WATER ACCESS TO RURAL COMMUNITIES IN PARAGUAY: EVALUATING THE IMPACTS OF ACCESS AND SUSTAINABILITY OF POTABLE WATER PROJECTS

Impact Evaluation Concept Note
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1. INTRODUCTION

As part of the Millennium Development Goals declared by the United Nations, sustainable and equitable access to safe water, adequate sanitation, and hygiene are recognized priorities for development, poverty reduction, and health promotion. Inadequate water supply and sanitation services affect billions of poor people in the developing world. In 2004, out of every ten people, almost two lacked access to safe water supply, and four had inadequate sanitation.[1] This number was even greater for rural populations, where three out of ten individuals lacked access to water and six out of ten lacked access to sanitation.

Inadequate water supply and sanitation affects several human development outcomes. Children are particularly vulnerable to the use of unsafe water and sanitation. Child morbidity and mortality rates associated with waterborne diseases in Latin America are high in the international comparison. In rural areas, inadequate sanitation, and wastewater disposal systems contribute to the degradation of groundwater, rivers, and affect rural incomes. In urban areas, poor sanitation results in increased prevalence of water-related infections and parasitic diseases. Furthermore, families without water connections dedicate a significant amount of time and physical effort in fetching water from distant sources. Women and children are usually responsible for this activity.

Poor sanitation, lack of access to clean water, and inadequate personal hygiene are responsible for an estimated 90 percent of childhood diarrhea (WHO 1997). The most affected are children under the age of five (the peak is between 6 and 12 month). The frequency and severity of diarrheal disease are mainly exacerbated by poor housing conditions; lack of access to sufficient clean water and sanitary disposal of fecal waste; and inadequate feeding practices, hand-washing, and care seeking. Incidence rates in Sub-Saharan Africa and Latin America are greater than in Asia or the Western Pacific regions.

Promotion of hand-washing reduces diarrhea incidence by an average of 33 percent (Huttly et al 1997); it works best when it is part of a package of behavior change interventions. Effects on mortality have not been demonstrated. However, the required behavior change is complex, and significant resources are needed. Washing hands after defecating or handling children's feces and before handling food is recommended, but it entails an average of 32 hand washes a day and consumes 20 liters of water (Graef et al, 1993). If soap is too costly, ash or mud can be used, but access to water remains essential (Esrey, 1996). Esrey et al (1985) analyzes six observational studies in the topic, with a resulting median reduction of 55 percent in all-cause child mortality associated with improved access to sanitation facilities. The greatest effect of improving sanitation systems is in areas of high population density and wherever the entire community, rather than single households, adopts the intervention.

Furthermore, water and sanitation programs have proved to be the most cost-effective intervention in improving the health of children under 5 (Disease Control Priorities in Developing Countries, 2006). Consequently, expanding water and sanitation access to the rural poor and increasing sanitation coverage in urban centers are by far the biggest challenges for the sector.

[1] World Bank (2005) "The World Bank Group Program for Water and Sanitation"

Several mechanisms targeting the expansion, better quality, and efficiency in water supply and sanitation (WSS) have been developed and implemented in developing countries during the past decades. The expected impacts of such programs range from improving access and quality of services to improvements in health, nutrition, social and gender inclusion, education, as well as income generation and consumption. Nevertheless, there are currently few rigorous scientific impact evaluation studies showing the effectiveness of WSS policies in delivering the desired outcomes[2].

Paraguay's Rural WSS Program is a good example of an innovative mechanism of provision with anecdotal evidence of success[3], but no rigorous impact evaluation. For more than 30 years, the program has been promoting and supporting sustainable access to water services in rural areas through the creation of community-based sanitation boards (*Juntas de Saneamiento*). The World Bank (WB) and the Inter American Development Bank (IADB), in partnership with the Government of Paraguay, financed several phases of this program, and are committed to continuing to finance future ones. Nevertheless, these multilateral agencies and the Government recognize the need for an accurate evaluation that will help to improve the program design, ultimately leading to more effective implementations in the future.

A formal impact evaluation of the Rural WSS program in Paraguay will: i) Precisely measure and document the impacts of the program; ii) Help improve the design and efficiency of the program; and iii) Contribute to the literature on formal evaluation of WSS policies.

2. Background

Paraguay is a middle-income country with a rapidly growing population. The fast pace of population growth (2.2 percent per year) presents a significant challenge to the provision of water and sanitation services, especially for rural areas[4] where 42.2 percent of the population lives. While over 80 percent of the population in urban areas is served by a network water connection, only 35 percent have similar access in rural areas. Adequate wastewater treatment is practically nonexistent. As in most developing countries, it is no surprise that the poor are disproportionately affected by the lack of access to water and sanitation services.

Inadequate water supply and sanitation affects several human development outcomes. Children are particularly vulnerable to the use of unsafe water and sanitation. Child morbidity and mortality rates associated with waterborne diseases in Paraguay are above the regional average[5]. In rural areas, inadequate sanitation and wastewater disposal systems contribute to the degradation of groundwater, rivers, and affect rural incomes. In urban areas, poor sanitation results in increased prevalence of water-related infections and parasitic diseases. Furthermore, families without water connections dedicate a significant amount of time and physical effort in fetching water from distant sources. Women and children are usually responsible for this activity.

