities or other organizations to pay (Sun et al., 2010).

The solution to this issue for many decades has been for non-governmental organizations or charities to build water delivery infrastructure in communities without access to safe water (Montgomery et al., 2009). These projects help push countries toward achieving the targets for access to water, and thus are generally supported by national governments. However, this method of water provision does not encourage sustainable implementation methods that will result in long-lasting access.

In an effort to improve the functionality and sustainability of water points in rural areas, the community-based management (CBM) system was developed throughout the 1980's and 1990's to shift the focus from top-down to locally-driven approaches (Whaley & Cleaver, 2017; Marks et al., 2014; Whittington et al., 2009). The demand-driven CBM model is meant to "foster a sense of community ownership" and lead to improved service delivery through a community "commitment to use and maintain the facilities" (Whittington et al., 2009). If managed properly, this model encourages sustainability through effective community demand, local financing and cost recovery and dynamic operation and maintenance (Montgomery et al., 2009).

Underlying the community-based management model is the theory of water as an 'economic good', meaning that local community members will be willing to pay for water if the systems are managed properly (Sun et al., 2009). While this theory may hold in other types of service delivery, it can be challenging to rely on in the water sector because there are often alternative water sources that require no cost to use (Sun et al., 2009). Even if water users are willing to pay, it can be difficult for community water committees to appropriately manage their systems due to a lack of training in the management, maintenance and operations of these systems (Foster, 2013; Cronk & Bartram, 2017; Sun et al., 2009).

Although there are clear barriers to the success of this management model, community-based management is now the most widely used management model in rural water supply in Sub-Saharan Africa (Whaley & Cleaver, 2017). While the most sustainable way to achieve the global goals for increased access to improved water systems would theoretically be through participatory approaches such as CBM, many implementers working to achieve these goals have focused less on the sustainability of the systems they build and more on meeting the targeted levels of coverage (Whaley & Cleaver, 2017). Without additional efforts put into training and funding local community committees to improve their capacity to manage their water points, simply building more water systems will not result in long-lasting access to safe water for all. Therefore, while the focus on demand-driven approaches has shifted the way the rural water sector functions over the past few decades, the approach through which the sector implemented this new management model presents challenges in providing sustainable access to safe water.

In determining the causes for the high breakdown rates of water points, many in the sector have pointed to the issue of NGOs or national governments building water points and then leaving all responsibility for maintenance in the hands of the local community without giving them the capacity to do so (Sun et al., 2009; Whaley & Cleaver, 2017). While the CBM model encourages local participation and ownership of the systems, there is a weakness in the management model resulting in high rates of water point breakdowns. Some have argued for the professionalization of the rural water sector to remove some of the responsibility from the local community and put it in the hands of those who are better trained to take care of these systems (IRC, 2011). Over the past few decades, many researchers have examined the factors that contribute to the low functionality rates of community-managed water points, incorporating both characteristics of the water points themselves, as well as characteristics of the groups in charge of maintaining them.

In assessing the management characteristics of the community groups that are responsible for maintaining water points, researchers have often looked at factors revolving around governance, operations and financial management (CWSA, 2014). Past studies have pointed to many of the same management factors that contribute to the functionality of water points. Some of these include community participation in the decision on the type of water points and where they should be placed, the social capital of the community, the collection of tariffs, good record keeping, the ability to perform minor repairs at the local level, and having women involved in the committees (Adank et al., 2016; Alexander et al., 2015; Cronk & Bartram, 2017; Foster, 2013; Sun et al., 2009). These findings show that when the community-based management system functions as it was intended to, water points tend to be functional and the model is successful.

However, in many places where this system is utilized, there are still high rates of breakdown. This issue brings to question whether the community-based management model is still the best option for rural water management. While it may be true that the management model can be successful where it is able to function properly, there are clearly barriers preventing it from being able to function properly. Determining the reasons that these barriers are so common and examining what external factors contribute to the failure of the management model can help the sector determine whether relying on CBM for rural water delivery still makes sense or whether it is time to rethink the way rural water is managed.

Investigating the causes of management failure requires the use of a systems thinking approach that incorporates all of the factors that could contribute to the management failure of a water point. For those management teams with functionality issues, the breakdowns could be resulting from the quality of the water points themselves or the environment in which they were built. The management team may not be receiving enough support from higher levels of government, leaving them with a lack of training or funding to complete minor repairs (Montgomery et al., 2009; Harvey & Reed, 2004). The community itself may not have a strong social capital, or the presence of already existing community groups and ties, making it more difficult for the community to feel a collective sense of ownership over the system (Sun et al., 2010). Considering that there are so many factors that contribute to the water point failure or the inability of the community to maintain its water point, further research into this topic must take into account the entire system that contributes to high breakdown rates.

Ghana and CBM

According to the Joint Monitoring Programme (JMP), access to safe water in Ghana has been improving since 2000 (JMP, 2018). Currently, an estimated 27% of the population have access to safely managed water, the 'gold standard' service, and only 6% continue to rely on surface water. While coverage of top-grade water services has been increasing over this period, there exists a large inequality in the distribution of services among Ghanaians. These inequalities exist across and within regions, as well as between urban and rural populations. Differences in wealth also play a role in the disparity, with the portion of the population in the lowest wealth quintiles falling into the lower rungs of the ladder (GSS, 2014).

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In analyzing potential reasons for the non-functionality of handpumps in Ghana, a necessary place to start is the WASH policy and management structure to understand who is responsible and how maintenance of handpumps is meant to take place. The basic governing and provision structures are decentralized to the local level (AMCOW, 2011).

The Ministry of Water Resources, Works and Housing holds a sector leadership role at the national level (Lockwood et al., 2017). Within the national government, the Water Resources Commission (WRC) and the Public Utilities Regulatory Commission (PURC) have regulation authority for rural and small-town water and urban water respectively. At the regional level, the CWSA is in charge of rural water service development and provision and provides direct support to the District Assemblies (DA). These Assemblies regulate and provide support to the small-town and small-community water and sanitation management teams—WSDBs and WATSANs (CWSA, 2014).

Managed as a professional water service, the Ghana Water Company Ltd (GWCL) provides water to urban areas. The provision of rural water, on the other hand, follows a community-based management (CBM) system. Although the CBM structures are regulated and supported by the District Assemblies, a local team manages day to day operations and maintenance (Foster, 2013). Ideally, these CBM teams collect revenues in order to cover all operations and maintenance costs, as well as some of the capital costs. These teams in Ghana, the Water and Sanitation Management Teams (WSMTs), are given the power to set tariffs, which are approved by the District Assembly. The National Community Water and Sanitation Strategy (NCWSS) lays out the role that each of these groups plays in water service provision, and the guidelines for effectively managing water systems are relatively straight-forward (CWSA, 2014). Unfortunately, translating these guidelines into practice has proven to be a challenge (Adank et al., 2013).

