WATER SYSTEM SUSTAINABILITY IN RURAL SUB-SAHARAN AFRICA: PARTICIPATION, SENSE OF OWNERSHIP, AND PERFORMANCE

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DOCTOR OF PHILOSOPHY

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Abstract

This dissertation is motivated by the need to improve water system performance and sustainability in rural areas of sub-Saharan Africa. Nearly one billion people worldwide lack access to an improved drinking water source. Over a third of the unserved are living in rural sub-Saharan Africa, where approximately one in two people collect their water from unprotected sources such as rivers and traditional wells. Limited access to safe water in this region is largely explained by poor functionality of existing water infrastructure. For example, it is estimated that an average of 36% of handpumps across sub-Saharan Africa are non-functional at any given time, and in some countries this figure is over 60%. This research draws on methods from environmental engineering, social psychology, and economics to understand the factors that explain sustainable outcomes for rural water supplies in Ghana and Kenya.

First, a review of the literature on rural water supply development summarizes the existing evidence related to sustainability, and current knowledge gaps are highlighted. In recent decades, the water sector throughout the developing world has attempted to confront sustainability problems by shifting to planning approaches that emphasize the participation of community members. Community participation in water supply projects includes users providing upfront cash and labor contributions to the capital cost of the system, attending planning meetings, and providing input on key decisions about the project. Several studies have established that participatory planning improves project outcomes throughout the developing world. However, empirical evidence regarding the type and extent of participation that leads to sustainable water systems is lacking. Moreover, there is little understanding of the causal mechanisms that explain how participatory planning leads to better outcomes. The empirical research presented in this dissertation focuses on these key knowledge gaps.

The extent to which different forms of community participation explain variation in handpump performance is investigated using data collected in 200

communities throughout rural Ghana. Data sources include structured interviews with 5,000 households and 200 water committees. In addition, focus group discussions were conducted with women and village leaders in each community, and an engineering assessment of each water point was completed. The number of meetings attended by the household, the mean cash contribution to the project, and households' involvement in managerial decisions about the project are each positively associated with indicators of handpump sustainability. Measures of the breadth of participation within the community, including the share of households contributing any money or attending any meetings, are not strong covariates of sustainability. Other variables are found to explain variation in sustainability above and beyond participation, including the presence of post-construction support and having fewer people per borehole. These results suggest that some forms of participation may matter more than others in terms of ensuring sustainable outcomes. Also, programmatic features, such as the provision of post-construction support, are important considerations for rural water programs.

One explanation for the link between community participation and water system sustainability is that participation engenders a sense of ownership for the infrastructure among community members. Such a sense of ownership, it is hypothesized, is essential for ensuring community members' willingness to pay for and operate the system over the long term. The final chapters in this dissertation focus on investigating this causal mechanism. Drawing on the 'psychological ownership' framework developed by scholars of organizational behavior, a composite measure for community members' sense of ownership for their water system is developed using principal components analysis. Empirical data for this investigation were collected in 50 communities throughout rural Kenya. Data sources include in-person interviews with 1,916 households, 312 water committee members and 50 system operators, and technical assessments of each water system.

The determinants of households' sense of ownership for their water system are investigated using regression analysis, with a particular focus on different forms of community participation in the system's planning and construction. Households' involvement in making decisions about the level of service obtained and making larger

(non-token) cash contributions are each associated with a high sense of ownership for the system. Labor contributions are associated with a moderate sense of ownership. Other significant covariates of sense of ownership include regular use of a working tap on the premises and a household member having served on the water committee. No association is found between sense of ownership and small cash contributions, education level, or broader leadership responsibilities within the community.

At the community level, households' and water committee members' sense of ownership for the water system is found to be inversely related. Water system sustainability (as measured by infrastructure condition, system management, and users' satisfaction) is modeled as a function of both group's sense of ownership for the system. All else held constant, infrastructure condition is positively associated with water committee members' sense of ownership, whereas users' perceptions and system management are positively associated with households' sense of ownership.

The study in Kenya establishes an empirical referent for sense of ownership for a communal water system, and shows that some (though not all) forms of community participation are associated with greater feelings of ownership. These results also show that sense of ownership for the system is heterogeneous across different groups within a community, and different groups' sense of ownership matters for different aspects of system sustainability. These findings challenge the bulk of published literature on rural water planning, which suggests a consistent and positive relationship between community participation, households' sense of ownership for the system, and system sustainability.

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This dissertation would not have been possible without the guidance and contributions of many people. First and foremost, Prof. Jenna Davis, my primary adviser, has been a source of intellectual inspiration and unending support throughout my PhD—through thick and thin. She could always revive my dedication to this work through her infectious enthusiasm and insistence that research can truly make a positive impact on people's lives. Doing fieldwork with Jenna in Kenya was one of the most rewarding parts of my Ph.D. She is a teacher in every sense of the word, and I feel extremely fortunate to have had the opportunity to be guided by one of the very best in our field.

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The enumerators and staff at Rural Focus Ltd. provided valuable input on these research questions and spent long hours in the field collecting the data presented in Chapters 4 and 5. I also thank Dr. Kristin Komives for her input into the results presented in Chapter 3, and Prof. Robert Hope for many memorable conversations that helped me formulate these research ideas. Finally, I am indebted to Julie, Jill, Brenda, Royal, and Helen for their organization and sense of humor that made navigating each step of the Ph.D. process enjoyable.

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1 Introduction

For people living in rural areas of the developing world, having access to a water tap within or near the home can greatly improve the quality of life. A protected water source provides an additional barrier to the water- and sanitation-related diseases that kill an estimated 1.9 million people globally each year [*World Health Organization*, 2004]. When a tap is brought closer to the home, women and girls spend fewer hours of their day fetching water, and this time may be spent on other activities such as attending school or earning extra income [*Crow et al.*, 2011; *Koolwal and Van de Walle*, 2010; *Moriarty et al.*, 2004].

The Millennium Development Goal's Target 7c aims to halve, by 2015, the share of people without sustainable access to an improved water source[1] [*United Nations*, 2000]. Based on the most recent global assessment, 1.8 billion people gained access to improved water between 1990 and 2008, and most of the world is on track to meet Target 7c. However, there are currently 884 million people who are not served by an improved water source, 37% of whom live in sub-Saharan Africa [*Joint Monitoring Programme*, 2011]. Low access to improved water in sub-Saharan Africa is largely a rural issue, with approximately half of all rural dwellers depending on unprotected water sources for their domestic water needs. Progress toward reducing the share of the unserved in this region has been challenging, and sub-Saharan Africa will most likely miss Target 7c. Between 1990 and 2008 the percentage of people with access to improved water rose only one percentage point, from 46% to 47%, whereas coverage throughout the rest of the developing world rose from 87% to 92% during the same period [*Joint Monitoring Programme*, 2010a].

[1] The WHO-UNICEF Joint Monitoring Program (JMP) defines an improved water source as "one that, by nature of its construction or through active intervention, is protected from outside contamination, in particular from contamination with faecal matter." From a practical standpoint this is defined as the existence of piped water to the yard or home, a public kiosk, a borehole with a pump, a protected dug well or spring, or a rainwater collection system.

1.1 Sustainability challenges in rural sub-Saharan Africa

The persistent gap in domestic water supply coverage in sub-Saharan Africa has been attributed to several root causes. First, the water and sanitation sector has experienced relatively low levels of international donor assistance and weak support from national governments [*Iyer et al.*, 2006]. Second, the rate of population growth in sub-Saharan Africa has outpaced all other regions of the world, with 304 million (or 59%) more people living on the continent than in 1990[2] [*Joint Monitoring Programme*, 2010a].

Another major barrier to realizing Target 7c is that investments in rural water supply infrastructure often fail to achieve sustainable service delivery. Sustainability in this context refers to the ability of the infrastructure to deliver water to communities for the duration of its design life without major interruptions. The relatively simple water systems common to rural areas of the developing world often have an overall 'life expectancy,' *e.g.,* handpumps typically last 12-15 years [*Erpf*, 2003]. For more complex systems such as piped networks with motorized pumping, design properties can vary dramatically across the various system components.

The Rural Water Supply Network (RWSN) monitors the functionality status of handpumps across Africa and estimates that 36% of the installed handpumps are not operating at any given time [*Rural Water Supply Network*, 2009]. In some countries, such as Côte d'Ivoire, over 60% of the installed handpumps are non-functional (Table 1-1). Piped water networks—especially those that are gravity-fed—are less prone to a complete failure of the water service, though these systems are often operating well below their expected performance level [*Lockwood and Smits*, 2011; *Schouten and Moriarty*, 2003].

Despite strong signals indicating that water projects in rural sub-Saharan Africa are performing poorly, a clear understanding of the extent and nature of the problem is hampered by data scarcity issues and a lack of coordination among monitoring organizations. Like RWSN's handpump monitoring effort, most organizations rely on a single measure of technical performance—most commonly, whether a water point is

[2] Whereas sub-Saharan Africa has experienced the greatest rate of change in population since 1990, Southern Asia has experienced the most growth in terms of absolute numbers. There are 469 million more people in Southern Asia today than in 1990, a growth rate of 39%.

physically functioning at the time of the visit. Scholarly studies often employ an index-based approach, drawing on multiple indicators to develop a composite score for overall system performance [*Gross et al.*, 2001; *Isham and Kähkönen*, 2002; *Khwaja*, 2004; 2009; *Narayan*, 1995; *Prokopy*, 2004; *Sara and Katz*, 1998]. Other studies have opted to present multiple indicators of sustainability, which permits a more nuanced understanding of the various aspects of water system performance and avoids possible difficulties with interpreting composite indices [*Davis et al.*, 2008; *Kleemeier*, 2000; *Manikutty*, 1997; *Prokopy*, 2005]. In the absence of a standardized approach for monitoring rural water supplies over time, scalable solutions have remained elusive.

For the many broken handpumps and malfunctioning piped networks throughout sub-Saharan Africa, the cost of rehabilitation is significantly greater over the design life of the infrastructure than the cost of routine preventative maintenance [*Baumann*, 2006]. As a result, rural water programs must allocate a share of their resources to the rehabilitation of existing water points, in lieu of expanding access to unserved populations. Even worse, many broken water points are prematurely abandoned due to cost barriers or difficulties with locating the necessary parts or technical assistance [*Rosenberg*, 2011]. In these cases, households that were formerly served by a protected water source are often forced to return to rivers or traditional wells.

1.2 The emergence of participatory planning

The International Drinking Water Supply and Sanitation Decade (1981 to 1990) marked a global campaign to achieve universal access to improved water sources. This decade was characterized by rapid construction of water points worldwide, which was facilitated through centralized planning schemes in most countries. Toward the end of this decade, however, problems with the sustainability of water programs became apparent. Governments and donors were unable to provide ongoing subsidies and support programs to communities, and water committees were unable to maintain and operate their systems in isolation [*Therkildsen*, 1988]. Water points throughout the world were either malfunctioning or abandoned only a few years after installation [*Briscoe and Ferranti*, 1988].

Following the disappointments of the 1980s, rural water programs shifted to a decentralized, demand-oriented approach to planning [*de Regt*, 2005; *Garn*, 1997] (see Appendix A for a historical perspective on the emergence of participatory planning in the rural water sector). Demand-oriented planning emphasizes community participation in the planning and construction of the water system. Community participation includes households making contributions of cash and labor to the capital cost of the project, attending planning meetings, and making key decisions about the project.

Early supporters of participatory planning promoted this approach based on normative and pragmatic reasoning. Normative arguments include that participation in development is a human right as well as an essential practice for preserving indigenous culture [*Gamer*, 1982]. Others argue that participation empowers community members and thus is an end in itself [*Finsterbusch and Van Wicklin*, 1987]. Community participation in planning was also promoted for practical purposes; in theory, demand-oriented planning directs scarce resources toward those communities that are relatively more willing and able to maintain new water infrastructure, thereby improving the likelihood of financial sustainability for the system over the long-term [*Garn*, 1997].

Over time the reasoning for participatory planning evolved into a standard set of mobilization strategies that were widely adopted as best practices [*Mundial*, 1996]. First, community members typically submit a formal application to the water program indicating their desire to receive an improved water supply. This is followed by a contractual agreement stating that the community is responsible for financing ongoing operation and maintenance of the system. Next, community members make up-front contributions to the capital cost of the system—usually 5-10% in the form of both cash and labor. Selected community members typically also agree to serve on a water committee that oversees operation and maintenance of the water point(s), often on a volunteer basis.

Next, the process of matching a water system design to users' felt needs and preferences begins with one or more meetings with community members. These meetings provide a forum for dialogue between project staff and community members, giving households an opportunity to share their opinions and expectations related to the project. Community members may also share relevant information about local conditions with project staff, such as the location of known water sources or seasonal considerations. Through open dialogue, community members and the project team should be able to make informed choices from a menu of water service levels and technology options [*Gross et al.*, 2001]. Service level options include communal point sources, private water connections in the home or yard, or a water scheme that provides both. Technology options may include choosing whether point sources will be equipped with a handpump or a generator-driven pump, whether communal storage tanks or rainwater collection will be provided, or where boreholes will be drilled.

Several causal pathways are hypothesized to explain how community participation enhances the sustainability of projects (Figure 1-1). First, participation in project planning and construction is widely thought to engender a sense of ownership for the project among community members. Such a sense of ownership, it is argued, ensures that communities will be willing to pay for, operate, and maintain the system over the long term [*Yacoob*, 1990]. Second, it is noted that the flexibility inherent to the participation process enables dialogue between the project implementers and beneficiaries. This sharing of information between project implementers and beneficiaries should allow for customized projects that are ultimately better suited to local conditions and more likely to survive over the long-term [*de Regt*, 2005; *Whittington et al.*, 2000]. Finally, participatory planning is also thought to enhance transparency and trust between community members and the project team. Transparency and trust should lead to greater satisfaction and willingness to pay among households [*Manikutty*, 1997].

Based on the existing empirical evidence, there is little doubt that participatory planning has led to better project outcomes in rural areas of the developing world since the days of supply-driven infrastructure planning [*Briscoe and Ferranti*, 1988;

Narayan, 1995; *Sara and Katz,* 1998; *Whittington et al.*, 2009]. Still, progress toward improving levels of access in sub-Saharan Africa has been slow, and this region will most likely miss the Millennium Development Goal's drinking water supply target. This reality has led many to question whether every form of participation is necessary for achieving better project outcomes [*Prokopy*, 2005]. Some suggest that other programmatic features, such as the provision of ongoing institutional support, may matter as much or more than community participation for ensuring project sustainability [*Davis et al.*, 2008; *Lockwood and Smits*, 2011; *Whittington et al.*, 2009].

1.3 Dissertation organization

The goal of this dissertation research is to identify the key determinants of sustainable rural water supply delivery, with a particular emphasis on participatory planning and its associated causal pathways. A review of the literature (Chapter 2) reveals that several knowledge gaps exist based on the conceptual model shown in Figure 1-1. These knowledge gaps are the focus of the empirical research that makes up the bulk of this dissertation (Chapters 3-5), with each study taking the form of a stand-alone manuscript with its own introduction, methods, results, and discussion sections. Supplemental information for each empirical study can be found in the appendices. The dissertation concludes with a summary of the main findings and suggestions for areas of future research (Chapter 6). The references used throughout each chapter are merged and appear at the end of the document. All co-authors are identified at the beginning of Chapters 3-5. I was responsible for the planning, data analysis, and writing of each chapter.

In Chapter 2, an expanded review of the literature on rural water supply sustainability is presented. This review builds on the description of the participatory planning model that is presented in Chapter 1 and Figure 1-1. The goal of Chapter 2 is to define the evidence landscape for rural water supply sustainability and highlight knowledge gaps. Three main research questions are identified:

- **Which forms of community participation lead to sustainable outcomes for rural water systems?** It is broadly accepted that participatory planning has improved project outcomes as compared to supply-driven planning approaches in rural areas of the developing world. However, little is known regarding the type or extent of community participation that is associated with indicators of sustainability for rural water supply systems. An understanding of the influence of specific elements within the participatory process will allow community members and rural water program managers to better direct limited resources.
- **Does community members' participation in their water system's planning and construction enhance their sense of ownership for it?** Community sense of ownership for the project is widely believed to follow participatory planning, yet there is no rigorous research that has attempted to test this hypothesis. Specifically, there is a need to develop a quantitative measure for community members' sense of ownership for the water system, and to understand how this measure is associated with different forms of community participation. This research will establish an empirical referent for a social phenomenon that is widely discussed in the development literature, and will contribute empirical evidence to the ongoing speculation regarding its determinants.
- **Does community sense of ownership for rural water systems ensure the sustainability of the infrastructure?** There is a need to understand whether community members' sense of ownership for the water system ensures the system's ongoing performance. To date, the existing evidence on the relationship between community sense of ownership and water system sustainability is anecdotal and sparse. Moreover, existing accounts have failed to consider whether different groups within the community may matter more than others in terms of influencing outcomes for the water system. This dissertation research acknowledges community heterogeneity by examining different groups' sense of ownership for the communal water system. These

findings will directly inform rural water programs by highlighting the community groups that matter most for ensuring water system sustainability.

The empirical research presented in Chapters 3-5 of this dissertation contributes evidence to each of the above knowledge gaps. In Chapter 3, a cross-sectional research design is used to investigate the determinants of handpump sustainability in rural Ghana. I explore the hypothesis that some forms of community participation during planning and construction matter more than others for ensuring handpump sustainability. Data sources include household surveys, structured interviews with water committee members, and engineering assessments of handpumps within 200 communities throughout the Volta and Brong Ahafo regions of Ghana. Using multivariate regression, indicators of handpumps sustainability are modeled as a function of community participation and other covariates known to influence the success of handpump projects.

Chapter 4 presents work from a 2009 field study conducted in 50 communities in rural Kenya with piped water systems. This investigation draws on the 'psychological ownership' framework developed by scholars in the fields of social psychology and organizational behavior. Based on this framework, a proposed empirical measure for community members' sense of ownership for their water system is presented. Drawing on 1,140 household surveys, a composite ownership measure is constructed using principal components analysis. Next, we investigate whether households' participation in project planning and construction is associated with their sense of ownership for the water system. Special attention is given to the forms of participation that households were involved in and the level of ownership that households feel for the project.

Chapter 5 extends the previous chapter's investigation within Kenya to examine the extent to which variation in piped water system sustainability is explained by community members' sense of ownership for it. Ownership scores are assigned to two groups within the community (households and water committee members), and sustainability is measured in terms of the infrastructure condition, ongoing management practices, and users’ perceptions of the project. In this community-level analysis, sustainability is modeled as a function of households’ and water committee members’ sense of ownership, while controlling for other factors known to influence water system performance.

Chapter 6 summarizes the main findings and describes the implications of this research for rural water supply programs throughout the developing world. This chapter concludes with a discussion of future areas for research in this field.

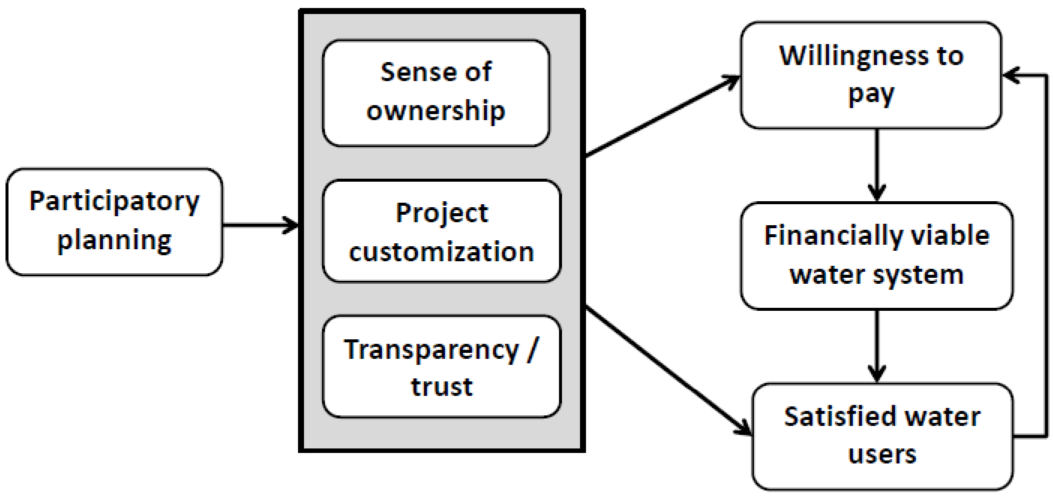
1.4 Tables

Table1-1 Handpump functionality in selected countries in sub-Saharan Africa (2009). Database available on the Rural Water Supply Network website: www.rwsn.ch.

Country	**Est. # of handpumps**	**# not functioning**	**% not functioning**	**Data source**
Angola	4,500	1,350	30%	UNICEF inventory
Benin	6,700	1,500	22%	
Burkina Faso	22,400	5,600	25%	UNICEF Country Profile
Cameroon	9,000	2,250	25%	Estimate J. Rihouey
DRC	1,500	1,000	67%	
Ethiopia	30,046	10,379	35%	DHS 2000/HP # calculated
Cote d'Ivoire	12,500	2,500	20%	UNICEF Country Profile
Guinea	12,500	2,500	20%	UNICEF Country Profile
Kenya	12,000	3,600	30%	DHS 2003/Estimates
Liberia	1,350	930	31%	UNICEF Country Profile
Madagascar	2,500	250	10%	
Malawi	19,000	7,600	40%	MICS 2000 + 2006/WHO
Mali	14,200	4,800	34%	UNICEF inventory
Mozambique	17,000	4,300	25%	Nat. Water Directorate Data
Niger	7,175	2,150	35%	Min. Hydraulics 2005 for # HP
Nigeria	80,000	40,000	50%	JMP and UNICEF
Sierra Leone	2,500	1,625	65%	UNICEF inventory/MICS2005
Uganda	30,000	6,000	20%	
Zambia	15,000	4,800	32%	MLGH estimate
Zimbabwe	38,200	11,400	30%	UNICEF inventory
TOTALS	**345,071**	**124,709**	**36%**	

1.5 Figures

Figure 1-1 Conceptual model of participatory planning and water system sustainability based on a review of the development literature.
Causal pathways are represented by arrows.



2 Points of a departure: A review of the literature

This literature review will be combined with the introduction presented in Chapter 1 and submitted as a review article to a refereed journal in Fall 2012. Jennifer Davis will appear as a co-author for her contributions to the literature search and manuscript improvements.

2.1 Abstract

Nearly one billion people globally are without access to an improved source of water. The greatest challenges are experienced in rural sub-Saharan Africa, where over half of the population currently lacks access to an improved water supply. Low rates of access in this region are in large part due to premature failure of existing water points. To confront the sustainability challenge, the rural water sector has shifted in recent decades to a participatory approach that emphasizes community members' participation in project planning and construction. Community participation in rural water projects includes households' contributions to the capital cost of the system and involvement in key planning decisions. We examine the evidence regarding the impact of community participation on the sustainability of water infrastructure and highlight key knowledge gaps within the literature. There is a need for more evidence on the specific forms of participation that lead to sustainable outcomes for water projects; a better understanding of the role that community members' sense of ownership for the water system plays in mediating the relationship between participation and water system performance; and scholarly agreement on appropriate and feasible performance indicators for the water supply technologies common to the developing world.

2.2 Key definitions

Rural community. A rural community is defined as a group of people who describe themselves as living together in a particular geographic area that is located outside of an urban or peri-urban zone. In this context, a rural community typically consists of 10,000 people or less. Communities contain a number of sub-groups relevant to rural water supply, including local leaders or elites, the water committee, women, *etc*.

Water system sustainability. This review borrows from the definition of rural water system sustainability offered by Carter *et al*. (1999): The uninterrupted delivery and use of the water from the system for the duration of the infrastructure's design life. Though they are outside of the scope of this review, issues related to water resource availability and ecosystem health are essential considerations for a comprehensive investigation of sustainability.[3]

Community participation. Community members may be involved in the planning, construction and ongoing management of the water system in a number of ways. Participation includes initiating the project by submitting an application to a water program that indicates a collective desire to receive an improved water supply; attending meetings related to the water system before, during, and after construction; voicing opinions and contributing to key decisions about project (*e.g*., the level of water service to be provided, tariff design, water committee membership, the hours of water service, *etc*.); making contributions to the capital cost of the project (*e.g*., cash, labor, land, materials, *etc*.); operating and managing the water system by serving (often on a voluntary basis) as a water committee member, tap attendant, caretaker, *etc*.

[3] A broader definition of rural water supply sustainability is presented by Harvey and Reed (2003) in *Sustainable rural water supply in Africa: Rhetoric and reality*: "The water sources are not over-exploited but naturally replenished, facilities are maintained in a condition which ensures a reliable and adequate water supply, the benefits of the supply continue to be realized by all users over a prolonged period of time, and the service delivery process demonstrates a cost-effective use of resources that can be replicated."

Technology options. We focus on improved water supplies, which the WHO-UNICEF Joint Monitoring Program (JMP) defines as "one that, by nature of its construction or through active intervention, is protected from outside contamination, in particular from contamination with faecal matter" [*Joint Monitoring Programme*, 2006]. From a practical standpoint, this is defined as the existence of piped water to the yard or home, a public kiosk, a borehole with a pump of some kind, a protected dug well or spring, or a rainwater collection system. Unimproved water sources—including surface water sources, unprotected point sources (e.g., wells, springs), and water delivered by mobile distributors (tankers and vendors)—are outside of the scope of this review.

Public vs. private water services. A public water point refers to a point source within the community such as a handpump or a public water kiosk. Water users often must stand in a queue at these sources and haul their water back to their homes. Private taps refer to water that is piped to yards or homes. Private taps may be used by one family (individual private tap) or more than one family (shared private tap). These water sources are located close to or within the home and there is no queuing for water.

2.3 Community participation and rural water system sustainability: Evidence of an association

Community participation aggregated

Following the adoption of demand-oriented planning in the water sector, several impact evaluations of rural water programs were conducted. These studies aimed to understand whether community participation improved project outcomes overall, so the variables of interest were typically presented as composite measures that aggregated several other variables.

Among the first of these studies is *Water for Rural Communities – Helping People Help Themselves* by Briscoe and Ferranti (1988), which describes the World

Bank's experience with rural water projects through the 1980s. In case studies from Kenya, Tanzania, and India, the authors summarize the challenges experienced by water programs that had assigned primary responsibility for designing and operating schemes to the national government. A major pitfall included the inability of governments to maintain subsidies or other forms of support to communities over the long term. In the absence of external support, isolated water committees were unable to successfully operate and maintain their water systems. In addition, many governments had assumed that the cheapest and simplest water supply scheme would be adequate for meeting the needs of households. In reality, many households were dissatisfied with the water service they had received and opted to use other sources of water. Water committees were unable to collect fees for water, and eventually these water points fell into disrepair [*Briscoe and Ferranti*, 1988].