Expanding water and sanitation access to the rural poor and increasing sanitation coverage in urban centers are by far the biggest challenges for the sector. For this reason, the Government of Paraguay has requested support from the World Bank for a new comprehensive Water and Sanitation Sector Modernization Project (US$60 million) to include not only rural but also urban water and sanitation investments, support for improving sector governance, as well as planning and policy making. The component-- ***sustainable water and sanitation services and hygiene education for rural areas*** (US$ 22 million), which is a scaling up of the fourth phase of Paraguay's Rural WSS program, is the intervention analyzed in this impact evaluation.

[2] Except for health impacts demonstrated by studies such as Fewtrell et al. (2005) and Kremer at al. (2006).
[3] IEG, World Bank (1998) attempt to evaluates the three first phase of the program.
[4] Rural areas in Paraguay include small towns with population of less than 10,000 inhabitants. Urban centers are defined as those with a population over 10,000 inhabitants.
[5] In 2005, 25 over 1000 kids die under the age of five in Paraguay according to the World Health Organization, approximately 70 percent of those deaths were related to diarrhea.

[ADD A PARAGRAPH ABOUT THE IADB'S PROJECT]

3. THE INTERVENTIONS

The modulus, ***Sustainable water and sanitation services and hygiene education for rural areas,*** was designed to improve living conditions in small and low income settlements by providing access to safe water supply and sanitation facilities. The project includes:

(i) The construction of sustainable water distribution systems, either directly by the community or through an output based aid subsidy concession to private providers;

(ii) The implementation of a hand-washing campaign; and

(iii) The expansion of the *Juntas de Saneamiento* (Water Boards) model.

The campaign will re-enforce the health impact of the first intervention by further reducing children mortality and morbidity associated with water born diseases. Diarrhea, for example, seems inversely related to the promotion of hand washing at critical times (such as before handling food and after contact with feces). Both activities will be coordinated and implemented by SENASA[6]. The impact evaluation will measure the combined impact of the two actions.

Paraguay rural model of water provision is implemented through the creation of a *Juntas de Saneamiento* within each community. *Juntas de Saneamiento* are legal entities responsible for promoting adequate health practices in their communities. The Juntas own the distribution systems; they are responsible for repaying[7] SENASA the amount borrowed to finance the construction of the systems. The systems are fully administered, operated, and maintained by the Juntas. The community's sense of ownership and responsibility seems to play an important role in the quality, sustainability and future expansion of water services. Along with the water supply and sanitation investments, the government supports health and education programs. The implementation of a rural water project follows seven steps (See Annex A).

In conclusion, the main objective of this intervention is to **mitigate precarious living and health conditions in rural communities by providing safe water supply and information**. In line with this purpose, the project delivers three direct outputs: i) Water distribution systems; ii) Hygiene education; and iii) Community training and capacity building. The next section illustrates how these outputs relate to the main impacts and outcomes we intend to measure.

Community Capacities' Development for the Sustainability of the Program (Treatment 2) [TBD]. We adhere to the following definition of sustainability "it is the ability of a WSS development project to maintain or expand a flow of benefits at a specified level for a long period after project inputs have ceased" (U.S. Agency for International Development –USAID-, 1994). In water projects, it may happen that once the program finishes, the community is not longer capable of keeping the system working. It is important to work on the most efficient way to provide organizational capacity, financial options, government back-up and supply of materials and labor force, and human capital, so that the provision of safe water continues (or is even expanded to new neighbors) once the program finishes. According to USAID (1994) the following factors must be taken into consideration, because they affect the sustainability of donor-assisted rural water supply projects: local institutions, development processes, technologies available, contextual factors and forces, project organization and process, and potential futuHoI want tre donors.

For example, potential types of support that could be implemented are [TO BE DECIDED]: The creation of an office that will provide technical assistance to the communities. This institution will be in charge of giving advice to the local communities regarding regulation and tariffs. In the beginning the probability of having to afford maintenance/operative costs and the probability of baring the burden of those that will not

[6] SENASA (*Servicio National de Salud Ambiental*) is the branch of the Ministry of Health responsible expanding and supporting the provision of water services in rural areas.

[7] Partially of fully depending on the community's size and income level.

pay will be estimated. This institution will visit the communities constantly to determine the necessity (or not) of tariff's adjustment, re-estimating those probabilities. This organization, with the approval of the community, will keep a reserve fund and will set clear rules to decide how to spend it. In addition to these, this technical assistance office will act as a commitment devise for the communities.

4. RESEARCH QUESTIONS

This evaluation comprises two treatments: the first one involves establishing the water boards, the provision of clean water and sanitation, together with a campaign to promote hygiene habits, and the second one main focus is the sustainability of the water and sanitation supply.