After years of relying on CBM for rural water provision and countless efforts to build the capacity of WSMTs, there are still challenges with the lack of professionalization and systematic operation of services, financing deficits and limited monitoring capabilities. This begs the question of whether CBM can still be recovered as an effective management of rural water provision, or whether it is time for the water sector in Ghana and elsewhere to rethink the system entirely.

In discussing a shift from community-based management, it must be acknowledged that there is a spectrum in management structures between CBM and full professionalization. It may not be necessary for an entirely new management structure to be implemented when CBM is not functioning properly, but a shift towards professionalization may benefit the water sector in providing safe water in Ghana. Because CBM structures in Ghana are so prevalent, we must consider the steps that are involved in the shift towards professionalization—does the sector require an entire reboot or can the existing structure be reformulated?

Chapter 3: Project Content

Methodology

Introduction

Between the years of 2012 and 2014, as part of the Triple-S Project, IRC and the Community Water and Sanitation Agency (CWSA) developed and tested a water service monitoring initiative. This initiative aimed to collect and analyze data on all improved water facilities in three districts (Kumasi et al., 2014). In order to monitor these water facilities and the teams managing them, a national monitoring framework was developed. The Framework included indicators on handpump and pipe scheme water services (quantity, quality, reliability, distance to source, and coverage), service providers and service authorities (CWSA, 2014). The indicators for service providers, or WSMTs, assessed Governance, Operations and Financial Management. The Governance indicator assessed the composition of the WSMT, the skills of the operational team, the financial and operational records and whether there was political interference in the creation of the WSMT. The Operations indicator looked at availability of spare parts, breakdown repair, routine maintenance and water quality testing. Lastly, the Financial Management indicator assessed revenue/expenditure balance, presence of a bank account, tariffs and facility management plans. The service authority indicators assessed support given from the District Assemblies to WSMTs for major repairs and for management of the system.

A 2014 report on the Triple-S initiative found that both service providers and service authorities at the local and district levels were often not complying with the guidelines laid out in the National Community Water and Sanitation Strategy (Adank et al., 2013). Around a third of handpumps were not functioning and many of the indicator benchmarks for providers were not met. Financial Management indicators were the lowest scoring indicators across the board for service providers, resulting mainly from a lack of tariff collection and negative revenue/expenditure balances. Service authorities, on the other hand, often did not have the financial or human resources available to provide necessary support to the providers (Adank et al., 2013). Thus, when water service authorities and providers were not able to follow the policies provided by the government, service provision suffered, and many people were left without water.

In addition, economic growth in Ghana over the past decade has resulted in changes in the type and quantity of development support available to WASH and other sectors. Because the country has been considered a lower-middle income economy since 2011, foreign aid is on the decline despite the significant infrastructure gap still remaining (Lockwood et al., 2017). This poses a significant threat to the construction of new water points. Because of the need for new infrastructure, as well as the need to focus on the sustainability of existing infrastructure in Ghana, the community-based management system in rural Ghana must be evaluated. Water service authorities at the District level need to ensure that the proper management structures are in place in communities to build and maintain water delivery systems once much of the foreign aid has been halted.

In making decisions on whether the CBM model will continue to be a feasible option for rural Ghana going into the future, the Government of Ghana (GoG) will benefit from an understanding of which management factors contribute most to the sustainability of systems. If the key factors that contribute to water point sustainability are those that cannot be feasibly improved in each community, it may be necessary to rethink the management system used for rural water delivery. If these changes are feasible, the system may simply require some restructuring to provide the necessary financial or human resources required for the WSMTs to succeed. Assessing the successes and challenges of the CBM model in rural Ghana will aid the water sector in Ghana in understanding what needs to change to improve access to safe water going forward.

SMARTerWASH

Using the national monitoring framework developed by the Community Water and Sanitation Agency, CWSA partnered with IRC to implement monitoring on a larger scale than under the Triple-S initiative. The SMARTerWASH project involved the aggregation of data on water facilities collected through the national District Monitoring and Evaluation Systems (DiMES), SkyFox infrastructure monitoring and AKVO Flow mobile phone data collection throughout six of the ten regions in Ghana (Adank, 2016). Handpumps and piped schemes were given service level scores based on the Framework indicators—quantity, quality, reliability, non-crowding and distance (CWSA, 2014). Management characteristics of the service providers and authorities were also scored based on the indicators and sub-indicators from the Framework—Governance, Operations and Financial Management. These data were collected into separate databases for water source monitoring and management monitoring.

This analysis further explores the monitoring data on service provider and service authority management characteristics and handpump functionality. By analyzing which management characteristics are related to the functionality of handpumps, and which service authority characteristics are related to service provider performance, conclusions can be drawn on the necessary focus areas for improving water access in rural Ghana.

Population and sample

Under the SMARTerWASH initiative, distinct datasets were established for the management characteristics of service providers and authorities and the functionality characteristics of handpumps and piped schemes. For this analysis, two datasets were used—one describing the characteristics of handpump service providers and authorities and one describing the characteristics of the handpumps themselves. All handpumps on which data was collected are manual pumps. In order to cross-analyze the two databases, a merged dataset was created by matching the management data to each of the handpumps respectively.

This dataset includes data on handpumps managed by WSMTs, private persons, institutions and "other" management structures, as well as those without a management structure. Descriptive analysis was conducted on this total population of handpumps (14,694) to analyze functionality by management type and handpump type. After this analysis, all management types that were not community-based were removed from analysis to allow for exploration of data on the CBM structures specifically. This completed dataset for handpumps managed by WSMTs allowed for the analysis of 11,597 handpumps across the Northern, Central, Brong Ahafo, Upper East, Upper West and Western Regions.

Data analysis

The indicators that were developed by CWSA and used to monitor handpumps by service level are seen in the figure below (Tables 1 & 2). Management factors were also analyzed based on indicators and sub-indicators for service providers and service authorities (Tables 3 & 4).

