Predicting Sustainable Performance and Household Satisfaction of Community-Oriented Rural Water Supply Projects

A Quantitative Evaluation of Evidence from Ghana and Peru

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A dissertation submitted to the faculty of the University of North Carolina at Chapel Hill in partial fulfillment of the requirements for the Doctor of Philosophy in the Department of City and Regional Planning.

Chapel Hill
2007

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ABSTRACT

RICHARD E. THORSTEN II: Predicting Sustainable Performance and Household Satisfaction of Community-Oriented Rural Water Supply Projects: A Quantitative Evaluation of Evidence from Ghana and Peru
(Under the direction of Dr. Dale Whittington)

This dissertation assesses what project, community, and external household and village-level factors are associated with household-level sustainability indicators for community-managed rural water schemes in Peru and Ghana. Methodological contributions include the use of multi-level random effects and structural equation models to analyze data collected from large samples of households and villages in the two countries. Descriptive results indicate that the participatory, demand-driven model of rural water service provision has generally delivered well-designed, functioning systems which many beneficiaries are using and remain satisfied with. Most households are paying something for the water they receive, although cost recovery remains an elusive goal for many villages. Regression results suggest that certain household and village factors directly and/or indirectly impact outcomes. Household knowledge of committee activities is associated with current satisfaction and confidence in future performance, while other household factors (such as income and social capital) demonstrate mixed results. Project factors such as direct election of water committees, training, and the presence of a non-governmental organization as the planning agency (in Peru) positively influenced sustainability indicators, while committee experience was negatively associated with outcomes. This dissertation also augments research on the role of post-

construction assistance by finding that visited households participate more often and are more engaged in a water committee's financial dealings. Finally, the study sheds new light on household preferences for scaling up service by indicating that households are more likely to favor scaling up if they are currently aware of and participate in the current governing process and understand how the committee collects and spends its money. Other important village factors include elected committee structures, distance to the nearest area mechanic, and village size.

ACKNOWLEDGEMENTS

I am grateful to many people who provided opportunities, encouragement, and support during my last five years as a doctoral student. I would like to first thank Dale Whittington for his guidance, educational investment in my career, the opportunity to conduct original research in this field, and his friendship. Also I am indebted to other faculty members in my department and to Jeff Hughes at the Environmental Finance Center for their interest and support during my time at Carolina.

I have been extremely fortunate to work with gifted individuals in the United States and around the world. I want to thank the members of this study's research team (Dale, Linda Prokopy, Kristin Komives, Jennifer Davis, Heather Lukacs, and Marc Jeuland), Alex Bakalian and Wendy Wakeman of the World Bank, our consultants in Peru and Ghana, and the field team members who collected our data admirably under difficult circumstances. This research was funded by the Government of Netherlands' Partnership Program.

Completing a doctoral program requires genuine perseverance and emotional support. My parents have remained a constant source of love and encouragement during this time, and I have gained new friends along the way who also deserve my appreciation. Most importantly, I devote this dissertation to Vanessa R. Thorsten – my wife who has given me everything I have asked for and so much more that I have needed.

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I. Introduction

1.1. Problem Statement

The provision of potable water to the estimated one billion people who lack access to it remains one of the foremost challenges of human development today. For nearly fifty years, donors and leaders in developing countries have devoted public resources and leveraged private funds to construct improved water systems in urban and rural areas. While coverage rates have improved over time (World Health Organization, 2000), growth in rural service has lagged in comparison to the higher percentages of urban residents in developing countries who have gained access to better service.

In the early 1990s, the development community began to reach a new consensus on a water sector delivery strategy. This was embodied in this restatement of the principles outlined at the 1992 "Dublin" water conference: 1) the essential and finite nature of water resources, 2) the importance of a participatory approach to sector and project planning, 3) the central role of women in providing and managing water resources, and 4) the economic dimension of water (ICWE 1992). This strategy places importance on community-driven development, women's participation, elicitation of household demand for technologies and levels of service, and users' financial contribution toward the costs of construction and routine operation and maintenance (Sara et. al 1997, Whittington et. al 1998). Water sector practitioners have since incorporated some or all of these principles into many country programs and regional water projects.

The last ten years has witnessed some notable evaluations of these types of "community-oriented" rural water supply projects. Many of these have focused on the determinants and effects of community participation (Narayan 1995, Isham and Kahkonen 1999, Dayal et al. 2000, Kleemeier 2000, WSP 2000, Prokopy 2002). Others (Kleemeier 2000, OED 2000, WSP 2001, Engel et. al 2003, Rawlings et al 2004) have examined household contributions to projects and responses to tariff structures. These studies have focused on a variety of project outcomes, including physical operation, consumer use, water quality, management schemes, financial cost recovery, and user satisfaction. Some studies have attempted to define and evaluate dimensions of "sustainability" and their associated factors (Sara et al. 1998, Dayal et al 2000, WSP 2001, Prokopy 2002, Rawlings et. al 2004). While all of these studies use quantitative methods to explore relationships, few studies (Kwahja 2002, Rawlings et. al 2004) are capable of demonstrating causal relationships and asymptotically estimating both village and household factors that explain household-level performance. Most studies do not ***simultaneously*** evaluate the effects of project and community factors on multiple indicators of household performance, nor allow for causal relationships among household-level factors.

One of the more recent development paradigms of donor organizations and some governments in developing countries is a shift toward decentralization and alternative service delivery strategies. Some central government authorities view this as a mechanism for shifting responsibility away from their agencies. Others believe that devolving service delivery and empowering other organizations can enhance user participation and improve long-term effectiveness. Social funds – financial mechanisms that operate semi-independently from central governments and encourage local leaders and community organizations to identify and implement projects - have become one popular alternative to "top-down" water service planning, particularly in Latin America. Donors have also invested greater resources in non-governmental organizations (NGOs) that assist and provide local villages with water and sanitation infrastructure, sometimes at a regional or country-wide scale.

Studies on the effectiveness and long-term impacts of social funds (Tendler 2000, van Domelen 2002, Rao and Ibanez 2003, Rawlings 2004) and non-governmental organizations (Narayan 1995, Riddell 1995, Isham and Kahkonen 1999, Kwahja 2002) demonstrate mixed results. These studies usually evaluate the performance of an institution, occasionally comparing it to a central government program. A recent review of community-based development studies from Mansuri and Rao (2003) indicates there are many unanswered questions concerning the development impacts of social funds and NGOs. Moreover, there has not been a serious attempt to compare two alternative service delivery mechanisms – specifically social funds and large-scale NGO programs – within the water sector.

Coverage rates and many of the recent studies cited above indicate some evidence that governments and other institutions of the rural water sector are making progress in delivering potable water to rural communities around the world. Some sector practitioners are now focusing on how to "scale up" investments in successful communities. This may include increasing levels of service (e.g. public taps to private connections), expanding the service area within or outside a target community, increasing the amount of water provided, and improving the reliability and/or quality of water. Other efforts in development practice concern the ability to leverage success in one form of community infrastructure (e.g. water) to other community development objectives (e.g. sanitation, health, etc.). The joint effectiveness of improved water, sanitation, and health services are well known both in practice and in the literature (Esrey et. al 1990, 1991). Some have argued that the long-term institutional and social capital impacts of these projects are as important as the original project intent (Kleemeier 2000, Schouten & Moriarity 2003).

A few case studies have detailed the successes and failures of attempts to expand water projects and export success into related environmental services. And there is some anecdotal evidence (e.g. Schouten et al 2003) on the potential for "scaling up" rural water programs. Yet there has been little systematic empirical investigation into local support for enhanced water service and the expansion into other categories of environmental services, such as solid waste, sanitation, and health practice. Specifically, what project and community factors are associated with a household's support for improving water and other environmental services in villages? Does project success encourage respondents to demand improvements or expansions to their service? Does this success translate into requests for other environmental and health services? As the demand-oriented service model expands in use and scope, these issues deserve greater attention.

1.2. Dissertation Setting

These questions are evaluated in this dissertation in the context of two different geographical, cultural and programmatic settings. The World Bank's Water and Sanitation Program, with funding from the Bank of the Netherlands Water Partnership, initiated a three-country study to evaluate the impact of post-construction support on the sustainability of rural water systems. The countries studied for this project were Peru, Ghana, and Bolivia. Rural water schemes have served villages in these countries between three to twelve years. Although programs operated differently, all were implemented under the demand-oriented community development model.

The Peru and Ghana studies form the basis for this investigation. The Peru study was conducted in 2004-05 in the Cuzco region, which lies in the mountainous area of the country. High rates of poverty and limited access to potable water and other infrastructure characterize many rural areas. The study evaluated two water service programs – the national FONCODES social investment fund and the SANBASUR program, funded by the Swiss government and operating as an NGO. Both programs were designed to involve community participation, train system operators and water committee members, elicit household demand and require household contribution for construction, and transfer operation to the community upon completion. The SANBASUR program offered the prospect of additional, limited post-construction support while the FONCODES program did not during the years in which the projects are evaluated (1993-2001).

The Ghana study was also conducted in 2005. Two regions were selected for the study – the Brong Ahafo region in central Ghana and the Volta region in the eastern part of the country. This study examined the sustainability of village water systems built under Phase I of the central government's Community Water and Sanitation Program. The key (observed) difference between the two regions was the presence of a routine post-construction monitoring and assistance program (MOM), funded by the Danish government agency DANIDA. Villages in both schemes did have varying degrees of access to post-construction assistance through the creation of District Water and Sanitation Teams (DWSTs). Villages in the Volta region, however, obtained additional support via the MOM program. As in Peru, Ghana's CWSP I program featured community participation and selection, household contributions (usually at 5% of capital costs), and a build-transfer scheme that placed ownership, operational, and maintenance responsibilities in the hands of community water and sanitation (watsan) committees.

1.3. Research Methodology

The World Bank study was an ex-post evaluation involving treatment and control groups in each country. The study purported to evaluate performance beyond an initial operating stage (at least three years) among rural villages.

The Peru study sample consisted of FONCODES and SANBASUR villages with the following characteristics: 1) they contained populations between 350-2000 people, 2) they had received a project during the period 1991-2000, and 3) they were located in the Department of Cuzco. All SANBASUR projects were located in the mountainous areas of the Cuzco region. We excluded FONCODES projects in the La Convencion district of Cuzco, since it features lower elevations and tropical rainforests. This enabled controlling for topography, hydrology, and technology (all projects employed gravity-fed water schemes). A total of 56 FONCODES and 43 SANBASUR projects qualified for the sample.

The Ghana study sample was divided into the Volta and Brong Ahafo regions. Approximately one-hundred villages built under the CWSP I program from each region were selected. Both regions' beneficiary communities: 1) contained populations between 250 – 2500 people, 2) began operating their projects between the years 1993-2001, and 3) received one or two boreholes as the basis of their project. Villages in the Volta region were also selected based on whether they had received regular, quarterly assistance from the MOM program for at least three years.

Researchers in both country settings developed household questionnaires, focus group surveys with water committee, village leaders, and village women, and system operator/caretaker interviews. Enumerator teams consisted of a team leader, who was generally responsible for executing the field work and conducting focus group surveys, and enumerators who handled the household surveys. Female team members administered the village women's focus group survey where possible. The studies also relied on technical expertise. Engineers visited Cuzco villages to administer the system operator's survey and conduct a technical assessment of the system. In Ghana, team leaders worked with DWST officials to estimate the number of consumers and liters drawn upon a village's main borehole for one day and tabulated payments obtained for the service.

Initial data for both of these studies was obtained in fall 2005. The research team completed final reports to the World Bank in 2006. This dissertation uses descriptive statistics, principal components analysis, and multi-level random effects and structural equation models for the data analysis. Dependent variables are measured at the household level, while factor effects occur at both the household and village level. Table 1 overviews the dependent variables featured in this dissertation.

Table 1: Household-level Indicators of Sustainability

MEASURE	COUNTRY	TYPE
# Breakdowns last 6 months	Peru	Physical
# Days to repair last problem	Peru	Physical
Household pays for water	Ghana, Peru	Financial
Amount HH pays for water	Ghana, Peru	Financial
Satisfaction – water pressure	Ghana, Peru	Satisfaction – water
Satisfaction – water safety	Peru	Satisfaction – water
Satisfaction – water taste	Ghana	Satisfaction – water
Satisfaction – operation & maintenance	Ghana, Peru	Satisfaction – service
Satisfaction – water committee	Ghana, Peru	Satisfaction – service
Trust – water committee	Ghana, Peru	Satisfaction – service
Satisfaction – water system	Peru	Satisfaction – overall
Five-year confidence in water system	Ghana, Peru	Future sustainability
Ten-year confidence in water system	Peru	Future sustainability
Committee should scale up water service	Ghana, Peru	Scaling up
Committee should handle related needs	Peru	Leveraging

1.4. Research Questions

Chapter 3 will present the theoretical constructs and specific hypotheses tested in this dissertation. Three broad areas of inquiry form the basis of this study.

1.4.1. What village-level (project, community, institutional) and household factors (project and non-project) directly and indirectly influence current household performance, financial payments, satisfaction with water and service attributes, and perception of a water project's future performance?

1.4.2. How do alternative service delivery models – specifically social investment funds and NGO programs – perform as vehicles for delivering sustainable rural water service and recovering costs in gravity-fed water schemes?

1.4.3. What village and household factors predict support among households for “scaling up” water services and “leveraging” water investments toward other forms of environmental health infrastructure?

1.4.3.1. What project, community, and household factors can lead to support for upgrading water service?

1.4.3.2. Do successful water projects lead to household support for related community services, such as sanitation, solid waste, and primary health care?

1.5. Organization of Dissertation

This dissertation contains eight chapters. Chapter Two reviews the principal theoretical and methodological approaches in the literature on evaluating project performance, sustainability, scaling up, and leveraging in the water and sanitation sector of developing countries. Chapter Three presents theoretical constructs, specific hypotheses, data analysis techniques, general and country-specific research designs, and threats to validity. Chapter Four overviews the study areas and includes details on national water sector strategies and regional programs. Chapter Five describes field activities conducted as part of the study. Chapter Six presents descriptive and model results. Chapter Seven compares the results and discusses the implications of the findings. Chapter Eight reviews these findings in light of contributions to the literature, addresses limitations, and suggests avenues for further research. Additional Appendix materials and references appear at the end.

II. Literature Review

2.1. Introduction

This dissertation focuses on what project and non-project factors are associated with sustainable household water service in community-based, demand-oriented programs, what village and household-level factors influence user payments, satisfaction, and perceptions about sustainability, and what factors predict the willingness of villagers to favor improvements to potable water and other environmental health services.

The next section will review concepts of sustainability and their application to evaluating water project performance in developing countries. The section will also discuss some theoretical project, community, and external factors that may influence elements of sustainability. Methodological approaches and findings from key studies at the village level are examined in Section 2.3. Section 2.4 will review qualitative and quantitative studies which have evaluated factors associated with increased household water use, satisfaction, and perceptions of improved household water supply. These include single and multi-construct approaches, single and multi-country studies, household-level models of behavior, and village-level impacts.

Section 2.5 briefly overviews theories and prospects for "scaling up" successful water projects and "leveraging" investments to accommodate other environmental and health services. Finally, Section 2.6 identifies gaps in existing literature and addresses what "grey areas" this dissertation will address.

2.2. Evaluating Sustainability and Performance of Village Water Systems

2.2.1. Theories of Sustainability and Application to Rural Water Provision

Sustainable development was introduced to the global community through the efforts of the 1987 World Commission on Environment and Development (named after its chair, Gro Brundtland). It was the first large-scale attempt to link environmental and development issues together. The Brundtland Commission defined sustainable development as 'development that meets the needs of the present without compromising the ability of future generations to meet their needs' (WCED 1987). The Commission attempted to bring together economic development, social equity, and environmental protection objectives into a more holistic perspective on development (Berke 2000).

The application of sustainable development differs among theoreticians. Barbier (1987) adopted a "maximization" approach, similar to that in traditional economics, in which the goal is to maximize a set of objectives under biological, economic, and social constraints. Sustainability enters into a "blueprint" framework, in which techniques such as cost-benefit and environmental impact analysis attempt to quantify objectives and constraints and allow decision-makers to make tradeoffs among policy alternatives (Tacconi and Tisdell 1992, Angelsen and Sumalia 1997). For example, in the water sector, freshwater could be introduced as a non-declining capital stock constraint (Pearce, Markandya, and

Barbier 1989). Goodland and Daly (1996) suggested a hierarchy of methods in which natural capital can be considered – from perfect substitution among sets of capital (weak sustainability) to no depletion or use of non-renewable resources (absurd-strong). Others have argued for a "participatory" approach; placing individual decision-makers at the center of sustainable development (Chambers 1983, 1994a, Therkildsen 1988). Individual self-esteem and empowerment become important measures of project success and sustainability. Tradeoffs among goals are more limited, and there is a greater emphasis on a flexible learning process between donors and beneficiaries (Korten 1980, Kottak 1985).

In the water sector evaluation literature, there has been an emphasis on sustainability as maintaining program outcomes over time. The USDA (1987, from Bohm et al 1993) defined sustainability as "the collective ability to continue a flow of valued benefits or outcomes beyond a given investment period at an acceptable cost." WASH (1994) provided a similar definition of a sustainable project as one that "maintains or expands a flow of benefits at a specified level for a long period after external funding has been withdrawn." The World Health Organization's handbook on financial management for water supply and sanitation understands sustainability as the "creation and maintenance of conditions that ensure the technical, social, and financial success of projects, subject to availability and adequate sharing of responsibilities between the community and the agency" (WHO 1994).

Sustainability enters the realm of rural water sector planning in different capacities. The environmental dimension of sustainability (arguably the initial motivating force behind the concept) translates into a need to identify water sources that are not constrained for other social purposes or fraught with ecological stresses. This may include a greater emphasis on using marginal extraction and opportunity cost as a benchmark for water pricing (Warford 1994). A related environmental problem also arises in providing new water services to villages without adequate sanitation. The introduction of more water can sometimes exacerbate sanitation problems by creating negative health externalities for members of a village.

Other practitioners have attached a different meaning to sustainability. Their concern is rooted in the lack of public resources available to tackle the problem of covering increasing populations with improved water services. The capital provided for rural water schemes has often not been sufficient to meet development targets. Moreover, many water schemes have enjoyed short life spans and frequently failed (Therkildsen 1988). One often-cited problem has been that many beneficiaries were never involved in the water planning process and never contributed to the capital or operation and maintenance (O&M) costs of the water systems. Many development practitioners had believed that "the poor" were incapable of contributing, although studies (MacRae and Whittington 1986, Briscoe and de Ferrenti 1988) had shown that low-income households sometimes paid sizable amounts of their income for water in the absence of improved infrastructure. It appeared that water and sanitation schemes needed to become financially more self-sufficient. This would involve asking beneficiaries to financially contribute – at least toward routine maintenance and operation (Black

1998). Economic assessments, in turn, would be able to compare willingness to pay with the costs of maintaining a project over its designed life span (Whittington and Swarna 1994).

Some evaluations of rural water schemes have incorporated sustainability criteria in their methodologies. WASH (1994) developed one of the first sets of published criteria to evaluate sustainability in the water sector. A reprinted list of questions suggested in designing evaluations appears below (the authors considered the first two questions as primary criteria):

- ***Are most people covered by the project using the facilities? (50% level usage considered acceptable).***
- ***Are the facilities in operational order (75% of systems should be operational in any given time)? Requires support of qualified repair person, supplier of spare parts, and adequate funds.***
- *Are management committees functioning? (75% of committees should meet periodically and implement tasks). Should maintain community support and ensure that O&M funds are adequate.*
- *Are extension agents meeting with committees regularly to facilitate ongoing activities?*
- *Are trained repair persons and supplies of parts easily available?*
- *Is a specific government agency effectively managing the sector?*
- *Is there an importer or manufacturer of spare parts?*
- *Does each institution have adequate financial resources?*

Other researchers used some of these criteria in developing sustainability and performance benchmarks to evaluate programs. A later section will address their use in key evaluation studies.

2.2.2. Factors Hypothesized to Influence Sustainability and Performance

2.2.2.1. Project Factors - Technology

Technology choice is often determined by geographic and hydrological factors. For example, villages in the Cuzco region rely on gravity-fed schemes from surface or spring water sources above the community. In contrast, many Ghanaian villages depend on boreholes and pumps which bring water from underground. Technology scale and complexity have received scrutiny in the water sector since the beginning of donor-assisted rural water projects in developing countries. Early development programs often followed an engineering-style model, with a heavy emphasis on large-scale capital systems that were often expensive and delivered water to a small set of wealthy consumers (Black 1998). These systems were rarely feasible or cost-effective in rural areas, and frequently failed when attempted. The 1970s witnessed the advent of appropriate technology (Schumacher 1973), which tended to feature smaller-scale systems. These systems often cost less to build and sometimes included a degree of citizen participation. Yet some critics (Feacham 1980, Schouten et al 2003) allege that these systems were not so "appropriate" because they were often planned in absence of demand forecasts and were not designed for expansion.

2.2.2.2. Project Factors – Community Participation and Management

One of the hallmarks of the community management model is its emphasis on greater participation among beneficiaries. Early instances of participation can be found beginning in the late 1960s (van Wijk 1979, 1981), but the community involvement paradigm gained greater momentum after the 1977 Mar de Plata water conference in Argentina (Black 1998).

Early theoreticians such as Hirschmann (1970) and Chambers (1983) demonstrated the potential viability of community management models. Both advocated "bottom up" approaches to development and developed early

participatory models. Ostrom (1990) showed how communities were capable under certain circumstances of managing common pool resources.
Oakley (1991) lists some key arguments in favor of the effectiveness of the community participation model. These include 1) participation empowers rural people to make decisions and take actions that represent their development interests, 2) empowerment can lead to improved community capital which can translate into other beneficial projects, 3) participatory projects can be more cost-effective (in terms of supply potable water per capita) than other projects. Narayan (1995) has also highlighted the importance of participation as a means of improving water supply service along effectiveness, efficiency, empowerment, equity, and coverage objectives (see Prokopy 2002 for a discussion).

Others theoreticians have suggested that the CM model faces difficulties in organizing for collective action and providing for public goods. Olson (1971) argued that large groups will have difficulty in organizing to pursue common interests because they face higher organizational costs and the prospect that individuals will "free ride" on the work of other community members. Hardin (1982) argued that the nature of common pool resources allowed for individual plundering at the expense of collaborative interest (i.e. the "tragedy of the commons").

Likewise, not all have been sold on the merits of community management in the water sector. Feacham (1980) argued that community participation models are no more effective than other methods if they fail to account for basic water planning requirements such as water sources and demand. Mansuri and Rao's

(2004) assessment of community management models has criticized project planners for injecting a formulaic approach to community participation in infrastructure projects. Some early attempts at participation, for example, emphasized “requirement” checklists (WASH 1993) as opposed to soliciting citizen interest for project planning and design. This “requirement” role of participation may conflict with another potential factor of sustainability – responsiveness to local demand.

2.2.2.3. Project factors – Demand Responsiveness

Demand responsiveness stands alongside community involvement as one of the pillars of rural water programs over the last ten years. The demand-oriented approach marks a fundamental paradigm shift in development thought and practice. Many water projects over the first four decades of development assistance focused on a supply-oriented drive to maximize coverage. Justifications included basing investments on “objective” health criteria, basic needs assessments, or the “rights” of groups to water sources. While these aspects of water supply may be important in planning new systems, by the 1990s it became clear that the performance of low-cost rural water systems depended on healthy consumer demand (World Bank Water Demand Research Team 1993, Black 1998). Weak consumer demand indicated that villagers would not contribute toward the operation and maintenance of the system, would not use the system on a regular basis, and/or would not be satisfied with the system once it was built.

Neglecting demand has often placed new systems in a "low-level equilibrium trap" (Serageldin 1994, Tamayo et al 1999). When project planning, particularly for low-cost systems, ignores anticipated demand over time, users are not willing to pay for the improved service because it does not reflect their demand for a higher level of service; even though they might be willing to pay for a better system. As a result, the community cannot generate enough resources to sustain and expand the system upon completion, and it falls into disrepair. Many systems that the U.S. Water and Sanitation Program for Health evaluated in the 1980s and early 1990s fell into this category (WASH 1993).

Demand can also depend on the payment mechanisms used to collect funds. Questions of how to pay for water services are faced by communities of all sizes throughout the world. In addition to its revenue implications, payment vehicles can also affect the demand for levels of service. The financial viability, efficiency, and equity of tariffs have been discussed extensively in the literature (Therkildsen 1988, Munasinghe 1992, Whittington and Swarna 1994). Generally, one of the main obstacles in many rural areas is the notion that water is a free gift and should not be priced for any purpose. The significance of financial payments and payment schemes has not been studied in great detail in the rural water sector.

2.2.2.4. Project Factors – Non-Governmental Organizations and Social Funds

While churches and other non-governmental organizations (NGOs) have assisted in constructing rural water projects since before World War II, the rise of the NGO as an important actor in the sector began in earnest during the 1980s with the growth of the community participation movement (Schouten 2003).

Initially a small-scale enterprise, NGO development has increased both in size and scale over the last two decades; spending by the early 1990s an estimated U.S. $6 billion worldwide on development assistance (Riddell et al. 1995).

NGO-led development has been viewed by some as an important strategy. Some practitioners have argued that NGOs are better equipped than the state to reach the poor, improve community participation, and enhance local capacity for community management. Others have suggested that NGOs are more efficient in delivering a level of service to customers at a lower unit cost due to their more flexible structure and less wasteful use of resources.

The evolving literature on the role of information in public economics (Dixit 2002, Besley and Ghattak 2003) suggests a more theoretical reason why NGOs can be more successful purveyors of public goods. In contrast to private goods, public goods often lack a market structure that allows suppliers and customers to place their respective values on goods and services and complete transactions. One of the aims of public goods theory is to recommend alternatives to simulate market conditions. Under contracted conditions organized by the state, civil parties (e.g. NGOs) will reveal how much they value the production of a specific public good to a targeted population. Unlike profit-seeking private actors or rent-seeking state actors, NGOs lack incentives to underestimate the value they place on producing a certain good. Their interest (in theory) lies more with the delivery of the service. Thus, they have incentive to reveal their true willingness to pay for implementing a contract.

Social funds have become another popular vehicle for delivering a variety of public goods and social services over the last ten years. Originating in response to national emergencies, social funds have diversified and become more permanent investments in development portfolios across the developing world. Social funds are developed by countries and usually are designed to reach people living in poverty. Many share a set of common characteristics formulated by Wietzke (2000) and Jorgensen and van Domelen (2000).

- *Social funds are second tier agencies that finance investments, rather than implement programs carried out by line ministries, NGOs, or communities.*
- *Social funds offer a menu of investment options. Depending on the country, these can be limited to a few choices or a variety of social and infrastructure programs.*
- *Investments are driven by demand, reflecting a bottom-up approach in which communities, NGOs, and other ministries apply for funds to the executing agency.*
- *Social funds operate independently from line ministries, although in theory their investments complement macro-economic and macro-sector policies.*

Social funds are considered to have some potential advantages in providing public services versus traditional line ministries. Their operational autonomy potentially allows staff to bypass traditional bottlenecks in ministries. In theory they provide a range of investment options and allow communities to select what type and level of service they want. The model also claims to be more participatory, often by requiring community organization in soliciting, planning, and implementing projects. However, some have argued that social funds are no more effective than line ministries in providing infrastructure. Reasons include 1) their position as another bureaucratic agency without the resources or clout of line ministries, 2) a limited set of alternatives available for community selection, 3) a lack of projects that can provide for genuine participation (Tendler 2000).

2.2.2.5. Community Factors – Village Size

Village size can be an important community factor in predicting whether a system will function sustainably over time. At the village level, systems serving a small population often require higher per household capital and operating costs. Economies of scale can thus favor larger systems from a cost recovery standpoint. Others also suggest that smaller villages are poorer than larger ones and do not have as many resources – financial or human capital – to maintain systems (particularly schemes which require complicated repairs and spare parts). On the other hand, since the 1970s some have argued that small scale systems are a more appropriate technology for many villagers in terms of project success and user participation in the process.

2.2.2.6. Community Factors – Distance and Location

Distance to water sources has been mentioned as an important possible factor in the sustainability of water systems. Large distances to water sources can increase the initial cost of supplying water. For gravity-fed systems, the expanded network can lead to a greater possibility that one or more of its parts will break down – increasing operating and/or replacement costs. Among borehole systems, a borehole located far from a village can also decrease the likelihood that people will use it.

A slightly different but related issue is the location of a village relative to other cities and towns. Cairncross et al (1980) has argued that villages in more remote, less accessible locations are less likely to receive funding for improved water infrastructure. Sharma (2001) found this relationship to be true in comparing service provision in a valley community versus a hill town in Nepal. In addition, more remote communities may find it more difficult to obtain forms of external post-construction assistance, as discussed below.

2.2.2.7. Community Factors - Social Capital

The literature on social capital and its effects on social services, including water supply, has grown considerably over the last decade since Putnam's (1995) seminal work on the subject. One of the key hypotheses is that communities with higher social capital are better equipped to work together as a community in the planning, implementation, and management of a rural water system. Putnam and others have argued that communities with shared norms, high degrees of community trust, and civic institutions that foster a community ethos are more likely to organize more effectively than heterogeneous communities that lack this communal spirit. Advocates of improving social capital believe that communities, particularly smaller ones like villages, can overcome some of the pitfalls of collective action earlier referenced by Olson (1971).

2.2.2.8. External Factors –Post-Construction Support

Post-construction support refers to various forms of assistance which villages may receive from donor agencies, levels of government, non-governmental organizations, churches, etc to keep the system operating. This can take several different forms. Communities may receive additional technical, financial, health, or administrative training for specific tasks. Villages may receive financial support, either in the form of cash or in-kind assistance. Local mechanics may visit sets of villages to assist with major repairs. They may also assist in procuring spare parts. Villagers may receive manuals or other written materials to educate the public or assist technicians. Moreover, users may receive more direct assistance in the forms of health education, basic maintenance training, visits to encourage participation, and/or monitoring household or yard taps to ensure they are functioning. Sometimes these forms of support are requested by the leaders or persons responsible for operating the system. In other cases, support may originate by program design – in effect becoming a supply-driven process.

2.3. Village-level Evaluations

This section overviews qualitative and quantitative methods that researchers have adopted in evaluating factors and elements of sustainability at a village level. Some studies incorporated mixed methods; where significant, this section will reference those studies in both sub-sections.

2.3.1. Qualitative Approaches

Case studies and qualitative analysis trace a long history in village-level evaluations of rural water system performance. Therkildsen's (1988) study of donor-assisted projects in East Africa denoted an important contribution to the field. His interest laid in understanding why so many water projects funded by European donors and the World Bank failed. He focused on the planning and implementation process of five donor agencies working in Tanzania over a fifteen year period. Therkildsen argued that these agencies had adopted a control-oriented approach to project planning that centralized decision-making in their hands (including the extent of beneficiary participation). His case studies found that this donor activity was unsustainable and not suited for water sector planning in Tanzania. Reasons included 1) a lack of agreement among donors, recipients, and beneficiaries on a common set of objectives for plans, 2) a decentralized institutional structure that inhibited this donor strategy, 3) a lack of predictability in the water sector, and 4) the high resource cost needed to maintain control over decision-making in the absence of building post-project domestic capacity. Instead, he advocated an adaptive approach to planning which would feature more emphasis on participation and institutional capacity. He also called for a more active emphasis on organizational learning (from Korten 1980) that would improve the quality of village-level institutions necessary for community management. Therkildsen's work critiqued the failures and some of the important problems inherent in centralized planning. He was one of the first researchers to call for greater participation in the planning process by studying its implementation at a donor level. His research, however, did not examine the dynamics of participation at a local level.

Other researchers would study the effectiveness of village-level participation and community management. Smith (1993) conducted case study research in Indonesia. Two NGOs – CARE and Dian Desa of Indonesia – had built water systems in her study area. She examined the determinants of participation and suggested that the emphasis on participation (in this case for gravity-fed water schemes) improved system performance. Her study also identified conditions that led to successful community management. These included: 1) strong local understanding of the technology, 2) active community fundraising for project capital, 3) projects that sustained operation and maintenance through local resources. Finally, she compared villages in her study with similar communities in the region which had received government water systems. The systems she evaluated were in good condition, and communities had collected some funds for capital and O&M. Smith's research was helpful in understanding community dynamics of successful participation. The non-random sample of communities she studied and her comparison with other "typical" villages, however, limited the external validity of her results.

Narayan (1995) combined quantitative and qualitative analysis of 121 rural water projects in 49 African, Asian, and Latin American countries. Via quantitative analysis, she selected the most effective projects for in-depth case study. Narayan examined the effects of participation, gender, ownership, project management, and socio-economic factors on water system coverage, function, and village economic and environmental benefits. Her review of project documents and field interviews suggested that while effective participation came in many forms, it manifested itself only when donor agencies relinquished control over the project. This confirmed Therkildsen's notions on the importance of participatory planning. Generally she found that communities practicing effective participation had successfully addressed physical and technological constraints in their projects. Adaptive social institutions, however, remained an elusive goal. Finally, she found that NGO projects, while representing only 15% of his cases, accounting for ½ of the successful projects. In particular, local NGOs held the most trust among village leaders and beneficiaries interviewed for the study. Narayan's case studies presented examples of best practices among successful communities, yet they are less useful in demonstrating cases where participation alone failed to overcome other constraints in meeting project objectives.

The role of non-governmental organizations featured prominently in two other sets of case studies. Riddell et al (1995) examined whether NGOs were more capable of and cost effective than state institutions in alleviating poverty in developing countries. They reviewed sixteen cases in four countries (Bangladesh, India, Uganda, and Zimbabwe) and found that 75% had achieved most of its stated goals and reduced poverty rates. However, they did note that these NGOs encountered important problems, including 1) an inability to reach the "poorest of the poor", 2) failing to provide the level of cost reductions which some had touted in the development sector, and 3) the need for additional external resources to maintain the benefits of projects over time. While they found that a major expansion of the number of NGOs would not have a major impact on world poverty, NGOs had generally outperformed state-sponsored social programs. Their work represented a more comprehensive approach to evaluating the effectiveness of NGOs across different sectors and country settings. Yet they did not concentrate heavily on water supply and sanitation issues.

In contrast, the Social Policy and Development Center (1996) evaluated NGO water projects in the Punjab region of Pakistan. Their work reviewed three previous reports which had evaluated rural water schemes in the region and also conducted interviews with leaders at seven villages. Overall, they found that most NGOs were not equipped to mobilize, educate, and train communities to undertake system management. The Center's review also criticized the lack of field experience, personnel, and financial resources to assist villages in taking over new schemes. They found that NGOs were not representative and did not embrace projects unless the objectives meshed with their organizational goals. The report indicated that in some cases, the community organization crumbled soon after the NGO lost interest in sustaining the project. The Center's study calls attention to the possible lack of resources among NGOs and the likelihood that they also have interests that may conflict with long-term sustainability. However, many of their results hinged on previous reports from non-random samples of villages and they acquired little original data to substantiate their claims.

An important sustainability study in the context of a large-scale, participatory rural water program was conducted by Kleemeier (2000). Her team assessed sustainability by evaluating the physical condition of water systems in seven Malawian communities. A political scientist returned to four villages and spent four to six days interviewing water committees, repair teams and monitoring assistants to learn about operation and management structures. Generally she found that the smallest and newest projects performed well, supplying water approximately 80% of the time. Less than half of the taps worked at four other sites, however, and the systems were completely non-functional at one-third of the communities. Kleemeier noted that scale was an important consideration in the operation of projects, even within a participatory planning regime. Larger systems required external forms of technical support to help monitor the system for breaks and leakages and carry out repairs. She also suggested that the early introduction of cash (as opposed to in-kind) contributions from users may have provided a better incentive for committee members and technicians to mobilize the community when problems arose. However, she also admitted that her team had not acquired enough information about differences in cash vs. in-kind contributions to make judgments about these vehicles of demand. Kleemeier's study was one of the first to evaluate participatory regimes among communities of ranging size.

One of the most comprehensive set of case studies on community management was published by the International Research Centre's Participatory Action project (Schouten et. al 2003). The IRC wanted to know if the community management model has proven both sustainable and capable of expanding potable water coverage in rural areas. Over a four year period, the institute assessed participatory water schemes across 22 villages in six countries. Essentially, the IRC concluded that communities alone were not capable of fully maintaining their improved systems. They required additional post-construction support and a supporting country-level institutional structure. The authors adopted a broad definition of sustainability, including 1) a physical system that functions over time, 2) a sustaining water resource base over time, 3) an assumption of service equity, 4) capital replacement, and 5) a potential for system expansion. All of the systems surveyed contained operation, management, cost-recovery, and/or other problems. In some cases, the authors blame a blueprint approach to participation which homogenizes the beneficiary communities and fails to mobilize support. In other cases, however, the assumption that participation would lead to better outcomes was not tenable due to sources of tension within the target communities. The authors encouraged water practitioners to focus more heavily on planning for external forms of support, which they argue is the single most overlooked aspect of rural service provision. The IRC's review marks one of the largest set of case studies on participatory rural water supply, and its results convey a great deal of experiences and anecdotal information. However, the authors did not apply a research-based methodological approach to compare and contrast villages, country experiences, etc. IRC's approach was based more in learning from their experiences than with testing elements of the participation model in practice.

Two examples of recent literature reviews provide some final insights into community management and post-construction support. Perhaps the largest overview on community management in the development field was conducted by Mansuri and Rao (2004). This review included impact evaluations and case studies from over one-hundred sources conducted by independent researchers and/or peer reviewed by others. A summary of several main conclusions appears below:

- Community projects have not often successfully reached their intended beneficiary population, especially the poor.
- These projects have generally improved infrastructure and welfare, although it is unclear whether the participatory aspects led to these gains.
- Empirical work on socially heterogeneous communities shows a complex relationship. Many cases indicate a U-shape curve between project inequality and outcomes.
- There is considerable evidence of elites capturing the benefits of these projects, although study designs have not permitted researchers to evaluate the impact of this occurrence on disadvantaged village residents.
- An enabling, receptive institutional environment is critical to program success. The danger is that a CM model in practice will become "supply driven demand driven development".
- While CM models can empower local residents, they do not necessarily do so in practice. The authors call for more analysis of their implementation in practice.

Finally, Lockwood (2003) provides the most comprehensive review to date on the significance of post-construction support to village sustainability. Lockwood finds limited evidence on the effectiveness of post-construction support. His major reasons for these gaps are that: 1) there are few operational programs with post construction support, 2) quantitative studies measuring sustainability have focused more on pre-construction factors, 3) models for post-construction support are relatively new, and systematic post-construction support has not been in place long enough to evaluate, 4) the limited evidence largely stems from 'abnormal' cases such as China and Honduras which both featured substantial donor investment, and 5) case studies of support models all have problems which limit extension of their results.

2.3.2. Quantitative Approaches

Some studies, including a few mentioned above, have employed quantitative techniques for measuring factors of sustainability. Narayan (1995) was one of the first to do this. Examining project reports, she and fellow researchers developed a time series analysis to measure the impact of participation on project outcomes, as well as a number of non-project determinants. Her list of project outcomes included 1) project effectiveness, 2) the percentage of the system in acceptable functioning condition, 3) the economic value of benefits, 4) the percentage of the target population reached, 5) equality of access in the community, and 6) environmental impacts. Narayan found that only 21% of projects contained significant degrees of village participation and only 17% substantially involved women. However, community participation was a significant factor in determining what percentage of the water system remained in good condition, the economic benefits generated by the project, and the percentage of the target population reached. Villages with higher participation represented a higher percentage of systems which were in good condition and had improved consumer access (coefficients ranged from 0.29-0.30 and

0.17-0.25, respectively) and also attained higher economic benefits (0.26-0.27). Moreover, Narayan argued that the only other significant factors - the availability of spare parts and repair technicians – also require some degree of community participation and mobilization. Women's participation, by contrast, did not play an important role in increased water use or expansion of coverage. While innovative, Narayan's study suffered from important drawbacks. The study relied on information from project evaluations which varied in terms of quality and access to village participatory dynamics. The authors also acknowledged that they relied on coding schemes to rate participation and other attributes. The study did not attempt to show causal relationships, only associations. Finally, Prokopy (2002) has noted that the relationship between participation and project outcomes may be considered endogenous, since improvements in project performance may also improve participation. Endogeneity potentially biases multivariate regression models (Verbeek 2002).

One of the few large-sample quantitative analyses of sustainability in the rural water sector was performed by Sara and Katz (1998) on behalf of the World Bank. Sara and Katz examined both stand-alone water and sanitation projects and those listed as part of an investment portfolio (social funds would fall under this category). The authors conducted a total of 1875 household surveys and collected other data from 125 communities in six countries. Their particular interests centered on the importance of participation and demand responsiveness as contributing factors to sustainability. Their indicators of sustainability included physical condition of the systems, consumer satisfaction, operation and maintenance capacity, financial management, and the stated willingness to sustain system. Demand responsiveness was measured in terms of 1) implementation, 2) community involvement in initiation, 3) degree of informed community choice on project, and 4) levels and quality of household and water committee training. They also identified 75 potential socio-economic variables which could affect project performance.

The researchers used multivariate regression techniques and developed indices for their measurements. The following model posits that village-level sustainability (S) is influenced by the following factors:

$S = \beta 0 + \beta 1 [DR] + \beta 2 [PR] + \beta 3 [EX] + u$ where:

S: measure of sustainability (dependent variable)
DR: level of demand-responsiveness (independent variable)
PR: project-related factors (rules not related to demand)
EX: external factors
$\beta 0$, , $\beta 3$: intercept and slope terms
u: stochastic [random] error term.

* *Note: External factors in this model refer to community factors, such as population size and density, distance to cities and water sources, educational level, and system age.*

Their study found that demand responsiveness, especially when based on household input, significantly contributed to sustainability. Training, community organization, construction quality, and the scale of technology also improved sustainability. Per capita costs were lower with higher community contributions, strict cost control measures, defined per capita subsidy ceilings, and when NGOs managed projects versus government entities. However, Sara and Katz noted that most villages did not link service levels to costs.

Sara and Katz's study operationalized sustainability indicators for quantitative analysis. Their study was the first to rely on extensive primary field data collection from both household surveys and village focus groups. They considered project and community factors across villages, projects, and countries. Their results provided evidence that participation and demand are important factors associated with sustainability and assessed the determinants of cost and cost-recovery goals. The authors also cross-checked their results with qualitative assessments to verify their findings.

There are some important limitations to their study. First, the study design presents challenges in demonstrating causal relationships, primarily because village and household sample sizes were limited. Data were collected from 125 villages over six countries and multiple projects. Additionally, the study only obtained data from fifteen households per villages and aggregated household values to the village level. This potentially limits the representation and distribution of household values within a particular village setting. The study relied heavily on an additive approach for factors and indicators of sustainability using ordinal scoring. While this method reduces the problem of interpreting coefficients of variables with different scales, it weighs heavily on the side of subjective measurement and may unduly limit the extent of variation present among different variables. Finally, the researchers elected to estimate each of the indicators of sustainability in separate regression models. This method ignores the potential relationship among the indicators. Conceptually, it also implies that "sustainability" is determined according to the sum of its parts.

In 2000, two reports further investigated the sustainability of rural water systems. The Operations Evaluation Division of the World Bank published an evaluation of fifteen free-standing water projects which they had supported in seven countries. The OED measured performance, sustainability, and institutional development. They found that 67% of water schemes achieved satisfactory performance. "Performance" was defined in three dimensions – relevance, efficaciousness, and efficiency. The relevance of projects focused on whether the project's intent met the World Bank's goal of improving the lives of the poor, particularly women, via clean water. Efficacy measures centered on benefit impacts, such as time savings calculations, distance reductions, increases in consumption, and changes in health status (though the authors noted that this last impact was impossible to ascertain due to other programs and other health-related conditions). The efficiency gains were constructed by comparing per capita costs across sites. The report's discussion on sustainability featured the ability of local entities to manage their projects and the availability of external support for these efforts. This was strongly related to institutional development, an area where researchers found that only 43% of projects had attained substantial institutional impacts in the community. The lack of institutional development troubled evaluators who suggested that the lack of demonstrated organizational capacity jeopardized long-term sustainability. OED noted that most villages required some degree of external support to maintain an acceptable level of operation and maintenance. While these findings provided solid details on project performance across countries, the authors made no attempt to consider what factors explained project success.