The research questions related to Treatment 1, are basically the impacts in health (especially children's health) and in time allocation of adults and children, of the clean water system. The main indicators regarding health are those related with diarrheal illnesses and child morbidity (that in 70 percent of the cases is caused by diarrheal illnesses in poor rural areas). Nevertheless, the variables we are interested in go beyond health and time allocation; we will also analyze children development, household income, and satisfaction. The indicators should include the following:

- Presence of parasites in children aged 0-5 years (feces samples are required for this purpose).
- Prevalence and incidence[8] of diarrhea in children aged 0-5 years.
- Prevalence and incidence of other infectious illnesses (respiratory, for example) in children aged 0-5 years.
- Prevalence of Anemia in children aged 0-5 years (blood samples are required for this purpose)
- School attendance of children aged 5-16 years.
- Cognitive development of children aged 3-7 years.
- Time allocation of teenagers and adults.
- Stress and life quality standards of the mother.
- Income of the household.
- Expenditure in water and sanitation of the household.
- Other expenditures of the household.
- Satisfaction of the households with respect to hygiene and sanitation.

As regards Treatment 2, we are mainly interested in the sustainability of the water system. The principal (though simplest) indicator regarding sustainability is the presence of clean water coming out from the taps and pumps built during Treatment 1. This indicator, although simple, is very pragmatic and the rationale for using it is that in order for water to be coming out of the tap, repairs must have been made, some finance must be collected to keep it running, and somebody must be managing it (Water for People Report, 2008).

[8] See section 6 for a discussion on prevalence and incidence.

Figure 1: Potential impacts of the intervention.

Intervention => Output	=> Immediate Impacts	=> Impacts in the short-run	=> Impacts in the medium-run
• Water Distribution System • Hygiene Education • Community training and capacity building	**Individual impacts:** • less time and effort allocated to access water • improved access to potable water • change in hygiene habits • development of technical skills	**Individual impacts:** • change in time allocation • reduction in physical injuries that result from water fetching activities (i.e. back problems, miscarriages, etc) • reduction in the incidence of waterborne diseases and parasites (and their symptoms) • reduction in child mortality and morbidity	**Individual impacts:** • increase in the time dedicated to income generating activities (especially for women) • improved health and nutrition • increase in work attendance, productivity and income generation • improvement in school attendance and performance • increased time dedicated to child care
	Collective impacts: • improve the organizational capacity of the community • develop financial and managerial capacity • develop a "service culture"[9]	**Collective impacts:** • implement a sustainable management of water system • generate demand for other infrastructure services	**Collective impacts:** • promote community growth • increase in property values • expand water distribution • promote coordination and diversification of production activities • promote inclusion of women in the community decisions

[9] "Services culture" can be defined as the awareness of the community about their roles and responsibilities in promoting, financing, and maintaining the provision of water (or infrastructure services) in general.

In the second Follow-Up Survey, each community leader will be surveyed, together with the representatives of the local institution created for water supply management and maintenance. And the reports of the technical assistance office created to provide Treatment 2 will also be employed. The indicators of interest in that instance will be:

a. Coverage of the water system.
b. Cost of maintenance of the system.
c. Reported problems and ways in which the community dealt with them.
d. Structure of the institution in charge of maintaining the system.
e. Household payment for the service (amount, tariff design, adjustment of payments through time, ways in which money is collected and compliance with payment).
f. Plans for the next years (budget, election of authorities of the local institution, expansion of the water supply to new neighbors, etc).

Our study seeks to understand if the implementation of the Rural WSS Program actually led to the outputs and outcomes presented and measure the size of the effects. As illustrated in Figure 1 the analysis goes beyond the health effects from water distribution. It considers factors such as changes in time allocation, gender issues, and productivity, among others.

5. EVALUATION DESIGN

The main purpose of an impact evaluation is to correctly identify and measure the causal effects of an intervention and its outcomes. In order to isolate and assess these effects, it is necessary to determine what would have happened in the absence of the program, i.e. the counterfactual to the program.

As a true counterfactual is naturally unobservable, a common procedure involves constructing a proxy for the counterfactual by dividing the sample into two comparable groups:

- **Treatment Group (TG)** – a representative sub-sample of the target population that will receive the intervention.
- **Control Group (CG)** – a representative sub-sample of the population that will not be intervened (at least initially).

Ideally, groups should be identical (*ex-ante*). They should be equally affected by observable and, especially, unobservable factors, such that on average, the single difference between the two groups is the result of the implementation of the program.

As this study evaluates a program that will be expanded, it is important to consider the validity and replicability of the results found. In order to verify the strength and robustness of the estimated impacts, this study proposes two different identification strategies. The first and main strategy is to construct internal treatment and control groups, i.e. groups, whose base is the pool of individuals pre-selected to participate in the fifth phase of Rural WSS Program. The second strategy consists of a cross-phase design taking advantage of the different phases of the program to assign individuals into groups.

a. Internal Design

The random assignment of individuals into treatment and control groups is a good mechanism for constructing comparable groups.[10] However, full randomization in WSS interventions is often politically or ethically unfeasible. Once the distribution infrastructure is in place, it is extremely costly for the government to prevent interested households from connecting to the system.

