Impact Evaluation of the Rural Water Activity Under a Cooperative Agreement between MCC and Stanford University

Impact Evaluation Design and Implementation Report

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List of Abbreviations

DPOPH	Department of Public Works and Housing, Mozambique
GIS	Geographic information system
GPS	Global positioning satellite
HH	Household
LPCD	Liters *per capita* per day
MCA	Millennium Challenge Account
MCC	Millennium Challenge Corporation
MIPAR	Rural Water Supply Implementation Manual (National Directorate of Water, Ministry of Public Works, Mozambique)
RWSA	Rural water supply activity
SSS	Small-scale piped system
VT	Virginia Polytechnic Institute and State University (or "Virginia Tech")
WC	Water committee

1 Introduction

The Millennium Challenge Corporation (‘*MCC*’) is a Federal Corporation created under Title VI of the Foreign Operations, Export Financing, and Related Programs Appropriations Act, 2004. It is tasked with managing and implementing the Millennium Challenge Act, which Congress approved to provide United States assistance for global development. The key tenets of this assistance are the promotion of economic growth and elimination of extreme poverty.

MCC’s mandate is to rigorously evaluate the projects it funds to assess its investment impact and contribute to the development literature for knowledge dissemination. MCC is committed to using impact evaluation resources where they will provide the most useful lessons. Government and organizations often design and fund projects where the link between the activity and poverty reduction is anecdotal. In these cases, rigorous impact evaluations can help establish, or refute, the links between costly investments and stated benefits. Also, MCC often funds similar projects in several countries and is interested in evaluating the effectiveness of these projects in different contexts. In some circumstances, governments may expand program(s) following the MCC investment using the result of the impact evaluation. In all of these scenarios, impact evaluation should provide lessons that will help in focusing limited funds where they can address development priorities most effectively.

In 2007, the MCC signed a $506.9 million compact designed to reduce poverty in Mozambique by promoting sustainable economic growth. Among the planned investments is the installation of 600 improved water points in rural communities across the provinces of Nampula and Cabo Delgado. Most of the water points are boreholes equipped with Afridev handpumps, but in Cabo Delgado eight boreholes have been upgraded to small piped water supply systems where there is sufficient water supply and unmet demand. The Rural Water Supply Activity (‘*RWSA’*) of the Mozambique Compact is intended to increase sustainable access to improved water supply in some of the country’s poorest districts.

Stanford University and Virginia Tech (‘*Stanford-VT’*) are collaborating with the MCC on an impact evaluation of the RWSA investments to be undertaken in the province of Nampula. The main in-country partner for the impact evaluation is WE Consult (Mozambique).

This document provides an overview of the design of the RWSA impact evaluation. The first two sections (2 and 3) describe the overall research objectives, questions, design, and sample frame for the evaluation of the handpumps installed in the province of Nampula. Section 3 also reviews how the sample frame has changed since the 2011 baseline study and presents a series of illustrative power calculations for the revised sample. The section concludes with an outline of the activities planned for the 2013 follow-up study in Nampula, and outlines the new data collection activities that will be undertaken. Section 4 describes the study of the eight small-scale piped water system installed in the province of Cabo Delgado. The section outlines the research objectives, methods, and questions that will be pursued in the study. The final section of the document provides information on the management of the impact evaluation, which includes a discussion of team roles, responsibilities, and ethical clearance; data quality and management; and the work plan.

2 Objectives of the Rural Water Supply Activity and its Evaluation

The Mozambique Compact describes the objectives of the Rural Water Supply Activity (‘*RWSA*’) as follows:

> *The Rural Water Supply Activity will increase beneficiary productivity and income by:*
>
> 1. *Providing time savings by reducing the time burden of water collection. Time savings from an improved water supply will increase beneficiary productivity and incomes.*
>
> 2. *Reducing water-related illnesses (diarrhea, dysentery, etc.). Health improvements resulting from an improved water supply will increase beneficiary productivity and incomes.*

The objective of the RWSA impact evaluation is to design and implement a rigorous impact evaluation for the rural water investment within the Mozambique Compact that examines the extent to which these program objectives have been realized. Rigorous impact evaluations should allow causal claims to be made about program interventions and observed changes in outcome indicators, typically by comparing the beneficiaries of the program to a comparison group.

The Stanford-VT team worked with colleagues in the Monitoring & Evaluation unit of the MCC to develop a set of research questions that underpin the evaluation. In addition to collecting evidence regarding the RWSA objectives above, the Stanford-VT team also included a number of questions that will leverage the MCC’s investment in the impact evaluation to generate additional learning regarding the measurement of, and distribution of, costs and benefits of rural water infrastructure improvements; the value that households have for different features of water supply options; and the relationship between community participation in rural water planning, community and water committee sense of ownership for installed assets, and prospects for sustainability of those assets.

The full set of research questions to be pursued within the evaluation of the handpumps installed in the province of Nampula is presented in Section 0. Unless otherwise stated, answering each question will entail a comparison of data collected during baseline (2011) and follow-up (2013) studies for households in the treatment *versus* comparison communities. The general format for each entry is as follows:

#. Research question

- Description of the variable(s) necessary to answer the question
    - Sources of data for those variables (*e.g.*, household survey module(s), water committee interview, *etc.*)

2.1 Research Questions: Nampula

1. **How does the installation of handpumps through the MCC program affect the time costs of water collection?**
   - Person-hours per day devoted to water collection, per household
     - HH survey: Water supply module
   - Person-hours per day required to fetch 20 LPCD, per household
     - HH survey: Water supply module
   - Time required to complete one round trip between the home and water point
     - HH survey: Water supply module, and GPS coordinates
     - Google maps: digitized track data between HHs and water points

2. **How does the use of alternative indicators of distance affect the estimated time cost of water fetching?**
   - Self-reported one-way walk time from the home to the water source
     - HH survey: Water supply module
   - Track distance from each home to the water source
     - Google maps
   - Euclidean distance from each home to the water source
     - Google maps
   - Walking pace
     - HH survey: Water supply module
     - Published literature

3. **How are the time costs of water collection distributed across male, female, adult, and youth members of the household?**
   - Person-hours per day devoted to water collection, by gender and age category (adult, adolescent, youth)
     - HH survey: Water supply module
     - HH survey: Demographics module

4. **How does the installation of handpumps through the MCC program affect the human energy cost of water fetching?**
   - Distance traveled (person-meters) per household per day for water fetching
     - HH survey: Health module
   - Load carried (kg.) from home to water point, and from water point to home
     - HH survey: Health module
   - Type of terrain between home and water point (*e.g.*, rocky, grassy)
     - HH survey: Health module
   - Slope of terrain between home and water point
     - Field measurements
   - Metabolic expenditure per unit distance under varying loads (*e.g.*, empty jerricans, 1 or 2 full jerricans, *etc.*)
     - Field and laboratory measurements with OxyCon mobile monitoring device (parallel investigation in partnership with Universidade Lúrio)

5. **How does the installation of handpumps through the MCC program affect the amount of water from improved and unimproved sources used by households?**
   - LPCD obtained from all sources, for rainy and dry season
     - HH survey: Water supply module
   - LPCD obtained from improved sources, for rainy and dry season
     - HH survey: Water supply module
   - Percentage of households that obtain ≥ 20 LPCD from an improved source, for rainy and dry season
     - HH survey: Water supply module
   - Percentage of households that make use of the MCC water point
     - HH survey: Water supply module
     - WC interview

6. **What is the relative contribution of water source features to household choice of source in the rainy and dry season?**
   - Number and type of water sources available to household, by rainy and dry season
     - HH survey: Water supply module
   - Price of water obtained from each available source
     - HH survey: Water supply module
   - Time costs of water obtained from each available source
     - HH survey: Water supply module
   - Availability (hours per day) of supply from each available source
     - HH survey: Water supply module
   - Predictability of supply from each available source
     - HH survey: Water supply module
   - Perceived safety of supply from each available source
     - HH survey: Water supply module
   - Perceived aesthetic acceptability (*e.g.*, taste, odor) of supply from each available source
     - HH survey: Water supply module

7. **To what extent do community members express a sense of ownership for the infrastructure installed by the MCC program? How is sense of ownership related to community members' participation in planning, construction, and ongoing management of the water points?**
   - Percentage of households identifying themselves as 'owners' of the water point
     - HH survey: Water supply module (multiple questions)
   - WC perception of who initiated the water point project (*e.g.*, the community, government)
     - WC interview
   - WC perception of whether most households in the community were aware of the project prior to construction
     - WC interview
   - Number of meetings held about the project prior to construction
     - WC interview
   - Extent of women's participation in pre-construction meetings