By contrast, rural water programs in Thailand and Malawi had instead adopted a more participatory framework for planning, and water systems were reported to be functioning well several years after their installation. Communities within these programs had contributed cash and labor to the capital cost of the water system, the contribution amount depending on the level of service provided by the system. Community members were also made aware that they would be responsible for the ongoing operation and maintenance of their systems. Based on the findings of these case studies, the authors hypothesized that community participation ensured the sustainability of water infrastructure. They suggested that future research focus on testing for an association between the existence of community participation in rural water project planning and ongoing performance of the water project [*Briscoe and Ferranti*, 1988].

In one of the best-known of such quantitative studies, *The Contribution of People's Participation* (1995), Deepa Narayan draws on World Bank water project reports from 121 rural communities worldwide to investigate the extent to which community participation in the projects' planning is associated with project effectiveness. The main variable of interest, community participation, is defined as the extent of beneficiary control over the project during various stages of the project. The outcome variable, project effectiveness, incorporates measures of the project's construction quality, ongoing management, and benefits delivered to community members.

Composite scores for each project's level of participation and effectiveness were derived from a series of ratings available in the project reports. An overall score for community participation is an aggregate of ratings for both women's and all community members' involvement in design, construction, and system maintenance of the system (five items total). A project that featured only basic exchanges of information between the project team and community members received the lowest rating, whereas a project that granted community members exclusive control over project-related decisions received the highest rating. The composite measure for project effectiveness included ratings for the quality of the system's construction, the ongoing management of the system, households' knowledge about health and sanitation, and the extent to which benefits such as income generation had accrued to households.

The main finding from Narayan's study is consistent with Briscoe and Ferranti's results. Community participation was found to be positively and significantly associated with more effective water projects [*Narayan*, 1995]. A critique of this study includes that the ratings were subjective in nature and therefore lack external validity. Others raise concerns with internal validity, pointing out that the ratings within one World Bank project report are assigned by a single person, introducing the risk that s/he may be influenced to change the measure of one variable due to the observed state of another variable. Narayan and others confront each of these econometric objections in a subsequent publication, arguing that there remains strong statistical evidence that increasing beneficiary participation leads to better project outcomes [*Isham et al.*, 1995].

In another empirical study, Jennifer Sara and Travis Katz collected primary data in 125 rural communities throughout six countries in *Making Rural Water Supply Sustainable: Report on the Impact of Project Rules* [*Sara and Katz*, 1998]. To investigate the relationship between the degree of demand-responsiveness during project planning and the functionality of the water system over time, the authors conducted interviews with households, focus group discussions with water committees, and technical assessments of all water systems. A rating of 1-10 was assigned based on the degree of 'demand-responsiveness' of the project. This rating was created using a series of survey questions that probed whether households had initiated the project, the extent to which they were informed about choices related to the project, and how much they had contributed to its installation. A score for 'project sustainability' was similarly created by drawing on the systems' physical functioning, financial status, and consumer satisfaction with the service provided. Findings show that overall demand responsiveness varies across projects, and all else held constant, the demand-responsive approach is positively associated with sustainability [*Sara and Katz*, 1998].

Following on the large sample statistical analyses presented above, Manikutty (1997) use a comparative case study research design to examine the impact of community participation on project outcomes within two water programs. Both water programs were operating in Kerala, India simultaneously and were highly comparable in all ways except for their approach to community participation. The Danida program placed a strong emphasis on community members' participation in their water system's planning and operation. In this program, households had been involved in decisions about tap placement, local women had been being trained to chlorinate wells, the community had nominated a water management team, and everyone had received health and hygiene training. By contrast, the Kerala Water Authority (KWA) program included no such participation component. Manikutty describes the KWA program as "simply a water supply project, and the [Kerala Water Authority] engineers designed the project and located and constructed the facilities in their own way" [*Manikutty*, 1997]. Within the Danida communities, there were, on average, more functional taps, more households that were using the project source, more households that were satisfied with the project, more households practicing safe water storage, and better cost recovery for operation and maintenance.

The rich description provided by Manikutty contributes supporting evidence to the large-sample statistical analyses. Potential publication bias notwithstanding,[4] this body of literature presents a strong causal argument that community participation leads to better outcomes for rural water projects, as compared to the supply-driven approaches of the past. However, these studies defined participation somewhat coarsely and inconsistently, did not attempt to compare the various elements of the participatory process against each other, and potential causal mechanisms that explain how participation leads to better projects were not explored. Indeed, little could be said beyond "participation is better than no participation," and the field was left open for further inquiry.

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Community participation disaggregated

More recently, studies have begun to tease out the relative contribution of different forms of community participation to rural water system sustainability. For example, Prokopy (2005) developed a tiered ranking system for classifying various forms of household participation based on the level of control over the project conferred to the community. In a study of 45 Indian villages with various types of water schemes, she finds that households' cash contributions to the capital cost of the project (low control) and involvement in project-related decisions within pre-defined limits (medium control) are both significantly and positively associated with outcomes of household satisfaction, equality of access, and time savings [*Prokopy*, 2005].

Nance and Ortolano (2007) conducted a comparative case study of seven communities in Recife and Natal, Brazil that experienced varying levels of participation in condominial sewer projects[5]. A purposeful sampling approach is

[4] A note on publication bias: many of the studies presented in this section are published by and for a practitioner audience, and unfortunately there was little incentive (and most likely a disincentive) to report findings from failed water projects.

[5] This study is focused on sanitation in urban areas, but the nature of the intervention, as well as the ways in which participation and performance were measured, are similar to rural water supply studies. As such, we chose to include the findings of this study here.

employed to target illustrative cases of good and poor project outcomes and high and low levels of community participation [*Geddes*, 2001]. Communities were assigned a performance score based on their project's relative operational effectiveness and beneficial impact on the community.

The authors find among communities with high performance scores, households had consistently undergone mobilization (*i.e.*, involvement in activities to express or generate demand for the project) and participated in decisions related to the project [*Nance and Ortolano*, 2007]. However, households within these high performing communities had contributed to construction and maintenance activities to differing degrees, and no clear relationship was apparent. By contrast, the single poor performing community had contributed much to construction and maintenance, but had not been mobilized, nor given the opportunity to participate in project-related decisions. These findings suggest that pre-construction demand generation and community consultation are necessary (though possibly not sufficient) ingredients for achieving sustainable outcomes for sewer projects, whereas community participation in labor-related activities is not positively associated with sustainability.

Other studies have focused specifically on the role that decision-making by community members plays in determining project outcomes. Gross et al. (2001) examined the precursors of good project outcomes in 88 rural communities with water supply infrastructure that had been installed three or more years prior to the study. The authors hypothesized that projects that had incorporated the input of poor women, poor men, well-off women, and well-off men throughout the planning and construction process would be more likely to deliver effective and sustainable water services than those projects that had excluded these groups.

The 'effectiveness' of water services was approximated by measuring the percentage of households with access to the system, the percentage that uses the project as their main drinking water source, and the existence of a proper drainage scheme. 'Sustainability' was measured in terms of the extent of cost recovery for routine operation and maintenance, the time until breakdowns are repaired, and whether users feel the quality and quantity of the water is adequate for domestic purposes. The authors find strong positive associations between the extent to which all groups (poor and well-off, men and women) had been involved in making informed choices about the project, and the sustainability and effectiveness of the services provided [*Gross et al.*, 2001].

To investigate the *types* of decisions that matter for sustainable outcomes, Khwaja (2004) conducted a cross-sectional study of 132 infrastructure projects across rural Pakistan[6]. The outcome variable in this study is called 'project maintenance,' a composite variable that draws on the technical functioning of the project at the time of the study. He finds that households' involvement in non-technical decisions, such as choosing among options for managing and financing the project, is positively associated with project maintenance. Households' involvement in technical matters such as choosing the technology type or site for the project is found to be detrimental to project maintenance [*Khwaja*, 2004].

Table 2-1 summarizes the findings from the known studies that investigate the effect of different forms of community participation on project sustainability throughout the developing world. Though the number of studies investigating the impact of different forms of participation on project outcomes is relatively low (especially if limited to rural water supply projects), a few key themes are observed in this body of literature. First, it is clear that all forms of community participation are not equal in terms of their ensuring sustainable outcomes. In each study, different forms of community participation showed positive or negative associations with sustainability to varying degrees. Second, among the studies investigating the impact of different types of upfront contributions to the project, it is noted that contributions more directly linked to households' demand (cash rather than labor) are positively associated with project sustainability. Finally, studies that focus on the extent of control households have over key decisions about the project report that project outcomes are better when the decision-making process is inclusive of women and the poor, and is non-technical in nature.

[6] Khwaja (2004) includes several types of infrastructure projects in his sample, including rural water supply projects.

Based on the evidence above, a key knowledge gap is apparent. Whereas the above studies have focused on different forms of community participation, none have attempted to employ a comprehensive set of indicators for the many ways in which community participation takes place. For predicting sustainable outcomes, how does the share of households that contribute cash compare to the share of households that contribute labor? Is there a threshold level of contribution that matters, in terms of the amount of money or the number of days of labor? Do *other* forms of community participation matter, such as attending meetings? There is a need for a study that examines and directly compares the many forms of community participation as possible determinants of project sustainability.

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Measuring and monitoring sustainability

It is also important to note that the studies described in this review measure water system sustainability in a number of ways. Some studies choose to simply use a single indicator, in this case whether or not the infrastructure is physically functioning at the time of the study (for example, Komives *et al.*, 2006). A more popular approach has been to develop a sustainability index based on a composite score of two or more measures of water system performance over time [*Gross et al.*, 2001; *Isham and Kähkönen*, 2002; *Khwaja*, 2004; 2009; *Narayan*, 1995; *Prokopy*, 2004; *Sara and Katz*, 1998]. Still others opt for multiple indicators of sustainability to present a more nuanced picture than is possible using a single indicator, while avoiding possible difficulties with interpreting composite indices [*Davis et al.*, 2008; *Kleemeier*, 2000; *Manikutty*, 1997; *Prokopy*, 2005].[7] Among studies employing the latter approach, it is often the case that indicators do not align perfectly, e.g., systems that are technically functioning are not achieving recurrent cost recovery [*Davis et al.*, 2008].

[7] Interestingly, results from the latter category of studies show that different conceptions of water system sustainability do not necessarily align, for example physically functional systems may not be collecting any water payments at the time of the study.

To date, however, there appears to be no standard set of sustainability indicators, which would allow for comparisons to be made across projects and programs.[8] No studies to date have employed a set of indicators that capture the breadth of factors influencing water service delivery, including technical-, environmental-, and service-related aspects. Instead, most studies focus on technical and service aspects only, and bypass any measures related to the responsible management of limited water resources. It is thus unclear to date how accurate, reliable, and holistic measures of sustainability can be derived and promoted for the purposes of drawing comparisons across studies.

2.4 Causal mechanisms

There are three main causal pathways that are assumed to explain how the participation process leads to water system sustainability. First, the participation process increases the transparency of the planning activities surrounding the water project, which encourages trust between community members and the project team. Transparency and trust lead to greater satisfaction with the project among water users and willingness to pay for the services received. Second, the dialogue that occurs between the project implementers and beneficiaries leads to a customized project design that is based on local expertise, and thus is better suited for operating under local conditions. Third, community members' participation in the planning and construction process is believed to lead to their collectively feeling a sense of ownership for project. Such a sense of ownership, it is argued, is essential for ensuring that community members will be willing to operate and maintain the system over the long-term. This section will briefly review the relevant empirical evidence for each causal argument.

[8] There is a large extant body of research evaluating the performance of water supply systems in industrialized settings. By contrast, for the relatively simple systems found throughout rural areas of the developing, much less prior research exists.

Transparency and trust

A participatory process typically includes regular community meetings about the water system. These meetings enforce accountability among water users and the water committee through reporting of financial matters and discussion of water tariffs [*Isham and Kähkönen*, 2002]. Van Wijk-Sijbesma (1998) summarizes the importance of community-level accountability and trust in successfully managing a water system:

> Where users pay for a service, accountability for proper delivery and management becomes very important. Where such accountability is not arranged for properly, the risk grows that users lose trust…Users generally have little insight into the types and amount of expenditure required for water provision. Accounting for the amount of funds available, the ways they were spent and the performance of the system, as well as budgets and tariffs for covering next year's costs helps users gain better insight and contributes to a system of control and encourages trust [*van Wijk-Sijbesma*, 1997].

At the project level, Prokopy's (2005) study of 45 water projects in rural India finds that community-level transparency is an important covariate of system sustainability. In this study a composite transparency measure was created from several variables, with weights assigned using principal components analysis. The variables include the share of households that were aware that they would be responsible for the system's operation and maintenance before construction; the share that know how the water tariff is set; the share that know whether other households pay fees for water; the share that know what happens at committee meetings; and, the share that know someone on the committee [*Prokopy*, 2005]. However, it is noted that this study employed an observational research design, and at the community level it cannot be known with certainty which direction causality is flowing, *i.e*., does participation lead to better transparency, or does transparency make participation possible?

Empirical evidence from a study of 132 infrastructure projects in rural Pakistan approximates project-level transparency by measuring the distribution of benefits from the project [*Khwaja*, 2009]. A variable for project share inequality was derived using a GINI index that captures how project returns were distributed among community members. The project performance measure was the unweighted average of three variables measured on a 0-to-100 scale: the percentage of the project that is in its initial physical state, the extent to which the initial project purpose has been satisfied, and the extent of maintenance work required at the time of the visit. Khwaja finds that the relationship between maintenance and the distribution of project benefits is defined by a U-shaped curve. That is, maintenance is best within communities with either a highly equal or highly unequal distribution of benefits from their projects, and maintenance is worst in communities where the distribution of benefits is neither highly equal nor highly unequal.

On the program-level, Gross *et al*. (2001) find that rural water projects in 88 communities in 18 countries are better sustained when women and the poor are meaningfully engaged in the participatory process. Involvement of these traditionally marginalized groups, the authors argue, promotes equity and enforcement of project rules [*Gross et al.*, 2001]. In the comparative case study of two rural water programs in Kerala (detailed above), Manikutty (1997) noted that within communities with a strong participation component, water committees had publicly posted the proposed tap locations for the new system as it was being planned. Community members were encouraged to provide feedback on the proposed scheme, and changes were made iteratively as needed. As compared to communities that did not allow for such input from households, these high-transparency communities had water systems that were functioning much better years after installation. Manikutty suggests that this process had ensured that households' opinions were heard, elite capture of local water resources was avoided, and thus water users were more satisfied and willing to pay for the water services [*Manikutty*, 1997].

At the national-level, a study of Uganda's water sector finds that politicians are not "walking the talk" as they make promises to deliver rural water supply improvement but often fail to follow through [*Quin et al.*, 2011]. These authors suggest that local planning processes adopt reforms holding their local political representatives accountable.

Project customization

Existing empirical studies of household demand for rural water services show that households often prioritize improved water supply to such an extent that they are willing to pay more for service improvements than many project engineers assume. For example, just prior to the installation of communal water points in Lugazi, Uganda, Whittington et al. (1998) conducted a rapid appraisal of household demand for improved water services, including a contingent valuation survey of their willingness to pay for different types and levels of service.

The authors find that households consider a safe and reliable water supply to be their top priority within the community, and that many were willing and able to pay the full cost of private connections to their homes [*Whittington et al.*, 1998]. They conclude that, had the implementing agency adopted a more flexible and collaborative approach to planning, a broader set of design options would have been revealed based on households' preferences.[9] On the other hand, if households are bypassed during the planning process as they had been in this case, then the installed system is unlikely to match what they want and are willing to pay for. This leads to a serious risk of the system being under-used, or even completely abandoned.

A similar story was illustrated by Isham and Kähkönen (2002) in their study of 44 Indonesian communities that had received water supply systems under the auspices of a demand responsive program. Contrary to program specifications, the authors find that project implementers had largely cut corners during the planning phase by consulting with village leaders instead of households. The village leaders were more likely to choose communal water points (the most inexpensive service option) from the menu of technology choices, whereas households most often chose private piped connections. The authors conclude that village leaders assume, just as external parties had done in the Lugazi project, that poor households prefer the cheapest technology

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[9] Of course a water supply scheme is a complex and dynamic system, with real limits in terms of the available resource and number of users it can support, so household demand must be met within the constraints of technical and environmental feasibility.

options. In fact, these households expressed demand for the more convenient, more expensive option. For those villages where the installed scheme matched users' felt needs and preferences, households were on average more satisfied with the project, more likely to report improved health since its installation, and the infrastructure was better maintained in the short run [*Isham and Kähkönen*, 2002].

Community sense of ownership – from case studies to theory

Practitioners and scholars widely cite the importance of participatory planning for instilling a sense of ownership for the water system among community members (for illustration: [*Bakalian and Wakeman*, 2009; *Breslin*, 2003; *de Regt*, 2005; *Garn*, 1997; *Gross et al.*, 2001; *Harvey and Reed*, 2003; *Isham and Kähkönen*, 2002; *Katz and Sara*, 1998; *Komives et al.*, 2006; *Manikutty*, 1997; *Mundial*, 1996; *Sara and Katz*, 1998; *The World Bank*, 2006; *Whittington et al.*, 2009; *World Bank*, 2003; *Yacoob*, 1990]). Community members' sense of ownership for the project, it is argued, is essential for ensuring that the community will assume responsibility for ongoing operation and management of the system after its installation. The importance assigned to this pathway to sustainability is summarized by Yacoob (1990):

> Many factors enter into sustainability, and there are continual shifts in the conceptual paradigm. However, a key factor for small, rural systems appears to be community ownership and responsibility for the system. The greatest manifestation of this sense of ownership is held to be willingness to use, operate and maintain the system properly [*Yacoob*, 1990].

Empirical evidence related to community sense of ownership for the system is sparse and anecdotal. For example, Sara and Katz (1998) find that poorly performing water systems within a six-country study often served households that reported feeling no ownership for it. In one such community, the authors note that "there is no sense of ownership about the [project]. Almost all the respondents said that the scheme belongs to World Bank, not to the community" [*Sara and Katz*, 1998]. In another case, they write "…community members often expressed dissatisfaction with the service, possessed a low sense of ownership, and had little willingness to pay for the maintenance of the service" [*Katz and Sara*, 1998].

In another case study drawn from a sample of 121 rural water supply projects, Narayan (1995) describes how community participation and sense of ownership explain the observed success for one project:

> The CARE project staff had extensive dialogues with the community before construction began—which had not happened with previous projects in the area—and community members themselves worked to construct the water system. After construction was completed, community members expressed a strong sense of ownership and responsibility for the water systems. Users have since carefully maintained the premises and have protected the installations from vandalism, in marked contrast to their treatment of previous water systems constructed by outsiders [*Narayan*, 1995].

Manikutty (1997) contributes further evidence by comparing communities that had and had not participated in the planning of their water system:

> In villages [that had participated], the caretakers and water committee members…followed up the repairs [and] fairly good records were also kept. The members of the community we spoke to said that they were 'their taps' and if they were not functioning properly, this was not in their interests…In contrast, in [projects without any community participation], there was no such sense of ownership. It was 'their (i.e. the government's) job' since the facility was 'theirs': a typical attitude towards facilities provided by the government [*Manikutty*, 1997].

Some authors have attempted to identify a particular form of participation that is best suited for building sense of ownership. For example, Isham and Kähkönen (2002) hypothesize that "…contribution to construction by each household is likely to promote the sense of common ownership of the service, thereby increasing households' willingness to maintain it. This leads to improved performance." In contrast, Gross et al. (2001) claim that “users derive their sense of ownership and responsibility for sustaining their services from exercising control over planning, financing and constructing the facilities, and then having the services managed to their satisfaction” [*Gross et al.*, 2001]. The World Bank’s Water and Sanitation Program (WSP) in Pakistan likewise attributes the success of several rural water projects to flexible financing mechanisms, since “implementation responsibilities for communities strengthen ownership and sustainability” [*World Bank*, 2003].

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As case studies like those described above accumulate, the literature has come to offer generalizations regarding the importance of community sense of ownership in rural water supply planning. For example, Garn attributes the failed projects of the 1980s to a centralized planning model in which “intended beneficiary communities had no role in determining design and service level issues; no financial stake; and no sense of ownership” [*Garn*, 1997]. Whittington et al. (2009) echo Garn with a summary of projects installed in Bolivia, Peru, and Ghana in the 1980s:

> …regardless of the type of technology utilized, systems were not being repaired and were falling into disuse. Cost recovery was minimal and revenues were often insufficient to pay for even operation and maintenance, much less capital costs. Communities did not have a sense of ownership in their water projects and households were not satisfied with the projects that donors and national governments installed [*Whittington et al.*, 2009].

Harvey and Reed (2006) summarize failed rural water projects throughout sub-Saharan Africa in the following way: “Many of the reasons for low levels of sustainability are related to community issues such as limited demand, lack of affordability or acceptability among communities, [users] perceived lack of ownership, limited community education, and limited sustainability of community management structures” [*Harvey and Reed*, 2006].

In addition, the literature concerned with 'best practices' for employing a demand-oriented water program have followed suit. A widely cited handbook on participatory methods in development describes how community stewardship of irrigation and drinking water systems will follow "when farmers feel a greater sense of ownership" [*Mundial*, 1996]. In a review of World Bank water programs that had incorporated participatory planning, de Regt (2005) emphasizes that an iterative and adaptive process is necessary, and "at the community level, it is important to include community groups early in the project design, so they have a sense of ownership of the development process" [*de Regt*, 2005].

Governments, too, have adopted this rhetoric, as seen by recent water policy documents in many developing countries that mention the importance of ensuring community sense of ownership for projects. For example, Tanzania's 2002 National Water Policy states that sector reforms shall strive to impart "communities with a feeling of ownership of sustainable water supply schemes" through their direct involvement in planning, design, and construction [*United Republic of Tanzania*, 2002]. The Government of Mozambique writes in the *Manual de Implementação de Projectos de Água Rural*:

> In order to guarantee the sustainability of the services, the responsibility for managing water points must be given to the communities, while the supply of goods and services is left to the private sector. It is expected that this will lead to the reinforcement of the sense of ownership of the water points by the users, allowing the government to concentrate on its ruling and regulating duties [*Republic of Mozambique*, 2001].

The received wisdom surrounding the linkages between community participation, sense of ownership for the installed system, and water system sustainability is widely accepted throughout the sector. Yet the empirical evidence to date is based on isolated cases and inconsistent methodologies, as there has been no rigorous investigation of this causal pathway. Specifically, there is a need for research that provides an empirical referent for community sense of ownership, so that this psychological state may be measured among community members. Next, research that sheds light on the determinants of community sense of ownership for their water system is needed, with a particular focus on community members' participation in the system's planning and construction. Development of a reliable measure for community sense of ownership for the system would also allow for a quantitative comparison between this factor and others known to influence the sustainability of rural water systems (see Appendix A for a summary of factors known to influence the sustainability of rural water systems in the developing world). Such a comparison would reveal the relative contribution of this hypothesized causal pathway to sustainability.

Finally, it's important to note that existing case studies have not considered the possibility that different groups within the community may matter more than others in terms of the level of ownership they feel for the water system. The extant literature treats communities as homogenous organizations, typically emphasizing that sense of ownership for the project must be instilled among all community members. Yet at least one study on rural water supply development has established that "communities exist, but they are not homogeneous, nor are they islands" [*Schouten and Moriarty*, 2003]. An important area of future research will be to consider different community groups' sense of ownership for their water system *vis-à-vis* the water system's performance.

2.5 Lessons from the 'psychological ownership' framework

Whereas the development literature offers little in terms of a framework for rigorously investigating the knowledge gaps highlighted above, scholarship in the field of organizational and management science can provide a useful starting point. In this section, we briefly review the literature on a social psychological phenomenon called *psychological ownership* (PO), introduced but Jon Pierce and others [*Pierce et al.*, 1991; *Pierce et al.*, 2001]. Pierce et al. (2001) define PO as "that state in which individuals feel as though the target of ownership (material or immaterial in nature), or a piece of it, is 'theirs'". Van Dyne and Pierce (2004) later specified psychological ownership of organizations as an area of particular interest, and developed a means of measuring this phenomenon using seven Likert-scaled attributes, shown in Figure 2-1. PO proved to be conceptually distinct from other constructs (e.g., satisfaction) after undergoing rigorous statistical tests and the scrutiny of experts in the field [*Van Dyne and Pierce*, 2004].

Empirical studies of PO lend insights to a better understanding of how community sense of ownership may shape outcomes for rural water services. Van Dyne and Pierce (2004) hypothesize that PO for the company explains variation in employee attitudes and behaviors related to their jobs. They test their hypotheses using data from over 800 structured interviews with, and observation of, employees in a variety of industries. The authors find that that PO is positively associated with employees' job satisfaction, level of commitment to their jobs, organization-based self-esteem, and volunteering to do extra tasks related to their job. In addition, regression analysis reveals that PO increases explained variance in self-esteem and volunteering over and above the effects of other psychological constructs [*Van Dyne and Pierce*, 2004]. However, in these models PO is not significantly associated with overall employee productivity, which is consistent with findings of a recent meta-analysis of the field [*Pierce and Rodgers*, 2004]. Vandewalle et al. (1995) reinforce the link between volunteerism and PO by showing that students' PO for a university housing cooperative was positively associated with their willingness to engage in meetings or organize orientation activities [*Vandewalle et al.*, 1995].

Whereas the above empirical studies focus on the hypothesized consequences of PO (job performance, volunteerism, etc.), there is only one known study that examines its hypothesized determinants. Paré et al. (2005) examined the extent to which physicians' participation in the development of a new clinical information system relates to their acceptance of the technology, with PO as the hypothesized mediating factor. In this context, participation involved serving on a steering committee, testing the system in a laboratory setting, helping with configuration of the system, and supporting colleagues during the integration phase. They find that those physicians that had participated in the development process embodied PO for the new technology, perceived it to be useful for their job, and expressed a positive attitude regarding adoption of the technology [*Paré et al.*, 2005]. Extending the findings of this study to rural water services suggests that community members' involvement in the development of their water system will lead to their enhanced sense of ownership for it. Moreover, feelings of ownership may in turn cultivate users' positive perceptions about the service received.