Instead of intentionally preventing households from accessing the program, this identification strategy uses the natural timing and logistic limitations of the project to construct a counterfactual to the program. SENASA has already pre-selected a group of 200 communities, which will receive support in the construction and management of their water distribution systems. However, SENASA's physical and human capacity constraints limit the implementation of the program to, at most, 50 communities per year. Inevitably it would take SENASA four years to serve all the pre-selected community candidates. The identification strategy consists of using a public lottery[11] to randomly distribute the communities into four different groups. Each group will receive the intervention in subsequent years; the communities intervened in the fourth year will serve as a control group for the communities reached in the first year.

The randomization over a critical number of communities assures that on average individuals in the treatment and control groups are identical with respect to observable and unobservable characteristics that could influence the results of the program. Choosing from the pool of pre-selected communities strengthens the internal consistency of the evaluation; these communities are likely to have similar levels of organization, motivation, income, and geographic conditions. Finally, randomization across communities is fundamental to having a fair and transparent method for choosing the phase each community receives the program. It protects the communities against political favoritism and it is likely to be accepted by both the communities and SENASA.

[ADD A PARAG ABOUT THE DESIGN FOR THE SECOND TREATMENT]

b. Cross-phase Design [TBC based on budget constrain]

This identification strategy takes advantage of the gradual implementation of the Rural WSS Program in the construction of treatment and control groups. The Program has been active since 1978 and it is currently in its fifth phase. This phase is mainly an expansion of the work developed in the fourth phase. In particular, the characteristics of the intervention and the community eligibility criteria are the same for the two phases. For this reason, it is likely[12] that the communities that selected themselves into the program and were intervened during the fourth phase share the same ex-ante characteristics (organization, motivation, etc) as the ones participating in the fifth phase. Furthermore, if the design of the program remains unchanged, it is likely that communities intervened in phase six are also comparable.

There is a possibility of taking advantage of the information coming from the rural communities in the fourth phase, in order to get a hint of the magnitude of the effect of the intervention earlier than in the follow-up survey of the fifth phase communities (in 3 years). For this purpose, the treated communities in the fourth phase should be sampled and asked a questionnaire comprising the same questions that the fifth phase communities will answer in the baseline, plus a set of retrospective questions.

After collecting the baseline survey for the treated communities in the fifth phase (all the communities that will be treated during the four years of the intervention; approximately 200 communities), and the comprehensive survey for the treated communities in the fourth phase, the communities will be matched according to the pre-treatment outcomes and other characteristics not related to the treatment. Then, we could use the group of prospective treated communities as a control group for the already treated

[10] Technically, randomly assigned treatment and control groups are only going to be identical with infinite sample sizes (which are unaffordable and unnecessary). The study seeks to minimize that the means of treatment and control groups differ significantly.
[11] With representatives of all the selected communities.
[12] Although unlikely, it is still possible that some unobservable characteristics impact the ordering communities self-select into the program such that communities in the fourth phase are somehow different from those on the fifth. This is the main problem with the cross phase design and the reason why it was chosen as a secondary approach.

communities, provided that we have enough retrospective pre-treatment information of the treated and matching could be performed successfully.

This alternative strategy contributes to the evaluation in different ways. It allows a preliminary assessment of the program after the first round of data collection. This assessment will work as a benchmark to be compared with the actual results from the internal design. It will help to verify the implicit assumption that, individuals in the treatment and control group would evolve at similar pace (trend). In addition, if the impacts estimated by the two methodologies prove to be consistent, the alternative treatment group could be used to identify long-run (8 years) outcomes from the program.

Figure 2 illustrates the impacts estimated under the two designs. TG1 and CG1 refer to the treatment and control groups generated through internal randomization. TG0 represents the alternative treatment group. “A” represents the impact of the program identified by our internal design strategy while “B” represents the cross-phase estimated effect. Ideally, under the proposed identification hypothesis “A” and “B” should be equal.

Figure 2: Internal Design Cross-phase Design

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6. SAMPLE DESIGN AND POWER CALCULATIONS

This project comprises two treatments, and thus, the evaluation sampling methodology requires different approaches for the interventions.

Treatment 1:

We are interested in measuring the effect of clean water supply and sanitation, together with the hand-washing promotion campaign on different outcomes. Mainly we are interested in some variable Y, such as diarrhea incidence.

$$Y_{i:jk:l} = \mu + \delta C_l + \sum\nolimits_{j=2}^{t} \beta_j T_j + \sum\nolimits_{j=2}^{t} \gamma_j TC_{jl} + G_{k:l} + TG_{jk:l} + M_{i:k:l} + \varepsilon_{i:jk:l}$$

$Y_{i:jk:l}$	*Diarrhea incidence on child i, measured at time j on group k, under treatment l*	TC_{jl}	*Time condition interaction dummy: 1 if Treatment and time j, 0 otherwise.*
μ	*Grand mean*	$G_{k:l}$	*Group/Village random effect*
δ	*Treatment Effect*	$M_{i:k:l}$	*Individual random effect*
β_j	*Trend in outcome*	$TG_{jk:l}$	*Time varying Group/Village random effect.*
C_l	*Condition dummy: 1 if Treatment 1; 0 if control*	$\varepsilon_{i:jk:l}$	*Error term*
T_j	*Time Dummy:1 if time j; 0 otherwise.*		*All error terms are serially uncorrelated and uncorrelated between each other.*