    - WC interview
- WC perception of who has had the greatest influence over decisions related to the water point
    - WC interview
- Type and amount of cash, labor, and in-kind contributions made by community members toward the project
    - HH survey: Water supply module
    - WC interview
- Percentage of households that made cash, labor, and in-kind contributions toward the project
    - HH survey: Water supply module
    - WC interview

8. How does the installation of handpumps through the MCC program affect school attendance for girls and boys?

- Percentage of households reporting that child school attendance is affected by water fetching duties, total and by gender
    - HH survey: Water supply module

9. How well are the handpumps installed by the MCC project performing from a technical perspective?

- Percentage of handpumps found operational at time of interview
    - Technical assessment
- Number of breakdowns reported since installation
    - WC interview
- Duration of longest breakdown since installation
    - WC interview

10. What are the prospects for long-term sustainability of the MCC handpumps?

- Household satisfaction with the handpump project
    - HH Survey: Water supply module; Participation module
- Number of meetings held in the community about the handpump in the year prior to interview
    - HH survey: Water supply module
    - WC interview
- Amount of revenue collected *versus* operation and maintenance expenditures
    - HH survey: Water supply module
    - WC interview
- WC perception of revenue sufficiency to carry out preventative maintenance and minor repairs
    - WC interview
- Type of water supply tariff used and share of households paying
    - WC interview
    - HH survey: water supply module
- Number of maintenance duties regularly completed by the water committee
    - WC interview

- WC perception of the ease with which spare parts can be obtained
    - WC interview
- WC perception of their ability to execute their responsibilities successfully
    - WC interview
- WC report of any conflict within the community related to the water point
    - WC interview
- Community members' opinion of whether the water point will continue to function over the next 1, 5, and 10 years
    - HH survey: Water supply module
    - WC interview

11. How does the installation of handpumps through the MCC program affect the 7-day prevalence of gastrointestinal and respiratory illness?

Note: All variables in this section refer to the 7-day time period prior to interview.

- Percentage of households that reported seeking treatment or medical advice for any member with gastrointestinal and/or respiratory illness
    - HH survey: Health module
- Percentage of children with symptoms of gastrointestinal illness (both simple and highly credible)
    - HH survey: Health module
- Percentage of children with symptoms of respiratory illness (both simple and highly credible)
    - HH survey: Health module
- Among households seeking treatment or medical advice, the amount of time (in person-hours) devoted
    - HH survey: Health module
- Among households seeking treatment or medical advice, the amount of money expended
    - HH survey: Health module
- The percentage of under-4 children with a height-for-age Z-score (HAZ) of -2 or lower (stunting)
    - HH survey: Health module

12. How does the installation of handpumps through the MCC program affect the microbiological quality of water supplies being used by households?

- Concentration of *E. coli* and enterococci fecal indicator bacteria (Most Probable Number (MPN) of colony forming units per 100mL) in water obtained from community sources (*e.g.*, handpump, well, river)
    - Water quality testing
- Concentration of *E. coli* and enterococci fecal indicator bacteria (Most Probable Number (MPN) of colony forming units per 100mL) in stored drinking water within households
    - Water quality testing

13. How does the installation of handpumps through the MCC program affect sanitation and hygiene practices?

- Percentage of households that practice open defecation
    - HH survey: Sanitation module

- Percentage of households using an improved latrine (with a concrete slab)
  - HH survey: Sanitation module
- Percentage of households that report using soap or ash to wash their hands
  - HH survey: Sanitation module
- Percentage of households that installed a latrine between baseline and follow-up
  - HH survey: Sanitation module
  - WC interview

14. How does the installation of handpumps through the MCC program affect household income and consumption?

- *Per-capita* household expenditure per week
  - HH survey: Income module
- Annual household income from all sources
  - HH survey: Income module
- Diversity of foods consumed (index created from responses about consumption of many different food types)
  - HH survey: Health module
- Number of times household members ate meat/protein within 7 days prior to interview
  - HH survey: Health

3 Impact Evaluation Design: Nampula

In order to assess the impacts of the installed water points on households in the RWSA communities, the research design employs a panel survey. Panel surveys are specifically designed to compare communities/households "before" and "after" an intervention, which permits a "difference-in-differences" approach to the analysis of data collected. Thus, the impact evaluation was designed around a baseline survey in 2011, mainly targeted to collect pre-intervention information, and a follow-up survey planned for 2013.

As discussed in Section 3.1.2, the original sample included 18 Phase 1 treatment and comparison communities (nine in each group). Since the Phase 1 treatment communities had received a water point at the time of the baseline study, the analysis of data from these communities was intended to focus on the extent to which observed benefits of the water points are sustained over time. More specifically, Phase 1 treatment communities will be compared with Phase 2 treatment communities to determine whether and how the handpump effects vary as the handpumps age (*e.g.*, changes in water use behaviors, shifts in productive activities among household members that result from time savings, changes in household income and consumption). Such comparison requires the assumption that pre-construction conditions in Phase 1 communities were comparable to those in Phase 2 communities, an assumption that cannot be verified with empirical data.

None of the Phase 2 treatment communities included in the sample had received a water point at the time of the baseline survey. Thus, the evaluation of the Phase 2 treatment and comparison communities will use a standard difference-in-differences approach in which outcomes are observed for two groups for two time periods.[1] The treatment group is exposed to the intervention by the second period, but not in the first period. The comparison group is not exposed to the treatment during either period. In the case where the same units within a group are observed in each time period, the average gain in the second (comparison) group is subtracted from the average gain in the first (treatment) group. This approach removes biases in second-period comparisons between the treatment and comparison group that could be the result from permanent differences between those groups, as well as biases from comparisons over time in the treatment group that could be the result of general trends.

Modeling of these data takes the general form of $y = \beta_0 + \beta_1 dB + \delta_0 d2 + \delta_1 d2 \times dB + u$, where *y* is the outcome of interest (*e.g.*, time cost of water fetching), and *d2* is a dummy variable indicating the second time period (follow-up). The dummy variable *dB* addresses possible differences in the treatment *versus* control groups at baseline, while the dummy variable *d2* addresses trends that would result in change in this outcome even in the absence of the intervention (*i.e.,* the RWSA). The coefficient of interest, $\delta 1$, is multiplied by the interaction term *d2xdB*, which takes the value of 1 only for treatment observations in the second (follow-up) period. The difference-in-differences estimate is thus given by $\hat{\delta}_1 = (\bar{y}_{B2} - \bar{y}_{B1}) - (\bar{y}_{A2} - \bar{y}_{A1})$.

The difference-in-differences approach assumes that in the absence of the intervention, the values of outcome variables of interest would be changing at the same rate in the two cohorts. The Stanford-VT team developed a sample frame that tried to minimize the potential for systematic differences to exist between the treatment and comparison groups. It must be recognized, however, that the RWSA was based upon a demand-responsive approach to rural water planning. As such, communities that wanted to receive a water point had to organize themselves and successfully manage several programmatic demand filters (*e.g.*, forming a committee and collecting approximately US$90 in capital cost contributions from community members) in order to be eligible for a water point. Such communities may have characteristics that differentiate them from those (comparison) communities that were not able to mobilize the resources to qualify for the RWSA.

Acknowledging this potential for sample bias, analysis of the 2011 baseline data (presented in the Stanford-VT *Mid-Term Report*) is encouraging. At the time of the baseline survey, there were no significant differences observed in the treatment *versus* comparison communities in terms of [1] the average volume of water consumed by households; [2] the level of access to improved water sources; [3] the average time spent collecting water per household; and [4] average total household expenditure per month. These observations provide some confidence that the comparison communities are similar to the treatment communities on key metrics. In addition, some communities originally classified as comparison cohort members were re-classified as treatment communities (see Section 3.2). Such re-classification could be interpreted as evidence that the two cohorts were reasonably comparable in terms of their ability to organize and obtain a water point.

[1] Note: Phase 1 *comparison* communities were intended to measure the changes between 2011 and 2013 in the absence of a handpump and will be used in the difference-in-differences analysis.

These findings notwithstanding, it is unreasonable to assume that the treatment and comparison communities are the same with respect to every characteristic of interest. The difference-in-differences approach, however, requires only that, absent the rural water program intervention, the unobserved differences between the two groups would be equivalent over time. In addition, control variables can be included in the difference-in-differences regression models to address confounding or common response concerns.

The data collected from the study will also support a geospatial analysis of the factors associated with household water source choice. During the baseline and follow-up studies, GPS coordinates will be taken at each household surveyed and at the location of each main community water source. The local name of each water source will then be referred to during the household survey when respondents are asked about the main water sources (up to three) they use (one of which could have been an handpump installed *via* the RWSA). By analyzing these data it will be possible to determine the distance from the household to each source it does *and* does not use. Data will also be collected on the perceived quality of the water obtained from each source, how the water is used, as well as data on any payments that are made. Respondents will also be asked about whether their household uses the nearest available water source and if not, why. These geospatial and survey data will enable the creation of a model of water source choice (in all sample communities) as a function of distance and other service features, in order to quantify the relative effect of each on the likelihood that a given source is chosen.

