ove Office of Evaluation and Oversight

Study on the Performance and Sustainability of Water and Sanitation Initiatives in Rural Areas

Drinking Water Supply and Sanitation in Small Communities (PR0118)

IDB Inter-American Development Bank

IIC Inter-American Investment Corporation
A Member of the IDB Group

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Study on the Performance and Sustainability of Water and Sanitation Initiatives in Rural Areas

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Inter-American Development Bank
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Acronyms and Abbreviations

DIGESA	Dirección General de Salud Ambiental [Environmental Health Division]
EPH	Encuesta Permanente de Hogares [Permanent Household Survey]
ERSSAN	Ente Regulador de Servicios Sanitarios [Sanitation Service Regulatory Agency]
FONPRODE	Fondo para la Promoción del Desarrollo [Development PromotionFund]
MDG	Millennium Development Goals
OVE	Office of Evaluation and Oversight
PCR	Project completion report
SEAM	Secretaría del Ambiente [Environmental Secretariat]
SENASA	Servicio Nacional de Saneamiento Ambiental [National Environmental Health Service]
WHO	World Health Organization

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Although much of the country is endowed with an optimal water supply in terms of both quality and accessibility, in 1990 only 53% of the population had access to an improved source of water. In rural areas, the rate of access to improved sources of safe drinking water was 23%, and there was virtually no piped water.

Executive Summary

Access to safe drinking water is a basic right that is closely tied to the concept of development.It also has important social and economic implications, such as for reducing the incidence of water-borne disease. For these reasons, access to water and sanitation has been identified as one of the United Nations Millennium Development Goals (MDG).

Since 1990, Paraguay has made great strides in expanding water coverage, especially in rural areas. Although much of the country is endowed with an optimal water supply in terms of both quality and accessibility, in 1990 only 53% of the population had access to an improved source of water. In rural areas, the rate of access to improved sources of safe drinking water was 23%, and there was virtually no piped water. Since then, Paraguay has been one of the countries that has worked the hardest to expand coverage, especially in rural areas, dramatically stepping up investment in this sector since the mid-2000s. The model employed by the government, through the National Environmental Health Service (SENASA), is to apply external loans and grants to subsidize investments in water systems for small communities. In addition to this investment in infrastructure,financing is provided to strengthen the sanitation boards, non-profit entities set up to operate and maintain the systems. Since the late 1990s, the IDB has been supporting this intervention model through a series of loans and grants to expand coverage.

Low performance and sustainability levels of rural water systems over time is a global concern. The lack of sustainability of these investments conspires against achieving the development goals.It is estimated that 40% of existing systems are not in working order at any given moment in time and that 10 years after installation one in four do not work. Given that water and sanitation investments have been identified as a key infrastructure investment priority in developing countries, the lack of sustainability isvery troubling. In response, a large body of qualitative literature has researched the main determinants of sustainability.

This evaluation looked at the performance and sustainability of 100 water systems that were installed in Paraguay between 2004 and 2010 as part of a project supported by the IDB. As part of the study, a technical review was conducted of the systems eight to ten years after entry into service, and interviews were held with users, sanitation boards, and the executing agency (SENASA). After establishing the level of performance, the evaluation studied factors that are correlated with a higher level of performance and sustainability, relative to both the original design parameters and the changing needs of the beneficiary communities.

The evaluation found that the performance level of the systems is very high. Virtually all the systems built under the program are in service. Moreover, the users and the sanitation boards are satisfied with the quality of service in terms of water quality and reliability. Eight to ten years after installation, only 4% of the systems are not in service, compared with the rate of 20% to 25% that would be expected based on available data from around the world.

A closer look at the reasons underlying the high performance levels reveals that a key factor is the capacity of the sanitation boards to respond to the main problem affecting the systems—broken pumps. Although system failures were relatively common, they were mainly limited to problems with the pump.The boards were able to fix these problems by drawing on reserves, and indeed nearly the entirety of the post construction investment went to that purpose. The sanitation boards' efficiency in fixing these problems and the availability of sufficient economic resources to do so explain the high performance level of the systems.