Table 1. Handpump Service Level Indicators	
Service Level Indicators	**Standard**
Quantity	Handpump and standpipe: 20 lpcd: Household Connection: 60 lpcd

Quality	Meets all Ghana Standards Authority standards for water quality of drinking water
Crowding	Hand dug well: max 150 people per facility; borehole or standpipe: max 300 people per facility
Distance	Up to 500 m between facility and users
Reliability	The facility is providing water for at least 95% of the time

Table 2. Handpump Service Levels	
Service Level	**Description of Service Level**
III	Handpump provides water services meeting the standard on all the service level indicators
II	Handpump fails to meet the standard on one or more of the service level indicators
I	Handpump is not functioning or not used

Table 3: Service Provider Performance	
Indicator Group	**Indicator-benchmark**
Governance	**WSMT composition** – in line with guidelines and members have been trained
	Operational team – At least half filled by qualified staff
	Financial and operational records – kept up to date
	Political interference – no political interference in composition of WSMT
Operations	**Spare parts** – Available within 3 days
	Area mechanic (HP) / technical services – available within 3 days
	Routine maintenance – done at least annually / according to maintenance schedule
	Water quality testing – done by certified institute on regular basis
Financial Management	**Revenue/expenditure** – Positive balance
	Bank account – available and accounts up to date / 3 bank account up to date
	Tariff – Tariff set
	Facility management plan – Facility management plan in place

Table 4: Management Sub-Indicators Included	
Indicator Group	**Sub-Indicator**
Governance	WSMT Composed of at Least 30% Women
	Treasurer Present
	Caretaker Present

	Initial Training Conducted
	Record Keeping and Accountability
Operations	Spare Parts Available Within Three Days
	Area Mechanic Services Available Within Three Days
	Breakdown Repairs Conducted Within Three Days
	Routine Maintenance Conducted
	Water Quality Testing Conducted
Financial Management	Positive Revenue and Expenditure Balance
	Up-to-date financial and operational records
	Tariff Setting
	Facility Management Plan
Service Authority Indicators	Monitoring Support
	Repair Support

Using the handpump and management merged dataset, descriptive and logistic regression analyses were conducted using STATA 15.1 (Tables I, II, III and IV).

Descriptive Analysis

The descriptive analysis describes the functionality of handpumps across districts. Using the explanatory variables included in the analysis, handpumps were divided based on those that met the benchmark for each indicator and those that did not. The percentage of the total handpumps that each group represents was calculated. Lastly, the non-functionality rate was calculated for each group of handpumps.

The first analysis describes non-functionality rates of handpumps by management type and handpump type for all 14,694 handpumps (Table I). The second analysis describes the non-functionality rate of the 11,597 handpumps that were managed by WSMTs, the community-based management teams (Table II).

Logistic Regression

Following the descriptive analysis, a logistic regression analysis was conducted on management factors as explanatory predictors for basic functionality as the dichotomous variable. For this analysis, handpumps performing at a service level of II or III were considered to be functional and those performing at service level I were considered to be non-functional. While this one-time measure of functionality does not consider all of the factors involved in the sustainability of systems, it is commonly chosen as a proxy for logistic regression analysis on water point data (Alexander et al., 2015; Cronk & Bartram, 2017; Foster, 2013; Whittington et al., 2009).

The logistic regression included all 14 main indicators from the CWSA framework as well as six of the 21 sub-indicators. Of the sub-indicators previously found to be significant predictors in other analyses, the six chosen for this analysis were those that had enough data collected to be representative of the total handpumps. Age and handpump type were also included in this analysis to account for some of the factors outside of management that could be affecting the functionality of handpumps.

Because functionality does not truly address the question of sustainability of handpumps, another analysis was conducted to explore which management characteristics are associated with handpump reliability. Handpumps that meet the benchmark for reliability are those that are functioning at least 95% of the time. This indicator is also a proxy for sustainability and cannot address all of the aspects that contribute to the sustainability of water systems. However, the reliability indicator gives a better overall picture of the functionality of handpumps given that is not a one-time measure of functionality.

The logistic regression included an unadjusted analysis, as well as an adjusted analysis. The unadjusted analysis gives an odds ratio (OR) for the relationship between the outcome and the indicated independent variable. The multilevel analysis gives the OR for the relationship between the indicated independent variable and the outcome controlling for the other independent variables in the data set. Modelled for non-functionality, the OR calculated from the regression indicate the odds of a handpump being nonfunctional for each predictor. The reliability analysis, on the other hand, is modelled for reliability with the OR indicating the odds of a handpump being reliable. Based on prior research on modelling of this type of data from the literature, I chose not to conduct a stepwise selection (Mundry & Nunn, 2009; Whittingham et al., 2006). Therefore, the model accounts for predictors not significantly associated with the outcome. Those predictors that are significantly associated are indicated as such in Appendix III.

Ethical consideration

IRB approval was waived for this project because it is an evaluation that does not consist of human subjects research.

Limitations and delimitations

This statistical analysis does have limitations that prevent its generalizability, precision and accuracy. While the completed dataset allowed for the analysis of over 11,000 handpumps, there were some water points that could not be merged into the dataset because of a lack of identifying information on either the handpump or management side. This analysis also did not take into account piped schemes, which are also managed by community-based management teams. However, these water points were not considered because of the increased funding and technical assistance the management teams receive due to the increased complexity of these systems.

Another limitation of the study is that factors external to the management team and the handpump characteristics could not be explored in detail because of a lack of data on these factors. For example, this dataset offers some information on funding and support from higher levels of government but does not include other political information or support from other non-governmental entities that may play a role in the functionality and management of handpumps. Using contextual information, however, these factors have been considered in the discussion and recommendations.

While this statistical analysis does have limitations, it is useful because it explores the management of handpumps in six of the ten regions of Ghana and offers insight into the major management structure relied upon in the rural areas of the country. This analysis does not seek to generalize to CBM structures across countries, but rather to offer recommendations for improving the management of handpumps in rural Ghana.

Results

Descriptive Analysis

According to the descriptive analysis, 61% of handpumps were fully functional on the scale of non-functional, partially functional and fully functional; however, only 6% were providing water services at a level in accordance with national norms—performing at a service level III. Around half of handpumps were the AfriDev type, which showed the highest functionality of all models. Handpumps classified as “other” were the lowest functioning models. WSMTs manage a majority of the handpumps and show an average non-functionality rate of 24%. The other management types have similar rates of non-functionality; however, they only represent 9% of handpumps collectively. Those without a management structure have the highest non-functionality rate (33%) and represent 12% of the total handpumps.

Logistic Regression Analysis: Functionality

The odds of non-functionality increased for each increasing age category, with those handpumps that had been installed less than five years ago showing the lowest odds of non-functionality. The average age of handpumps was 17.6 years (95% CI: 17.44, 17.85). The likelihood of a handpump being non-functional were almost nine times higher for handpumps classified as “other” (OR = 8.84, 95% CI: 5.91, 13.23). The likelihood of a handpump being non-functional were also higher for those WSMTs that had a treasurer (OR=1.14, 95% CI: 1.01, 1.29), record keeping and accountability (OR = 1.34, 95% CI: 1.11, 1.62) and facility management plans (OR = 1.33, CI: 1.20, 1.49).