The Water and Sanitation Partnership (Dayal et al 2000) also commissioned a study to examine the relationship between demand, gender, poverty, and sustainability. This initiative assessed eighteen projects in fifteen countries. "Sustained" service measured the level of operation and maintenance implemented and contributed from the community. Overall they found that participation was positively correlated with sustained water use, which was measured as the degree of operation and management carried out and contributed by the community. With respect to gender, programs that were more gender sensitive did not improve technical or financial performance of the systems. Additionally, "good governance" – defined as the extent to which a local organization monitors construction and deals with defaults, women's participation in monitoring and control, the degree of training for males and females, and the transparency of accounts – was positively associated with sustained water service. Unfortunately, this study depended on a non-random sample of projects recommended by the NGOs that implemented the projects, so selection bias is likely. Moreover, the study only assesses correlations and does not attempt to demonstrate causality.

Isham and Kahkonen (1999) interviewed 1088 households in India about their water supply. Their interest focused on how social capital, NGO provision, and community factors (household size, wealth, and hygiene) affect service rules and practices, which in turn were hypothesized to influence system performance and ultimately health impacts. They were among the first to develop a social capital index for communities, which takes into account household membership in a variety of groups and the function of these groups in a community. They found that this index was significantly correlated with village participation in the design of new service (0.28) and also affected the impact of piped water on household health (although this magnitude, at 0.02, was quite small). Isham and Kahkonen also noted that NGOs had been more successful in improving water project performance (although it is important to consider that these organizations selected the villages in which they worked). Their model controlled for a limited number of other project and community factors. Service rules and practices were determined to impact the quality of construction and satisfaction with service design, yet other factors (such as the extent of community participation in planning or construction) were not considered. Finally, the authors measured impacts in terms of responses to questions concerning perceptions of health outcomes and reported incidence rates of diarrhea. Yet they failed to obtain information on access to health care or other determinants of health outcomes.

Prokopy (2002) followed up this study by examining the importance of social capital and participation. Her study adopted some of the ideas about social capital from the Isham & Kahkonen study, hypotheses about participation and demand responsiveness from the literature, and sustainability measures from the Narayan and Sara & Katz studies. She collected village and household level data from 45 villages in two Indian states. Her village models tested the following hypotheses on participation and sustainability:

- Smaller villages and those with higher social capital have more participation and transparency.
- Villages with greater needs will have higher participation and transparency in operations.
- Smaller villages will report enhanced project outcomes.
- Villages with higher transparency have better outcomes.

- Villages with greater overall levels of participation will have better outcomes.
- Higher participation among women will yield better village outcomes.

She used quantitative methods, such as principal components analysis, biprobit and multivariate regression with household and village level data, and village case studies. Generally she found that villages with higher social capital demonstrated more effective water committees with higher degrees of participation and transparency. Communities with higher degrees of overall participation did attain better project outcomes on satisfaction (coefficient = 0.2), improved access (0.39), and time saving (0.44), yet women's participation did not improve project effectiveness. Prokopy found mixed results on the nature of demand-driven practices and sustainability. She found that village satisfaction increased as village contribution (measured as the percentage of households contributing to initial capital costs) rose. Nevertheless, this factor did not statistically influence water service improvements. Villages with functioning, transparent water committees featured higher levels of satisfaction and higher payments from tariffs. There was no relationship between village size and project effectiveness or user satisfaction.

Prokopy's work advanced the understanding of the determinants of participation and social capital and their effects on project performance. Her study successfully controlled for a number of community and project factors. Other factors, such as the program management and degrees of external support, were not focal points of her work. Moreover, her study contained a relatively small sample size (45) of villages from two different Indian states.

Khawja (2002) reviewed the determinants of success in public infrastructure projects in 132 Pakistani villages. His team collected household and village-level data and created performance measures for physical condition (the percentage of the project functioning as in the beginning), functionality (the percentage of the original purpose satisfied), and maintenance work (the percentage of maintenance needs attended). He was interested in the importance of social capital, community leadership, community inequality, and participation. He found that community inequality and project maintenance exhibit a U-shaped relationship. Initial increases in inequality lower project maintenance, as households that benefit do not compensate for the loss in contributions from households with declining benefits. As inequality increases further, however, beneficiaries can afford to hire labor outside the household, effectively compensating households which have not gained or lost as a result of the project. Khawja also finds that, while projects succeed more often in socially homogenous communities with strong project leaders, well-designed projects can "overcome" the constraints of lower social capital. In addition, he found evidence that community participation was beneficial in non-technical decisions but not helpful in making engineering decisions. Finally, infrastructure projects initiated by NGOs were better maintained than projects implemented by local governments.

Other quantitative studies have focused more specifically on the impacts of social funds. Early reviews (Batley 1999, Jorgensen and van Domelen 1999) were mixed. Generally, efficiency improved, while the long-term performance varied widely across programs. Health and environmental investments performed better than other governmental programs, while economic programs showed little difference in benefit.

The record on sustainability was questionable, and limited by a lack of household data and comparisons to other programs. Van Domelen (2002) conducted later impact evaluations of social funds. She found that social funds had improved their focus on the poor over time, had largely reflected community priorities, and successfully increased access, quality, and use of social services. However, she also concluded that most water projects, despite operational facilities, were likely not sustainable given the lack of cost-recovery policies.

Others have been more critical on the promise of social investment funds. Tendler (2000) raised several key problems with the design and performance of social investment funds. Her review of World Bank and other donor reviews provided evidence that social funds did not perform poorly, but also were not outperforming government projects. She argued that this comes as no surprise, given the nature of social funds. Social funds do not devolve authority to local governments because they are normally operated by another central government agency. Moreover, social funds were designed to meet certain objectives, not to serve as vehicles for community contribution nor long-term sustainable development. Cost-recovery has not occurred, since most depend on outside donor agencies. Finally, she mentions that, according to the World Bank and Inter-American Development Bank reports, sustainability was even less likely in the water sector.

Rawlings et al (2004) produced the most comprehensive cross-country evaluation of social funds in the literature. Unlike other studies, this evaluation used a variety of techniques to measure the effect of social investment funds against counterfactuals. The authors used different research design methods, including randomized control designs, propensity score matching, and comparisons with "pipeline" communities located near project villages that would be eligible for future project lending. The research collected primary data from over 21,000 households, national household surveys covering 42,000 households, and generated facilities surveys from more than 1,200 schools, health centers, and water and sanitation projects. The authors sought to answer the following questions:

- *Do social funds reach poor areas and poor households?*
- *Do social funds deliver high-quality, sustainable investments?*
- *Do social funds affect living standards?*
- *How cost-efficient are social funds and the investments they finance, compared with other delivery mechanisms?*

Generally, the evaluation found that social funds were reaching poorer geographic areas. Most facilities were working and delivering high quality services at levels of maintenance at least as high as those in comparison groups. Participation was substantial in the planning and implementation phases, and only fell slightly during the management phase. However, complementary inputs were lacking in some cases (particularly for health clinics), and many (including water projects) did not meet cost-recovery objectives in their operation.

The evaluation included a separate chapter on water supply and sanitation evaluations conducted in Armenia, Bolivia, Honduras, Nicaragua, and Peru. The authors' objectives of this sub-section of the study were the following:

- *Are the infrastructure investments in water, sewerage, and latrines leading to improvements in the quality and availability of services?*
- *Have household access and utilization improved as a result of the social fund intervention?*
- *What is the final impact on social welfare of social fund water and sanitation investments, as measured by time and distance to water sources and by health impacts?*

• *Are these water, sewerage, and latrine investments sustainable?*

The Peruvian case study found that most systems were operating and providing water for nearly 90% of village residents. Over 90% of operators reported routine cleaning of the systems, and 68% reported general repairs. About 50% of villages reported paying for water, although in many cases these were nominal in comparison to costs. Peruvian families gained an average of 34 minutes per day in reduced wait time. Finally, after controlling for household and environmental factors, incidence rates for diarrhea declined by 3% in children under 10 while dysentery rates fell by 1.7% in children ages 2–8.

Finally, Prokopy and Thorsten (2005) evaluated village-level sustainability of water projects built under the FONCODES and SANBASUR programs in the Cuzco region of Peru. They analyzed the role of post-construction support as well as other project and community factors in the physical operation, financial management, consumer use and satisfaction (defined in this study as the aggregate percentage of households using the system and the percentages of households satisfied with various water, service, and management attributes). They found that post-construction support was not an important determinant of sustainability – most systems functioned well in absence of concerted post-construction assistance. However, a sub-sample of villages operating at the margins could benefit from a systematic influx of additional assistance.

2.4. Household-level Evaluations

Household-level studies focus on those which use the household as the principal unit of analysis. Unlike the previous section, few investigations have adopted a qualitative approach to understanding household behavior. Instead, most have surveyed a sample of households, often within a relatively small number of villages.

White et al (1972) published one of the initial studies of household water use and behavior. A team of researchers visited villages in Uganda, Kenya, and Tanzania to learn about water practices, health and economic effects, and the social costs of disease in East Africa. This study used household surveys, excreta and urine specimens, clinical exams and existing records. The researchers discovered that size, family composition, and wealth were generally significant indicators of water use. As household size increased, per capita use declined in villages with and without piped water. Consumption rose with the level of household wealth. Additionally, water use was lower in rural locations for users not connected to local water systems. Finally, rural household use did not vary initially with distance for up to one mile, yet beyond this distance per capita water use declined. The White study was an important first contribution to studying household behavior in different villages across countries.

Briscoe et al (1981, 1989) followed White's work with a more complex, discrete choice analysis of household water use in South Asia and Brazil. The 1981 study found that per capita water consumption rose among households with larger incomes and asset bases. In particular, Briscoe noted that wealthier households chose water sources based on water quality and not on the likelihood for conflict (as poor households did). The 1989 study found that wealthier, more educated, and formally employed households were more likely to connect to a piped water system. Distance in these studies did not seem to be an important factor for water source choice – many villagers were willing to travel several kilometers to obtain better quality water.

Some of these results have been confirmed in later studies. For example, Asante (2002) applied a discrete choice model for Ghanaian villages and found that the probability of choosing an improved versus unimproved water sources rose rapidly as incomes increased. These studies focused more on household-level determinants of behavior rather than village-level or external effects.

Willingness to pay measures play important roles in identifying the strength and significance of demand. Bohm et al (1993) devised a study that would compare ex ante consumer demand for new service with the costs of building and operating new gravity-fed water schemes in the Philippines. Sustainability was measured in terms of financial cost recovery. As expected, willingness to pay was correlated with income. They found that aggregate willingness to pay was too low to recover capital and operating costs in all but the richest areas with the lowest unit costs. Subsidies would be necessary to move forward with these projects, at least in order to meet capital costs. This study contributed to the literature on using household demand as a mechanism for comparing projects in terms of financial cost recovery. However, it did not consider other sustainability objectives or their relationship to cost recovery.

Dayal et al (2000) examined household impacts of improved water services. Their team estimated "effective use", which incorporated three measures: 1) whether a household had "easy" access to improved water supply, 2) whether households always use the improved source, and 3) environmental indicators, such as the presence of drainage and absence of nearby stagnant water. They discovered that increased household demand responsiveness – as indicated by the priority households placed on the initial project - was statistically associated with effective water use.

However, higher ex ante demand for service – as expressed by initial cash and in-kind contributions – was negatively associated with their indicators of sustained water use. This suggests that higher demand is positively related to use and access to water service, but negatively related to its physical and technical functioning of the system. Again, these relationships were developed only as statistical correlations, and village-level factors did not play a role in estimation.

Prokopy (2002) examined household level models in the context of understanding participation and its relationship to project effectiveness. She used fixed and random effects model to account both for village and household-level impacts. She tested the following hypotheses:

- Households in smaller villages and in those villages with less wealth inequality are more likely to contribute to capital costs, attend meetings, and contribute toward making decisions.
- Households are more likely to participate if they are wealthier, more literate, and larger. Poorer households and those with female household heads are less likely to participate.
- Higher distances, reliability, and quality of previous scheme yield increased participation.
- Participation improves household satisfaction, increases the chances that a household will pay a tariff, and improves the likelihood that a family will connect to the system.
- Higher level of overall participation in a village make it more likely that individuals are satisfied and pay tariff.
- More transparent committee operations are correlated with increased household satisfaction and an increased likelihood to pay a tariff.

She found that 1) an increase in the percentage of contributing households was associated with greater household satisfaction, yet not related to the level of water improvements, 2) greater household participation translated into higher degrees of household satisfaction, and 3) enhanced levels of committee transparency improved the likelihood that households would pay tariffs. Additionally, larger households tended to participate more often than small households in designing and implementing the new water projects in India. This result complemented previous findings from Isham and Kahkonen (1999), who found that larger households tended to benefit more from the introduction of public taps in Indian villages. She also found that households that regularly attended meetings and were involved in key decisions were more satisfied with the results of the water projects.

Prokopy's results showed that a (fixed effects) multi-level modeling framework could detect both household and village-level determinants of household participation and satisfaction with the water projects. Her sets of questions revolved around participation and aspects of performance and less on providing an analysis of sustainability, including the relationships among indicators of performance.

Finally, Rawlings et al (2004) study of social investment funds showed that in all six countries, social funds were more likely to reach poorer households vs. wealthier ones. Low income persons were well represented as beneficiaries in the projects – the poorest 20% of households accounting for between 23-27% of beneficiaries in all countries except Armenia. FONCODES investments in Peru were considered the most "pro-poor" by the authors. Access to potable water expanded in all countries, although rates escalated higher in urban areas. There were positive health impacts in all but one nation, and household collection times for water declined on average in four of the six country settings. The comprehensive nature of this study (across project and country settings), the use of pipeline communities to make comparisons across households in treatment and control villages, and the large samples of households and villages in the study created a robust research design. Yet unlike

Prokopy, the authors did not examine how village-level influences can mediate household outcomes.

2.5. Rural Water Systems - Prospects for "Scaling up" and "Leveraging"

This dissertation addresses questions concerning the ability of and interest in villages to "scale up" and leverage their investments. These terms require brief definition and discussion.

Scaling up here refers to the ability of a community to either expand services to areas not served by a recent water project or improve the quality of service offered by a project. An example is provided in WASH's (1994) classification of benefits.

- Class I: Benefits exceed end of project levels due to replication or expansion of WS&S systems to beneficiaries beyond target population.
- Class II: Benefits continue for original target group at near end of project levels. Lack of funds or other resources prevents expansion
- Class III: Benefits drop to stable level after project. Least skilled of communities are marginal, some fail. Sustainable if benefits continue at acceptable level.
- Class IV: Benefits drop below acceptable level, continue decline. Project considered a failure.

This definition would encompass benefits listed under Class I, although it also includes enhancing the level of benefit; for example, due to improvements in water quality, number of operating hours/days, and increased level of service (e.g. from a public tap to household connections).

Davis and Iyer (2002) reviewed the limited literature available on scaling up from fields as diverse as agriculture, education, HIV prevention/treatment, nutrition and population, irrigation, and urban slum upgrading. Overall they found that there has been no published work on systematically investigating determinants of scaling up in any sector, including rural water supply. Their discussion paper addresses factors that enhance and limit the ability of agencies and organizations to expand rural water supply coverage in a sustainable manner. They note that expanding service may sometimes conflict with sustainability features, including meaningful community participation and management, education, and demand responsiveness. In interviews with fifty practitioners in various infrastructure sectors of six countries, Davis and Iyer identified four major obstacles: 1) resource constraints, 2) lack of knowledge or shared understanding, 3) resistance among key stakeholders, and 4) untested implementation conditions resulting from the movement of pilot projects to new areas. This discussion paper mirrors early works on participation and sustainability in that it reviews existing literature and interviews practitioners from other sectors to learn about best practices. The IRC study (2003) also contains a section on scaling up, although the discussion focuses more on lessons from community management than avenues for future practice. The limited amount of systematic research, particularly at the household and village levels, makes this a compelling arena for further study.

There are a few more references on the issue of leveraging. *Leveraging* here refers to the ability of and interest in villages with successful water projects to participate and implement additional investments in related environmental infrastructure. Sanitation, solid waste, and health services are possible examples because, like water, they each have the potential to improve health status. Previous studies (Shuval 1981, Esrey 1991, Dayal 2000) indicate the importance of complementary investments to increase the impact of improved water service on health outcomes. Serageldin (1994) perhaps illustrates this perspective most candidly in reference to water and sanitation.

> *In this nexus of service and environmental issues, it is instructive to consider the sequence in which people demand water supply and sanitation services. Consider, for instance, a family that migrates to a shantytown. Their first environmental priority is to secure an adequate water supply at reasonable cost. This is followed shortly by the need to secure a private, convenient, and sanitary place for defecation. Families show a high willingness to pay for these household or private services, in part because the alternatives are so unsatisfactory and so costly. They put substantial pressure on local and national governments to provide such services, and it is natural and appropriate that the bulk of external assistance in the early stages of development goes to meeting this strong demand. The very success in meeting these primary needs, however, gives rise to a second generation of demands for removal of wastewater from the household, then from the neighborhood, and finally from the city. And success in this important endeavor gives rise to another problem: the protection of the environment from the degrading effects of large amounts of waterborne waste.*

A couple of evaluations mention some evidence for this nexus. Abraha (1991) looked at factors that led individuals in Swaziland to adopt sanitation practices and participate in development. Abraha identified the following determinants: 1) respondents' resettlement status, 2) level of education, 3) economic status, and 4) exposure to extension agents. However, the dissertation did not explicitly consider villages with previously successful water projects.

Smith's case studies in Indonesia (1993) and the WSP review of cases in East Africa (2000) suggest anecdotal evidence that successful project communities had begun to shift resources toward other development priorities. If this has begun to occur, it would fulfill one of the promises of the community management model – the empowerment of communities and individuals to shape and take on other development priorities. Again, though, leveraging was not the focal point of these studies. It is also very important to mention the real possibility that some communities with successful projects and high demand for water do not share the same demand for other forms of environmental infrastructure. Previous studies have noted that the demand for sanitation and prospects for other infrastructure may be less than water (WASH 1993, OED 2000, WSP 2000).

2.6. Gaps in Existing Literature

The evaluation literature on rural water supply in developing countries has an extensive history. It has evolved as the debates and frameworks have shifted over time. The last ten years has witnessed greater interest in community participation, demand-responsiveness, sustainability, and institutional development objectives.

There are several possible definitions and interpretations of sustainability in the literature, and more recent attempts to apply sustainability criteria to evaluate rural water projects. An important distinction that studies have often confounded rests between the *indicators* of sustainability and the *conditions* of sustainability. An indicator here refers to an outcome of a sustainable water system, such as the production of clean water at a tap. A condition, in contrast, represents an element of the water supply system that allows an indicator to occur. One example might be a trained technician, who maintains and occasionally repairs the water tap. In some studies, conditions are distinguished from *factors* of performance and sustainability, such as community participation. Unlike some studies which include indicators and conditions of sustainability (and occasionally factors) in the same category, this study will operationalize certain variables previously considered conditions of sustainability and treat them as factors which predict sustainability outcomes.

Some village-level studies that attempt to measure the associative or causal factors of sustainable rural water schemes have examined different indicators of sustainability, such as cost recovery, physical performance, use, and user satisfaction. Only a few studies have collected data from a large sample of villages in a few key regions. Larger-village studies allow researchers to control for the variety of project, community, and external factors which can predict sustainability and examine their relative contributions at the village level. For example, prior studies have covered effects on physical performance measures in some detail, yet there remain some questions concerning the impacts of participation and demand responsiveness on financial performance. An interesting institutional comparison also arises in Peru between the NGO and the social investment fund models of development. Which model has performed better in meeting the indicators of sustainability, after controlling for other project and community factors?

The literature revealed a number of studies dedicated to understanding household water behavior and satisfaction. There have also been a few attempts to augment village-level data with household surveys. Yet there has been little systematic effort into placing questions of household water use, satisfaction, and perceptions of future performance into a multi-level framework. Nor have there been important attempts to examine the effect of household attitudes toward social capital. Past approaches have frequently either not considered the relevance of village-level factors on household responses and/or have potentially mis-specified models which failed to account for clustering of household units within villages. These approaches also fail to estimate project effects within villages. In part, a lack of interest or a limited sample of villages to detect effects may explain this situation. Regardless, an evaluation of sustainability from the user's perspective – do they use the system, are they satisfied with the water and management, do they pay for their water, and do they believe the system will continue functioning over time – requires a better understanding of how users' responses differ both across villages and within a particular village.

Researchers investigating sustainability in this sector usually assign the concept a set of characteristics and then modeled impacts separately for the indicator(s). There has not been an attempt to define sustainability as a concept – indicated by a set of measures – and then estimate the village and household-level effects on these measures simultaneously. This approach recognizes that 1) sustainability itself can be considered a concept with some degree of "latentness"; i.e. measurement error and 2) indicators of sustainability are likely correlated among one another.

Finally, while some have anticipated that sustainable water investments would lead people to demand better levels of service and access to other forms of environmental infrastructure, few studies have investigated this in practice. One major reason may lie in the limited number of highly successful projects. As targeting and performance have improved, the time is ripe for asking questions about the viability of scaling up and leveraging investments. The limited literature available often assumes a sense of hopefulness that people will demand improved water or related environmental health infrastructure once the barriers are removed. This dissertation will empirically test support for this belief, by estimating what household, community, and project factors (and sustainability indicators) can predict household support for scaling up and leveraging.

III. Research Design and Data Analysis Techniques

3.1. Theoretical Framework and Constructs for Inquiry

The main focus of this dissertation rests in identifying and predicting what factors promote or inhibit sustainable service, user payments and satisfaction, and household support for future endeavors in community-managed, demand-oriented rural water supply projects. This section will develop the theoretical basis for and the constructs of sustainability, the factors which are hypothesized to influence sustainability, and the nature of the predicted relationships.

3.1.1. Sustainability

3.1.1.1. Constructing and Measuring "Sustainability" Indicators

This investigation begins from the premise that the concept of sustainability in the water sector refers to the maintenance of a set of benefits over the life of the improved water project. The life of a project generally means the number of years that a project is designed to deliver water, depending on source and technical constraints – although it is possible to extend this life through major capital replacements or improvements.

The direct benefit of a project refers to the water provided by the system. This benefit can be categorized into project outcomes, which serve as indicators of sustainable performance. These categories appear below:

1) ***Physical Delivery:*** Generally, does the water system supply potable water to users when it should be available? The latter part of this definition is important. A system may technically function, yet may only deliver water at certain times of the day or certain seasons during the year. The focus here is on providing water on a consistent basis to users. .

Since the unit of analysis for this dissertation rests at the household level, only the Peru study tests this category. The Peru study focuses on evaluating the physical performance of household taps from gravity-fed schemes which mostly draw water from mountain lakes and underground springs. A set of water mains, storage and break-pressure tanks, and distribution lines bring the water to private taps located in households or their yards. In contrast, users draw water from community boreholes in Ghana. Household factors are not expected to affect physical performance of these handpumps.

2) ***Consumer Use:*** A water system may consistently deliver potable water. Yet consumers may not use it. They may not trust some aspect of the water source, dislike the quantity and quality of water, prefer other water sources for primary or secondary uses, live too far away from the taps, or have other reasons. Regardless, if consumers are not using an improved water source, the project has failed to reach some portion of its intended population. As with physical delivery, some elements will be more likely than others - depending on technology, location, cultural practices, and other attributes. In Peru, household distance to the tap is

not likely to be an important measurement since nearly all households have either in-house or yard taps. The Peru and Ghana studies both contain measures for whether consumers use the improved service as the primary source.

3) ***User Satisfaction***: The benefits of improved water may be diminished (literally and figuratively) if consumers are unhappy with some aspects of the water they receive. This category can include several possibilities involving the quantity, availability, and quality of water. It is possible to construct "objective" measures related to these characteristics, such as testing the water pressure or water quality. Our studies did not have such instruments at their disposal, so this dissertation focuses instead on perceptions of user satisfaction with both the water and institutional services (in the forms of operation and maintenance and administration).

3.1.1.2. Introducing Cost and Time

The first three indicators reflect benefits to beneficiaries with a set of values that denote its worth to users. In return, many users are asked to pay for water service.

There are two forms of financial (as opposed to economic) costs. The first represents the cost of capital. Villages in both project areas were required to contribute to the cost of infrastructure. In Ghana, households were supposed to contribute a total of 5% of the financial cost of capital. In Peru, FONCODES and SANBASUR programs differed in application, yet in both cases villages were supposed to collect contributions for the project (often these came in the form of “in-kind” contributions such as labor and materials). Household contributions toward these capital costs are not considered in constructing an indicator for sustainability since they occurred before the project began delivering water to residents. However, they are used in providing a proxy for one hypothesized factor of sustainability - pre-project demand. The second stream of payments represents the amount that villages pay toward operating and maintaining the water service. This flow of revenues can originate from the users (levied either when they obtain water or as a periodic fee for service) or from the community in the form of voluntary or imposed village collections.

In both country settings, the programs were not designed for communities to contribute to the cost of capital recovery. This suggests that the systems are not financially sustainable in the fullest sense of the term. In a limited sense, however, communities are financially self-sustaining to the extent that households pay for water service and, furthermore, pay amounts that enable communities to cover their operating costs.

Sustainability implies a temporal dimension. Benefits and financial payments are not expected to stop tomorrow – they are expected to occur over the project life cycle. Ideally, the best method to measure sustainability is through the use of multiple measurements over time. However, this study is limited to cross-sectional data obtained at a time T years from the completion of the improved system, where T depends on each village and the programs studied. Therefore, this study does not attempt to truly explore the temporal nature of sustainability.

Rather, this investigation generally handles time in two ways. The first approach is to measure what has occurred from the initial supply of potable water until the present. The projects in both countries have operated for a minimum of three years and a maximum of fifteen years. Age of water taps (in Peru) is considered as a factor influencing physical performance. The second method addresses the confidence of household respondents in each community regarding the future performance of the water system. This technique gauges community opinions regarding the likelihood that a village water system will continue to function over the next five and ten year periods. This measure shows how confident villagers perceive that their system will continue to deliver benefits over periods of time. Thus, it reflects users' perception of sustainability over time.

3.1.1.3. Correlations Among Indicators

Naturally these indicators are related a priori to one another. Consumers cannot use a tap if it does not deliver water, nor can they be satisfied with the service if they do not use it (although their decision not to use a service may indicate a low degree of satisfaction). Consumers will not pay a tariff if they do not use the improved source, and likewise less satisfied customers may delay their payments. In addition, villagers in places with failing systems or a lack of funds to make basic repairs are more likely to believe their systems will not function over time.

These inter-relationships suggest models which can either expressly estimate the statistical correlations among the indicators or ignore them for the sake of emphasizing causal relationships. The models make different specification assumptions about these relationships.

3.1.2. Factors of Sustainability

This dissertation conceptualizes that sustainability, as indicated by a set of outcomes, is influenced by a set of community, project, and external factors measured at household and village levels. These categories are described below.

3.1.2.1. Community and Demographic Factors

Studies have shown that community and demographic factors influence some of the conditions and indicators of sustainability. These factors may include measurements at either a household or village level. Community factors measured at a village level include village size (population and geographic size) and, in Ghana, the regional location of the villages.

Household-level factors represent those variables taken from household surveys. The household-level variables include:

- *Household size* (the number of people living in the home).
- *House size* (measured by the number of rooms in a house).
- *Respondent's age*
- *Annual income,* measured as a categorical variable in the Peru study.
- *Monthly expenditures* (in the Ghana household survey) – measured as the log of a continuous variable.
- *Asset index,* including the number of non-farm assets and the number of animals owned by households. Filmer and Pritchett (2001) have developed a technique for developing an asset index which this dissertation employs.
- *Household perception of social capital*: Unlike village size and location, social capital is not readily observed. Rather, it must be constructed. This dissertation adopts the index construction approach to identifying social capital found in other studies (Putnam 1995,

Isham and Kahkonen 1999, Prokopy 2002). The focus here rests on **household** attitudes concerning social capital. Sets of questions in the household survey are transformed into a social capital index, which includes the following topics:

- Degree of trust among community members
- Degree of trust relative to other communities
- Degree of trust in comparison to trusting other communities
- Degree of trust for different actors (local leadership, local government officials, central government officials)
- Confidence in borrowing money
- Number of groups found in the community.

3.1.2.2. Project Factors

Project-related factors are often considered important determinants of sustainability. Project variables incorporate decisions involving the choice of water source, the degree of community participation involved in the project, the contribution which households made to the project, the quality of construction, and the local management and technical support structure in place to operate and maintain the system. Village-level measurements include:

- ***Water Source and System Characteristics***. An ideal description of a water source will include objective measurements concerning the quantity and quality of water provided year-round over the life of the project. These data sources were not available for these studies. Field teams instead gathered information from system operators concerning the quantity and availability of source water in rainy and dry seasons and the distance of the water source to the village (in Peru). Field team engineers in Peru also conducted system assessments to determine whether there were leaks in the storage tanks and visible distribution lines.

- ***Local Management and Technical Capacity***: This sub-category gauges the capacity of local system operators and water committees to maintain the system. It incorporates several elements:
    - Training received by operators and water committee members before the project began operating.
    - The years of experience reported by current water committees and system operators and the number of village caretakers (in Ghana).
    - The management structure for the project; specifically whether the local village elected committee members. In Peru, some local governments have taken over the operation of systems, while in Ghana some NGOs have essentially adopted communities and met their requests on demand.
    - In Ghana, enumerators also learned the distance to the nearest area mechanic. Mechanics often are called to resolve problems which village caretakers are unable to handle.
- ***Tariff System and Cost Recovery Practices***: In both countries, field teams learned what tariff structures water committees had put in place to collect operating revenue from households. Nearly all Peruvian villages used flat fees; however there were different structures in place in Ghana. Committee members also presented information to compare annual operating costs and household revenues.
- ***Role of Program Institutions:*** The implementing agencies have shaped some of the project factors via their influence over selecting water sources, designating roles for community participation and fostering demand, and selecting training villagers to take over the water systems. In addition, program officials are partly responsible for identifying villages to conduct projects. These decisions affect the sample of communities selected (and thus the values for community factors for the studies). This study, however, focuses on program effects **after** controlling for project and

community effects. This is particularly relevant in Peru, where the study compares performance of a social investment fund to an NGO-based program. This factor is not explored in the Ghana study, since local and regional governments were responsible for the projects.

Household-level project factors also are hypothesized to influence sustainability. Household surveys contain information on the degree of household participation, specifically the number of project decisions in which households participated. Surveys also contain proxies for the level of pre-project household contribution. While this is an imperfect measure of ex ante demand, other studies have used similar measures as proxies. The study further controls for the confidence of users in the construction of their water system and considers two current measures of household involvement: 1) meeting awareness and participation, and 2) knowledge of how committees spend financial resources.

Some factors, such as water source, pre-project participation and contributions, system age, and attitudes toward system construction involve decisions taken before the present day. Others, including current meeting attendance, awareness of finances, operator and committee attributes, and tariff and cost recovery decisions encompass present-day activities. This distinction is important to remember when evaluating the results of the study.

3.1.2.3. External Factors

External factors fall outside of the characteristics of projects and the communities that receive improved water service. The main factor identified in this study is post-construction support (PCS). PCS refers to support received from external government agencies, charities, or other parties to maintain existing levels of service. This study does not consider village-level PCS effects (these are treated in other studies emerging from this research), but rather focuses on whether households receiving external visits have benefited additionally from the project in terms of outcomes. In Peru, households may have been visited for observation, assistance with maintenance, hygiene education, and/or other purposes. Environmental health assistants (EHAs) and District Water and Sanitation Team representatives made periodic visits to households and villages in Ghana. Possible reasons for visits may have included maintenance training, user education, hygiene education, or other purposes.

Table 2 summarizes the set of all dependent and independent variables considered in this study.

Table 2: Summary of Sustainability Indicators and Factors

VARIABLE	INDICATOR / FACTOR	MEASURED LEVEL	TYPE	COUNTRY	SCALE
# Tap breakdowns last 6 months	Indicator	Household	Physical	Peru	Continuous
# Days to repair last breakdown	Indicator	Household	Physical	Peru	Continuous
Household pays for water	Indicator	Household	Financial	Ghana, Peru	Binary
Amount household pays for water	Indicator	Household	Financial	Ghana, Peru	Continuous
Satisfaction – water pressure	Indicator	Household	Satisfaction – water	Ghana, Peru	Ordinal
Satisfaction – safety	Indicator	Household	Satisfaction – water	Peru	Ordinal
Satisfaction – taste	Indicator	Household	Satisfaction – water	Ghana	Multinomial
Satisfaction – operation & maintenance	Indicator	Household	Satisfaction – service	Ghana, Peru	Ordinal
Satisfaction – committee	Indicator	Household	Satisfaction – service	Ghana, Peru	Ordinal
Trust in committee	Indicator	Household	Satisfaction – service	Ghana, Peru	Ordinal
Satisfaction – water system	Indicator	Household	Satisfaction – overall	Peru	Ordinal
Five-year confidence	Indicator	Household	Future sustainability	Ghana, Peru	Binary
Ten-year confidence	Indicator	Household	Future sustainability	Peru	Binary
Committee should scale up service	Indicator	Household	Scaling up	Ghana, Peru	Binary
Committee should handle related needs	Indicator	Household	Leveraging	Peru	Binary
Years connect (tap age)	Factor	Household	Project	Peru	Continuous
Participation – # decisions	Factor	Household	Project	Ghana, Peru	Continuous
Household contributed pre-operation	Factor	Household	Project	Ghana	Binary
Household contribution – labor days	Factor	Household	Project	Peru	Continuous
Attendance at current meetings	Factor	Household	Project	Ghana, Peru	Ordinal
Attitudes re: construction	Factor	Household	Project	Ghana, Peru	Continuous
Knowledge how committee spends funds	Factor	Household	Project	Ghana, Peru	Ordinal
Received post-construction visit	Factor	Household	External	Ghana, Peru	Binary

Age of respondent	Factor	Household	Community	Ghana, Peru	Continuous
# Household members	Factor	Household	Community	Ghana, Peru	Continuous
# Household rooms	Factor	Household	Community	Ghana, Peru	Continuous
Annual income	Factor	Household	Community	Peru	Ordinal
Monthly expenses	Factor	Household	Community	Ghana	Continuous
Asset index	Factor	Household	Community	Ghana, Peru	Continuous
Attitudes regarding social capital	Factor	Household	Community	Ghana, Peru	Continuous
Household treats water	Factor	Household	Community	Ghana, Peru	Binary
SANBASUR village	Factor	Village	Project	Peru	Binary
Volta Region	Factor	Village	Project	Ghana	Binary
Years operator served in village	Factor	Village	Project	Peru	Continuous
Operator trained	Factor	Village	Project	Peru	Binary
# Operators	Factor	Village	Project	Ghana	Continuous
Source - # Dry months/year	Factor	Village	Project	Ghana, Peru	Continuous
Source – Km from village	Factor	Village	Project	Peru	Continuous
System – degree of storage cracks	Factor	Village	Project	Peru	Ordinal
System – leaks in distribution lines	Factor	Village	Project	Peru	Ordinal
Tariff system type	Factor	Village	Project	Ghana	Binary (multiple)
Recovers operating cost with tariffs	Factor	Village	Project	Ghana, Peru	Binary
Committee elected	Factor	Village	Project	Ghana, Peru	Binary
Distance to area mechanic	Factor	Village	Project (location)	Ghana	Continuous
Committee – years of existence	Factor	Village	Project	Ghana, Peru	Continuous
Committee trained	Factor	Village	Project	Ghana, Peru	Binary
Village population	Factor	Village	Community	Ghana, Peru	Continuous
Village size (minutes to travel end-to-end)	Factor	Village	Community	Ghana, Peru	Continuous

3.2. Avenues of Inquiry

3.2.1. Relationship between Sustainability and Hypothesized Determinants in Community-Driven Development Models of Rural Water Supply

3.2.1.1. Note on Programs Selected for Study

Both the Peru and the Ghana country studies in this investigation resulted from a collaborative selection process among members of the research team, local consultants, and World Bank staff members to examine the impact of post-construction support on sustainability in ***community-driven*** rural water supply projects. This mechanism of program selection is critical to framing this investigation. This dissertation is not designed to compare the performance of community-based, demand-oriented water projects with centrally-planned, supply-driven water supply projects. Projects in both regions of Ghana and in both programs of Peru were built under the intentions of 1) soliciting community participation, 2) responding to local demand, and 3) expanding coverage to areas and populations without improved water sources. Under programs in both countries, communities were responsible for generating proposals, working with program staff, and taking over the projects upon completion of the project. In essence, communities have to some degree self-selected themselves into the programs relative to other villages. One might expect that these projects ought to perform better than traditional projects and that these communities would feature more social capital since they theoretically have come together to advocate and organize for an improved water project.

Instead, this dissertation addresses the relative importance of community, project, and external factors as they determine household-level physical performance, financial payments, use, and satisfaction of rural water projects under an *assumed* framework of participatory input, demand responsiveness, and community management. In practice there may be variation in the degree of community participation, demand responsiveness, and community management. Measuring this variation is an important part of the study.

Moreover, there should be variation in the post-construction support indicators, since the original World Bank study methodology selected programs (in Peru) and regions (in Ghana) with differences in post-construction support. In Peru, the FONCODES program under study (during the period 1993-2000) was not designed to provide any post-construction support (although some villages may have received it), while SANBASUR offered a mechanism for obtaining short-term PCS (either at the household or village levels). In Ghana, both regions offered post-construction support. Yet one region (Volta) provided regular, ongoing assistance through district environmental health assistants (EHAs) while in the other region (Brong Ahafo), villages needed to request support.

Other community factors (e.g. village size, location, and socio-economic status) and project factors (e.g. water source characteristics, local management and technical capacity) are expected to vary, although it was impossible to predict ex-ante the extent of variation among the sampled villages.

3.2.1.2. Overview of Hypothesized Effects

Table 3 below overviews the categorical hypotheses for this study.

Table 3: Hypothesized Effects of Categories of Determinants on Sustainability

INDICATOR	COMMMUNITY FACTORS *(direction)*	PROJECT FACTORS *(direction)*	EXTERNAL FACTORS *(direction)*
Physical Function (Peru only) 1) Number of breakdowns in last six months 2) Number of days to repair last problem	Village Size, Pop. (?) HH Size (+) HH Econ. status (-) HH Respondent age (?) HH Social capital (?) Village Region (?)	Agency (Peru) – NGO or social fund (?) System age (+) Source quality (-) System quality (-) HH Pre-Participation (-) HH Pre-Contribution (-) HH Participates/Knowledge(?) Operator capacity (-) Management capacity (-) Management elected (-) Tariff structure (?)	HH PCS (+)
Financial Payment 1) Household pays for water 2) Amount paid for water	Village Size, Pop. (?) HH Size (?) HH Econ. status (+) Respondent age (?) HH Social capital (+) Village Region (?) Village Distance (?)	Agency (?) System age (-) Source quality (+) System quality (+) HH Pre-Participation (+) HH Pre-Contribution (+) HH Part./Knowledge (?) Operator capacity (+) Management capacity (+) Management elected (?) Tariff Structure (+)	HH PCS (+)
Consumer Satisfaction 1) water attributes 2) repair service 3) management	Village Size, Pop. (?) HH Size (?) HH Econ. status (+) Respondent age (?) HH Social capital (+) Village Region (?) Village Distance (-)	Agency (?) System age (-) Source quality (+) System quality (+) HH Pre-Participation (+) HH Pre-Contribution (+) HH Part./Knowledge (+) Operator capacity (+) Management capacity (+) Management elected (?) Tariff structure (-)	HH PCS (+)
Future Performance 1) Five year period 2) Ten year period	Village Size, Pop. (?) HH Size (?) HH Econ. status (+) Respondent age (-) HH Social capital (+) Village Region (?) Village Distance (-)	Agency (?) System age (-) Source quality (+) System quality (+) HH Pre-Participation (+) HH Pre-Contribution (+) HH Part./Knowledge (?) Operator capacity (+) Management capacity (+) Management elected (?) Tariff structure (?)	HH PCS (+)

Physical performance centers on the number of breakdowns households experience and the number of days it takes to restore service when they occur. Community factor hypotheses suggest that higher-income, wealthier households are less likely to break down and more likely to have service more quickly restored. Larger households are more likely to break down (due to use), but equally likely to receive repairs. No discernable relationships are proscribed between physical performance and village size. Economies of scale may improve performance, yet larger villages (in population and size) may lower household-level performance. Neither age, social capital attitudes, nor village region (in Ghana) are expected to be related to physical performance. In contrast, households in villages with longer dry seasons, further water sources, and systems judged of lower quality are more likely to face problems. Villages with greater household pre-project participation and contributions are more likely to maintain their taps, yet probably no more likely to obtain better service. The effect of current participation and knowledge is uncertain; households that participate in current meetings may do so because they do not receive good service, or they may participate because they are pleased with the results. Households which understand financial dealings are no more likely to experience breakdowns or wait longer than others. Villages with more experienced, better trained, and elected committees are more likely to contain households with improved service. Tariff structures are not anticipated to affect household yard tap performance. However, post-construction household visits may improve physical performance functioning if they encouraged household members to better maintain their taps.

Financial indicators focus on whether households pay for service and the monthly amounts they pay. Community factors that are hypothesized to influence these indicators include household income, wealth, and social capital (households with more positive attitudes regarding social capital are more likely to pay for services). Household size and respondent age are indeterminable household factors, while village size, distance, population, agency type, and region are also difficult to predict. Regarding project factors, households with older taps are less likely to be willing to pay for water service. Source and system quality are believed to influence the likelihood and amount of payment. The degrees of pre-project participation and contributions conceivably influence the extent to which people will pay for water service. It is difficult to predict whether current participation and knowledge about committee affairs are expected to influence the likelihood and amount of payment, since it depends on whether their participation and knowledge reveals that their committees are doing a good or poor job. Greater technical and management capacity is believed to improve the chances that people will pay for water and the amounts paid. Post-construction support may improve financial payments if households believe their water systems are better supported by external agencies. The presence of tariff structures should influence financial performance because they require users to pay for the water they receive.

The consumer satisfaction category features questions regarding water attributes, operation and maintenance service, and administrative satisfaction and trust. The effects of village size, population, and region, as well as household size and respondent's age, are indeterminable. Households with more income, wealth, and higher social capital scores are expected to be more satisfied with the project. In Ghana, households in villages located farther away from mechanics and spare parts are more likely to be less satisfied with water and services. Project-related household factors hypothesized to influence household satisfaction include tap age (-), previous participation and contributions to the project (+), and current meeting participation and knowledge of financial activities (+). This dissertation also predicts that households in villages with more reliable and closer water sources, fewer system problems, and more technical and management capacity are more likely to be satisfied. Households in communities with tariffs are less likely to be satisfied after controlling for other factors since they must pay for service. Households receiving external support are also more likely to buy into the water project and thus more satisfied with water and services. Finally, future performance is expected to be a function of most project, community, and external categories (and hence partially a function of the present performance of the water projects along with unobservable measurement error).

3.2.1.3. Summary of Prior Village-Level Findings – Peru

Prokopy and Thorsten's study in Peru examined five measures of physical performance: 1) the percentage of yard taps working in the village, 2) the number of hours per day the system provided water, 3) the number of breakdowns reported over the last six months, 4) the repair time needed to restore service after the last breakdown, and 5) an engineer's assessment of the technical condition of the system.

Table 4, reprinted from that study, overviews basic descriptive statistics on physical performance.