In summary, empirical research on PO suggests that for rural water supply, sense of ownership among community members may relate to their confidence and commitment level to the system, their satisfaction with the water service, and their willingness to perform certain duties on a voluntary basis. However, based on the PO literature, extrapolations regarding the effect of sense of ownership on overall performance of the water system are more difficult to make. In addition, these results suggest that PO may also vary among community members using the same water system.

Whereas physicians' offices and other workplaces within the U.S. are quite a different type of organization than rural communities in Africa, the approaches used by these authors to investigate PO may be adapted to a different cultural context. Indeed, Van Dyne and Pierce (2004) write, "our study is bounded by cultural and geographic factors. Future research should examine psychological ownership in […] non-Western settings where cultural values such as collectivism and role obligations may [differ]." More recently, a theoretical article arguing for the possibility of *collective* psychological ownership has been put forth [*Pierce and Jussila,* 2010], though there is no known empirical study to date.

2.6 Summary and key knowledge gaps

Existing empirical studies have provided the foundation for understanding how participatory planning leads to sustainability of water systems in rural communities throughout the developing world. First, it has been established that participatory planning improved the sustainability of water systems as compared to the centralized, supply-driven approaches of the past. It has also been shown that, under various circumstances, some forms of community participation are stronger predictors of sustainability than others forms.

Understanding of the causal mechanisms that explain the link between participation and sustainability is growing. Hypothesized mediators include enhancing the transparency of the planning and operation of the water system, customizing the water system to better meet users' needs and preferences, and instilling a sense of ownership for the water system among community members.

This review reveals several important knowledge gaps, which are the focus of the remaining chapters of this dissertation. First, most studies define participation coarsely and inconsistently, missing an opportunity to disaggregate this measure into its various forms for comparison purposes. There is a need to develop a comprehensive set of indicators for the many forms of community participation, as well as the many dimensions of water system performance. Using these indicators, it would then be possible to investigate the extent to which the various types and degrees of community participation in this context lead to sustainable water service delivery.

Second, there is a need for research that investigates the hypothesized associations between community participation, sense of ownership for the installed system, and system sustainability. Within the development literature, the existing evidence regarding this causal mechanism is based on isolated observations and inconsistent methodologies. Moreover, all studies to date have treated the community as a homogeneous entity and failed to consider the possibility that different groups within the community may matter more than others.

We propose that a more rigorous investigation of community members' sense of ownership for their water system may begin with the psychological ownership framework developed by scholars of organizational behavior. Using this framework, it is possible to develop an empirical measure for community members' sense of ownership for their water system. This measure may be applied to a quantitative investigation of the determinants of community sense of ownership for the water system, with a particular focus on community members' participation in project planning and construction. In addition, there is a need to understand the extent to which variation in the water system's performance is explained by community members' sense of ownership for it. For each stage of this investigation, examining the various sub-groups of the community is likely to provide valuable insights.

In summary, future research efforts should focus on testing for associations between various forms of community participation and various aspects of water system sustainability; developing a rigorous measure for community sense of ownership for the water system; investigating which form of participation lead to a sense of ownership for the water system; and finally, examining the empirical relationship between community sense of ownership and water system sustainability (Figure 2-2).

2.7 Tables

Table 2-1 Summary of the literature that investigates the effect of different forms of participation on rural water supply projects

	Sustainability measured as…		
Type of community participation	**Infrastructure status** (e.g., handpump functioning, % taps working, etc.)	**Financial status** (e.g., cost recovery, fees collected regularly, etc.)	**Water user status** (e.g., satisfaction, using the system, equal access, etc.)
Cash contributions			Prokopy (2005) – *cash, any level*
Labor contributions			Isham and Kähkönen (2002) – *public wells only*
Attendance to meetings about the water system			
Decision-making	Khwaja (2004) – *non-technical decisions only* Nance & Ortolano (2007) Gross et al. (2001) – *decisions inclusive of women and the poor*	Gross et al. (2001) – *decisions inclusive of women and the poor*	Prokopy (2005) – *more than one decision* Nance & Ortolano (2007) Gross et al. (2001) – *decisions inclusive of women and the poor*

2.8 Figures

Figure 2-1 Seven-item measure for psychological ownership of the organization. From Van Dyne and Pierce (2004), *Psychological ownership and feelings of possession: Three field studies predicting employee attitude and organizational citizenship behavior*.

Psychological ownership

Instructions: Think about the home, boat or cabin that you own or co-own with someone, and the experiences and feelings associated with the statement 'THIS IS MY (OUR) HOUSE!' The following questions deal with the '**sense of ownership**' that you feel for the organization that you work for. Indicate the degree to which you personally *agree* or *disagree* with the following statements.

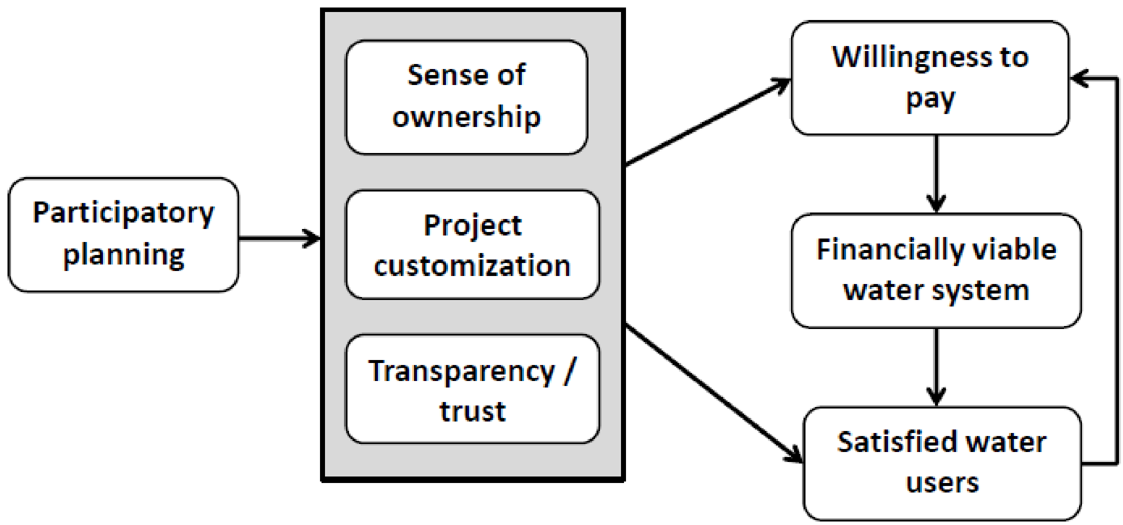
Item

1. This is MY organization.
2. I sense that this organization is OUR company.
3. I feel a very high degree of personal ownership for this organization.
4. I sense that this is MY company.
5. This is OUR company.
6. Most of the people that work for this organization feel as though they own the company.
7. It is hard for me to think about this organization as MINE. (reversed)

Figure 2-2 Conceptual model for community participation in rural water supply planning
Dissertation chapter themes are shown in boxes.

Ch. 3: Which forms of community participation lead to water system sustainability?

Ch. 4: Can community sense of ownership for the water system be measured?



Ch. 4: Which forms of community participation instill a sense of ownership for the system among community members?

Ch. 5: To what extent does community sense of ownership ensure water system sustainability?

3 Community participation and handpump sustainability in Ghana

This chapter will be submitted as an original research article to the Journal of Planning Education and Research in May 2012. The tentative title is "Evaluating the role of community participation in sustaining handpumps in rural Ghana." Jennifer Davis will appear as a co-author for her contributions to study design, data interpretation, and manuscript improvement.

3.1 Abstract

Community participation in the planning and construction of water points in the developing world is widely thought to lead to project sustainability. However, to date there is little understanding of the forms of participation that matter most for ensuring better project outcomes. We investigate the extent to which different forms of community participation explain variation in handpump sustainability using data collected in 200 communities throughout rural Ghana. Data sources include 5,000 household surveys, and structured interviews with the water committee, village leaders, and women. An engineering assessment of the handpump was also completed in each community. The mean number of pre-construction meetings attended by households and the mean cash contribution to the project are each positively associated with handpump sustainability. Measures of the breadth of participation within the community, including the share of households contributing any money and attending any meetings, are not strong covariates of sustainability. In addition, we find that project outcomes are better, all else constant, within communities where a greater share of households made management-related decisions and worse within communities where more households made technical decisions about the project. Other variables are found to explain variation in sustainability above and beyond participation, including the presence of post-construction support and having fewer

people per borehole. These results suggest that different forms of participation matter more than others in terms of ensuring sustainable outcomes. Provision of other programmatic features, such as ongoing post-construction support, is also an important consideration for rural water programs in sub-Saharan Africa.

3.2 Introduction

It is estimated that some 780 million people worldwide do not have access to an improved water source, with more than one third of the unserved lived in rural sub-Saharan Africa [*Joint Monitoring Programme*, 2010b]. Each year, governments and donors invest nearly $8 billion in water and sanitation infrastructure in this region, with a substantial share of this investment being put toward wells with handpumps [*Banerjee and Morella*, 2011]. Under ideal circumstances a handpump provides communities a safe supply of drinking water that is more convenient to access than unimproved water sources. Yet if the handpump breaks down before the end of its useful life these potential benefits are not fully realized, which is the case for an estimated 36% of shared water points throughout sub-Saharan Africa [*Rural Water Supply Network*, 2009].

In an attempt to tackle the persistent challenge of maintaining sustainable rural water points, planners have shifted in recent decades from a supply-driven, centralized planning process toward a demand-oriented approach. This approach emphasizes community participation in all phases of the project cycle and vests community members with key decisions related to technology choice, pricing, and management [*Narayan*, 1995; *Sara and Katz*, 1998]. In theory, demand-oriented planning directs scarce resources toward those communities that are relatively more willing and able to maintain new water infrastructure, thereby improving system sustainability over the long-term [*Garn*, 1997].

In practice, a demand-oriented approach typically includes a contractual agreement between the relevant government body and each community which details the community's responsibilities. These responsibilities include contributing some share of the initial capital cost of the infrastructure (typically through a mix of cash and labor); financing ongoing operation and maintenance of the system (typically 100%); and participating in meetings and trainings related to the project. During community meetings households are also expected to evaluate and choose among several options for their water infrastructure, such as the location of handpumps or the water tariff structure. Communities are also typically required to identify a set of residents willing to serve on a water committee that oversees operation and maintenance of the water point(s), often on a volunteer basis.

Engaging community members in water services planning through these activities is hypothesized to improve service sustainability through several causal mechanisms. The "demand filters" of capital cost and labor contributions help to ensure that communities with a strong interest in improved water supply, as well as the willingness and capacity needed to maintain installed infrastructure, are those prioritized for investments [*Garn*, 1997]. Community members' participation in key decisions about the type of service to be delivered and the local management regime helps to ensure that projects deliver the water supply services that communities actually want. Finally, community members' up-front investments in project planning are purported to engender a sense of ownership for the system and increase households' willingness to use and maintain it over time [*Yacoob*, 1990].

The association between a participatory approach to planning and improved outcomes for rural water projects is well documented in the empirical literature [*Briscoe and Ferranti*, 1988; *Isham et al.*, 1995; *Narayan*, 1995; *Sara and Katz*, 1998]. Comparatively few studies, however, have explored whether different forms of community participation matter more than others in terms of achieving better project outcomes. In an investigation of 45 rural water projects in India, Prokopy (2005) found that the share of households that had contributed money toward the capital cost of the system, as well as the share that had made decisions about the project, were positively associated with better water system performance [*Prokopy*, 2005]. Water system performance in this study is measured in terms of households' satisfaction with the project, experienced time savings, and equality of access within the community.

In another study of 99 community-managed infrastructure projects in Northern Pakistan, Khwaja (2009) found that households' involvement in non-technical decisions (e.g., usage rules, administration, etc.) was associated with better maintenance of projects. Households' involvement in technical decisions (e.g., infrastructure design, scale, etc.) was detrimental for project maintenance [*Khwaja*, 2009]. Finally, a study of 50 rural communities in Kenya revealed that households that made substantial cash contributions to their piped water project's construction and that had helped decide the level of service to be installed were more likely to feel a high sense of ownership for their water system [*Marks and Davis*]. Sustainability of these systems, however, was dependent on water committees' sense of ownership, as well as households' sense of ownership [*Marks et al.*].

These studies represent an important start toward understanding the forms of participation that matter for sustainable rural water supplies in the developing world. Whereas past research has considered the *breadth* of community participation, as measured by the percentage of households that participated in a particular planning activity, only the Kenya investigation focused on the *depth* of community participation, meaning the extent of engagement by a typical household in the community. The goal of the present study is to investigate how both breadth and depth of community participation is associated with handpump performance, using the case of Ghana, West Africa.

In the next section, we briefly review the rural water programs that were operating in two regions of Ghana at the time of the study. Next, section 3.4 describes the sample frame and data collection strategy. Section 3.5 presents findings on the sample characteristics, the type and extent of participation experienced by households, and the sustainability of the project handpumps (as measured by the condition of the infrastructure condition, the quality of the water service, and the ongoing management practices of the water committee). Next, handpump sustainability is modeled as a function of community members' depth and breadth of participation. Section 3.6 concludes with a discussion of the main findings of the study.

3.3 Study site: rural water supply in Ghana

Ghana has a population of about 25 million people, with 50% living in urban areas and 50% living in rural areas. The World Health Organization-UNICEF Joint Monitoring Program (JMP) estimates that the percentage of people with access to an improved water source in rural Ghana was 37% in 1990, and has since increased to 74% in 2008.

This progress has been made despite an average annual increase in the country's population of 2.5% over this period [*Joint Monitoring Programme*, 2010a].

Since the 1990s, national water policy in Ghana has included the goal of delivering effective and sustainable services to rural areas, where most of the country's unserved live, through a decentralized "demand-driven" approach [*The World Bank*, 2006]. The national Community Water and Sanitation Agency (CWSA) is responsible for coordinating and facilitating the activities of the rural water sector, as well as for providing management training to district assemblies who are responsible for planning and implementing rural water investments. Communities submit proposals for new rural water projects to the district assemblies; if a community's proposal is accepted, it is expected to form a water and sanitation committee and engage water users (especially women) in decisions regarding technology options and management choices [*The World Bank*, 2006]. Following construction of the project, communities are expected to operate and maintain the system, with district assemblies holding the infrastructure in trust.

This study takes place within 200 communities in the Volta and Brong Ahafo regions, where the Danish International Development Agency (Danida) and the World Bank's International Development Association (IDA) financed rural water programs, respectively. The Danida and IDA programs are comparable in the type of technology delivered (deep boreholes with manual handpumps) and in their approach to mobilizing community members. In both programs, capacity building during project planning included initial training in management skills for water committees and technical training for handpump caretakers. Community members were consulted about key decisions such as tariff design, water committee membership, and/or borehole siting. Communities were also expected to make contributions toward the capital costs of the water point, and to provide labor during its installation. The cost of installing a water point in this region is typically in the range of US$10,000-12,000 as of 2009 [*Whittington et al.*, 2009].

Communities in our sample also had access to several forms of post-construction support for maintaining their water points. The Danida-funded program in Volta included quarterly visits by environmental health assistants who provided technical and administrative assistance to water committees. Communities within both regions had access to the district water and sanitation team (DWST), which consisted of an engineer, a hygiene expert, and a community mobilizer. The DWST did not provide circuit rider visits, but would send a technician trained in routine maintenance and repair work if requested by a community. In addition, other *ad hoc* forms of post-construction support were available in certain districts, including grants provided by members of parliament or free repairs provided by non-governmental organizations [*Komives et al.*, 2008]. At the time of the study, the project boreholes had been installed for between four and eight years; 94% were working at the time of the study team's visit.

3.4 Methods: Sample frame development and data collection activities

Development of the study sample frame was driven by a prior investigation focused on post-construction (PCS) support for rural handpumps [*Komives et al.*, 2008; *Whittington et al.*, 2009]. The two study regions were chosen because they provided different forms of PCS to communities (Figure 3-1). Otherwise, they were similar in terms of water resources availability and the design and implementation of the rural water program. Within each region, districts were matched based on the available socio-economic data, with four districts selected within Brong Ahafo and five districts selected within Volta.

Within selected districts, community sampling was limited to communities that had received one or two boreholes with handpumps through the Danida or IDA programs at least four years prior to the study. Based on these criteria, 120 communities within Brong Ahafo and 97 communities within Volta were identified. In Brong Ahafo 103 of the 120 communities were randomly selected and all 97 communities within Volta were retained, for a total of 200 communities. At the time of the study (2005) the population within the sampled communities ranged from 200 to 5,000. Within each community 25 households were chosen at random for participation in the study.

Across the 200 sample communities, a total of 5002 household surveys, 195 group interviews with water committee members, 200 interviews of village leaders, and 200 focus group discussions with women were completed. In addition, a technical assessment of each community's water point(s) was conducted by district government engineers collaborating with the study team. All interviews were conducted in either Twi or Ewe languages. Field teams spent about one full day in each community to complete all data collection activities.

3.5 Findings

3.5.1 Sample characteristics

Village and household characteristics

The typical village in our sample contained 100 households and was 7 miles from a paved road (Table 3-1). Half of the sample villages had received one borehole and the other half had received two. Each borehole served a median of 177 people. In terms of social capital, an average of 45% of households said that they could borrow money from someone outside of their family, and the same proportion agreed that most people within their village are willing to help their neighbors if needed. Three quarters of households said that they trust their neighbors.

The typical household survey respondent was 43 years old and lived in a household with five other people (Table 3-2). Sixty-one percent of household respondents were women, and 64% of all respondents had at least a primary education. Households reported a mean monthly expenditure *per capita* of about US$13.60. The majority of households owned a radio and lived in a home with a cement floor and durable roofing material. Roughly half of the interviewed households were land owners, 14% had a working electricity connection, and virtually no respondents had cell phones at the time of the study.

On average, 95% of households within a sampled village reported using the project boreholes on a regular basis, although 38% also continued to collect water from unprotected sources during the dry season. The vast majority (94%) reported that they did not boil or filter their drinking water before consuming it. When asked about their main type of sanitation service, most households reported using a public latrine (45%), a private traditional pit latrine (16%), or defecating in the open (21%).

Water committees and external support

Most water committees (83%) reported undergoing some form of training since the handpumps were installed, although three quarters of the committees had not received any technical training within the past three years. In terms of managerial duties, most water committees reported being responsible for a variety of management functions including contacting area mechanics for technical assistance when needed (96%); maintaining a financial records and a maintenance log book for the water point (96%); facilitating training and education sessions for households within the community (81%); and resolving water use conflicts within the community or with other communities (90%). Water committees reported being responsible for relatively fewer technical tasks, including performing regular maintenance checks (70%); making minor repairs (51%); and ensuring that the water points remains clean (55%).

Post-construction external support played an important role in many of the sampled communities (Table 3-3). Since their water points were installed, nearly two thirds (67%) had received assistance with repairs, maintenance, or management matters. A quarter of the sample communities reported receiving such visits on a regular basis, and 17% had received a free unsolicited repair since the installation of the handpump. Despite the availability of such support, 39% of the water committees reported that it is difficult to get the area mechanic to come to the village when needed.

3.5.2 Community participation in planning and construction

Breadth of participation is measured in terms of the share of households that reported having been involved in a particular planning or construction activity. Depth of participation is measured in terms the amount of cash or labor contributed to the project, the number of meetings attended before the water system's construction, and the share of households that reported that the community had the most influence over project decisions.

Cash and labor contributions

On average, 52% of households within a community reported contributing cash toward the capital cost of the water point, and 25% reported contributing labor (Table 3-4). The typical household reported attending about three pre-construction meetings and contributing US$0.60 (equivalent to 7% of current average weekly expenditure). At the community level, a mean of 4% of the capital cost of the project handpumps was contributed by households. In terms of labor, the median contribution was less than one day, with only 18% giving one or more days. It was expected that labor contributions from households would be small for these projects, since installation of a borehole and handpump is relatively less labor-intensive as compared to the construction of piped water networks, which require extensive digging of trenches for pipes.

Households' decision-making

Across the sample communities, an average of 87% of households had attended meetings about the project before construction. Forty-three percent and 75% of households interviewed said that they had been involved in making technical and management decisions, respectively, about the project (Table 3-4). Technical decisions included choosing the type of handpump to be installed, identifying possible sites for the waterpoint(s), and choosing where to drill the boreholes. Management-related decisions included selecting water committee members, determining operating hours for the water point, establishing requirements for cash and/or labor contributions by households, and choosing a tariff structure for their water service. The average household was involved in 2.5 decisions about the water project, most commonly related to water committee membership and cash/labor contribution requirements.

When asked an unprompted question about which group or individual had the greatest influence in decisions about the water project overall, approximately one in five households responded that community members had the most influence. The majority of households (two thirds) reported that community leaders or the water committee had had the most influence over the project.

3.5.3 Sustainability of project handpumps

Sustainability was operationalized along several dimensions based on concepts presented in two previous studies of rural water supplies [*Davis et al.*, 2008; *Prokopy*, 2005]. First, *current infrastructure condition and functioning* was measured in terms of (1) whether all handpumps were functioning at the time of the study, (2) whether there had been an unexpected interruption in the water service during the six months prior to interview, and (3) the handpump platform's condition as recorded in the engineer's technical assessment. Second, the *quality of the water service* was evaluated using measures of (1) the share of households that reported being satisfied with their water service, and (2) the share of women focus groups participants that had collectively said they were satisfied with the operation and maintenance of their water point, and (3) the share of women focus group participants satisfied with the quality of water supplied by the handpump. Third, the *ongoing operation and management* of the water point was measured in terms of (1) community members' opinion about whether their water point will continue to function over the next 5 years, (2) revenue sufficiency for regular operation and maintenance expenditures, (3) expenditures as a percentage of capital costs, and (4) the share of water committee holding regular meetings with users.

Infrastructure condition and user satisfaction

In 89% of the sampled communities, all project handpumps were functioning at the time of the field team's visit; however, the water committees reported ongoing challenges with operating and maintaining their water points. According to village leaders, in the past six months nearly half of the communities (47%) had experienced at least one interruption in their water service that lasted one day or longer (Table 3-5). The median length of time before the water service was restored following an interruption was 14 days. In addition, more than one third of villages had handpump platforms judged to be in poor condition by the study team engineers.

Household satisfaction with the project handpumps was generally high. At the community level, an average of 78% of households reported being satisfied with the preventative maintenance of, repair services for, and committee's management of the water point. Similarly, 80% of women's focus group participants reported high levels of satisfaction with the operation and maintenance of their boreholes. In half of the sample communities women also collectively reported being satisfied with the pressure, taste, color, odor and safety of water obtained from the handpump.

Ongoing functioning and management practices

Water committee members and households were asked if they thought their water point would continue to function for one and five years from the date of the study. Most water committees (80%) believed that their handpumps would continue to function for one year, but only 56% thought that they would operate for five years. Households were more optimistic, with a mean of 89% and 76% expressing confidence that their handpumps would function after one and five years, respectively.

The likelihood of sustained handpump operation was also approximated by measuring revenue sufficiency for regular maintenance expenditures. In 71% of communities user fees for water were collected regularly; monies were collected "as needed" in 16% of communities and not at all in 13% (Table 3-6). A comparison of the revenues collected from users with the expenditures for operation and maintenance of each water point over the year prior to interview revealed that 56% of water committees were achieving recurrent cost recovery. However, 63% of water committees reported that they had collected sufficient user fees to cover all recurrent expenditures for the water point. This discrepancy between the calculated and reported revenue sufficiency suggests that financial bookkeeping was not perfect, that financial records differed from water committee members' perceptions, and/or that some water committees may have been considering other sources of revenue when answering the question.

The ratio of operation and maintenance expenditures to the capital cost of the system was also computed for each community. About one quarter of the water committees had spent at least 1%of the capital cost of the water points (US$110/handpump) over the past year; only 7% had spent the equivalent at least 2% of the capital cost of the water points (US$220/handpump) (Table 3-6). Just over half of the water committees spent US$25 or more in the year prior to interview, a value that has been proposed as a minimum for sustained operation and maintenance of a typical borehole/handpump system over the medium-term [*Baumann*, 2006].

Finally, we examine the frequency with which management committees hold meetings with water users in each community (Table 3-7). Nearly half (45%) of the water committees interviewed reported holding meetings with users on a regular basis; 27% held meetings "as needed," and 28% had not held any meetings with water users since the handpumps were installed. Among those committees holding regular meetings, a median of 6 meetings were held in the year prior to interview. Among all communities holding meetings (regular or as-needed), the water committee reported an average of 11-12% of community members attending. Women's participation in meetings was reportedly greater in communities whose water committees had held regular meetings, as compared to committees that held meetings on an *ad-hoc* basis.

3.5.4 Explaining variation in sustainability: regression analysis

This section presents the outputs of several multivariate regression models of handpump sustainability indicators as a function of community members' depth and breadth of participation. These models control for other factors that are known to influence the functionality of water points in rural settings, including households' socioeconomic status, the existence of secondary water sources within the community, and the water committee's access to post-construction support.

Infrastructure condition

None of the breadth of community participation variables described in section 3.5.2 is significantly associated with handpump functioning at the time of the study (Table 3.8, Model 1); however, as noted previously little variation exists in the value of this variable across the sample communities. Contrary to expectations, communities in which a smaller share of households reported attending pre-construction meetings are more likely to have handpumps with platforms in good condition ($p=0.04$) (Table 3-8, Model 2). Platform condition is also better, all else held constant, in communities where household reported being relatively more involved in management decisions ($p<0.01$) and relatively *less* involved in technical decisions ($p<0.01$). Depth of participation as measured by the average cash contribution within a community is negatively associated with both handpump functioning ($p=0.07$) and platform condition ($p=0.14$), although the latter is not statistically significant. No other indicator of depth of household participation was significant in models of infrastructure status.

All else constant, a community was 3.7 times more likely to have its handpump(s) functioning at the time of the interview if households reported using no other water sources during the dry season ($p=0.07$). The share of households that say they trust their neighbors is negatively associated with handpump functioning but positively associated with platform condition (both $p<0.01$). Finally, for water committees that had access to post-construction support through the DWST, the odds of having a handpump platform in good condition were five times greater, all else constant, than the odds of having a platform in poor condition ($p<0.01$).

Quality of water services

Models 3 and 4 identify covariates of households' satisfaction with the maintenance, repairs, and management of the water point, and whether or not women in focus group discussions reported being satisfied with operations and maintenance of their water points (Table 3-9). Households' satisfaction with the water service is lower, all else constant, as the share of households that reported being involved in technical decisions about the project increases ($p=0.02$). Holding all else constant, there is a 20% increase in the odds of women reporting being satisfied with operation and maintenance for every additional 10% increase in the share of households contributing cash toward the construction ($p=0.04$). All other breadth of participation indicators were non-significant in models of water service quality.