Management teams that have spare parts available within three days were 19% less likely to be non-functional compared to those that do not have parts available within three days (OR = 0.81, 95% CI: 0.73, 0.91). Teams that complete breakdown repair within three days were 25% less likely to be non-functional compared to those that do not complete repairs within three days (OR = 0.75, 95% CI: 0.67, 0.83). Having a positive revenue and expenditure balance decreases the likelihood of non-functionality by 32% compared to having a negative balance (OR = 0.68, 95% CI: 0.59, 0.80). For WSMTs that report having needed repair support from the service authority, there is no significant difference in the odds of non-functionality between teams that receive support versus those that do not. However, for WSMTs that have not had to request repair support, the likelihood of being non-functional are much lower than for teams that required support (OR = 0.52, 95% CI: 0.47, 0.58).

Table 5. Unadjusted and Multivariable Logistic Regression Models for Non-Functionality.

Explanatory variables	Unadjusted OR (95% CI)*	p-value	Multivariable Adjusted OR (95% CI)*	p-value
Handpump Type				
AfriDev	1		1	
Ghana modified India Mark II	**0.62 (0.57, 0.68)**	<.0001	**0.72 (0.64, 0.79)**	<.0001
Nira AF-85	**0.55 (0.49, 0.62)**	<.0001	**0.59 (0.52, 0.67)**	<.0001
Vergnet	**0.74 (0.62, 0.87)**	<.0001	**0.80 (0.67, 0.97)**	0.019
Other	**0.322 (0.23, 0.46)**	<.0001	**0.38 (0.26, 0.56)**	<.0001
Age				
0-5 years	1		1	
6-10 years	**0.50 (0.38, 0.65)**	<.0001	**0.49 (0.38, 0.65)**	<.0001
11-15 years	**0.36 (0.28, 0.47)**	<.0001	**0.37 (0.28, 0.49)**	<.0001
16-20 years	**0.32 (0.24, 0.42)**	<.0001	**0.34 (0.26, 0.45)**	<.0001
21-40 years	**0.23 (0.18, 0.30)**	<.0001	**0.26 (0.20, 0.35)**	<.0001
+40 years	**0.48 (0.36, 0.66)**	<.0001	**0.56 (0.40, 0.76)**	<0.001
30% Women Benchmark	**1.23 (1.13, 1.34)**	<.0001	1.02 (0.92, 1.12)	0.752
Treasurer	1.00 (0.91, 1.10)	0.934	0.90 (0.81, 1.01)	0.062
Caretaker	1.10 (0.99, 1.21)	0.072	1.07 (0.95, 1.20)	0.250
Initial Training	**1.21 (1.10, 1.31)**	<.0001	**1.14 (1.04, 1.26)**	**0.008**
Record Keeping and Accountability	0.98 (0.87, 1.10)	0.699	0.95 (0.83, 1.10)	0.539
Spare parts supply	**2.07 (1.90, 2.23)**	<.0001	**1.44 (1.31, 1.60)**	<.0001
Area Mechanic Services	**1.67 (1.54, 1.81)**	<.0001	1.05 (0.94, 1.16)	0.401
Breakdown Repairs	**1.85 (1.71, 2.00)**	<.0001	**1.49 (1.35, 1.63)**	<.0001

Routine Maintenance	1.07 (0.99, 1.15)	0.098	1.07 (0.98, 1.17)	0.116
Water Quality Testing	1.02 (0.89, 1.17)	0.814	1.04 (0.90, 1.20)	0.595
Revenue and Expenditure Balance	**1.13 (1.02, 1.26)**	0.021	**1.16 (1.01, 1.33)**	0.033
Up-to-date financial and operational records	1.02 (0.91, 1.15)	0.712	0.95 (0.79, 1.13)	0.583
Tariff Setting	**0.88 (1.04, 1.24)**	0.005	**0.88 (0.79, 0.98)**	0.019
Facility Management Plan	**0.84 (0.77, 0.91)**	<.0001	**0.88 (0.80, 0.97)**	0.012
Monitoring Support	**0.80 (0.73, 0.89)**	<.0001	0.99 (0.83, 1.18)	0.907
Repair Support				
Yes	1		1	
No	**0.80 (0.68, 0.94)**	0.005	**0.79 (0.67, 0.94)**	0.007
No Need	**2.04 (1.88, 2.22)**	<.0001	**1.69 (1.55, 1.86)**	<.0001

*Bolded ORs are significant at the <0.05 alpha level

Logistic Regression Analysis: Reliability

The odds of reliability decreased for each increasing age category. Those handpumps classified as "other" were 62% less likely to be reliable than traditional handpumps (OR = 0.38, 95% CI: 0.26, 0.56). Those WSMTs that did not receive repair support from the service authority when needed were 20% more likely to be non-reliable as compared to those teams that needed support and received it (OR= 0.80, 95% CI: 0.68, 0.94). WSMTs that had a facility management plan were 16% less likely to be reliable as compared to those teams without facility management plans (OR = 0.84, 95% CI: 1.88, 2.22).

WSMTs with spare parts available within three days were 44% more likely to be reliable compared to those without spare parts available (OR = 1.44, 95% CI: 1.31, 1.60). Those with breakdown repair within three days were 49% more likely to be reliable (OR = 1.49, 95% CI:

1.35, 1.16) and those with a positive revenue and expenditure balance were 16% more likely to be reliable (OR = 1.16, 95% CI: 1.01, 1.33) as compared to those WSMTs without breakdown repair or a positive balance. Those WSMTs that did not require repair support from the service authority were 69% more likely to be reliable than those that did require support and received it (OR = 1.69, 95% CI: 1.55, 1.86).

Table 6. Unadjusted and Multivariable Logistic Regression Models for Reliability.