3.1 Nampula Sample Frame

3.1.1 Key Decisions that Shaped the Nampula Sample Frame

The decision to limit the evaluation to Nampula province (excluding Cabo Delgado) was made in 2009 as a result of both budgetary and validity concerns. Through consultation with MCC staff the Stanford-VT team concluded that spreading the available evaluation resources across both provinces would (1) substantially reduce the number of communities and households that could be included in the study and (2) result in a sample frame that did not allow for meaningful comparisons between the provinces.

The rural water program was based on principles laid out in the MIPAR, the rural water supply implementation manual developed by the Rural Water Department of Mozambique's National Directorate of Water, housed in the Ministry of Public Works. The MIPAR operationalizes national water policy by providing implementation guidelines for relevant institutions at the national, provincial, district, and community level. Key among the MIPAR principles is a demand-responsive (rather than supply driven) orientation, including the requirement that communities participate throughout the planning, construction, operation, and maintenance of rural water infrastructure.

Given the MIPAR framework underpinning Mozambique's rural water sub-sector, the allocation of water points in the MCC-supported project had to be based on communities' meeting the eligibility criteria for the program (*e.g.*, forming a water committee, contributing toward the capital cost of the handpump, *etc.*). From an impact evaluation perspective, the ideal strategy for a sample frame would be to identify all communities that met these criteria, then to randomly select a subset of those to receive a handpump. Such an approach was deemed infeasible from the perspective of procedural fairness. As one example, a number of communities had been approved for a handpump as part of a previous project (ASNANI) but were ultimately left unserved when project resources were exhausted. Randomization of water points in the MCA rural water project would have conflicted with the privileged status that these communities were considered to have in the selection process.

As a second option, the Stanford-VT team proposed a randomized roll-out of water point installation among communities that were approved to receive a handpump in the MCA rural water program. The evaluation strategy envisioned was to use communities in the latter 'waves' of handpump installation as controls for the earlier waves. This too was viewed as infeasible, as it would impede the contractor's ability to organize drilling and well installation in the most cost-effective manner and made it impossible to reach the RWSA construction targets within the available budget.

The Stanford-VT team then proposed that those communities who were approved to receive a handpump in Phase 1 and 2 of the program, but who were subsequently found to have unfavorable geophysical conditions and were rejected from the program, could serve as control communities for the impact evaluation. The idea of collecting data from these communities was strongly resisted by the MCA, based on the concern that these communities might confuse this action as signaling that they were still part of the rural water program. Additional concerns were raised about the potential for these communities to respond negatively toward outside groups asking questions about water-related issues, following the disappointing experience of a negative borehole test.

A fourth proposal put forward by the Stanford-VT team was to select communities that were not part of the rural water program, and that did not have access to an improved water sources, from the same districts in which the rural water program is operating. This proposal was rejected by the DPOPH in Nampula, based on concerns that the presence of a research team in these communities might raise their expectations for receiving a water supply improvement in the future.

After considerable discussion among the Stanford-VT team, MCC and MCA staff, and senior officials of the DPOPH, it was ultimately agreed that comparison communities would only be selected from *localidades* (or localities, the lowest geographical level of the central state administration that normally consists of multiple communities) that were benefitting from at least one MCA handpump. This approach was the only one that received the support of the Director of the DPOPH in Nampula, who subsequently granted the Stanford-VT team permission to conduct the study. It was also discussed with the staff in the National Statistics Institute of Mozambique (INE), whose endorsement was critical to the study's credibility. The final approach also resulted in comparison communities being selected from within the same locality as a community receiving an MCA handpump, *i.e.*, in closer geographic proximity as compared to sampling at the district level.

The procedure by which comparison communities were selected began by the Stanford-VT team meeting with the *Chefe de localidade* to explain the study and seek permission to conduct research in a given locality. The team then explained to the *Chefe* the need to select a community to *compare* against the community receiving an MCA handpump. The *Chefe* was asked to work with the field team to develop a list of comparison communities—none of which had a handpump—located within his *localidade*. Those communities that were included in Phase 1 or 2 of the rural water program were removed from the list, along with communities that were originally approved for the program but were subsequently removed due to unfavorable geophysical conditions (*e.g.*, negative test borehole results, as explained above).

Once the list was developed, the *Chefe* was asked to personally select one community at random by drawing a slip of paper out of a hat. Because the *Chefe de localidade* was fully involved in the selection of the comparison community, he was well positioned to answer any questions that might arise about why a community not included in the rural water project had been included in the study.

The time required for the protracted discussion between the Stanford-VT team, MCC, MCA, DPOPH, and INE of how to identify a suitable set of comparison communities effectively made data collection before the installation of Phase 1 water points an impossibility. Acknowledging the lack of pre-intervention data in these communities, the decision to include them in the study sample was the result of several important considerations. First, since Phase 1 and 2 of the rural water program each targeted three different districts, if Phase 1 had been excluded we would have only studied one-half of the rural water program in Nampula. Second, including Phase 1 communities in the sample meant that we could study the performance of, and benefit streams from, the handpump beyond its one-year warranty. When designing the baseline sample, there was a concern that some of the handpumps in Phase 2 might be installed within months or weeks of the 2013 follow-up study. The inclusion of Phase 1 communities in the study meant that we could collect data on the performance and impact of the handpumps at least two years after their installation, which was deemed important by MCC/MCA staff.

Third, based on the high occurrence of negative geophysical results among otherwise eligible communities in Phase 1 of the rural water program, the Stanford-VT team was concerned that the same situation might occur during Phase 2. Including Phase 1 communities with operational handpumps in the baseline ensured that we captured data on the effects of providing water supply from improved sources. We note that 11 of our original 18 Phase 2 treatment communities did indeed obtain negative geophysical results (see Section 3.2), suggesting that such concern was warranted.

Finally, since the MCA had not selected the Phase 3 communities at the time of the baseline study, it was not possible to include this group in the design of the sample.[2] Thus, Phase 1 was also included to ensure that data were collected on two of the three phases of the rural water program in Nampula.

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[2] In addition, it is important to note that Phase 3 water point installations will occur towards the end of the RWSA, allowing insufficient time for the full impacts of the interventions to be realized before the follow-up study. Further, these water points will still be under warranty at the time of the follow-up study, precluding meaningful investigation of communities' ability to manage these assets on a sustainable basis.

3.1.2 The 2011 Baseline Sample Frame in Nampula

Given the above context, the sample frame was developed in an effort to draw confident causal inference about the impacts attributable to the installation of water points in the RWSA. Following the purposive first-stage selection of Nampula, the selection of districts and communities was conducted as follows:

1. **Districts** within Nampula province were selected that contained communities receiving water points during Phases 1 and 2 of the RWSA.

2. **Treatment communities** were selected from all communities that have received or will receive a water point from the RWSA during Phase 1 or 2 of the RWSA. There are two groups of treatment communities. The first group consists of communities that had recently received their water point at the time of the baseline study in May 2011. These communities were selected from Phase 1 of the RWSA. The second group consists of communities from Phase 2 of the RWSA that have been approved to receive an improved water point between the baseline and follow-up surveys.

   Treatment communities were selected from lists provided by MCA and CoWater of the communities that received a water point in Phase 1 and that are scheduled to receive a water point in Phase 2. The locality of Quixaxe Sede in Mogincual district was excluded based on advice from CoWater regarding possible security risks for the enumeration team. Among the remaining localities communities were selected randomly, although a maximum of three treatment communities was allowed per locality so as to ensure a spread of communities throughout each district.

3. **Comparison communities** were selected within the same geographic areas as the treatment communities, following the procedure described in Section 3.1.1. An equal number of treatment and comparison communities were included in the sample. Comparison communities are not expected to receive an improved water point from the RWSA; however, it is possible that these communities may receive a water project from another organization within the timeframe of the impact evaluation. No attempt was made to limit potential external interventions in these communities, although efforts have been made to monitor changes in water supply infrastructure resulting from other interventions.

4. **Cluster/quateirão selection:** Within each sampled community, households selected into the study were located within a cluster of households, or *quateirão*, of approximately 500 people. The rationale for focusing on a cluster/quateirão was that (1) each water point is intended to serve 500 people, and (2) assuming approximately 5 people per household, the cluster will include approximately 100 households. This number of households is comparable with enumeration areas as used by Mozambique's national statistics institute, INE. In communities with no sub-divisions, the entire community was included in the cluster. In communities with multiple quarteiraõs, the community leader was asked to

randomly select one. Community guides were asked to aid in identifying the households belonging to the selected cluster.