Table 4: Physical Performance of Water Systems - Peru

MEASURE	SOURCE	FONCODES Average (N=56)	SANBASUR Average (N=43)	ANOVA p-value
System Age	Committee	7.57 years	6.13 years	0.007***
Taps working	Operator	95%	93%	0.489
Hours of operation (per day)	Household avg.	18.8	19.9	0.249
Major unplanned interruptions in water supply service for at least one day in past 6 months	Operator	89%	59%	0.129
Major unplanned interruptions in water supply service for at least one day in past 6 months	Leaders	70%	55%	0.117
Number of days to fix problems	Operator	4.53	1.06	0.047**
Number of days to fix problems	Leaders	2.08	2.58	0.755
Leaks on main pipe to village in past month	Household avg.	23%	21%	0.464
Leaks on main pipe to village in past 6 months	Household avg.	50%	43%	0.253
Distribution line breakages in past month	Household avg.	28%	20%	0.054*
Distribution line breakages in past 6 months	Household avg.	24%	39%	0.003***

**** difference between villages is significant at less than .01 level; ** difference is significant at less than .05 level; * difference is significant at less than .1 level.*

Generally the water taps were working and providing water throughout the day in most villages. A majority of villages reported experiencing breakdowns. Average repair times for system problems, however, averaged less than three days. Engineers reported that many systems were well-maintained, although there were some cases of storage tank and main line breakages and water lines crossing river streams (increasing the likelihood of ruptures). SANBASUR households on average contained taps that were over one year younger and reported lower repair times than FONCODES villages.

Prokopy and Thorsten used factor analysis and multivariate regression to estimate the impact of village-level factors on physical performance. Factor analysis did not generate meaningful results but regression models detected important effects. Community factors such as village size, distance from water source, and household attitudes toward social capital were significant in some models, while project factors such as community participation were important as well. The extent of training and whether a community had received post-construction support also figured prominently. However, the models contained a high degree of unexplained variation, in part because many systems performed rather well at the village level.

In contrast to the generally satisfactory working condition of many systems, the researchers found that financial performance varied considerably by village. Table 5 highlights basic financial responses to survey questions.

Table 5: Summary of Financial Performance Measures - Peru

MEASURE	SOURCE	FONCODES Average	SANBASUR Average	ANOVA p-value
Amount collected enough to operate system	Committee	46%	49%	0.841
Amount collected enough to make minor repairs	Committee	61%	92%	0.001***
Amount collected enough to make major repairs	Committee	7%	16%	0.225
Users currently pay for water	Household avg	69.5%	83.5%	0.037**

**** difference between villages is significant at less than .01 level; ** difference is significant at less than .05 level; * difference is significant at less than .1 level.*

Although many villages charged households for water use, less than one-half collected enough to routinely operate the water system. Minor repairs posed less of a problem, yet household collections rarely covered major repairs or expansions. SANBASUR households on average were more likely to pay for service, yet paid less than FONCODES households for water.

The researchers used the same techniques as above to explain financial performance in terms of the sign of net revenues (calculated as the difference between annual household collections and operating costs) and survey responses to cost recovery questions. Regression models showed that community factors (village size and social capital), project factors (participation), and external factors (water committee training and household visits by external agencies) were positively associated with cost recovery. Women's pre-project participation and household contributions (defined in terms of labor days), by contrast, negatively affected these measures. These models explained a higher percentage of total variation across villages than the physical performance measures.

3.2.1.4. Summary of Prior Village-Level Findings – Ghana

Table 6, reprinted from the cited study, presents information concerning the physical performance of borehole systems in Ghana.

Table 6: Physical Indicators of Sustainability – Ghana

MEASURE	SOURCE	VALUE
Average hours operating per day	Women's group	21 hours
Percent villages reporting breakdowns last six months	Leaders' group	57%
Median number of breakdowns last six months	Leaders' group	1.6
Percent villages reporting fewer or equal breakdowns in the last three years, compared to initial operation	Leaders' group	63%
Average number of days to repair technical problems	Leaders' group	18 days

As in Peru, most systems were delivering water consistently throughout the day. Breakdowns occur less frequently in Ghanaian villages, but repair times are longer than in Peru.

The multivariate analysis focused on whether project boreholes were working and the length of time necessary to repair breakdowns. Boreholes were more likely to operate in communities with smaller populations, higher average household expenditures, larger shares of households paying for water service, more caretakers, and greater trust of leadership. Repair times were lower in communities with more boreholes and greater confidence in leaders and higher in places where no one was responsible for maintenance, where area mechanics were further away, and where users paid for water service.

Table 7 concerns financial performance measures in Ghana.

Table 7: Financial Indicators of Sustainability – Ghana

MEASURE	SOURCE	VALUE
Percent of villages collecting user payments	Committee	77%
Percent reporting that collections fund operations	Committee	66%
Percent reporting that collections fund minor repairs	Committee	80%
Percent reporting that collections fund major repairs	Committee	37%
Percent reporting that collections fund expansions	Committee	3%
Percent of villages that recover average operating costs	Committee	53%

Many water committees report that they collect regular tariffs or household contributions and that these often fund operations and minor repairs. However, less than half of committees covered monthly operating costs or collected enough tariff payments to handle major breakdowns.

3.2.1.5. Multi-level Sustainable Water Service Models

Village-level models are important to estimate indicators of sustainability which are measured at a village level, such as financial cost recovery and overall system operation. Multi-level models, however, are more conceptually attractive when measuring household-level variables, since they incorporate variation from data collected from both village and household-level instruments.

Understanding sustainability from the household perspective is important in evaluating the performance of these projects. These projects were built under a participatory, demand-oriented framework which involved citizen input and contributions toward the project. Measuring household-level outcomes enables researchers to recognize how well the new systems are satisfying their needs. Multi-level models suggest that their responses can vary according to characteristics of the household and of the village. Moreover, these models can detect differences in distributional impacts within a particular village.

A common, simpler alternative to a multi-level model would obtain household level data, estimate medians (for binary and categorical variables) and averages (for continuous variables), and use these values to estimate village-level models. However, this practice ignores the distribution and variance of household data. There are important drawbacks in using uni-level analysis on multilevel data. Parameter estimates are usually unbiased but inefficient, while standard errors are often negatively biased, resulting in spurious "significant" effects (Snijders and Bosker 1999, Hox 2002). In addition, village-level models typically limit the set of factors or indicators which could be increased with a multi-level model (Verbeek 2000).

Moreover, the increased sample size for household-level measurements can also improve the accuracy of the estimates. Peru and Ghana's larger household datasets allow one to estimate more precise confidence intervals for household-based estimates and maintain greater confidence in hypothesis testing once clustering impacts at the village level have been considered.

It is important to consider the degrees of variation among villages and within villages. Limited variation within a village would negate the significance of using a multi-level model. As a first step, this dissertation analyzes the variance components to partition the variance into village and household levels. Inter-cluster correlations are examined to determine which of the proposed variables make appropriate candidates for multi-level analysis.

This dissertation features three types of multi-level models. The first set of models uses a random intercepts framework. Each specification features a single indicator of sustainability and sets of village and household factors (represented also as single measurements, indices, or factor scores). The random effects estimator "assumes that the intercepts of individuals (households) are different, but that they can be treated as drawings from a distribution with mean *u* and variance σ^2 (Verbeek 2002). Thus:

$y_{ij} = B_{oj} + B_{1j}X_{ij} + e_{ij}$ where *j* represents household *j* in village *i,* and

$B_{oj} = \gamma_{oo} + \gamma_{o1}z_j + \delta_{oj}$ $\qquad$ $B_{1j} = \gamma_{1o} + \gamma_{11}z_j + \delta_{1j}$

Combining these terms yields:

$y_{ij} = \gamma_{oo} + \gamma_{o1}z_j + \gamma_{1o}x_{ij} + \gamma_{11}z_jx_{ij} + \delta_{oj} + \delta_{1j}X_{ij} + e_{ij}$

The model posits that the household's response depends on a base constant γ_{oo}, a vector of village-level covariates $\gamma_{o1}z_j$, a vector of household covariates $\gamma_{11}x_{ij}$, an interaction term $\gamma_{11}z_jx_{ij}$, and a set of three error terms which are all normally distributed with means of zero.

A key assumption is that there is no correlation between households in one village and households in another village. This allows the interaction term above to have a mean of zero. The random effects model assumes that the selection of households is independent of the characteristics of the explanatory variables in the above equation. This estimator ignores differences within individual households; focusing instead on differences among households which are important for making inferences about the population of each village in the model.

The Peru study also additionally features a random slope and intercepts framework for cases where the program (SANBASUR) is significant in the intercepts-only model. This will test whether the slope of household factors within each village is correlated with their location in a SANBASUR or FONCODES community – e.g. do SANBASUR households respond differently than FONCODES households with respect to the effects of their sets of household characteristics? This technique allows household factors to vary across villages in terms of their effect on the outcome variables.

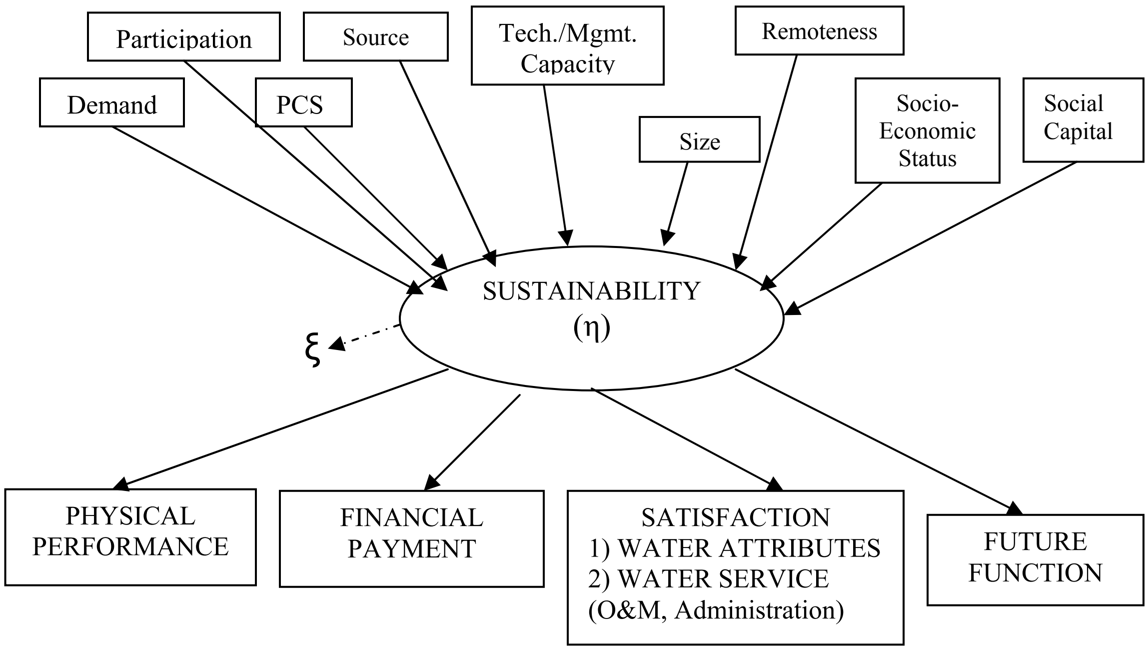
The second set of models follows the same premises as the random intercept models. Yet they divide household factors into exogenous and endogenous factors for further analysis. Prior research suggests that some of these factors are related to one another. In particular, some household factors (such as income/wealth, social capital, and other attributes) may influence other household factors (e.g. pre-project involvement, current knowledge, etc.); which in turn affect outcomes. These models estimate the direct effects of all variables on the outcome (as the previous random intercept specifications have done). In addition, the models allow for indirect effects; i.e. those impacts where an exogenous factor affects the outcome variable via an endogenous variable. For example, income may influence the level of participation in a project, and the level of project participation in turn may increase household satisfaction. Income therefore may have both a direct effect on household satisfaction and an indirect effect via household participation if both coefficients are significant. It is important to note that these effects may not necessarily occur in the same direction. The models concentrate on those with significant, endogenous effects in the initial random intercept specifications. All models are estimated simultaneously (as opposed to a staged regression approach).

The random effects model allows researchers to use household and village level data in estimating the direct and indirect effects of village and household determinants upon indicators of sustainability measured at a household level. One drawback of using this estimation procedure is that the models assume that each dependent variable represents the construct (or some portion of the construct) of "sustainability". However, sustainability is neither directly observed nor defined. One can consider sustainability as a "latent" variable –

a concept which can be indicated by the set of categories described above, but also contains a degree of measurement error. It is entirely possible that water systems may be simultaneously sustainable on one measure while less so on other accounts.

Figure 1 represents a typified model in which sustainability is considered as a latent variable, indicated by a set of observed variables and influenced by a set of factors. This model is a recursive (unidirectional) structural equation model in which estimates are calculated simultaneously using maximum likelihood. Use of multi-level structural equation models is well established. Structural equation models for multilevel data have been formulated in such fields as education, psychology, sociology, and the social sciences (see Hox and Maas 2004 for a brief review, also see Raudenbush and Bryk 2002 and Goldstein 1995 for references). Their application to the field of development and water supply evaluation is one of the novel elements of this dissertation.

Figure 1: Sustainability Model with Multiple Observed Factors & Indicators



3.2.2. Institutional Framework Comparison

The models in this dissertation will compare the effect of program characteristics of a non-governmental service provider (SANBASUR) and a social investment fund (FONCODES) on indicators of sustainable water supply in Peru. These programs operate in the same region over an equivalent time frame. Both programs are based on the community development model, which touts participation and demand-responsiveness. Agency effects are considered as dummy variables in the multi-level models, which control for other factors hypothesized to affect sustainability. The Ghana study does not permit a similar comparison. In both cases, regional and district government agencies implemented the programs, including most of the post-project support.

3.2.3. Scaling Up and Leveraging in the Rural Water Sector

"Scaling up" water service – making expansions or improvements to the new water systems – requires in practice some knowledge of both supply and demand schedules. This dissertation does not consider actual situations in which villages and/or households have attempted to scale up services. Instead, it attempts to predict whether village groups and households would be willing to support a local water committee's decision to improve services. The purpose of this question was to gauge the level of support among respondents for water system improvements and understand their perception of the ability of the water committee to handle these needs. It represents a form of demand; not in an economic framework with costs and/or prices, but nonetheless revealing some degree of preference and confidence. A hallmark of the community participation and management rural water service model in Ghana and Peru is that providers decided where to build these projects in part according to the ability of communities to voice and organize their support. Therefore, measuring household and village respondents' perceptions is an important method of learning the degree of political support for future water infrastructure improvements.

Leveraging refers to the ability to capitalize on water service improvements to garner support for other environmental health services, such as sanitation, garbage collection, and primary health clinics. The main hypothesis that this support can be explained by a set of project, community, and external factors is similar in theme to predicting water system expansion. However, there are some important differences which are considered below.

This dissertation hypothesizes that the decision among village respondents and households to support a local committees' attempt to provide other environmental services is partially determined by the performance of the water system under their leadership. Community factors, such as size, proximity to other infrastructure and larger areas, socio-economic status, and household-level social capital attitudes are hypothesized to positively influence a decision to favor other needs. However, not all project factors are believed to impact this decision. Water source characteristics should not directly influence this decision. Nor should pre-project demand for water services – it may be related, but the demand for new services can in principle differ substantially. The hypothesized effect of agency type is also unclear. The models will test the hypothesis that participation in one community-based water service can influence respondents' support for other services. The dissertation anticipates that the technical capacity of a system operator should not directly influence respondents' decisions to favor other needs, but a water committee's management capacity can impact that decision. Finally, household-level visits in the post-construction phase are hypothesized to influence the likelihood that people will support leveraging.

The dissertation uses a random intercepts framework with household and village-level covariates to predict households' decisions to support water system improvements and to favor leveraging. Readers should consider these as strictly exploratory findings. The literature has suggested that communities which have succeeded in providing community-managed water service may be capable of scaling up and leveraging into other service areas. However, the relationship between determinants and indicators of success and specific types of services marks new territory in the field.

3.3. Study Overview

3.3.1. Peru Study

Ninety-nine villages were selected for this study in the Cuzco Department of Peru. Projects were constructed in these villages from two programs – the FONCODES social investment fund and the SANBASUR non-government organization program funded by the Swiss government. These water projects began operating as early as 1991 and as late as 2001. All of the systems are gravity-fed water systems. Field teams conducted focus groups with women, leaders, and water committee members and interviewed system operators in each village. In addition, they also interviewed 25 households in each village; resulting in a total of 2450 household surveys.

3.3.2. Ghana Study

The Ghana study sampled 200 villages – 100 from the Brong Ahafo and Volta regions of the country, respectively. Projects were built under the central government's Community Water and Sanitation Agency Phase I program between 1995-2001 in partnership with local communities and regional and district governments. The projects in this study feature borehole-based systems with 1-2 handpumps constructed in each village. Unlike the Peruvian case, which features villages that received and did not receive post-construction support, all villages were eligible to receive PCS by program design. The key distinction among regions is that villages in the Volta region received quarterly post-project assistance through the MOM program, funded by the Danish government. Villages in the Brong Ahafo needed to request assistance from district governments. A total of 200 villages were included in the sample. Data were collected in each village from the following sources: 1) village women, 2) village leaders, 3) water committee officials, and 4) system operators. In addition, 5000 household surveys were completed by field teams – or 25 surveys per village.

3.4. Validity Issues

Validity issues confound most studies, and this dissertation is no exception. While there have been previous empirical attempts to estimate sustainable performance and benefits in the rural water sector, there are few theoretical sources that guide most investigations (including this one). I have noted places where theory suggests possible testable hypotheses, but also recognize the dearth of theoretical foundation in this study.

The cross-sectional nature of this study eliminates several internal validity issues, such as testing, attrition, and instrumentation effects (Shadish, Cook, and Campbell 2002). The greatest internal validity problems in the study design are the potential for selection bias and history effects. Selection bias occurs when the comparison groups are different in unobservable characteristics that may cause all or part of the treatment effect. Random assignment typically handles this problem, yet in Peru and Ghana the villages were not randomly assigned to receive water projects. The issue of the self-selected sample under the auspices of community development has already been discussed. Another concern is that villages in the FONCODES and SANBASUR frames in Peru and the Volta and Brong Ahafo regions of Ghana differ systematically from one another in dimensions unaccounted for in this study. This is particularly relevant in evaluating post-construction assistance, since villages were selected by program (Peru) and by region (Ghana) based on these differences. The issue seems to have greater importance in the Ghana study, where sampling occurred in two separate regions of the country. Peru likely poses less of a problem, since FONCODES and SANBASUR villages were sampled in several of the same districts. History (in the form of other conditions and activities occurring during the period of study) also represents a related threat – again particularly in the Ghana sample.

The use of cross-sectional survey data and multiple constructs, methods, and techniques should limit the extent of construct invalidity. Field studies that involve surveys always create the possibility for some degree of biased responses, although the training and preparation of field teams emphasized the importance of objectivity for enumerators. Satisfaction is considered a construct that represents project success in this dissertation. While it does represent an important component in measuring participatory rural water projects, others have found that satisfaction may be considered a function of pre-conceived expectations (Van Ryzin 2004). Diffuse treatments among villages are likely; yet estimating the diffuse effects is one of the objectives of the analysis. Construct validity does arise as an issue when using indicators to identify latent variables in the analysis.

Earlier sections in the chapter discussed how this study would improve statistical validity over previous work via the use of larger samples, multi-level modeling, and estimation techniques that would introduce measurement error. Other sources often depend on the individual variables. One particular source of concern with this study is the range of values available among some of the variables. Limited variation on independent variables limits the likelihood that they will influence values of the dependent variable due to increased standard errors. Conversely, a low variance on the dependent variables runs the risk of making inappropriate inferences of the factors' causal impacts.

The comparison of relative impacts in two country settings with two different technology types improves the external validity of the study. The use of multiple units and outcomes also enhances more generalized causal inference. A possible shortcoming is that failures or successes within one of the two study areas may depend on aspects of the cultural settings which were not considered in the analysis. These issues create challenges for interpreting the results. Overall, however, the study design has identified and addressed many potential pitfalls of quasi-experimental research design.

IV. Rural Water and Sanitation Service Provision in Study Areas

4.1. Peru

4.1.1. Overview of Service Provision in Peru

The Peruvian water sector has undergone some degree of structural reorganization in every decade since the 1980s. Before 1980, the central government administered water services through the Ministry of Vivienda (for urban areas) and the Ministry of Health (MINSA) for rural areas. Rural potable water coverage through the 1970s was below 20% according to official statistics. In the 1980s, the central government reorganized the urban water sector by creating a new agency (SENAPA) to promote a more economic treatment of water services (via pricing) and facilitate more investment in the sector. Rural areas, however, remained under the management of MINSA. Urban coverage rose during the 1980s, yet official rural coverage remained low at 22%.

The central government again reorganized the water sector during the 1990s. On the urban side, SENAPA was deactivated and replaced by two agencies: PRES (which handled policy decisions) and SUNASS (which functioned as a national regulator). MINSA remained the de facto manager of rural water services in areas where they had constructed projects. However, the government began to funnel much of its investment in social and small-scale economic sectors (including potable water) through two new institutions – FONAVI in urban areas and FONCODES in rural areas. FONCODES was one of the first social investment funds in Latin America, following on the heels of the Bolivian Social Investment Fund in 1989 (Rawlings et. al 2003). The program soon became the largest source of investment in Peruvian rural water projects during the 1990s, and it continues as the major source today. The fund significantly enhanced access to potable water service in rural villages. By 1998, official reports estimated that the percentage of communities with improved water service had more than doubled, rising to 50.6%.

In 2002, the government under President Toledo again reoriented the water sector. The government vested authority over rural water planning and investment into a reorganized Ministry of Vivienda, Construccion, and Saneamiento (VCS). The Ministry of VCS is now solely responsible for policymaking for the water sector. They work with the Ministry of Economics and Finance to set investment priorities and assign resources, with MINSA to establish health standards and norms (though MINSA alone is responsible for implementation and monitoring), and with several other governmental and non-governmental agencies to execute and evaluate policies and programs. In consultation with the World Bank, the VCS administers the PRONASAR (the National Program for Water and Sanitation). PRONASAR includes funding for policymaking and sector reinforcement at the national level as well as a new decentralization program for local governments. The decentralization process began in 2003 via the Organic Law of Municipalities, which created regional governments.

During the first three years of its existence, PRONASAR made investment decisions for communities based on indicators such as disease incidence, poverty, and availability of current water and sanitation services. PRONASAR is now responsible for funding the FONCODES program in water and sanitation. However, FONCODES remains solely responsible for implementing its own water and sanitation projects.

MINSA constructed approximately 12,000 systems during its tenure as manager of the rural water sector. FONCODES has constructed about 15,000 systems since 1991 (FONCODES interview 2004). According to 2002 government statistics, 62% of rural communities contained improved water systems. However, evaluations have acknowledged that these statistics do not consider the number of seriously deficient or collapsed systems in rural areas. A May 2003 study of 104 rural communities across Peru, funded by the World Bank Water and Sanitation Program, found that 31.7% of the communities' systems were "sustainable", 44.3% functioned at deteriorating levels of efficiency and quality, and 24.1% of the systems had either collapsed or were on the brink of doing so (WSP 2003).

Studies of the Peruvian water sector funded by WSP and other organizations found several deficiencies (WSP 2003). Some of the major criticisms included:

1) Lack of a sector-wide strategy for investment, coordination, and operation, leading to duplication of efforts and institutional disorder.

2) Lack of a formal legal structure with defined ownership roles and responsibilities.

3) Lack of focus on social factors (organization and demand of community, and health and hygiene) in development of systems.

4) Lack of local government involvement in decisions affecting their district.

5) Lack of capacity among district governments to support water service provision decisions.

6) Poor service quality and low coverage rates among the poorest communities.

7) Lack of organized participation from community members concerning planning and construction decisions.

8) Lack of a culture of payment among users and management entities.

9) Limited support for training for administration, operation, and maintenance during and after construction is complete.

10) Overall, a lack of funding to meet all the needs of the rural water sector.

In short, the Peruvian water sector has expanded coverage and improved services in rural communities over the last fifteen years, thanks to enhanced external funding and a greater commitment to serve these areas. However, many financial, technical, structural, and social problems have limited further expansion and threatened the sustainability of many rural systems. In personal interviews with WSP, PRONASAR, and COSUDE officials in May 2004, I found that government and external donor organizations seemed aware of these issues and were working to overcome some of these problems, particularly the need for decentralization and enhanced local community participation and organization.

4.1.2. Selection and Description of Programs of Inquiry

4.1.2.1. FONCODES

FONCODES is a social investment fund that currently receives the majority of its funds from the national PRONASAR (66%) and the World Bank and other donors (30%) (PRONASAR interview 2004). The overall objective is to improve the quality of life for rural people in the country, particularly those in rural communities (under 2000 people) that fall under the official poverty line. FONCODES funds projects in each of the 24 departments of Peru. It is a multi-sector fund, promoting work in the following areas:

1) Social Infrastructure: Nutrition, health, hygiene, education, and water and sanitation.

2) Economic Infrastructure: Agriculture, transportation, energy, and multi-sector strategies and coordination.

3) Projects that improve production among smaller-scale businesses.

4) Other special projects.

From 1991-99, FONCODES invested a total of $1,453 million. $361 million, or approximately 25%, of these investments went to water and sanitation projects (primarily the development of potable water systems). This investment comprised 85% of the central government's total spending on water and sanitation projects in rural areas during the decade (FONCODES interview 2004).

FONCODES water projects operate under a kind of contracted design-build-transfer model with communities. FONCODES staff decides what areas to begin work in each region. In theory, this is supposed to be a demand-driven process, but outside interviews and reports suggest that poverty indicators play a more important role. Their staff contacts village leaders about the possibility of working in their respective communities. FONCODES engineers survey the water resource situation and design the basic project schemes.

Communities receive certification from the Ministry of Agriculture to guarantee the availability and quality of water and land resources for a project. The community is responsible for organizing a "nucleo ejectcutor" (N.E.) – a committee that participates in the planning process, presents a project for FONCODES approval, and subsequently enters into a contract with a private contractor to orchestrate the construction of the project. The N.E. assumes financial responsibility for administering FONCODES funds and community contributions. It selects Inspector-Residents to work in the village, help execute the project, provide technical assistance, and assist the N.E. in administration and financial accountability. FONCODES is supposed to provide training through these inspectors on system functions, repairs, maintenance, and administration of the new project. This includes manuals, a few local workshops, sets of operational and administrative rules and regulations, and sometimes user education.

Once the project is complete, the N.E. operates the project for a six-month period. During this time, the Inspector-Resident ensures that the population has received prior sufficient training and that a new organization elected by the community is prepared to assume full responsibility for the project. FONCODES then transfers legal responsibility for the project into the hands of a “JASS” – an administrative authority created by the village that replaces the N.E. FONCODES’ official role in the project ends with the transfer.

The scope of FONCODES water projects include building main lines from the water source, filtrating and chlorinating the water, and transmitting the water into a village distribution network. FONCODES traditionally has built the transmission system and public distribution taps; it does not install private connections. However, a 2000 evaluation of FONCODES water projects noted that 52% of households surveyed did have private connections. These connections were likely financed and built by households or communities after the transfer of the project. Another report indicates that many people were dissatisfied with public taps because no one in the communities handled maintenance and care of the taps.

According to FONCODES officials, the program significantly increased its training program before and during construction in 1997. They funded social capacitors to make three or four visits to each community to assist with training. Once the transfer was complete, the JASS groups and/or the local municipality were responsible for additional training. FONCODES has subsequently developed a pilot ex-post construction assistance program. However, at the time of the study, FONCODES had not put this program into operation.

In 2000, the Apoyo Institute was paid by FONCODES to evaluate water and sanitation projects constructed between 1997 and 1999 (Apoyo 2000). They evaluated 382 projects, of which 70 were in the Sierra Sur region (comprising the Departments of Cuzco, Arequipa, and Puno). Apoyo found that FONCODES projects had improved household connection rates (from 50% to 58%, though not by design), improved water quality perceptions, and reduced both the number of average system failures (from 3.58 to 1.86 over the system lifetime) and collection times. They found that households with private connections had experienced reductions in rates of infant diarrhea (3.3%) and infant mortality (2.9%). It should be noted that the authors did not control for a variety of other potentially explanatory health care factors.

According to the Apoyo report, most systems failed once, and there was an even split among those that had never failed and those failing twice. Another 13% failed more than three times. Over 60% of households and operators reported that they did not have any problems with major interrupted service.

With respect to training, 23% of communities featured no training for households, 40% featured trainings for up to 30% of households, 24% reported trainings for up to 50% of households, and 13% reported trainings for 50-70% of households. 78% of households interviewed reported that they had attended at least one assembly meeting for the project. A smaller percentage of women reported that they were involved in the project. Apoyo encouraged FONCODES to develop better programs to promote women's participation.

Apoyo and others, including the World Bank's Water and Sanitation Program (WSP), have been critical of other aspects of the FONCODES model. Apoyo found that many systems were weakly sustainable, due to the temporal nature of the NE's and the lack of post-construction support. In a 2001 report, WSP also criticized the NE system for not representing the needs of the majority in a democratic process. The WSP also critiqued FONCODES projects on several other accounts, including: 1) lack of promotion; 2) limited demand elicitation and limited service options; 3) an uncoordinated O&M training strategy, which constituted only 2% of investment funds; 4) no training geared toward health and hygiene promotion; 5) no local synergies or inter-institutional coordination with local district governments; and 6) a lack of post-project support (WSP 2001). NGO interlocutors who had worked on SANBASUR and FONCODES projects that were interviewed in Cuzco evoked similar comments about FONCODES projects. They criticized FONCODES for its weak demand responsiveness, lack of participation, and post-project training and support. In an interview with FONCODES officials, they acknowledged the lack of participation in some projects and post-project intervention. However, they stressed the lack of funding and poverty in communities as main reasons why more projects were not sustainable.

FONCODES projects are an important set of projects to evaluate for this study. FONCODES is the principal investment arm of the Peruvian rural water supply sector. One can attribute much of the growth in official coverage to FONCODES. Moreover, FONCODES is the first major government-sponsored program in Peru to adopt a partnership approach with local communities. In theory, their projects are supposed to be more demand-responsive and participatory. FONCODES adopted a deliberate training strategy during the construction phase of development. Finally, their model requires a strict transfer of responsibilities, without defined post-project support (during the period on which villages were selected).

4.1.2.2. SANBASUR

SANBASUR stands for Saneamiento Basico en El Sierra Sur. Currently the project only works in the Cuzco Department. The project is funded by COSUDE, the development agency of the Swiss government. It works in concert with MINSA, CTAR (the transitional regional government of Cuzco), local district governments, NGOs (which serve as executing interlocutors for projects), and local communities. SANBASUR seeks to improve water and sanitation services for impoverished rural people in order to improve health outcomes among these people. Specifically, SANBASUR works to:

1) Provide basic water and sanitation services using a strategy that stresses promotion, training for organizations, hygiene education, and system construction.

2) Strengthen the institutional capacity of municipal districts, organizations, and their counterparts.

3) Disseminate positive experiences and models to other communities.

SANBASUR constructed 141 projects over the period 1996-2000 in four provinces in the Cuzco Department. Approximately 50,000 people have benefited from those projects. The agency has since expanded to three other provinces and completed a total of 238 projects by 2004 (SANBASUR interview 2004).

The SANBASUR model works with interlocutor agencies. SANBASUR originally selected provinces with high rates of extreme poverty, then developed partnerships with development agencies that had previous experience working in rural communities in these areas. Interlocutors contacted communities, which had expressed initial interest in improved water supply and were willing to participate in the SANBASUR process. They scheduled visits to profile these communities and the state of their water resources and supplies. The interlocutors worked with the communities to prepare project proposals and budgets, and then they both submitted these documents to SANBASUR for their approval. Upon approval, SANBASUR transferred cash funds to the interlocutor for construction. Communities were required to form administrative organizations and contribute labor, materials, and/or cash for the projects (on average, approximately 30% of direct costs and 1/6 of all costs). Once the projects were completed, the committee became responsible for all aspects of system operation, maintenance, and administration. The entire process usually lasted approximately one year.

SANBASUR's work has evolved in different phases of time:

- Phase I *(March 1996 – October 1997)* objectives focused on providing basic water services in priority communities and involving people, particularly women, in decision-making. Actions also focused on improving health behaviors and hygiene education, and increasing exchanges among interlocutor organizations.

- Phase II *(November 1997 – October 2000)* included Phase I objectives and added the following: 1) strengthen local health and educational institutions in line with SANBASUR goals, 2) consolidate and foment self-management among the committees, and 3) unify water and sanitation proposals and formulate models of success.

- Phase III *(November 2000 – October 2002)* objectives were similar to those in Phases I and II. SANBASUR sought to perfect their model and expand its program to other provinces during this period.

- Phase IV *(November 2002 – Present)* objectives include those in other phases. However, the priority in Phase IV has shifted from the micro to the meso-level, as SANBASUR attempts to strengthen the capacities of local district governments to support communities. Phase IV projects were not considered in our study.

Similarly, SANBASUR's training and capacity-building programs have also evolved. Early projects in 1996 only trained interlocutors. In 1997, SANBASUR and local interlocutors planned trainings in communities with local health and technical personnel and representatives from municipal districts. They held 2-3 day workshops in communities, trained technicians and facilitators, and showed others how to teach people about their new systems. They also trained committees in legal and administrative matters, system operations and maintenance, care of water resources, and repair of distribution lines and household connections. At the end of Phase II, SANBASUR found they had better results when they entrusted trainings to local third parties. SANBASUR also produces O&M and educational manuals for every village.

Water committees are monitored for a period of six months after completion of projects to determine if they are capable of taking on full management responsibilities. Evaluations are based on eighteen indicators. After the final transfer takes place, MINSA employees are responsible for monitoring water quality, while local governments are responsible through their contracts with SANBASUR to work with the committees on ongoing system needs. SANBASUR is also available upon written request to provide additional technical support and training for the committees. However, SANBASUR encourages communities to solve their problems independently or with local government assistance before contacting them. After the first six months of standard support, only seven communities to date have ever requested this follow up assistance directly from SANBASUR.

Three known evaluations have been published on the SANBASUR program. The first two evaluations focused on Phase I and II results. One evaluation, published in 2000, praised SANBASUR's coverage accomplishments and ongoing system operations. The authors criticized SANBASUR for focusing too much on poverty and less on demand elicitation. The report called for more cooperation among government sectors and suggested that more work was necessary at the national level in terms of defining legal responsibilities and seeking more complementary arrangements with FONCODES (which sometimes had previously worked in the same village). In addition, committees and local government organizations required capacity-building. Systems were more sustainable in places with stronger groups, particularly where new leaders received training from original members. Solid training also played an important role in sustainability, according to the report.

A 2002 evaluation of SANBASUR's first two phases recognized the important role of community participation and pre-project promotion. Promoters who had been more active in assigning roles helped to reinforce responsibilities among committee members. The report lamented that women's participation in groups was limited and that hygiene practices had not improved during the first two project phases. Authors praised the role of post-project intervention in achieving better hygiene practices and in promoting more effective organizations.

COSUDE and the World Bank financed a study that examined SANBASUR projects in four districts. In two districts, SANBASUR installed water connections in the district capitals and in nearby villages. In the other two districts, SANBASUR only worked in rural areas. They found that more than 90% of households retained in-house connections and about 50% had service more than 16 hours each day. Satisfaction among households was recorded at 90% in areas where local committees worked. However, discontent among the remote provinces where local governments administered the services was higher.

The authors reported that these areas exhibited a culture of paternalism where very few people paid their water bill regularly.

The three NGO interlocutors interviewed before fieldwork commenced all reported that they had achieved positive community results in the SANBASUR model. All suggested they would be willing to continue working with SANBASUR on future projects if additional resources were available. Two projects that received the greatest interest were latrine construction (which SANBASUR begun in 2000) and a system of drainage (a problem which has likely grown with the increase in piped water).

SANBASUR villages provide an interesting counterpart to FONCODES villages for our study. Both programs strive to reduce poverty, respond to local demand, encourage community participation, and encourage self-sufficiency through active training programs for new village leaders and household members alike. Based on published evaluations, neither program has achieved complete success in these objectives. Both programs have used intermediaries to fund their projects, albeit through different mechanisms. Whereas FONCODES has distanced itself from projects after completion, SANBASUR has provided short-term post-project support in conjunction with local governments. However, SANBASUR (like FONCODES) has also encouraged self-reliance among its client communities, urging them to collaborate with local Ministries of Health and Education officials and local governments.

4.1.3. Selection and Description of Study Area

Approximately 25.7 million people live in the Republic of Peru. Peru ranks 82nd among the 175 countries listed in the 2002 Human Development Index. It is considered a lower-middle income country according to the World Bank classification scheme, with a 2004 per capita gross national product of U.S. $2130. The average life expectancy of a Peruvian is sixty-nine years, and there are a recorded 39 deaths per 1,000 births. The overall literacy rate of the population is 96%. All of these indicators fall in the middle one-third of countries worldwide. Among Latin American and Caribbean (LAC) nations, Peru ranks tenth on the Human Development Index among the twenty-three nations in the region.

Peru is divided into twenty-four political departments. The Department of Cuzco was selected as the target area for the study because SANBASUR and FONCODES both have worked extensively in this department since 1993. The department is further sub-divided into thirteen provinces, which together hold 108 districts. Most of these provinces lie in the Sierra Sur region, characterized by high mountains and river valleys that range from 2500 – 5000 meters in height. Due to the mountainous terrain, most villages obtain their water from rivers, lakes, and springs set near the mountain peaks. The major exception in the region is the La Convencion province, which slopes northwest into the Peruvian rain forest basin of the Amazon River.

Information from the last national census was only available from 1993. Table 8 summarizes some basic information about the rural population in Cuzco during this period. Additionally, the INEI (the National Statistical Office) periodically conducts a National Survey of Households. Table 9 summarizes other useful information from this survey about the entire population of the Cuzco Department.

Table 8: Socio-Economic Information from Peru's National Census (1993)

CATEGORY	VALUES
Population (Total)	1,066,495
Population (Rural)	557,038
Population (Rural Males)	283,991
Population (Rural Females)	273,047
Rural Population, % Quechua-speaking (>4 years old)	71.5%
Rural Population, Literacy Rate (> 4 years old)	53.8%
Rural Population, % households with any unmet basic needs	95.2%

Table 9: Socio-economic Data from National Survey of Households (2002)

CATEGORY	VALUES
Total Number of Households (urban and rural)	289,091
% Female Population	53.2%
% Population in Extreme poverty	34%
% Population in Less-Extreme poverty	26%
Percentage of Total Population with Household water taps	51.6%
Percentage of Total Population with Electricity	62.4%
Percentage of Population with in-house toilets	25.2%
Estimated Total Population (2005)	1,252,201

4.2. Ghana

4.2.1. Overview of Service Provision in Ghana

The Ghana Water and Sewage Cooperation (GWSC), an agency of the central government, was originally charged with the task of providing an adequate supply of domestic water to the country's rural and urban population. Census data from 1990 indicated that only 28% of rural communities had access to an improved water source vs. 76% in urban areas. The central government alone was not capable of significantly increasing access to improved water sources given the size of the problem, other competing needs, periodic political instability since independence, and the economy's wide revenue fluctuations due to its dependence on gold and cash crops such as coffee and cocoa.

In the early 1990s, Ghana was one of the first countries in Africa to introduce community water management as a new strategy for improving water supply in rural areas. As part of a general policy of decentralizing the public sector, the Ghanaian government began a set of institutional reforms of the domestic water sector that continues today. The government separated the urban and rural domestic water sector. In 1994, the government established the Community Water and Sanitation Division to oversee rural and small-town water and sanitation services. Initially, this division was under the auspices of the GWSC. In 1995, this division became an autonomous institution, the Community Water and Sanitation Agency (CWSA); which is now responsible for implementing the rural portion of the national community water and sanitation strategy (Act 564, 1998). The GWSC retained responsibility for urban service provision, and was later converted into the Ghana Water Limited Company in 1999.

The CWSA has been the main coordinating and facilitating body for rural water system planning and strategy. They have set goals for the program. Two basic program goals are 1) to ensure that there is a minimum basic service of water – 20 liters per capita per day - which is protected all year, within 500 meters from the consumers and serving not more than 300 persons per water service point and 2) to reach 85% of the rural population with these services by 2009.

Actual implementation, ownership and management of water facilities rest with district assemblies and communities (which are represented by district representatives at assemblies). District assemblies hold the systems in trust for the communities. Each district maintains a District Water and Sanitation Team (DWST) that coordinates planning efforts, supervises construction, and assists communities with technical, managerial, and financial duties after projects are completed. The CWSA has Regional Offices (RWSTs) that provide technical assistance to the district assemblies for some of this work.

CWSA invests in and ultimately transfers ownership and management of water and sanitation systems to rural communities and small towns (the latter generally are areas with a population of at least 5,000 persons). Villages are responsible for organizing water and sanitation (watsan) committees, which initially raise the community contribution to construction costs and prepare to take over system operation when the project is complete. Under CWSP I (and later CWSP II) communities are involved in designing, planning, and operating the new systems. These systems are usually point-source systems, featuring drilled boreholes with hand pumps attached at the top of the mechanism. This is a more demand-driven approach than the traditional central service provision approach favored by the government through the mid 1990s. Women, who are usually responsible for determining water needs and securing water for the household, have been given a more primary role in designing and managing these systems. Villages are responsible for generating 5% of the initial capital cost. They are also expected to fully cover operation and maintenance costs, although they often depend on district assemblies for some support. As a result, the communities must decide how to raise money to cover these costs via per-container fees, monthly bills, periodic collections, etc. Finally, private firms and non-governmental organizations are encouraged to work with communities during the implementation and ownership phases of the projects.

4.2.2. Overview of Regional Water Projects

4.2.2.1. Volta Region

CWSA receives support from international donor agencies, including the World Bank and national development agencies such as the Danish agency DANIDA. DANIDA has focused much of its attention on improving water access in the Volta region. The Volta Region Rural Water and Sanitation Project started in 1993 with sponsorship from DANIDA. The project is in two phases. Phase I covered the period 1993-2003. In Phase I of the project, both point sources and pipes systems were constructed.

DANIDA has worked through the CWSA to expand water services to rural communities under the same guidelines mentioned above. Project rules for the programs are essentially the same. The major differences are that DANIDA focuses on the Volta region and the nature of post-construction assistance and support offered in Volta is more systematic than in other regions.

CWSA began providing decentralized technical and managerial assistance to communities after CWSP I to assist them with maintaining their new facilities. They invested in spare parts outlets in each region, as well as three spare parts depots in Accra, Kumasi, and Tamale. They also worked with regional bodies to train watsan committees in each of the villages to take over responsibility. District Water and Sanitation Teams monitor progress, refer mechanics on demand, educate and train watsan committees, and respond to other issues communities face. These post-construction programs operate at different levels around the country. Essentially, however, these are demand-driven forms of assistance. In the Brong Ahafo and Ashanti regions of central Ghana, for example, communities normally must request assistance before DWSTs will send representatives to examine the problem.

In the Volta region, however, DANIDA has instituted a more formal monitoring program (MOM). Here, DWSTs work with Environmental Health Assistants (EHAs) who visit communities at least four times per year to educate villagers on water, sanitation, and health issues and learn about what problems have arisen in communities with respect to the new water systems. DWSTs, in turn, respond to challenges in different ways. For example, if a community needs a spare part, the DWST will work with the area mechanic to locate the nearest parts depot. They will ask other mechanics in a district to travel to villages outside their community to consult on technical problems. DWST agents will visit communities to examine financial records and help resolve conflicts within the watsan committees or within the broader village. This is a more supply-driven approach, intended to proactively provide post construction support to communities.

4.2.2.2. Brong Ahafo Region

The office of the regional CWSA was established in 1994 but became active in 1995-96. The region has benefited mainly from two project interventions. These are the CWSP 1 and the European Union Small Towns Water Scheme. CWSP 1 focused on point sources while the EU project supported construction in five small towns in the region. The regional program operates in much the same way as the Volta program, although without the external support from DANIDA.

4.2.3. Description of Study Area

There are 20.2 million people who live in the Republic of Ghana. Ghana ranks in the bottom one-third of all countries in each of the categories of the 2002 Human Development Index. These include low GNP per capita (US $400 per year), average life expectancy (57 years), and literacy rates (72% of the population). Infant mortality rates, at 57 deaths per 1,000 births, also rank in the bottom one-third of all countries. On the whole, Ghana features lower indicators of human development than Peru. However, its composite HDI rank (129) is the highest among all West African nations and fourth among all sub-Saharan African countries.

Table 10 contains population information and Table 11 contains primary sources of drinking water used by households in the Brong Ahafo and Volta districts according to the latest 2000 national census.