Explanatory variables	Unadjusted OR (95% CI)*	p-value	Multivariable Adjusted OR (95% CI)*	p-value
Handpump Type				
AfriDev	1		1	
Ghana modified India Mark II	**0.62 (0.57, 0.68)**	<.0001	**0.72 (0.64, 0.79)**	<.0001
Nira AF-85	**0.55 (0.49, 0.62)**	<.0001	**0.59 (0.52, 0.67)**	<.0001
Vergnet	**0.74 (0.62, 0.87)**	<.0001	**0.80 (0.67, 0.97)**	0.019
Other	**0.322 (0.23, 0.46)**	<.0001	**0.38 (0.26, 0.56)**	<.0001
Age				
0-5 years	1		1	
6-10 years	**0.50 (0.38, 0.65)**	<.0001	**0.49 (0.38, 0.65)**	<.0001
11-15 years	**0.36 (0.28, 0.47)**	<.0001	**0.37 (0.28, 0.49)**	<.0001
16-20 years	**0.32 (0.24, 0.42)**	<.0001	**0.34 (0.26, 0.45)**	<.0001
21-40 years	**0.23 (0.18, 0.30)**	<.0001	**0.26 (0.20, 0.35)**	<.0001
+40 years	**0.48 (0.36, 0.66)**	<.0001	**0.56 (0.40, 0.76)**	<0.001
30% Women Benchmark	**1.23 (1.13, 1.34)**	<.0001	1.02 (0.92, 1.12)	0.752
Treasurer	1.00 (0.91, 1.10)	0.934	0.90 (0.81, 1.01)	0.062
Caretaker	1.10 (0.99, 1.21)	0.072	1.07 (0.95, 1.20)	0.250
Initial Training	**1.21 (1.10, 1.31)**	<.0001	**1.14 (1.04, 1.26)**	**0.008**
Record Keeping and Accountability	0.98 (0.87, 1.10)	0.699	0.95 (0.83, 1.10)	0.539
Spare parts supply	**2.07 (1.90, 2.23)**	<.0001	**1.44 (1.31, 1.60)**	<.0001
Area Mechanic Services	**1.67 (1.54, 1.81)**	<.0001	1.05 (0.94, 1.16)	0.401
Breakdown Repairs	**1.85 (1.71, 2.00)**	<.0001	**1.49 (1.35, 1.63)**	<.0001
Routine Maintenance	1.07 (0.99, 1.15)	0.098	1.07 (0.98, 1.17)	0.116

Water Quality Testing	1.02 (0.89, 1.17)	0.814	1.04 (0.90, 1.20)	0.595
Revenue and Expenditure Balance	**1.13 (1.02, 1.26)**	0.021	**1.16 (1.01, 1.33)**	0.033
Up-to-date financial and operational records	1.02 (0.91, 1.15)	0.712	0.95 (0.79, 1.13)	0.583
Tariff Setting	**0.88 (1.04, 1.24)**	0.005	**0.88 (0.79, 0.98)**	0.019
Facility Management Plan	**0.84 (0.77, 0.91)**	<.0001	**0.88 (0.80, 0.97)**	0.012
Monitoring Support	**0.80 (0.73, 0.89)**	<.0001	0.99 (0.83, 1.18)	0.907
Repair Support				
Yes	1		1	
No	**0.80 (0.68, 0.94)**	0.005	**0.79 (0.67, 0.94)**	0.007
No Need	**2.04 (1.88, 2.22)**	<.0001	**1.69 (1.55, 1.86)**	<.0001

*Bolded ORs are significant at the 0.05 alpha level

Chapter 4: Discussion, Conclusion and Recommendations

Discussion

The current analysis examined handpumps in rural Ghana to investigate which management factors and handpump characteristics may be related to functionality and reliability. Understanding the contextual factors that relate to handpump functionality is important in understanding what we might focus on to improve the sustainability of water points in Ghana. Alexander et al. (2009) outline a conceptual model for water scheme functionality linking factors related to the contextual environment, implementation, system governance and functionality (Appendix I). Using the pertinent factors outlined in this model, we compared findings from the current analysis to those of past analyses. This comparison allowed for an improved understanding of the findings as they relate to the effectiveness of the CBM model.

Contextual Environment

Political

Functionality and reliability were higher among those WSMTs that did not require repair support and lower among those that required support and did not receive it. Of those WSMTs that reported having needed repair support, only 16% received it. Although 84% of WSMTs reported not having received monitoring support, our analysis revealed no difference in the level of functionality or reliability between the WSMT's that received monitoring support and those that did not. However, because so many WSMTs reported not receiving monitoring support and not receiving repair support when it was needed, there appears to be a larger issue in the District Assembly fulfilling its role in the management of WSMTs.

Water projects implemented through development partners may actually adhere to national guidelines better than those implemented by the central government (Agbemor et al., 2017). Confusion around roles and responsibilities has often been noted as an issue with service provision at the local level and may be a potential contributing factor in the poor performance of service authorities seen here (Lockwood et al., 2017). The differences in modes of implementation between development partners and the GoG also led to challenges in effective management of systems. Oftentimes, the District Assemblies were not involved in the implementation process, which caused problems when they were expected to manage the water facilities in their jurisdiction (Agebemor et al., 2017). The funding mechanisms also differed between implementers resulting in challenges in the management of funds at the local level (Agebemor et al., 2017).

Implementation

Technology Choice

This analysis found that of all handpump models, Afridev handpumps were the most likely to be functional; and handpumps classified as "other", or not one of the most commonly used types/brands, were the least likely to be functional. The difference in functionality rates between the two pump types may be related to the lack of a managerial capacity to fund, operate and maintain handpumps in these communities in Ghana. These functionality rates may also result from differences in the implementing partners and how they follow through after construction. In past analyses on handpump characteristics and functionality, handpumps classified as "other" also showed a much higher rate of non-functionality than those used more commonly (Fisher et al., 2015; Foster, 2013). Further, in his analysis on handpumps in Sierra Leone, Liberia and Uganda, Foster (2013) found no difference in the odds of functionality between Afridev and India Mark pumps. Our analysis on rural Ghana showed that Afridev handpumps were more likely to be functional than India Mark. Foster argues that differences in non-functionality may be observed between Afridev and India Mark pumps because the Afridev type are less technologically challenging (Foster, 2013). He also argues that managerial factors may be even more influential on functionality than the technological difficulty of maintaining pumps (Foster, 2013).

The difference in functionality between pump types could also be related to the relative commonality of Afridev pumps in Ghana and the presence of more spare parts and knowledge about these pumps locally. Another possible factor is that the type of project that constructs the water points may be linked to the choice of pump, and that projects that favor Afridev pumps are implemented in a fashion that results in longer-term sustained functionality than other types of projects.

Training, Capacity Building

We found no association between initial training of WSMT members and improved functionality. While somewhat surprising, this finding does support the results from Liberia, Sierra Leone and Uganda where training was often only given once, and that the context of the training was inadequate to truly make a difference (Foster, 2013).. The same phenomenon may be occurring in rural Ghana where training of WSMT members often occurred during the project planning phase for many handpumps but was not necessarily conducted at any later point (Marks, Komives and Davis (2014). While this training may be offered for the majority of management teams, initial training may be insufficient, and therefore may not play a role in the functionality of handpumps.