Household satisfaction is greater, all else constant, among respondents who attended a greater number of pre-construction meetings about the project ($p=0.05$). By contrast, women's satisfaction is negatively associated with the mean number of meetings attended by households ($p=0.06$). In both models, the share of households who said the community had the most influence over decisions about the project was positively associated with satisfaction (both $p=0.04$).

The odds of a household being satisfied with their water service is nearly two times greater in communities that receive regular post-construction support ($p=0.09$). Reported satisfaction is also significantly more likely in villages whose handpump was working at the time of the study. Household and women's satisfaction is lower, all else constant, in villages with more people per borehole ($p=0.07$ and $p<0.01$, respectively).

Operation and maintenance

Two final regression models explore association between participation and the financial health of the water points (Table 3-10). Specifically, the dependent variable in Model 5 is a dummy that takes the value of 1 if the water committee spent the equivalent of at least 1% of capital cost of the water point on operation and maintenance in the year prior to interview, and 0 otherwise (expenditure sufficiency). A full calculation for expenditure sufficiency for the hardware should include the operation and maintenance costs that were covered by the post-construction support team, but these data were not available at the time of the study. In Model 6 the dependent variable takes the value of 1 if water committee members reported having collected enough monies from users to cover all regular operation and maintenance expenditures in the year prior to interview (revenue sufficiency).

In each model, measures of the community's breadth of participation in planning and construction activities have limited explanatory power or were not statistically significant. All else held constant, the share of households that contributed cash to the project is negatively associated with ongoing financial sustainability ($p=0.09$ in Model 5 and $p=0.06$ in Model 6). The odds of a water committee reporting expenditure sufficiency is greater, all else constant, in communities where a greater share of households attended meetings before construction ($p=0.03$). However, the share of households attending meetings is negatively associated with revenue sufficiency ($p=0.03$). Revenue sufficiency is also 40% more likely, all else constant, for every 10% increase in the share of households had made management-related decisions about the project ($p=0.03$).

The mean cash contribution given by households is positively associated with financial sustainability in both outcomes ($p=0.04$ in Model 5 and $p=0.01$ in Model 6). The odds of a water committee reporting revenue sufficiency for operations and maintenance is greater, all else constant, in communities with a relatively higher mean number of pre-construction meetings attended by households ($p=0.02$). Revenue sufficiency is negatively associated, however, with the share of households reporting that the community had the most influence over key project decisions ($p=0.01$).

The likelihood that at operation and maintenance spending amounted to at least 1% of capital costs in the year prior to interview is negatively associated with household wealth ($p=0.05$) and with a village's receiving regular post-construction support ($p=0.04$). Expenditure sufficiency is also positively associated with a greater number of people per borehole ($p=0.02$). Finally, water committees in the Brong Ahafo region are significantly more likely to report collecting sufficient O&M revenues from users as compared to those located within Volta ($p<0.01$).

3.6 Discussion and conclusions

It is notable that almost 90% of handpumps were functioning at the time of the visit. This finding is surprising considering a recent estimate that, on average, 36% of installed handpumps in sub-Saharan Africa are not functioning at any given time [*Rural Water Supply Network*, 2009]. At the same time, in the six months prior to the study nearly half of the sampled communities had experienced an interruption in their water service that typically required two weeks to fix. Moreover, nearly half of the water committees were not collecting enough in user fees for water to cover ongoing regular operation and maintenance. These findings demonstrate the importance of operationalizing sustainability with multiple indicators that enable a comprehensive and nuanced understanding of handpump functioning.

This investigation is limited by its reliance on respondents' descriptions of events that took place within their community, often several years prior to the study. Moreover, the cross-sectional research design allows for the possibility of reverse causality. For example, within communities with a well-functioning water point, households may be more likely to report that they had the most influence over decisions during planning and construction. It is also difficult to explore the contribution of community participation to handpump functionality given the limited variation in several variables, particularly the functionality status of the handpumps and households' upfront labor contributions.

Given these caveats, the investigation suggests several insights. First, the depth and breadth of community participation have different relationships with sustainability outcomes. We find that the breadth of participation shows no or weak association with the handpump sustainability indicators used in this study. By contrast, depth of participation (*e.g.*, attending more pre-construction meetings, making larger cash contributions) is significantly associated various aspects of handpump sustainability. Notably, we find no evidence that labor contributions—either in terms of the share of households providing labor or the number of days the average household gives—are associated with better outcomes for handpumps.

Second, we find that project outcomes are better within communities where a greater share of households reported participating in management-related decisions and worse within communities with greater household participation in technical decisions about the project. This trend is observed for across several different management- and technically-oriented decisions, though the effect sizes in models of sustainability that control for confounding factors are relatively small. These findings are consistent with prior research on development project outcomes in rural areas of the developing world, and suggest that it is not in the best interests of project implementers to solicit input from households on matters that require engineering expertise.

Finally, we find that factors such the community's access to post-construction support services, as well as the number of people that use the handpump, are more consistent predictors of handpump sustainability outcomes. Interestingly, post-construction support is positively associated with better handpump platform condition and households' satisfaction with their water service, but is negatively associated with expenditure sufficiency for operation and maintenance of the infrastructure. This finding could possibly be explained by the fact that post-construction support programs may provide discounted or even free repair services, thereby reducing the amount of money water committees must spend to maintain their water point.

There are several lessons from this study for the rural water sector. Historically there has been a strong emphasis on community mobilization in the pre-construction phase of rural water projects, with such mobilization presumably ensuring the sustainability of water points. Yet the failure rate of handpumps across sub-Saharan Africa remains disappointingly high. The findings of this study do not support an argument for soliciting all forms of participation from every single member of a community. Rather, we find that only certain types of participation from households matter for sustainability, including the mean cash contribution toward the capital cost of the project and households' involvement in key decisions about the management regime for water point.

Above and beyond the effects of community members' participation in planning and construction, we find evidence that institutional support in the post-construction period is an important predictor of better project outcomes. Indeed, recent studies have brought to light the importance of post-construction support to rural communities for ensuring sustained service delivery in rural communities [*Davis et al.*, 2008; *Lockwood and Smits*, 2011; *Prokopy et al.*, 2008; *Schouten and Moriarty*, 2003]. These studies followed on a sector-wide shift from supply-driven centralized government provision of water services to a more decentralized demand-oriented approach that emphasized community participation in planning and construction. Despite marked improvements in functionality rates over supply-driven planning, community participation alone has failed to ensure the sustainability of rural water services.

Future research should strive to better understand the causal pathways that explain sustainable outcomes for rural water services, including the contributions of both community participation and post-construction support, as well as other programmatic inputs. The water sector is also in need of a standard set of indicators for monitoring water service performance over time, which would allow for the sharing of knowledge and lessons learned across different rural water programs. In this study we have attempted to contribute evidence to these two knowledge gaps by investigating the specific forms of participation that matter for various aspects of handpump sustainability, as well as other factors that explain sustainable outcomes.

3.7 Acknowledgments

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3.8 Tables

Table 3-1 Village characteristics

% villages with only 1 borehole (n=200)	50%
Number of users per borehole (n=184)	Median: 177 Mean: 212 St.dev.: 167
Population (households) (n=184)	Median: 100 Mean: 202 St. dev.: 226
Distance (km) to the nearest paved road (n=200)	Median: 7 Mean: 11 St. dev.: 13
% HHs reporting they can borrow money outside of immediate family (n=200)	Median: 44% Mean: 45% St.dev.: 20
% HHs that agree that "most people in village are willing to help if you need it" (n=200)	Median: 44% Mean: 45% St.dev.: 15
% HHs that say they trust their neighbors (n=200)	Median: 76% Mean: 75% St.dev.: 14

Table 3-2 Household characteristics (n=200)

Age of respondent (years)	Mean: 43 St.dev: 14
Gender of household survey respondents	Male: 39% Female: 61%
# of people per HH	Mean: 6.0 St.dev: 3.1
% households w/ at least one household head completing primary school education	Mean: 64% St.dev: 27%
Spending/month/cap (USD)[10]	Mean: USD 13.57 St.dev: 9.42
Percentage of HHs with indicated asset	Radio: 78% Land: 52% Mobile phone: 1% Electricity: 14% Cement floors: 64% Durable walls: 41% Durable roof: 69%

[10] In March 2005, the exchange rate was 9,000 GHC = 1 USD.

Table 3-3 Post-construction support to water committees (n=195)

Percentage of villages that receive post-construction support on a regular basis (at least once per year)	24%
Percentage of villages that had received: (a) Assistance with repairs and/or maintenance (b) Assistance with financial or administrative matters (c) A free unsolicited repair (d) Any form of external support	a) 52% b) 32% c) 17% d) 62%
Distance to area mechanic (km)	Median: 13.0 Mean: 19.5 St. dev.: 18.9
Percentage of water committees reporting difficulties in getting area mechanic to come to village	39%

Table 3-4 Households participation in planning and construction as defined by measures of breadth *versus* depth (n=200)

BREADTH MEASURES		DEPTH MEASURES	
CASH		**CASH**	
Percentage of households that contributed cash toward construction costs	Median: 52% Mean: 52% St. dev.: 32%	Value of up-front cash contribution made per household (US$)	Median: 0.60 Mean: 1.00 St. dev.: 1.61
		Percentage of total capital costs contributed by households	Median: 1% Mean: 4% St.dev.: 12%
LABOR		**LABOR**	
Percentage of households that contributed labor to the project	Median: 24% Mean: 25% St.dev.: 22%	Number of days' labor contributed during construction	Median: 0.3 Mean: 1.2* St.dev.: 2.1
DECISIONS		**DECISIONS**	
Percentage of households involved in any *technical* decisions	Median: 45% Mean: 43% St. dev.: 25%	Number of decisions made by households	Median: 2.4 Mean: 2.5 St. dev.: 1.2
Percentage of households involved in any *management* decisions	Median: 75% Mean: 75% St. dev.: 17%	Percentage of households reporting that the community had greatest influence over the project decisions	Median: 16% Mean: 18% St. dev.: 17%
MEETINGS		**MEETINGS**	
Percentage of households that attended meetings before construction	Median: 88% Mean: 87% St. dev.: 11%	Number of planning meetings in which household members participated[11]	Median: 3.4 Mean: 3.6 St. dev.: 2.8

**Mean excludes 7% tail of distribution. It is believed that these extreme values reflect represent households whose members were formally hired as laborers for the project.*

[11] Mid-point values of ordinal "meeting" answer choices used to calculate mean/median

Table 3-5 Recent handpump functioning

Percentage of communities with all handpumps functioning at the time of the study (n=200)	89%
In the past six months, percentage of communities experiencing at least one interruption in service lasting one day or longer (n=171)	47%
Among those experiencing interruptions, number of days needed to solve the last interruption (n=86)	Median: 14 Mean: 62 St. dev.: 166
Among those experiencing interruptions, number of interruptions experienced (n=86)	Median: 1.0 Mean: 1.6 St. dev.: 1.1

Table 3-6 Financial health of the project handpumps

Percentage of water committees collecting user fees (a) regularly, (b) as needed, (c) not at all	a) 71% b) 16% c) 13% N=193
Working ratio (annual revenues/annual recurrent costs)	Median: 1.0 Mean: 3.5 St. dev.: 9.6 N=183
Percentage recovering all recurrent costs	56% N=183
Percentage water committees reporting collecting sufficient revenues to cover all O&M costs	63% N=193
Percentage water committees that spent at least X amount in the year prior to the study: a) $25/handpump b) $110/ handpump (1% capital cost) c) $220/ handpump (2% capital cost)	a) 51% b) 26% c) 7% N=193

Table 3-7 Regular or as-needed meeting with water users

	Meetings held *regularly*	**Meetings held *as-needed***
Share of communities	45%	27%
Number of meetings held in year prior to interview	Median: 6 Mean: 14 St. Dev.: 22	No data
Frequency of meetings held in year prior to interview	Held quarterly: 20% Held monthly: 32%	No data
Typical share of community members attending meetings	Median: 11% Mean: 17% St. Dev.: 21	Median: 12 Mean: 24 St. Dev.: 31
Percentage water committees reporting that women participate (a) more than, (b) less than, (c) the same as men.	a) 55% b) 34% c) 11%	a) 40% b) 50% c) 10%

Table 3-8 Regression analysis results: infrastructure condition

	Mean (SD)	**Model 1**: binary logit *1=all handpumps are working, 0=otherwise*	**Model 2**: binary logit *1=platform in good cond'n, 0=otherwise*
Breadth of participation:			
Percentage HHs contributing any cash toward construction	52 (32)	1.02 (1.68)	1.01 (1.68)
Percentage HHs that gave any labor to BH construction	25 (22)	1.00 (0.08)	0.99 (0.31)
Percentage HHs that attended 1 or more meetings before construction	87 (11)	1.02 (0.32)	0.95** (4.06)
Percentage HHs that made technical decisions	43 (25)	1.00 (0.1)	0.96*** (9.76)
Percentage HHs that made management decisions	75 (17)	1.03 (1.82)	1.05*** (10.26)
Depth of participation:			
Mean HH cash contribution to construction (USD, natural log)	-0.86 (-0.48)	0.55* (3.24)	0.74 (2.24)
Mean labor contribution to construction (days, 7% trimmed mean)	1.2 (1.2)	0.83 (0.64)	1.09 (0.18)
Mean # of meetings HHs attended before construction	3.6 (1.2)	0.79 (0.52)	1.23 (1.04)
Percentage of HHs reporting community had greatest influence over project decisions	18 (17)	1.00 (0.02)	1.01 (0.96)
Other variables:			
HHs report using secondary source(s) in the dry season (dummy)	0.20 (0.40)	0.29* (3.28)	0.86 (0.11)
Percentage of HHs that report they trust their neighbors	75 (14)	0.93*** (7.78)	1.05*** (8.94)
Village receives at least one visit from DWST per year (dummy)	0.24 (0.43)	0.81 (0.09)	5.07*** (9.35)
# of people per borehole (natural log)	6.2 (0.9)	1.49 (1.11)	1.16 (0.39)
Regional dummy (Brong Ahafo=1, Volta=0)	0.52 (0.50)	1.72 (0.43)	1.58 (0.72)
Constant	--	4.28 (0.12)	0.02 (2.26)
Quasi R^2 (Nagelkerke), % correctly predicted		0.27, 89%	0.29, 64%
N		175	176

*Exp(B) reported with Wald test statistic in parentheses. * 0.05 < p ≤ 0.10. ** 0.01 < p ≤ 0.05. *** p ≤ 0.01.*
**Mean excludes 7% tail of distribution because it is believed that these values were reported by households whose members were hired as laborers for the project.*

Table 3-9 Regression analysis results – user satisfaction

Independent variables	**Mean (SD)**	**Model 3:** % of *HHs satisfied with O&M, repairs (Ordinal logit: 1= 0-75%, 2= 75-90%, 3=91-100%)*	**Model 4:** *Women satisfied with O&M of boreholes (Binary logit)*
Breadth of participation:			
Percentage HHs contributing any cash toward construction	52 (32)	1.00 (0.02)	1.02** (4.38)
Percentage HHs that gave any labor to BH construction	25 (22)	1.00 (0.17)	0.99 (0.27)
Percentage HHs that attended 1 or more meetings before construction	87 (11)	1.00 (0.003)	1.02 (0.38)
Percentage HHs that made technical decisions	43 (25)	0.98** (5.24)	0.98 (2.11)
Percentage HHs that made management decisions	75 (17)	1.00 (0.10)	1.00 (0.01)
Depth of participation:			
Mean HH cash contribution to construction (USD, natural log)	-0.86 (-0.48)	0.99 (0.01)	0.71 (2.21)
Mean labor contribution to construction (days, 7% trimmed mean*)	1.2 (1.2)	1.10 (0.32)	0.88 (0.36)
Mean # of meetings HHs attended before construction	3.6 (1.2)	1.39* (3.72)	0.64* (3.48)
Percentage of HHs reporting community had greatest influence over project decisions	18 (17)	1.02** (4.34)	1.03** (4.02)
Other variables:			
Mean regular monthly expenditures per capita (USD)	13.57 (5.51)	0.95 (1.99)	1.14** (5.39)
HHs report using secondary source(s) in the dry season (dummy)	0.20 (0.40)	1.64 (1.62)	0.84 (0.11)
Village receives at least one visit from DWST per year (dummy)	0.24 (0.43)	1.91* (2.95)	1.14 (0.07)
Handpump working at time of study (dummy)	0.94 (0.24)	5.64** 4.14)	4.52* (2.87)
Percentage of HHs that report they trust their neighbors	75 (14)	1.05*** (12.97)	0.99 (0.42)
# of people per borehole (natural log)	6.2 (0.9)	0.69* (3.38)	0.42*** (9.05)
Regional dummy (Brong Ahafo=1, Volta=0)	0.52 (0.50)	0.51 (2.07)	1.23 (0.11)
Constant			26.82 (1.13)
Quasi R2 (Nagelkerke), % correctly predicted		0.32	0.22, 80%
N		176	176

*Exp(B) reported with Wald test statistic in parentheses. * 0.05 < p ≤ 0.10. ** 0.01 < p ≤ 0.05. *** p ≤ 0.01.*
**Mean excludes 7% tail of distribution because it is believed that these values were reported by households whose members were hired as laborers for the project.*

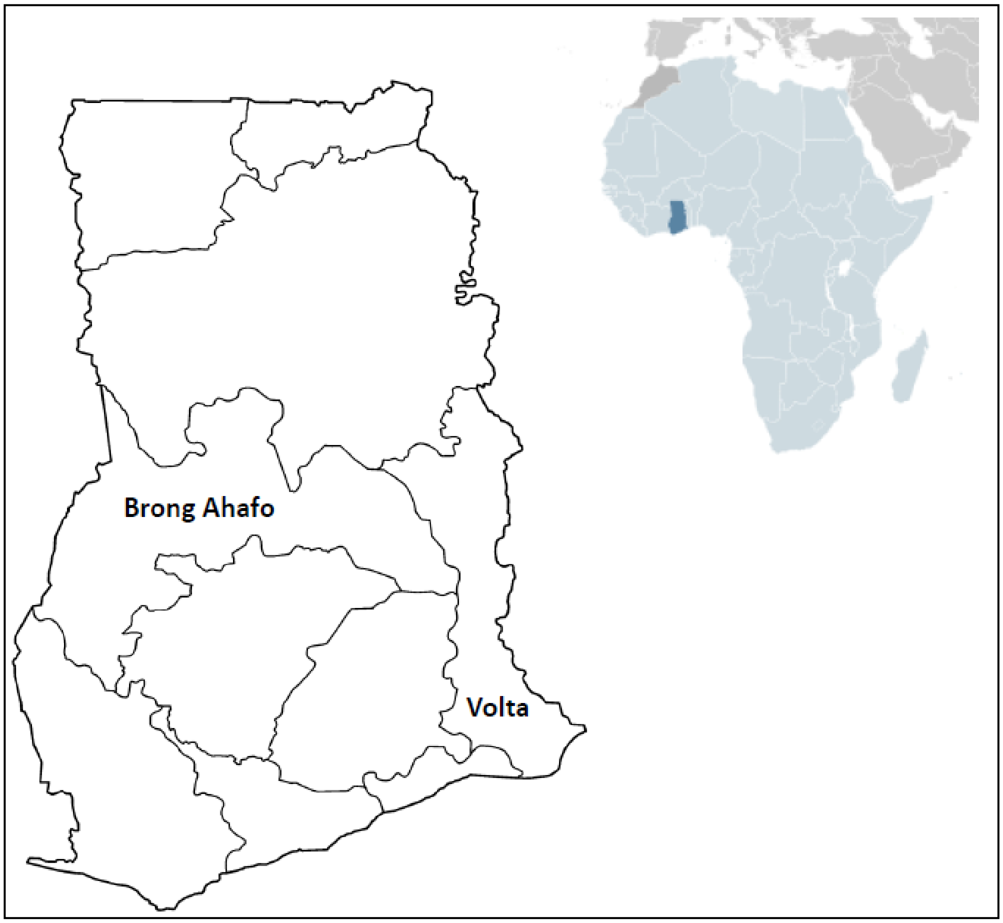
Table 3-10 Regression analysis results – financing maintenance

Independent variables	**Mean (SD)**	**Model 5:** Water committee *spent at least 1% of capital cost on O&M (binary logit)*	**Model 6:** W*ater committee reports sufficient revenues to cover regular O&M expenditures (binary logit)*
Breadth of participation:			
Percentage HHs contributing any cash toward construction	52 (32)	0.98* (2.89)	0.98* (3.63)
Percentage HHs that gave any labor to BH construction	25 (22)	1.01 (0.8)	0.95*** (15.93)
Percentage HHs that attended 1 or more meetings before construction	87 (11)	1.06** (4.33)	0.94** (5.05)
Percentage HHs that made technical decisions	43 (25)	0.99 (0.22)	1.00 (0.01)
Percentage HHs that made management decisions	75 (17)	0.99 (0.68)	1.04** (5.03)
Depth of participation:			
Mean HH cash contribution to construction (USD, natural log)	-0.86 (-0.48)	1.55* (4.17)	1.83*** (8.04)
Mean labor contribution to construction (days, 7% trimmed mean*)	1.2 (1.2)	1.16 (0.59)	0.94 (0.09)
Mean # of meetings HHs attended before construction	3.6 (1.2)	0.97 (0.02)	1.63** (5.3)
Percentage of HHs reporting community had greatest influence over project decisions	18 (17)	1.02 (1.59)	0.96** (6.42)
Other variables:			
Mean regular monthly expenditures per capita (USD)	13.57 (5.51)	0.92** (4.01)	1.02 (0.19)
HHs report using secondary source(s) in the dry season (dummy)	0.20 (0.40)	0.46 (2.44)	1.53 (0.77)
Village receives at least one visit from DWST per year (dummy)	0.24 (0.43)	0.35** (4.11)	0.83 (0.17)
# of people per borehole (natural log)	6.2 (0.9)	1.84** (5.5)	1.33 (1.34)
Regional dummy (Brong Ahafo=1, Volta=0)	0.52 (0.50)	1.30 (0.21)	5.18*** (7.87)
Constant		0.001*** (6.86)	6.49 (0.65)
Quasi R2 (Nagelkerke), % correctly predicted		0.25, 73%	0.34, 62%
N		176	176

*Exp(B) reported with Wald test statistic in parentheses. * 0.05 < p ≤ 0.10. ** 0.01 < p ≤ 0.05. *** p ≤ 0.01.*
**Mean excludes 7% tail of distribution because it is believed that these values were reported by households whose members were hired as laborers for the project.*

3.9 Figures

Figure 3-1 Map of Ghana showing the sample regions



4 Community participation and sense of ownership for the water system in Kenya

This chapter is reprinted from World Development with permission from the copyright holders, Elsevier Ltd. The article is currently in press, and the title is "Does user participation lead to sense of ownership for rural water systems? Evidence from Kenya." Jennifer Davis is a co-author for her contributions to study design, data collection, modeling, and manuscript improvements.

4.1 Abstract

Despite broad acceptance of the idea that a "sense of ownership" among community members is critical to water infrastructure sustainability in the developing world, little is known about what sense of ownership for a water system is, or what forms of participation during planning and construction engender feelings of ownership. We develop a composite measure for households' sense of ownership for communal water systems and test this measure using empirical data collected from 1,140 households in 50 Kenyan villages with piped water systems. Using regression analysis, we examine the extent to which variation in the ownership measure is explained by the type and extent of household participation during project planning and construction. Labor contributions are significantly associated with a moderate level of sense of ownership; large cash contributions are associated with a high sense of ownership. Household members' participation in decisions regarding the level of service provided is also associated with a high level of sense of ownership, as is having a working tap on the premises, serving on the water committee, income, and access to credit. No association was found between sense of ownership and small cash contributions, education level, or other leadership responsibilities within the community. This study establishes an empirical referent for households' sense of ownership for their water system, and suggests that certain types of participation during project planning and construction enhances community members' sense of ownership for rural water projects.

4.2 Introduction

Rates of access to an improved water source in rural sub-Saharan Africa (SSA) are among the lowest worldwide, with approximately 1 in 2 rural dwellers, or 278 million people in total, lacking access [*Joint Monitoring Programme*, 2010b]. Low levels of access to improved water supply in developing countries have been attributed to, *inter alia*, inappropriate system designs, poor management of water resources, rent-seeking behavior, and limited institutional capacity [*Brookshire and Whittington*, 1993; *Downs et al.*, 2000; *Lovei and Whittington*, 1993; *Pattanayak et al.*, 2005; *Singh et al.*, 1993; *Weiskel et al.*, 2007]. In addition, communities often have considerable difficulty in sustaining operation and maintenance of water supply infrastructure over the useful life of the hardware [*Davis et al.*, 2008].

In an attempt to address this sustainability challenge, the rural water sub-sector has increasingly incorporated community participation in the planning and construction of projects in recent decades [*Davis et al.*, 2008; *Pritchett and Woolcock*, 2004]. This shift toward participatory planning has been credited with enhanced sustainability in rural water projects worldwide [*Isham et al.*, 1995; *Whittington et al.*, 2009]. In particular, practitioners and scholars widely cite the essential role that participatory planning plays in engendering a sense of ownership for the water system among community members, which in turn ensures users' commitment to long-term operation and maintenance *[Manikutty, 1997; Republic of Mozambique, 2001; Whittington et al., 2009; Yacoob, 1990]*. Such sense of ownership, it is argued, is stimulated when users are involved in key decisions related to the system, contribute toward the capital costs of system construction, and participate directly in planning and construction activities.

Despite wide acceptance of the idea that community participation begets a sense of ownership for water projects, evidence for this relationship is based largely on qualitative analysis from a small number of studies. Moreover, prior analyses have focused on the association between sense of ownership and a combined suite of participatory planning activities (*e.g.,* capital cost and labor contributions, decision-making, *etc.*). As such, it is not clear which types of participation are important for engendering a sense of ownership, or even how sense of ownership can be reliably measured. This study attempts to contribute to both knowledge gaps.