Table 10: Population by Region and District – Brong Ahafo and Volta Regions (2000 Census)

REGION	DISTRICT	POPULATION	URBAN	RURAL	% RURAL	% REGION
Brong Ahafo	Asunafo	174,026	49,381	124,645	72%	9.6%
	Dormaa	150,299	103,304	46,995	31%	8.3%
	Kintampo	146,770	39,545	107,225	73%	8.1%
	Tano	123,404	53,321	70,083	57%	6.8%
	Wenchi	166,641	50,152	116,489	70%	9.2%
Volta	Ho	235,331	80,489	154,842	66%	14.4%
	Jasikan	111,285	22,241	89,044	80%	6.8%
	Kadjebi	51,998	8,249	43,749	84%	3.2%
	Nkwanta	151,276	35,916	115,360	76%	9.2%

Table 11: Primary Sources of Household Drinking Water in Brong Ahafo and Volta Regions (2000 Census)

SOURCE	VOLTA	BRONG AHAFO
Piped Inside	5%	5%
Piped Outside	20%	18%
Tanker	1%	1%
Well	23%	16%
Borehole	9%	25%
Spring/Rain	6%	6%
River/Lake	26%	26%
Dugout	10%	3%
Other	1%	0%

V. Description of Field Activities

5.1. Peru

5.1.1. Questionnaire Development

From April until July 2004, team members developed a set of survey instruments for the project. There were five instruments in this study: 1) a household questionnaire, 2) a water system operator questionnaire, 3) a focus group questionnaire for the village water committee charged with managing the boreholes in the community, 4) a focus group questionnaire with informal and formal village leaders, and 5) a focus group questionnaire with women from a diverse set of backgrounds, ages, ethnic, and income groups.

The household survey contained seven sections. Section 1 was developed for enumerators to screen prospective interviewees. The target respondents were household heads and/or spouses who had lived in the village and were aware of the project when the new system was built. Enumerators also selected only those interviewees who were not current members of the village water committee to avoid introducing biased results from the households. The second section consisted of a water use table and a set of questions concerning the use, operation, and attitudes concerning the reliability of the current system. From the water table, enumerators asked what water sources households used during the rainy and dry seasons, how these various sources were used, how respondents felt about the quantity, reliability, and quality of the water obtained at these different sites, how much time and money households spent in collecting water from these sources, and the payment system. Enumerators also learned about what changes had taken place in the operation of the piped system, the frequency and duration of breakdowns, and attitudes concerning the operation, maintenance, and future operation of the system in the village. Section 3 revisited the water use table; but the focus of this section was on the previous water sources used before the piped system was put into operation.

The fourth section focused on the planning, construction, and current management of the water system. Enumerators queried respondents about the degree of household awareness of and participation in the planning decisions for the project. Respondents revealed their contributions toward the project during the construction phase and gave their opinions concerning the planning process and construction quality of the system. Enumerators also probed into the degree of household satisfaction with system management and respondents' perceptions on the abilities of the committee to expand and/or improve the new system and take on other village infrastructure challenges. The research team also learned about the extent and quality of trainings offered and accepted by households during all phases of the project.

In Section 5, enumerators learned what other types of infrastructure households were using. These questions focused on sanitation, telephone, and electricity services and the bills household paid (if any) for these services. Section 6 featured questions concerning the extent of social capital found in the community. Section 7 covered the socio-economic status of the household, including the respondent's age, ethnic origin, and religious affiliation and household measures of income and wealth, education, occupational status, and availability of infrastructure. A final section allowed enumerators to assess the quality and veracity of the responses they received from household interviewees.

The system operator survey consisted of an interview with the caretaker, who was responsible for operation, maintenance, and basic repairs of the water system and a brief technical assessment of the major parts of the system (i.e. source, storage tanks, break-line tanks, and distribution lines where possible). The first section covered the basics of the system; e.g. the number of private and public taps, latrines, etc. in the village, changes made to the new system since construction was completed, and the days and hours of normal operation during the rainy and dry seasons. Section 2 queried caretakers concerning their experience, skills, training and payment received for their work, their access to spare parts and technical assistance, and the frequency and extent of ongoing maintenance and repairs at the sites. In the third section, enumerators asked the caretakers about the use, quantity, quality, and sufficiency of the water source. This section also gave caretakers an opportunity to express their opinions concerning system improvements and the capacity of the committee to meet other village needs.

Section 4 focused on the efficacy of the functional aspects of the water system. Enumerators learned how often caretakers would check the parts, perform maintenance, and respond to breakdowns. Section 5 centered on the types of support (technical, managerial, financial, access to spare parts, etc.) available to caretakers and how villages responded to major breakdowns and malfunctions. The last part of the survey was conducted separately by the team engineer. This person visited the storage tanks and break-pressure tanks to examine their quality. They also checked distribution lines to see where if they were located away from rivers and latrines and whether they were fissured. Finally, we asked engineers to speculate whether the system would remain in operation for the next three years, based on their findings.

Field coordinators conducted the village water committee survey with current members and a few persons who served on the committee during project planning and construction. Field team leaders obtained information on the scope, function, and responsibilities of the current committee and changes in these categories which may have taken place before and after operation of the new water system. The survey elicited information on relations with the community at large since operation and training which previous, current, and new members of the committee may have received to handle their ongoing duties. Field coordinators also learned about what external sources of technical, administrative, and financial assistance the community receives (and would like to receive) to keep the system running, the activities and quality of area mechanics, and access to spare parts. Committee members described the tariff structure and the extent to which these and other revenues cover operational costs, repairs, and expansions. They also discussed ownership and future plans for the committee's work. A final section with previous committee members covered the history of the planning and construction of the project.

The final two focus group surveys – the village leaders and village women's surveys – gained perspective from these different groups along several different topic areas, including participation during project planning, the frequency and duration of breakdowns, and attitudes concerning tariff structures, cost recovery, and operation and management. The village leaders' survey also elicited demographic and location information about the village, attitudes concerning the degree of social capital in the village, and relations with their district assemblies. Conversely, the women's focus group provided additional information on water use and satisfaction with the water obtained from the new system and the water resource situation in the village, such as the effects of seasonal variation and drought and flooding conditions on supply.

5.1.2. Sampling Frame

The sampling frame in Peru was developed over two stages of the project. In June 2004, researchers obtained lists of FONCODES and SANBASUR communities in the Cuzco Department that had maintained completed water projects for a minimum of three years and contained a population of 400-2000 people at the time of project implementation. The following provides an overview of these villages.

Table 12: Sampling Overview in Cuzco Region

PROJECT	PROVINCES	VILLAGES	VILLAGES NOT IN SANBASUR	TOTAL
FONCODES	13	67	60	60
SANBASUR	4	46	0	46

Villages which received assistance from both projects are counted as SANBASUR villages in total.

All seven FONCODES villages that fell in the La Convencion province of Cuzco were excluded. As mentioned earlier, most of the La Convencion province is located in the low altitude Amazon basin of Peru. This area exhibits vastly different geographical and hydrological features than the projects in the other provinces of Cuzco – features that pose different technical challenges for communities in comparison to other communities that have received program assistance. Thus, the initial sample contained 99 villages – 53 villages with FONCODES projects only and

46 villages with SANBASUR projects. There were a total of eight projects which had first received FONCODES assistance and later SANBASUR intervention. In these cases, SANBASUR extended services to include private household connections.

During the fieldwork, researchers learned that some designated FONCODES villages did not actually receive water projects, but had received other forms of assistance from the investment fund. The research team and consultants were able to obtain the correct information from the agency and remove some of the deleterious villages from the sample. At the end of the fieldwork, however, there were twenty-one villages that did not belong in the sample frame. An inspection of the field notes suggested that there were three other communities where field teams could not gather data from all of the surveys and where the teams encountered problems locating enough credible people to interview. Thus, the research team decided to remove a total of 24 villages from the sample.

Researchers obtained permission to conduct a second phase of fieldwork with the consultant. The final sample contains 53 FONCODES villages and 46 SANBASUR villages for a total of 99 villages in the study.

Another level of selection occurred at the household level. Field teams selected twenty-five households for interviews in every community, regardless of size. The protocol encouraged the use of random list sampling, but in practice such lists were not available. Field teams employed geographic sampling in proportion to community size, dividing each village into geographic areas and sampling households based on population estimates. A copy of the household sampling protocol appears as Appendix I.

5.1.3. Fieldwork Procedures

Initially, the research team gathered information about the FONCODES and SANBASUR programs through the agencies, and read previous evaluations at the World Bank offices in Lima. The research team interviewed FONCODES and SANBASUR staff members in June 2004 to learn about project rules, the communities they worked in, and their opinions on the success and challenges of their respective water service provision programs. The research team also visited interlocutor NGOs in Cuzco that had previously worked with SANBASUR to understand their role in the process.

The research team hired the consultant in July 2004. The consultant was responsible for hiring field coordinators, enumerators, and engineers for the teams. Training and pre-testing of all survey instruments occurred during two weeks in August 2004. In total, there were four field teams – each containing a field coordinator who supervised the team and facilitated most of the focus group interviews and four enumerators who conducted the household surveys. There were also four engineers hired to implement the System Operator Survey and conduct the technical assessment described above.

During the first phase of the fieldwork (August – September 2004), the field teams visited a total of 99 villages in the region. Phase I data were available and assessed in December 2004 and January 2005. In the second phase of the fieldwork (May – June 2005), a member of the research team and the consultant retrained two field teams. The two teams spent one month visiting the additional villages which comprised the second sample. The consultant finalized the new datasets in August 2005, and in September 2005 the research team verified the quality of the data.

5.2. Ghana

5.2.1. Questionnaire Development

In January and February 2005, a different research team worked collaboratively to develop a set of survey instruments for use in Ghana. The Ghana team used the same five types of survey instruments that the Peru team had implemented. However, given differences in technology, payment structure, culture, and research interests, the Ghana team tailored the instruments to elicit their own set of data.

The household survey contained six sections. The first section was identical to the Peru survey. The second section also consisted of a current water use table featuring a similar set of questions as in Peru. In Peru, researchers focused on asking the utilization, quantity, quality, and payment questions for those sources which were used at least ½ of the time during the rainy season or the dry season. The research team in Ghana chose to extend this set of questions for all of the sources that existed in the village. Another difference was that the Ghana team chose not to readminister the water use table for previous uses (Section 3 of the survey). As in Peru, enumerators learned about what changes had taken place in the operation of the handpumps, the frequency and duration of breakdowns, and attitudes concerning the operation and maintenance of the handpumps and their future operation in the village. The third section of the Ghana survey resembled Section 4 of the Peru survey; it focused on the planning, construction, and current management of the water system.

Section 4, which featured questions concerning household attitudes toward social capital, and Section 6 (the enumerators' assessment of the interview) mimic the Peru survey. Section 5 (like Section 7 of the Peru survey) covered socio-demographic and socio-economic status of the household. This section also folded in questions concerning other household infrastructure.

There were two departures of this survey with respect to infrastructure. The research team in Ghana wanted to elicit respondents' infrastructure preferences more closely than in the Peru study. Section 5 first asked respondents to rank in order of priority what types of infrastructure they would like to see under the hypothetical situation that government officials would make these different services available to the village. From this point, the section (and the respondents' portion of the survey) concluded with a choice model experiment. Results from the choice model exercises are not considered in this dissertation.

The Ghana study also featured a system operator survey. This survey instrument consisted of 1) an interview with the caretaker, who was responsible for operation, maintenance, and basic repairs of the boreholes, 2) an interview with the attendant(s), who sometimes collected money from customers at the boreholes on a per container basis, and 3) a brief technical assessment of the handpumps. In the first section, enumerators asked questions concerning the caretaker's experience, skills, training and payment received for their work, their access to spare parts and technical assistance, and the frequency and extent of ongoing maintenance and repair at the sites. If there was no caretaker in the village, a separate section asked similar relevant questions to a member of the watsan committee. The second (and third if there were two attendants in the village) section(s) was aimed at the selection, skills, and payment of the attendant. Respondents answered questions about normal user queue times and the amount of money collected from users in the village. The final part of the survey was conducted separately by a technical member of the team. There were two pump tests to determine how much water flowed from all of the handpumps in the village and how many strokes were required to obtain water from the pumps after rest. Engineers also assessed the functional quality of the pumps and area around the sites and speculated whether they would remain in operation for the next three years.

The other three survey instruments (the watsan committee survey, the village leaders' focus group, and the village women's focus group) were very similar to the Peru survey instruments. One main difference was that the Ghana team did not obtain a detailed list of information about the various social groups that existed in the villages and the degree of homogeneity that existed within these groups. This information was important for the objectives of the Peru research team.

In addition to these five survey instruments, field teams gathered two other sources of information in Ghana. Field coordinators worked with DWSTs to arrange a one-day source observation in each village. During the source observation, a representative of the village spent a full day tallying the number of different-sized containers filled by people at the main borehole in the village. They also found out from the attendant or designated watsan committee member how much money was collected for that day. This information allowed the research team to estimate daily water consumption and fee collections. Finally, the research team recorded GPS location and altitude coordinates for each of the villages in the study. The data yielded spatial locations of the villages and topographical information to use in comparing water source situations among villages and districts.

5.2.2. Sampling Frame

Projects from the CWSP I began in 1993 and completed by 2001; thus, each of the villages studied had managed a new water system for at least four years. The research design was based on selecting villages from two different regions; one region that received supply-driven post-construction assistance via the MOM program and another region that only received post-construction support upon request. Districts in the Volta region had participated to varying degrees in the MOM program over the last four years since completion of the first phase of the DANIDA-funded rural water supply project. Researchers selected four districts – Ho, Jasikan, Kadjebi, and Nkwanta – in the Volta region that had participated in MOM during every quarter of the four-year period. The Ho district was the most urbanized and closest to Accra, while the Nkwanta district was the least urbanized and most remote of those in the sample.

Initially the research team considered villages in the Asante and Brong Ahafo regions that had benefited from CWSP I during the same time frame. Researchers conducted a round of informal interviews with District Water and Sanitation Team (DWST) leaders and found little difference in the demand-oriented nature of PCS offered to their respective communities. The research team selected the Brong Ahafo region for a control group because one PCS variable of interest was the distance of villages to spare parts depots, located in three main cities of Ghana. The Asante region contains one of three depots in the country (in Kumasi), whereas the Brong

Ahafo and Volta regions are located further away from these facilities. The distance and travel time among Brong Ahafo districts to Kumasi and among Volta districts to Accra (home of a second depot) was similar. Therefore, the team decided to select the Brong Ahafo region for the study.

There were eight districts that had received water projects under CWSP I in Brong Ahafo. The research team obtained technical information on all of the projects and the most recent census data from 2000 for the villages and districts in question. After reviewing the technical and census data and incorporating our combined knowledge of the linguistic and cultural aspects of the region, five districts – Asunafo, Dormaa, Kintampo, Tano, and Wenchi – were selected. These districts were similar to those selected in the Volta region in terms of economic and demographic indicators. Moreover, the team, which featured skilled local researchers with prior experience in the region, judged that these districts contained more similar dialects and cultural practices to one another than the other districts in the region. This helped minimize the probability of unobserved covariates in the analysis.

Projects in CWSP I varied from dug wells to boreholes and piped systems. Researchers selected those villages with technologies identical to those in the Volta region: the use of deep boreholes and public handpumps. Beneficiary communities received anywhere from one to five project boreholes. The team decided to limit the scope of villages to those that received only one or two boreholes under the respective program. This effectively also limited the size of the villages. The estimated size of the beneficiary areas ranged from 200 to approximately 5000 people. The application of these technical (and population) criteria created a potential sampling frame of 100 villages in the Volta region and 120 villages in the Brong Ahafo region. All 100 villages for the Volta region were included in the final sample, and the team selected 100 villages at random from the 120 in the Brong Ahafo region for a total of 200 villages in the study.

Household selection was very similar in design and practice to the experience in Peru. Field teams employed geographic sampling in proportion both to community size **and** according to the number of communities that used a project borehole (since there were some cases where more than one village used a single project borehole). A copy of the household sampling protocol appears as Appendix II.

5.2.3. Fieldwork Procedures

The research team began working in the autumn of 2004. Team members gathered and reviewed information on the two programs of interest – the Community Water and Sanitation Program (CWSP, phase I) and the Volta Regional Water and Sanitation Program. The Volta program was confined to the Volta region of Ghana, which lies mostly east of Lake Volta in the country. Although CWSP I was implemented in several regions of Ghana, the research team concentrated its efforts in the central Brong Ahafo region.

The research team interviewed District Water and Sanitation Team (DWST) members in both regions to learn more about the nature of post-construction project support (PCS), which they provided to communities since completion of the water projects. DWSTs and Environmental Health Assistants (EHAs) provide technical support, information, assessments, and education to villages in the study areas. These interviews provided perspective on the extent of PCS available "on the ground" and attitudes concerning the performance of this work. The team also obtained village-level socio-economic and infrastructure data in each region from the most recent National Census taken in 2000.

A total of nine field coordinators and forty-five enumerators were assembled and trained for the fieldwork. Researchers spent three weeks training field team members and pre-testing and revising the survey instruments. The fieldwork began in late March and concluded in early May 2005. Each team spent one day conducting the field surveys and made separate arrangements for the source observation and for an engineer to conduct the system operator survey and take the GPS readings. Field teams visited a total of 200 villages – 100 in the Volta and Brong Ahafo regions, respectively. The consultant entered and processed all of the study data, and sent all of the datasets to the research team by September 2005. The data were cleaned and prepared by November 2005.

VI. Study Results

6.1. Descriptive Results

6.1.1. Household-Level Indicators of Sustainability

Household level measurements of sustainability represent physical performance, consumer use, satisfaction, and attitudes concerning future system operation. Household responses also include whether water committees should tackle other village water needs and whether they should expand to include other environmental infrastructure. Table 13 summarizes these measurements, while Appendix III overviews their frequency distributions.

Table 13: Household-level Descriptive Statistics for Sustainability Indicators

Measure	Category	Ghana	Peru
Average Number of Breakdowns Last Six Months	Physical	[redacted]	0.6 (0.86)
Average Number of Days to Repair Service	Physical	[redacted]	18 (88)
Percent of Households Reporting Payment for Service	Financial	62%	77%
Estimated Monthly Water Payments for Paying Customers ($USD)	Financial	$1.06 (1.20)	$1.07 (0.89)
Percent of Households Using System as Primary Source	Use	95%	95%
Percent of Households Reporting Satisfaction with Maintenance and Repairs	Satisfaction	85%	70%
Percent of Households Reporting Satisfaction with Administration and Management	Satisfaction	85%	61%
Percent of Households that Trust Administration and Management	Satisfaction	78%	61%
Percent of Households Reporting Satisfaction with Water Pressure in Dry Season	Satisfaction	72%	70%
Percent of Households Reporting that Water Has No or Sweet Taste	Satisfaction	58%	89%
Percent of Households Reporting that Water is Safe to Drink	Satisfaction	86%	72%
Percent of Households Reporting Overall Satisfaction with System	Satisfaction	75%	63%
Percent of Households Believing System will Function Next 5 Years	Future	55%	75%
Percent of Households Believing System will Function Next 10 Years	Future	[redacted]	48%
Percent of Households Believing that Committee Should Expand/Improve System	Scaling	86%	84%
Percent of Households Believing that Committee Should Handle Other Needs	Leveraging	[redacted]	39%

** Standard deviations in parentheses*

Peruvian households experience breakdowns fairly irregularly; some do not break down at all while other taps break down more often. It takes an average of 18 days to get the taps working again, but household responses varied dramatically (many wait less than one week while others have waited for months to have their service restored). Reported household financial results are similar to those reported by village-level surveys. Over 75% of households in Peru pay for water. On average they pay $0.70 per month. A smaller percentage of households in Ghana reported that they pay some positive amount for water service (62% vs. 77% reported by the water committees). However, Ghanaian villagers who do pay report paying more on average for monthly service.

Households in both Peru and Ghana report overwhelmingly that they use the improved source as their primary source in both rainy and dry seasons. Respondents in both settings report that they occasionally use other dry season sources as well. Due to the high percentage of primary users of improved water in both villages, consumer use is not a good measure to use as an indicator of sustainability in regression analysis.

Satisfaction measures include water attributes, current management, and operation and repair practices. Over 2/3 of respondents in Peru believe their water is safe, available, and sufficient to meet their needs in either season and nearly 90% believe it tastes good. Ghanaians have even more faith in the safety of water from boreholes, yet over 40% find some problem with its taste. There were also high degrees of satisfaction reported among Ghanaians concerning repair service, administration, and management. In Peru these figures indicated a moderate degree of satisfaction (between 60% and 70% of all respondents). Overall, ¾ of Ghanaian households were satisfied with their systems, while five out of eight Peruvian households report approval.

Despite the higher degrees of satisfaction reported among the sample of Ghanaian households, however, a smaller proportion (55% in Ghana vs. 75% in Peru) believe that their systems will function in the next five years. Peruvian households are more confident in the future of their systems; nearly the same percentages of Peruvians think their systems will function in ten years time as Ghanaians believe theirs will last five years. These numbers compare favorably with country-level responses from village water committees. Fifty-six percent of water committees in Ghana believed their systems would last another five years, while 84% of Peruvian committees agreed that their system would continue to function during the same period. Support for some form of scaling up is high in both countries. Leveraging, however, represents a significant departure among the sample in Peru – only 40% of Peruvian households want their committees to handle other responsibilities.

6.1.2. Household-Level Factors

Table 14 shows how household-level factors vary by category. Over ½ of households in both countries use some form of sanitation besides open defecation or night soil collection. Electricity use represents a dramatic difference between the two countries. Most everyone owns their own home in Peru while ¾ of Ghanaian respondents are homeowners. The average household contains six people in the Ghana sample and five in the Peru sample. Room size and acreage of land owned are similar in Peru and Ghana. Over ½ of Peruvian households report that their annual income was less than U.S. $150 per year, while in Ghana median household expenses equal over $700 per year. Attitudes toward social capital among households was generally more positive in Ghana than Peru, yet with respect to lending and borrowing, fewer Ghanaians believed they could definitely or probably borrow money from their neighbors or friends.

Household participation and involvement in water training was relatively even in Peru and Ghana. However, women were much more involved in Ghana than Peru. High percentages of households were aware of the project before construction and contributed something to the project during construction. Many projects required cash contributions in Ghana; yet the median contribution was very low compared to other monthly household expenses. Peruvians contributed varying degrees of labor to the project. Over ¾ of respondents in both countries reported regular meeting attendance. However, knowledge of how money was spent in the village differed, with Ghanaians more likely to be aware of expenditures than Peruvians. Finally, about ¼ of Peruvian households reported that they were visited in the post-construction phase of the project by a government agency, SANBASUR, and/or supporting non-governmental organization. The percentage was slightly higher among Ghanaian respondents with respect to whether they had been visited by district level environmental health assistants or engineers, or representatives from donor and non-governmental agencies.

Table 14: Household-Level Descriptive Statistics for Hypothesized Factors of Sustainability

Measure	Category	Ghana	Peru
Percent of Households Reporting Electricity Connection	Socio-economic	14%	60%
Percent of Households Reporting Some Form of Improved Sanitation	Socio-economic	55%	57%
Number of Household Members	Socio-economic	6.02 (3.38)	4.91 (1.96)
Number of Rooms in Household	Socio-economic	3 (1.89)	3.4 (1.73)
Percent of Households Reporting Home Ownership	Socio-economic	76%	97%
Acres of Land Owned (median)	Socio-economic	2 (7401)	2.47 (3.10)
Age of Respondent	Socio-economic	42 (14.38)	47 (14.5)
Percent of Population Earning US $150 or less per year (cash income)	Socio-economic	[redacted]	60%
Median Annual Household Expenditures (USD)	Socio-economic	$707 (141)	[redacted]
Percentage of Households who Trust their Neighbors	Socio-economic	75%	56%
Percentage of Households who Trust their Local Leaders	Socio-economic	77%	51%
Perceived Ability to Probably or Definitely Borrow Money	Socio-economic	37%	59%
Percentage of Households that Boil or Filter Their Water	Socio-economic	6%	[redacted]
Median Household Participation Score re: input on decisions (range 0-13 Peru, 0-9 Ghana)	Project	4 (3)	6 (3.9)
Median Range of Meetings Attended by Household (range 0-4; 4 is greater than 10 meetings)	Project	2	2.5
Percent of Households Contributing to Project	Project	71%	86%
Amount of Labor Contributed by Households (days)	Project	1.16 (6.62)	18 (19.92)
Amount of Funds Contributed per Household (USD)	Project	$1.92 (6.27)	N/A
Percent of Households that Have Attended Current Meetings	Project	73%	75%
Percent of Households who Believe System was Well-Constructed	Project	93%	69%
Percent of Households Aware of How Money is Spent Regarding Project	Project	67%	55%
Age of Household Tap (years)	Project	[redacted]	8.1 (6.6)
Percent of Households Receiving any Post-Construction External Visits	External	29%	25%

** Standard deviations in parentheses*

6.1.3. Village-Level Factors

Table 15 reports key statistics for sets of determinants hypothesized to influence sustainability. On the whole, Ghanaian villages are larger than Peruvian ones sampled, although both exhibit considerable variation. Ghanaian villages are also denser, as evident by the shorter average amount of time it takes to go from one edge to the other of a village. Peruvian villages are more remote than Ghanaian villages. Households experience a shorter dry season in Ghana than in Peru, where it lasts on average for over half of the year. The average daily wage among unskilled laborers, including farmers (who represent the majority of respondents in both cases) would indicate that full-time wage earners make about U.S. $750 per year in both countries.

Table 15: Village-Level Descriptive Statistics for Hypothesized Factors of Sustainability

Measure	Category	Source	Ghana	Peru
Average Number of Households in Village	Socio-economic	Leaders	202 (216)	182 (246)
Average Number of People in Village	Socio-economic	Leaders	1119 (1361)	750 (821)
Average Number of Minutes to Walk from One End of Village to Other	Socio-economic	Leaders	13 (11)	45 (280)
Average Number of Kilometers to Nearest Paved Road	Socio-economic	Leaders	11 (13)	35 (50)
Average Number of Kilometers to Nearest Area Mechanic	Socio-economic	Committee	20 (19)	[redacted]
Average Number of Kilometers to Nearest Water Source	Socio-economic	Leaders	1.36 (1)	3.75 (7.91)
Average Months of Dry Season	Socio-economic	Women	3.6 (1)	6.4 (1.91)
Average Daily Wage for Unskilled Male Laborer (US Dollars)	Socio-economic	Leaders	$2.22 ($0.77)	$1.91 ($1.76)
Average System Age (years)	Project	Committee	6 (3)	7 (3)
Average Kilometers of Transmission Line from Source to Village	Project	Operator	[redacted]	2.2 (2.3)
Percent of Water Systems with No Storage Cracks	Project	Engineers	[redacted]	68%
Percent of Water Systems with No or Very Few Leaks in Distribution Lines	Project	Engineers	[redacted]	72%
Average Number of Years of Operator's Experience	Project	Operator	[redacted]	4 (3.75)
Percent of Villages where Operator Received Technical Training	Project	Operator	36%	36%
Average Number of Years Water Committee Has Existed in Community	Project	Committee	7.6	8 (6.8)
Average Number of Committee Members	Project	Committee	8 (3.3)	5 (2.4)
Percent of Projects Managed by Elected Water Committees	Project	Committee	42%	63%
Percent of Committees Trained During or Post-Project	Project	Committee	85%	61%
Percent of Villages without Tariffs	Project	Committee	13%	11%
Percent of Villages with Monthly Fee Tariff Structures	Project	Committee	25%	82%
Percent of Villages with "Pay as You Fetch" Tariff Structure	Project	Committee	39%	0%
Percent of Villages Recovering Operating & Maintenance Costs	Project	Committee	53%	53%

** Standard deviations in parentheses*

Generally, transmission lines from water sources to the villages in Peru are relatively short in distance. Engineers in Peru found water systems in relatively good shape in 2/3 of the communities surveyed. Water committees have existed longer in Ghanaian communities than Peruvian ones. On average, they have more representatives and are much more likely to have received training. However, Peruvian committees are more likely to have been elected by citizens. Operators are equally likely to have been trained in both settings. Operators in Peru have served in their roles an average of nearly four years, while no comparative information was available for Ghanaian villages.

Most villages in Peru and Ghana had enacted water tariffs, although in both countries over ten percent of villages did not have any tariff in place. There was little variation among Peruvian communities with respect to the type of tariffs committees had adopted; over 80% chose flat fees systems in which users paid on a periodic (often monthly) basis. Watsan committees in Ghana were more likely to select different options. Government authorities have encouraged the most popular type – user payments for water as they collected it from the boreholes – yet less than 40% of villages relied on this system. Regardless of these differences, however, an equal proportion (slightly more than ½ of committees) reported that annual household revenue collections covered operating expenses.

While village-level project cost data was not available for this study, village water committees were asked to recall what percentage of construction cost was contributed by residents. In Ghana, projects were designed such that villages contributed approximately 5% of total cost to the project. The FONCODES and SANBASUR programs incorporated different rules for village contributions (for example, many villages contributed labor in lieu of cash), and reported contribution percentages from committees differed dramatically among Peruvian villages. In contrast, equal proportions of village water committees (53%) in Peru and Ghana reported that revenue collections covered operating and maintenance costs. Cost and revenue figures varied widely across both countries. Moreover, there were some cases where household data regarding water payments did not appear to coincide with reported household revenues. However, most water committees could tell enumerators whether or not user fees covered O&M costs.

6.2. Constructs and Variance Analysis

6.2.1. Wealth Constructs

Wealth indices were constructed based on a series of binary responses to questions concerning the materials used in home construction, assets owned by the household, and whether families used any improved sanitation and electricity. Principal components analysis generated factor scores and index values, using the first component to explain the maximum proportion of variance. Tables 16 and 17 present the scoring factors and index values contributed for Peru and Ghana.

Table 16: Wealth Index for Peruvian Households

ITEM	MEAN	ST. DEVIATION	SCORING FACTOR	INDEX VALUE
Floors (non-ground)	0.1036	0.3048	0.2913	0.9557
Walls (non-adobe)	0.0458	0.2092	-0.0155	-0.0741
Roof (non-grass or thatch)	0.7199	0.4491	0.3938	0.8769
Radio	0.9148	0.2792	0.2243	0.8034
Clock/watch	0.6482	0.4776	0.3394	0.7106
Bicycle	0.2972	0.4572	0.355	0.7765
TV	0.3722	0.4835	0.4674	0.9667
Motorcycle	0.0102	0.1007	0.1199	1.1907
Car/Tractor	0.0229	0.1497	0.1446	0.9659
Sanitation	0.5696	0.4952	0.1446	0.2920
Electricity	0.6069	0.4885	0.4393	0.8993

Table 17: Wealth Index for Ghanaian Households

ITEM	MEAN	ST. DEVIATION	SCORING FACTOR	INDEX VALUE
Floors (non-ground)	0.6432	0.4791	0.2362	0.4930
Walls (mud)	0.5756	0.4943	-0.2257	-0.4566
Roof (non-grass or thatch)	0.6908	0.4622	0.277	0.5993
Radio	0.7962	0.4028	0.2407	0.5976
Clock	0.3677	0.4822	0.3477	0.7211
Watch	0.7536	0.431	0.2632	0.6107
Bicycle	0.4953	0.5	0.1489	0.2978
TV	0.0931	0.2905	0.3743	1.2885
Motorcycle	0.3474	0.1831	0.3118	1.7029
Car	0.0313	0.1741	0.3487	2.0029
Tractor	0.015	0.1217	0.3222	2.6475
Sanitation (private)	0.2525	0.4345	0.1002	0.2306
Sanitation (none)	-0.1506	0.2044	0.4033	-0.3734
Electricity	0.151	0.358	0.2256	0.6302

The wealth indices explained approximately 25% of the variation in the Peru household sample and 20% of the variance among Ghanaian households. Table 18 presents the descriptive statistics for the wealth indices generated for the two samples and their correlation coefficients with land and income.

Table 18: Descriptive Statistics & Correlations for Peru & Ghana Wealth Indices

MEASURE	PERU	GHANA[1]
# Households	2442	4922
# Components	11	14
Mean Wealth Index	3.26	3.01
Standard Deviation	1.66	1.69
Correlation – land	0.127	0.005
Correlation – income[2]	0.414	0.241

1: Negative values normalized to zero.

2: Income reflected by income categories in Peru. Income reflected by log expenditures in Ghana.

Table 18 suggests that Peruvian households on average own more assets than Ghanaian households, particularly since the total potential scores are higher in Ghana than Peru (as observed by the number of components). Both sets of households on average do not report high asset indices, and both contain some degree of variance within each sample. Correlations between wealth indices and land are positive but low in both cases. Income/expenditure correlations are higher in both samples, although imperfectly correlated. Both income/ expenditure measures and wealth indices are used in the multivariate analysis.

It should be mentioned that this dissertation does not include the error associated with the generated measures into the multilevel model results. More conservative tests of significance for these variables are probably necessary in the absence of this error information.

6.2.2. Variance Decomposition

Tables 19 and 20 present the results of decomposing the variance of the dependent model variables into the village and household levels.

Table 19: Variance Composition Analysis – Peru

CATEGORY	INDICATOR	VARIANCE	ERROR	%VILLAGE	%HH
Physical	Tap breaks last 6 month	1.530	0.706	68%	32%
	Days to repair taps	79.02	78.350	50%	50%
Financial	HH pays for service	0.263	0.071	97%	3%
	Amt. paid/month	4.711	0.601	89%	11%
Satisfaction	Water pressure	1.760	0.466	79%	21%
	Water safety	2.747	0.665	81%	19%
	Overall satisfaction	2.103	0.364	85%	15%
	Satisfaction with O&M	2.272	0.452	83%	17%
	Satisfaction with Administration	2.861	0.498	85%	15%
	Trust in management	1.872	0.421	81%	19%
Future	5 Years	13.911	6.416	68%	32%
	10 Years	27.24	14.520	65%	35%
Scaling &	Scaling up	0.3	0.126	70%	30%
	Leveraging	0.588	0.225	72%	28%

Table 20: Variance Composition Analysis – Ghana

CATEGORY	INDICATOR	VARIANCE	ERROR	%VILLAGE	%HH
Financial	HH pays for water	7.57	1.19	76%	24%
	Amt. paid/month	262.18	579.33	76%	24%
Satisfaction	Water pressure	2.04	0.49	66%	34%
	Water taste	3.01	0.242	66%	34%
	Satisfaction with Administration	1.7	0.264	82%	18%
	Trust in management	2.027	1.062	96%	4%
Future	1 Year	0.603	0.072	77.5%	22.5%
	5 Years	44.47	12.615	91%	9%
Scaling Up	Scaling up	0.559	0.102	84%	16%

The variance analysis implies the following about the distribution of sustainability indicators across households and villages in Peru and Ghana. As expected, the frequency of breakdowns and the number of days it takes to repair them vary widely across and within villages in Peru, since the unit of analysis is the household's tap. The variance for repair times is nearly equally partitioned between the household and village levels.

The variance of household responses to whether they pay for water and the amount paid do not vary much at all among Peruvian households. Three-quarters of households pay for water service, and nearly all of these customers pay flat fees or contribute labor in lieu of payment within villages. This suggests that many household factors are not likely to influence payment. Analyzing the variance of the Ghana sample shows, however, that there is a moderate degree of intra-class correlation among households within villages. This may be due to the presence of tariffs based on household size (found in 7% of the sampled villages) and/or differences in the abilities of households to obtain water at lower prices.

A review of the variance analysis for household satisfaction with water (water pressure, safety, and overall satisfaction in Peru and water pressure and taste in Ghana) finds that village-level effects explain more variation in Peru vs. those in Ghana. Both contain some degree of intra-class correlation, although this appears higher in the Ghana sample of households. With respect to satisfaction with the operation and management of services, both samples exhibit a fair degree of within-level correlation – although village effects explain much more in both cases. Interestingly, trust almost does not vary at all within clustered households in Ghana, while it does to a limited extent in Peru.

Responses to whether systems will function over five and ten year time frames vary over villages and within them in Peru. The Ghana data suggest some intra-class correlation for one-year responses, yet very little (less than 10%) for five-year data. Similarly, household-level variation is a more important determinant of the overall variance for whether a household believes the water committee should scale up services in Peru than in Ghana; explaining almost double the variation in the Peru dataset vs. that of Ghana. Leveraging also varies to a moderate degree within households in Peru, while this question was omitted from the Ghana study.

6.3. Multivariate Model Results

6.3.1. Random Intercept and Slope Models - Peru

The random intercept models postulate that each indicator of sustainability, measured at the household level, can be explained as a function of household-level factors and village-level factors. The models allow the intercept for each village to vary, which enables different "base-case" scenarios for the dependent variables in each village. The slopes in these models, however, do not vary; nor do the effects of the factors on the indicators.

The following random intercept and structural model results for Peru and Ghana were generated with M Plus software. M Plus uses an accelerated Expected Maximization (EM) algorithm as an optimization method to obtain full information maximum likelihood estimates (Dempster, Laird, & Rubin 1977). A standard integration option (rectangular numerical integration with 15 integration points per level) was selected to construct the analysis. EM algorithms do not decrease observed likelihood functions, but they do not guarantee that the sequence will generate a maximum likelihood estimate (Goldstein 1995). The programs use robust standard errors for significance testing (M Plus 2006).

The following tables present the results from the random intercept models tested on the sample of households and villages in Peru. Each table shows the sample size, loglikelihood statistic for the model, a pseudo-R^2 using Akaike Information Criteria (AIC), the residual variance of the model (for continuous variables), and model specification. Pseudo R^2 resembles a goodness-of-fit measure which compares the AIC of the model with a null model featuring only a constant (a lower AIC indicates that the model better fits the structure of the data). The statistic should not be interpreted as a linear regression R^2, since it compares information from the hypothesized vs. null model rather than the residual sum of squares. Its' formula appears below:

$R^2_{AIC} = 1 - AIC_i / AIC_0$ where $AIC = 2K - 2*Ln(L)$

K = *number of parameters in the model* L = *Likelihood function*

A zero-inflated Poisson model accounted for the frequency of tap breakdowns, including the moderate number of households which reported zero breakdowns. An Ordinary Least Squares model examined what factors were associated with the number of days a household waited for restoration of service among those that needed a repair. A second OLS model predicted monthly household water payments. Binary and ordinal logit models were fitted to the remaining categorical indicators. Unstandardized coefficients with asterisks represent those which pass robust tests of significance at the ten percent rejection level (one *), five percent rejection level (two *) and one percent rejection level (three *). Factors with positive and significant (at least 10% rejection level) are noted in cells with upward-sloping lines, while cells with downward-sloping lines represent significantly negative factors. Odds ratios also appear in the tables for household and village factor effects generated from random intercept models that contain categorical dependent variables.

Table 21 presents results from the physical performance models. Several household and village factors were associated with the number of tap problems a household experienced over the previous six months. Larger households (both in terms of the number of people and the size of the home) experienced more outages. A one-person increase in household size was associated with an 8% increase in the frequency of breakdowns and a one-room increase in the size of the home was associated with a 6% increase. Older taps also broke down more often – for a three-year increase in the age of the tap, households experienced an additional breakdown every six months. Households with higher incomes and wealth indices experienced fewer breakdowns. Households in the next highest income class were about 25% less likely to experience breakdowns every six months, while those with a unit increase in the asset index were 10% less likely. All of these effects appear in the expected directions. In addition, older respondents tended to report breakdowns more often. Other factors, such as pre-project participation & contributions, current involvement and support, household social capital attitudes, and attitudes concerning system quality did not affect breakdowns.

A set of village factors also predicted the frequency of tap breakdowns. As with size factors at the household level, village size (in terms both of population and distance) was associated with more frequent household breakdowns. For every additional 100 people who lived in the village and for every additional one hundred minutes of end to end travel distance across the village, household taps broke down 1% more often every six months. Moreover, representation by elected committee members appeared to lower the frequency of breakdowns experienced. Households were 23% less likely to have breakdowns every six months if they were governed by elected water committees. In addition, households located in villages where engineers reported problems with fissures in storage tanks reported more tap problems. This comes as no surprise, given that reported tap problems may have been influenced by system malfunctions. Other potential village factors, such as program differences, operator and other committee factors, and source characteristics were not associated with increased breakdowns.

Table 21: Peru Random Intercept Models - Physical Performance

	#HH LEAKS	DAYS REPAIR
MODEL INFORMATION		
Sample N	771	470
Loglikelihood	-676	-1501
Pseudo R Square	0.749	0.515
Residual Variance	1.37***	1.59***
Model Type	Zero-Inflated Poisson	OLS
HOUSEHOLD EFFECTS (e^B)		
Tap Age	0.33*** (1.39)	0.11
Participation - # Decisions	-0.03 (0.97)	0.01
Contribution – # Labor Days	-0.01 (0.99)	-0.00
Meeting Attendance	0.06 (1.06)	0.12**
PCS Visit Received	-0.06 (0.94)	0.00
HH Members	0.08*** (1.08)	0.06**
HH Rooms	0.06*** (1.06)	N/A
Income Category	-0.27*** (0.76)	0.07
Asset Index	-0.11** (0.90)	-0.21*
Age of Respondent	0.01*** (1.01)	-0.01
Social Capital Score	0.001 (1.001)	N/A
System Well Constructed	0.09 (1.09)	N/A
Knowledge How Funds Spent	-0.05 (0.95)	N/A
VILLAGE EFFECTS		
SANBASUR	-0.10 (0.90)	-0.25
Operator Years Experience	-0.03 (0.97)	-0.003
Operator Trained	-0.06 (0.94)	0.04
Source – # Dry Months	-0.05 (0.95)	0.01
Source – Length of Distribution Line	0.003 (1.00)	0.00
System – Storage Cracks Detected	0.28*** (1.32)	N/A
System – No Distribution Leaks Detected	0.30*** (1.35)	N/A
Village Population	0.001* (1.001)	-0.001***
Village Size	0.001* (1.001)	-0.01***
Committee – Years Experience	-0.001 (0.999)	0.01
Committee Elected	-0.26* (0.77)	0.19
Committee Trained	0.19 (1.21)	-0.11

** significant at 10% rejection level, ** significant at 5% rejection level, *** significant at 1% level.*

Table 21 also shows results for the model which predicted the number of repair days a household reported for the last breakdown. Several iterations of the model predicting repair times were attempted, owning to convergence difficulties associated with a restricted sub-sample of households which had experienced a breakdown during the period. Household size and assets remained important household determinants, while others (such as household size, and tap and respondent age) dropped out. A one-person increase in the number of household members was associated with a 1.5 hour increase in the time needed to restore service. Conversely, households with more assets (a unit increase in the asset index) experienced five hour declines in the wait time before the problem was fixed. Current meeting attendance was positively associated with increased breakdowns; a jump to the next category of meeting participation was associated with a three-hour increase in wait time. This may indicate that people began going to meetings more often as they experienced problems. At the village level, while village population and distance increased tap difficulties, households in larger communities actually experienced lower wait times to restore water service. For every additional 1,000 people in the village and for every 100 minutes of travel across the village, household repair times declined by one day.

Table 22 highlights the results from models that predict whether a household currently pays for water service and the monthly amount households paid to receive water.