System Governance

Maintenance

We found that having spare parts available within three days and being able to complete breakdown repair within three days were predictors of handpump functionality and reliability. This finding aligns with past studies, underscoring the importance of WSMTs to have the ability to conduct minor repairs themselves rather than relying on external technical support or funding from service authorities or from NGOs and other development partners (Alexander et al., 2015; Fisher et al., 2015, Foster, 2013).

Handpumps with area mechanics available within three days had a higher average non-functionality rate, while we found no effect of area mechanics on functionality or reliability when controlling for other factors. This is surprising according to both common sense, and to the findings from Foster's analysis that having an area mechanic decreases the non-functionality rates of handpumps (Foster, 2013). It is true that simply having an area mechanic may not automatically lead to improved functionality. Perhaps local area mechanics are available but lack training or resources. If this is the case, it cannot be assumed that handpump functionality will improve simply with the presence of area mechanics.

Management

Having a caretaker was associated with handpump functionality and reliability in rural Ghana, aligning with findings from community-based water schemes in Ethiopia (Alexander et al., 2015). Those caretakers that were paid seem to be even more important in developing a sense of community ownership of the system. Caretakers in Ghana and Bolivia improved performance because they were able to locate and obtain the necessary resources that may not be immediately available for water point maintenance (Whittington et al., 2009).

Finance

Some of the findings from this analysis were unexpected based on prior analyses and assessments of CBM. The most surprising finding was the lack of an association between tariff collection and functionality of handpumps. In all of the past studies reviewed, researchers found tariff collection to be an important predictor of handpump functionality (Alexander et al., 2015; Cronk & Bartram, 2017; Fisher et al., 2015; Foster, 2013). Considering the need for revenue and financing to conduct repairs at the daily operation level, this could suggest that tariff collection does not necessarily lead to an availability of funds when needed by operators.

This discrepancy in funds may be due to factors interfering with the positive effect that tariff collection usually has on handpump functionality. For example, a major challenge identified in the CWSA Organizational Assessment was that few WSMTs collect tariffs and of those that do, they do not collect a high enough tariff to impact the functionality of their water schemes (Lockwood et al., 2017). The tariff collection structures may be preventing any incoming funds from having a substantial impact on the functionality of handpumps. This result may point to the need for increased tariff charges or for a restructuring of funding from the national government to subsidize communities unable to pay high enough tariffs to maintain their water facilities.

Accountability

Having a treasurer, record keeping and accountability, and facility management plans were all negatively associated with functionality and reliability. While these results were surprising, they may reflect a lack of managerial capacity within WSMTs. It is possible that investing time and resources into these managerial components while relying on volunteers that are not trained or incentivized actually has a negative effect on the provision of services. If these factors were properly implemented, perhaps they would offer a benefit for the WSMT that allows for improved functionality of handpumps.

Recommendations

Given that community-based management is so embedded in the rural water sector in Ghana, it is important to think about possible approaches for improving the capacity of WSMTs to maintain and operate facilities. Below are some possible recommendations for improving WSMT capacity.

Service Authorities

- Better coordination between stakeholders in rural water throughout the planning, construction and post-construction phases.
- District Assemblies may require an organizational transformation in order to better manage budgets and plan for future breakdowns, as well as successfully monitor and evaluate service providers. Building this capacity of DAs would allow them to support the WSMTs in managing and maintaining their water systems on a regular basis, rather than only supporting those WSMTs who struggle to maintain functioning handpumps.

Service Providers

- Improved training and knowledge of area mechanics to conduct minor repairs
- Improved WSMT member capacity to maintain records and finances and develop facility management plans

System Restructuring

Rather than focusing on capacity building at the WSMT and DA level, the entire framework could be reassessed to determine how the critical roles of these bodies could be shared or transferred to alternative parties. This restructuring could include:

- Professionalization of services: By reassigning responsibility for activities such as financial management or breakdown repair to a professional service, the burden of these activities could be taken off of WSMTs who rely on volunteer members.
- Restructuring budget allocations: Given that most WSMTs do not collect user fees, it may be necessary to restructure budget allocations or to institute new tariff structures at the local level. This would increase WSMT financial capacity to manage their systems or to pay for professionalized services.
- Centralizing handpump management: Management may be rendered more efficient by clustering handpumps together under a larger management structure with more capacity to manage. While the government intentionally adopted the decentralization strategy that led to the current roles played by the DA and the WSMTs, it may be useful to move back to a more centralized system that allows for improved support from higher levels of government.
- Reevaluating the role of the private sector: Some Water and Sanitation Development Boards (WSDBs), which manage water systems in larger communities, create contracts with private operators to completely operate and maintain their water systems (IRC, 2011). However, this only applies to those WSDBs that manage complex water supply systems. While WSMTs that manage handpumps in rural Ghana may not require fully

privatized maintenance, it may be beneficial for these teams to extend privatized services for some aspects of the operations and maintenance of their water points.

    - Privatization can elicit a fear of increased service costs and marginalization of vulnerable populations, however, the inclusion of private sector actors with the knowledge and capacity to install and maintain water facilities into the rural water sector may improve the sustainability of water facilities in rural Ghana. These actors can function within the system, such that the sector management is still community-based, and these actors can be regulated by the District Assembly, the service authority.

- <u>Conversion to a fully professional service</u>: Akin to the structure of urban water utility, complete professionalization of the system may be a more sustainable method for water delivery.
- <u>Other methods of provision</u>: Testing out other methods, such as self-supply, that may reach those community members with no access to water currently.

Conclusion

As of 2015, only 7% of the rural population in Ghana has access to safely managed water services (JMP, 2015). With a large gap left to fill before the country can achieve Sustainable Development Goal 6.1, what can the sector do to improve?

In looking at the community-based management structure in rural Ghana, there are large challenges that need to be addressed to improve the provision of water. This analysis sought to contribute evidence to the larger question of whether it is worthwhile to continue investing in CBM or whether it is time to think about new methods for management. The results of this analysis on handpump functionality and service provider and service authority management in rural Ghana provide evidence that the management of handpumps must be improved. There are certain management characteristics that predict better handpump performance and those that predict worse performance. Perhaps this evidence can be used to improve the current CBM model or to develop new models to be tested.

Community-based management has often been criticized for the same issues that were raised through this analysis. However, CBM remains a very present model in many places around the world. While it may not be necessary to completely forgo the CBM model, the water sector can use evidence from sustainability analyses such as this one to restructure the system to function more effectively.

Many people in rural Ghana still rely on surface water and new infrastructure will need to be built to reach these populations. The proper management structures must be in place when these systems are built, or they will not be sustainable. It is the hope this study can contribute to the discussion on which management models are the most effective in water service provision and to encourage the improvement and reform of existing and future management systems that are capable meeting the needs of all segments of the population.