5. **Households** were selected for the study using the following process:
   a. The field team leader met with the community leader and confirmed that the household survey could be undertaken within the community.
   b. A community guide took the field team leader to the start point of the surveying cluster. The start point of the survey was defined as follows:
      - Treatment community: The start point was the recently installed water point or the planned location of the water point.
      - Comparison community: The start point was the house of the community leader.
   c. From the start point a bottle/pen was spun to define the position of a random line running from the start point. The first and second enumerators walked in opposite directions along this line. The bottle was spun again to establish the line for the remaining enumerator and team leader. Every 2nd household in a rural setting, and every 3rd household in a peri-urban setting, was selected for the survey. If an enumerator reached the edge of a community, he/she returned to the start point and spun the bottle/pen again to define a new random line.
   d. Between 26 and 33 households were interviewed in each cluster. Households are defined as consisting of people that eat together. An individual who has been away must have returned home in the last three months to be included as a member of that household.

Table 1 presents the number of treatment and comparison communities selected from each district and phase of the RWSA. At baseline, the sample contained three treatment and three comparison communities from each Phase 1 district, and six treatment and six comparison communities from each Phase 2 district.

Table 1: Baseline Sample Frame: RWSA Impact Evaluation

District in Nampula	Total population(2010)[3]	MCA phase	# of MCA water points in sampled communities	# of treatment communities sampled	# of comparison communities sampled
Meconta	170,299	1	30	3	3
Mogovolas	313,863	1	40	3	3
Nampula-Rapale	234,713	1	30	3	3
Moma	337,503	2	60	6	6
Mogincual	144,433	2	34	6	6
Murrupula	155,071	2	52	6	6
Totals	**1,355,882**	**-**	**246**	**27**	**27**

Figure 1 provides a map of the six districts in Nampula that were included in the baseline study. In total, 54 communities were selected for the sample.

[3] Source: projections made by INE (National Bureau of Statistics) based on Census 2007.

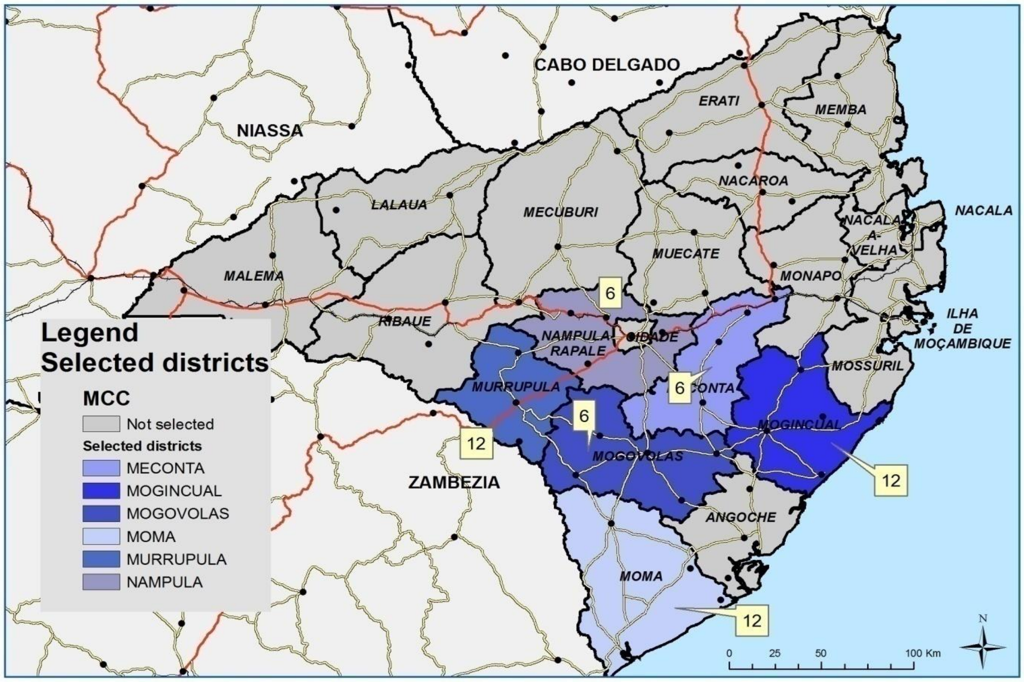

Figure 1: Districts Included in the Baseline Study and the number of communities sampled in each district

Figure 2 provides a schematic of the 2011 baseline sample frame and illustrates how the communities are grouped into two treatment and two comparison groups.

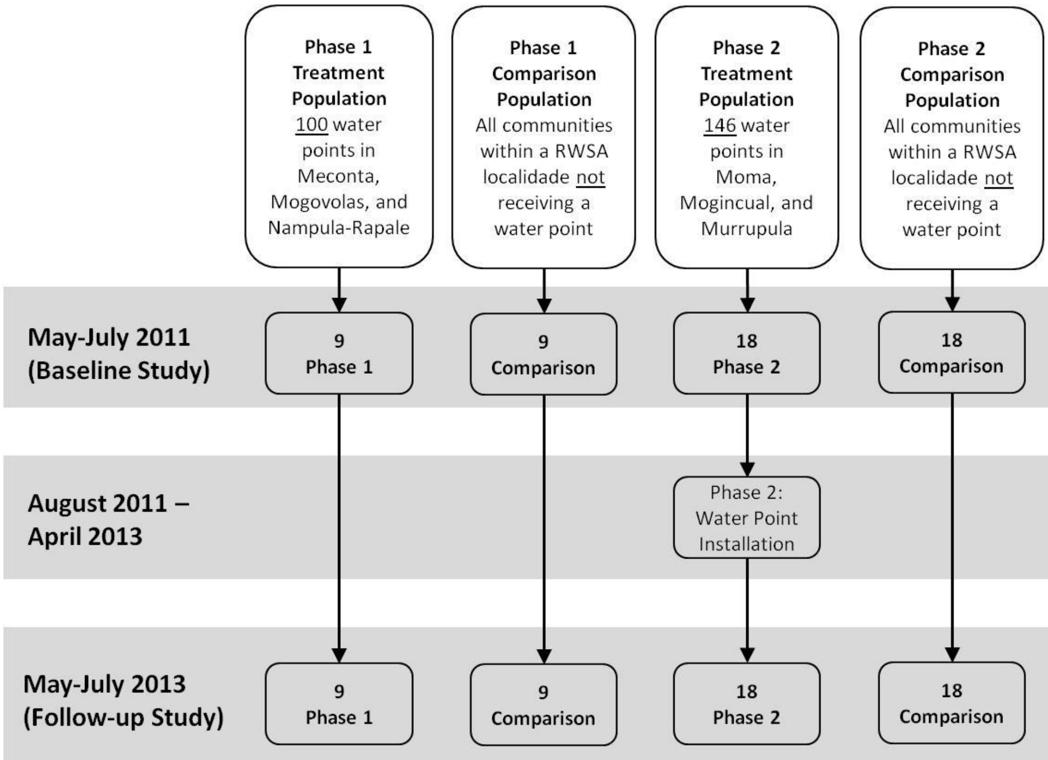

Figure 2: Schematic of the 2011 Baseline Sample Frame

Table 2 provides a list of the treatment and comparison communities included in the 2011 baseline survey. The treatment communities are numbered 01 to 27.

Table 2: List of Communities Included in the 2011 Baseline Survey

ID	Distrito	Phase
01	Rapale	1
51	Rapale	1
02	Rapale	1
52	Rapale	1
27	Rapale	1
77	Rapale	1
03	Meconta	1
53	Meconta	1
04	Meconta	1
54	Meconta	1
05	Meconta	1
55	Meconta	1
06	Mogincual	2
56	Mogincual	2
07	Mogincual	2
57	Mogincual	2
08	Mogincual	2
58	Mogincual	2
09	Mogincual	2
59	Mogincual	2
10	Mogincual	2

ID	Distrito	Phase
60	Mogincual	2
11	Mogincual	2
61	Mogincual	2
12	Moma	2
62	Moma	2
13	Moma	2
63	Moma	2
14	Moma	2
64	Moma	2
15	Moma	2
65	Moma	2
16	Moma	2
66	Moma	2
17	Moma	2
67	Moma	2
18	Mogovolas	1
68	Mogovolas	1
19	Mogovolas	1
69	Mogovolas	1
20	Mogovolas	1
70	Mogovolas	1
21	Murrupula	2
71	Murrupula	2
22	Murrupula	2
72	Murrupula	2
23	Murrupula	2
73	Murrupula	2
24	Murrupula	2
74	Murrupula	2
25	Murrupula	2
75	Murrupula	2
26	Murrupula	2
76	Murrupula	2

3.2 Sample Integrity Following 2011 Baseline

The baseline study was undertaken in Nampula during the period May to August, 2011. In total, 1,606 household surveys were completed in the 54 communities surveyed.[4] In addition, 54 water committee interviews were undertaken, one in each community.[5] Water sampling/testing was

[4] The household survey was designed to focus on the MCC's principal objectives for the RWSA and the research questions present Section 0. The survey consisted of six main modules and included a total of 560 questions. The survey modules covered: household demographic characteristics (*Questions 1 to 201*); participation of household members in water project planning and implementation (*Questions 202 to 241*); water sources and services used by the household (*Questions 242 to 398*); health of household members (*Questions 399 to 454*); sanitation facilities used by members of the household (*Questions 455 to 490*); and household income and expenditure (*Questions 491 to 560*).