Table 22: Peru Random Intercept Models – Household Payment and Amount Paid/Month

MODEL INFORMATION	HH PAYS FOR WATER	MONTHLY HH PAYMENT
Sample N	752	646
Loglikelihood	-159	-437
Pseudo R Square	0.538	0.754
Residual Variance	N/A	0.10***
Model Type	Binary Logit	OLS
HOUSEHOLD EFFECTS (Odds Ratio)		
Tap Age	0.54 (1.71)	0.07
Participation - # Decisions	-0.05 (0.95)	-0.01
Contribution – # Labor Days	-0.03* (0.87)	-0.01*
Meeting Attendance	0.29 (1.34)	-0.02
PCS Visit Received	-0.37 (0.69)	0.06
HH Members	0.11 (1.11)	0.002
HH Rooms	0.19 (1.21)	-0.004
Income Category	-0.19 (0.83)	0.05
Asset Index	0.12 (1.13)	-0.02
Age of Respondent	0.01 (1.01)	-0.002
Social Capital Score	-0.01 (1.00)	0.02*
System Well Constructed	0.125 (1.15)	0.03
Knowledge How Funds Spent	0.59*** (1.80)	-0.05
VILLAGE EFFECTS		
SANBASUR	3.49*** (32.79)	-0.52***
Operator Years Experience	-0.25* (0.78)	0.004
Operator Trained	0.48 (1.62)	0.17***
Source – # Dry Months	0.20 (1.22)	-0.08**
Source – Length of Distribution Line	0.001 (1.001)	0.004
System – Storage Cracks Detected	-0.87 (0.42)	0.05
System – No Distribution Leaks Detected	-0.03 (0.97)	-0.05
Village Population	0.001 (1.001)	0.00
Village Size	0.001 (1.001	0.00
Committee – Years Experience	-0.01 (0.99)	-0.02**
Committee Elected	0.94 (2.56)	-0.25
Committee Trained	0.12 (1.13)	0.27*

** significant at 10% rejection level, ** significant at 5% rejection level, *** significant at 1% level*

Few household or village factors explained whether a household paid for service. At the household level, this is not surprising given the limited degree of within-village variation of the data. Households contributing more labor to project construction were less likely to pay for water service – every increase in labor days decreases the odds of paying by 13%. Households which claim to know progressively more about how their water committee spends money were more likely to pay by a factor of 1.80. More surprisingly, most village factors also do not inform the decision on whether households pay for service. Households in SANBASUR communities are considerably more likely to pay for service than those in FONCODES-only areas. In contrast, those located in villages with longer-serving operators do not pay as often. For every additional year an operator has served, the odds of payment decline by over 20%.

More village factors explain the monthly amount that households pay for water service. SANBASUR households may be more likely to pay for service, but they pay about 0.52 soles (US $0.16) less for the water they receive after controlling for other factors. Households in communities with longer dry seasons pay less than those with longer rainy seasons (every additional month of the dry season is associated with a 0.08 soles decline in payment). Training also appears correlated with higher water payments – households in villages with trained operators and water committees pay 0.17 and 0.27 soles per month, respectively, more than those in villages which lack training. Just as operator experience reduced the likelihood of paying for service, committee experience was associated with lower customer payments, although the magnitude of the effect (-0.02

soles/month for every additional year) is negligible. Most household factors were not associated with water payments. Project contributions were negatively associated with payments, although the strength of the relationship is weak – for every ten days of contributed labor, monthly household payments decline by 0.1 soles. Household attitudes toward social capital improve payment amounts, but the magnitude and significance of this relationship are also weak.

The next three models, summarized in Table 23, predict dissatisfaction with water attributes – water pressure, safety, and overall quality. Lower water pressure affects households in the sample relatively uniformly, although water pressure levels do vary by village. Those who complain less about problems tend to believe their systems are well constructed, attend meetings more often, and surprisingly have older taps than those who have water pressure issues. Households who perceive that their water system was well-constructed are 37% less likely to think they experience water pressure problems, while every year increase in the age of the tap decreases the likelihood of the perception of water pressure difficulties by a factor of 0.65. Meeting attendance registers a similar negative correlation; decreasing the odds of reporting low water pressure by a factor of 0.67. At the village level, households located in villages where water travels longer distances from its water source do experience worse pressure in the dry season than those in other villages (for every additional kilometer, the likelihood of reporting lower pressure rises by 11%). Those in larger villages actually are less likely to experience declines in water pressure, although the magnitude is slight (an increase of 100 minutes of travel time decreases the probability of reporting pressure problems by about 10%). Communities without water leaks experience less of a problem with pressure. Yet the length of the dry season does not arise as an important factor. Trained operators and elected committees also reduce the likelihood that a household will experience lower water pressure by about 25% and 45%, respectively.

While variance analysis showed moderate amounts of within-level variance on responses regarding water safety, multilevel results revealed that the threshold levels in the models were not statistically significant. Thus, many household-level factors were not important determinants of whether a household believed in the safety of their water. Those who valued the construction of the system were less likely to say that their water was unsafe, as expected. Higher-income households were also more likely to believe that their water was not safe – as income rose from one category to the next, the likelihood of perceiving that their water was not safe increased by 76%. A few village-level factors explained household perception of water safety. For every additional month in the dry season, households were 37% less likely to report unsafe water, while those with fewer leaks were more 54% likely to contain household respondents who thought their water was safe. Rainy months can bring washouts and other system contamination problems, while those without leaks would tend to have fewer opportunities for contamination.

Table 23: Peru Random Intercept Models – Water Attributes

MODEL INFORMATION	LOW WATER PRESSURE	UNSAFE WATER FROM TAP	OVERALL DISSATISFACTION
Sample N	734	739	738
Loglikelihood	-737	-335	-541
Pseudo R Square	0.689	0.869	0.751
Model Type	Ordered Logit	Ordered Logit	Ordered Logit
HOUSEHOLD EFFECTS (Odds Ratio)			
Tap Age	-0.43*** (0.65)	-0.24 (0.79)	-0.79*** (0.45)
Participation - # Decisions	-0.003 (1.00)	-0.05 (0.95)	-0.03 (0.97)
Contribution – # Labor Days	0.00 (1.00)	-0.002 (1.00)	0.01 (1.01)
Meeting Attendance	-0.16* (0.67)	-0.132 (0.88)	-0.004 (1.00)
PCS Visit Received	0.10 (1.11)	-0.05 (0.95)	0.01 (1.01)
HH Members	-0.26 (0.98)	0.01 (1.01)	-0.04 (0.96)
HH Rooms	0.04 (1.05)	0.01 (1.01)	-0.07 (0.94)
Income Category	0.07 (1.07)	0.57* (1.76)	0.19* (1.22)
Asset Index	-0.10 (0.91)	-0.06 (0.94)	-0.10 (1.10)
Age of Respondent	-0.01 (0.99)	0.002 (1.00)	-0.003 (1.00)
Social Capital Score	-0.01 (0.99)	0.01 (1.01)	0.08*** (1.08)
System Well Constructed	-0.41*** (0.63)	-0.61* (0.52)	-0.73*** (0.44)
Knowledge How Funds Spent	-0.18 (0.84)	-0.11 (0.90)	-0.15 (0.86)
VILLAGE EFFECTS			
SANBASUR	-0.02 (0.98)	-0.17 (0.84)	0.50 (1.65)
Operator Years Experience	0.05 (1.05)	-0.05 (0.95)	0.13*** (1.14)
Operator Trained	-0.29* (0.75)	0.01 (1.01)	-0.19 (0.83)
Source – # Dry Months	0.07 (1.07)	-0.47*** (0.63)	-0.05 (0.95)
Source – Length of Distribution Line	0.10* (1.11)	-0.05 (0.95)	0.03 (1.03)
System – Storage Cracks Detected	0.04 (1.04)	0.37 (1.45)	-0.72* (0.49)
System – No Distribution Leaks Detected	-0.57** (0.57)	0.43* (1.54)	-0.76*** (0.47)
Village Population	0.000 (1.00)	-0.000 (1.00)	0.000 (1.00)
Village Size	-.001*** (0.999)	-0.000 (0.999)	-0.004*** (0.996)
Committee – Years Experience	0.01 (1.01)	0.002 (1.002)	0.03 (1.03)
Committee Elected	-0.60* (0.55)	-0.58 (0.56)	-0.67 (0.51)
Committee Trained	-0.09 (0.91)	0.03 (1.03)	-0.04 (0.96)

** significant at 10% rejection level, ** significant at 5% rejection level, *** significant at 1% level*

A majority (63%) of households was overall satisfied with their drinking water. A balance of both household and village factors predicted overall dissatisfaction. People who believed their system was well-constructed were 56% less likely to be unhappy with their water. Surprisingly, though, people with more positive social capital attitudes and those with higher income were more displeased with the water from the project. Unit increases in social capital scores increased overall dissatisfaction by a factor of 1.08, while a household's movement to the next income class in the village was associated with a 22% increase in the likelihood of dissatisfaction. And those with older taps actually were more satisfied than others. Village effects were also puzzling. System quality measures appear to move in opposite directions (in villages with storage cracks and no leaks, households were not dissatisfied with their services). Every additional year of operators' service was associated with a 14% higher likelihood of displeasure, while people in villages of larger size were less likely to be unhappy with their service.

The analyses shown in Table 24 considered satisfaction with operation and maintenance and the satisfaction and trust households held for their water committees. With respect to O&M satisfaction, pre-project participation and labor contributions are associated with O&M, but the negative relationships appear in the opposite directions of original hypotheses. An increase in the number of decisions in which a household originally participated decreases the odds of O&M satisfaction by 0.92, while an increase in project labor proffered by the household decreases the odds by 0.99 (the magnitude of the latter is very weak). Income class acts as a stronger household factor in explaining declining O&M support, as households moving from one category to the next are 24% less likely to have a positive opinion about operation and maintenance. Positive factors include satisfaction with original system construction (which may have less to do with actual repair service and more with the lack of need for repairs) and knowledge about how funds are spent (those with progressively more knowledge about how water committees spend their funds are about 40% more likely to demonstrate support for current O&M service). At the village level, households in villages with long-serving operators were 10% less satisfied with service for every additional year, while those in villages with elected committees appear 55% less satisfied with their O&M service. Those who live in larger villages overall are more satisfied with O&M than those living in smaller communities.

Satisfaction with administration follows similar lines as operation & maintenance. Household labor contributions are negatively associated with committee satisfaction, although again the odds ratio (0.99) is very weak. The odds ratios for attitudes concerning system construction and spending (at 1.85 and 1.46, respectively) are nearly proportionately equal in magnitude and strength of significance to satisfaction with O&M. On the village side of the equation, households with elected committees are again over 50% less satisfied with administration, while those in larger-sized villages are more pleased with the progress of the committees.

The model predicting household trust in the water committee showed that pre-project participation in decisions and respondents' age are negatively associated trust, although the magnitudes of the odds ratios (0.94 and 0.98, respectively) are fairly weak. Knowledge regarding water committee spending, however, was an important factor in gaining household trust, as it increased the likelihood of trusting the committees rose by a factor of 1.62. Interestingly, higher social capital scores did not affect household trust in the water committee. Operator experience joins elected committees as a factor in explaining lower trust (although the magnitude of the effect of elected committees is much lower than those of committee satisfaction and O&M service). Finally, both village size and population are positively associated with household trust.

Table 24: Peru Random Intercept Models - Satisfaction with O&M, Satisfaction and Trust in Water Committees

MODEL INFORMATION	O&M SATISFACTION	COMMITTEE SATISFACTION	COMMITTEE TRUST
Sample N	775	775	772
Loglikelihood	-548	-585	-599
Pseudo R Square	0.765	0.773	0.743
Model Type	Ordered Logit	Ordered Logit	Ordered Logit
HOUSEHOLD EFFECTS (Odds Ratio)			
Tap Age	0.07 (1.07)	0.13 (1.14)	0.22 (1.32)
Participation - # Decisions	-0.08* (0.92)	-0.03 (0.97)	-0.07* (0.94)
Contribution – # Labor Days	-0.01** (0.99)	-0.01* (0.99)	-0.01 (1.00)
Meeting Attendance	-0.02 (0.99)	-0.03 (0.99)	0.11 (1.12)
PCS Visit Received	-0.23 (0.80)	-0.05 (0.95)	0.03 (0.97)
HH Members	0.04 (1.05)	0.07 (1.07)	0.02 (1.03)
HH Rooms	0.04 (1.04)	0.04 (1.04)	0.11 (1.12)
Income Category	-0.28** (0.76)	-0.20 (0.82)	-0.15 (0.88)
Asset Index	0.02 (1.02)	-0.04 (0.96)	-0.02 (0.98)
Age of Respondent	0.001 (1.00)	0.005 (1.00)	-0.02*** (0.98)
Social Capital Score	-0.04 (0.96)	-0.04 (0.96)	0.02 (1.02)
System Well Constructed	0.82*** (1.85)	0.80*** (1.82)	0.17 (1.19)
Knowledge How Funds Spent	0.33*** (1.39)	0.38*** (1.46)	0.46* (1.62)
VILLAGE EFFECTS			
SANBASUR	0.54 (1.72)	0.30 (1.35)	0.69 (1.99)
Operator Years Experience	-0.11*** (0.90)	-0.06 (0.94)	-0.08***(0.92)
Operator Trained	0.11 (1.12)	-0.01 (0.99)	0.004 (1.004)
Source – # Dry Months	0.12 (1.13)	0.05 (1.05)	0.10 (1.11)
Source – Length of Distribution Line	-0.08 (0.92)	-0.05(0.95)	0.00 (1.00)
System – Storage Cracks Detected	0.17 (1.19)	0.58 (1.79)	0.00 (1.00)
System – No Distribution Leaks Detected	0.11 (1.12)	0.09 (1.09)	0.00 (1.00)
Village Population	0.000 (1.00)	-0.000 (1.00)	0.001*** (1.001)
Village Size	0.001*** (1.001)	0.001*** (1.001)	0.001* (1.001)
Committee – Years Experience	-0.01 (0.99)	-0.003 (0.997)	-0.001 (0.999)
Committee Elected	-0.79** (0.45)	-0.71* (0.49)	-0.05* (0.95)
Committee Trained	-0.05 (0.95)	-0.07 (0.93)	0.18 (1.20)

** significant at 10% rejection level, ** significant at 5% rejection level, *** significant at 1% level*

Table 25 demonstrates the results from factors predicting household perception of sustainable water service over five and ten year periods. Over three-quarters of all respondents believe that the system will function over the next five years, and results show that this does not vary to a large extent within villages. However, less than half of Peruvians (48.5%) have confidence that their system will keep running over a ten-year span; and these responses do vary both across and within villages. Four household factors predict system confidence over five and ten year periods: 1) pre-project labor contributions (+), 2) the perception that the system is well-constructed (+), 3) income category (-), and 4) whether a household has received a visit from an external agency (-). A one-day increase in household labor for the current water system increases the chances that a household believes the system will keep running by 2% over a five year period and 11% over ten years. Naturally, those who think they have a well-designed system are more likely to have confidence in its function over time, although the significance of this relationship in the shorter term can be rejected at a 5% level. Higher-income households are less likely to think their systems will continue to function by factors of 0.69 and 0.64 for five and ten-year horizons, respectively. Households receiving post-construction visits are as equally unlikely to have confidence in their systems as those in the next income bracket. Village population is the only village factor that predicts whether households believe a system will function over a five year period. Respondents in larger villages are more likely to think that their water committee can keep the system running. This drops out as important in estimating the ten-year confidence model, yet village size assumes its place in direction and significance. Households in SANBASUR villages are 46% less likely to think their system can function over a ten year period. For every additional year of committee service, households are 3% less satisfied with results. Among households located in villages with trained operators and well-maintained distribution systems, households are 30% and 70% more likely to believe their systems can work over the long term.

Table 25: Peru Random Intercept Models - System Confidence

MODEL INFORMATION	FIVE YEAR CONFIDENCE	TEN YEAR CONFIDENCE
Sample N	776	776
Loglikelihood	-438	-689
Pseudo R Square	0.818	0.742
Model Type	Binary Logit	Binary Logit
HOUSEHOLD EFFECTS (Odds Ratio)		
Tap Age	-0.06 (0.95)	-0.08 (0.93)
Participation - # Decisions	-0.02 (0.99)	-0.04 (0.96)
Contribution – # Labor Days	0.02** (1.02)	0.12*** (1.11)
Meeting Attendance	0.03 (1.03)	0.03 (1.02)
PCS Visit Received	-0.44** (0.64)	-0.33* (0.72)
HH Members	0.01 (1.01)	-0.001 (1.00)
HH Rooms	-0.04 (0.96)	-0.11 (0.89)
Income Category	-0.37*** (0.69)	-0.44*** (0.64)
Asset Index	-0.08 (0.92)	0.05 (1.05)
Age of Respondent	0.01 (1.01)	0.01 (1.01
Social Capital Score	0.04 (1.04)	-0.01 (1.00)
System Well Constructed	0.41* (1.34)	0.38** (1.34)
Knowledge How Funds Spent	0.07 (1.07)	0.16 (1.17)
VILLAGE EFFECTS		
SANBASUR	0.03 (1.03)	-0.62* (0.54)
Operator Years Experience	0.01 (1.01)	-0.01 (0.99)
Operator Trained	0.22 (1.25)	0.27* (1.31)
Source – # Dry Months	-0.03 (0.97)	-0.03 (0.97)
Source – Length of Distribution Line	-0.01 (0.99)	0.06 (1.06)
System – Storage Cracks Detected	0.36 (1.43)	0.31 (1.36)
System – No Distribution Leaks Detected	0.37 (1.45)	0.53*** (1.70)
Village Population	0.001*** (1.001)	0.000 (1.00)
Village Size	0.001 (1.001)	0.000* (1.00)
Committee – Years Experience	-0.01 (0.99)	-0.03*** (0.97)
Committee Elected	0.35 (1.42)	0.43 (1.54)
Committee Trained	0.29 (1.34)	0.21 (1.23)

** significant at 10% rejection level, ** significant at 5% rejection level, *** significant at 1% level*

The vast majority (85%) of respondents believes their villages should scale up services. Table 26 shows that a number of both household and village factors successfully predict this outcome. People with older taps, who attend meetings, and who know how funds are spent are more likely to scale up service. For every year increase in the age of the tap, the odds of favoring a scale up rise by 34%. The magnitude (37%) of the effect of favoring improvements among households who know how committees spend their money is similar to system age, although its significance can be rejected at a higher level. Households that attend meetings are also more likely to favor scaling up, although this effect (at 1.04) is much smaller. People from older generations are also more likely to support scaling up. People who value the original construction are less likely to support scaling up, as are those with positive attitudes regarding social capital and those who have been visited by an external agency. Every unit increase in a household's social capital score lowers the likelihood of favoring the decision by a factor of 1.08, while those who have been visited by external agencies are half as likely to support scaling up. Important positive village factors include village population, the presence of storage cracks, and whether a community has an elected committee. Respondents are over twice as likely to support scaling up in areas where engineers detected storage cracks and where committee members are elected. The latter is somewhat surprising, given the previously-revealed associations between elected committees and dissatisfaction with O&M and management.

Table 26: Peru Random Intercept Models - Support for Scaling Up and Leveraging

MODEL INFORMATION	VILLAGE SHOULD SCALE UP	VILLAGE SHOULD LEVERAGE
Sample N	777	776
Loglikelihood	-195	-466
Pseudo R Square	0.773	0.708
Model Type	Binary Logit	Binary Logit
HOUSEHOLD EFFECTS (Odds Ratio)		
Tap Age	1.10*** (1.34)	-0.31 (0.74)
Participation - # Decisions	0.01 (1.01)	0.01 (1.01)
Contribution – # Labor Days	0.01 (1.01)	0.01 (1.01)
Meeting Attendance	0.04* (1.04)	-0.18 (0.84)
PCS Visit Received	-0.66* (0.52)	-0.27 (0.76)
HH Members	-0.01 (1.00)	-0.03 (0.97)
HH Rooms	0.16 (1.17)	-0.001 (1.00)
Income Category	-0.18 (0.84)	-0.59*** (0.56)
Asset Index	0.13 (1.14)	0.05 (1.05)
Age of Respondent	0.02* (1.02)	0.01 (1.01)
Social Capital Score	-0.08** (0.92)	-0.07** (0.94)
System Well Constructed	-1.14*** (0.66)	0.24 (1.22)
Knowledge How Funds Spent	0.32* (1.37)	0.03 (1.03)
VILLAGE EFFECTS		
SANBASUR	0.84 (2.32)	0.19 (1.21)
Operator Years Experience	0.04 (1.04)	0.03 (1.03)
Operator Trained	0.08 (1.08)	0.10 (1.11)
Source – # Dry Months	-0.09 (0.91)	-0.08 (0.92)
Source – Length of Distribution Line	0.02 (1.02)	-0.01 (0.99)
System – Storage Cracks Detected	0.79** (2.20)	0.59*** (1.80)
System – No Distribution Leaks Detected	0.39 (1.48)	0.25 (1.28)
Village Population	0.001* (1.001)	0.000 (1.00)
Village Size	0.001 (1.001)	0.001*** (1.001)
Committee – Years Experience	-0.003 (0.997)	-0.02 (0.98)
Committee Elected	0.76** (2.14)	-0.35 (0.70)
Committee Trained	-0.31 (0.73)	-0.78*** (0.46)

** significant at 10% rejection level, ** significant at 5% rejection level, *** significant at 1% level*

Leveraging enjoyed much more limited support (39%) among households than scaling up. Among household factors, only income and social capital – both negative – explained whether a household would support leveraging investments. Moving from to the next income category decreases the likelihood of favoring a leveraging strategy by a factor of 0.56, while social capital score gains decrease the chances of household support by 0.94. As with the decision to scale up, households are more likely to support leveraging in areas where engineers detected storage cracks in the water system. However, respondents were no more likely to favor leveraging in villages with elected committees, and those who have been trained actually received over 50% less support among households.

Overall, variables in the random intercept models appear as statistically significant approximately 25% of the time. Household and village-level factors average out as significant an equal 25% of the time. Models which feature the largest number of significant factors feature the number of breakdowns and the decision to scale up as their dependent variables. Models which contain the fewest significant variables are those that feature the decision to pay for water and water safety as the dependent variables. Model fit (as measured by the pseudo R square values) indicates that most models provide a significant amount of useful information on the variation of the dependent variables in comparison to the constant-only models. Goodness of fit values are at or near 70% for all models except 1) whether a household pays for water, and 2) the repair time reported by households during their last breakdown.

The random intercept models revealed program differences between SANBASUR and FONCODES regarding whether households paid for water, the amount they paid, and whether the system would function over a ten-year period. A random slope and intercept model also allows one to determine whether the location of households in a SANBASUR vs. a FONCODES village improves the strength of the relationship (positive or negative) between household factors and the dependent indicators in cases where SANBASUR emerged as an important factor. Results suggest that the presence of SANBASUR positively (and significantly beyond a 10% rejection level) increases the slope of household factors shaping whether a household pays for water service and also for those respective factors shaping whether a household believes that the system will function over a ten year period. There was no difference in the slope effect with respect to the amount households paid for service.

6.3.2. Random Intercept Models – Ghana

Table 27 presents findings with respect to household financial measures, specifically whether a household pays for service and the log amount of water payments. Neither variable differs significantly within villages in these models, and in both cases, the various employed tariff structures largely determine whether a household pays and the monthly payment (compared to no tariff). Two household participation variables – previous participation in project decision-making and current participation – both were positively associated with whether a household pays for service. Every additional pre-project decision shaped by households increases the likelihood of payment by a factor of 1.39, while an increase in current meeting participation more than doubles the payment likelihood. By contrast, households that contributed to the project during construction paid about ½ as much in monthly log payments as those who did not.

Table 27: Ghana Random Intercept Models – Household Pays for Water and Monthly Log Payments

MODEL INFORMATION	HH PAYS FOR WATER	AMOUNT PAID FOR WATER/MONTH (Log)
Sample N	916	916
Loglikelihood	-105	-1527
Pseudo R Square	0.948	0.814
Residual Variance	N/A	2.38**
Model	Binary Logit	OLS
HOUSEHOLD EFFECTS (Odds Ratio)		
Participation Index	0.33*** (1.39)	0.02
HH Contributes	-0.85 (0.43)	-0.53**
Meeting Awareness	0.78*** (2.17)	0.03
PCS visit	-0.74 (0.48)	0.05
Social Capital	-0.11 (0.90)	-0.01
Age of Respondent	-0.02 (0.98)	-0.002
HH Members	0.06 (1.06)	-0.01
HH Rooms	-0.19 (0.83)	-0.02
Treats water	0.48 (1.61)	0.41
Monthly Expenditures (log)	0.01 (1.01)	-0.004
Asset Index	-0.03 (0.97)	0.002
System Well Constructed	-0.70 (0.45)	-0.06
Knowledge How Funds Spent	-0.45 (0.64)	0.045
VILLAGE EFFECTS		
Volta Region	1.57 (4.81)	0.27
Watsan Elected	-0.09 (0.91)	0.48
Watsan Years	1.55 (4.71)	-0.04
Watsan Trained	0.37 (1.45)	0.04
Operator – Number of	-1.65 (0.19)	0.21
Distance to Area Mechanic	0.03 (1.03)	0.01
Source: # Dry months	-0.09 (0.91)	0.23
Village Population	-0.000 (1.00)	-0.000
Village Size	0.000 (1.00)	0.000
Tariff Payment – as needed	-0.96	0.328
Tariff Payment - flat fee	6.82***	7.18***
Tariff Payment - HH fee	10.19***	6.86***
Tariff Payment – pay as fetch	9.65***	3.99***

** Significant at 10% rejection level, ** Significant at 5% rejection level,*

**** Significant at 1% rejection level*

Table 28 summarizes the results from regressing two water attribute variables – water pressure and taste – on household and village factors. Households which received some form of PCS were less likely to complain of low pressure by a factor of 0.45, as were those that believed their village had a well-designed system. Households which knew how funds were spent by the watsan committee were significantly more likely to believe that they had lower pressure in the dry season by a factor of 1.83. In villages with any tariff structure, households felt they faced worse water pressure. All were highly significant effects, and the magnitude was strongest among households which were charged "pay as you fetch" tariffs. Households in the Volta region were still over twice as likely to experience lower water pressure. However, those who lived in communities with elected watsans were less than half as likely to report this as a problem.

While the model for water taste employed a multinomial logit model (to account for chemical and mineral tastes as well), the results presented in this table are only based on salty taste. Model results suggested numerous associations. Pre-project household participation and contribution were both positively associated with saltier water, as was current water treatment, respondent age, wealth, and knowledge how funds were spent. Negative household factors included social capital and perception of construction. Nearly all village factors were associated with saltiness. Positive factors included 1) presence in Volta region, 2) elected and trained watsan committees, 3) village size, 4) most tariff schemes. Negative factors were 1) watsan years, 2) number of operators, 3) distance to mechanic, 4) length of dry season, and 5) village population.

Table 28: Ghana Random Intercept Models – Water Attributes

MODEL INFORMATION	LOW WATER PRESSURE	WATER HAS SALTY TASTE
Sample N	932	946
Loglikelihood	-801	-489
Pseudo R Square	0.820	0.828
Model	Ordered Logit	Multinomial Logit
HOUSEHOLD EFFECTS (Odds Ratio)		
Participation Index	0.002 (1.00)	-0.20
HH Contributes	-0.43 (0.65)	4.85***
Meeting Awareness	-0.18 (0.83)	2.19***
PCS visit	-0.79*** (0.45)	-0.88
Social Capital	-0.01 (0.99)	-0.59***
Age of Respondent	0.002 (1.00)	0.175***
HH Members	-0.01 (0.99)	0.334
HH Rooms	0.02 (1.02)	-0.51
Treats water	-0.45 (0.64)	10.7***
Monthly Expenditures (log)	0.06 (1.06)	-0.50
Asset Index	-0.06 (0.94)	0.74**
System Well Constructed	-0.88*** (0.38)	-1.43*
Knowledge How Funds Spent	0.60*** (1.83)	4.68***
VILLAGE EFFECTS		
Volta Region	0.84* (2.32)	22.08***
Watsan Elected	-0.74** (0.48)	3.32***
Watsan Years	0.03 (1.03)	-0.33***
Watsan Trained	0.05 (1.05)	3.57***
Operator – Number of	-0.55 (0.58)	-2.06***
Distance to Area Mechanic	-0.002 (1.00)	-0.08***
Source: # Dry months	-0.55 (0.58)	-2.98***
Village Population	0.000 (1.00)	-0.001*
Village Size	-0.02 (0.98)	0.52**
Tariff Payment – as needed	1.18**	2.24
Tariff Payment - flat fee	1.22***	5.96***
Tariff Payment - HH fee	0.85**	23.16***
Tariff Payment – pay as fetch	1.77***	6.83***

** Significant at 10% rejection level, ** Significant at 5% rejection level*

**** Significant at 1% rejection level*

Administrative satisfaction and trust both rated high among over 80% of Ghanaian household respondents. Table 29 reports respective model results. Variance analysis detected some within-village variation for administrative satisfaction and very little variation with respect to trust. Yet thresholds for both models appeared significant in model estimation. Household factors that predicted both satisfaction and trust included 1) the number of people in a household (+), 2) the size of the house (-), 3) social capital (+), 4) knowledge how funds are spent (+). An increase of one additional person in the household is associated with higher administration by a factor of 1.12 and higher trust by a factor of 1.05. Respondents are 8-9% more likely not to be satisfied with nor trust the watsan committee for every additional room in the home. The magnitude of social capital attitudes resonated higher with respect to watsan trust and satisfaction – unit increases in scores were associated with approximately 25% gains in satisfaction and trust. Finally, household knowledge concerning the watsan's financial dealings impacted satisfaction and trust to the largest extent, as households with progressive increases in awareness were almost three times as likely to support watsan activities. As with Peru, income (as measured in Ghana by monthly expenditures) arises as a negative predictor of watsan satisfaction, yet watsan trust was not swayed by differences in logged expenditures. Several other household factors additionally appear as important determinants in watsan trust. Households are 7% more likely to trust watsans for every additional pre-project decision in which they participated, but less likely if they currently are involved with meetings (although the magnitude of this effect is negligible). Households who contributed to the project are more suspicious of the committee than those who did not do so. Households also tend to trust watsans if they have been visited by an external agency – a visit increases trust by over 40% compared to no visit.

The two village factors that are related both to trust and satisfaction are the distance of an area mechanic (negatively related) and the use of periodic collection fees vs. no fees (positively related). Every additional kilometer a mechanic lives from the village was associated with lower degrees of watsan satisfaction by 1% and trust by 2%. Village size has a positive effect on satisfaction but no effect on watsan trust. Households in villages with occasional collections are much more likely to be satisfied with their committees than those which have no fees, but only slightly more likely to trust the watsans. Those who pay flat water fees trust their committees a little more than those with no fees, but no detectable difference exists when measuring household satisfaction. Households trust watsans about 6% less for every additional year of service, while they place over 40% more trust in them if they have been trained to handle their committee responsibilities.

Table 29: Ghana Random Intercepts Models – Watsan Satisfaction & Trust

MODEL INFORMATION	WATSAN SATISFACTION	WATSAN TRUST
Sample N	1111	1103
Loglikelihood	-426	-559
Pseudo R Square	0.884	0.846
Model	Ordered Logit	Ordered Logit
HOUSEHOLD EFFECTS (Odds Ratio)		
Participation Index	0.02 (1.02)	0.07* (1.07)
HH Contributes	-0.10 (0.90)	-0.73*** (0.48)
Meeting Awareness	0.15 (1.16)	-0.001*** (1.00)
PCS visit	1.02 (2.77)	0.34* (1.41)
Social Capital	0.24*** (1.27)	0.22*** (1.24)
Age of Respondent	-0.003 (1.00)	0.004 (1.00)
HH Members	0.12*** (1.12)	0.05* (1.05)
HH Rooms	-0.10** (0.91)	-0.09** (0.92)
Treats water	0.47 (1.60)	0.28 (1.33)
Monthly Expenditures (log)	-0.34* (0.71)	-0.04 (0.96)
Asset Index	-0.05 (0.96)	-0.05 (0.95)
System Well Constructed	0.23 (1.25)	0.32* (1.38)
Knowledge How Funds Spent	1.02*** (2.77)	0.89*** (2.43)
VILLAGE EFFECTS		
Volta Region	-0.53 (0.59)	-0.36 (0.70)
Watsan Elected	0.34 (1.40)	0.26 (1.30)
Watsan Years	-0.06 (0.94)	-0.06* (0.94)
Watsan Trained	0.25 (1.28)	0.35*** (1.42)
Operator – Number of	0.52 (1.68)	-0.04 (0.96)
Distance to Area Mechanic	-0.02** (0.98)	-0.01* (0.99)
Source: # Dry months	-0.13 (0.88)	-0.17 (0.84)
Village Population	-0.000 (1.00)	-0.000 (1.00)
Village Size	0.03* (1.03)	0.015 (1.015)
Tariff Payment – as needed	1.78***	1.03*
Tariff Payment - flat fee	0.49	0.96**
Tariff Payment - HH fee	-0.04	0.74
Tariff Payment – pay as fetch	-0.28	0.21

** Significant at 10% rejection level, ** Significant at 5% rejection level*

**** Significant at 1% rejection level*

Table 30 highlights effects on household responses to five year performance and the decision to scale up services. About 70% of households think their system will perform over the next five years. Household factors influence this decision more frequently than village-level attributes in the sample. Households with higher social capital scores, which treat water, and who believe in the integrity of their systems have more confidence in this short-term performance. Unit increases in social capital scores increase the likelihood of system confidence by a factor of 1.04, while those who value system construction are about 40% more likely to believe the handpumps will keep running. However, households that are more aware of meetings and how funds are spent are less confident in the watsan to keep the system running. Meeting awareness exhibits virtually no statistical impact on perceptions of future performance, but increases in the knowledge of watsan financial dealings are associated with a decreased likelihood of household confidence in five year system operation by a factor of 0.70. The distance of area mechanics plays a minor role in responses – villages where area mechanics travel further to get there contain households which are 1% less ebullient about future function for every additional kilometer. Finally, regional differences persist. Volta households are about 80% more confident that their systems will keep going than Brong Ahafo residents after controlling for other factors.

An overwhelming number of respondents would like the watsan committees to scale up their efforts. Households that originally contributed to the project, report higher social capital scores, and know how their money is spent are more likely to support these efforts. Committee knowledge is particularly important since households are more than twice as likely to support a watsan's efforts to scale up. A number of village-level factors influenced household responses. Households with elected watsans were over twice as likely to support scaling up practices. Volta households were over five times as likely to do the same. Increases in mechanic's distances increased the probability that villagers would choose to scale up by 2% for every kilometer and 1% for every additional traveled minute in the village. Negative influences featured village population and the number of operators in a village. For every additional caretaker, households were 65% less likely to support the idea.

Factors in these analyses appear as significant an average of 38.5% of the time. Village-level factors are significant on average slightly more often than household factors (39% to 38%). Water taste and watsan trust contain the largest number of significant factors, while the two financial models perform the poorest in this regard. Pseudo R-square values are relatively high for all of the models, indicating that the household and village variables included have added important information to the structure of the data over models which only feature a constant.

Table 30: Ghana Random Intercept Models – Five Year Confidence and Prospects for Scaling Up Services

MODEL INFORMATION	FIVE-YEAR CONFIDENCE	WATSAN SHOULD SCALE UP
Sample N	1112	1062
Loglikelihood	-4018	-319
Pseudo R Square	0.781	0.766
Model	Binary Logit	Binary Logit
HOUSEHOLD EFFECTS (Odds Ratio)		
Participation Index	0.03 (1.03)	-0.05 (0.95)
HH Contributes	0.27 (1.32)	-0.04 (0.97)
Meeting Awareness	-0.002*** (1.00)	0.32* (1.38)
PCS visit	0.15 (1.17)	0.03 (1.03)
Social Capital	0.04** (1.04)	0.05* (1.05)
Age of Respondent	0.004 (1.00)	-0.01 (0.99)
HH Members	-0.02 (0.98)	-0.001 (1.00)
HH Rooms	0.02 (1.02)	-0.02 (0.99)
Treats water	0.97*** (2.64)	0.17 (1.18)
Monthly Expenditures (log)	-0.03 (0.97)	-0.25 (0.78)
Asset Index	0.02 (1.02)	0.09 (1.09)
System Well Constructed	0.32*** (1.41)	0.06 (1.07)
Knowledge How Funds Spent	-0.36*** (0.70)	0.73*** (2.08)
VILLAGE EFFECTS		
Volta Region	0.58* (1.79)	1.63*** (5.10)
Watsan Elected	0.15 (1.16)	0.76*** (2.14)
Watsan Years	-0.01 (0.99)	0.05 (1.05)
Watsan Trained	-0.03 (0.97)	0.15 (1.16)
Operator – Number of	0.17 (1.19)	-1.06*** (0.35)
Distance to Area Mechanic	-0.01*** (0.99)	0.02*** (1.02)
Source: # Dry months	0.01 (1.01)	0.16 (1.17)
Village Population	0.000 (1.00)	-0.001*** (0.999)
Village Size	0.002 (1.00)	0.04***(1.04)
Tariff Payment – as needed	0.01	-0.71
Tariff Payment - flat fee	-0.32	-0.98
Tariff Payment - HH fee	-0.10	-0.29
Tariff Payment – pay as fetch	-0.43	-0.57

** Significant at 10% rejection level, ** Significant at 5% rejection level *** Significant at 1% rejection level*

6.3.3. Structural Models – Peru

Table 31 summarizes the household-level exogenous and endogenous variables considered in these models.

Table 31: Household-level Exogenous and Endogenous Variables in Structural Equation Models

VARIABLE	TYPE	HYPOTHESIZED EFFECTS ON ENDOGENOUS VARIABLES
# Members	Exogenous	Participation (-), Contributions (+), Meetings (-), Funds Spent (-)
# Rooms	Exogenous	Participation (+), Contributions (+), Meetings (+), Funds Spent (+)
Income	Exogenous	Participation (+), Contributions (+), Meetings (+), Funds Spent (+)
Assets	Exogenous	Participation (+), Contributions (+), Meetings (+), Funds Spent (+)
Respondent Age	Exogenous	Participation (-), Contribution (-), Meetings (-), Funds Spent (-)
Social Capital	Exogenous	Participation (+), Contribution (+), Meetings (+), Funds Spent (+)
PCS Visit	Exogenous	Participation (0), Contribution (0), Meetings (+), Funds Spent (+)
Age of Tap	Exogenous	None
Perception of Construction	Exogenous	None
Pre-Project Participation	Endogenous	None
Pre-Project Contribution	Endogenous	None
Current Meeting Attendance	Endogenous	None
Current Knowledge How Funds Spent	Endogenous	None

The ideas behind the indirect hypotheses are as follows. Adults in households with larger families are less likely to have participated in pre-project decisions and less likely to be aware of current dealings due to the need to take care of more people in the household. However, they are more likely to have contributed labor because more family members would have been available. Families with larger homes, higher incomes, greater wealth, and a stronger sense of social capital would be more likely to participate in projects, contributed more easily to projects, participate in current meetings, and know how funds are spent. Older respondents would be less interested in participation, less capable of contributing labor, and less aware how funds are spent. Post-construction support would neither affect pre-project participation or contributions (since these occurred before operation), yet it may positively enhance current participation and awareness how funds are spent. This analysis does assume that any change in the exogenous variables before and after the project remains proportional (i.e. incomes among households did not shift from the time a project was designed until the present that would change how income may have affected pre-project vs. post-project endogenous factors). It is an important assumption, but there is no evidence of dramatic changes in these communities that would challenge its' credibility.

These models are specified based on information from the random intercept models. At the household level, all direct effects are estimated. Indirect effects for exogenous variables are estimated based on the significance of the endogenous variables. For example, regressing the number of tap leaks on household-level variables would not require a structural model because none of the endogenous variables above significantly influenced the outcome in the random intercept model. Yet a structural model would be in order for the other physical performance outcome variable – repair days – since meeting attendance was initially associated with an increase in the number of repair days needed. Thus, each structural model calculates all household-level direct effects and regresses significant endogenous variables from the previous models on the specified exogenous factors to determine any additional indirect effects. These models are intended to present a more complete picture of the relationships between non-project household variables, project-based variables, and outcomes of performance.

The focus of these models rests primarily on detecting household-level impacts. Village-level factors are mostly exogenous in these models since very few (e.g. water source, village size, etc.) can be considered functions of other variables. The program type variable (SANBASUR) may influence other village-level factors, such as operator and water committee training, yet the lack of information on other village factors inhibits structural model estimation. Previous model results inform specification of these models. Most models include program type, village population, and village size. In addition, each model which contained significant village factors from the RI models are included as controls in the structural models below. Finally, these models have included a variable for 'cost recovery' – measured as a binary variable indicating whether the committee has indicated that revenues from households cover annual operating costs – in those situations where the dependent variable represents administrative satisfaction, trust, and future operation. These represent the only cases where village-level indirect effects are calculated.

This background forms the basis of the models summarized below. The top of each table resembles the format of the random intercept table results, except that a sample size-adjusted Bayesian Information Criterion is reported instead of a pseudo R^2. The latter statistic is not useful in structural models since there is more than one equation to consider in estimation. Each of the following tables' first columns list unstandardized coefficients (and odds ratios for categorical variables) which are considered direct effects on the outcome variables. The second column reports the effects of exogenous variables on significant endogenous variables, which are listed in the third column beside it. A fourth column highlights the sign of the indirect effect of the exogenous variable on the outcome. White cells indicate that indirect effects were estimated but were not significant in the model. Cells with upward-sloping lines indicate significant positive effects, while cells with downward-sloping lines indicate significant negative effects. Cells with trellises (cross-hatched lines) represent cases where indirect effects may be considered both positive and negative – these are situations where an exogenous variable positively influences the outcome via one endogenous variable and simultaneously, negatively influences the outcome via a second endogenous variable. Finally, cells coded in gray represent cases where effects were not estimated.

There are four possibilities which determine the cells in the fourth column (besides the gray cells). Variables which contain white cells in the table are those where either the direct effect of the endogenous variable on the outcome is not significant or the effect of the exogenous variable on the endogenous variable is not significant. That is, both coefficients must be significant in order to have any indirect effect. Cells with upward-sloping lines indicate the presence of a positive indirect effect. This occurs in two cases: 1) where an exogenous variable positively influences an endogenous variable and that endogenous variable positively influences the outcome, or 2) where an exogenous variable negatively influences an endogenous variable which in turn has a negative impact on the outcome. The latter situation occurs because indirect effects are calculated as the product of the two coefficients – allowing for a 'double negative' (and thus positive) association with the outcome. Cells with downward-sloping lines exhibit the reverse situation (the third case), in which only one of the significant effects is negative. For example, if household income is positively associated with household contributions but contributions in turn negatively impacts water committee satisfaction, then one can infer that income indirectly is negatively associated with satisfaction. The final case (cross-hatched lines in a cell) occurs when positive and negative indirect effects are present. This happens when there are at least two significant indirect effects (e.g. mediated by two different endogenous variables) that have opposite signs. Treatment of these indirect effects is consistent with the literature on structural equation modeling.

With this background in mind, the reader may now turn to the results. The physical performance results from the application of the random intercept models in the case of Peru demonstrated that none of the four endogenous variables (pre-project participation, contributions, current meeting attendance, and awareness of committee spending) influenced the number of household breakdowns. Thus no structural models were attempted. However, current meeting attendance did influence the length of repair days, so a structural model calculated the direct effects of all household variables on repair days as well as the indirect effects of exogenous household variables on repair days via their influence on meeting attendance. The results are shown in Table 32.

Respondents in wealthier households and older respondents reported fewer days to repair problems with household taps. Households with increases in asset index scores experienced over 2 ½ fewer days in repair times. Those with higher social capital scores reported longer wait times, although the effect (less than one full day) is fairly weak. The magnitude of the effect of household membership size declines in importance in this model as compared to the RI model, as does the influence of village population. The model postulated that meeting attendance (a significant variable in the RI model) could be explained as a function of seven exogenous household variables. However, since meeting attendance is not significantly associated with wait time, no indirect effects emerge as important in this model.