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Tables

Table I

Descriptive Analysis including all handpumps.

Explanatory Variable	n (%)	NFR
Handpump Type		
AfriDev	8082 (55%)	20%
India Mark II	3478 (24%)	29%
Nira AF-85	2078 (14%)	35%
Vergnet	790 (5%)	27%
Other	267 (2%)	62%
Management Type		
WSMT	11,604 (79%)	24%
Institutional	28 (0.2%)	25%
Private Person	679 (5%)	25%
Other	626 (4%)	23%
No Management Structure	1757 (12%)	33%

Table II

Prevalence of handpump and management characteristics and non-functionality rates.

Explanatory Variable	n (%)	NFR
Age		
0-5 years	499 (4%)	24%
6-10 years	2,505 (22%)	18%
11-15 years	2,920 (25%)	25%
16-20 years	1,755 (15%)	25%
21-40 years	3,275 (28%)	31%
+40 years	650 (6%)	15%
Proportion of Women in WSMT		
Benchmark Met	8,659 (75%)	24%
Benchmark Not Met	2,546 (22%)	26%
No Data Available	295 (3%)	27%
Treasurer		
Present	8,958 (77%)	24%
Not Present	2,646 (23%)	24%
Caretaker		
Present	9,587 (83%)	24%
Not Present	2,017 (23%)	31%
Training		
Completed	8,632 (74%)	24%
Not Completed	2,972 (26%)	24%

Up-to-date financial and operational records		
Present	1,400 (12%)	24%
Not Present	10,197 (88%)	24%
Area Mechanic available within 3 days		
Yes	7,816 (67%)	22%
No	3,781 (33%)	28%
Spare Parts available within 3 days		
Yes	5,935 (51%)	20%
No	5,662 (49%)	29%
Breakdown Repair within 3 days		
Yes	6,333 (55%)	21%
No	5,264 (45%)	29%
Routine Maintenance at least annually		
Yes	5,604 (48%)	24%
No	5,993 (52%)	24%
Water Quality Testing Conducted		
Yes	1,021 (8%)	26%
No	10,576 (91%)	24%
Bank Records Kept		
Yes	1,523 (13%)	24%
No	10,074 (87%)	24%
Positive Revenue/Expenditure Balance		
Yes	1,968 (17%)	20%
No	9,629 (83%)	25%
Tariffs in place		
Yes	2,912 (25%)	24%
No	8,685 (77%)	24%
Facility Management Plan		
Yes	3,182 (27%)	28%
No	8,422 (73%)	23%
Monitoring Support from Authority		
Yes	1,908 (16%)	27%
No	9,689 (84%)	24%
Repair Support from Authority		
Yes	757 (7%)	31%
No	3,955 (34%)	33%
No Need	6,885 (59%)	19%
Total	11,597 (100%)	24%

Table III

Unadjusted and Multivariable Logistic Regression Models for Functionality.

Explanatory variables	Unadjusted OR (95% CI)*	p-value	Multivariable Adjusted OR (95% CI)*	p-value
Handpump Type				
AfriDev	1		1	
Ghana modified India Mark II	**1.55 (1.40, 1.72)**	<.0001	**1.31 (1.17, 1.46)**	<.0001
Nira AF-85	**1.93 (1.71, 2.19)**	<.0001	**1.85 (1.62, 2.12)**	<.0001
Vergnet	**1.37 (1.14, 1.65)**	<.0001	**1.23 (1.01, 1.51)**	0.037
Other	**8.24 (5.69, 11.92)**	<.0001	**8.84 (5.91, 13.23)**	<.0001
Age				
0-5 years	1		1	
6-10 years	**1.34 (1.02, 1.76)**	0.034	**1.32 (0.99, 1.75)**	0.055
11-15 years	**2.01 (1.54, 2.62)**	<.0001	**1.88 (1.42, 2.38)**	<.0001
16-20 years	**2.00 (1.52, 2.63)**	<.0001	**1.79 (1.34, 2.38)**	<.0001
21-40 years	**2.73 (2.10, 1.47)**	<.0001	**2.35 (1.79, 3.10)**	<.0001
+40 years	1.06 (0.76, 1.47)	0.741	0.86 (0.61, 1.23)	0.418
30% Women Benchmark	**0.88 (0.79, 0.97)**	0.011	0.98 (0.88, 1.09)	0.680
Treasurer	1.03 (0.93, 1.14)	0.598	**1.14 (1.01, 1.29)**	0.035
Caretaker	**0.86 (0.77, 0.96)**	0.008	**0.84 (0.74, 0.95)**	0.007
Initial Training	1.02 (0.92, 1.12)	0.758	1.05 (0.94, 1.17)	0.394
Record Keeping and Accountability	1.01 (0.89, 1.14)	0.913	**1.34 (1.11, 1.62)**	0.002
Spare parts supply	**0.60 (0.55, 0.65)**	<.0001	**0.81 (0.73, 0.91)**	<.0001
Area Mechanic Services	**0.74 (0.68, 0.81)**	<.0001	1.00 (0.89, 1.13)	0.935
Breakdown Repairs	**0.64 (0.59, 0.69)**	<.0001	**0.75 (0.67, 0.83)**	<.0001
Routine Maintenance	1.02 (0.93, 1.11)	0.691	0.97 (0.87, 1.05)	0.366
Water Quality Testing	1.10 (0.95, 1.28)	0.183	0.97 (0.83, 1.14)	0.747
Revenue and Expenditure Balance	**0.74 (0.66, 0.84)**	<.0001	**0.68 (0.59, 0.80)**	<.0001
Up-to-date financial and operational records	0.95 (0.92, 1.09)	0.486	0.85 (0.70, 1.03)	0.098
Tariff Setting	0.99 (0.90, 1.09)	0.799	0.96 (0.85, 1.08)	0.458
Facility Management Plan	**1.31 (1.19, 1.43)**	<.0001	**1.33 (1.20, 1.49)**	<.0001

Monitoring Support	**1.19 (1.06, 1.33)**	0.002	1.10 (0.96, 1.24)	0.196
Repair Support				
Yes	1		1	
No	0.93 (0.79, 1.10)	0.424	0.88 (0.74, 1.05)	0.157
No Need	**0.49 (0.43, 0.51)**	<.0001	**0.52 (0.47, 0.58)**	<.0001

*Bolded Ors are significant at the 0.05 alpha level

Table IV

Unadjusted and Multivariable Logistic Regression Models for Non-Reliability.