[5] Note: Since no water committee existed in five of the communities, the community leader responded to the water committee interview in these communities. The water committee interview consisted of nine sections that collected information on the community, the structure of the water committee and its responsibilities, training received by members of the water committee, the status of the rural water project, water tariffs, etc. The survey was developed in close collaboration with WE Consult and was administered by the leader of each household survey team.

undertaken in 11 of the Phase 2 treatment communities in the districts of Murrupula, Moma, and Mogincua.[6]

Since 2011, there have been several changes to the sample frame resulting from negative boreholes (i.e., boreholes that did not reach a viable underground water source) and non-MCC interventions occurring in several treatment and comparison communities. Table 3 provides a summary of the status of the sample frame. The full information is shown in Table 4.

Table 3: Summary of the Status of the Sample Frame

District	**Treatment** OK = water point installed OK / INT = water point installed + other intervention(s) OUT = no water point installed			**Comparison** OK = no interventions in community OK / INT = intervention(s) in community, but not water-related OUT / WP = water point installed in community		
	OK	**OK / INT**	**OUT**	**OK**	**OK / INT**	**OUT / WP**
Rapale	2	1		2		1
Meconta	3			3		
Mogincual	4		2	4		2
Moma			6		6	
Mogovolas	1	2		1	2	
Morrupula	3		3	5	1	
Total	**13**	**3**	**11**	**15**	**9**	**3**

Water points have been installed in 16 of the 27 treatment communities. Three of the 16 communities also benefited from additional hygiene, sanitation, and health-related interventions. In 9 of the remaining 11 communities, geophysical surveys revealed that it was not possible to install a water point in the community. Therefore, these communities will not receive a water point through the RWSA and might instead be considered as comparison communities in the impact evaluation analysis. One community in Mogincual received a water point, which has since been declared negative because of an insufficient yield. One community in Murrupula received a water point from World Vision, so this community is no longer part of the RWSA, but will be kept in the sample. None of the six treatment communities in Moma will receive a water point due to unfavorable geophysical conditions.

As of April 2013, 24 of the comparison communities had not received a water-related intervention. However, four of these communities (in Mogincual) have been selected as candidates for a water point in Phase 3 of the RWSA. Three of the 27 comparison communities were reported to have received a water point – two from Phase 2 of the RWSA and one from an external project. Finally, of the 24 communities that have not received a water-related intervention, nine have been involved with a health- and/or sanitation-related project that is not part of the RWSA. Thus, 15 of the 27 comparison communities can be considered as being

[6] The rationale for pursuing water quality testing was based in the Stanford-VT team's concern that data regarding health impacts (one of MCC's key outcomes of interest) would be collected only twice during a 2.5-year period, which would make it highly unlikely to detect meaningful differences between the treatment and control communities. Water quality data could thus serve as a rough proxy for health risk from waterborne disease between the two groups. The 11 communities were randomly selected from the 18 Phase 2 treatment communities included in the sample.

generally unaffected by other projects, although four of these may receive a water point as part of the RWSA.

Based on the data in Tables 3 and 4, it is likely that several treatment communities will be reclassified as comparison communities and several comparison communities will be reclassified as treatment communities. The extent of the changes to the sample will not be fully known until the completion of the follow-up study in 2013. However, the sample frame still allows for testing the hypotheses and drawing causal inference (with associated levels of confidence) about the difference between the treatment and comparison groups.

Table 4: Changes to the Sample Frame (as of April 9, 2013)

ID	District	Number of Households Surveyed	Phase	Received HP	Months from HP Installation to Follow-up Study	2011 Baseline Classification	2013 Follow-up Classification	Comments (from Co-Water)
1	Nampula-Rapale	34	P1	1	27	Treatment	Treatment	Positive borehole. No external intervention so far.
2	Nampula-Rapale	29	P1	1	27	Treatment	Treatment	Positive borehole. No external intervention so far.
3	Meconta	32	P1	1	29	Treatment	Treatment	Positive borehole. No external intervention so far.
4	Meconta	26	P1	1	29	Treatment	Treatment	Positive borehole. No external intervention so far.
5	Meconta	30	P1	1	27	Treatment	Treatment	Positive borehole. No external intervention so far.
6	Mogincual	30	P2	1	26	Treatment	Treatment	Positive borehole. No external intervention so far.
7	Mogincual	28	P2	1	-	Treatment	**Comparison**	Positive borehole. No external intervention so far. *Since declared negative b/c of insufficient yield.*
8	Mogincual	30	P2	0	-	Treatment	**Comparison**	Negative geophysics. No borehole installed.
9	Mogincual	30	P2	1	14	Treatment	Treatment	Positive borehole. No external intervention so far.
10	Mogincual	30	P2	1	14	Treatment	Treatment	Positive borehole. No external intervention so far.
11	Mogincual	30	P2	1	10	Treatment	Treatment	Positive borehole. No external intervention so far.
12	Moma	30	P2	0	-	Treatment	**Comparison**	Negative geophysical results. No borehole installed. Sanitation intervention by ADECOM.
13	Moma	30	P2	0	-	Treatment	**Comparison**	Negative geophysical results. No borehole installed. Hygiene & sanitation intervention by SCIP.
14	Moma	30	P2	0	-	Treatment	**Comparison**	Negative geophysical results. No borehole installed. Hygiene & sanitation intervention by SCIP.
15	Moma	33	P2	0	-	Treatment	**Comparison**	Negative geophysical results. No borehole installed. Hygiene & sanitation intervention by SCIP.
16	Moma	30	P2	0	-	Treatment	**Comparison**	Cowater is working in Mutamala of the AP of Chalawa, not in Mutamala of the AP of Mucuali.
17	Moma	26	P2	0	-	Treatment	**Comparison**	Negative geophysical results. No borehole installed.
18	Mogovolas	30	P1	1	28	Treatment	Treatment	Positive borehole. No external intervention.
19	Mogovolas	30	P1	1	28	Treatment	Treatment	Positive borehole. Interventions by Okhalihana (2011, population), SCIP (2011, HIV/AIDS, hygiene & sanitation), and Ocumi (2008 food security & health).

ID	District	Number of Households Surveyed	Phase	Received HP	Months from HP Installation to Follow-up Study	2011 Baseline Classification	2013 Follow-up Classification	Comments (from Co-Water)
20	Mogovolas	28	P1	1	28	Treatment	Treatment	Positive borehole. Interventions by ADPP (2011, HIV/AIDS), AFRICA CUAM (2010, microfinance and small enterprise), and Save the Children (2009-2012, nutrition).
21	Murrupula	28	P2	1	9	Treatment	Treatment	Positive borehole. No other intervention.
22	Murrupula	30	P2	0	-	Treatment	**Comparison**	Positive geophysics, not drilled due to high risk of negative borehole. No external intervention so far.
23	Murrupula	27	P2	1	15	Treatment	Treatment	Positive borehole. No other intervention.
24	Murrupula	27	P2	0		Treatment	**Comparison**	Negative geophysical results. No borehole installed.
25	Murrupula	29	P2	1	15	Treatment	Treatment	Positive borehole. No other intervention.
26	Murrupula	28	P2	0	-	Treatment	**Comparison**	Cowater is not working in this community, since World Vision drilled a borehole prior to the commencement of Phase 2.
27	Nampula-Rapale	30	P1	1	28	Treatment	Treatment	Positive borehole. External intervention of SCIP in a program of hygiene and sanitation.
51	Nampula	27	-	0	-	Comparison	Comparison	No external intervention.
52	Nampula	25	-	0	-	Comparison	Comparison	No external intervention.
53	Meconta	30	-	0	-	Comparison	Comparison	No external intervention.
54	Meconta	27	-	0	-	Comparison	Comparison	No external intervention.
55	Meconta	30	-	0	-	Comparison	Comparison	No external intervention.
56	Mogincual	30	-	1	14	Comparison	**Treatment**	Water point installed in Phase 2.
57	Mogincual	29	-	Possible P3	-	Comparison	Unknown	Included in Phase 3.
58	Mogincual	30	-	1	10	Comparison	**Treatment**	Water point installed in Phase 2.
59	Mogincual	30	-	Possible P3	-	Comparison	Unknown	Reserve community for Phase 3.
60	Mogincual	28	-	Possible P3	-	Comparison	Unknown	Reserve community for Phase 3.
61	Mogincual	30	-	Possible P3	-	Comparison	Unknown	Included in Phase 3.
62	Moma	30	-	0	-	Comparison	Comparison	External hygiene and sanitation intervention by SCIP.
63	Moma	27	-	0	-	Comparison	Comparison	External hygiene and sanitation intervention by SCIP.
64	Moma	30	-	0	-	Comparison	Comparison	External hygiene and sanitation intervention by SCIP.