Our investigation is based on data collected from rural communities in Kenya, where planning for water infrastructure installation has incorporated various approaches to community participation over the past several decades [*Chambers*, 1994; *Republic of Kenya*, 2007; *Thomas*, 1987]. Using information gathered from 1,140 households in three provinces, we investigate the extent to which households feel a sense of ownership for their community's piped water system. We also identify the forms of participation pursued during water system planning and construction that are associated with a greater sense of ownership. In the following section, we present the conceptual framework underpinning this investigation. The study site and data collection strategy are described in section 4.4 and 4.5. In sections 4.6 we summarize the relevant characteristics of our sampled communities, describe our approach for measuring households' sense of ownership for the water system, and present results on the association between sense of ownership and households' participation in their system's planning and construction. We conclude in section 4.7 with a discussion of the implications of this work for participatory planning approaches in Kenya's rural water sector.

4.3 Conceptual framework: Psychological ownership in organizational theory

The literature on water infrastructure development offers little in terms of a theoretical framework for investigating the relationship between participatory planning and community members' sense of ownership for rural water projects. This theoretical gap is particularly striking considering the frequency with which the concept of sense of ownership is invoked as a key element of successful sector policy and programs. Scholarship in the field of organizational and behavioral science, however, provides a useful framework for investigating this phenomenon. Pierce and others developed the *psychological ownership* construct, defined as "that state in which individuals feel as though the target of ownership (material or immaterial in nature) or a piece of it is 'theirs'" [*Pierce et al.*, 1991; *Pierce et al.*, 2001]. Pierce *et al.* (2001) hypothesize that the three main causal pathways for developing a sense of ownership for an object are controlling, intimately knowing, and investing oneself into it. More recently, this theory has been extended to include the potential for a shared mindset among members of a group within certain work environments, known as collective psychological ownership [*Pierce and Jussila*, 2010].

Empirical studies on psychological ownership have evaluated this theory largely within occupational settings in the United States. Psychological ownership has been shown to emerge within work environments that enable employees to become intimately familiar with, as well as to exert influence or control over, technologies or processes [*Pierce et al.*, 2004]. For example, physicians that had actively participated in the development of a clinical information system, and had assumed control over the new tool's integration into their work setting, developed feelings of ownership for the technology over time [*Paré et al.*, 2005]. In turn, workers who have relatively stronger feelings of psychological ownership are more likely to exhibit job satisfaction, organization-based self-esteem, and citizenship behavior (*e.g*., volunteering one's time to an organization) [*Van Dyne and Pierce*, 2004; *Vandewalle et al.*, 1995].

The insights from the psychological ownership literature suggest that, within the realm of rural water infrastructure development, community members' sense of ownership for their water system could be expected to arise from their participation in its planning and construction. As such, we define community participation in rural water supply planning as the contribution of cash, land, or materials toward the construction of the system; participation in key decisions about the project, such as the level of service to be provided to households; and the contribution of labor (*e.g.*, in completing civil works) during system construction. Community members' sense of ownership for the water system is defined as households' expressed attitudes of ownership and commitment related to the infrastructure, as measured at the time of our study. We hypothesize that all forms of community participation are positively associated with a sense of ownership for water infrastructure among community members.

4.4 Study site: rural water supply in Kenya

Kenya is located in east Africa, with a population estimated at 39 million in 2010 [*Central Intelligence Agency*, 2010]. Approximately three quarters of Kenyans live in rural areas. Rapid population growth and rainfall variability over the past 30 years has led to a significant decline in the country's renewable freshwater availability *per capita*, from 1,853 cubic meters in 1969 to 647 cubic meters in 2007 [*Institute of Economic Affairs*, 2007]. Freshwater availability has been especially problematic in recent years as a result of three consecutive years of drought.

These severe constraints on freshwater availability, coupled with poor records of sustainability for water infrastructure (especially in rural areas), underpin the formidable challenge the country faces in improving levels of access to improved water supplies. In 2008, an estimated 59% of Kenyans were considered to have access to improved water supply; within rural areas, 52% of households had access [*Joint Monitoring Programme*, 2010a]. In addition, it is estimated that 30% of the approximately 12,000 handpumps throughout the country are not functioning, and a similar proportion of piped water systems are beleaguered by partial or total system failure [*Rural Water Supply Network*, 2009].

In an effort to improve sustainability of and rates of access to improved water supply, the Government of Kenya instituted a set of reforms, detailed in the 2002 Water Act. These reforms include decoupling water resources management from water service provision; decentralizing water sector administration and service delivery to provincial and district level institutions; and improving accountability and communication between water consumers and water service providers. The Water Act specifies the goal of "reach[ing] at least 50% of the underserved in rural areas with safe and affordable water by 2015, and thereafter, to move to sustainable access for all by 2030"[*Republic of Kenya*, 2007]. To reach this goal, one identified strategic action is to “increase investments and ownership for sustainable access to water in rural areas,” as well as to “[achieve] sustainability of rural water systems by promoting beneficiary participation in planning, implementation and management”[*Republic of Kenya*, 2007].

4.5 Methods: Sample frame and data collection strategy

No existing sample frame of rural communities with piped water systems was available for use in this study. With the help of key informants in the Kenyan water sector we identified three provinces with a substantial number of piped systems serving rural communities: Central, Eastern, and Rift Valley. Within each selected province, districts that were located in a peri-urban zone, or in the commuter belt extending from the capital Nairobi, were excluded from the sample. Twelve districts were selected for inclusion in the study that each had a minimum number of rural communities with piped water systems.

Within each selected district, water systems about which sufficient information could be obtained, and which served a population of 500-8,000 people, were included in the parent population from which the sample of study communities was drawn. From this meta-database of 621 community water systems, 313 functioning or partially functioning water systems were identified. A province-stratified random sample was then drawn from this parent population that included 20 communities from Central Province, and 15 communities each from Eastern Province and Rift Valley Province (Figure 4-1).

Forty-four of the 50 water systems included in the study sample served two or more distinct communities. In such cases, one community was chosen at random for the collection of primary data for the study. Along with interviews of community leaders, water committee members, and system operators, household surveys were completed with a median of 28 families in the community. Households were selected using systematic sampling (every *n*th household) after dividing the community into zones based on the layout of the water network and other water sources (*e.g.*, handpumps, wells, rivers, and springs).

Data collection occurred during the months of July through September 2009. Field teams spent three to four days in each community conducting a variety of data collection activities as described above. A total of 1,140 household surveys were completed. Surveys were carried out in the participants' preferred language, either Kiswahili, Kikuyu, Kalenjin, Meru, or Kamba. Each survey was conducted with the male (32%) or female (62%) household head (in 6% of interviews, both household heads participated). Only data collected from households that were present in the village before the water system was installed were analyzed for this study.

Respondents were asked about household water supply services; participation in planning and construction of the water system; attitudes and behaviors related to the water system; and socioeconomic and demographic characteristics of their households. The survey instrument was developed through an intensive and iterative process, pre-tested in two communities that were not ultimately included in the study, and revised. The median length of an interview was 91 minutes.

4.6 Findings

4.6.1 Water service and household characteristics

A typical water system in the study sample supplies water to five communities; each community includes a median of 190 households and 935 people. In all communities, a water committee of between three and eight people is responsible for financial and administrative management of the system. One or more technicians is responsible for operation, maintenance and repair of the water supply infrastructure. In 20% of study communities, shared water points (kiosks) are the only level of improved water supply service available to households. Another 38% of communities have no kiosks, instead distributing piped water exclusively through individual yard taps. The remaining 42% of communities have a mix of kiosks and private taps. The median age of the water system is nine years (mean=13.9 years). Half of the systems draw water from a deep borehole, while the rest are supplied by surface sources such as rivers, springs, or reservoirs. Seven in eight water systems were reported by the water committee to be functional year round. At the time of interview, however, water committees reported that a median of 15% of installed taps were out of service.

Sampled households include a mean of 5.4 people; 40% are located in family compounds with multiple households and 60% are located on single-household plots (Table 4-1). The average age of respondents was 47 years. Seventy-two percent of respondents reported having completed primary school, and 29% completed secondary school. More than 60% of sampled households had lived in their community for at least 20 years. The majority of respondents live in a home that they own, with wood or brick walls, corrugated metal roofing, and earthen floors. Only 4% of respondents have a working electricity connection in their home. The median regular weekly expenditure for households was US$13.16, and the median land holding was 4 acres. In terms of water supply, 30% of households had a working connection in their house or yard, while 26% used a public tap or kiosk and 38% said that they did not make use of the piped water system at all. The majority of households use two or three water sources during the dry months of the year.

4.6.2 Participation and sense of ownership for the water system

All households included in this study were living in their village during the planning and construction of their water systems. Despite the median length of time since water system construction of nine years, the majority of study participants had clear recollections about the event, one that typically represented an important milestone in their community's development. Seventy-three percent said they had been aware of the water project before construction began, and 71% identified local actors (*e.g.*, the water committee, village residents) as having had the greatest influence over decisions related to service level, tariff structure, and the amount of up-front contributions required of users (Table 4-2). This information is consistent with data collected from water committee members, 80% of whom reported that community members organized without external support to initiate the project that resulted in their water system's installation.

Most heads of household were able to recall the extent of their family's participation in pre-construction meetings and decision-making related to the design of their community's water system; only 2.5% were unable to answer questions about these topics. Three quarters of respondents reported that no one in their household attended meetings related to planning for water supply improvements before construction of the system began. Forty-four percent of households said that they were involved in deciding what sort of contribution households would be expected to make toward construction of the system; one third said they were involved in decisions related setting water tariffs, and 27% said they helped to decide the levels of service that would be provided.

Ninety-one percent of respondents were able to report the amount of money they had contributed to the installation of the water system. Among the 48% of sampled households who reported making up-front cash contributions toward water system construction, the median cash payment was US$91 (in 2009US$). For many communities, such contributions were viewed as quasi membership dues that enabled households to have the option of obtaining an individual tap in the future. Installing this high level of service required additional, distinct payments that often ranged into the hundreds of US$s given the dispersed settlement patterns of sample communities. Despite concerted efforts to develop and administer clear survey questions that respondents about these different types of contributions, a small share of respondents (4%) reported making contributions toward community system construction of more than $500 (in 2009US$), likely in reference to the payments they made to obtain household taps.

Ninety-seven percent of respondents were able to recall whether their families had contributed any days of labor during water system construction. Among the 60% who said their household did contribute labor, however, almost half (48%) could not recall the precise number of person-days of labor devoted. A median of 30 person-days was contributed by those households who could report the amount of labor they contributed. Twenty-nine percent of households reported making no up-front cash or labor contribution at all.

4.6.3 Measuring and explaining variation in sense of ownership

Construct development

In order to create a composite measure for households' sense of ownership for their water system, six Likert-style questions were posed to respondents that probed their perceptions of and attitudes toward the water system (see Appendix C). For each question, respondents were asked the extent to which they agreed with a statement read aloud. A four-item response scale was employed, with answers ranging from 'strongly disagree' or 'not at all concerned,' to 'strongly agree' or 'very concerned' (Table 4-3).

Principal components analysis (PCA) was performed on these data to reduce the variables into orthogonal groupings ('principal components') that account for a substantial share of variation in the dataset. The PCA used oblique rotation (KMO = 0.68, Bartlett's test of sphericity X^2=4224, df=15, p < .001). Four of the six survey items comprised a single component that explains 46% of the variance in the data (Cronbach's α = .81). As we had no *a priori* justification for the relative importance of each item to an overall measure of households' sense of ownership, a composite measure was created by simply averaging the four response values for each respondent. Alternative approaches to analyzing the sense-of-ownership data (*e.g.*, using eigenvalue weighting and various data transformations) were employed and found not to yield any difference in substantive conclusions. Given the comparative simplicity of the unweighted measure, it was chosen for the analyses presented in this paper.

The composite sense of ownership measure has a range of values from one to four, with higher values indicating a stronger sense of ownership. Over all respondents, this variable has a mean of 3.00 (SD = 0.82). Three quarters of respondents scored a 2.5 or higher. Ownership scores were also divided into roughly equal groups and coded as "low" (scores between 1.0 and 2.7), "moderate" (scores between 2.8 and 3.5), or "high" (3.6 and above) sense of ownership.

Households that were using of the piped water system at time of interview were significantly more likely to express greater sense of ownership for it as compared to households that obtained their water supply from non-piped sources (Figure 2). For example, four out of five households classified as having "high" sense of ownership obtained water from the piped system, compared to one out of five households that do not use the system. As noted above, it may be that households who opted out of participatory activities during water system planning and construction were subsequently not permitted (or did not feel entitled) to avail of piped water services. For this reason, in the following section multivariate analysis of sense of ownership is restricted to households who were using the piped system at the time of interview.

Explaining variation in sense of ownership among system users

Multivariate regression techniques were employed to model sense of ownership for the water system as a function of household participation in planning and construction, as well as system and service characteristics, and socioeconomic characteristics of households. Because of the possibility that households who did not participate in system design could be excluded from use of the system in operation, this analysis was restricted to households who reported having an individual water connection or using public taps or kiosks in their community.

A multinomial regression model (MNL) was fit to the data in order to identify explanatory variables associated with varying levels of sense of ownership for the water system. An ordinal logit model was rejected as too restrictive because the proportional odds assumption of that model form was violated. The MNL model generates two sets of parameter estimates: The first (Model 1, Table 4-4) is related to the probability of a respondent falling in to the "moderate" *versus* "low" sense of ownership category, and the second (Model 2) is related to the probability that a respondent is a member of the "high" *versus* "low" sense of ownership reference category. The value of the Wald test statistic is provided in parentheses below each odds ratio.

Among the community participation variables, respondents whose households made up-front cash contributions of US$50 or less (in 2009 US$) were no more likely to expressed moderate or high sense of ownership for the water system as compared to households that made no cash contribution at all (all $p>0.30$). Respondents whose households' contributions were greater than US$50 were twice as likely to express moderate *versus* low sense of ownership ($p=0.17$) and four times as likely to express high *versus* low sense of ownership ($p=0.01$). Labor contributions during construction are associated with a two-fold increase in the odds that a respondent voiced moderate *versus* low sense of ownership ($p=0.02$), but are not associated with high sense of ownership ($p>0.25$). Respondents who reported that their households participated in the selection of service levels during the planning of their water systems were 3.9 times more likely to express high sense of ownership ($p<0.01$), but such decision-making was not significantly associated with moderate *versus* low sense of ownership.

A household's having its own yard tap is significantly associated with sense of ownership; a respondent was 4.6 and 6.2 times more likely to have moderate or high *versus* low sense of ownership, respectively, for the community's water system (both $p<0.01$) as compared to households that only use public taps or kiosks. All else constant, a respondent was 1.2 times more likely to express a high *versus* low sense of ownership for the system for each additional US$100 income earned per year ($p=0.09$). Other measures of socioeconomic and demographic status (education, age, gender, *etc*.) were tested within the models and found to have no meaningful relationship with sense of ownership. Satisfaction with water supply service (a proxy for service quality) was not significantly associated with sense of ownership. Respondents whose household use a greater number of water sources in the dry season, however, were significantly less likely to express a high *versus* low sense of ownership ($p=0.05$).

Having a household member that has served on the water committee is associated with a 2.5-fold increase in the likelihood of being classified as having a moderate *versus* low sense of ownership (p=0.02) and 3.1-fold higher odds of expressing high *versus* low sense of ownership (p<0.01). Older projects are more likely to elicit expressions of high sense of ownership (p<0.01), and those located in Rift Valley are associated with increased likelihood of users expressing both moderate and high levels of ownership.

4.7 Discussion and conclusion

A principal finding of this work is that community sense of ownership for the water system can be meaningfully measured. To the best of our knowledge, this is the first attempt to quantify households' sense of ownership for their water system, as well as to identify features of the planning process and characteristics of households that are associated with it. It is important to note that the study is limited by a cross-sectional design that allows conclusions to be drawn only about the magnitude and significance of associations between households' sense of ownership for their water supply project and hypothesized causal factors, measured at one point in time. Nonetheless, every attempt was made to address potentially confounding factors within the analysis, and the modeling results presented are robust to variations in specifications and indicator choice.

It is also notable that fewer than one quarter of sampled households expressed a low sense of ownership for their system, which is not what the literature on rural water planning would suggest to be the case for most developing countries. Our explanation for this finding within our sample rests on two observations. First, the water systems in 80% of the communities included in our sample include individual household water taps. This higher level of service is often not provided through developing country rural water supply investments (shared point sources are far more common); it was also found to be significantly associated with enhanced sense of ownership among sample households. Second, a substantial share of the communities included in our sample initiated their water schemes during the 1990-2000 period when a "self help" model dominated rural water planning in Kenya [*Wilson*, 1992]. To a greater extent than many rural water projects in developing countries, those included in our sample engaged community members in design, capital cost sharing, construction, and system management—investments that are hypothesized to be associated with heightened sense of ownership.

At the same time, our hypothesis that all forms of participation in rural water project planning are positively associated with sense of ownership was not supported. Instead, our analysis suggests a more nuanced set of relationships. For example, we observed a threshold effect in the association between capital cost contributions and sense of ownership. Only those households who contributed at least US$50 (in 2009 USD)—an amount equivalent to one month's income for a typical household at the time of interview—were significantly more likely to express a moderate or high *versus* low sense of ownership. Smaller contributions showed no significant association with sense of ownership. These findings are consistent with the findings from Ghana, which show that the depth rather than breadth of participation matters most in terms of achieving better project outcomes. These findings also suggest that the capital cost sharing policies of many developing country governments and international donor agencies may be broadly useful for instilling community sense of ownership for installed water supply infrastructure, but not when project rules require only small or 'token' contributions from households. Additional research is needed to understand the effects that stiffening requirements for up-front contributions (both in terms of depth of the contribution and breadth of the community contributing) might have on both water system sustainability and the distribution of benefits from rural water investments.

Other forms of participation in water system planning had more variable associations with sense of ownership. Labor contributions were significantly associated with moderate *versus* low ownership expressions, but were not linked to a high sense of ownership. By contrast, households' involvement in decisions about the level of service to be provided in their water project was a significant predictor of high sense of ownership, but was not significant in the moderate ownership model. These findings suggest that different types of community engagement may affect households' sense of ownership to varying degrees.

Not surprisingly, households that obtain water from their community's piped system on a regular basis have significantly stronger ownership feelings than households using other water sources. A strong and significant association was also observed between sense of ownership and having an individual water connection. It is possible in this study that households with individual water connections conflated the idea of material ownership (of their taps) with sense of ownership for the water system more broadly. It is also feasible, however, that having water supply infrastructure at the household level enables the sort of "intimate knowledge" of the system that enhances sense of ownership, as postulated by scholars of organizational theory. The findings from this study also lend support to other hypothesized determinants of feelings of ownership, including households' involvement in decisions about the level of service to be delivered (experienced control) and making non-token cash contributions (investing oneself).

Whereas the focus of this research is limited to developing measurement tools for, and identifying correlates of, households' sense of ownership for their water system, planners and policymakers would benefit from an understanding of whether and how sense of ownership relates to long-term sustainability of installed infrastructure. Currently, considerable effort is given to the design and execution of participatory processes in rural water planning, with the belief that the benefits of these activities—in terms of engendering the capacity and commitment within a community to keep their water system running—outweigh their costs. Future work that evaluates the relationship between sense of ownership and sustainability outcomes would represent a valuable test of such assumptions.

4.8 Acknowledgments

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4.9 Tables

Table 4-1 Characteristics of sample households (n=1140)

Mean (SD) number of people in household (HH)	5.4 (2.6)
% living in multi-household compound	40
Mean (SD) age of respondents	47 (15)
% living more than 20 years in village	61
% with 1+ head who completed primary school	72
% with 1+ head who completed secondary school	29
% of HHs that own their home	99
% of HHs with wood or brick walls	66
% of HHs with cement or concrete floors	33
% with access to electricity	4
Mean (SD) weekly expenditures (US$2009)	18.71 (20.72)
Median weekly expenditures (US$2009)	13.16
Mean (SD) land owned (acres)	6.9 (17.7)
Median land owned (acres)	4.0
% of HHs with a working, private water connection	30
% of HHs that use a public tap or kiosk	26
% of HHs that do not use the piped system	38
Mean (SD) number of water sources used in the dry season	2.3 (0.7)

Table 4-2 Household participation in planning and construction (n=1140)

% of households aware of the water project before construction	73
% identifying local actors as having greatest influence over project decisions	71
% attending meetings before water system construction	26
% involved in decision about household contribution levels	44
% involved in decision about water tariffs	33
% involved in decision about levels of service to be delivered	27
% contributing cash to water system construction	48
Among those reporting cash contributions, median, trimmed mean* (SD) cash contribution to water system construction (in US$2009s)	91 493 (783)
% contributing labor to water system construction	59
Among those reporting labor contributions, median, trimmed mean* (SD) days contributed	30 85 (124)

*95% trimmed mean

Table 4-3 Components of households' sense of ownership measure (n=1,095)

	% giving response of "3" or "4"
Survey items	
I feel that I am one of the owners of the water system. (1=strongly disagree, 2=disagree, 3=agree, 4=strongly agree)	75
My family is one of the owners of the water system. (1=strongly disagree, 2=disagree, 3=agree, 4=strongly agree)	76
The water system is owned by all water project members. (1=strongly disagree, 2=disagree, 3=agree, 4=strongly agree)	81
To what degree are you personally concerned with the O&M of the piped water system? (1=not concerned at all, 2=not very concerned, 3=somewhat concerned, 4=very concerned)	46

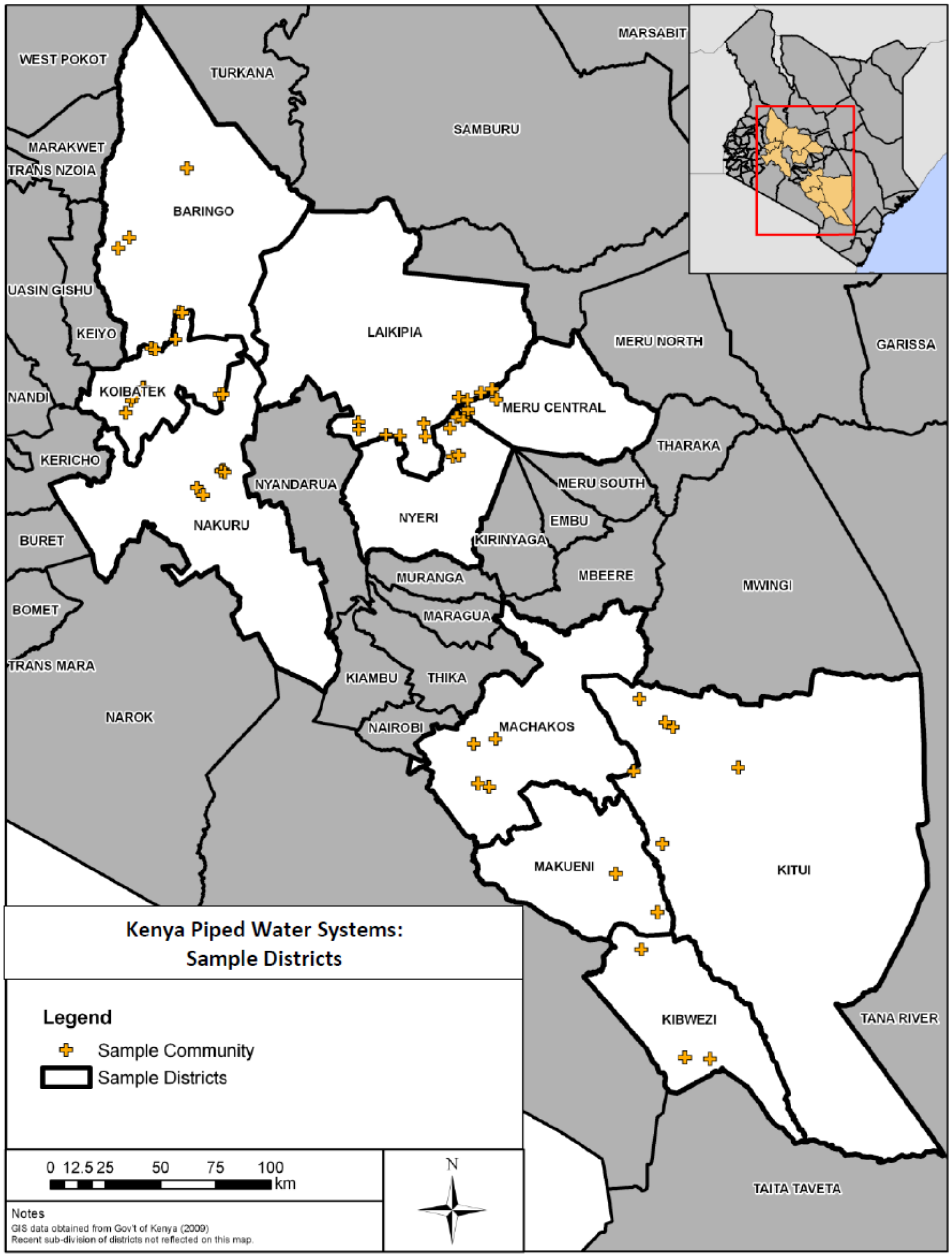
Table 4-4 Multinomial regression analysis of household sense of ownership for the water system

	Mean (SD) for all households (*n*=756)	Model 1: Moderate *versus* low sense of ownership:	Model 2: High *versus* low sense of ownership:
HH contributed > $0 and ≤ $50 to capital cost (dummy)	0.19 (0.39)	1.06 (0.03)	1.43 (0.88)
HH contributed > $50 to capital cost (dummy)	0.31 (0.47)	2.02 (1.90)	3.98*** (6.56)
HH contributed labor to construction of the water system (dummy)	0.70 (0.46)	1.99** (5.92)	1.46 (1.28)
HH participated in deciding level of water service to be provided (dummy)	0.33 (0.47)	1.16 (0.16)	3.94*** (13.12)
Natural log of HH's annual income (US$100s)	1.64 (1.37)	1.11 (1.05)	1.21* (2.95)
HH member serves/served on the water committee (dummy)	0.22 (0.41)	2.47** (5.38)	3.10*** (7.59)
HH has a working tap on the premises (dummy)	0.45 (0.59)	4.58*** (9.64)	6.23*** (12.29)
HH is "satisfied" with quality of water supply services (dummy)	0.20 (0.40)	1.17 (0.20)	1.34 (0.56)
Number of water sources used by the HH in the dry months	2.37 (0.78)	0.81 (1.02)	0.63** (3.75)
Natural log of the age of the project in years	2.13 (1.02)	1.16 (1.71)	1.49*** (8.48)
Rift Valley province (dummy)	0.36 (0.48)	2.15** (5.53)	4.55*** (15.59)
Central province (dummy)	0.37 (0.48)	1.57 (1.11)	1.06 (0.01)
Observations = 756	Cox & Snell quasi R^2 = 0.38		

Table values are log odds (exponentiated parameter estimates from MNL estimation).
Wald test statistic values are in parentheses. Robust standard errors used to generate test statistics.
* $0.05 < p \leq 0.10$. ** $0.01 < p \leq 0.05$. *** $p \leq 0.01$.