The aim of this section is to determine the minimum detectable differences with different sample sizes, fixing the power and significance level. To calculate the sample sizes required, we have to calculate first the variance of the estimator. Consider that we were interested in the minimum detectable difference

(MDD)[13]. To calculate the MDD, we have to find an expression for the variance of the estimator we are interested in, and then, plug it in the following expression that relates the MDD $\hat{\Omega}$, variance of the estimator σ_{Ω}^2, power (1-β) and significance level (α):

$$\frac{\hat{\Omega}}{\sigma_{\Omega}} = \left(t_{\alpha}^{*} + t_{\beta}^{*}\right)$$

Where t* represents the t-student critical values for a one-sided α% level test with power *1-β*.

In the case of the mean difference estimator, the variance formula is the following (when the proportion of treated sample surveyed is 0.5):

$$\sigma_{\Omega}^2 = 2\left(\frac{\sigma_M^2 + m\sigma_G^2}{mg}\right)$$

The main issue in a group-randomized trial is to decompose the variance of the outcome variable of interest in its individual and group components.

If we consider diarrhea as an indicator of interest, there are some methodological issues that must be taken into consideration to choose the most accurate way of measure it, which can be also feasible considering the budget constraint.

Brief Comment on Measurement of Diarrhea Indicators

As regards the measurement of Diarrhea, in the literature there are two ways that are the most common: diarrhea prevalence or diarrhea incidence.

With respect to the first measure, the ***diarrhea prevalence*** is typically defined as the number of days that individuals (usually children under 2 or 5 years old) had diarrhea episodes in a certain lapse. The time span in which the episodes are measured is usually a year. Diarrhea prevalence aims at pointing to more structural causes for the illness, typically present in poor environment where there is not an adequate supply of water and living conditions are rudimentary. Diarrhea prevalence implies tracking the same individuals through time to know the episodes per child per year, or episodes per child per month, for example.

For instance, Luby (2006) studied the effect of hand-washing promotion and disinfected drinking water supply in Karashi, Pakistan. In this study, field workers surveyed participating households at least weekly, for 37 weeks (April 2003–December 2003), and asked the mother or other caregiver if the children had diarrhea (three or more loose stools within 24 h) in the preceding week, and, if so, for how many days. Typically, field workers visited each household twice during the week to ensure that episodes of diarrhea from both early and late in the week were recalled. The primary study outcome was the weekly longitudinal prevalence defined as the percent of person-weeks (within the 37 weeks surveyed) that study subjects had at least one day of diarrhea, and the daily longitudinal prevalence (analogous to weekly but taking into account the days with episodes in each of the 37 weeks).

On the other hand, ***diarrhea incidence*** is defined as a dummy variable that has a value of 1 if the individual had an episode of diarrhea in a determined time span, and a zero otherwise. This variable is also indicative of the health situation of the target population, however it reveals less information than the prevalence indicator. The advantage of this variable is that it can be measured with less error and does not require households to be tracked through time.

[13] Indeed we will estimate the Difference-in-Difference estimator in a panel, but as we will consider a short lapse and only two periods in the first survey, we can use the cross sectional approach without loss of generality.

With respects to sample size requirements and power calculations, when diarrhea prevalence is measured the standard deviation is usually reduced (in relation to the mean) with respect to the case of diarrhea incidence, which in turns reduces the sample size needed to attain a certain power level. Another factor that reduces the variance of the indicator is having repeated measures of the diarrhea incidence, because even though the proportion of the variance corresponding to the group effect remains unchanged, the individual effect is divided by the number of measurements.

In this case, the formula of the variance of the mean difference estimator, is the following (when the proportion of treated sample surveyed is 0.5):

$$\sigma_{\Omega}^{2} = 2\left(\frac{\sigma_{M'}^{2} + m\sigma_{G'}^{2}}{mg}\right)$$

where $\sigma_{M'}^{2} = \sigma_{M}^{2} + \sigma_{\varepsilon}^{2} / t$ and $\sigma_{G'}^{2} = \sigma_{G}^{2} + \sigma_{tg:c}^{2} / t$

However, the problem with repeated measures is that it requires following the same individuals through time, which increases the attrition level, or due to *survey-fatigue*, the answers could be biased to underreporting diarrhea episodes. Different cross-sections could also be interviewed, but there is a risk that the composition of the groups changes and we will not be able to identify the desired causal effect.

In summary, we recommend measuring diarrhea prevalence (and incidence could be deduced from the prevalence reports). However, if due to budget constraints it is not possible, measuring incidence (in the last 2 days, 7 days and 15 days), and also asking the number of episodes within the last month, will provide a hint about the effects of the program on prevalence.