ID	District	Number of Households Surveyed	Phase	Received HP	Months from HP Installation to Follow-up Study	2011 Baseline Classification	2013 Follow-up Classification	Comments (from Co-Water)
65	Moma	32	-	0	-	Comparison	Comparison	External hygiene and sanitation intervention by SCIP.
66	Moma	29	-	0	-	Comparison	Comparison	External hygiene and sanitation intervention by SCIP.
67	Moma	30	-	0	-	Comparison	Comparison	External hygiene and sanitation intervention by SCIP.
68	Mogovolas	30	-	0	-	Comparison	Comparison	External intervention by WE Consult (water supply), CULIMA (HIV/AIDS prevention), WETT (domestic violence), OPHAVELA (population), Ministry of Agriculture (food assurance), and Medicos sem Fronteira (health).
69	Mogovolas	30	-	0	-	Comparison	Comparison	External intervention of Save the Children (2009-2012 nutrition program).
70	Mogovolas	28	-	0	-	Comparison	Comparison	No external intervention.
71	Murrupula	29	-	0	-	Comparison	Comparison	No external intervention.
72	Murrupula	30	-	0	-	Comparison	Comparison	External intervention of SANA (project on mother-child health).
73	Murrupula	28	-	0	-	Comparison	Comparison	No external intervention.
74	Murrupula	29	-	0	-	Comparison	Comparison	No external intervention.
75	Murrupula	27	-	0	-	Comparison	Comparison	Cowater drilled two negative boreholes during Phase 2. No external intervention.
76	Murrupula	30	-	0	-	Comparison	Comparison	No external intervention.
77	Nampula	29	-	0	-	Comparison	**Comparison/ Treatment**	Received a water point during the 2008 ASNANI project. External hygiene and sanitation intervention by SCIP.

3.3 Illustrative Power Calculations

The study is powered to detect meaningful effects in the key variables described in Section 0. None of the Phase 1 treatment communities were included in the power calculations.

As one example, consider the average number of person-hours required for a household to collect 20 LPCD. The study design focuses on the difference between treatment and control communities between baseline and follow-up, *i.e.*, whether households in the treatment communities experience a significant decrease in the time costs of water fetching relative to those in the control communities.

Variable: Person-hours per Household to collect 20 LPCD

Analysis: We will use a repeated measures mixed effects regression analysis of household data, with fixed effects due to treatment (whether the community received a handpump during Phase 2) and random effects based on community, with a household-level random effect for those households surveyed at both baseline and follow-up.

Power Calculation: Assuming alpha=0.05 and that the standard deviation of the average difference in the variable of interest is 0.6 hours, the minimum detectable effect size of the difference (9 Phase 2 treatment communities compared to 31 Phase 1 and 2 comparison communities) in differences (baseline to follow-up) is shown in Figure 3 for various levels of power. For 80% power, the minimum detectable effect size will be 0.575 hours. In other words, if the true impact of the handpumps is to decrease the time required to collect 20 LPCD by at least 35 minutes, we will have 80% power to detect a statistically significant difference between the treatment and comparison communities. To put this value into context, during the baseline study we observed an average difference of 61 minutes between the Phase 1 treatment and comparison communities, 1.8 times this minimum detectable effect size.

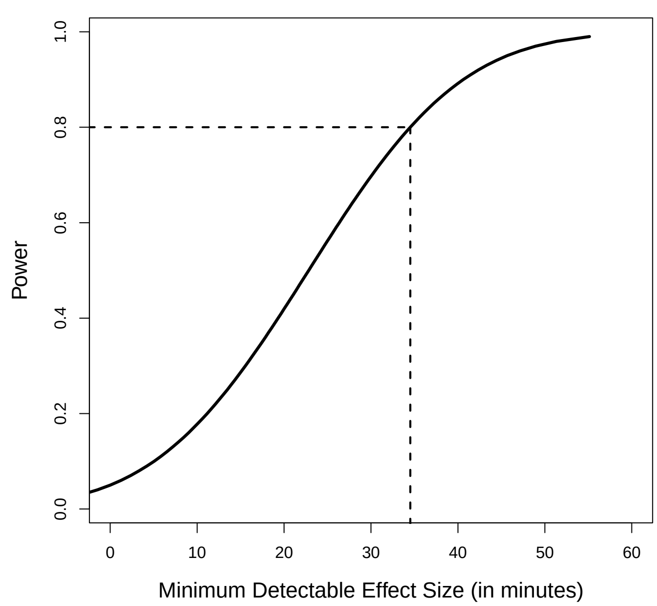

Figure 3: Person-hours per HH to Collect 20 LPCD (Power vs. Effect Size)

Note: This minimum detectable effect size of 35 minutes at 80% power is actually a conservative estimate, because it employs an approximate analysis with lower power (two-sample t-test); our actual analysis will explain relatively more of the variability between households, and will thus have higher power.

Variable: LPCD per Household from protected sources

As a second example, we can investigate whether households in the treatment communities collect more water (LPCD) from protected sources than the households in the comparison communities. In other words, what change in protected LPCD collected do we observe due to the installation of the handpumps?

Analysis: We will use a repeated measures mixed effects regression model of household data, with fixed effects due to treatment (whether the community received a handpump during Phase 2) and random effects based on community, with a household-level random effect for those households surveyed at both baseline and follow-up.

Power Calculation: Assuming alpha=0.05 and that the standard deviation of the average difference in LPCD collected from protected sources is 7.0 LPCD, the minimum detectable effect size of the difference (9 Phase 2 treatment communities compared to 31 Phase 1 and 2 comparison communities) in differences (baseline to follow-up) is shown in Figure 4 for various levels of power. For 80% power, the minimum detectable effect size will be 6.7 LPCD. In other words, if the true impact of the handpumps is to increase the volume of protected source water by 6.7 LPCD, we will have 80% power to detect a statistically significant difference between the treatment and comparison communities. To put this into context, we observed a difference of 14.8 LPCD between the Phase 1 treatment and comparison communities, more than twice this minimum detectable effect size.

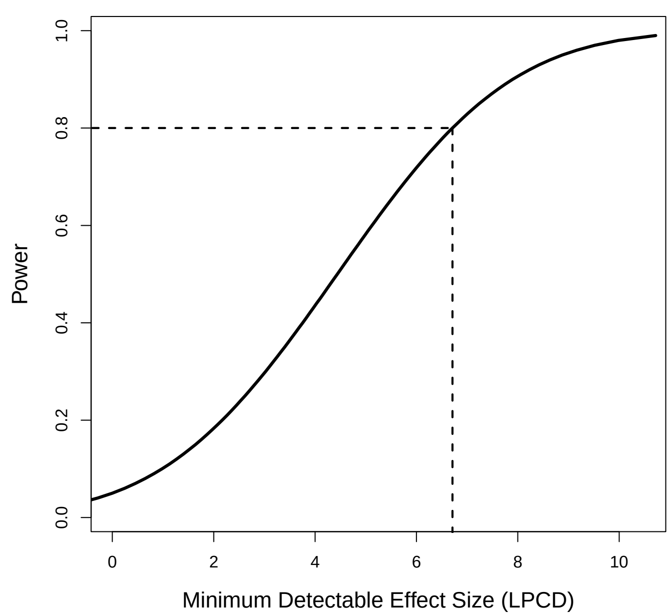

Figure 4: LPCD per HH from Protected Sources (Power vs. Effect Size)

Note: This minimum detectable effect size of 6.7 LPCD at 80% power is actually a conservative underestimate because our actual statistical analysis will explain more of the variability between HHs, and thus will have higher power than the two-sample t-test.