4.10 Figures

Figure 4-1 Location of sample communities, Kenya



5 Sense of ownership and water system sustainability in Kenya

This chapter is reprinted from the Journal of Water, Sanitation and Hygiene for Development with permission from the copyright holders, IWA Publishing. The article is currently in press and the title is "Does sense of ownership matter for rural water system sustainability? Evidence from Kenya." Jennifer Davis and Kyle Onda are co-authors for their contributions to study design, data collection, data analysis, and manuscript improvements.

5.1 Abstract

Community sense of ownership for rural water infrastructure is widely cited as a key factor in ensuring sustainable service delivery, but no empirical investigation has evaluated the relationship between sense of ownership and sustainability outcomes. This study examines the association between system sustainability with sense of ownership among households and water committees, using primary data collected throughout 50 rural communities with piped water systems in Kenya. Data sources include in-person interviews with 1,916 households, 312 water committee members and 50 system operators, as well as technical assessments of water systems. Using principal components analysis we create composite measures of system sustainability (infrastructure condition, users' confidence, and ongoing management), and of water committees' and households' sense of ownership for the system. All else held constant, infrastructure condition is positively associated with water committee members' sense of ownership, whereas users' confidence and system management are positively associated with households' sense of ownership. These findings stand in contrast with much of the published literature on rural water planning, which assumes homogeneity of ownership feelings across all members of a community and which suggests a consistent and positive association between households' sense of ownership and sustainability.

5.2 Introduction

Rates of access to domestic water services in rural sub-Saharan Africa (SSA) are among the lowest worldwide, with approximately 1 in 2 rural dwellers, or 278 million people in total, lacking access to an improved water source [*Joint Monitoring Programme*, 2010b]. Africa is the only developing region that is not predicted to meet the Millennium Development Goal for water supply, having made limited progress in expanding access as compared to the rest of the developing world. One reason for the slow rate of progress is that installed water infrastructure regularly fails before the end of its design life. Indeed, it has been estimated that some 30% of water and sanitation facilities in sub-Saharan Africa do not function properly [*Joint Monitoring Programme*, 2005], and many projects fail completely [*Kleemeier*, 2000].

Improving the sustainability of water supply infrastructure is thus a critical component of expanding access to safe, reliable services. Prior research has identified a number of factors associated with greater sustainability, including demand-driven planning approaches [*Isham et al.*, 1995; *Narayan*, 1995; *Sara and Katz*, 1998; *Whittington et al.*, 2009], appropriate project design [*Khwaja*, 2009], and management-oriented post-construction support [*Davis et al.*, 2008]. In addition, practitioners and scholars in this field widely cite the essential role that community "sense of ownership" for water infrastructure plays in ensuring its sustainability [*Madrigal et al.*, 2011; *Manikutty*, 1997; *Nance and Ortolano*, 2007; *Whittington et al.*, 2009]. For example, in a comparative case study of high and low performing water systems in rural Costa Rica, Madrigal *et al*. note that most households in high performance communities reported that the system was owned by the community itself, whereas households in low performing communities were usually unclear about who owned the system, or reported that the government is the owner [*Madrigal et al.*, 2011]. Such sense of ownership, it is argued, contributes to users' willingness to operate, use and maintain their water system properly over the long term [*Yacoob*, 1990].

However, to date there has been no direct investigation of the role that community members' sense of ownership for rural water infrastructure plays in determining system performance outcomes. Further, in discussions of sustainability and sense of ownership, virtually all accounts refer simply to "community" sense of ownership, with the implicit assumption that all community members hold similar feelings of ownership for the water system [*Nauges and Whittington*, 2009; *Nayar and James*, 2010; *Whittington et al.*, 2009; *Yacoob*, 1990]. The potential for heterogeneous feelings of ownership among different groups within one community is overlooked in the planning literature, as is the possibility that sense of ownership by particular groups may be more important than others in terms of water supply sustainability.

Insights from related fields such as common pool resource management and rural development, however, suggest that community heterogeneity does influence outcomes in important ways [*Agarwal*, 2001; *Pagdee et al.*, 2006]. It would thus seem that exploring the relationship between sense of ownership and water system performance could benefit from disaggregating the community into sub-groups whose ownership feelings might differ from one another, and might have distinct relationships with water system sustainability.

In this study, the association between sustainability of piped water systems and community members' felt sense of ownership for these systems is explored across 50 communities in rural Kenya. Specifically, we test the hypothesis that sense of ownership among households matters most in terms of predicting sustainable outcomes for the piped systems. Sense of ownership is defined as a psychological state in which individuals feel as if their community's water supply system is "theirs" [*Marks and Davis*; *Pierce et al.*, 2001]. Sustainability of sampled water systems is measured across three dimensions: the physical condition of the infrastructure, users' satisfaction with and confidence about their water supply service, and the extent to which water committees and system operators fulfill their responsibilities for system upkeep and service reliability. Sense of ownership for the water system is measured through surveys of household and water committee members as described below.

Following this introduction, we describe the study site, sample frame development, and data collection methodologies employed for the investigation. Next, we describe community, water system, and household characteristics. We then present our methodology for creating composite measures for sustainability, as well as for households' and water committee members' sense of ownership for their water system. Findings show that infrastructure condition is positively associated with water committee sense of ownership, whereas system management and users' confidence are positively associated with households' sense of ownership. We conclude with discussion of these findings. Additional analyses related to the association between water committee and household sense ownership are provided in the Supplemental Material.

5.3 Study site: rural water supply in Kenya

The study employs a cross-sectional research design using primary data collected through short, intensive visits to 50 rural communities in the Central, Eastern, and Rift Valley provinces of Kenya (Figure 1). Data were collected during the period July-September 2009. Kenya has a total population estimated at 39 million in 2010, approximately three quarters of whom live in rural areas [*Joint Monitoring Programme*, 2010a]. Rapid population growth and deforestation over the past 30 years has led to a significant decline in the country's renewable freshwater availability *per capita*, from 1,853 cubic meters in 1969 to 647 cubic meters in 2007 [*Institute of Economic Affairs*, 2007].

In spite of these constraints on freshwater availability, Joint Monitoring Program data indicate steady increases in the share of rural households with access to improved water supply in Kenya over the past several decades. An estimated 52% of rural dwellers had access to improved services in 2008, compared to just 30% in 1990 [*Joint Monitoring Programme*, 2010a]. Nevertheless, rural water infrastructure sustainability remains a persistent challenge in Kenya. It is estimated that approximately 30% of the approximately 12,000 handpumps throughout the country are not working, and a similar proportion of piped systems have serious functionality problems or have failed [*Rural Water Supply Network*, 2009].

The Government of Kenya's 2002 National Water Strategy was designed to expand access to sustainable services through a number of sector reforms, including decoupling water resources management from water service provision; decentralizing water sector administration and service delivery to provincial and district level institutions; and improving accountability and communication between water consumers and water service providers [*Republic of Kenya*, 2007]. Consistent with the broader literature on water supply services, the Strategy identifies “limited community ownership of the water system” as a key explanation for the country’s historic challenges with sustainability of its rural water infrastructure.

5.4 Methods: sample frame and data collection strategy

The study made use of data collected during a separate investigation focused on the productive use of domestic water supplies in rural communities [*Davis et al.*, 2011]. Key sector informants helped to identify three provinces in Kenya with a substantial number of piped systems serving rural communities: Central, Eastern, and Rift Valley. Within these provinces, twelve districts were randomly selected for inclusion in the study from all districts known to have at least 20 rural communities with piped water systems.

Within each selected district, piped water systems about which sufficient information could be obtained and which served a population of 500 to 8,000 people were included in the parent population from which the sample of study communities was drawn. From this parent population of 621 community water systems, 313 functional water systems were identified. The study team then drew a province-stratified random sample of 50 communities from this parent population (Figure 5-1).

Forty-four of the 50 water systems included in the study sample served two or more distinct communities. In these cases, one community was chosen at random for the collection of primary data for the study. In these cases, one community was chosen at random for the collection of primary data for the study. In each community, approximately 40 households were selected for in-depth interviews. Households were selected using systematic sampling (every *n*th household) after dividing the community into zones based on the layout of the water network and other water sources (*e.g.*, handpumps, wells, rivers, and springs).

Given the purposive sampling approach used to identify province- and district-level sampling units, the findings presented here must be viewed as illustrative rather than representative. Study sample communities do exhibit socioeconomic and demographic characteristics similar to those of rural Kenya more broadly; for example, 72% of household survey respondents have completed primary school, the same share reported by UNICEF for rural areas of Kenya (UNICEF, 2010). The Ministry of Energy reports 4-10% electricity coverage for rural areas, similar to the 4% of sample households with such service. Access to improved water sources, however, is substantially higher in the sample communities as compared to the rest of rural Kenya. For example, 87% of households in the study sample reported using an improved water source, as compared to only 52% throughout rural Kenya. Similarly, the share of households in our sample with piped water supply is 30%, as compared to the national-level statistic of 12% [*Joint Monitoring Programme*, 2010a].

In each community, a team of two or three qualified engineers assessed water system performance. Collected data were used to estimate hydraulic models of each system using EPANet software (US Environmental Protection Agency, Cincinnati, Ohio). Additional information about water system functioning was obtained through in-depth interviews of the system operator(s) and water committee members in each community. In addition to factual information about their piped water system, respondents in these exercises were also asked about their experience and training related to their positions, as well as their sense of ownership for the systems they manage.

An in-person survey was also used to collect data from households and water committee members regarding their sense of ownership for their water system. A total of 1916 household interviews were carried out across the 50 communities. Each survey was conducted with the male (29%) or female (66%) household head (in 5% of interviews, both were present). In addition to their attitudes of ownership toward the system, respondents were asked about their household's water supply services;

participation in planning and construction of their water system; and socioeconomic and demographic characteristics of their households. An average of 38 households were interviewed within each community. As the unit of analysis in this study is the community, household survey data is aggregated to mean or median values for each community.

Survey instruments were developed through an intensive and iterative process, and were pre-tested in two communities that were not ultimately included in the study. The median length of an interview was 91 minutes. All interviews were carried out in the participants' preferred language, (Kiswahili, Kikuyu, Kalenjin, Meru, or Kamba). Field teams spent three to four days in each community to complete all data collection activities.

5.5 Findings: sample characteristics

The study communities had a median of 538 households and 4,011 residents. A primary and secondary school exists within 72% and 32% of the sampled communities, respectively; 24% have a health clinic. The mean distance from the community center to the nearest all-weather road is 2 km, and the mean distance to the nearest market is 6 km.

Piped water systems

The majority (53%) of sampled communities is served by a mix of public kiosks and private yard taps (Table 5-1). In 12% of the study communities the water system delivers water to public kiosks exclusively; in another 35% water is delivered through private yard or home taps exclusively. Forty percent of water systems charge users a flat fee each week or month; 12% charge by volume; and 46% use both tariff structures (one community does not charge users for water supply service).

Half of the systems draw groundwater from a deep borewell using a pump-motor unit (pumped systems); the other half are mainly gravity fed from surface sources such as rivers, springs, or reservoirs (gravity flow systems). The age of sampled water systems ranges from less than one year to 64 years, with a median of 9.5 years since construction.

As a result of the dispersed settlement patterns in the study region, piped water services reach only about 60% of households in each community. Even for those households located within the service area, water services were often reported to be unreliable. For example, a typical water system in the sample experiences one three-day interruption every three months, the equivalent of being out of service for a total of 12 days each year. Gravity flow systems report more frequent interruptions in service than pumped systems, but are also able to resolve their problems relatively more quickly. At the time of the study, an average of 25% of the taps installed in each community were not functioning. In communities with pumped systems, these sustainability-related challenges were most often related to the failure of a generator, motor, or pump. For gravity flow systems, service interruptions were most commonly caused by breaks or blockages in the distribution system (Table 5-1).

Management of water systems

Each community has a water committee, consisting of three to eight members, that is responsible for the financial and administrative management of the system. The committee's responsibilities typically include collecting water user fees, managing new applications for service, acquiring spare parts and supplies, and ensuring smooth operation and preventative maintenance (typically carried out by system operators). Only one water committee monitors the quality of water of its own system, and an additional 20% of systems are monitored by an external government agency. The remaining 78% of systems are not monitored for water quality at all.

Almost all committee members report having been elected to their positions and say they do not receive any cash payments for their work; however, 42% report receiving *per diem* compensation for travel and other expenses related to their jobs. Three quarters of the committee members interviewed report no previous experience in water and sanitation-related projects, and 24 of the 50 water committees had not received training related to their jobs. In terms of socioeconomic status, water committee members are, on average, ten years older than household survey respondents (Student's $t = 9.1$, $p<0.01$, $df=2225$), and a greater share have completed primary school (Student's $t = 5.6$, $p<0.01$, $df=2225$).

Households

The average household survey respondent is 47 years old and lives in a household of 5 people. Seventy-two percent of respondents have completed primary school, and 29% completed secondary school. Roughly two thirds of sampled households have lived in their community for at least 20 years. The majority of respondents live in a home that they own, with wood or brick walls, corrugated metal roofing, and earthen floors. The median land holding among the 83% of households owning any land is 4.5 acres. Only 4% of respondents reported having a working electricity connection in their home. The median regular weekly expenditure per household is $13.16. In terms of water supply, nearly two thirds of households use the piped water system regularly, and the remaining rely instead on surface water, open wells and rainwater collection. Among those that use the piped system, half have a working connection in their house or yard, 31% use a neighbor's tap, and 42% use a public tap or kiosk (answers do not sum to 100% because some households make use of more than one source).

5.6 Measuring sustainability and sense of ownership

Sustainability of sampled water systems is measured across three dimensions: the physical condition of the infrastructure, users' confidence in and satisfaction with their water supply service, and the extent to which water committees and system operators are fulfilling their responsibilities for system upkeep and service reliability. Sense of ownership for the water system is measured using Likert-style instruments, administered through in-person surveys of household and water committee members. Similar approaches have been used in sub-Saharan Africa to evaluate attitudes, perceptions, and feelings about a wide range of topics, including health service quality

[*Mugisha et al.*, 2004], community work ethic [*Rono and Aboud*, 2003], and HIV risk [*Puffer et al.*, 2011].

Water system sustainability

For each sustainability dimension, composite scores were created using data from the water committee, household, and system operator interviews, as well as from the engineering assessments (Table 5-2). Principal components analysis (PCA) was used to identify the orthogonal linear combinations of variables that explain the maximum amount of variance among a set of system sustainability indicators [*Filmer and Pritchett*, 2001]. Three such combinations (components) were identified through the PCA. The authors ascribed an underlying construct related to water system sustainability to each of the three sets of indicators: infrastructure condition, user confidence, and system management. Each of these composite measures is further described below.

The *infrastructure condition* score for each water system is based on (a) a four-point scale that summarizes the structural condition of its tanks, pipe junctions, and intake; (b) the number of days required to resolve the last service interruption lasting one day or more; and (c) the adequacy of preventative maintenance carried out, as represented by the ratio of annual operation and maintenance expenditures made by the water committee in the year prior to interview to the cost of running the system for one year as estimated through the study team's engineering assessment.

The score for *user confidence* incorporates two variables from the household survey data: (a) the percentage of households reporting that they are satisfied with their water supply service, and (b) the percentage of households who said they were confident that their water system would still be operating one year following their interview. Finally, the score for *system management* is based on the number of (a) administrative tasks and (b) technical tasks that are currently being performed by the water committee and/or system operator, and (c) meetings convened by the water committee with community members or the district water office during the year prior to interview.

Weighted composite scores for the three sustainability dimensions were generated by PCA after normalizing each observation by the mean and standard deviation of the variable for the full dataset. PCA was used to identify the linear combinations of the normalized variables that maximized the variance in the data. Weights (or 'loadings') for each variable were computed based on their relative contribution to the linear equation [*Filmer and Pritchett*, 2001].

Composite scores were then converted to an index that ranges in value from zero to one, with higher values indicating more sustainable ratings (Formula 5-1).

Formula 1. $$\text{Index value} = \frac{x - \min}{\max - \min}, \quad (5\text{-}1)$$

where *min* and *max* refer to the minimum and maximum scores, respectively, among sample systems. Table 5-2 reports the central tendency for each variable and composite measure. As is expected for principal components, which are orthogonal, composite measures are uncorrelated with each other.

Sense of ownership

To measure sense of ownership for the water system, households and water committee members were posed a set of Likert-style items that probe perceptions and attitudes related to the water system (Table 5-3). Additional detail regarding the development and validation of these indicators are provided in Marks & Davis (2012). Each ownership indicator is coded on a scale of zero to one, with higher scores representing greater sense of ownership for the water system.

The composite ownership score for households and water committee members is an unweighted average of each indicator. Committee- and community-level user scores are computed by averaging the relevant individual scores. (Alternative analytical approaches, *e.g.*, eigenvalue weighting and arithmetic transformations, were also explored and found not to yield any difference in substantive conclusions.)

5.7 Findings

5.7.1 Sense of ownership among households *versus* water committee members

At the community level, the mean sense of ownership score among households and water committee members is significantly and negatively correlated, $\hat{\rho}$ (48) = -0.39 ($p < 0.01$). OLS regression analysis was undertaken in order to identify possible sources of the divergence in sense of ownership scores between these two groups (Table 5-4). We hypothesize that sense of ownership for the water system is influenced by the origin of the project, the amount of time the system has existed in the community, the level of service delivered to water users, and the size of the community. Consistent with our findings reported in Chapter 4, households' sense of ownership is positively associated with a community having a relatively larger role in the design and construction of their water supply system, as well as the provision of relatively more individual household taps as opposed to shared point sources [*Marks and Davis*]. Conversely, water committee ownership is negatively associated with community-initiated water projects, although the coefficient for this variable did not reach statistical significance.

Households living in Central and Rift Valley provinces also have significantly higher mean ownership scores as compared to those living in Eastern province. By contrast, sense of ownership is significantly lower among water committee members in these provinces. Committee sense of ownership is higher in larger communities ($p=0.09$). No other explanatory variable achieves even a marginal degree of statistical significance for this second model, and the explanatory power of the model is low overall. Additional variables tested include the extent of training water committee members received, whether or not committee members had prior experience, and whether or not committee members received compensation for their work. Additional research is needed to understand the drivers of ownership feelings among members of committees charged with managing rural water systems.

5.7.2 Sustainability and sense of ownership

Ordinary least squares (OLS) regression analysis was used to model the three sustainability composite measures as a function of ownership, controlling for additional factors that have been shown to influence sustainability of rural water supplies. Exploratory data analysis revealed that the relationship between sustainability and sense of ownership appears to be defined by a U-shaped curve (see Appendix D for further explanation of these analyses). To account for a potential curvilinear relationship between sense of ownership and sustainability, a squared term is included in each model. Also included in the initial model estimations were indicators of "demand responsiveness" in project planning, ongoing technical and non-technical support, as well as system and community characteristics.

The reduced model results are presented in Table 5-5. All else held constant, households' sense of ownership is positively and significantly associated with user perceptions of sustainability and sustainable water system management (Models 1 and 2, all $p<.01$). Water committee members' sense of ownership is positively associated with infrastructure condition but only marginally significant ($p=0.08$).

Water projects that were initiated through community-level organizing, rather than through the efforts of an external agency (government, NGO, *etc.*) have significantly lower users' confidence scores ($p<0.01$), all else held constant. This finding runs counter to expectations based in the "demand responsive" infrastructure planning literature, which suggests that in-depth community engagement in project design and implementation is associated with more sustainable outcomes (Isham *et al*., 1995). A community's having received post-construction technical or management support in the two years prior to interview was not significantly associated with these sustainability outcomes. All else held constant, higher infrastructure condition scores are associated with gravity fed ($p=0.08$) and younger ($p<0.01$) systems. Larger communities have higher scores for user confidence ($p=0.10$) and system management ($p<0.01$). Users' confidence in their water system services is significantly lower in

Rift Valley and Central provinces as compared to Eastern province (both $p<0.01$), while sustainable management scores exhibit the opposite trend.

A number of other variables were tested and found not to be significantly associated with the outcome measures. These indicators include water service features (*e.g.*, ratio of taps to households, percentage of households using a secondary water source); socio-economic measures (*e.g.*, household wealth, assets, education levels); committee characteristics (*e.g.*, share of committee members that are women, recent training received); and community characteristics (*e.g.*, distance from a major town center).

5.8 Discussion and Conclusions

Sense of ownership is widely cited as a key factor in ensuring sustainability of water systems in rural areas of the developing world. To date, however, there has been limited investigation of the empirical referents of sense of ownership, and no known study of its contribution to sustainability outcomes. In addition, to the best of our knowledge previous research has focused solely on ownership feelings among households, and has not considered how sense of ownership among other groups in the community might affect water system sustainability.

This study evaluates sense of ownership among both water committees and households, and examines the extent to which each group's ownership feelings are associated with measures of water system sustainability. The investigation yielded three key insights about sense of ownership within the sample communities. First, sense of ownership among water committee members tends to track in the opposite direction from that of households. Within a given community, high sense of ownership for the water system might be expressed by the water committee *or* by households, but rarely by both groups simultaneously. This unexpected result underscores the importance of understanding the heterogeneity of ownership feelings across different groups in the community, and determining whether and among what group(s) sense of ownership contributes to water system sustainability.

Second, the relationship between several measures of water system sustainability and sense of ownership suggests is best described by a U-shaped curve. For example, system management is strongest when households' sense of ownership is very low or very high, but relatively poor management is associated with household ownership scores that are in the middle range. These findings challenge the bulk of published literature on rural water supply planning, which suggests a consistent and positive association between households' sense of ownership and sustainability.

Third, among sample communities we find that households' sense of ownership is significantly associated with two measures of sustainability—users' confidence and sustainable management—but not with the condition of their community's water infrastructure. The physical health of a water system is often considered to be the most objective facet of sustainability, as well as being the ultimate goal of many project elements designed to engender sense of ownership among users. Instead, we find it is water committees' sense of ownership that is positively associated with infrastructure condition. Identifying the drivers of ownership feelings among members of committees charged with managing rural water systems thus appears to be an important area for future research.

Other avenues for future inquiry raised by this study include the relationship between different facets of rural water sustainability, *i.e.*, how do users' confidence, sound management practices, and infrastructure condition relate to each other? How do different management models, such as community-based operation and maintenance *versus* service contracts such as those increasingly used for piped water systems in Kenya and other developing countries [*Lockwood and Smits*, 2011], mediate the relationship between different groups' sense of ownership and sustainability? Under what conditions would investments in promoting a sense of ownership among users actually translate into more sustainable outcomes?

This study represents the first known attempt to measure sense of ownership empirically for two groups within rural communities with piped water supplies, and to investigate how these measures relate to sustainable outcomes for the system. It is limited by a cross-sectional design to identifying significant associations at a point in time; there may well exist feedback loops between water system sustainability and sense of ownership that could be illuminated only through collection of longitudinal information. Nevertheless, our findings suggest a relationship between community sense of ownership and system sustainability that is more nuanced than previously acknowledged in the literature. Improving understanding of both the drivers and consequences of ownership feelings can benefit the design of developing country rural water programs, and can improve the long-term sustainability of investments in resource scarce settings.

5.9 Acknowledgments

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5.10 Tables

Table 5-1 Water system characteristics

Number served per water system	Households	Mean: 897 Standard deviation: 1670 Median: 447
	Persons	Mean: 4948 Standard deviation: 6745 Median: 2400
Age of water system	Years	Mean: 14.6 Standard deviation: 13.7 Median: 9.5
Raw water source	Percentage of systems	Surface water: 50 Ground water: 50
Level of service	Percentage of systems	Public kiosks only: 12 Private home/yard taps only: 35 Mix of kiosks and yard taps: 53
Number of days needed to resolve the last interruption in service	Gravity systems (n=25)	Mean: 6 Standard deviation: 14 Median: 2
	Pumped systems (n=25)	Mean: 10 Standard deviation: 19 Median: 4
Number of service interruptions during 6 months prior to interview	Gravity systems (n=25)	Mean: 20 Standard deviation: 26 Median: 9
	Pumped systems (n=25)	Mean: 2 Standard deviation: 1 Median: 2

Table 5-2 Sustainability indicators and composite measures

Variable	*Data source(s)*	*Mean, standard deviation, median of sample*	*Composite index value*
1. INFRASTRUCTURE CONDITION			
a. Number of days required to resolve the last interruption in water service*	System operator interview (n=45)	Mean 8.4 St. dev. 16.6 Median 3.0	Mean 0.41 St. dev. 0.21 Median 0.34 *N* 50
b. Structural condition of tanks, pipes, and intake, ranging between 1 (highly decayed) and 4 (appears new)	Engineering assessment (n=47)	Mean 3.4 St. dev. 0.5 Median 3.5	
c. Ratio of routine operation and maintenance expenditures in year prior to interview to the cost of running the system for one year	Committee inter-view, engineering assessment (n=38)	Mean 0.91 St. dev. 0.68 Median 0.91	
2. USERS' CONFIDENCE			
a. Percentage of households reporting satisfaction with their water supply service	Household interview (n=50)	Mean 0.59 St. dev. 0.19 Median 0.57	Mean 0.55 St. dev. 0.26 Median 0.54 *N* 50
b. Percentage of households that believe their water system will be operating one year following interview	Household interview (n=50)	Mean 0.67 St. dev. 0.19 Median 0.66	
3. SYSTEM MANAGEMENT			
a. The number (between 0 and 6) of major administrative duties performed by the water committee	Water committee interview (n=50)	Mean 4.2 St. dev. 1.2 Median 4.0	Mean 0.55 St. dev. 0.21 Median 0.56 *N* 50
b. The number (between 0 and 10) of major technical duties performed by the system operator and/or water committee	Water committee interview (n=50)	Mean 4.7 St. dev. 1.6 Median 5.0	
c. The total number of meetings convened in the prior year by the water committee with community members and/or district water office staff	Water committee interview (n=50)	Mean 16.4 St. dev. 12.6 Median 15.0	

**Coding for this variable was inverted for consistency with others in the PCA analysis, i.e., a higher score indicates increased sustainability.*

Table 5-3 Indicators and composite measures for household and water committee sense of ownership.
Mean values for each community are reported (n=50).