Power Calculations

In the first Follow-Up Survey, we will have 100 communities affected by treatment 1 and 100 still not treated. The 100 treated communities will have different lengths of exposure to the treatment (in Group 1 the Treatment 1 will have been implemented on average 1.5 years before the survey and Group 2 will have on average 0.5 years of exposure).

Therefore, we need to determine which is the MDD in the indicators of interest that we will be able to detect with a defined number of households per community, given that we have 100 communities treated and 100 untreated; and considering a power of 0.8 and significance level of 5 percent. To estimate the sample size required, we need to have an idea of the effect we expect to be able to detect given the baseline level of the indicators of interest. To the best of our knowledge, there is no data available regarding diarrheal diseases at community level for Latin American countries.

The most updated disaggregated data available for Paraguay, comes from the DHS from 1990. The problem with this survey is that the measure of diarrhea employed is not very precise. Mothers (from 15-49 years old) are asked about the times their children aged less than 5 years had diarrhea in the last 12 months. In the following table we show the summary of the data (taking into account only rural households without access to drinking water piped into the dwelling or backyard:

Paraguay – DHS (1990)

Variable	**Obs**	**Mean**	**Std. Dev.**	**ICC**
Diarreha incidence (<5) in the last 12 months	2555	0.543	0.498	0.052

To detect differences of 10 percent in diarrhea incidence in a year (from 0.54 to 0.49, i.e. 5 percentage points), the number of children needed to be surveyed per community is only 3, while to detect differences of 5 percent, we need 10 children pre community (total sample size of 1,000 in treated and 1,000 in control groups). Although this result is very optimistic, we consider that the baseline mean is not precisely measured, denoting an underestimation of the diarrhea incidence in a year for areas with no clean water supply. Nevertheless, it is useful to have an idea of the intra-cluster correlation in the data of this country.

Another source of data to approximate the actual situation in the treated countries, is the baseline dataset for the evaluation of hand-washing promotion in Peru (World Bank project in progress). The advantage of this dataset is that it is updated, properly measured and the variables inquired in the survey are probable those that will be reported in this study. However, the surveyed population in Peru, is not similar to the targeted in the treated countries with respect to access to water. Therefore the incidence of diarrhea is supposed to be much smaller in the Peruvian dataset (that comprises households with access to water) than in the actual population of the targeted rural communities in the selected countries. The data from Peru is the following:

Peru – Hand-Washing Promotion Program baseline

Variable	Obs	Mean	Std. Dev.	ICC
< 2 years old				
Diarrhea incidence 2 days	3708	0.106	0.308	0.039
Diarrhea incidence 7 days	3708	0.186	0.389	0.063
Diarrhea incidence 14 days	3708	0.203	0.402	0.066
< 5 years old				
Diarrhea incidence 2 days	5137	0.084	0.277	0.033
Diarrhea incidence 7 days	5137	0.152	0.359	0.048
Diarrhea incidence 14 days	5137	0.165	0.372	0.050

If we use these data, we could detect a reduction of 25 percent in 14 days diarrhea incidence in children younger than 5 (incidence going from 0.165 to 0.124) with a sample of 20 children per community, which gives a total sample size of 4,000[14]. If the minimum effect we could detect was 30 percent -keeping all the other parameters equal- the number of children per community needed decreases to 11, which equals to a sample size of 2,200 children. The size of the effects is in line with what we could expect from a water supply intervention combined with hand-washing campaign, in light with the results of the literature reviewed.

According to the previous results that were computed using parameters from different sources of data to approach what could be the baseline situation and expected gains in the treated countries, we find that it is crucial to define precisely the diarrhea variable we are interested in and the way in which it will be measured. We suggested gathering as much information as the budget allows: although measuring diarrheal diseases' incidence is more practical and less demanding, it would be interesting to have an idea of its prevalence, at least asking retrospectively about the previous month and have a hint of what happened in the previous year.

Regarding the sample size, assuming that there will be a 15 percent of attrition, to detect an effect of 25 percent in children younger than 5 years, we would need a sample of 4,600 children that in the baseline are **aged less than 3 years**, and if the minimum effect was 30 percent we would need 2,530 of those children. The sample size chosen should be between these numbers (2,500 and 4,600); we recommend to survey 15 families with a child younger than 3 in the baseline. Then, in the follow-up this same families should be surveyed and also all the community should be sampled to add to the sample the new-born between the baseline and the follow-up.

Treatment 2 [TO BE CONFIRMED]

[14] The power level is set in 0.8 and the significance level in 5 percent.

The evaluation of this treatment aims at exploring the sustainability of the water and sanitation provision once the Treatment 1 is implemented and the program is finished. It will be a treatment (and consequently an evaluation) at community level, and will be analyzed in the second Follow-Up Survey. There will be 50 control communities and 50 treated with Treatment 2: half of Group 1 will have been treated 1.5 years before and half of Group 2, 0.5 years before this Survey. The outcome, at community level, will be a binary variable that will be equal to 1 if the project was sustainable and zero otherwise. The meaning of sustainability should be precisely defined. As explained before, a pragmatic and simple one would be the presence of water coming out from the taps and pumps built.