Variable: Households reporting that their children's school attendance is negatively affected by having to collect water

As a third example, we can investigate whether households with school-age children in the treatment communities report less often that their children's school attendance is negatively impacted by their water collection duties than the households in the comparison communities.

Analysis: We will use a repeated measures generalized mixed effects regression model of data from households with school-age children, with fixed effects due to treatment (whether the community received a handpump during Phase 2) and random effects based on community, with a household-level random effect for those households with children at both baseline and follow-up. Specifically we will use a logistic regression with fixed and random effects to estimate how the change in the probability of reporting that school attendance is negatively impacted by collecting water differs between households in the Phase 2 treatment communities with the comparison communities.

Power Calculation: Assuming alpha=0.05 and that the standard deviation of the average change in percent of households reporting that water collection negatively impacts school attendance is 15%, the minimum detectable effect size of the difference (9 Phase 2 treatment communities compared to 31 Phase 1 and 2 comparison communities) in differences (baseline to follow-up) is shown in Figure 5 for various levels of power. For 80% power, the minimum detectable effect size will be 14.4%. In other words, if the true impact of the handpumps is to decrease the percentage of households whose children's school attendance is negatively impacted by collecting water by 14.4%, we will have 80% power to detect a statistically significant difference between the treatment and comparison communities. To put this into context, we observed a difference of 17.2% between the Phase 1 treatment and comparison communities.

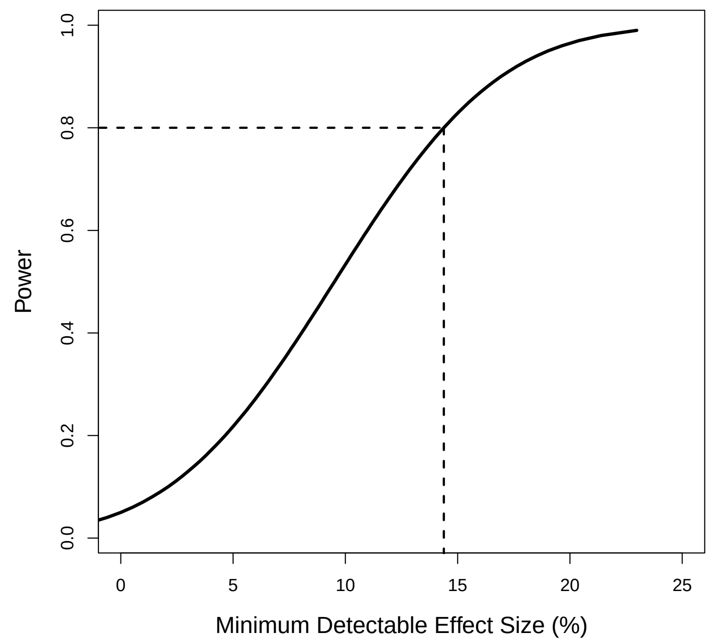

Figure 5: School Attendance Negatively Affected (Power vs. Effect Size)

Note: This minimum detectable effect size of 14.4% at 80% power is actually a conservative underestimate because our actual statistical analysis will explain more of the variability between households, and thus will have higher power than the two-sample t-test.

3.4 2013 Follow-up Study in Nampula

The follow-up study in Nampula is planned for the summer of 2013.

The enumerator and water sampling team training is planned for two weeks starting in mid-May, 2013. Stanford-VT will attempt to hire as many as possible of the same enumerators/water samplers who worked on the 2011 baseline study. However, the training will assume that the enumerators/water samplers will be new to the study to ensure a consistent surveying standard is achieved.

A pilot test of the household survey will occur following the enumerator/water sampler training, after which instrument revision and additional training of the household survey team leaders will be undertaken. These tasks are expected to require approximately five days.

The fieldwork will begin in June 2013, and will run for approximately six weeks. The water quality sampling team will work alongside the household surveying teams. The enumerators will use GPS devices to attempt and find the same households that were surveyed during the 2011 baseline study. If a household/respondent cannot be found, the enumerator will be instructed on how to select a neighboring household to interview.

The results from the follow-up study and impact evaluation are expected to be available in September, 2013.

3.4.1 New Data Collection Activities during the 2013 Follow-up Study

Discussions between the Stanford-VT team and MCC following the baseline study highlighted the desire for the follow-up study to generate information about the spatial ‘reach’ of benefits emanating from the project water points. As a result, a new data-collection activity will be added to the follow-up study. Specifically, a day-long water point observation will be undertaken in each of the treatment communities. In addition to documenting the number of persons fetching water, the age and gender of each person, and the volume of water obtained, each individual will be asked where s/he lives and how long it took to reach the handpump from his/her home.

During the follow-up study, the water committee will also be asked to estimate the share of handpump users who reside within *versus* outside the one-kilometer radius. The water committees will also be asked where most ‘outsiders’ using the handpump live and how far they are traveling to avail of it. This approach has limitations in terms of data quality, but at a minimum can be used as a double-check of the information obtained during the water point observation.

Finally, if time and resources permit, the household sample of the follow-up survey will contain a larger number of households in located at least 1 kilometer away from the water point in treatment communities. The intention for the follow-up study is to interview the same households as those interviewed during baseline; however, it is anticipated that some level of attrition will occur from families moving or traveling, and from respondents being ill or otherwise unavailable. Rather than seek replacements for these “attrition” households within the 500-meter radius of the handpump, households will be randomly selected at a distance greater than 1km from the handpump.

Taken together, such data will help to delineate the area in which beneficiary households are located. These data can also be used to quantify the spillover effects of the rural water investment on neighboring communities, thus providing a more complete accounting of the program’s impacts.

4 Study of the Small-Scale Piped Systems in Cabo Delgado

The objective of the Cabo Delgado study is to qualitatively analyze the financial, institutional, and management structures of the eight small-scale piped systems (SSS) installed in Cabo Delgado by the MCC. This research is driven by the hypothesis that the SSS and private operator model, in larger, more densely settled communities, better serves water users’ needs, is more cost effective, and more sustainable over the long term, than the handpump and water committee management approach.

Nearly 90% of rural water projects in Mozambique use the handpump and water committee management model. Within the government and development community there is interest in trying a new approach. The few scattered alternative models currently being experimented with in Mozambique (including the small piped systems and private operator management models) are relatively unevaluated. Considering this context, the installation of the eight small piped systems in Cabo Delgado managed by private operators and/or water committees presents a unique opportunity to explore the financial, institutional, and management implications of a higher level of service in larger, more densely settled communities.

The Cabo Delgado study will take place from June to August, 2013. Prior to the commencement of the study, the Stanford-VT will submit the proposed research design to the MCC for review/approval.

The preliminary findings from the Cabo Delgado study are expected to be available in September, 2013.

4.1 Methods

This study will be conducted in each of the eight communities where the SSS were installed by the MCC in Cabo Delgado. In each community the following research methods will be used:

- Household surveys (approximately 30 per community);
- Water point observation (one day in each community);[7]
- Focus groups with water users;
- Semi-structured interviews with water committees and/or water operators; and
- Semi-structured interviews with Cowater operators in each district served by the SSS.

Considering the small sample size, the quantitative data provided from the household surveys will be used primarily to provide descriptive statistics.[8] The final report will comprise a series of case studies about each of the SSS communities, along with an executive summary.

4.2 Research Questions: Cabo Delgado

The general format for each entry below is as follows:

#. Research question
- Description of the variable(s) necessary to answer the question
    - Sources of data for those variables (*e.g.*, household survey module(s), water committee interview, *etc.*)

1. What is the institutional, financial, and management structure of the SSS installed by the MCC in Cabo Delgado?

- Tariff structure
    - Interview with Cowater animator
    - WC and/or operator interview
- Expenditures on operation and maintenance, salaries, and other regular costs

[7] This water point observation survey will be conducted in the same manner as the water point observation in Nampula.
[8] Based on the small sample size and the differences between communities in Nampula and Cabo Delgado, valid comparisons between the two sample populations are not possible.