Table 32: Peru Structural Equation Models – Number of Repair Days

MODEL INFORMATION	EFFECT ON OUTCOME	EFFECT ON SIGN. ENDOGENOUS VARIABLE	SIGNIFICANT ENDOGENOUS VARIABLE[1]	DIRECTION OF INDIRECT EFFECT[2]
Sample N	512			
Loglikelihood	-4696			
BIC-adjusted	9508			
Residual Variance	17.51			
Model Type	Ordinary Least Squares			
HOUSEHOLD EFFECTS				
Tap Age	-0.37			
Participation - # Decisions	0.20			
Contribution – # Labor Days	-0.09			
Meeting Attendance	-0.95			
PCS Visit Received	-0.82			
HH Members	1.16			
HH Rooms	-1.03			
Income Category	-0.95			
Asset Index	-2.76**			
Age of Respondent	-0.47***			
Social Capital Score	0.93*			
System Well Constructed	2.55			
Knowledge How Funds Spent	-3.88			
VILLAGE EFFECTS				
SANBASUR	-2.41			
Operator Years Experience				
Operator Trained				
Source – # Dry Months				
Source – Length of Distribution Line				
System – Storage Cracks Detected				
System – No Distribution Leaks Detected				
Village Population	0.000			
Village Size	-0.01***			
Committee – Years Experience				
Committee Elected				
Committee Trained				
Operating Costs Recovered from HHs				

** significant at 10% rejection level, ** significant at 5% rejection level, *** significant at 1% level*

1: No significant endogenous variables in model

2: Grey cells = not included in model, White cells = not statistically significant at 10% rejection level, Cells with upward lines = positive and significant at 10% level, Cells with downward lines = negative and significant at 10% level

The next model, reported in Table 33, considers the direct and indirect effects of household factors and direct village-level influences on whether a household pays for water. Households that know how money is spent in the village for the project and those with more wealth are more likely to pay for water service by factors of 1.48 and 1.44, respectively. Contribution levels no longer are associated with whether households pay for water as in the RI model. Regressing household knowledge of committee spending on exogenous variables shows some interesting indirect effects. The impact of wealth is directly and indirectly associated with whether households pay for water – wealthier households are about 20% more likely to keep tabs on committee's finances. Households with higher social capital are also more likely to know how money is spent (unit increases increase the likelihood by over 10%), which influences whether they pay for service. By contrast, older respondents are less certain how funds are spent in the village and therefore less likely to pay for water. Regarding village impacts, households in SANBASUR communities and larger-sized areas were again more likely to pay for water service and less likely in cases with long-serving operators (as previously seen in the RI model).

The other financial indicator – household payments – is also regressed on village and household factors. Results appear in Table 34. At the village level, only two of the regressors – SANBASUR and the length of the dry season – emerge as significant explanatory variables. Both are negative as in the previous model specification. SANBASUR households pay -0.29 soles less than FONCODES households when controlling for other factors, while an increase in the number of months of the dry season is associated with slightly lower payments (-0.08 soles) per month. Households with older taps, higher income, and more positive attitudes about social capital pay more for water service, although the effect sizes are very small. Household labor contributions during the construction phase are also negatively associated with water expenditures, although again the effects are limited in size. A regression of contributed household labor on exogenous factors suggests divergent indirect effects for the two important household factors; income and social capital. Social capital and labor were positively associated, which means that the total effect of social capital on water payments is reduced due the presence of this negative indirect relationship. By comparison, households with higher incomes contributed less labor. Thus, the total effect of income on payments is strengthened due to this 'double negative' indirect effect.

Table 33: Peru Structural Equation Models – Users Pay for Water Service

MODEL INFORMATION	EFFECT ON OUTCOME	EFFECT ON SIGNIFICANT ENDOGENOUS VARIABLE	SIGNIFICANT ENDOGENOUS VARIABLE	DIRECTION OF SIGNIFICANT INDIRECT EFFECTS[1]
Sample N	1199			
Loglikelihood	-6481			
BIC-adjusted	13102			
Model Type	Binary Logit			
HOUSEHOLD EFFECTS (Odds Ratio)				
Tap Age	0.43 (1.53)			
Participation - # Decisions	-0.04 (0.96)			
Contribution – # Labor Days	-0.01 (0.99)			
Meeting Attendance	0.16 (1.17)			
PCS Visit Received	-0.18 (0.838)			
HH Members	0.05 (1.05)	0.003 (1.003)	Funds Spent	
HH Rooms	0.07(1.07)	-0.02 (0.98)	Funds Spent	
Income Category	-0.23 (0.79)	-0.10 (0.90)	Funds Spent	
Asset Index	0.36*** (1.44)	0.19*** (1.21)	Funds Spent	
Age of Respondent	-0.01 (0.99)	-0.02*** (0.98)	Funds Spent	
Social Capital Score	-0.06 (0.95)	0.11*** (1.12)	Funds Spent	
System Well Constructed	0.10 (0.90)			
Knowledge How Funds Spent	0.39*** (1.48)			
VILLAGE EFFECTS				
SANBASUR	2.59*** (13.33)			
Operator Years Experience	-0.18* (0.84)			
Operator Trained				
Source – # Dry Months				
Source – Length of Distribution Line				
System – Storage Cracks Detected				
System – No Distribution Leaks Detected				
Village Population	0.000 (1.00)			
Village Size	0.001** (1.001)			
Committee – Years Experience				
Committee Elected				
Committee Trained				
Operating Costs Recovered from HHs				

** significant at 10% rejection level, ** significant at 5% rejection level, *** significant at 1% level*

2: Grey cells = not included in model, White cells = not statistically significant at 10% rejection level, Cells with upward lines = positive and significant at 10% level, Cells with downward lines = negative and significant at 10% level

Table 34: Peru Structural Equation Models – Payments for Water Service

MODEL INFORMATION	EFFECTS ON OUTCOME	EFFECTS ON SIGNIFICANT ENDOGENOUS VARIABLES	SIGNIFICANT ENDOGENOUS VARIABLES	DIRECTION OF SIGNIFICANT INDIRECT EFFECTS[1]
Sample N	889			
Loglikelihood	-5316			
BIC-adjusted	10770			
Model Type	OLS			
Residual Variance	0.14***			
HOUSEHOLD EFFECTS				
Tap Age	0.04*			
Participation - # Decisions	-0.01			
Contribution – # Labor Days	-0.01*			
Meeting Attendance	-0.01			
PCS Visit Received	0.05			
HH Members	-0.01	0.49	Contributions	
HH Rooms	-0.001	-0.11	Contributions	
Income Category	0.04**	-3.54**	Contributions	
Asset Index	-0.01	-0.57	Contributions	
Age of Respondent	-0.001	-0.03	Contributions	
Social Capital Score	0.01**	0.88***	Contributions	
System Well Constructed	0.01			
Knowledge How Funds Spent	-0.04			
VILLAGE EFFECTS				
SANBASUR	-0.29**			
Operator Years Experience				
Operator Trained	0.02			
Source – # Dry Months	-0.08***			
Source – Length of Distribution Line				
System – Storage Cracks Detected				
System – No Distribution Leaks Detected				
Village Population	0.000			
Village Size	0.000			
Committee – Years Experience	-0.01			
Committee Elected				
Committee Trained	0.09			
Operating Costs Recovered from HHs				

** significant at 10% rejection level, ** significant at 5% rejection level, *** significant at 1% level*

2: Grey cells = not included in model, White cells = not statistically significant at 10% rejection level, Cells with upward lines = positive and significant at 10% level, Cells with downward lines = negative and significant at 10% level

The previous random intercept models did not detect any statistically significant relationships between endogenous household variables and water safety. Low water pressure was correlated with meeting attendance; thus a structural equation model predicts direct effects as well as indirect household effects using meeting attendance as an intermediary variable. Table 35 finds that low pressure is negatively associated with older taps, higher construction quality, and meeting attendance. Meeting attendance was regressed on other variables, and indirect effects are witnessed for respondent age (positive) and social capital, income, and PCS (all negative). Households with higher degrees of social capital, higher incomes, and those that received post-construction visits are 9%, 32%, and over 165% more likely to attend meetings and thus indirectly less likely to report lower water pressure. At the village level, significant direct factor effects occur in the same direction as the RI model except that operator training (a previously weak negative determinant) drops out in importance in the structural model.

Table 35: Peru Structural Equation Models – Low Water Pressure

MODEL INFORMATION	EFFECTS ON OUTCOME	EFFECTS ON SIGNIFICANT ENDOGENOUS VARIABLES	SIGNIFICANT ENDOGENOUS VARIABLES	DIRECTION OF SIGNIFICANT INDIRECT EFFECTS[1]
Sample N	813			
Loglikelihood	-3123			
BIC-adjusted	6419			
Model Type	Ordered Logit			
HOUSEHOLD EFFECTS (Odds Ratio)				
Tap Age	-0.29* (0.75)			
Participation - # Decisions	-0.01 (0.99)			
Contribution – # Labor Days	0.00 (1.00)			
Meeting Attendance	-0.19*** (0.82)			
PCS Visit Received	0.06 (1.06)	0.98*** (2.66)	Meeting Attendance	
HH Members	-0.04 (0.96)	-0.02 (0.98)	Meeting Attendance	
HH Rooms	-0.02 (0.98)	0.08 (1.08)	Meeting Attendance	
Income Category	0.19 (1.21)	0.28*** (1.32)	Meeting Attendance	
Asset Index	-0.12 (0.89)	-0.12 (0.89)	Meeting Attendance	
Age of Respondent	-0.01 (0.99)	-0.02*** (0.98)	Meeting Attendance	
Social Capital Score	-0.02 (0.98)	0.09*** (1.09)	Meeting Attendance	
System Well Constructed	-0.50*** (0.60)			
Knowledge How Funds Spent	-0.15 (0.86)			
VILLAGE EFFECTS				
SANBASUR	0.12 (1.13)			
Operator Years Experience				
Operator Trained	-0.26 (0.77)			
Source – # Dry Months				
Source – Length of Distribution Line	0.13** (1.14)			
System – Storage Cracks Detected				
System – No Distribution Leaks Detected	-0.50*** (0.60)			
Village Population	-0.000 (1.00)			
Village Size	-.001*** (0.99)			
Committee – Years Experience				
Committee Elected	-0.66* (0.52)			
Committee Trained				
Operating Costs Recovered from HHs				

** significant at 10% rejection level, ** significant at 5% rejection level, *** significant at 1% level*

2: Grey cells = not included in model, White cells = not statistically significant at 10% rejection level, Cells with upward lines = positive and significant at 10% level, Cells with downward lines = negative and significant at 10% level

Operation and maintenance satisfaction is handled slightly differently than other models. This model postulates it as a function of the household and village-level regressors plus the repair time a household experiences. At the household level, therefore, there are five endogenous variables: 1) pre-project participation, 2) pre-project contributions, 3) current participation, 4) knowledge how funds spent, and 5) repair time. Table 36 shows that participation, contribution, and knowledge of how funds are spent no longer are significant in the model (as they were in the random intercept specifications). However, higher repair times and meeting attendance are negatively associated with satisfaction (as expected). The previous regression showed that asset wealth and respondent age were associated with lowered responses on wait times, and here these variables are also indirectly associated with improving satisfaction. In this model, social capital drops out as carrying any significant indirect effects on satisfaction with O&M, even though it originally appeared as significant in the regression on wait time. The three explanatory variables which arose as important from the other O&M model specification (SANBASUR, operator service, and village size) also appear significant in this model.

Table 36: Peru Structural Equation Models – O&M Satisfaction

MODEL INFORMATION	EFFECTS ON OUTCOME	EFFECTS ON SIGNIFICANT ENDOGENOUS VARIABLES	SIGNIFICANT ENDOGENOUS VARIABLES	DIRECTION OF SIGNIFICANT INDIRECT EFFECTS[1,2]
Sample N	485			
Loglikelihood	-4705			
BIC-adjusted	9300			
Model Type	Ordered Logit			
HOUSEHOLD EFFECTS (Odds Ratio)				
Tap Age	-0.15*** (0.86)			
Participation - # Decisions	-0.04 (0.96)			
Contribution – # Labor Days	-0.002 (0.998)	-0.003	Repair Days	
Meeting Attendance	-0.29 (0.75)	0.05	Repair Days	
PCS Visit Received	0.05 (1.05)			
HH Members	0.01 (1.01)	0.05	Repair Days	
HH Rooms	0.04 (1.04)			
Income Category	-0.21 (0.81)			
Asset Index	-0.04 (0.96)	-0.15***	Repair Days	
Age of Respondent	-0.02 (0.98)	-0.02***	Repair Days	
Social Capital Score	-0.03 (0.97)			
System Well Constructed	0.44** (1.55)			
Knowledge How Funds Spent	0.27 (1.31)			
Number of Repair Days – last breakdown (log)	-0.30*** (0.74)			
VILLAGE EFFECTS				
SANBASUR	1.08*** (2.94)			
Operator Years Experience	-0.12*** (0.89)			
Operator Trained	0.000 (1.00)			
Source – # Dry Months				
Source – Length of Distribution Line				
System – Storage Cracks Detected				
System – No Distribution Leaks Detected				
Village Population	0.000 (1.00)			
Village Size	0.001*** (1.001)			
Committee – Yrs. Experience				
Committee Elected				
Committee Trained				
Operating Costs Recovered				

** significant at 10% rejection level, ** significant at 5% rejection level, *** significant at 1% level*

1: Grey cells = not included in model, White cells = not statistically significant at 10% rejection level, Cells with upward lines = positive and significant at 10% level, Cells with downward lines = negative and significant at 10% level

2: Indirect effects via repair time

Tables 37 and 38 examine some direct village and household effects and signs of indirect household effects on committee satisfaction and trust. Some differences emerge in comparing the RI model for administrative satisfaction with the structural model. Households which contributed less labor and believe the system is well-constructed are still more satisfied with water committees. Again, the magnitude of the effects is small for contributions (0.99) and large for construction quality (2.07). Respondents who knew how funds were spent were more no more likely than others to have confidence in the committee. Other factors assume greater importance in this model. Increases in social capital scores decrease administrative satisfaction by a factor of 0.93, while every additional member in the household increases the likelihood of committee support by a factor of 1.095. When contributions are regressed on exogenous factors, the negative relationship between social capital and the satisfaction with the water committee is actually strengthened, since people with more social capital also contributed more labor to the project. In contrast, the total positive effect of household size is mitigated by the fact that larger households were more likely to contribute project labor. The effect of income is indirectly positive, since wealthier households contributed less labor than others. At the village level, the training of committees in villages has led households to support their water committees. There is also a strong positive relationship between cost recovery and committee satisfaction. However, the only village-level variable that significantly influenced cost recovery was whether SANBASUR had organized the project – in these areas, households were nearly six times more likely to be satisfied with the committee if they were recovering their costs.

An examination of household trust in the committees also produced some interesting total effects. Table 38 reports that older respondents were slightly less trustworthy than others with respect to the committee, yet those with older taps were much more trustworthy by a factor of 1.36. Those who knew how the committee spent its resources trusted their leaders as often as those with older taps. Regressing this endogenous factor found that wealth, social capital, and PCS visits exerted indirect positive effects on trust in the water committees, while household size and respondent age registered as negative indirect impacts. Unit increases in social capital scores and asset index values improved the likelihood of knowing how funds were spent by factors of 1.13 and 1.22, while households visited in the post-construction phase were more than twice as likely to know how funds were spent. Operator service remained a negative influence on trust (as in the RI model), but others factors (such as village size and election of committees) flipped their signs. Since cost recovery was not an important determinant of committee trust, no indirect effects were reported in the table.

Table 37: Peru Structural Equation Models – Administrative Satisfaction

MODEL INFORMATION	EFFECTS ON OUTCOME	EFFECTS ON SIGNIFICANT ENDOGENOUS VARIABLES	SIGNIFICANT ENDOGENOUS VARIABLES	DIRECTION OF SIGNIFICANT INDIRECT EFFECTS[1]
Sample N	796			
Loglikelihood	-4877			
BIC-adjusted	9940			
Model Type	Ordered Logit			
HOUSEHOLD EFFECTS (Odds Ratio)				
Tap Age	0.05 (1.05)			
Participation - # Decisions	-0.002 (0.99)			
Contribution – # Labor Days	-0.01** (0.99)			
Meeting Attendance	-0.10 (0.90)			
PCS Visit Received	-0.16 (0.85)			
HH Members	0.09** (1.10)	0.09**	Contributions	
HH Rooms	0.01 ((1.01)	-0.10	Contributions	
Income Category	-0.17* (0.84)	-3.15**	Contributions	
Asset Index	-0.02 (0.98)	-0.07	Contributions	
Age of Respondent	0.004 (1.00)	0.18	Contributions	
Social Capital Score	-0.07*** (0.93)	0.69**	Contributions	
System Well Constructed	0.73*** (2.07)			
Knowledge How Funds Spent	0.15 (1.16)			
VILLAGE EFFECTS				
SANBASUR	-0.20 (0.82)	1.77** (5.87)	Operating Costs	
Operator Years Experience				
Operator Trained				
Source – # Dry Months				
Source – Length of Distribution Line				
System – Storage Cracks Detected				
System – No Distribution Leaks Detected				
Village Population	0.000 (1.00)	0.001 (1.001)	Operating Costs	
Village Size	-.003*** (0.99)	0.03 (1.03)	Operating Costs	
Committee – Years Experience	-0.02 (0.98)	0.10 (0.90)	Operating Costs	
Committee Elected	-0.55 (0.58)	-0.81 (0.44)	Operating Costs	
Committee Trained	0.57* (1.77)	-0.90 (0.41)	Operating Costs	
Operating Costs Recovered from HHs	0.45*** (1.57)			

** significant at 10% rejection level, ** significant at 5% rejection level, *** significant at 1% level*

1: Grey cells = not included in model, White cells = not statistically significant at 10% rejection level, Cells with upward lines = positive and significant at 10% level, Cells with downward lines = negative and significant at 10% level

Table 38: Peru Structural Equation Models – Administrative Trust

MODEL INFORMATION	EFFECT ON OUTCOMES	EFFECT ON SIGNIFICANT ENDOGENOUS VARIABLES	SIGNIFICANT ENDOGENOUS VARIABLES	DIRECTION OF SIGNIFICANT INDIRECT EFFECTS[1]
Sample N	884			
Loglikelihood	-3882			
BIC-adjusted	7933			
Model Type	Ordered Logit			
HOUSEHOLD EFFECTS (Odds Ratio)				
Tap Age	0.30** (1.36)			
Participation - # Decisions	-0.03 (0.97)			
Contribution – # Labor Days	-0.002 (1.00)			
Meeting Attendance	0.01 (1.01)			
PCS Visit Received	-0.14 (1.04)	0.71*** (2.03)	Funds Spent	
HH Members	0.05 (1.05)	0.05 (1.05)	Funds Spent	
HH Rooms	0.03 (1.03)	-0.10** (0.90)	Funds Spent	
Income Category	-0.02 (0.98)	-0.14 (0.87)	Funds Spent	
Asset Index	0.03 (1.03)	0.20*** (1.22)	Funds Spent	
Age of Respondent	-0.01*** (0.99)	-0.02*** (0.98)	Funds Spent	
Social Capital Score	0.04 (1.04)	0.12*** (1.13)	Funds Spent	
System Well Constructed				
Knowledge How Funds Spent	0.34*** (1.41)			
VILLAGE EFFECTS				
SANBASUR	0.08 (1.08)			
Operator Years Experience	-0.07* (0.93)			
Operator Trained				
Source – # Dry Months				
Source – Length of Distribution Line				
System – Storage Cracks Detected				
System – No Distribution Leaks Detected				
Village Population	0.00 (1.00)			
Village Size	-0.002*** (0.99)			
Committee – Years Experience				
Committee Elected	0.65** (1.92)			
Committee Trained				
Operating Costs Recovered from HHs	0.20 (1.22)			

** significant at 10% rejection level, ** significant at 5% rejection level, *** significant at 1% level*

1: Grey cells = not included in model, White cells = not statistically significant at 10% rejection level, Cells with upward lines = positive and significant at 10% level, Cells with downward lines = negative and significant at 10% level

Tables 39 and 40 summarize model results for whether a respondent believes their system will function over the next five and ten year periods. People whose households contributed to the water system were slightly more likely to have confidence over both periods of time. Those who judged their systems as well-designed and knew how money was spent were more likely to believe their systems would perform over both time frames. The magnitudes for these effects were relatively large – households that viewed system construction more favorably were more likely to have confidence by a factor of 1.79, while those who knew how funds were spent also exuded more confidence by a factor of 1.27. In contrast, movements into higher income brackets lowered confidence by one-third; an effect similar to that found in the RI specification. Respondent age and attitudes toward social capital (weakly) also improved the chances they would say yes over a five year period, but failed to reject the null hypothesis over a ten year frame. Indirect effects were identical across five or ten year periods. Via labor contributions, households with more members thought their systems would function over time while higher-income households did not think this was the case. Indirect effects of post-construction support, social capital, and wealth via knowledge of spending showed that these households were more likely to believe they would perform, while older respondents and again higher-income households did not find that their system would be maintained over these time frames. No village factors emerged as significant in the five-year model, while only households in SANBASUR communities were more likely to believe that their system would not function in the next ten years.

Table 39: Peru Structural Equation Models – Confidence Over Five Year Period

MODEL INFORMATION	EFFECT ON OUTCOME	EFFECT ON SIGN. ENDO. VARIABLE	SIGNIFICANT ENDOGENOUS VARIABLE	DIRECTION OF INDIRECT EFFECTS[1]
Sample N	955			
Loglikelihood	-5499			
BIC-adjusted	11127			
Model Type	Binary Logit			
HOUSEHOLD EFFECTS (Odds Ratio)				
Tap Age	0.23 (1.26)			
Participation - # Decisions	0.03 (1.03)			
Contribution – # Labor Days	0.02** (1.02)			
Meeting Attendance	0.05 (1.05)			
PCS Visit Received	-0.36 (0.70)	0.59*** (1.80)	Funds Spent	
HH Members	-0.02 (0.98)	0.84***, 0.05 (1.05)	Contribution, Funds Spent	
HH Rooms	0.07 (1.08)	-0.23, -0.07 (0.93)	Contribution, Funds Spent	
Income Category	-0.41*** (0.67)	-2.60**, -0.19 (0.83)	Contribution, Funds Spent	
Asset Index	-0.13 (0.88)	0.18, 0.16*** (1.17)	Contribution, Funds Spent	
Age of Respondent	0.02** (1.02)	-0.09, -0.02*** (0.98)	Contribution, Funds Spent	
Social Capital Score	0.05* (1.05)	0.40, 0.11*** (1.12)	Contribution, Funds Spent	
System Well Constructed	0.58*** (1.79)			
Knowledge How Funds Spent	0.24** (1.27)			
VILLAGE EFFECTS				
SANBASUR	-0.15 (0.86)			
Operator Years Experience				
Operator Trained				
Source – # Dry Months				
Source – Length of Distribution Line				
System – Storage Cracks Detected				
System – No Distribution Leaks Detected				
Village Population	0.000 (1.00)			
Village Size				
Committee – Yrs. Experience				
Committee Elected				
Committee Trained				
Operating Costs Recovered	0.03 (1.03)			

** significant at 10% rejection level, ** significant at 5% rejection level, *** significant at 1% level*

1: Grey cells = not included in model, White cells = not statistically significant at 10% rejection level, Cells with upward lines = positive and significant at 10% level, Cells with downward lines = negative and significant at 10% level

Table 40: Peru Structural Equation Models – Confidence Over Ten Year Period

MODEL INFORMATION	EFFECT ON OUTCOME	EFFECT ON SIGN. ENDO. VARIABLE	SIGNIFICANT ENDOGENOUS VARIABLES	DIRECTION OF INDIRECT EFFECTS[1]
Sample N	799			
Loglikelihood	-5379			
BIC-adjusted	10916			
Model Type	Binary Logit			
HOUSEHOLD EFFECTS (Odds Ratio)				
Tap Age	0.22 (1.24)			
Participation - # Decisions	-0.01 (0.99)			
Contribution – # Labor Days	0.01*** (1.01)			
Meeting Attendance	-0.03 (0.97)			
PCS Visit Received	-0.07 (0.94)	0.25*** (1.28)	Funds Spent	
HH Members	-0.001 (1.00)	0.78** 0.02 (1.02)	Contribution, Funds Spent	
HH Rooms	-0.04 (0.97)	0.10, -0.03 (0.97)	Contribution, Funds Spent	
Income Category	-0.35*** (0.70)	-3.31***, -0.04 (0.96)	Contribution, Funds Spent	
Asset Index	-0.11 (0.90)	0.36, 0.09*** (1.10)	Contribution, Funds Spent	
Age of Respondent	0.002 (1.00)	-0.07, -0.01** (0.99)	Contribution, Funds Spent	
Social Capital Score	-0.02 (0.98)	0.59*, 0.04*** (1.04)	Contribution, Funds Spent	
System Well Constructed	0.37*** (1.45)			
Knowledge How Funds Spent	0.36*** (1.44)			
VILLAGE EFFECTS				
SANBASUR	-0.79*** (0.45)			
Operator Years Experience				
Operator Trained	0.03 (1.03)			
Source – # Dry Months				
Source – Length of Distribution Line				
System – Storage Cracks Detected				
System – No Distribution Leaks Detected	0.12 (1.13)			
Village Population				
Village Size	-0.002 (1.00)			
Committee – Yrs. Experience	-0.02 (0.98)			
Committee Elected				
Committee Trained				
Operating Costs Recovered	0.13			

** significant at 10% rejection level, ** significant at 5% rejection level, *** significant at 1% level*

1: Grey cells = not included in model, White cells = not statistically significant at 10% rejection level, Cells with upward lines = positive and significant at 10% level, Cells with downward lines = negative and significant at 10% level

6.3.4. Structural Models – Ghana

These models identify the same set of endogenous and exogenous variables as those in the Peru study. The key difference between these models and the previous section is the presence of variables which account for different tariff schemes in Ghanaian villages.

Tables 41 and 42 describe the direct and indirect effects on financial indicators. At the household level, only previous participation and current meeting awareness determine whether a household pays for water after controlling for other factors. An increase in the number of decisions a household gave input upon increased the likelihood of payment by a factor of 1.39, while meeting awareness more than doubled the likelihood of payment. Both of these endogenous factors were regressed on the exogenous household factors in this model. Older respondents and those in households with higher expenditures were indirectly more likely to pay for water service via participation in the process. Additionally, those with higher incomes, a more positive attitude about social capital, and who had been visited in the past by outside agencies indirectly were more likely to pay for service via their current involvement in meetings. Tariff structures solely explained the village-level factors that predict whether a household paid. Regressions of the two most common tariffs (flat fees and pay as you fetch) on other village factors suggested that households communities with elected watsans are about 70% less likely to pay flat fees and nearly three times more likely to pay as they fetch (hence the cross-hatched cell in the last column).

Table 41: Ghana Structural Equation Models – Users Pay for Water

MODEL INFORMATION	EFFECT ON OUTCOME	EFFECT ON SIGNIFICANT ENDOGENOUS VARIABLES	SIGNIFICANT ENDOGENOUS VARIABLES[1]	DIRECTION OF SIGNIFICANT INDIRECT EFFECTS
Sample N	928			
Loglikelihood	-3900			
BIC-adjusted	8074			
Model	Binary Logit			
HOUSEHOLD EFFECTS (Odds Ratio)				
Participation Index	0.33** (1.39)			
HH Contributes	-0.79 (0.45)			
Meeting Awareness	0.76** (2.13)			
PCS visit	-0.79 (0.46)	0.23 (1.26)	Meeting Aware.	
Social Capital	-0.10 (0.90)	0.05, 0.05*** (1.05)	Participation, Meeting Aware	
Age of Respondent	-0.02 (0.99)	0.03***, 0.004 (1.004)	Participation, Meeting Aware	
HH Members	0.06 ((1.06)	0.05, -0.04* (0.96)	Participation, Meeting Aware	
HH Rooms	-0.19 (0.83)	-0.05, 0.002 (1.002)	Participation, Meeting Aware	
Treats water	0.48 (1.62)			
Monthly Expenditures (log)	0.003 (1.00)	0.50***, 0.21* (1.23)	Participation, Meeting Aware	
Asset Index	-0.02 (0.98)	0.07, 0.04 (1.04)	Participation, Meeting Aware	
System Well Constructed	-0.70 (0.50)			
Knowledge How Funds Spent	-0.43 (0.65)			
VILLAGE EFFECTS				
Volta Region	0.46 (1.58)	-0.57 (0.57), 0.78 (2.18)	Flat fee, pay as fetch	
Watsan Elected	1.02 (2.77)	-1.49** (0.23), 1.06** (2.88)	Flat fee, pay as fetch	
Watsan Years	-0.08 (0.92)	0.03 (1.03), -0.05 (0.95)	Flat fee, pay as fetch	
Watsan Trained	0.28 (1.32)	-0.15 (0.86), -0.22 (0.80)	Flat fee, pay as fetch	
Operator – Number of				
Distance to Area Mechanic				
Source: # Dry months	-0.28 (0.68)	-0.30 (0.74), 0.16 (1.17)	Flat fee, pay as fetch	
Village Population	-0.00 (0.999)	0.000, 0.000 (1.00)	Flat fee, pay as fetch	
Village Size	0.05 (1.05)	-0.004 (0.996), 0.03 (1.03)	Flat fee, pay as fetch	
Tariff Payment – as needed				
Tariff Payment - flat fee	7.29***			
Tariff Payment - HH fee	10.35***			
Tariff Payment – pay as fetch	9.92***			
Operating Costs Recovered				

Table 42: Ghana Structural Equation Models – Monthly Log Water Payments

MODEL INFORMATION	EFFECT ON OUTCOME	EFFECT ON SIGN. ENDOGENOUS VARIABLE	SIGNIFICANT ENDOGENOUS VARIABLE[1]	DIRECTION OF SIGNIFICANT INDIRECT EFFECTS
Sample N	932			
Loglikelihood	-1526			
BIC-adjusted	4307			
Model	OLS			
Residual Variance	1.30**			
HOUSEHOLD EFFECTS				
Participation Index	0.03			
HH Contributes	-0.28			
Meeting Awareness	0.07			
PCS visit	-0.03			
Social Capital	-0.01			
Age of Respondent	-0.002			
HH Members	-0.01			
HH Rooms	-0.02			
Treats water	-0.23			
Monthly Expenditures (log)	-0.03			
Asset Index	0.01			
System Well Constructed	-0.45			
Knowledge How Funds Spent	0.05			
VILLAGE EFFECTS				
Volta Region	-0.09	-0.57, 0.78	Flat fee, pay fetch	
Watsan Elected	0.06	-1.49**, 1.06**	Flat fee, pay fetch	
Watsan Years	-0.02	0.03, -0.05	Flat fee, pay fetch	
Watsan Trained	0.02	-0.15, -0.22	Flat fee, pay fetch	
Operator – Number of				
Distance to Area Mechanic				
Source: # Dry months	0.12	-0.30, 0.16	Flat fee, pay fetch	
Village Population	0.00	0.000, 0.000	Flat fee, pay fetch	
Village Size	0.01	-0.004, 0.03	Flat fee, pay fetch	
Tariff Payment – as needed				
Tariff Payment - flat fee	5.36***			
Tariff Payment - HH fee	5.20***			
Tariff Payment – pay as fetch	2.54***			
Operating Costs Recovered				

Tables 43 and 44 summarize the results of structural models that examine household satisfaction and trust in the watsan committees. The same positive (social capital, household members, and knowledge of funds) and negative (household size and income) relationships emerge as direct effects as those in the RI specifications. Households with higher social capital scores are 27% more likely to be satisfied with the watsan committee. Increases in household members also raise this likelihood by 1.12, while gains in financial knowledge improve the likelihood by almost three-fold. Regressing knowledge of how committees spend their funds on other household variables found that attitudes toward social capital, PCS visits, and logged expenditures indirectly improved the level of household satisfaction with committees. Unit increase in social capital scores produced 17% gains in knowledge of committee spending, while expenditure increases were associated with an even higher probability of understanding. Since income also is positively correlated with knowledge, this effect mitigates the overall negative perception which higher-income households may have concerning the committees' work. Moreover, households which have been visited by external agencies are almost 75% more likely to know how committees spend their money and thus more likely to be satisfied with their work. Households are less satisfied in places where area mechanics live further away and happier with watsans when they only collect fees every once in a while (as opposed to never). Cost recovery was not a significant component in predicting watsan satisfaction; thus no indirect effects are reported.

Household levels of watsan trust were associated with similar factors as watsan satisfaction (social capital, household members, household size (-), and knowledge of spending). The magnitudes of odds ratios for social capital (1.27), household membership (1.05), and knowledge of committee spending (2.06) are less than those reported for committee satisfaction. People who believed in the integrity of the water systems and who were aware of meetings also were more likely to trust watsans more often (by factors of 1.37 and 1.33, respectively), while those who contributed to the project were about ½ as trusting after controlling for other factors. Three significant endogenous variables (contribution, meeting attendance, and spending knowledge) were regressed simultaneously in the model. Results showed that larger-person households were less aware of meetings and of spending and thus indirectly were not as trusting of the committees. Positive indirect effects were tallied for household size (since those in larger households actually contributed less often), social capital (via knowledge of meetings and spending), income (via the same), and respondent age (via meeting involvement). At the village level, the area mechanics' distance negatively impacted watsan trust, though the magnitude of this relationship was limited given the weak size of the direct effect.

Table 45 presents the final structural model, which features five-year system confidence as the indicator of sustainability. People with more positive attitudes toward social capital, who treated their water, and who perceived that contractors built their system well were more likely to have confidence that they would have water from project boreholes over the next five years. The effect of social capital attitudes was minor (unit increases increased the probability of saying yes by a factor of 1.04), while system construction registered higher values (at 1.37). Those who treated their water were most confident, as they were more than twice as likely to believe the handpumps would continue to run. Surprisingly, those who knew how the watsan spent its money were less sanguine about this projection. When this variable was regressed on exogenous household factors, positive associations with this knowledge (income, social capital, and PCS visits) meant that those with higher income, more positive attitudes about social capital, and who had received visits were indirectly less promising about the chances of future operation. Once again, at the village level, distance to the area mechanic was a key negative explanatory factor in predicting household confidence. Regional differences between Volta and Brong Ahafo from the previous RI model also appeared here, as Volta residents on the whole were 57% more likely to believe that their systems would function over five years than those in Brong Ahafo. The practice of recovering operating costs did not emerge as a significant direct impact, therefore no significant village-level indirect effects were detected.

Table 43: Ghana Structural Equation Model Results – Watsan Satisfaction

MODEL INFORMATION	EFFECT ON OUTCOMES	EFFECT ON SIGNIFICANT ENDOGENOUS VARIABLES	SIGNIFICANT ENDOGENOUS VARIABLES	DIRECTION OF SIGNIFICANT INDIRECT EFFECTS
Sample N	1111			
Loglikelihood	-5050			
BIC-adjusted	10276			
Model	Ordered Logit			
HOUSEHOLD EFFECTS (Odds Ratios)				
Participation Index	0.01 (1.01)			
HH Contributes	-0.06 (0.94)			
Meeting Awareness	0.16 (1.18)			
PCS visit	0.22 (1.24)	0.55*** (1.73)	Funds spent	
Social Capital	0.24*** (1.27)	0.16*** (1.17)	Funds spent	
Age of Respondent	-0.003 (1.00)	0.001 (1.001)	Funds spent	
HH Members	0.11*** (1.12)	-0.04 (0.96)	Funds spent	
HH Rooms	-0.11** (0.90)	-0.04 (0.96)	Funds spent	
Treats water	0.45 (1.56)			
Monthly Expenditures (log)	-0.34* (0.71)	0.29*** (1.34)	Funds spent	
Asset Index	-0.04 (0.97)	-0.05 (0.95)	Funds spent	
System Well Constructed	0.26 (1.29)			
Knowledge How Funds Spent	1.00*** (2.71)			
VILLAGE EFFECTS				
Volta Region	-0.57 (0.57)			
Watsan Elected				
Watsan Years				
Watsan Trained				
Operator – Number of				
Distance to Area Mechanic	-0.02*** (0.98)			
Source: # Dry months				
Village Population				
Village Size	0.03 (1.03)			
Tariff Payment – as needed	1.91***			
Tariff Payment - flat fee				
Tariff Payment - HH fee				
Tariff Payment – pay as fetch				
Operating Costs Recovered from HH fees	-0.48 (0.61)			

** Significant at 10% rejection level, ** Significant at 5% rejection level, *** Significant at 1% rejection level*

Table 44: Ghana Structural Equation Model Results – Committee Trust

MODEL INFORMATION	EFFECT ON OUTCOME	EFFECT ON SIGN. ENDOG. VARIABLES	SIGNIFICANT ENDOGENOUS VARIABLES	DIRECTION OF SIGN. IND. EFFECTS
Sample N	1103			
Loglikelihood	-9443			
BIC-adjusted	19177			
Model	Ordered Logit			
HOUSEHOLD EFFECTS (Odds Ratios)				
Participation Index	0.06 (1.06)			
HH Contributes	-0.72*** (0.49)			
Meeting Awareness	0.29** (1.33)			
PCS visit	0.32 (1.38)	0.28 (1.32), 0.66** (1.93)	Meeting Aware., Funds Spent	
Social Capital	0.22*** (1.24)	0.05 (1.05), 0.04** (1.04), 0.15*** (1.16)	Contribution, Meetings, Funds Spent	
Age of Respondent	0.002 (1.00)	-0.004 (0.99), 0.01* (1.01), 0.001 (1.00)	Contribution, Meetings, Funds Spent	
HH Members	0.05* (1.05)	0.07 (1.08), 0.04** (1.04), -0.04* (0.96)	Contribution, Meetings, Funds Spent	
HH Rooms	-0.09** (0.92)	-0.09**(0.91), -0.001, (1.00), 0.06 (1.06)	Contribution, Meetings, Funds Spent	
Treats water	0.35 (1.41)			
Monthly Expenditures (log)	-0.06 (0.94)	-0.06 (0.94), 0.18* (1.20), 0.25** (1.28)	Contribution, Meetings, Funds Spent	
Asset Index	-0.05 (0.95)	0.09 (1.10), 0.02 (1.02), -0.03(0.97)	Contribution, Meetings, Funds Spent	
System Well Constructed	0.32* (1.37)			
Knowledge How Funds Spent	0.80*** (2.26)			
VILLAGE EFFECTS				
Volta Region	-0.20 (0.82)			
Watsan Elected	0.35 (1.42)			
Watsan Years	-0.05 (0.95)			
Watsan Trained	0.40*** (1.49)			
Operator – Number of	0.40 (1.49)			
Distance to Area Mechanic	-0.01* (0.99)			
Source: # Dry months				
Village Population				
Village Size				
Tariff Payment – as needed	0.48 (1.62)			
Tariff Payment - flat fee	0.70*** (2.01)			
Tariff Payment - HH fee				
Tariff Payment – pay as fetch				
Operating Costs Recovered	-0.29 (0.75)			

Table 45: Ghana Structural Equation Model Results – Five-Year Confidence

MODEL INFORMATION	EFFECTS ON OUTCOME	EFFECT ON SIGN. ENDOG. VARIABLES	SIGNIFICANT ENDOGENOUS VARIABLES	DIRECTION OF SIGN. IND. EFFECTS
Sample N	1112			
Loglikelihood	-9737			
BIC-adjusted	19731			
Model	Binary Logit			
HOUSEHOLD EFFECTS (Odds Ratio)				
Participation Index	0.03 (1.03)			
HH Contributes	0.27 (1.30)			
Meeting Awareness	-0.04 (0.97)			
PCS visit	0.16 (1.18)			
Social Capital	0.04** (1.04)	0.15*** (1.16)	Funds Spent	
Age of Respondent	0.004 (1.00)	0.002 (1.002)	Funds Spent	
HH Members	-0.02 (0.98)	-0.04 (0.96)	Funds Spent	
HH Rooms	0.02 (1.02)	-0.06 (0.94)	Funds Spent	
Treats water	0.97*** (2.64)			
Monthly Expenditures (log)	-0.02 (0.98)	0.24** (1.27)	Funds Spent	
Asset Index	0.02 (1.02)	-0.04 (0.96)	Funds Spent	
System Well Constructed	0.32*** (1.37)			
Knowledge How Funds Spent	-0.36*** (0.70)			
VILLAGE EFFECTS				
Volta Region	0.57* (1.57)			
Watsan Elected	0.18 (1.20)			
Watsan Years	-0.003 (0.997)			
Watsan Trained	-0.01 (0.99			
Operator – Number of				
Distance to Area Mechanic	-0.01*** (0.99)			
Source: # Dry months	0.01 (0.99)			
Village Population	0.00 (1.00)			
Village Size	0.001 (1.001)			
Tariff Payment – as needed				
Tariff Payment - flat fee	-0.14			
Tariff Payment - HH fee	0.07			
Tariff Payment – pay as fetch	-0.34			
Operating Costs Recovered	-0.15 (0.86)			

** Significant at 10% rejection level, ** Significant at 5% rejection level, *** Significant at 1% rejection level*

6.3.5. Structural Equation Models with Sustainability as Latent Variable

The final section of the chapter identifies a general model of sustainability for the Peru and Ghana cases. It uses a random intercept framework and ignores the distinction between exogenous and endogenous household variables. In these models, sustainability is conceived as a single-factor latent variable; indicated by six dependent variables which are estimated simultaneously along with the household and village factors. Table 46 lists the selected dependent indicator variables used in each model and the estimated coefficients. The signs of the coefficients are relative to those of the variable for which the model fixes the variance at 1 for estimation. Water pressure was substituted for overall water dissatisfaction in the Ghana analysis.

Table 46: Indicators and Values Used in General Sustainability Models

INDICATOR	PERU	GHANA
Household Pays for Water	Fixed at 1	1.043
Low Water Pressure	N/A	Fixed at 1
Water Dissatisfaction	-1.671***	N/A
O&M Satisfaction	2.296**	-1.87*
Committee Satisfaction	2.067***	-1.60
Five Year Confidence	0.776***	-0.486*

While both models converged successfully, Table 46 shows substantial differences in the quality of the results. The Peru model generated indicators which converged reasonably well around the notion of sustainability. All indicators were highly significant and in the expected direction (household satisfaction with O&M and committee work and five-year confidence all move in a positive direction while overall dissatisfaction moves in a negative direction).

In the Ghana case, the signs of these variables are reversed since they are based on their direction relative to low water pressure. However, only two of the four indicators in the Ghana study were significant indicators of the latent sustainability variable, and their significance can be rejected at a 5% level. The problem may have been due to the model's difficulty with the assumption of multivariate normality, which estimators can relax fairly well but which may have been too difficult a problem to overcome with the Ghana data. Another possibility is that the values of these variables are less related to one another in the Ghana case than they are in the Peru study. This would suggest that Ghana's indicators of sustainability do not reasonably measure sustainability together.

Table 47 in the Appendix summarizes the results from the Peru model. The model suggests that households who believe in the integrity of their systems and know how their water committee spends its money are more likely to have a positive outlook about the sustainability of their project. The strength and magnitude of attitudes concerning system design are very strong, while the magnitude of the knowledge coefficient is fair but the strength of significance is weak. Families with higher incomes are less likely to believe in the sustainable performance of their systems. Those with higher social capital scores are also less likely – yet the magnitude of the coefficient is fairly weak. The two village factors that emerge as determinants of sustainable performance are village population and length of operator service. The magnitudes of these coefficients, however, are fairly weak, limiting the relevance of the results.

VII. Discussion of Findings

7.1. Assessment of Sustainability of Rural Water Systems in Peru and Ghana

The success of many villages in both Peru and Ghana suggests that the participatory, demand-oriented model of development overall is working quite well. In Peru, over 90% of yard taps were found in working condition. Households in many villages experience few problems with their taps and wait less than one week for their service to be restored. Others encounter more periodic breakdowns and, in some villages, must wait much longer until someone can repair the problems. Most households are paying some flat fee for water service in each village, although the amounts in many places are relatively nominal. Water committees report that they are covering basic O&M costs in about half of the sampled villages. Many households are satisfied with water attributes like safety, color, and taste, although water pressure could be better in the dry season in some areas. A majority is satisfied overall with their potable water and with the work of the operators and water committees, yet there are clearly some villages where households registered dissatisfaction with their work. There are moderate degrees of difference across and within villages on these measures. Most respondents do believe the systems will function over the next five years, but less than half share the same confidence that the water committee can keep the systems running over ten years. Given the relative levels of poverty that exists among most of these communities and the remote locations of many villages, much of this news is encouraging for advocates of extending rural water services in highland Peru.