To perform power calculations for this treatment, we should use the variance of the mean difference estimator for simple randomized trials (not for group randomized trials as before). The baseline would be the proportion of communities treated in which the project is sustainable without a further intervention. To the best of our knowledge, there has been no evaluation analyzing the sustainability of water and sanitation programs. We do not have data about the sustainability in water projects in the region (we can have some idea about it with data from the previous 4 rounds of the WSS Program in Paraguay).

According to the organization Water for People (2008 Report), however, the water programs have a high sustainability rate: the data from three years of monitoring (2005-2008) shows that out of 484 water systems built, only 20 were no longer producing water (96 percent sustainability rate). [I FTHIS IS TRUE, THIS TREATMENT IS LESS INTERESTING FOR THE EVALUATION…]

To know the MDD that we will be able to detect, we consider the population of 50 communities treated with Treatment 2 and 50 controls after the third year of the program. We hypothesize different baseline proportions of sustainable programs and in the following table the respective minimum detectable differences are shown (with power of 0.8 and significance level of 5 percent):

Minimum Detectable Differences (MDD) for Treatment 2

Baseline Mean	MDD
0.3	0.26
0.5	0.28
0.7	0.26
0.8	0.20

Note that the baseline mean includes communities treated in the second and in the third year, so the proportions must be interpreted as averages of their treatment group rate. For example, from the 25 communities treated in the first year, 30 percent could be keeping the system, while from the 25 treated in the second year, 50 percent could be still working properly (higher rate because the treatment was applied a year later). Then, on average, the baseline mean would be approximately 40 percent.

In summary, we can only detect effects greater than 0.2, which means that only in the case that we assume on reasonable grounds that the Treatment 2 will make a high difference in the sustainability rate –of approximately 50 percent of the baseline mean-, it could be evaluated. In the case that more evidence is gathered from the region (for example, from the previous rounds of Paraguay WSS Program) reinforcing the idea of a high sustainability rate without an ad-hoc treatment, there we will not be well powered to detect small differences attributed to this treatment.

7. METHODOLOGY OF ANALYSIS

In addition to the identification of the research questions, the sample structure, treatment and control groups, a systematic impact evaluation requires the definition of a framework of analysis. The study will implement a Difference-in-difference (DiD) approach.

A DiD methodology consists of measuring the average changes in a given indicator between the periods before and after the intervention for both treatment and control groups, and then comparing the changes for the two groups. The differences between two groups reflect the isolated effect of the program.

This approach requires the existence of baseline and post-intervention information for both groups. Taking into account that the project will be implemented within four years, in order to measure the average changes between the treatment and the control group, a follow up survey will be launched before starting the fourth batch of interventions. Both the baseline[15] and the follow up survey will collect information about individual, household, and community characteristics of the beneficiaries as well as the indicators defined in Figure 1. The period between the baseline and the follow up surveys is three years. This will give the outcomes time to mature for two years before gathering the final survey. It was considered reasonable to assume that two years was enough time to identify significant changes in the main outcomes that drive the impact evaluation design.

A DiD econometric analysis will allow the IE team to verify the effectiveness of the randomization strategy, creating comparable groups, and correcting for some potential "contamination" of the data. The before- and after-difference for each group corrects for any remaining fixed difference between treatment and control, while the between groups approach deals with external factors that affect the target population during the interval of analysis. Assuming that those factors reach treatment and control equally, the second difference successfully isolates the true causal effect of the intervention.

8. Implementation Team

In order to assure that the team will successfully complete the evaluation as per the proposed design, the team composition will include: Word Bank and IADB teams, academics, local partners and capacity, local supervision, and consultants if necessary. The IE team will be led by Luis Andres and Darwin Marcelo (WB) and XXX (IADB), with the full collaboration of the World Bank and IADB project teams consisting of Miguel Vargas (TTL of the WB project) and Klebber Machado (TTL of the IADB project [CHK]). The team has already identified a strategic local partner in Paraguay, Fundación Desarrollo-- an institute that has local capacity for designing and implementing surveys as well as strong analytical skills [TO BE CONFIRMED DURING THE TECH MISSION]. Additionally, members of the GoP, who participated in the Impact Evaluation Workshop in Buenos Aires in 2006, are already familiar with the methodologies and have committed their support for this initiative. The team will also include Sergio Urzúa (Department of Economics, Northwestern University) and Sebastian Galiani (Department of Economics, Washington University in Saint Louis) as external technical advisors.

9. Timeline

- Mar to Jun 2010: Technical definition of the evaluation design, institutional arrangements, identification of technical teams, survey methodology, supervision methodology, and contracts needed.
- Jun to Aug 2010: Formal definition of the evaluation design, questionnaire design, sample design, implementation pilot and questionnaire test.
- August 2010: Preparation of field activities and training of the fieldwork team.
- September 2010: Baseline survey fieldwork
- Oct to Dec 2010: Preliminary assessment using cross phase approached described in section 5.

[15] Information for the period before the intervention.