    - WC and/or operator interview
- Community contributions to system construction
    - Interview with Cowater animator
    - WC and/or operator interview
- Amount of money generated from tariff revenues
    - WC and/or operator interview
- Roles and responsibilities of the operator, WC, leaders, and government officials
    - Interview with Cowater animator
    - WC and/or operator interview

2. **What are the prospects for long-term sustainability of the piped water systems in Cabo Delgado?**
    - Amount of revenue collected *versus* operation and maintenance expenditures
        - HH survey: Water supply module
        - WC and/or operator interview
    - WC and/or operator perception of revenue sufficiency to carry out preventative maintenance and minor repairs
        - WC and/or operator interview
    - Number of meetings held in the community about the SSS in the year prior to interview
        - HH survey: Water supply module
        - WC and/or operator interview
    - Number of maintenance duties regularly completed by the water committee and/or operator
        - WC and/or operator interview
    - WC and/or operator perception of the ease with which spare parts can be obtained
        - WC and/or operator interview
    - WC and/or operator perception of their ability to execute their responsibilities successfully
        - WC and/or operator interview
    - WC and/or operator report of any conflict within the community related to the water point
        - WC interview
    - Community members' opinion of whether the water point will continue to function over the next 1, 5, and 10 years
        - WC and/or operator interview
        - HH survey: Water supply module
    - Types of water supply tariff used and share of households paying
        - WC and/or operator interview
        - HH survey: Water supply module
    - Number and duration of breakdowns
        - WC and/or operator interview
        - HH survey: Water supply module

3. **How do community members perceived small piped systems *versus* handpumps in terms of satisfying their needs and preferences?**
    - Percentage of households satisfied with their water supply service

  - HH survey: Water supply module
- Perceptions of the differences between handpumps and SSS (in terms of time waiting for water, availability of water for multiple purposes, reliability, etc.)
  - Focus group with water users
- Number of SSS users
  - Water point counting
  - HH survey: Water supply module
  - WC interview
- Time required to complete one round trip between the home and water point
  - HH survey: Water supply module, and GPS coordinates
  - Google maps: digitized track data between HHs and water points
- LPCD obtained from improved sources, for rainy and dry season
  - HH survey: Water supply module
- Percentage of households that make use of the SSS
  - HH survey: Water supply module
- Use of water for multiple purposes
  - HH survey: Water module
  - Focus group with water users

5 Management of the Impact Evaluation

5.1 Evaluation Team Roles and Responsibilities

Table 5 provides a summary of the core personnel involved with the impact evaluation.

Dr. Jennifer Davis (Stanford), Dr. Ralph Hall (VT), and Dr. Eric Vance (VT) are the principle investigators (PIs). The PIs serve as the primary responsible party for technical work and deliverables and will manage the evaluation design and implementation process.

A team of 4 to 5 highly skilled graduate/doctoral students from Stanford and VT have been selected to support the fieldwork, data cleaning, and data analysis. These graduates have expertise in rural water supply systems/engineering, water quality testing, and/or statistics. They also speak Portuguese.

WE Consult (the main in-country partner) is responsible for the hiring of enumerators, providing country-specific background, fieldwork logistics, translation, and various other supporting functions for the baseline and follow-up studies. WE Consult should be considered as a core member of the Stanford-VT team.

For the 2011 baseline study, a total 16 people were trained, of whom 14 were eventually employed for the fieldwork. The remaining two individuals were kept on stand-by in case replacements were needed on the field teams.

Table 4: Personnel

Task / Role	2011 Baseline Study (Nampula)	2013 Follow-up Study (Nampula	2013 Cabo Delgado Study
Principle Investigators	Jenna Davis	Jenna Davis	Ralph Hall
	Ralph Hall	Ralph Hall	Eric Vance
	Eric Vance	Eric Vance	–
Stanford-VT Graduates	Emily Van Houweling	Emily Van Houweling	Emily Van Houweling
	Mark Seiss	Marcos Carzolio	–
	Kory Russel	Kory Russel	–
	Nick Cariello	Maika Nicholson	–
	Valentina Zuin	–	–
WE Consult Researchers	Wouter Rhebergen	Wouter Rhebergen	Wouter Rhebergen
	Sergio Barros	Ellen de Bruijn	–
	Arjen Naafs	–	
Field Team Leaders	Lurdes Mario Andre	TBD	TBD
	Chahide Ussene	TBD	–
	Ibraimo Issufo Ali	TBD	–
Assistant Field Team Leaders	Felizardo Jakson Felismino	TBD	TBD
Runner	Antonio Hiratsuka	TBD	TBD
Enumerators	Hortencia Romao	TBD	TBD
	Elisio Vicente	TBD	TBD
	Silvio Cajapuira	TBD	TBD
	Muhamade Anli	TBD	–
	Nelcesia Albino	TBD	–
	Lizete Gonsalves	TBD	–
	Benvinda Bras	TBD	–
	Andy Ismael Buanado	TBD	–
	Delito Real Raul Tomani	TBD	–
Stand-by Enumerators	Carolina Raja	TBD	–
	Arlete Velasco	TBD	–

5.2 Institutional Review Board Requirements and Clearances (in-country, international)

Both Stanford and Virginia Tech have a Human Research Protection Program ("HRPP") established in accordance with the principles and standards of the Association for the Accreditation of Human Research Protection Programs that is applicable to all research involving human subjects, including the Research Program, that includes: (i) submittal for prospective and continuing review to Stanford's and Virginia Tech's institutional review board ("IRB") under the federal regulations governing the protection of human research subjects, (ii) obtaining consent from human research subjects as specified in those regulations, (iii) conducting the research in accordance with ethical standards such as the Belmont Report.

The research conducted for the RWSA impact evaluation has received IRB approval from both Stanford and Virginia Tech. Further, in accordance with Stanford's IRB requirements, WE Consult has received IRB approval to conduct the fieldwork by WIRB (Western Institutional Review Board).

5.3 Data Quality and Management

During the fieldwork, the household survey data will be cleaned daily, and enumerators will be provided with feedback on any data entry errors identified within a very short period following data collection. This feedback is designed to improve the quality of data collected and enhance the enumerator awareness of the importance of communicating clearly with respondents and entering data carefully into the PDAs. Approximately once every two weeks during the fieldwork, summary data from the completed household surveys will be sent to the MCA/MCC for review.

The data collected from the household surveys, water committee interviews, and water quality testing during the baseline and follow-up studies will be managed in the following manner:

- Household surveys will be administered by trained enumerators employed by WE Consult. The enumerators will input survey responses into password-protected handheld PDAs. At the end of each day, field supervisors collect the PDAs and deliver them to our field statistician (a graduate research assistant) who will download the data to a computer, check the data for accuracy, and then erase the data from each PDA. The field computers will be kept secure by the field supervisors, with data stored in password-protected files. The GPS location and the first name of the respondent for each household will be recorded for purposes of data collection and analysis. Each household will be assigned an identification number generated by the field statistician. The respondent’s name and household ID will be marked on a community map to ensure in follow-up visits that the correct household and respondent have been relocated. These maps and names will be stored separately from the household survey responses so that the latter cannot be traced to any individuals. At the conclusion of the fieldwork, all data files will be given to the Stanford-VT team. Only the principal investigators and research assistants will have access to the household-level survey data, which will remain in password-protected files.
- Water committee survey responses will be collected using paper surveys and then entered into a password-protected Excel spreadsheet. This spreadsheet will be stored on the password-protected fieldwork laptop(s) and will be merged with other data during the data analysis process at Stanford-VT. Original paper surveys will be locked in a secure building during the fieldwork and upon return to the US.
- Samples of source and stored water will be labeled with household IDs as identified by the community maps and GPS locations. Test results will be identified by household ID, stored in a password-protected Excel file.

Similar data management protocols will be developed for the data collected during the Cabo Delgado study.

5.4 Work Plan

The following work plan is considered to be realistic given the resources:

2013 Follow-up Nampula study

- Surveyor training and pilot study – May 27 to June 9
- Fieldwork – June 10 to July 27
- Data analysis – June 10 to August 15 (*i.e., the on-the-ground statistician will begin data analysis during the fieldwork*)
- Report writing – August 16 to September 4
- Dissemination of results – The Stanford-VT team plans to present the *preliminary results* to government officials in Nampula and Maputo prior to the exit of the team from Mozambique. Upon the completion of the evaluation, main report, and documentation of datasets according to MCC Guidelines for Anonymization and Public Use, the research team will present the findings to the MCC in Washington, D.C.

Cabo Delgado Study

- Surveyor training – May 27 to June 9
- Interviews with water system operators, community user groups, Cowater animators, and community leaders – June 10 to July 15
- Household surveys (following the fieldwork in Nampula) – July 20 to August 3
- Data analysis – July 20 to August 15
- Report writing – August 16 to September 4
- Dissemination of results – The Stanford-VT team plans to submit a written report and present the main findings to the MCC in Washington, D.C. during September, 2013

Future work

The Stanford-VT team is interested in working with the MCC on developing a proposal for one or more additional follow-up rounds of data collection. Evaluations of rural water investments beyond the immediate post-construction phase are very rare, and afford the opportunity of exploring how key outcomes of interest continue to improve (*versus* ‘plateau-ing’ or reversing) over time. In addition, a follow-up study can shed light on the extent to which the water infrastructure investment has catalyzed other forms of community development, as well as allow for assessment of longer-term sustainability of operations-and-maintenance regimes established during the project.