Variable	*Mean, standard deviation, median of sample*	*Composite index value*
HOUSEHOLDS		
a. I feel that I am one of the owners of the water system, ranging between 1 (“strongly disagree”) and 4 (“strongly agree”)	Mean 3.03 St. dev. 0.95 Median 3.18 N 50	Mean 0.68 St. dev. 0.22 Median 0.73 *N* 50
b. My family is one of the owners of the water system, ranging between 1 (“strongly disagree”) and 4 (“strongly agree”)	Mean 3.03 St. dev. 0.95 Median 3.20 N 50	
c. The water system is owned by all water project members, ranging between 1 (“strongly disagree”) and 4 (“strongly agree”)	Mean 3.26 St. dev. 0.85 Median 3.58 N 50	
d. To what degree are you personally concerned about the O&M of the piped water system?, ranging between 1 (“not concerned at all”) and 4 (“very concerned”)	Mean 2.25 St. dev. 1.06 Median 2.16 N 50	
WATER COMMITTEE MEMBERS		
a. I feel that I am one of the owners of the water system, ranging between 1 (“strongly disagree”) and 4 (“strongly agree”).	Mean 3.72 St. dev. 0.45 Median 4.00 N 50	Mean 0.83 St. dev. 0.27 Median 1.00 *N* 50
b. The water system is owned by all water project members, ranging between 1 (“strongly disagree”) and 4 (“strongly agree”).	Mean 3.71 St. dev. 0.61 Median 4.00 N 49	

Table 5-4 Ordinary least squares regression of community-level household, water committee member sense of ownership (n=45)

	Mean (standard deviation)	*Model 1: Household sense of ownership*	*Model 2: Water committee sense of ownership*
Constant	-	0.34 (0.11)	0.84 (0.16)
Origin of water system project (1= community, 0=external agency)	0.82 (0.39)	0.16** (0.07)	-0.09 (0.11)
Project age in years (natural log)	15.16 (14.12)	0.00 (0.00)	-
Project age <2 years (dummy)	0.14 (0.35)	-	0.18 (0.12)
Community population in 1000s (natural log)	1.51 (0.92)	-0.03 (0.03)	0.09* (0.05)
Central province (dummy)	0.33 (0.48)	0.25*** (0.07)	-0.24** (0.12)
Rift Valley province (dummy)	0.33 (0.48)	0.30*** (0.07)	-0.21* (0.12)
# of household taps installed / 1000 persons	25.42 (40.24)	0.00* (0.00)	0.00 (0.00)
Adjusted R^2		*0.51*	*0.16*

Notes: Model standard errors in parentheses. *** $p \leq 0.01$; ** $0.01 > p \leq 0.05$; * $0.05 > p \leq 0.10$.

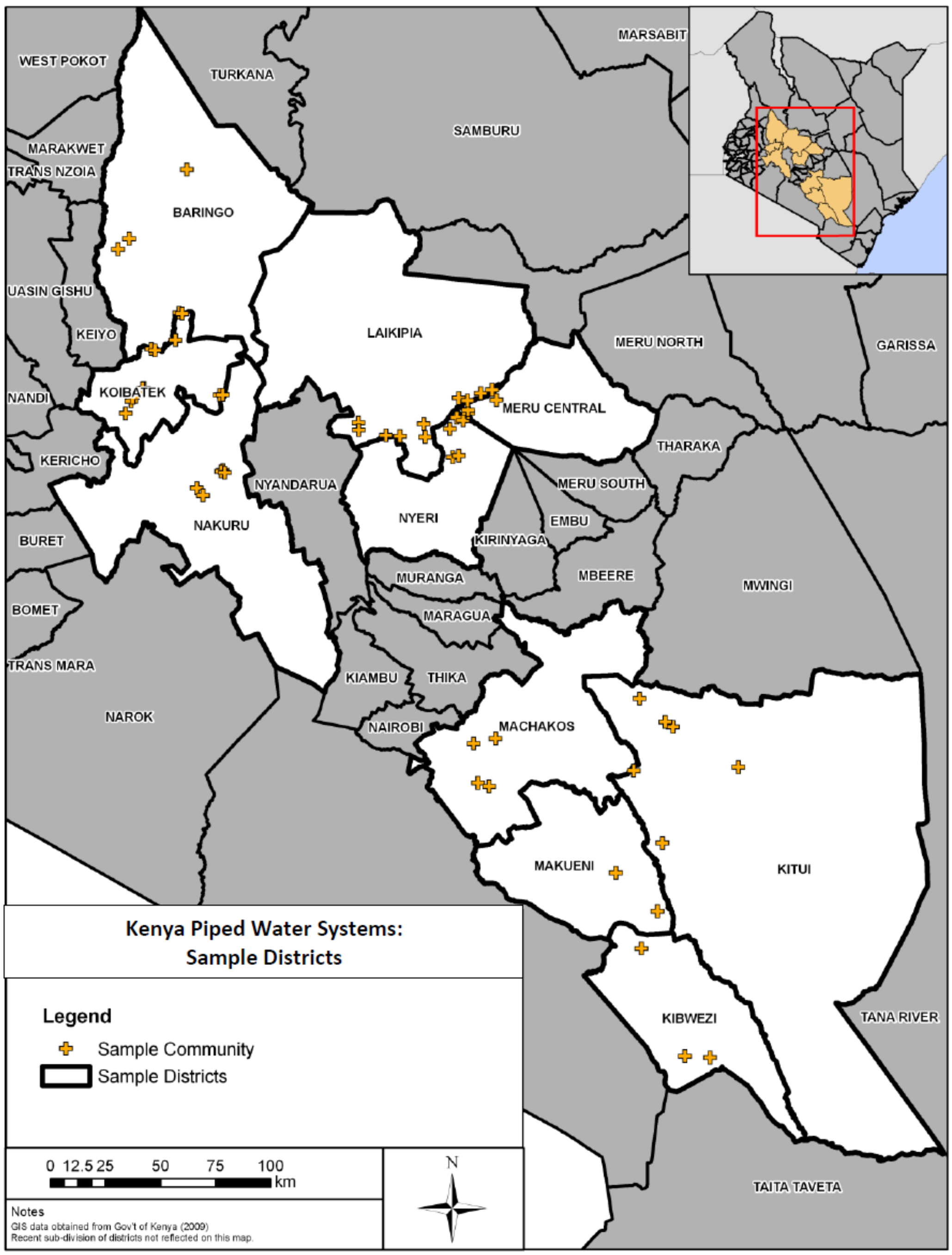
Table 5-5 Ordinary least squares regression of water system sustainability

	Mean (standard deviation)	*Model 1: User confidence*	*Model 2: System management*	*Model 3: Infrastructure condition*
Households' sense of ownership (HH SOO)	0.68 (0.22)	0.78*** (0.15)	0.48*** (0.17)	-0.27 (0.25)
HH SOO^2	0.81 (0.30)	0.59* (0.33)	1.04*** (0.40)	-0.31 (0.56)
Water committee's sense of ownership (WC SOO)	0.51 (0.28)	0.15 (0.19)	0.10 (0.18)	0.48* (0.26)
WC SOO^2	0.75 (0.38)	0.32 (0.19)	0.03 (0.39)	0.69 (0.57)
Water project was community initiated (1) *versus* externally initiated (0) (dummy)	0.82 (0.39)	-0.22*** (0.06)	--	--
Water committee has received non-technical support in prior 2 years (dummy)	0.12 (0.33)	--	0.03 (0.08)	--
Committee/operator has received technical support in prior 2 years (dummy)	0.50 (0.51)	--	--	-0.09 (0.09)
Water project has pump (1) *versus* gravity-fed (0) (dummy)	0.64 (0.48)	--	--	-0.17* (0.10)
Project age (years)	14.58 (13.71)	-0.001 (0.002)	-0.001 (0.002)	-0.010*** (0.003)
Community population in 10,000s (natural log)	-0.83 (0.94)	0.05* (0.03)	0.13*** (0.03)	0.02 (0.05)
Rift Valley province (dummy)	0.30 (0.46)	-0.58*** (0.08)	0.23*** (0.09)	0.25* (0.13)
Central province (dummy)	0.40 (0.49)	-0.62*** (0.07)	0.13 (0.09)	-0.01 (0.12)
Constant	--	1.16 (0.09)	0.50 (0.08)	0.58 (0.13)
	Adjusted R^2	*0.71*	*0.35*	*0.19*
	Observations	*45*	*46*	*49*

Notes: Model standard errors in parentheses. *** $p \leq 0.01$; ** $0.01 > p \leq 0.05$; * $0.05 > p \leq 0.10$.

5.11 Figures

Figure 5-1 Map of sample communities in ten districts of Kenya



6 Conclusions and future research directions

6.1 Conclusions

Conclusion 1: Different forms of community participation have different relationships with sustainability outcomes.

Historically there has been a strong emphasis on community mobilization in the pre-construction phase of rural water projects, with such mobilization presumably ensuring the sustainability of water points. Chapter 3 investigates the determinants of handpump sustainability in 200 rural communities in Ghana that had undergone demand-oriented water supply planning. We find that the breadth of participation shows no or weak association with the handpump sustainability indicators used in this study. By contrast, depth of participation (*e.g.*, attending more pre-construction meetings, making larger cash contributions) is significantly associated with various aspects of handpump sustainability. Notably, we find no evidence that labor contributions—either in terms of the share of households providing labor or the number of days the average household gives—are associated with better outcomes for handpumps. The findings of this study thus do not support an argument for soliciting all forms of participation from every single member of a community in sub-Saharan Africa.

In addition, we find that project outcomes are better within communities where a greater share of households reported participating in management-related decisions and worse within communities with greater household participation in technical decisions about the project. This trend is observed across several different management- and technically-oriented decisions. These findings are consistent with prior research on development project outcomes in rural areas of the developing world [*Khwaja*, 2009], and suggest that it is not in the best interests of project implementers to solicit input from households on matters that require engineering expertise.

Conclusion 2: Community members' sense of ownership for the water system can be empirically measured.

A major finding of this dissertation is that community sense of ownership for the water system can be meaningfully measured. We draw on the theoretical framework for psychological ownership in the workplace setting to develop a composite measure for community members' sense of ownership for their water system in sub-Saharan Africa. In Chapter 4 we show that households in rural Kenya feel varying levels of ownership for their communal water system. Chapter 5 compares households' and water committee members' sense of ownership for the system at the community-level and finds that ownership scores for these two groups are negatively correlated.

To the best of our knowledge, this research represents the first attempt to quantify community members' sense of ownership for the water system. This research establishes an empirical referent for a phenomenon that is widely documented throughout the scholarly and practitioner literature on rural water supply development. However, the knowledge generated through this research is not necessarily directly transferable to other settings. The ownership construct was developed in Kenya using a highly grounded approach to data collection, and the statistical techniques employed were suitable for exploratory data analysis. These findings from Kenya contribute to the evidence base for a substantive theory on community sense of ownership for rural water systems. The development of a more formal theory on individual or collective sense of ownership for communal infrastructure that can be generalized will require additional research grounded in other local realities. In summary, it is the grounded methodology of this study, and its findings, viewed as propositions, rather than the findings themselves, that are most readily transferred to other settings.

Conclusion 3: Certain types of participation during project planning and construction relate to community members' sense of ownership for their water system.

It is widely assumed within the practitioner literature that community participation in rural water project planning instills a sense of ownership for the water system among community members. In Chapter 4, our analysis within 50 communities in Kenya suggests a more nuanced set of relationships. We observed a threshold effect in the association between capital cost contributions and sense of ownership. Households who contributed at least US$50 (in 2009 USD)—an amount equivalent to one month's income for a typical household at the time of interview—were significantly more likely to express a moderate or high *versus* low sense of ownership. Smaller contributions showed no significant association with sense of ownership.

In addition, households' involvement in making decisions about the level of service obtained is associated with a high sense of ownership for the system. Labor contributions are significantly associated with moderate sense of ownership. No association is found between sense of ownership and small cash contributions, education level, or leadership responsibilities within the community. This study suggests that certain forms of participation during project planning and construction can serve to enhance community members' sense of ownership for rural water projects.

Currently, considerable effort is given to the design and execution of participatory processes in rural water planning, with the belief that the benefits of these activities—in terms of engendering the capacity and commitment within a community to keep their water system running—outweigh their costs. We find evidence that different types of community engagement may affect households' feelings of ownership to varying degrees. Based on this evidence, it can be concluded that the capital cost sharing policies of many developing country governments and international donor agencies may be broadly useful for instilling community sense of ownership for installed water supply infrastructure, but not when project rules require only small or 'token' contributions from households.

Conclusion 4: Different aspects of water system sustainability are predicted by the sense of ownership felt by different groups within the community.

In Chapter 5 we investigate the extent to which households' and water committee members' sense of ownership for the water system relates to water system performance. This study yields two key insights. First, within a given community in our sample, sense of ownership among water committee members tends to track in the opposite direction from that of households. Second, households' sense of ownership matters with regard to two measures of sustainability—users' perceptions and sustainable management—but is not significantly associated with the condition of a community's water system infrastructure. Instead, infrastructure condition is positively associated with water committee members' sense of ownership.

The bulk of the published development literature suggests a direct linear relationship between households' sense of ownership and system sustainability, yet our findings do not support this hypothesis. Additionally, the physical health of a water system is often considered to be the most objective facet of sustainability, as well as being the ultimate goal of many program and project activities designed to enhance households' sense of ownership. Our findings suggest that, rather than households, it is water committees' sense of ownership that is positively associated with infrastructure health. These findings challenge prevailing ideas about sense of ownership in the rural water sector, opening up a rich area for further inquiry. Such research will benefit the design of rural water programs that seek to improve the long-term sustainability of investments in resource scarce settings.

Conclusion 5: Community participation alone does not explain sustainable outcomes for rural water supply infrastructure.

Above and beyond the effects of community members' participation in planning and construction of handpumps in rural Ghana (Chapter 3), we find evidence that institutional support in the post-construction period is an important predictor of better project outcomes. In addition, other design-related factors—such as the fewer people using a water point and the absence of an electric submersible pump—are consistent predictors of system sustainability (Chapter 3, 5). Interestingly, post-construction support is positively associated with better handpump platform condition and households' satisfaction with their water service in Ghana, but is negatively associated with expenditure sufficiency for operation and maintenance of the infrastructure. This finding could possibly be explained by the fact that post-construction support programs may provide discounted or even free repair services, thereby reducing the amount of money water committees must spend to maintain their water point.

These findings are in line with recent studies that have highlighted the importance of providing post-construction support services to rural communities for ensuring sustained water service delivery in rural communities [*Davis et al.*, 2008; *Lockwood and Smits*, 2011; *Prokopy et al.*, 2008; *Schouten and Moriarty*, 2003]. These studies followed on a sector-wide shift from supply-driven centralized government provision of water services to a more decentralized demand-oriented approach that emphasized community participation in planning and construction. Despite marked improvements in functionality rates over supply-driven planning, this dissertation contributes to the evidence that community participation alone fails to ensure the sustainability of rural water services.

6.2 Future research

Further investigation of community sense of ownership for the water system in other settings

A large portion of this dissertation focuses on investigating the determinants and impacts of community sense of ownership for rural water supply systems. This research was conducted in 2009 within 50 rural communities in Kenya with piped water supply systems. It is possible that a similar investigation conducted at a different time or in a different setting may yield different results than those observed in this study. Fortunately, a data collection effort similar to Kenya's took place within 50 rural communities in Senegal during the same time period, which presents a valuable opportunity to repeat these analyses and draw comparisons between the two countries. Extending the investigation of sense of ownership for communal water supplies to Senegal (as well as other locales) will reveal the conditions under which the results presented in Chapters 4 and 5 hold. More broadly, expanding the evidence base for this topic area is critically important for development of a substantive theory on sense of ownership for communal water supply.

In addition to replicating the analyses presented in this dissertation, there are also several new areas of research that are worth pursuing. First, water committee members' sense of ownership for their water system was found to be a key factor in explaining better infrastructure condition in Kenyan communities, yet little is known currently about the nature or determinants of water committee members' feelings of ownership. Do water committees feel as if they "own" the problems related to the water system, or are their ownership feelings stemming from an actual stake in the system's continued operation? Identifying the main drivers of ownership feelings among members of committees charged with managing rural water systems is thus an important area for future research. We briefly investigate this question in Chapter 5 and find that the origin of the water project and the size of the community are both associated with water committee sense of ownership. As this investigation was not the focus of the study and data availability was limited, there is a need for further investigation.

The best research design for such an investigation would be a longitudinal survey within communities that tracks the water system's status alongside the feelings of ownership embodied by different groups in the community. Ideally, this investigation would begin before the planning and construction of the water infrastructure to capture the baseline scenario for community members' attitudes toward their water supply. To improve the strength of such a quasi-experiment, it would be best if the delivery of the infrastructure was cluster-randomized and included control communities. Collecting qualitative data (e.g., open-ended questions about the nature of water committee members' feelings of ownership) would also be very useful.

Second, there is a need for better understanding of the causal mechanisms that underpin the observed associations between participation, sense of ownership, and system sustainability. Qualitative research is especially valuable for understanding the causal pathways that explain sustainable outcomes for rural water services and could be undertaken alongside the longitudinal survey described above. In addition, a qualitative approach may uncover the interactions between the various dimensions of rural water sustainability, *i.e.*, how do users' satisfaction, sound management practices, and the system's physical health relate to each other? Such research will greatly inform the rural water sector's ongoing attempts to develop a standard approach for measuring and monitoring sustainability of rural water systems, which is also highlighted as an important area of future research below.

Relative importance of different programmatic inputs for rural water supply planning

Chapters 3 and 5 showed that other factors besides community participation matter for explaining variation in water system sustainability—in some cases above and beyond the effect of community participation. Following on this observation, there is a need for a study that comprehensively examines the full array of programmatic "inputs" that contribute to sustainability of rural water, including (but not limited to) community participation. Other inputs include post-construction support services, training and education programs, and infrastructure design and innovation (e.g., designing water supply systems that support multiple uses). This head-to-head comparison would allow for a better understanding of the relative importance of different types of investments into rural water programs.

One option for investigating the impact of various program inputs on outcomes of water system sustainability is to employ fuzzy set/qualitative comparative analysis (fs/QCA). This analytical technique—which can be successfully applied to intermediate numbers of cases (10-20 cases)—uses Boolean logic to make paired comparisons of combinations of conditions that produce a specific outcome [*Ragin*, 1989]. This is an ideal research approach for this research question, since there are likely two or more "recipes" that lead to sustainability of water systems in the developing world.

Development of a standard set of sustainability indicators for different types of water systems

Throughout this dissertation an array of indicators are used to approximate sustainability of various types of water systems. The choice as to which indicator(s) to use is based on previous research on rural water projects in Africa and the availability of data. There is a need for consensus in the water sector on a standard set of indicators for monitoring water system performance over time, which would allow for the sharing of knowledge and lessons learned across different rural water programs. Development of a standard set of sustainability indicators would complement the existing open-source platforms that track the status of water points in rural and urban settings. These platforms are becoming increasingly common throughout the world, the best known being the *Field Level Operations Watch (FLOW)* mapping technology developed by the Colorado-based NGO Water for People[12] and the *Proving It* campaign from the Washington-based NGO A Child's Right.[13] A standard set of indicators would enable comparison across and within these mapping technologies, ultimately facilitating informed decision-making.

[12] http://www.waterforpeople.org/programs/field-level-operations-watch.html
[13] http://www.achildsright.org/provingit/

A. Supporting information for Chapter 2

I. Community participation in planning and implementation of rural water services: a historical perspective

Sustainability of rural water services first became a principal concern for sector practitioners during the International Drinking Water and Sanitation Decade of 1981 to 1990 (hereafter referred to as the Decade), when the goal of 'water for all' spurred rapid construction of water systems based on a centralized planning model. This effort undoubtedly increased the number of people served with an improved water source, but the Decade's goal of achieving 100% coverage proved to be too ambitious [*Carter et al.*, 2007]. Even more disappointing, by the end of the Decade a high fraction of the newly installed systems were performing very poorly [*Briscoe and Garn*, 1995], with some countries reporting total breakdown rates of existing facilities that outpaced the construction of new ones [*Briscoe and Ferranti*, 1988].

Post-mortem investigations revealed that the approaches used by most donor-supported efforts to rapidly expand rural water services ultimately undermined the sustainability of installed infrastructure. Therkildsen (1988), for example, finds that most rural water programs in Tanzania were challenged by premature system breakdowns following construction because resources had largely been channeled through foreign consultants and manufacturers instead of in-country stakeholders. In the early phases of the project this had seemed like the most efficient use of resources, but in the long term communities and local government agencies found themselves ill-equipped, unable, or unwilling to operate the water systems that had been left in their hands [*Therkildsen*, 1988]. Therkildsen's study illustrates a fundamental tension between issues of access and sustainability, since meeting the pressing need for expanded services is often at odds with a patient, coherent approach that makes sustainability a top priority [*Briscoe and Ferranti*, 1988].

The emergence of the demand-responsive approach

The principal response to the insights illustrated by Therkildsen and other scholars was the incorporation of greater community involvement in planning and implementation of rural water projects. This shift in the rural water planning paradigm was pioneered by the World Bank's so-called "demand-responsive approach" (DRA), introduced toward the close of the 1990s [*Garn*, 1997]. DRA emphasized greater involvement of community members in the planning, construction, and financing of water supply projects; the use of users' willingness to pay (demand) to guide technology selection, levels of service provided, and other service design features; and decentralization of decision-making and system management to lower, often community, levels [*Briscoe and Ferranti*, 1988].

The World Bank's new planning model was largely taken up by other water sector practitioners, which led to significant changes throughout the sector. Community participation played a central role in the next tranche of rural water programs that followed the Decade. The guiding principles for this movement are articulated in the 1992 Dublin Statement, issued at the International Conference on Water and the Environment (ICWE). Though non-binding, the Dublin Statement's declarations that fresh water should be developed and managed based on a participatory approach involving users (especially women) was widely adopted throughout the water sector [*ICWE*, 1992]. From this point on, national governments moved away from direct provision and financing of the construction, operation, and maintenance of rural water supply, and toward a more limited role of determining policy, funding the bulk of capital costs, and regulating the sector. This arrangement still exists today throughout much of the developing world [*Pritchett and Woolcock*, 2004].

From the point of view of the World Bank and other early adopters of DRA, the overarching goals of this planning approach are to target communities that demonstrate a sincere commitment to an improved water supply project and, within those communities, to match technologies and service levels to users' felt needs and preferences. To target such communities, the project implementation team (often an NGO or company under contract) employs a series of 'demand filters.' In practice, these typically begin with a formal, written application that the community submits to the water program implementing agency. Next, a cost sharing arrangement is typically made between the project implementers and the community, in which community members are required to contribute a share of the construction costs (usually 5 to 10%) paid in cash or in-kind. In addition to capital contributions, community members are often required to provide days of labor during the construction phase. Finally, community members pledge to cover all routine operation and maintenance costs over the life of the project. These obligations are often summarized in a formal contract that community representatives sign before the project begins.

Next, the process of matching a water system design to users' felt needs and preferences begins with one or more meetings with the community. These meetings provide a forum for dialogue between project staff and community members such that households can share opinions and concerns, and eventually make an informed decision from the menu of technology options (e.g., protected well, borehole with a handpump, rainwater collection, piped system, etc.) and service levels (e.g., communal *versus* private water point) [*Gross et al.*, 2001]. In addition, training sessions are typically conducted to prepare the community (in particular, a water committee that is elected or appointed) to serve as the primary party responsible for the system's routine operation and maintenance after installation.

Under DRA, up-front contributions such as cash and labor are considered expressions of the community's collective demand for improved rural water services. The implicit assumption is that when communities are given such control over the initial phases of the project, they are more likely to feel a sense of ownership for the installed water system. This sense of ownership, coupled with the training received, leads to their willingness and ability to operate, maintain, and repair the system over time [*Briscoe and Ferranti*, 1988; *Garn*, 1997]. Such contributions also appeal to donors and governments, since sharing the burden of time, money, and labor spent on the project allows programs to do more with limited resources [*Lockwood*, 2004; *Yacoob*, 1990]. Management duties on the part of the water committee include collecting fees for water from users, using these revenues to purchase the necessary spare parts and supplies, and performing maintenance and repairs as needed. For water users, the consequences of DRA are thought to be a willingness and ability to pay fees for water and to hold the water committee responsible for ongoing operation of the system. All together, these hypothesized causal linkages lead to a sustainable water service that is satisfactory to users, feeding back into their willingness to pay for water.

Normative rationale for local participation: The alternative development strategy

Alongside the emergence of DRA, another popular movement emerged within the development sector that promoted beneficiary participation in community-scale projects based on *normative* arguments. A moral rationale for local participation in development efforts was introduced in the 1960s by the Inter-American Foundation (an independent donor concerned with Latin America and the Caribbean), and is often termed the 'alternative development strategy' (ADS) [*Finsterbusch and Van Wicklin*, 1987]. This body of literature emphasizes the moral imperative of the development community to preserve indigenous knowledge and skills, empower the poor, and work toward redistributing power in its efforts to alleviate poverty [*Gamer*, 1982].

Proponents of ADS cite its ability to build community capacity through training and education components related to the project. ADS is also thought to engender community members' commitment to (or 'sense of ownership' of) the project, thereby empowering them to manage their project and initiate new ones [*Finsterbusch and Van Wicklin*, 1987]. For rural water supply projects in particular, it is argued that households should play a major role in shaping its development since these projects are likely to have a major impact on lives and livelihoods [*de Regt*, 2005]. The major message of ADS is that the community participation is an end in itself, rather than a means of reaching sustainable outcomes [*Prokopy*, 2004].

Interestingly, whereas the origin and underlying reasoning behind DRA and ADS differ significantly, many of the processes involved for each within rural water supply planning overlap to the point of being nearly indistinguishable. For instance, up-front contributions and community involvement in decisions are employed in DRA in order to assess demand and exchange crucial information regarding the project. In ADS these practices are promoted as the means for engendering users' sense of ownership for the project. In DRA, the organization of community members into a water committee, and the use of training programs to ensure that the water committee can perform the necessary technical and administrative tasks, is the final step in ensuring that the system is well-matched to the intended users. Alternatively, in ADS, organization and training is treated primarily as an end in itself, since building local capacity and empowerment has inherent value and is a specific goal of these programs.