The situation in Ghana also holds promise for participatory, community-managed water projects. Villagers in the Brong Ahafo and Volta regions experience on average less than two breakdowns per month. Wait times for restoration of service are longer on average than in Peru (18 days vs. 5 days), and this varies considerably across villages. Almost three-quarters of Ghanaian households reported that they paid for water service, which leaves a substantial minority of users who do not pay for service. However, users who are charged for service pay more on average per month than Peruvian households. There are a variety of tariff structures utilized by villages to encourage payment. As a result, an equal proportion of villages (53%) in both countries reported that they covered basic operation and maintenance costs. While Ghanaian households detect that their water has an unfavorable taste much more often than their Peruvian counterparts, Ghanaian respondents are as likely to be satisfied with water pressure in the dry season and even more sanguine about the safety of their water (86%) than Peruvian respondents. Over three-quarters of households are satisfied with and trust their watsan committees. All of these indicators suggest that the new water systems are holding up fairly well after periods of five to ten years and that many are satisfied with their operation and administration. However, despite efforts to encourage villages to meet their own O&M costs with user revenues, this remains a problem among some water committees. In addition, Ghanaian households are more uncertain that their water committees have the resources to keep these systems running over the next five years. Almost ½ of respondents do not believe their handpumps will continue to deliver water in five years time.

7.2. Relationship Between Sustainability Indicators and System-Related Project Factors

From a planning perspective, project factors can be separated into two categories. The first category represents system-related characteristics and perceptions that describe the physical capacity of the existing water system. At a household level, these measures refer to the age of yard taps (in Peru) and the quality of system construction as perceived by respondents. One village-level measure (used in both Ghana and Peru) that potentially affects the ability of the source to deliver water to the system is the length of the dry season. Other measures found in the Peru case include assessments of storage tanks, distribution lines, and the length of the main transmission line from the source to the village. Planning responses to these factors primarily involve upgrading the structural integrity and capacity of the physical system and improving the efficiency of the system to store and deliver available water to residents.

Overall, many respondents in both countries praised the quality of initial construction and its' ability to continue to deliver water services through the present day. Household perceptions of the quality of initial system construction were positively and strongly associated with perceptions of water pressure in both countries, the safety of water in Peru, and the lack of salty, mineral, or chemical taste in Ghana. Households in Peru which valued the integrity of initial construction were more likely not to voice dissatisfaction with water from their tap. These results come as no surprise, given that households may associate initial construction with the quality of water attributes. Moreover, households in Peru are more likely to show satisfaction with watsan committees if they valued initial construction, while Ghanaian respondents are more likely to trust watsans for the same reason. There seems to be a spillover effect - watsan committees are praised for their efforts in areas where residents valued the initial construction. In addition, households in both countries are much more likely to believe that their systems will function in the next five years if they were confident in initial construction. System construction appears to be an area of strength for these potable water programs in both countries.

One might expect that if the system was not well constructed, over time the household would experience more problems. Yet there is little evidence that households with older taps are performing worse. Households which connected earlier to the system have experienced more breakdowns (an estimated one additional breakdown for every three years in age), but this is not a large number for many households at the moment. More importantly, households with older taps actually complain less of water pressure problems in the dry season and are more satisfied overall with their water. These effects are robust to sensitivity analyses which subsequently remove household predictors. Coefficients for the effect of older taps range in values from -0.43 to -0.53 for water pressure and -0.79 to -0.85 for overall satisfaction. These data suggest that water systems (at least in the Peruvian highlands) can be designed to bring water directly to households over long periods of time.

One potential factor considered by agencies in designing water projects is whether there is enough water at the source to meet village needs. The length of a dry season can impact the amount of available water and reduce the performance of the project. This factor did not influence results from the Peru and Ghana studies in a meaningful fashion. The main finding to emerge was that households located in villages with longer dry seasons in Peru (but not Ghana) paid less on average for water than those with shorter seasons. It would be troubling if there was a large discrepancy in payments, but the magnitude (at 0.08 soles per extra month) is too low to consider as important. Other system factors in Peru also did not emerge as empirically important in the results. The length of transmission lines was not a factor among most indicators. Engineers' assessments of storage cracks and fissures in distribution lines produced conflicting results with respect to the numbers of breakdowns households experienced as well as their satisfaction. While these systems in Peru may have structural problems, in most cases they are not imposing burdens on households, affecting payment for services, increasing dissatisfaction, or instilling a sense of foreboding about future system operation.

7.3. Relationship Between Sustainability Indicators and Management-Related Project Factors

The other category of project factors focuses on the actors, processes, and decisions regarding water system management. While system-related factors deal more with engineering decisions, these factors focus more on pre-project planning decisions, current management techniques and involvement, and external resources for system support. At the household level, variables in both countries included participation in pre-project decisions, contributions toward the project during construction, current meeting attendance, current awareness of how committees spend funds, and visits received for support in the post-construction phase. An additional variable measured in Ghana – household-level water treatment practices – was also considered. Several village-level measures entail management activities and operating support. Committee experience, training, and management structure are included as measures in both countries. In Peru, agency type, operator experience and training, and cost recovery practices were also considered; while in Ghana operating support, tariff structures and cost recovery practices, and the distance to nearby mechanics round out these variables.

Both the Peru and Ghana cases demonstrated that previous participation did not generally explain sustainable outcomes. Involvement in project decisions was not associated with better performance, satisfaction with water attributes, or future system confidence. Ghanaian households were more likely to pay for water service if they participated in the project, and the magnitude of the change in this likelihood was an important factor. However, this was not the case in Peru. Relationships between previous participation and attitudes toward operators and committees varied with the countries, as high-participating Peruvian households were less likely to be satisfied with O&M and trust their water committee while more involved Ghanaian households were more likely to trust watsans. The strengths of significance and effect sizes, however, were rather low for these relationships. It is not surprising that past participation in project decisions is not related to many of these measures.

Households that participated in more decisions may have an equal chance of having breakdowns, may receive less than satisfactory water, or believe that their system would not function over time. The evidence does not condemn participation per se, as the study design does not allow for comparisons against villages with no participation in obtaining new water services. However, it does suggest that pre-project participation does not guarantee post-project results.

What about the relationship between current meeting participation and indicators of sustainability? Results in Peru do not indicate strong correlations on most measures. Households who participate more often experience a few additional hours of repair time. They are, however, considerably less likely to report problems with water pressure. In Ghana, there is a strong association between meeting attendance and payment for water service. One speculation is that households attend meetings much more often if they pay for water service, rather than vice versa. They are also much more likely to report problems with salty water than those who don't pay and are significantly less trustworthy of watsans and prospects for the future (although the effect sizes on trust and future performance are virtually zero). This might indicate that one of the reasons households attend meetings is to complain about or encourage committees to improve water taste (which would not be surprising given that over 30% reported that their water tasted salty). In general, households are not using meetings as a major forum to either voice support for the committees' work or push for improvements to the system. Possible exceptions are the association with low water pressure in Peru and water taste in Ghana.

The results from both countries show that a household's contribution toward construction of the new project does not necessarily portend satisfactory results. The Peru study uncovered evidence that mean labor contributions are negatively associated with the likelihood of paying anything and paying more for water service (although the latter effect is negligible). The effect on the probability of payment is low, and once additional household factors (such as attitudes toward construction quality) are removed from the analysis, the significance can be summarily rejected. However, the estimate remains stable and significant regardless of household-level model specification. Many households in Peru appeared to have substituted labor for cash contributions, so they may be less willing to pay for service (but not necessarily less able, since wealth does not arise as a significant factor in predicting financial outcomes). Several other significant relationships emerge between pre-project contributions and indicators of sustainability, but the low odds ratios suggest that pre-project contributions do not impact satisfaction with current service or prospects for the future. A different picture arises in the Ghana case, however. Households which contributed to the project pay just over ½ less than those who did not contribute. This is possible, for example, if water committees waive tariffs (per bucket, flat fees, etc.) for those who contributed more toward the project. They are also four times as likely to report that their water tastes salty and half as likely to trust the watsan committee. The latter effect is relatively robust to removing household predictors, although its' significance declines when social capital is excluded. This may indicate that households which contributed to the project believe they deserved more from their water system and committee members, and are able and willing to refuse to pay for service. These results are also important in light of the fact that households in some villages were required to contribute funds toward their projects.

One of the key results to emerge from both countries is that households who are aware how the committee spends its funds (from the village, households, or both) are generally happier about their water projects. While no differences exist regarding financial payments in Ghana, Peruvian households are almost twice as likely to pay for water service if they know about the committee's financial dealings. They are also about one and one-half times more satisfied with and trustworthy of committee members. The relationship between keeping tabs on water committees and watsan satisfaction and trust is even higher in Ghana, as progressive increases in knowledge lead to rates of satisfaction that are two and three times higher than less knowledge. These findings suggest that greater transparency leads to higher user satisfaction and (in the case of Peru) a greater likelihood of paying for service. Villages where water committees make their financial dealings more known to the public contain households which are more likely to pay for service. A further, unintended consequence of improved knowledge of financial dealings is that well-informed households in Peru are also more likely to be satisfied with operation and maintenance in the village. The one caveat to this positive news is that transparency does not necessarily inspire future confidence. In Ghana, gains in financial knowledge were associated with reductions (of about 1/3) in the probability that households believed their systems would function in the next five years. Sensitivity analysis indicates that effects range from -0.26 to -0.36 and remain significant until social capital and income effects are excluded. This may represent a problem for the village if knowledgeable persons do not believe their committee's financial dealings enable them to be prepared for future threats to the system. If this is the case, however, interested parties may have other means of holding committee members accountable. In areas with elected committees, the democratic process is one possible method. Conversely, among those villages that appoint members, households may turn directly to village or district leaders.

The final management-related measure considered at the household level was whether households had received post-construction visits from external groups. The results of the association of this factor with sustainability indicators are decidedly mixed. In Peru, respondents who had been visited were about one-third less likely to have confidence in their water systems over five and ten-year periods. It is not clear why these households would exude less confidence. Perhaps they were unimpressed by the nature of the visits, or that these households were targeted based on related criteria (e.g. they were higher-income households with contacts to external agents). These results are also somewhat sensitive to model specification. Results from Ghana are more promising. Visited households were half as likely to complain of water pressure problems and about 40% more likely to trust their committee members. These results are not staggering, but they may indicate the effects of a more regular post-construction assistance program in Ghana (particularly the MOM program in the Volta region). Households visited by district-level representatives or outside non-profit organizations appear more understanding when problems with handpumps arise and less suspicious of committee activities.

The other possibility considered in this dissertation is that post-construction visits can also shape responses on other project related measures which in turn affect sustainability indicators. The structural models examined these impacts. In Peru, households with PCS visits were more likely to attend meetings and thus indirectly less likely to report water pressure problems. They were also more likely to know how funds were spent and therefore more trusting of their water committees. Furthermore, the impact of knowledge regarding financial dealings is indirectly associated with the confidence which households have concerning the future. On the whole, households visited by external agencies remain less optimistic than others, yet visits also improve the chances that households will become aware of committee activities and thus more confident in the future. A similar situation is revealed in the Ghana analysis. Households that received visits were more likely to know how funds were spent and thus more satisfied and trusting of their water committees. Household-level visits in both settings appear to have improved the level of understanding in villages which can have indirect, beneficial consequences.

A different form of post-construction support – area mechanics – was valued by many village leaders and committee members in Ghana (this form of support was not systematically available in Cuzco villages, nearly all of which had caretakers). The dissertation considered the association of the distance to the nearest area mechanics across several indicators. Households in villages where mechanics lived further away were significantly less likely to voice satisfaction and trust in their committees, and exhibit confidence in the future operation of the boreholes. The magnitudes of these relationships are relatively small but persistent (a 1-2% decrease in satisfaction &

confidence for every kilometer increase in distance). This relationship assumes greater importance in the Brong Ahafo region, where villages must call upon mechanics for assistance if they have problems, and in the northern areas of both regions where distances among villages are further apart.

At the village level, committee attributes – such as experience, training, and structure – can influence household measures of sustainability. The initial hypothesis regarding experience is that households in villages with more experienced committees would have better service, pay more often, approve of their committees' work, and express hope in the future. This theme did not resonate in either country. If anything, in Peru households paid slightly less for water and were slightly less confident in the future. A similar relationship occurs in Ghana, where households governed by more experienced watsan committees trusted watsan members less. Committee members' experience does not generate better results. It also appears that some water committees have members who have overstayed their welcome and that village leaders may want to consider bringing on new people to take over system administration. Committee training was hypothesized to positively affect indicators of sustainable performance. In Peru, there was little evidence of this effect in either direction, although households did pay more for water service in areas where committees were trained. Trained committees did inspire significantly more trust in Ghana among households.

An examination of the effect of electing water committees produced some interesting outcomes. Households in villages with elected committees report fewer tap breakdowns and better water pressure in Peru compared to other forms of governance (e.g. appointments, external management by a municipality, etc). Yet they are also much less satisfied with O&M and administration, and do not trust their committees as much (though this latter effect is slight). O&M satisfaction results are robust to different village-level specifications – effects range from -0.79 to -0.83. Water committee satisfaction also remains relatively robust, although the range of coefficients varies more (-0.62 to -0.84). The mismatch between elected committees' good performance on delivering water reliably and disenchantment with their work may represent a situation of democracy at work; where households have taken for granted the work that operators and committees have done and asserted their rights to focus on problems because they are elected. The effects are more nuanced in Ghana, as households in villages with elected watsan committees report better pressure but worse taste. Elected committees fare no better on other indicators of sustainability, although the reader will note later that respondents in more democratic areas are more likely to favor scaling up.

The impacts of operator characteristics resemble those found for committees in Peru. Households in villages with longer serving operators are significantly more likely to register dissatisfaction with O&M activities and overall water service. They are also more likely to not pay for water service and distrust their water committees. Again, this suggests that villages and supporting agencies should consider replacing and/or augmenting operators to take over or assist with their duties. Training for operators, by contrast, has posted some positive results – households pay more for water service, report better pressure, and are more confident in the future if they lived in a village with a trained operator. While training may improve prospects for sustainability in Peru, the number of operators was not meaningfully associated with sustainability indicators in Ghana.

The Peru and Ghana cases both considered whether committees that reported covering operating costs with household collections were more likely to feature improved household satisfaction and future confidence. The structural models largely did not bear this conjecture out. In Peru, households expressed considerably more satisfaction with committees that recovered costs, yet there was no statistical difference with respect to trust or future operations. Ghanaian households were no more satisfied, trusting, or confident of the future in those committees that recovered costs with household collections. These measures may prove less important, however, for committees who are trying to meet recurring costs while planning for the future. Models also examined the impact of tariff structures on indicators in Ghana. Households were obviously more likely to pay for (and pay more for) water with flat fee, household-based fee, or pay as you fetch tariffs in place (compared to villages with no tariffs). They also complained more often of water pressure and taste - voicing displeasure with water attributes more frequently when they are required to pay for it. There is good news for those who contend that enacting water fees will not necessarily promote public outcry. No negative relationships between tariff structures and committee satisfaction or trust were found. Moreover, advocates of flat fee structures can take some comfort in recognizing that households actually trusted water committees more often when they employed these tariffs (vs. no tariffs).

The final village-level variable considers whether the SANBASUR program outperformed the FONCODES program in Peru after controlling for other project, community, and external characteristics. Obviously these agencies selected the villages in which they decided to work, and this can impact comparison of program differences. Moreover, the programs themselves shaped some of the variables considered in the analysis. However, SANBASUR communities still differed from FONCODES villages, primarily in terms of financial impacts. SANBASUR households were over three times more likely to pay for service than FONCODES ones. While SANBASUR households paid about 0.5 soles less per month, SANBASUR committees reported that they recovered operating costs more frequently than FONCODES committees. The main concern for SANBASUR lies in the long-term sustainability of the project. SANBASUR respondents were about half as likely to express optimism for service over a ten year period compared to FONCODES respondents. This may reflect the fact that some FONCODES villages have allowed larger municipalities to take over their service, while SANBASUR villages are supposed to be self-sustaining. It should also be noted that these results are highly sensitive to model specification and less damaging, given the long-term speculation involved in the question. Nevertheless, the long-term sustainability of projects remains an important point for non-governmental organizations like SANBASUR to consider in designing and supporting effective rural water programs.

7.4. Relationship Between Sustainability Indicators and Demographic Factors

The literature on evaluating rural water systems did not yield consistent hypotheses on the relationship between village population, size, and sustainability in this study. On the one hand, some studies found that larger villages were able to achieve economies of scale and were better equipped with the necessary resources to operate and administer new projects. On the other hand, others had found that larger villages faced greater system challenges and required households to expend more time in collecting water.

Results demonstrated that village population made a difference among some indicators in Peru but not among those in Ghana. Households in larger villages experienced more breakdowns but shorter repair times. However, the relative magnitude of population effects was small. Respondents who lived in more populated villages were, however, significantly more likely to trust their water committees and exhibit greater confidence in five year operations. These measures seem to indicate that, in Peru, larger villages are more capable of finding a pool of committee members who can gain user trust and confidence (at least over a shorter term period). This was not the case among Ghanaian households. Possible explanations for these differences may lie in the populations found in samples of Peruvian and Ghanaian villages. Villages in Peru were smaller on average than those in Ghana. Moreover, the range of population sizes was more restricted. At least among smaller villages, then, the study uncovered evidence that more populated villages (i.e. 1000+ persons) may perform better than those of smaller sizes (i.e. 200-500 persons).

Village size registered as a more important factor in predicting physical indicators of performance in Peru. As with village population, the effect on household breakdowns was positive and significant but the magnitude was very small. Repair times were also significantly lower among households in larger villages, but again the effect of size was relatively minor. However, households were much less likely to report problems with water pressure and signify that they were dissatisfied with their water supply. They were also more likely to favor current O&M activities and support and trust the water committees in these villages. Finally, households in these villages were more likely to believe that the water committee over a ten-year time period would keep water flowing to the taps. To some extent, these findings are surprising for villages where water can travel some distance to taps across often hilly terrain. It raises the possibility that enumerators in some larger villages may have selected households which were closer to the center of town than others, although there was no evidence to support this contention in the field. It may also be the case that the systems have not yet reached those furthest from the main village. In any case, the evidence rejects the notion that piped water systems are necessarily more problematic in villages of larger size.

The other village-level variable tested as a geographic factor in Ghana was the region of the country. Volta households were more likely to report problems with water pressure and water taste. Regional differences in these water attributes do persist, although it should be noted that they can be rejected at a 5% level of significance. Households in Volta are also more likely to exude confidence in five year operation. The magnitude of the effect is large relative to other factors, but again the significance of the difference is not great.

Household-level characteristics were also considered in the analysis. The random intercept models predicted the direct effects of household demographic factors on responses, while the structural models also tested whether these factors indirectly influenced outcomes by also affecting endogenous project factors. These models consider not only how demographic characteristics affect household responses to sustainability outcomes, but also how they influence household factors related to planning, implementation, and current project activities.

Household size was measured both in terms of the number of members in the household and the size of the homes themselves. Household membership size in Peru did not directly influence most indicators of sustainability. Larger-person homes did experience more breakdowns and longer repair times, but the magnitude of these effects were small. An examination of the indirect effects in Peru finds that the effects of household membership size moves in opposite directions in influencing satisfaction with current committee activities and prospects for the future. Households with more members contributed more labor toward the construction of the project, and those that did were less likely to approve of their committees. This suggests that households which expend more total labor in projects may believe that their committees should have done a better job in administering their potable water resources. However, those expending more labor are also more likely to believe that their systems will keep delivering water over short and long-term periods (regardless of management). Larger households contributed more toward the project and are more convinced in the quality of their work. Overall, the evidence on the relationship between household size and outcomes is mixed in Peru. In Ghana, however, respondents with larger families and other occupants were more likely to be satisfied with watsan activities and trust their committee members. The indirect effects in Ghana were split – larger person households trusted committees more since they were more likely to attend meetings but trusted them less because they were less aware of committee financial spending. Overall in Ghana, then, larger-person households were more likely to approve of the watsan committees.

The physical size of a household bears little relationship to outcomes or project factors considered at a household level in Peru. No major direct effects emerge in the random intercept models. The structural models reveal that respondents in larger homes were less likely to know about committee spending toward the project and therefore less likely to trust the committee members, but the association seems spurious. In Ghana, however, respondents in households with more rooms are less likely to be satisfied with and trust watsan members. These effects move in the same direction as log expenditures; suggesting the presence of a wealth effect. Other wealth effects are described in more detail below.

Income class and expenditure measures of wealth offer an interesting mix of effects on project factors and outcomes. In Peru, high-income households report fewer breakdowns than low-income ones, but the difference is not great (slightly over one breakdown between the lowest and highest income bracket). The results are more dramatic and negative when considering other indicators. High-income groups are much more likely to complain of unsafe water and quality of existing service, less satisfied with operators, and less confident in performance over both short and long terms. Interestingly, there were no statistically different effects with respect to committee satisfaction and trust, indicating the real possibility that higher-income households are involved in those positions of leadership. These results provide evidence that these water systems are meeting the needs of lower-income groups but not necessarily the demands of upper-income members of the village. The structural models reveal that higher-income respondents were much less likely to contribute labor toward the project. Since upper-income households contributed less, they are also less likely to be dissatisfied with their committees but also less confident in system operation over time. These results reveal a stratification of responses by income class among households in Peru. High-income respondents are more likely to pay for water service but less likely to receive water and maintenance service at the level they desire.

In Ghana, respondents who spend more per month on total household expenses were more likely to show dissatisfaction with the watsan committee. Results from the structural models, however, mitigate this effect. Households which spend more are also more likely to be aware of how the committee spends its resources, which is associated both with committee satisfaction and trust. The reverse is true with respect to five-year confidence, since households which are more aware of financial activities are also less likely to believe their systems will keep functioning. A final identified indirect effect emerges with respect to the likelihood of paying for service. High-expenditure households are more likely to participate in the project and thus more likely to pay for water service in Ghana. The results are similar to those in Peru from the standpoint that respondents reporting higher expenditures pay more for service and are less confident in future operations. Yet while upper-income groups in Peru are frustrated with operators, high-expenditure respondents in Ghana register their disapproval at the committees. It should be noted that caretakers are often considered members of watsan committees in Ghana.

Differences among the random intercept and structural models emerge in considering another measure of wealth – the asset index. In both studies, this measure was directly correlated with few indicators of sustainability when the random intercept specifications were employed. The main exception to this finding was in Peru, where wealthier households experienced fewer breakdowns and spent less time waiting for restoration of service. However, the structural models reveal that asset wealth played other roles in shaping household responses in Peru. Wealthier households are more aware of how funds are spent (similar to the income measure). Thus they are more likely to pay for water, trust the committee, and show confidence in shorter and longer-term system operations. By contrast, asset indices were not associated indirectly with any measures of sustainability in Ghana.

Measuring wealth and determining its' impacts are not straightforward activities when dealing with rural areas of developing countries. Results from both countries show that while households with more assets experience fewer breakdowns and shorter repair times (in Peru) and pay more in monthly water expenses, they are also more likely overall to be dissatisfied with some aspect of the service (either O&M in Peru or administration in Ghana). Poorer households appear more satisfied that projects are meeting their needs while wealthier ones wish that the projects catered better to their demands. It is possible that poorer respondents are simply more deferential to enumerators and less willing to express their opinions. However, the total effects are mitigated by other factors. Households with more income/expenditures and assets are more likely to keep track of committee finances. The benefits of transparency fall to a larger extent upon these individuals and thus limit the extent of dissatisfaction with services. Moreover in Peru, wealthier households contributed less labor toward the project and thus do not disapprove of the lack of services (O&M and administration) as frequently. One explanation is that they do not share the level of entitlement that poorer households which contributed more labor do. They may also serve on committees more frequently. Wealth effects are thus more complicated than examining whether a project benefits "the rich" or "the poor", as other studies (van Domelen 2002, Engel 2004) have either attempted to evaluate or claim.

The other instructive measure considered in this dissertation was learning the effect of attitudes concerning social capital. While other studies measured social capital at a village level, this investigation examines household attitudes. In Peru, social capital attitudes were not directly associated with most indicators of sustainability, except that high SC households were moderately more dissatisfied with the overall water they received. Dissatisfaction among respondents with more positive attitudes toward social capital remained consistent regardless of model specification. However, the structural models show that respondents who report higher degrees of social capital are also more likely to know how water committees are spending their resources. Thus they are more likely to trust committee members and maintain faith in the future of the projects. These individuals are more likely to stay involved in the management of the water system, which improves trust and future confidence. In Ghana, stronger direct relationships between household attitudes toward social capital and outcomes emerged that confirmed initial hypotheses. High SC households were considerably more likely to be satisfied with and trust their committees, and slightly more confident in the future. Indirect effects detected in Ghana were similar to those in Peru and bolstered the direct results. Respondents with higher degrees of social capital were more likely to participate and thus more likely to pay for service. They also kept tabs on their committees more frequently, which was associated with greater committee satisfaction and trust. Conversely, though, they also displayed less confidence in future operations.

The results show a positive direct relationship in Ghana and a “no decision” direct relationship between household attitudes and outcomes of sustainability. Moreover, the structural models uncovered additional interesting findings because they demonstrate that, in both cases, social capital attitudes can shape outcomes through project-related household activities, even if no direct relationships emerge.

7.5. Factors Regarding Household Attitudes Concerning Scaling Up and Leveraging

Data from the Peru and Ghana studies reveal that most households (84% in Peru, 86% in Ghana) are interested in having their committees improve some aspect (quantity, quality, expansion of service, etc.) of their current water service. This study finds several factors in both countries are associated with the likelihood of households to support this decision.

The Peru case reveals some expected and unanticipated results. Households with aged taps are more likely to support scaling up, as are those who attend meetings more often (although this relationship is rather weak). Pre-project participation and contributions are not good predictors of support. Those who know how the committee handles its funds are more likely to encourage their committee to scale up their project since they know how the committee can utilize its resources. However, those who believe they have well-constructed systems are less likely to support improvements. Existing users may wish to keep their water situation “as is” and may show concern that committee tinkering or expansions may damage some aspect of the current system.

Larger households and wealthier ones are no more likely to support improvements than others. Other exogenous household-level variables yield some interesting findings. Older respondents are more likely to support scaling up. By contrast, those with more positive attitudes toward social capital are less likely to support improvements. Previous models would suggest that there are some indirect relationships that permeate this nexus, yet the direct negative effect of social capital on the decision to scale up appears counterintuitive. Households receiving some degree of PCS also fall into this category. In this situation, the lack of confidence in their systems may discourage this set of households into believing that scaling up is not possible. In any case, it does not substantiate the view that policymakers will find willing support for scaling up activities in areas with favorable household-reported social capital or areas with household-level post-construction support.

At the village level, households were more likely to support improvements if they lived in larger-populated villages with storage problems and/or had elected officials from the community. Larger villages may have more people willing and able to help the committee scale up. Fixing periodic water losses can be considered an improvement. The positive relationship with elected committees is interesting. These same respondents are less likely to be satisfied with the existing O&M and administration from elected committees, yet they are twice as likely to believe that the water committee should improve their project. Such respondents provide some incentive for democratic committees to expand their reach and build on previous project success, even if some are unhappy with existing services.

Results from the model on scaling up as applied to the Ghana sample suggest that household meeting participation and knowledge about watsan finances were associated with whether households believe their systems should be improved. Both effects are considerably larger (approximately 35% and 70%, respectively) among Ghanaian households than those in Peru. In contrast, however, social capital is positively associated with household support for village improvements. This may have something to do with the differences in technologies. The Ghana projects use a few handpumps placed in public areas of villages, while Peruvian households maintain their own private taps. Attitudes regarding social capital may apply more specifically to cases where respondents believe they must work together more closely to obtain clean water. Finally, it is also important to recognize that the magnitudes of social capital effects are not large in either country.

More village-level factors impact this household decision than household ones. Volta households are five times more likely to support scaling up, indicating large regional differences in attitudes. More populated communities are less likely to contain households supporting the decision to scale up, while larger-sized villages are more likely to contain supportive households. This distinction may be related to the distance which more remote households must travel to the handpumps (which usually are near the center of the village). Communities with more operators are less likely to support scaling up, while those that are further away are more likely. One explanation for the latter effect is that villagers believe their committees must respond more proactively to the lack of service they obtain since their mechanics reside further away. Finally, the chances that households will support improvements are twice as large in villages with elected committees. This adds credence to the notion that elected committees are more responsive to household demands.

In contrast to scaling up, less than 40% of Peruvians believe that their committees should leverage their resources into related environmental services such as sanitation, solid waste, and health/hygiene. High-income households are much less likely to support these investments. This may be true if these families already have access to these services on the premises or nearby. As with scaling up, though, social capital is again negatively associated with prospects of leveraging. Though the effect is not large, it provides further support to not predict support squarely on the basis of social capital. More household-level information is clearly needed, given the limited number of factors that accurately estimate significant effects on this decision. The same is also true at the village level. Household support is stronger among those villages where engineers detected leaks in storage tanks. This is rather surprising; one may expect that villages with such problems would be more likely to encourage their committees to focus their efforts on water improvements (as the results previously indicated) and not encourage leveraging. Committee training is also very counter-intuitive; one would expect that households would support leveraging if they know their committee has received training. Finally, village size also significantly influences the propensity for this decision. This effect is consistent since households in larger villages may have more difficulty obtaining these services (all else being equal). Overall, these models suggest some intriguing ideas. Yet more information is certainly needed to make these speculations more compelling.

7.6. Research and Policy Implications

The success of many villages in both Peru and Ghana suggests that the participatory, demand-oriented model of development overall is working quite well. This encouraging news holds promise for extending household connections in villages with gravity-fed systems as well as for sustaining service in villages that use handpump technologies. It is important to remember that the sampled communities represent those which successfully obtained a water project through a community-driven approach and have taken over operation of their systems. Thus, while results show that pre-project household participation in decisions does not account for most indicators of sustainability within these samples, the fruits of participation may lie in the ability of villages to mobilize support to obtain a project in a participatory-based program, not necessarily whether individual households participated in key decisions. Another pre-project factor – household contributions – was generally negatively associated with outcomes. This suggests that household contributions are not a good proxy for estimating ex ante demand or satisfaction with the project and may imply that contributing households believe they “deserved more” for their efforts. Moreover, current awareness and participation in meetings did not uniformly improve project outcomes. Meeting involvement may be viewed as “two-way street.” People may participate to help the village enhance project outcomes, yet they may also participate if they are not receiving decent service.

One factor which was associated with several improved outcomes in both cases was whether a household was aware of how the committee expended its financial resources. This suggests that a transparent process empowers households to understand how leaders are managing their systems and thus improves project outcomes from their perspective. A more open process may uncover problems in the finances or operation which may displease or give pause for some households. In these cases, though, households are more likely to favor new projects when they are aware of their committee's financial dealings.

Income and wealth effects at the household level exhibit some interesting influences on household outcomes which policymakers should take into account. Wealthier households are less likely to experience breakdowns and wait for their yard taps to be repaired in Peru. Yet they are also less satisfied and less confident in their water and management. This may signify that these projects are relatively "pro-poor"; since poorer households reported more satisfaction with water and service (or that poorer respondents are simply reporting what they wanted enumerators to hear). The results would also suggest that the current projects are not meeting the demands of upper class households for water and service. Indirect effects temper this relationship, however. Wealthier households tend to know how funds are spent in the village and less likely to contribute to projects (particularly in the form of labor). These differences in transparency and contributions mitigate negative perceptions of performance and future operations. The results provide evidence that the benefits of demand-responsive projects with transparent operations do not uniformly trickle down to all members of society.

The literature on social capital has generally shown that communities with higher social capital attain more positive project outcomes. No data are available here to compare social capital across communities that did and did not receive a project. It is possible that, due to the nature of the process for obtaining a project, villages with higher social capital were more effective at mobilizing to win a project. An analysis of household perceptions of social capital, however, presents a more split outcome. Ghanaian households that measured higher on the SC index were much more likely to be satisfied with their water, their committee, and the project's future outlook. The Peruvian case told a different story. Households with high social capital were more likely to pay, yet less likely to be satisfied with service. Indirect effects were also mixed. The effect of household attitudes regarding social capital, therefore, hinges on the ability to deliver good water and service, manage expectations, and promote understanding of how villages manage their projects. While projects may stand a better chance of succeeding in areas where villagers are more trusting and willing to come together, decision-makers should not use social capital as a primary basis for making project decisions.

This dissertation augments previous research (Prokopy and Thorsten 2005, Komives et. al 2006) conducted at the village level on the relationship between post-construction support and sustainability. Household-level analysis shows that households who received external visits were generally no more likely to report better physical performance (in Peru), higher water payments (in both countries), or increased satisfaction (in both countries). PCS visits have not improved these outcomes directly, yet indirectly they may increase the likelihood that households will be supportive because it has promoted more involvement in the process and more understanding of how committees spend their funds. PCS programs that increase participation and transparency would help to advance project outcomes by encouraging individuals to hold their leaders accountable for service and administrative objectives. These goals are not often the primary purposes of current visits, but external agencies and organizations should consider extending household visits in addition to existing village-level forms of post-construction assistance (and whether the benefits of extending these visits are worth the costs).

One of the important questions considered at the village level in Peru was whether alternative forms of service delivery (i.e. a social investment fund or a donor-assisted NGO) achieved better outcomes. Generally SANBASUR villages outperformed FONCODES villages on most measures of sustainability. However, after controlling for other factors, there were few substantial differences between household groups – save for financial payments and long-term assessments of operation. The SANBASUR program should consider encouraging people to pay more for water service and providing more ongoing support to villages to help ensure villagers that their systems will remain in tact over time. The FONCODES program should concentrate on reducing the number of failed systems, promoting a greater culture of payment to enhance operational cost recovery, and improving operator performance.

Results from both Peru and Ghana question the notion that more experience translates into better outcomes. Villages with long-serving operators and committee members should consider turning over these positions more often if they can find capable people to handle these responsibilities. The level of training among committees generally was not associated with higher measures on sustainability indicators. This would suggest that villages could replace and retrain new committee members relatively easily without losses in household-level performance. Trained operators (in Peru), however, are an important asset (not only in terms of better water pressure but also in the forms of higher water payments and more system confidence). Training new operators should remain an important objective for villages and programs that provide them with operational support. Another important external factor that programs should consider is the distance of villages to spare parts and other forms of assistance. Distance was an important factor in predicting household satisfaction and future confidence in Ghana (where spare parts are vital). Some Cuzco villages also represent even greater challenges due to their remote locations in mountainous terrain. Organizations interested in supporting these relatively nascent success stories should identify those communities where routine external assistance requires considerable time and expense.

The democratic nature of management – specifically whether villagers elect their own committees – was associated with positive water system outcomes such as fewer breakdowns (-0.26 fewer in Peru) and better water pressure (both cases). This research also uncovered some evidence that households (in Peru) were more likely to voice displeasure for operation & maintenance service and water committee satisfaction. Elected committee structures are not conclusively superior to other forms of administration, yet they have attained some positive results while allowing dissent. This phenomenon may benefit communities in the long run if elected committee members remain responsive to household input and needs.

Committees looking for additional guidelines should also take some comfort in knowing that making difficult tariff decisions do not necessarily produce negative feedback from households. In Ghana, households located in villages with tariff schemes are no more likely to voice opposition to watsan activities and slightly more likely to trust their committees. It is possible, however, that there are unobserved differences in villages that would lead to widespread household dissatisfaction if committees without tariffs schemes decided to impose them. Moreover, those villages that recover their operating costs with revenues contain households that are no more likely to show displeasure with watsans (in Ghana) and significantly more likely to be satisfied with water committees in Peru. In particular, the evidence demonstrates that households that are located in villages with a transparent, accountable management process are at least no more likely to mobilize against their committees who seek to reconcile cost recovery and user satisfaction objectives. These issues become more important for those communities which are in need of major repairs of or replacements to their existing systems (particularly those which have longer-serving projects). Most villages in both countries have not factored in the cost of major repairs (and certainly not capital replacement) in their tariff systems. While current needs do not seem very great, the long-term prospects of these systems could be jeopardized unless villages begin to develop the means to save for these overhauls. The demand for these measures is uncertain (the data do not reveal whether households have been asked by committees to make such payments), but one could anticipate that segments of the populations may be willing to pay for these services given the relatively high levels of satisfaction with the systems in both countries.

Issues of cost recovery also impact the interest in and demand for new services. Donors and communities looking to find support for scaling up water projects should engage households which are currently involved in meetings and are aware of how the committee operates and spends its resources. Village factors can also assist decision-makers in evaluating prospects. Households are more likely to support scaling up in villages where they have a voice in the process; i.e. via committee members elected by the community. Households in larger communities (measured by size) are generally more likely to support their endeavors (due in part to the larger distances required by households to obtain water from other improved or unimproved sources), as are those which are located in villages further away from towns and other places where mechanics, spare parts, and other services are available. Of course, each decision carries its own costs and benefits which officials at any level (village, district, national, etc.) must evaluate in conjunction with project beneficiaries before deciding on a course of action.

VIII. Conclusion

8.1. Contributions to the Literature

The methods and findings from this dissertation make several contributions to the literature on the sustainability of water service provision in developing countries. Previous studies that used quantitative methods have either focused their evaluations at the village level (which aggregates household level data and ignores the distribution of impacts within villages) or conducted household-level analysis while omitting village-level factors and clustering effects. The use of random intercept models estimates household and village-level factors that influence indicators of sustainability and allows the base case in each village (the intercept) to vary, which accounts for differences in performance. The study demonstrated that variation existed for many indicators at both household and village levels and that both sets of factors can influence a household's experience with physical performance, financial payment, use, satisfaction, and future confidence. The multi-level nature of these models and the use of multiple project, community, and external factors also allow this study to infer causal relationships better than other studies, which either lack data on household or village measures or sample size to estimate both household and village-level effects.

Previous research has attempted to examine the influence of non-project household factors on project decisions, such as the degree of participation in a project and how much to contribute toward its' attainment. Other studies have focused their attention (as this one does) on project outcomes. This study represents, to the authors' knowledge, the first attempt to simultaneously measure the influence of non-project household factors on project outcomes by estimating both direct effects and indirect effects via the endogenous project-level decisions and variables which can influence project success. This method provides a more holistic perspective on how variables like household size, income, and social capital are associated both with the set of project-related factors of performance and the outcomes themselves. It also demonstrates that indirect effects may either mitigate the extent of direct relationships or bolster the strength of direct effects.

Previous studies have normally assigned one or some set of indicators as sufficient in explaining sustainability. This dissertation hypothesized that previously-identified indicators of sustainability may not completely represent the concept itself. It considered the notion of sustainability as indicated by a set of variables while also containing some degree of measurement error, then modeled its relationship with household and village factors via a structural equation model. The results portrayed two different stories in Peru and Ghana. The Peruvian model showed that the indicators of sustainability were significantly related to one another, while a small set of household and village factors were associated with the concept. Results from Ghana indicate that the indicators did not "come together" so well and, as a result, no factors were related to the concept. The models were less useful in testing individual hypotheses of factors on sustainability, but helpful in demonstrating a method to determine to what extent the indicators of sustainability matched the concept as outlined in prior research.

The findings of this investigation also shed light on research in this field. One important first conclusion that emerges is that donors and managers in the water sector of different countries have begun to incorporate past experience and a new paradigm of participation and demand responsiveness into projects which have overall achieved some significant long-term impacts. Many projects still work despite challenging terrains (in Peru) and challenging technologies (in Ghana). A culture of payment has emerged among some villages in both settings, although O&M cost-recovery is not universal and full cost recovery (including major repairs and capital replacement) remains elusive. Almost everyone regularly uses the improved sources and many are satisfied with the water and service they receive. These results counter those of prior evaluations which decried the lack of success and sustainability in the water sector.

Specific contributions from testing individual hypotheses also arise from the study. Among participatory, community-managed projects, household-level participation in decisions and contributions do not influence outcomes over time, yet research has revealed the importance of transparency in achieving positive impacts. Households that are more aware of their committee's work are generally more likely to pay for service, support their efforts, and have confidence in the future (in Peru).

The study also unveiled some of the nuances in the relationship between non-project household factors, project-related factors, and current indicators of sustainability. The mixed relationship between income/wealth and outcomes supports studies that found that water projects have benefited lower-income groups while leaving upper-income group dissatisfied with the water and service they receive. Yet to the extent that wealthier households are aware of successful committees' work, they remain pleased with progress. The results also challenge some of the uniformly positive literature on the significance of social capital. This story held true in Ghana, where households with high social capital not only were more satisfied and confident in the outlook of the project, they were also more likely to stay involved in meetings and know how committees spent its resources. Households in Peru were also more likely to participate and stay abreast of committee activities, and these respondents were more likely to pay for water and register their approval. However, households with more positive attitudes toward social capital were slightly more dissatisfied in the performance of their water systems and less willing to support the committee's efforts to scale up or leverage their water project activities. Policymakers cannot presume that areas with high social capital will automatically lend themselves to favorable project impacts.

The study also contributed to decomposing the effect of post-construction support on project outcomes. Other studies from this research have focused on this question in terms of village-level outcomes. This research shows that households in Peru were no less likely to experience breakdowns, no more likely to pay for water, and no more satisfied than others if they were assisted at the household-level by external organizations after the completion of the project. Moreover, they were less sanguine about the prospect of future operation and scaling up. These less favorable findings, however, are brightened by the prospect that visited households participate more often and are more engaged in a water committee's financial dealings. Given the strong relationships between household understanding and support, donor agencies should consider focusing more attention on visits as a means of encouraging household participation and transparent processes at the village level.

The results also uncovered some of the roles which village factors play in predicting household outcomes. Generally the donor-assisted, NGO-based project fared better than the government's social investment fund at the village level, but program differences alone did not explain most household outcomes once other factors were controlled. It is important to recognize that some of these other village and household factors were influenced by participation in either the SANBASUR or FONCODES scheme. Nevertheless, each program has its own set of challenges – the social investment program needed to place more emphasis on user payment and cost recovery while the NGO scheme should consider working with partner agencies to encourage long-term support.

Another important finding to emerge was the negative relationship between experience and sustainability outcomes. Finding persons to be trained and serve as operators and committee members is one of the critical steps in designing and implementing projects intended to transfer operation to the village. This research suggests, however, that some villages may not achieve desirable outcomes because operators and committee members are serving too long in their roles. The lack of turnover may inhibit cost recovery, delay operation and maintenance, and produce stagnant committee leadership which appears unresponsive to customer needs. These issues become more important as communities which have achieved initial successes request more service, expansion, and movement into other areas of community need.

One activity which can potentially energize stagnant leadership is direct election of water committees. The research shows that elected water committees have achieved fewer breakdowns (in Peru) and better water pressure in both countries. Households may well complain more often about current leaders, but regular elections can promote needed changes in operation and management. Moreover, households in elected committees are more likely to voice support to scale up services. These findings present new information on how committee structures can influence household satisfaction and confidence.

Finally, this dissertation sheds new light on what other household and village factors predict support for scaling up. Research in this field is currently very limited. Results indicate that households are more likely to favor tackling these new responsibilities if they are currently aware of and participate in the current governing process and if they understand how the committee collects and spends its money. Social capital effects varied in the two countries. Village factors (besides elected committee structures) included the distance to the nearest area mechanic and village size. These initial findings can help researchers in designing studies to ascertain where and how much a successful potable water program can scale up its activities within villages and into other areas.

8.2. Study Limitations

One of the initial limitations of the study was the tight schedule field teams were presented with to collect data from a variety of households and village groups. Enumerators were unable to collect data from all households on all of the variables tested in this dissertation. The analysis contained enough information to proceed, on the assumption that the values were missing at random. Researchers were not able to return to villages to learn more once the initial data were collected and analyzed. This would have been helpful to check the quality of the information collected and also further address some of the relationships posited in the results.

This study represents an ex-post evaluation. Researchers did not collect data on most conditions in the village before the project. These baseline data would have been helpful to understand changes which may have taken place in villages and households that could have explained some of the findings. The information could have also been used to determine if there were unobservable differences in the villages that would account for some results. In Peru, for instance, it is possible that SANBASUR may have employed more favorable selection criteria for its communities than FONCODES (as was suggested by some officials) which would explain differences in water payments. Likewise in Ghana, regional differences could have produced some of the results which showed that Volta communities were more likely to have water pressure problems yet more confident in long-term operations. This study controlled for more village and household factors than similar published studies and thus can make more appropriate causal inferences than others. However, ex-post research designs are less effective than other approaches, such as natural experiments, in attributing causality of the factors presented in this study.

The success of many villages in both samples provides reason for celebration in the sector, yet the limited variation of some variables makes it more difficult to generate (and generalize) results. It was impossible to predict the success of these villages before inception. Employing this study in a more challenging environment would have allowed more rigorous examination of relationships between factors and outcomes.