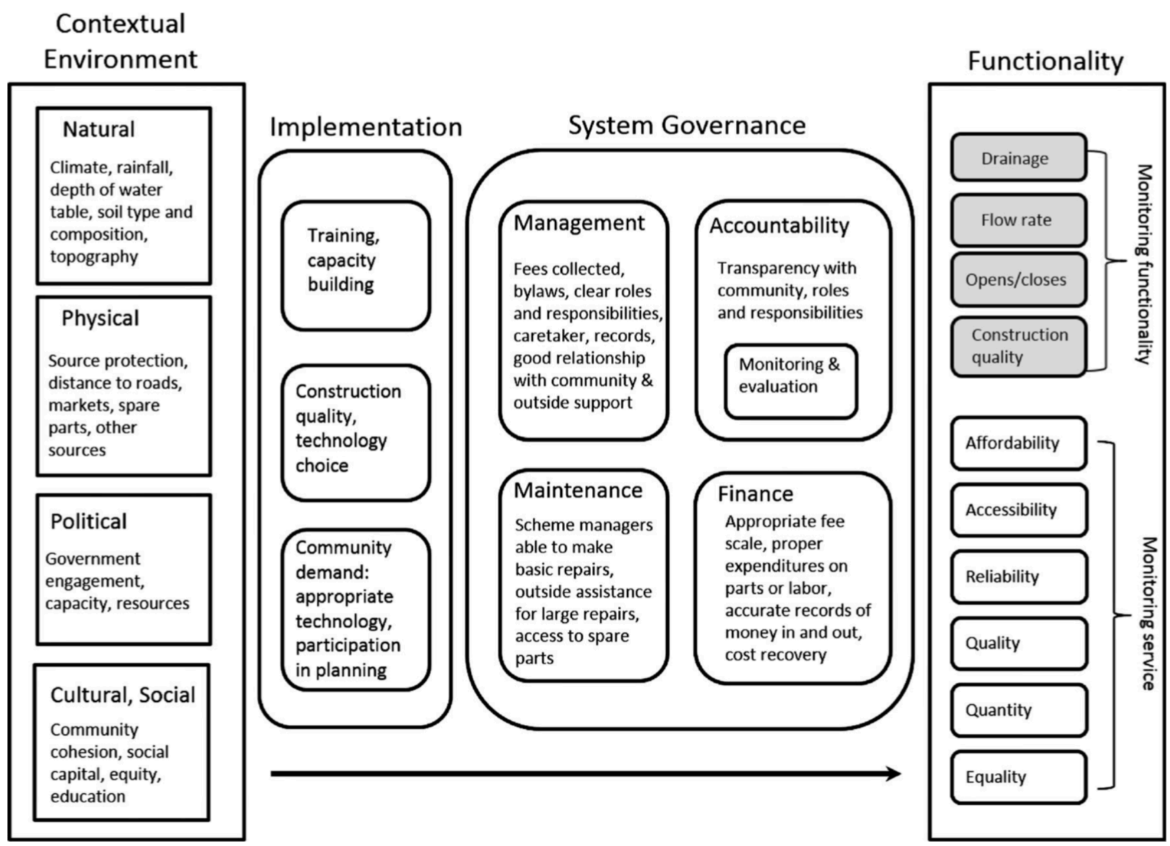
Explanatory variables	Unadjusted OR (95% CI)*	p-value	Multivariable Adjusted OR (95% CI)*	p-value
Handpump Type				
AfriDev	1		1	
Ghana modified India Mark II	**1.61 (1.46, 1.76)**	<.0001	**1.37 (1.23, 1.52)**	<.0001
Nira AF-85	**1.80 (1.60, 2.03)**	<.0001	**1.71 (1.51, 1.94)**	<.0001
Vergnet	**1.35 (1.14, 1.60)**	<.0001	**1.22 (1.02, 1.47)**	0.033
Other	**3.10 (2.19, 4.34)**	<.0001	**2.54 (1.73, 3.73)**	<.0001
Age				
0-5 years	1		1	
6-10 years	**2.01 (1.54, 2.62)**	<.0001	**1.89 (1.43, 2.50)**	<.0001
11-15 years	**2.80 (2.15, 3.64)**	<.0001	**2.54 (1.93, 3.33)**	<.0001
16-20 years	**2.13 (2.39, 4.10)**	<.0001	**2.78 (2.10, 3.68)**	<.0001
21-40 years	**4.38 (3.38, 5.68)**	<.0001	**3.58 (2.73, 4.69)**	<.0001
+40 years	**2.07 (1.52, 2.81)**	<.0001	**1.66 (1.20, 2.93)**	0.002
30% Women Benchmark	**0.82 (0.74, 0.90)**	<.0001	0.96 (0.87, 1.06)	0.409
Treasurer	1.00 (0.92, 1.10)	0.934	1.08 (0.97, 1.21)	0.178
Caretaker	0.91 (0.82, 1.00)	0.072	0.92 (0.82, 1.04)	0.198
Initial Training	**0.83 (0.76, 0.91)**	<.0001	0.86 (0.78, 0.95)	0.003
Record Keeping and Accountability	0.98 (0.87, 1.10)	0.699	1.07 (0.90, 1.27)	0.432
Spare parts supply	**0.48 (0.45, 0.52)**	<.0001	**0.69 (0.62, 0.76)**	<.0001
Area Mechanic Services	**0.60 (0.55, 0.65)**	<.0001	0.94 (0.84, 1.05)	0.264
Breakdown Repairs	**0.54 (0.50, 0.58)**	<.0001	**0.68 (0.62, 0.75)**	<.0001

Routine Maintenance	0.93 (0.86, 1.01)	0.089	0.93 (0.85, 1.02)	0.105
Water Quality Testing	0.98 (0.86, 1.13)	0.803	0.95 (0.82, 1.10)	0.463
Revenue and Expenditure Balance	**0.88 (0.79, 0.98)**	0.020	**0.86 (0.75, 0.98)**	0.030
Up-to-date financial and operational records	1.03 (0.91, 1.16)	0.654	0.96 (0.80, 1.14)	0.625
Tariff Setting	1.14 (1.04, 1.24)	0.005	1.11 (0.99, 1.24)	0.058
Facility Management Plan	**1.19 (1.09, 1.30)**	<.0001	**1.18 (1.07, 1.31)**	0.001
Monitoring Support	**1.24 (1.12, 1.38)**	<.0001	1.10 (0.98, 1.25)	0.118
Repair Support				
Yes	1		1	
No	1.25 (1.07, 1.46)	0.006	**1.24 (1.05, 1.46)**	0.012
No Need	**0.49 (0.45, 0.53)**	<.0001	**0.58 (0.53, 0.46)**	<.0001

*Bolded Ors are significant at the 0.05 alpha level

Appendix

Appendix I



Conceptual Model for Water Scheme Functionality. Source: Alexander et al., 2009