- Jan to Mar 2011: Dissemination of the results of the preliminary assessment.
- October 2012: First follow up survey fieldwork.
- Nov to Dec 2012: Evaluation and dissemination.
- October 2014: Second follow up survey fieldwork.
- Nov to Dec 2014: Evaluation and dissemination.

10. BUDGET DESCRIPTION

The main source of funding will be the SIEF (Spanish Impact Evaluation Trust Fund). The project has already received funding for the implementation of this evaluation from the Bank Netherlands Water Partnership Program in Water Supply and Sanitation (BNWP 2 - WSS) ($36,000). Finally, the World Bank and the IADB projects will commit budget to cost sharing this evaluation.

Both follow up survey (2012 and 2014) will be paid for by both projects (AIDB and WB).

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ANNEX A: Steps of the implementation of the rural water projects

The implementation of a rural water project follows seven main steps:

- **Step 1: Eligibility** – A community is defined as eligible based on a set of prioritization criteria, whichincludes socio-economical and technical characterization factors. The program targets the poor districts in favorable geographical areas[16] that fulfill the technical and administrative condition imposed by the project. Annex B lists the variables that are taken into consideration in the community eligibility process.
- **Step 2: Identification** - Generally, a team of two, an engineer and a social promoter, visits potentially eligible communities. The team looks for a community leader in order to get a first-hand impression of the community's predisposition towards a water system. The team also looks into the existence of other community services (electricity, schools, churches, clubs, etc.), which provide insight into the methods traditionally used by the community to pay for public services.
- **Step 3: Promotion and Field Work** - Once a community has expressed the desire to obtain a water system, a team (from SENASA or subcontracted to NGOs or consultancy companies) prepares a social, economic, and cultural profile of the community. They assess the community's attitude toward water supply and sanitation, as well as its willingness and financial capacity to commit itself to the construction and sound management of a water system. Preliminary studies are also made to define the water source, and check groundwater availability. This stage terminates with an announcement to the community relating the general feasibility of the project and detailing the requirements and responsibilities to which the community must adhere in order to receive a water system from SENASA.
- **Step 4: Preparation and Financing of the Project -** SENASA will contract out studies and designs and establish a reliable cost estimate for the project. With the estimated project cost, SENASA's financial department provides the repayment scheme for the community. Financial schemes depend mainly on the number of households, and it consists of: (a) 3 percent of the investment cost, as down payment in cash; (b) from 15 percent (less than 150 households) to 27 percent (more than 150) of the costs paid in community labor and/or materials during the execution of the works; (c) from 15 percent (for communities with less than 150 households) to 30 percent (more than 150) of the investment costs remain the responsibility of the *Juntas* to be repaid in real terms over a ten-year period. The government covers the residual part of the investment cost.
- **Step 5: Participation, Motivation, and Organization** - Once the studies and designs are available, SENASA promoters, who can also be contracted out, may seek full community support for the project. Meetings are scheduled, open to all community members, in which the pros and cons of the project and the requirement for self-help are discussed. Through a legal document supported by a specific law, the community creates a Junta made up of five representatives, four of which are nominated by public vote and one which is nominated by a corresponding municipality for the duration of two years. The Junta is asked to sign a contract with SENASA defining its financial and legal responsibilities. Promotion activities also include community training and hygiene and health education.
- **Step 6: Construction** - Construction of the project initiates upon signing of the contract between SENASA and the Junta. SENASA's water resource specialists drill and test the wells. The wells are then equipped and the electrical works are completed. The community participates in the works by supplying some of the materials and providing labor (such as pipe laying) under the guidance of a local foreman. SENASA keeps careful records of all community contributions.
- **Step 7: Maintenance and Operation** - Once inaugurated, the system becomes the property of the community. The Junta has full responsibility for its administration, operation, and maintenance. SENASA assists the *Junta*'s administration in the establishment of proper accounting systems and billing and collection procedures. The staff, named and paid by the Junta, usually consists of a

[16] areas with availability of water resources and low dispersion of households.

secretary who collects tariffs and maintains accounts, and a plumber who does all technical work. The Junta also decides on future system extensions and new connections.

ANNEX B: Eligibility Requirements

In order to become eligible to receive the implementation of a water and sanitation board and the construction of a new distribution system, the community must meet the following criteria:

i. *Density and scale:* There must be more than 50 households living in the community, such that the maximum distance between households is 100-meters.

ii. *Access to Infrastructure:* The community must have electricity and be connected by an access road.

iii. *Economic Sustainability:* The community must have enough economic resources to repay SENASA and to maintain a well functioning distribution system.

iv. *Groundwater availability:* The community must have a suitable amount groundwater resource.

v. *Community Interest:* There must be a perceived need for clean water in the community by both community members and SENASA. The community must show its interest and overall acceptance of the Project. An intention letter provides such evidence from the community (signed by local authorities) as well as pre-collecting 3 percent of the total cost of the project as down payment.

vi. *Support of local authorities:* The community must enjoy the support and commitment of local authorities and community leaders in to the project requirements, again evidenced by their signature in the community's letter of intention.