Random intercept models do not facilitate easy comparison in terms of overall model quality. Unstandardized results and odds ratios are reported since most indicators are categorical, yet these can be challenging to interpret. The structural models show the relationship between exogenous and endogenous household variables. However, calculating precise indirect (and total) effects of exogenous variables on outcomes was not attempted due to the differences in variable scales and types (continuous, ordered categorical, nominal, binary). It is also unfortunate that more household level information was not available to determine other indirect effects. For example, are there other factors that drove households to participate and contribute during project construction? What other household factors may influence household knowledge of water committee activities? In addition, there were situations where a non-recursive model may have more accurately represented household or village-level dynamics. One example at the household level is current participation. This dissertation speculates that current household participation influences water payments and satisfaction measures. Another possibility is modeled in a two-way path relationship; whereby household participation and water payments simultaneously influence each other. These models are more difficult to estimate and not possible given the complex survey data obtained and models employed.

Most path models did not concentrate on village-level factors due to limitations on data and village size. Except for the random slopes model in the Peru case, these models also did not feature cross-level interactions in which a set of village level factors could also influence household-level factors. Model estimation is more complicated using this approach and relies even more heavily on the discretion of the researcher. It is possible, however, that these interactions do exist (e.g. households know less about water committee activities because their committee is not elected).

Selection models would have been interesting to incorporate further in this study. For example, a selection model could have estimated how village factors affect sustainability indicators by initially modeling the probability that a village obtained a project (compared to non-project villages), then examining the conditional effect of village factors on the outcome. Another potential application at the household level would first model the probability that a household paid for water, then examine how much the household paid. Unfortunately there are limited examples of research that account for selection in multilevel modeling (Borgoni & Billari 2002, Bellio & Gordi 2003). Grilli & Rampachini (2005) demonstrate that the selection problem is more complex in multilevel modeling because it can occur at multiple levels, shape the variance/covariance matrix structure, and modify the hierarchical structure of the data which complicates estimation algorithms. This study did not consider such models, and thus its' statistical applications depend on the assumption that covariance parameters of the error terms at both levels are null.

8.3. Avenues for Further Research

The methods, results, and conclusions from this research open up new possibilities for evaluating the success and future outlook of rural water systems in developing countries. Comparisons on project performance could be strengthened by collecting and incorporating more data from the pre-project period. The baseline data would assist in analyzing the benefits that these systems have provided to villagers, particularly if the benefits are measurable (e.g. in an economic framework) and less subject to pre-project household and villages expectations. It would also help control for more pre-project differences.

Researchers who are interested in applying this framework should consider programs in countries where sustainability outcomes have been more difficult to attain. Another option is to conduct this analysis on a set of communities which received projects and compare them to others which have not received project assistance. Comparisons with villages which had been denied project assistance yet moved forward with building their own systems could further test the participatory framework against less participatory schemes using multi-level modeling. Researchers may also consider comparing project villages with pipeline communities (those in line for a project) if they were interested in further exploring the relationship between non-project household and village factors and sustaining potable water. These settings could provide venues for examining how households respond to less than desirable outcomes. For example, do households participate more in the process because they are not receiving quality water and/or service at the price they have paid? Do they demand more improvements, or simply return to unimproved sources?

Some of the counterintuitive associations uncovered in the analyses deserve future attention. The relationship between a household's socio-economic status and outcomes merits future consideration in rural settings. Research that identified wealth from a household perspective may elaborate on some of the opposing results obtained when using two different measures (income and assets). Case studies that probed further into the distributional impacts of these projects would strengthen quantitative research. At the village level, findings which show that larger-sized villages are outperforming smaller ones deserve further investigation. One might initially suspect that households in larger settings would be less satisfied (in Peru, due to the distance water and operators must travel to reach homes farther away and in Ghana, due to the longer distance villagers would have to travel to obtain water from handpumps). These households may, however, compare their present service with previous, unimproved supplies. Moreover, case studies that examined village dynamics, particularly the relationship between operators, water committees, and their communities, would enhance understanding of how well villages manage projects over time and what villages should do to ensure that well-functioning projects do not stagnate due to village failures. Finally, further analysis on the relationship between more specific post-construction support received by households and household impacts could assist policymakers in designing effective, targeted PCS at both the household and village levels.

This study compared performance of the FONCODES social investment fund and SANBASUR's NGO-driven water supply program in the Cuzco region of Peru. PCS programs in Brong Ahafo and Volta regions were also used as a basis of comparison for the World Bank study that generated data for this dissertation. One area of research which would augment studies of specific programs would analyze the cost-effectiveness of these programs. In Peru, for example, while SANBASUR generally outperformed FONCODES on village outcomes, their costs may have been much higher as well. Likewise in Ghana, the MOM program incurred more program cost to administer in the Volta region than the purely demand-driven program in Brong Ahafo. Research that compared the costs and benefits of alternative forms of service delivery and post-construction support would enable policymakers to make more appropriate economic decisions.

The literature on scaling up and leveraging certainly needs more treatment. One improvement to this investigation would involve a willingness to pay survey, in which researchers would provide households with hypothetical water and specific other improvements along with prices and ask if the household would pay specified amounts for the committee to provide the new service. This research would help assess how much existing customers would contribute toward water or leveraged service improvements. Other studies could focus on evaluating areas which have attempted to scale up or leverage investments. One option would examine a program which has attempted to extend a rural water scheme into nearby villages or districts. Another possibility is to evaluate a small set (case study) or a larger set (quantitative analysis) of communities which have attempted to scale up and/or leverage investments within their villages. This research would mark a crucial component in understanding what factors allow programs to expand rural water coverage and/or environmental health services while sustaining existing programs or services. As more rural water programs earn the level of success found in these studies, there will be more pressure to scale up and leverage these projects in order to meet the development challenges outlined in places such as Goal 7 of the Millennium Development Goals. Research that identifies areas where households are demanding improvements and demonstrates what factors can predict project success would improve the theory and practice of development in the water and sanitation sector.

Appendix I – Peru Protocol for Sampling Households within Communities

Introduction

There are different methods of selecting households for the household surveys in each community. Each technique depends upon the level of information available at each village. The following outlines the protocol that field coordinators should use to determine how to sample households at the village level. These options are ordered from best-case to worst-case scenarios. ***Field coordinators must select the option that best fits the amount of information available at the village level.***

First Steps

Upon arrival in a village, the field coordinator will seek out village leaders and ask to see a list of households in the village. Some villages will have a list of households either from census information or from village resources. ***If a village does have a complete list of households no more than two years old, field coordinators will use the Option 1 strategy for household selection described below.***

If a village does not have a complete, updated list of households, the field coordinator will ask village leaders to work with them in devising a sample map of households. For some SANBASUR projects, a preliminary map from the initial diagnostic (pre-project) study may already be available; field coordinators should check their documents to see if they have this map in hand. The field coordinator will work with the village leaders to sketch this map. In particular, this map should identify:

1) The location of the main pipeline within village limits
2) Higher-wealth and lower-wealth residential areas, providing a rough estimate of their relative sizes.

Upon completion of this map, the field coordinator will use the Option 2 strategy for household selection, described below.

Field coordinators may be unable to sketch a residential map of the area; possibly because they cannot find village leaders or others in the village that has the necessary information to sketch an informal map. This represents a **worst-case** scenario, and field coordinators should do their best to obtain either a list of households or a village map. ***In this case, field coordinators should proceed to the Option 3 strategy for household selection, described below.***

Option 1: Complete List of Households Available in the Village

Upon obtaining a complete list of households from the village, field coordinators will use simple random sampling to draw 40 households from the list. The simplest method for doing this is to write down numbers from one to the last number of households on small scrap sheets of paper, place them in a hat, bowl, etc., then randomly select 40 numbers. Field coordinators with computers that have random-number generating programs may use these programs as an alternative to this strategy.

These numbers will represent your sample of households. Field coordinators will collect address or location information for each household, and work with village leaders or registry keepers to determine what areas of town these households are located in. Field coordinators will divide these into four proportional areas of different sizes, and then send enumerators to each area to conduct household interviews during the day. Field coordinators will divide areas and assign households to each selected enumerator based on the following formula (please see Chapter 2 schedule for reference).

ENUMERATOR	# INTERVIEWS REQUIRED	# POTENTIAL HOUSEHOLDS ASSIGNED
1	3	5
2	6	10
3	6	10
4	8	15

Enumerators will visit each of the assigned households until they have completed the requisite number of interviews. If they have visited all of their households but have not completed their interviews, they should revisit the houses to check if a household member has returned. Once an enumerator has completed their interviews, they can return to a site designated by the field coordinator and begin checking surveys. If an enumerator was not able to locate the requisite number of interviewees in his/her area, the field coordinator can advise them to assist another enumerator.

Option 2: List of Households Unavailable, Detailed Social Map of Village Available

Once the field coordinator has produced a detailed sketch map identifying the main water pipeline, residential concentrations, and spatial areas of wealth in the village, the field coordinator will attempt to divide the village into clusters. These clusters will roughly typify the following categories:

1) Higher-wealth area, near the main pipeline
2) Higher-wealth area, further from main pipeline
3) Lower-wealth area, near the main pipeline
4) Lower-wealth area, further from main pipeline

Please see Figure 1 for an example of a detailed social map. It may be difficult to define these clusters. Some villages may feature little difference in wealth or distance from the main pipeline. Households in other villages may be more dispersed. The objective, however, is to sample households from areas of relatively higher and lower wealth and areas that are closer to and farther away from the main distribution line. If field coordinators determine, for instance, that the differences in wealth and distance from the main pipeline are small, then field coordinators should select clusters that represent the diversity of wealth and distance in the village.

Once these clusters have been identified, the field coordinator will place the clusters into the following groups. Group 1 will contain households in high-wealth, close-distance areas and low-wealth, close distance areas. Group 2 will contain households located in high-wealth, further-distance areas and households located in low-wealth, further-distance areas.

Field coordinators will send Enumerators #1 and #4 to work in the two groups near the main pipeline and send Enumerators #2 and #3 to work in the two groups further from the main pipeline. Enumerators will begin at an intersection in the group closest to the center of the village, and then walk through the cluster and interview households encountered based on the following formula with respect to village populations:

- ***Populations 400-599:*** Every 2nd Household
- ***Populations 600-799:*** Every 3rd Household
- ***Populations 800-999:*** Every 4th Household
- ***Populations 1000-1199***: Every 5th Household
- ***Populations 1200-1399:*** Every 6th Household
- ***Populations 1400-1599:*** Every 7th Household
- ***Populations 1600-1799:*** Every 8th Household
- ***Populations 1800-1999:*** Every 9th Household

Enumerators who are working through the day who have completed their walks through the clusters but have not completed their requisite number of interviews should return to the beginning household. If no one was home at this household during the first round, the enumerator should check to see if someone has since arrived to interview. If no one is home again, the enumerator should then go to the household next door (e.g. on the right). The enumerator will follow the same procedure for every *n* th household (i.e. the enumerator will go to the 5th household, check if they have been interviewed and knock if they have not, and then proceed to the household next door). Once an enumerator has completed their interviews, they can return to a site designated by the field coordinator and begin checking surveys.

If an enumerator was not able to locate interviewees in his/her area, the field coordinator can advise them to assist another enumerator. Enumerators who assist another enumerator in a different cluster must check with that person to determine where they are in the rotation, and operate using the same formula described above.

Option 3: List of Households Unavailable, Detailed Social Map Unavailable

If field coordinators are unable to obtain a list of households or sketch a detailed social map, field coordinators must resort to what is called systematic cluster sampling with random starting points. In this method, field coordinators will divide the village into four geographic areas (these are not based on wealth or distance since these measures are presumably unavailable), based on a walk through the village. Field coordinators will guess how many people live in each area, and then send enumerators to each geographic area in proportion to the assigned number of interviews they need to complete.

From the household closest to the village center, the enumerator will then proceed to count all of the houses in his/her geographic area and number them on a map they will sketch (please see Figure 2 for an example of a sketch map). Afterwards, the enumerator will select one number at random from the list and begin interviews at that household. Field coordinators will instruct enumerators to use the same strategies for interviewing subsequent numbered households as that described in Option 2.

Sampling Female and Male Respondents

Enumerators should try to achieve some balance of female and male respondents. It is likely that, in early interviews during the day, there will be more female respondents at home. Enumerators who conduct interviews later in the day should make a concerted effort to find male subjects. At least two of the interviews conducted by each enumerator in the afternoon should be men (or women, if the morning's enumerators find that they have a very high proportion of men in their sample). Field coordinators should work with enumerators to help ensure gender representation.

At the End of the Day

Field coordinators will explain in detail the procedures they used for sampling households in each village and justify their reasons for doing so in the Field Note. They will also report any difficulties they or their enumerators encountered along the way, and discuss what measures they took in response. This information is extremely important for the Study Team because it allows us to cross-check the collected household data with the protocols used by field coordinators and enumerators to determine the quality of the information obtained by households in each village.

Appendix II – Ghana Protocol for Sampling Households within Communities

Introduction

There are different methods of selecting households for the household surveys in each community. Each technique depends upon the level of information available and whether boreholes are located within the village or in a nearby community. The following outlines the protocol that field coordinators should use to determine how to sample households at the village level. ***Field coordinators must select the option that best fits the amount of information available at the village level.***

Step 1

Upon arrival in a village, the field coordinator will seek out the village President and/or the watsan committee Chairperson. The coordinator will need to learn the following from this/these person(s).

- The number of communities that use the CWSP/Danida borehole(s) and the location(s) of these villages.
- The numbers of people that live in each of the village(s) that normally use the borehole(s).
- Whether any of the village(s) maintains a current, complete list of households no more than two years old. Some villages may have a list of households either from census information or from village resources.

Step 2a (for localities in which only one village uses the borehole(s)

If households in only one village use the borehole(s), the field coordinator will sample in one of two ways. ***If a village has a complete list of households no more than two years old, field coordinators will use the Option 1 strategy described below.***

If a village does not have a complete, current list of households, the field coordinator will ask village leaders to work with them in devising a sample map of the village. This map should identify:

3) The location of the main borehole(s) within the village
4) An estimate of the number of households in each of four geographic areas in the community, using the borehole(s) as a central point.

Upon completion of this map, the field coordinator will use the Option 2 strategy for household selection, described below.

Option 1: Complete List of Households Available in the Village

Upon obtaining a complete list of households from the village, field coordinators will use simple random sampling to draw 40 households from the list. The simplest method for doing this is to write down numbers from one to the last number of households on small scrap sheets of paper, place them in a hat, bowl, etc., then randomly select 40 numbers. Field coordinators with computers that have random-number generating programs may use these programs as an alternative to this strategy.

These numbers will represent your sample of households. Field coordinators will collect address or location information for each household, and work with village leaders or registry keepers to determine what areas of town these households are located in. Field coordinators will divide these into four proportional areas of different sizes, then send enumerators to each area to conduct household interviews during the day. Field coordinators will divide areas and assign households to each selected enumerator based on the following formula (please see Chapter 2 schedule for reference).

ENUMERATOR	# INTERVIEWS REQUIRED	# POTENTIAL HOUSEHOLDS ASSIGNED
1	2	4
2	5	9
3	6	9
4	6	9
5	6	9

Enumerators will visit each of the assigned households until they have completed the requisite number of interviews. If they have visited all of their households but have not completed their interviews, they should revisit the houses to check if a household member has returned. Once an enumerator has completed their interviews, they can return to a site designated by the field coordinator and begin checking surveys. If an enumerator was not able to locate the requisite number of interviewees in his/her area, the field coordinator can advise them to assist another enumerator.

Option 2: List of Households Unavailable, Village Map Available

Once the field coordinator has produced a detailed sketch map identifying the main boreholes and residential concentrations, the field coordinator will divide the village into four geographic areas with a relatively even number of households. The field coordinator will send enumerators to each of these areas. Enumerators 1 and 2 will likely go to the same area (near the center of town, since they will work with the field coordinator on conducting focus groups later in the afternoon).

Enumerators will begin from the center of the village, then walk through their area and interview households. They will visit households based on the following formula with respect to total village populations:

- ***Populations 100-499:*** Every House
- ***Populations 500-999:*** Every 2rd House
- ***Populations 1000-1499:*** Every 3rd House
- ***Populations 1500-1999***: Every 4th House
- ***Populations 2000-2499:*** Every 5th House
- ***Populations 2500-2999:*** Every 6th House
- ***Populations 3000-3999:*** Every 7th House
- ***Populations 4000-4999:*** Every 8th House

This formula guarantees that field teams do not only interview those households that are closest to the borehole(s).

Enumerators who are working through the day who have completed their walks through the areas but have not completed their requisite number of interviews should return to their first household. If no one was home at this household during the first round, the enumerator should check to see if someone has since arrived to interview. If no one is home again, the enumerator should then go to the next household. The enumerator will follow the same procedure for every *n* th household (for example, the enumerator will go to the 5th household, check if they have been interviewed and knock if they have not, then proceed to the next household). Once an enumerator has completed their interviews, they can return to a site designated by the field coordinator and begin checking surveys (or preparing for the focus groups, depending on their role that day).

If an enumerator was not able to locate interviewees in his/her area, the field coordinator can advise them to assist another enumerator. Enumerators who assist another enumerator in a different geographic area must check with that person to determine where they are in the rotation, and operate using the same formula described above.

Step 2b (for localities in which more than one village uses borehole(s)

If the field coordinator learns that there is more than one village where households use a borehole, the field coordinator will need to send enumerators to different villages to gather household interviews. This will require a simple calculation.

The coordinator will take the total population of all of the villages that use the borehole(s). S/he will then estimate the proportion of the total population belonging to each village, and assign the corresponding number of enumerators to each village. Again, Enumerators 1 and 2 should remain at the village with the borehole, since they will be needed to conduct and/or take notes during afternoon focus groups.

For example: Village A contains a borehole and 1,000 people live there.
Village B uses the borehole and 500 people live there
Village C also uses the borehole and 500 people live there.

Thus, Village A represents 50% of the total, while Villages B and C each represent 25% of the total. The best alternative would be to keep Enumerators 1-3 in Village A, and send Enumerators 4-5 to Villages B and C, respectively. The field coordinators will need to use their judgment concerning how many enumerators to send to each village, but it is imperative that teams visit a sample of households in all villages that use the borehole(s)!

Once the field coordinator has decided how many enumerators to send to each village, teams will use either Options 1 or 2 described above to select what households to visit. If a village does have a complete list of households, use Option 1. If not, then use a modified version of Option 2. Here, cases will arise where only one or two enumerators will be placed in a village. Nevertheless, we still want teams to obtain geographic representation within the village, and to use the formula described above to interview households.

For example, if Enumerator #3 is selected to go to a village without a list of households, s/he should divide the village into three areas, then visit households in each area according to the population formula above (this translates into visiting probably every household or every other household for smaller villages). The enumerator would obtain two completed interviews from the first area, then move to the next area, etc. until finished. Field coordinators should discuss these strategies with enumerators before proceeding.

Sampling Female and Male Respondents

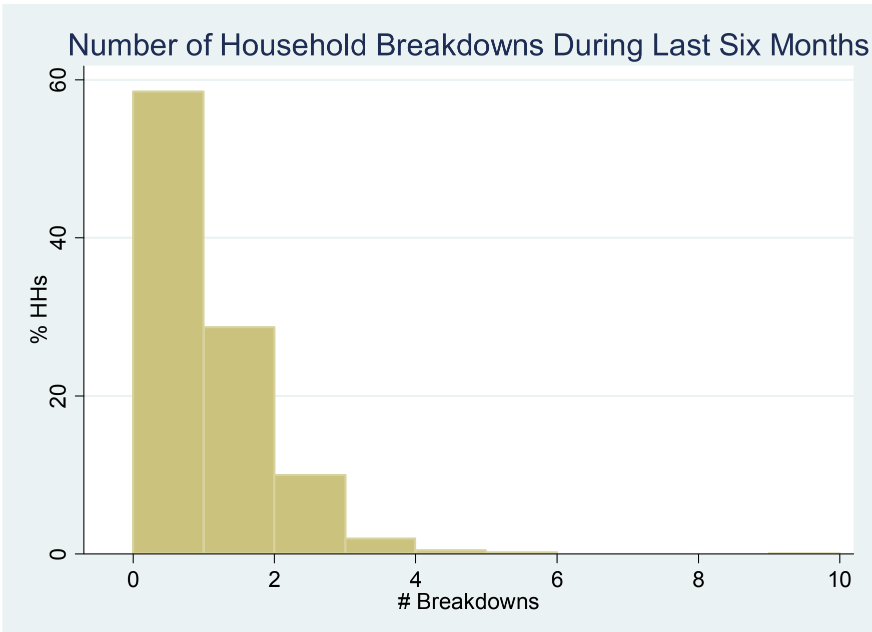
Enumerators should try to achieve some balance of female and male respondents. Enumerators 3-5 should try to interview at least two men and two women during their day. Enumerator 2 should try to interview at least one man and at least one woman. Field coordinators should work with enumerators to help ensure gender representation.

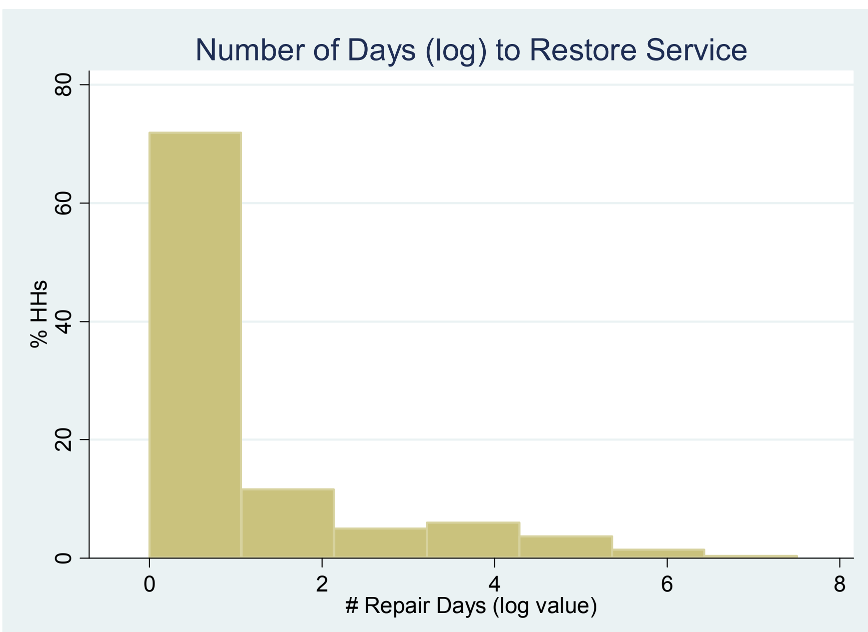
At the End of the Day

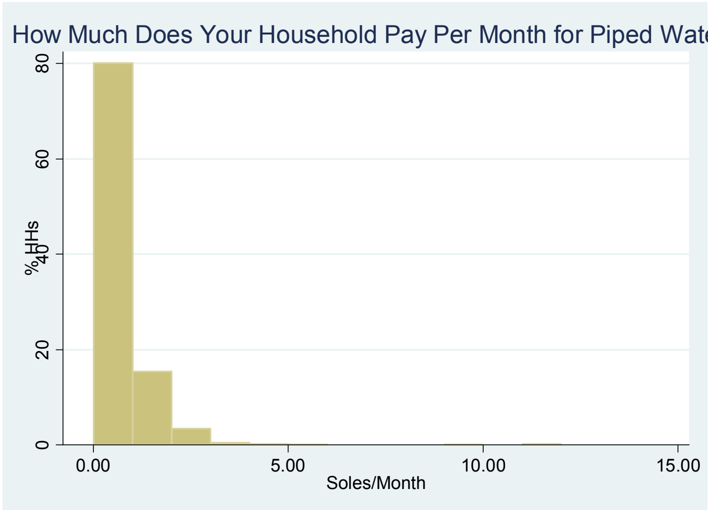
Field coordinators will explain in detail the procedures they used for sampling households in each village and justify their reasons for doing so in the Field Note. They will also report any difficulties they or their enumerators encountered along the way, and discuss what measures they took in response. This information is extremely important for the Study Team because it allows us to cross-check the collected household data with the protocols used by field coordinators and enumerators to determine the quality of the information obtained by households in each village.

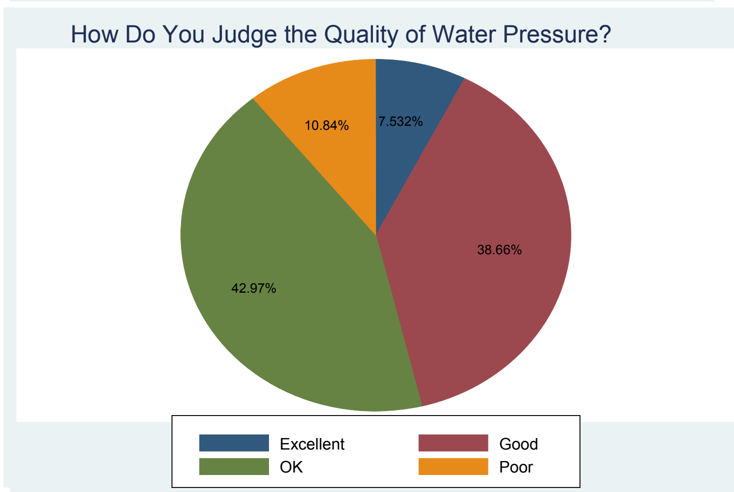
Appendix III: Frequency Distributions for Sustainability Indicators (dependent variables)

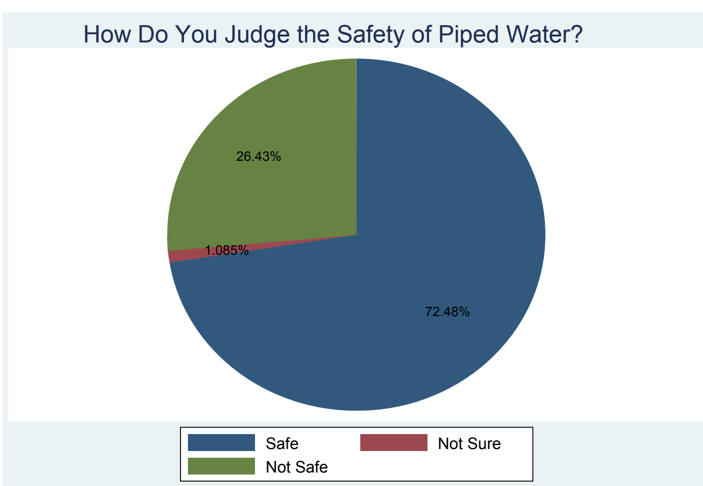
Peru Results

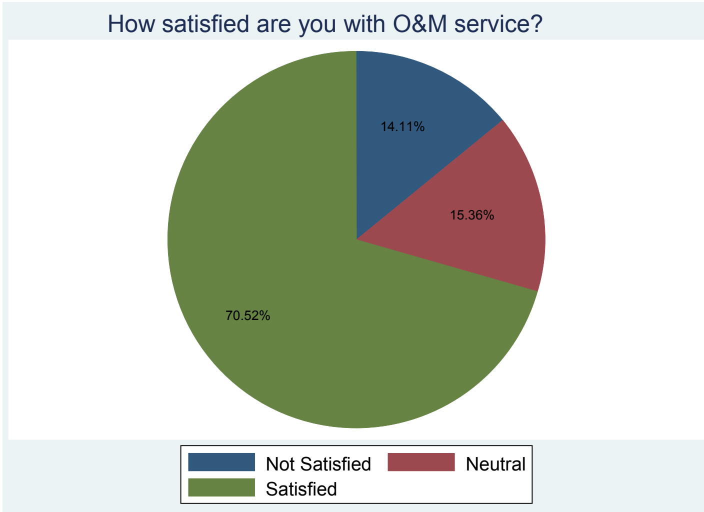


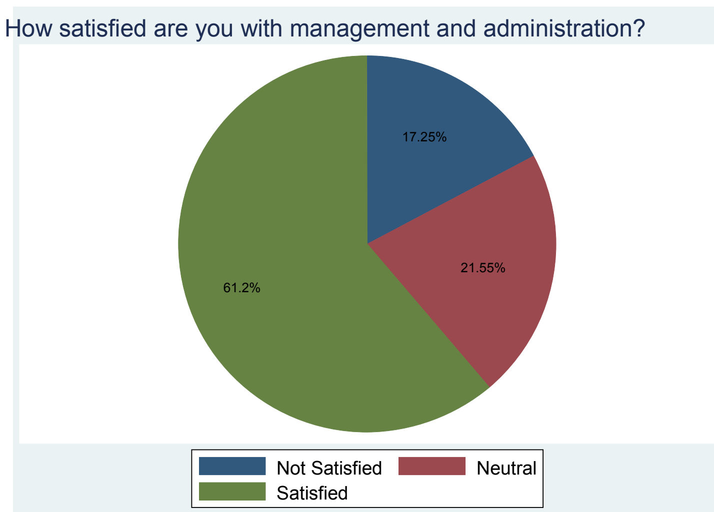


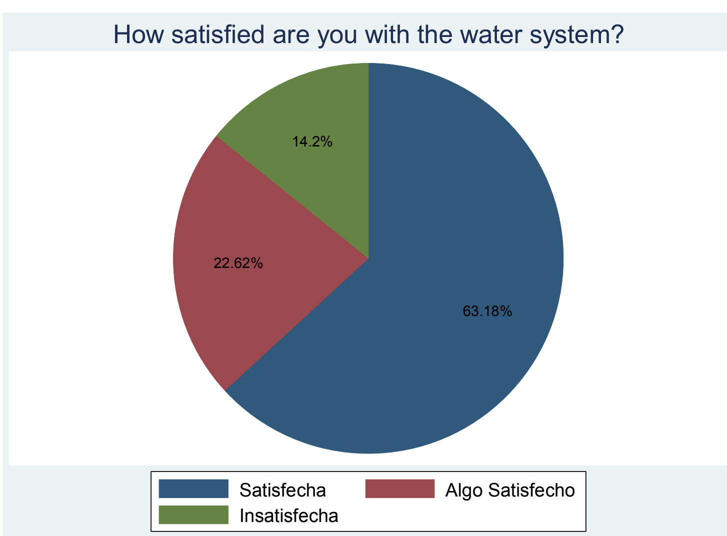

How Much Does Your Household Pay Per Month for Piped Water?
% HHs
0
20
40
60
80
0.00
5.00
10.00
15.00
Soles/Month

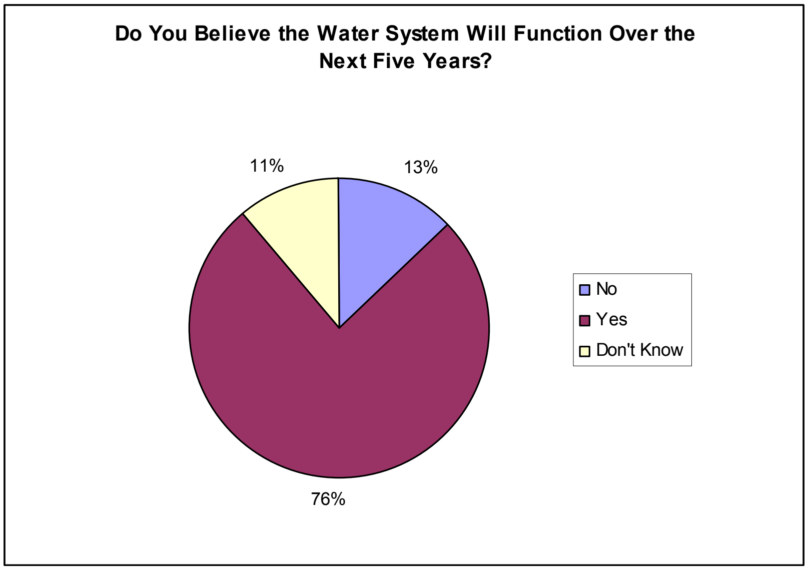

How Do You Judge the Quality of Water Pressure?
10.84%
7.532%
38.66%
42.97%
Excellent
Good
OK
Poor

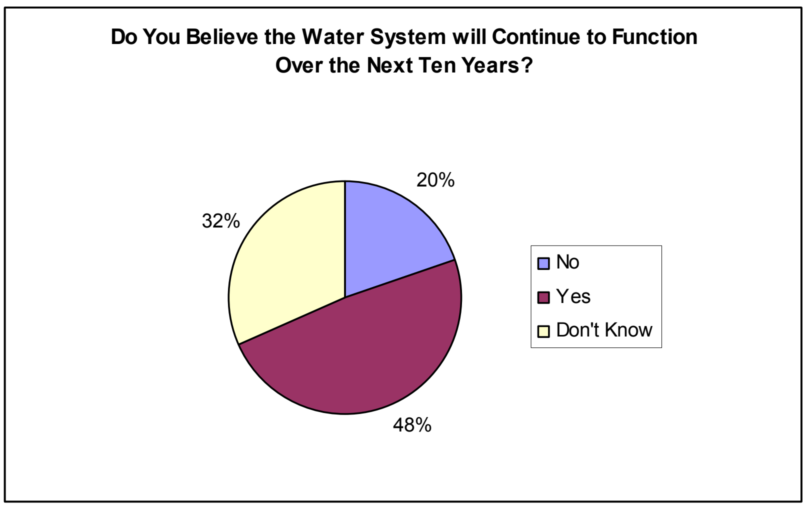

How Do You Judge the Safety of Piped Water?
26.43%
1.085%
72.48%
Safe
Not Sure
Not Safe


How satisfied are you with O&M service?
14.11%
15.36%
70.52%
Not Satisfied
Neutral
Satisfied

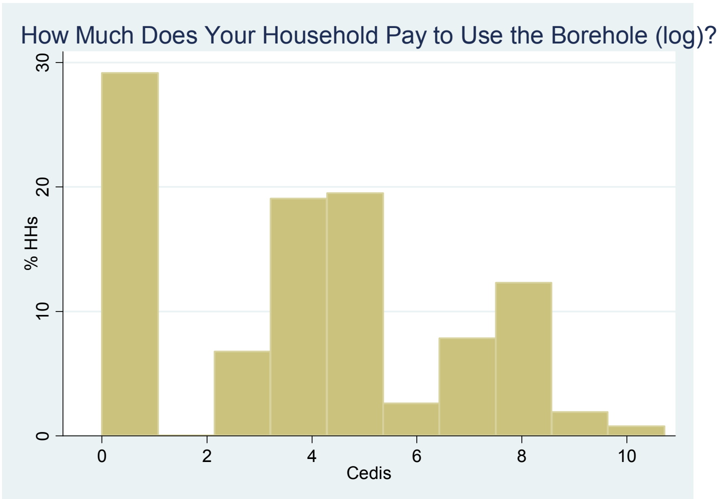

How satisfied are you with management and administration?
17.25%
21.55%
61.2%
Not Satisfied
Neutral
Satisfied

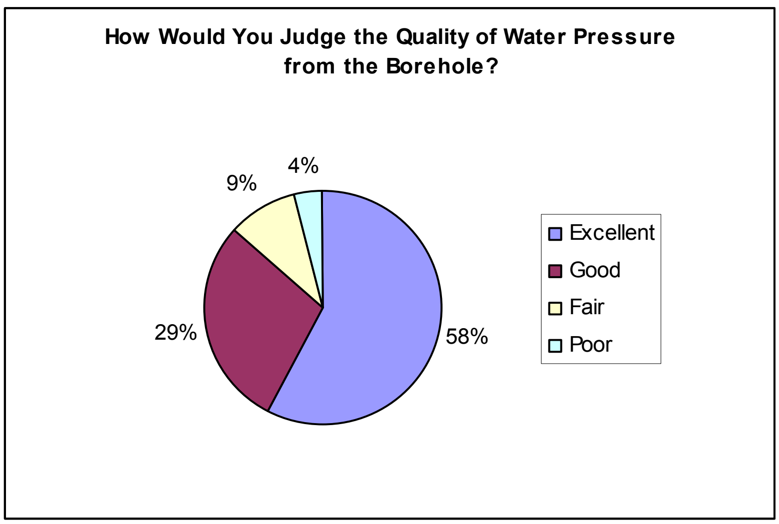

How satisfied are you with the water system?
14.2%
22.62%
63.18%
Satisfecha
Algo Satisfecho
Insatisfecha

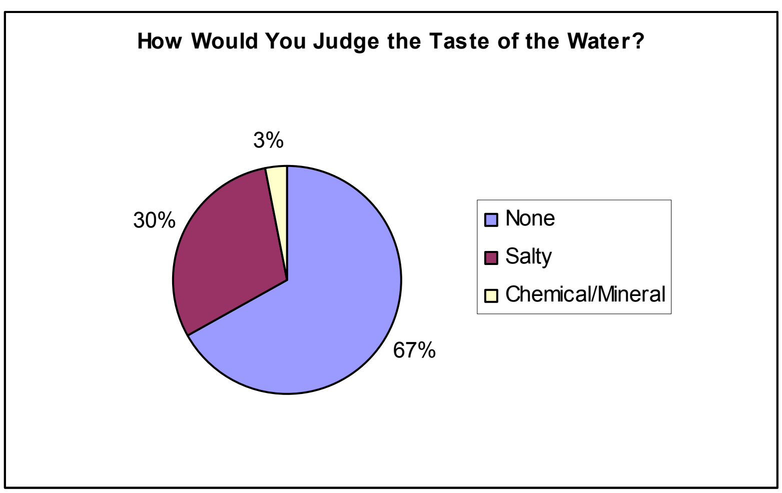

Do You Believe the Water System Will Function Over the Next Five Years?
11%
13%
76%
No
Yes
Don't Know

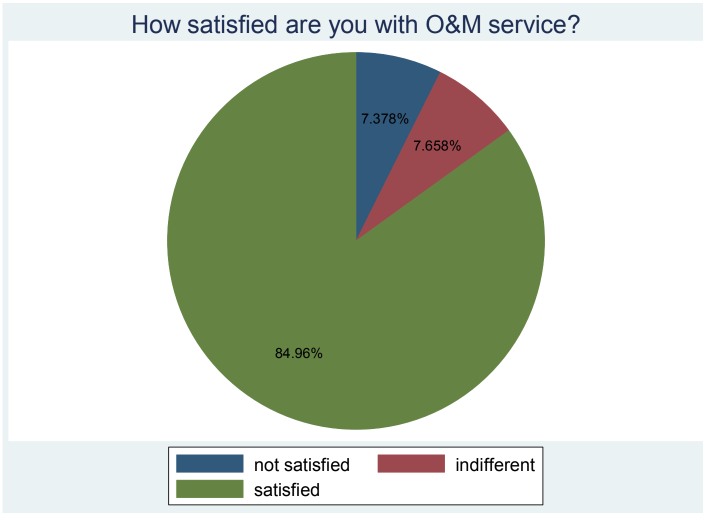

Do You Believe the Water System will Continue to Function Over the Next Ten Years?
20%
32%
48%
No
Yes
Don't Know

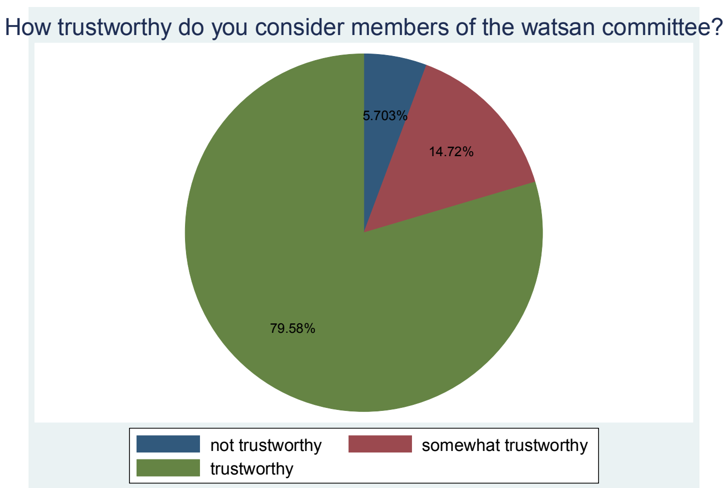
Ghana Results

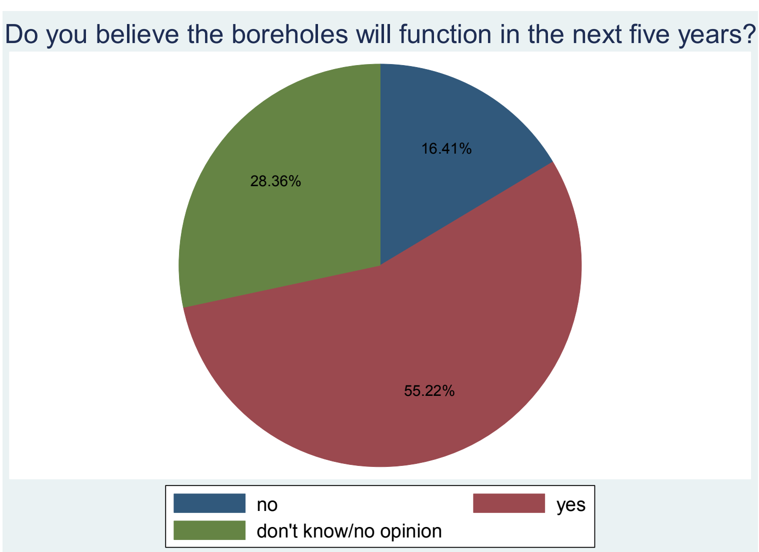


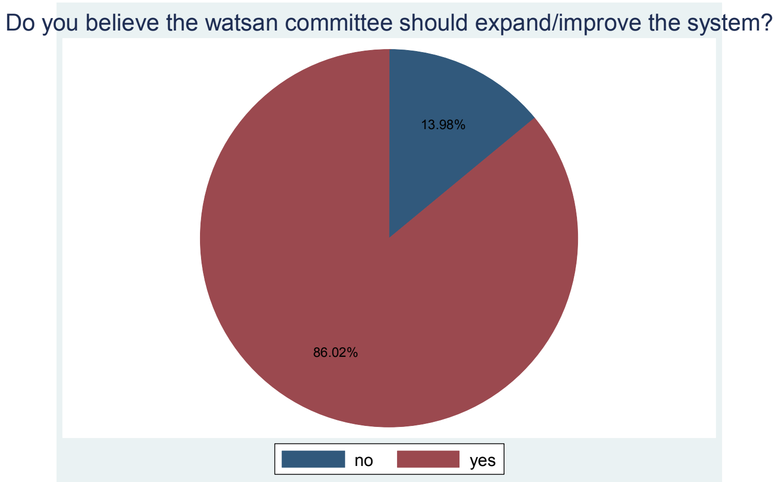





How satisfied are you with O&M service?
7.378%
7.658%
84.96%
not satisfied
indifferent
satisfied


How trustworthy do you consider members of the watsan committee?
5.703%
14.72%
79.58%
not trustworthy
somewhat trustworthy
trustworthy


Do you believe the boreholes will function in the next five years?
16.41%
28.36%
55.22%
no
yes
don't know/no opinion


Do you believe the watsan committee should expand/improve the system?
13.98%
86.02%
no
yes

Appendix 4: Model Results for Sustainability as Latent Variable - Peru

FACTOR	PERU
HOUSEHOLD	
Yrs. Connect	0.127
Part. Index	-0.01
Contribution	-0.004
Meeting Attd/Awareness	-0.039
PCS	-0.115
HH members	0.035
HH size	0.034
Income	-0.131**
Assets	-0.027
Age	-0.001
Social Capital	-.023**
System – Good Construction	0.433***
Knowledge How $ Spent	0.147*
Treats water	
VILLAGE	
Program	0.239
Volta Region	
Operator Experience	-0.054*
Operator Trained	0.065
Operators in village	
Source – Dry Months	0.03
Source - Distance	
System – Storage Cracks	0.236
System – No Leaks	0.208
System - Mechanic distance	
Population	0.000
Village Size	0.001**
Committee Experience	-0.009
Elected Committee	-0.029
Committee Trained	0.032
Payment system - collections	
Payment system - flat fee	
Payment system - HH fee	
Payment system - pay as fetch	
Model	SEM w/ RI
Sample N	940
BIC-adjusted	5907

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