The 'bundling' of models

Evidence of the DRA and ADS schools of thought intermingle throughout the rural water supply development literature, with references to, *inter alia*, the demand responsive approach [*Sara and Katz*, 1998; *Whittington et al.*, 1998], community participation [*Manikutty*, 1997; *Narayan*, 1995], beneficiary involvement [*Finsterbusch and Van Wicklin*, 1987], and community driven development [*Briscoe and Ferranti*, 1988; *de Regt*, 2005]. This evidence implies that DRA and ADS, which began as separate prescriptions invented by donors, have evolved into an array of planning approaches that all emphasize community participation in roughly similar ways. That is, up-front contributions, involvement in key decisions related to the water system, and organization and training activities are now part of a standard 'participation recipe' that has been adopted (often without explicit rationale) by many rural water programs throughout SSA in recent years [*Pritchett and Woolcock*, 2004].

As a consequence, there is little understanding of how or why implementers are carrying out community mobilization in the early phases of water projects. In addition, little is known about the impacts of various form of community participation, or the hypothesized causal mechanisms for achieving sustainable outcomes, including meeting users' felt needs and preferences, building local capacity, and instilling a sense of ownership for the water system among community members.

II. Additional factors influencing sustainability of water systems

Besides community members' involvement in the project there are other factors that are known to influence the sustainability of rural water projects. In this section we attempt to summarize the evidence regarding additional drivers of and barriers to sustainability or rural water supplies. These factors can be broadly categorized as social, technical, or external in nature.

Social factors

Social factors include the overall material wealth, educational attainment, ethnic composition, social capital, and the quality of local leadership. In this section we briefly review the hypotheses and evidence related to each of these factors. Wealth levels matter since wealthy people should in theory be better able to pay for water services and ensure financial sustainability of the system. In terms of education levels, higher literacy rates among households should also exert a positive influence on the water system's functioning, as literacy is thought to relate to community members' incentive to improve local conditions [*Krishna*, 2001]. Possession of certain assets has also been shown to be a reliable predictor of wealth in the absence of income data [*Filmer and Pritchett*, 2001].

A community's ethnic composition can also impact the sustainability of water infrastructure. Schouten and Moriarty (2003) describe cases studies from rural Nepal and Kenya where disputes over water arose along caste and ethnic lines, respectively, leading to poor performance for the piped water systems in these areas. In Nepal, the lower caste households were prevented from speaking at meetings, leading to these households' being subsequently unwilling to contribute money toward the system's ongoing maintenance. In Kenya, the installation of a new piped gravity system by an NGO reallocated water resources amongst two clans living within the same community, with one group benefiting more than the other. This diversion led to conflict and the eventual shut down of the water system [*Schouten and Moriarty*, 2003]. These studies illustrate the negative impact that social heterogeneity can have on the stewardship of communal resources in the absence of conflict resolution.

Another key community-level factor is social capital, defined by Narayan and Pritchett (1999) as the quantity and quality of associational life, and related social norms [*Narayan and Pritchett*, 1999]. Practically speaking, social capital is a measure of trust or social ties within a community, and thus the extent to which households have access to communal resources [*Krishna*, 2001]. Social capital also has value because it should predict the likelihood of community members cooperating for mutual benefit [*Putnam*, 1995]. Measurement of social capital can be difficult, since it is not a tangible object but rather "exists in the relations among persons" [*Krishna*, 2001]. It is therefore common for social capital to be approximated using a locally specific measure after careful observation of the workings of the community.

The effect of social capital on water system sustainability has been shown to vary dramatically. In some cases, social capital is related to the 'free rider' effect, wherein some households do not pay their own fees for water since they know others in the community will cover their share of the costs [*Komives et al.*, 2006; *Schouten and Moriarty*, 2003]. In another study, social capital as measured by the existence of active community groups was found to relate to the likelihood of households participating in the water system's design process, as well as regularly paying fees for water [*Isham and Kähkönen*, 2002].

Krishna (2001) finds that the combination of effective leadership *alongside* social capital explains good project performance, ostensibly because good leaders can recognize development opportunities arising outside the community and tap social capital resources as needed. However, social capital on its own represents merely the potential for sustainable projects [*Krishna*, 2001].

Technical factors

The design and construction of the water system itself also influences its likelihood of operating through its expected lifetime. The Afridev handpump, for example, has components that are particularly vulnerable to deterioration over time. These parts include the welded hook/eye section of the plunger rod, the plunger seal, and the foot valve's o-ring—all of which must be replaced after a certain period of time depending on the number of people using the water users [*Erpf*, 2003; *Osafo-Yeboah*, 1994]. In the absence of a dependable spare parts supply chain such wear and tear may lead to premature failure of the water system.

In addition, the complexity of a system can influence its likelihood of breaking down. Khwaja (2009) found that project complexity (an index based on the amount of capital and skilled labor required) is significantly and negatively associated with good maintenance for infrastructure projects in rural Pakistan [*Khwaja*, 2009]. Others found that larger schemes in Malawi and Colombia (in terms of the number of connections and extent of piping) were more vulnerable to major interruptions in service when external support was unavailable [*Kleemeier*, 2000; *Schouten and Moriarty*, 2003].

External factors

External factors include the existence of effective institutional support such as training or technical assistance programs and environmental issues such as climate change and water resource availability.

It is not uncommon for community training and education sessions to accompany a rural water project. The water committee may be trained in financial bookkeeping, technical maintenance, or conflict resolution [*Komives et al.*, 2006]. Some water programs require water users to complete educational sessions on hygiene and sanitation topics, such as ensuring protection of the water source and safe water storage in homes [*Manikutty*, 1997]. Such training and education attempt to addresses any problems with the community's insufficient capacity to maintain a functional water system over the long term.

In the absence of any training, even communities that are highly motivated may not be able to successfully manage a water system. Schouten and Moriarty (2006) describe a case where six Guatemalan communities had worked together to install one large water system—an arrangement that allowed them to cover the capital costs of the project. Shortly following installation, a major pipe broke and the water committee was unable to make the necessary repair themselves or find any help elsewhere. The authors highlight the low level of technical knowledge that the water community possessed and their relative isolation from water engineering resources. Dissatisfied household eventually switched back to unprotected water sources and stopped paying for water from the malfunctioning piped water system. Eventually the bankrupt water committee was forced to shut the water system down completely [*Schouten and Moriarty*, 2003].

In Kerala, India, Manikutty (1997) describes a particularly thorough community training approach that accompanied a piped water program organized by the local water authority. First, local volunteers delivered health awareness messages door-to-door within communities where piped water systems were planned to be installed. Next, women were hired to disinfect local wells, households received information on safe water storage practices, and local artisans were trained to promote latrine construction as a business opportunity [*Manikutty*, 1997]. On average, project outcomes within communities that had undergone the training and education campaign greatly differed from outcomes within communities that had received no such training. He found that significantly more households in trained communities had covered water vessels and knowledge of safe water practices. Additionally, trained communities were more likely to have financially sustainable water systems, functional taps, and satisfied water users.

Taken together, the studies detailed above suggest that the presence or absence of a training component alongside infrastructure delivery can significantly affect the water systems likelihood of functioning over the long-term.

***

Post-construction support (PCS) is a term used to describe visits to the community (either solicited or unsolicited) following the system’s installation, usually for the purpose of helping the water committee solve administrative or technical problems. Davis et al. (2008) investigated the effect of different forms of PCS on piped water projects within 100 rural communities in Cochabamba and Chuquisaca, Bolivia. The authors find that most of the sampled communities were receiving some form of PCS, and that management-oriented PCS visits were positively associated with sustainable water systems. Technically-oriented PCS visits, however, were not significantly associated with sustainability [*Davis et al.*, 2008].

Others have found that handpump in rural Ghana perform better in the presence of ongoing technical assistance [*Komives et al.*, 2008]. In Schouten and Moriarty's (2003) series of case studies on rural water supply they conclude that "however poor the capacity of government, it is a clear finding of this work that community-managed systems cannot be sustainable in the absence of external support" [*Schouten and Moriarty*, 2003].

Finally, environmental factors such as the existence of adequate water resources for human and ecosystem needs are critical for ensuring the water system sustainability. The pressure on water resources is growing due to population growth, development, and climate change. Most of the pressure on freshwater resources in developing regions is driven by agriculture, which is expected to increase as anthropogenic climate change causes temperature rise in some areas of the world. As freshwater availability *per capita* decreases in some areas, it is expected that water supply infrastructure will be negatively impacted by extended dry periods, especially shallow groundwater systems, roof rainwater harvesting, and surface water systems [*Joint Monitoring Programme*, 2011].

In addition, social arguments exist which link water scarcity to motivation levels among community members. Araral (2009) shows that the degree of water scarcity has a curvilinear relationship with the existence of collective action within communities, such that community members will not mobilize if very low or very high volumes of water are available locally. This may be explained by the fact that community members are not motivated to go to the trouble to maintain an improved water source if other sources are readily available, and it may be just as fruitless to self-organize if too little water is available. However, a mid-level volume is related to community members organizing themselves to form and manage irrigation systems [*Araral*, 2009].

B. Supporting information for Chapter 3

Results

Decision-making and sustainability

The results of this study suggest that, all else constant, households' involvement in making technical decision is detrimental for water points' sustainability, whereas their involvement in management decisions is associated with project sustainability. These findings are consistent with prior research which shows that project maintenance in rural communities in Pakistan is better if households make non-technical decisions, but worse if households are making technical decisions [*Khwaja*, 2004]. However, as the decision-making variables in this study are broadly defined as being technical- or management-related, there is little understanding of what decisions were actually made by households. In this section we examine the specific types of project-related decisions that were made by households (Table B-1), and test for basic association between each decisions and each indicator of sustainability (Table B-2).

Decisions that are broadly grouped as management-related include choosing the tariff structure, determining the handpumps' hours of operation, electing or choosing the watsan committee's members, and determining the level of contributions to be made the project's construction. Technical-related decisions include deciding on the type of handpump to be installed, identifying possible sites for the handpumps, and once the sites are chosen, choosing where to drill the borehole.

We find that among all of the statistically significant coefficients presented in Table B-2, the management-related decisions show a consistent positive association with sustainability measures. Technical decisions, however, are either positively or negatively associated with sustainability, depending on the type of decision and the particular sustainability indicator in question. This analysis is limited in that it does not control for other variables that could potentially impact sustainability outcomes. Nonetheless, these results allow for a direct comparison of various forms of decisions as they relate to sustainability.

Table B-1 Households' involvement in different decisions about the water project (n=200)

Percentage of households that were involved in:	%
Choosing the type of technology (e.g., deep well or borehole, type of handpump, etc.):	34
Identifying possible sites for the boreholes:	31
Choosing where to drill the boreholes:	29
Any technical decision:	**43**
Deciding on or electing the watsan committee:	59
Determining the hours and days that the water system would operate:	54
Deciding how much cash and/or labor each household would have to contribute:	60
Setting the tariff for water provided by the system:	54
Any management decision	**75**
A decision of any type (technical or management)	**76**

Table B-2 Simple regression analysis results – handpump sustainability *versus* household decision-making

		1=all handpumps working, 0=otherwise	1=continuous operation in past 6 months, 0=otherwise	1=platform condition is good, 0=otherwise	1= 0-75% HHs satisfied with O&M, 2= 75-90%, 3=91-100%	1=women satisfied with O&M, 0=otherwise	1= watsan thinks system will function in 5 years, 0=otherwise	1=O&M expenditures at least 1% capital costs, 0=otherwise	1=User fees cover regular O&M expenditures, 0=otherwise
***Technical decisions*:**	***Mean:***								
% choosing the type of technology (e.g., well or borehole, type of handpump, etc.)	34	0.05 (0.01)	0.01 (0.01)	-0.02** (0.01)	-0.02*** (0.01)	0.00 (0.01)	0.01 (0.01)	-0.01 (0.01)	0.02** (0.01)
% identifying possible sites for boreholes	31	0.13 (0.96)	0.33 (0.67)	-0.19 (0.60)	-0.91* (0.54)	0.16 (0.74)	0.21 (0.60)	-0.56 (0.69)	1.16* (0.64)
% choosing where to drill	29	0.02 (0.97)	0.42 (0.68)	0.02 (0.62)	-0.60 (0.55)	0.18 (0.75)	-0.10 (0.61)	-1.08 (0.73)	0.82 (0.64)
***Management decisions*:**									
% choosing or electing the watsan committee	59	0.98 (1.31)	0.61 (0.85)	0.85 (0.82)	1.59** (0.73)	-1.01 (0.98)	0.29 (0.80)	-0.08 (0.91)	0.98 (0.85)
% determining the hours of operation	54	2.02** (1.02)	0.15 (0.67)	0.14 (0.62)	-0.79 (0.56)	0.10 (0.75)	1.03* (0.62)	0.15 (0.70)	1.13* (0.66)
% choosing the tariff structure for water	54	2.53*** (0.93)	0.08 (0.62)	0.20 (0.57)	-0.23 (0.51)	0.99 (0.69)	0.71 (0.56)	-0.70 (0.63)	0.78 (0.59)
% deciding how much each cash and/or labor each household would have to contribute to the project	60	3.38*** (1.03)	0.30 (0.67)	0.42 (0.62)	-0.53 (0.55)	0.93 (0.74)	1.30** (0.62)	0.07 (0.69)	1.45** (0.65)

Standard errors in parentheses. * 0.05 < p ≤ 0.10. ** 0.01 < p ≤ 0.05. *** p ≤ 0.01.

C. Supporting information for Chapter 4

The following questions regarding households' attitudes toward their water system were posed to households that had been living in their community at the time of the water system's planning and construction. These questions were integrated into a larger survey related to the productive uses of domestic water. They are shown in no particular order below.

Q.1 Now, please think about the things that your family OWNS, such as a BICYCLE OR WHEELBARROW. Think about how you feel about these items, and what it means to say "this is MY bicycle," for example. I would like to ask you about your feelings of ownership towards the village's piped water system.

For each of the following statements, please tell me if you strongly agree, generally agree, generally disagree, or strongly disagree with each one.

***Read each statement and tick responses.

	strongly agree	agree	disagree	strongly disagree	don't know
I feel that I am one of the owners of the water system	❑ 1	❑ 2	❑ 3	❑ 4	❑ 5
My family is one of the owners of the water system.	❑ 1	❑ 2	❑ 3	❑ 4	❑ 5
The water system is owned by all water project members.	❑ 1	❑ 2	❑ 3	❑ 4	❑ 5

Q.2 To what degree are you PERSONALLY concerned with the MANAGEMENT and OPERATION of the piped water system?
***Prompt if necessary.

❑ 1 Very concerned
❑ 2 Somewhat concerned
❑ 3 Not very concerned
❑ 4 Not concerned at all
❑ 5 Don't know / No response

Q.3 Overall, how satisfied is your family with your current water supply situation?
***Prompt except 'Don't know.'

- ❑ 1 Generally satisfied?
- ❑ 2 Somewhat dissatisfied?
- ❑ 3 Very dissatisfied?
- ❑ 4 Dont know / No response

Q.4 How IMPORTANT would you say the water system is to the LIVELIHOODS of people in this village? Would you say it is...
***READ OUT each option (except 'Don't know') and tick response.

- ❑ 1 Very important?
- ❑ 2 Somewhat important?
- ❑ 3 Not very important?
- ❑ 4 Not important at all?
- ❑ 5 Don't know / No answer

D. Supporting information for Chapter 5

This section contains figures generated during exploratory analysis of the relationship between water system sustainability scores and community members' sense of ownership for their water system. Figure D-1 shows diagrams depicting the relative sense of ownership felt by different groups within the community under extreme scenarios for the water system. Based on these diagrams, households and water committees were identified as the critical groups for further investigation. Figure D-2 shows a scatter plot matrix of three facets of water system sustainability versus household and water committee sense of ownership scores (normalized by the mean value). Linear and quadratic curve estimations are shown in each scatter plot. This analysis suggests a non-linear relationship between sustainability and sense of ownership.

Next, ownership scores were classified as low, moderate, or high using k-means cluster analysis [*Aldenderfer and Blashfield*, 1984]. For water committee members, an ownership score of zero to 0.60 is defined as low, 0.61 to 0.90 is defined as moderate, and 0.91 to 1.00 is defined as high. For households, an ownership score of zero to 0.30 is defined as low, 0.31 to 0.70 is defined as moderate, and 0.71 to 1.00 is defined as high. Figure D-3 shows the mean sustainability scores plotted as a function of households' and water committee members' low, moderate, and high sense of ownership.

Figure D-1 Mean sense of ownership scores for different community groups under critical scenarios for the water system

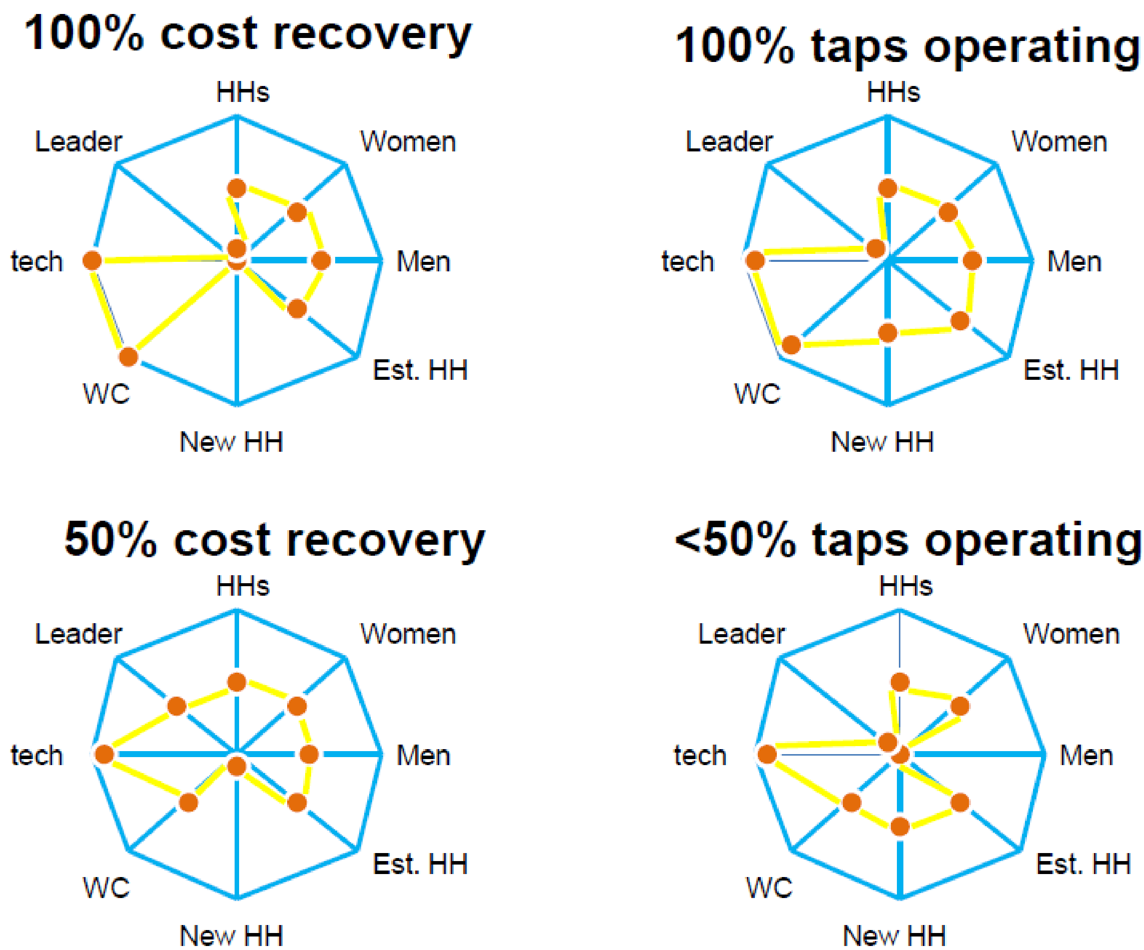


Figure D-2 Scatterplots of sustainability scores versus normalized household and water committee sense of ownership scores.

Each plot includes linear and quadratic curve estimation.

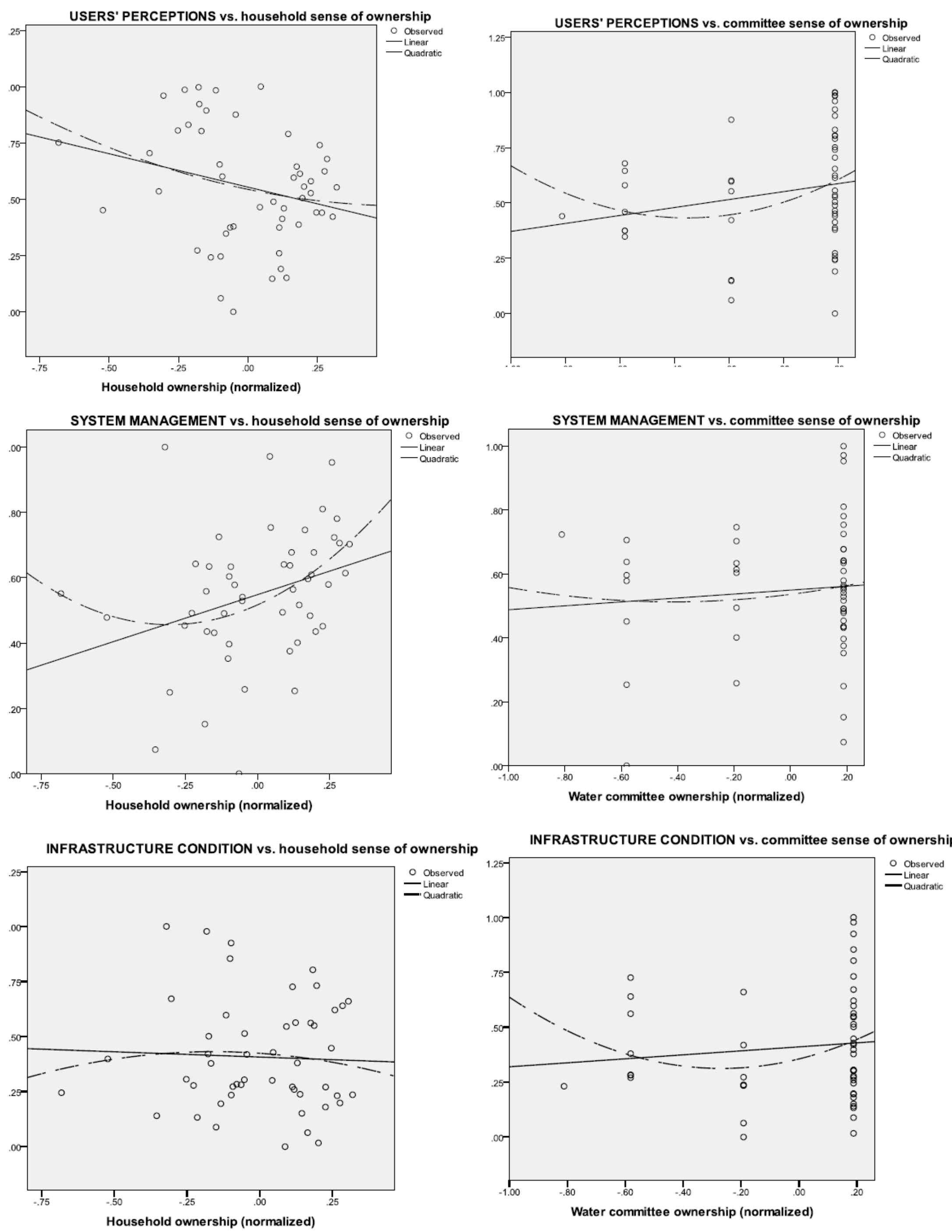
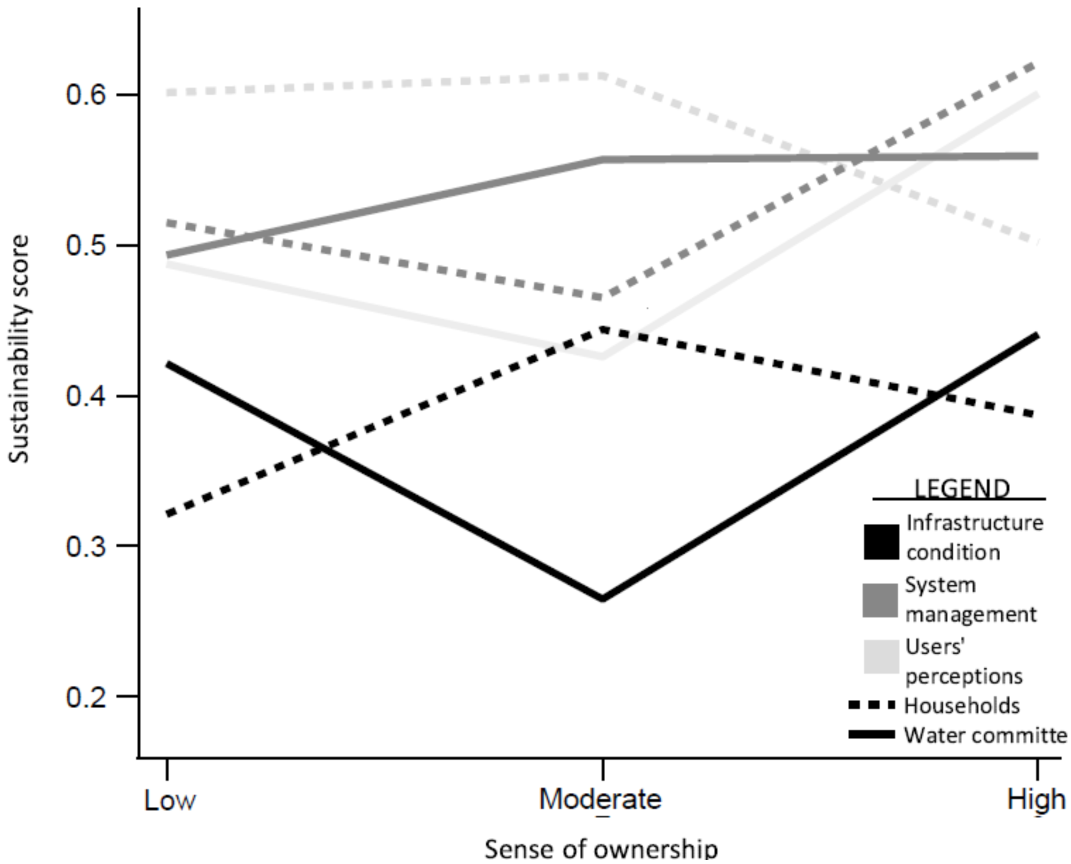


Figure D-3 Mean sustainability scores versus households' and water committee members' low, moderate, and high sense of ownership.



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