Community attitudes towards water and the ready availability of the resource in the program areas also contributed to the performance and sustainability of the systems. Given this availability, the systems that are required are simple in design, have low construction costs, and are relatively easy to maintain. In addition, the communities use a lot of water and place a high value on the resource, which means they are willing to pay enough to sustain continuous operation of the systems. Meanwhile, the amount that they are willing to pay for installation, while positive, is much lower than the actual investment costs. These findings would seem to support the current strategy of subsidizing the investment and using the monthly rate to cover operating and maintenance costs.

An analysis of the correlations between five measures of sustainability and possible explanatory factors points up the importance of technical and economic factors while downplaying the importance of social and environmental factors. The economic variables (e.g. rates, arrears) and technical variables (e.g. micro-metering percentage, growth in the number of connections) consistently correlated with the measures of performance and sustainability. In contrast, social participation and environmental variables did not correlate with any performance measure, belying the emphasis placed on these variables in the literature.

The systems would appear to be operating within design parameters, with the main challenges being lack of information on water quality and low chlorination levels.

However, the future sustainability of the systems could be affected by growth in the communities. On average, the number of connectionshas increased by 40% compared with the number that were initially installed, and in many cases the technical limit for the number of connections has already been, or is very close to being, exceeded. Although the sanitation boards have enough revenue to cover basic operating and maintenance costs, rates are not generating enough revenue to finance system expansions. As a result, the future sustainability of the systems depends on the availability of fresh resources to finance expansions.

Although rural water systems in Paraguay are operational and sustainable within design parameters, there is some room for improvement. One area that could be improved has to do with information. Work could be done to improve and systematize the information systems that SENASA keeps on the communities and the sanitation boards. At the community level, the consistency of sociodemographic data could be improved, as could information on other aspects, such as willingness to pay and attitudes regarding hygiene. With respect to sanitation boards, the capture of economic and financial data could be systematized. Also, more information on water contamination could be collected from the sanitation boards, particularly in areas that have seen an increase in large-scale agricultural activity (e.g., soybean farming).

Another area that could be improved is planning for system expansions, both from a technical and a financial viewpoint.In particular, the design of new operations should incorporate strategies to contend with growth in demand. The financing aspect of the expansion model has yet to be defined. If it is based on community financing, the current schedule of rates would need to be adjusted to that purpose. Alternatively, SENASA could incorporate criteria in its investment plans to prioritize the expansion of existing systems. Given the rapid growth seen in the communities supported by the IDB over the period of study, it would be wise to consider, during the design phase, technical and feasibility solutions to minimize the cost of future expansions.

Studying the performance and sustainability of the systems in other contexts could be useful for identifying the main causal factors. All the factors that this study found to be associated with sustainability could well be specific to eastern Paraguay (an abundant supply of good quality, easily accessible water, and the value placed on water). In order to deepen learning about the sustainability of water systems, similar studies could be carried out in diverse contexts in terms of the availability of the resource and the attitudes of the population.

1

Access to safe drinking water is a basic need that is closely tied to the concept of human development. Accordingly, the United Nations identified access to safe drinking water as a key indicator of development in the new millennium.

1 Introduction

Access to safe drinking water is a basic need that is closely tied to the concept of human development. Accordingly, the United Nations identified access to safe drinking water as a key indicator of development in the new millennium.[1] In addition to being a basic human right, there is a close correlation between water quality and the incidence of disease, particularly among children.[2] In fact, diseases associated with lack of access to safe drinking water exact a heavy toll on developing countries.[3]

Access to safe drinking water in Latin America and the Caribbean has improved significantly, particularly in rural areas. By the end of 2015, a full 95% of the region's population had access to an improved source of water,[4] and the region led the developing world in terms of access to piped water in the home (89%). The region not only outperformed the global averages (91% coverage, 58% piped water) but also did well enough to meet the MDG target. The region's success in achieving the target can be attributed to the expansion of coverage in rural areas, from a rate of 63% to 84%.[5] The increase in piped water coverage, in particular, stands out. Indeed, of the 16 countries around the world that expanded coverage by more than 25 percentage points, 7 are in Latin America, with Paraguay leading the globe (53 percentage points).

Along with the progress made in terms of access comes the challenge of ensuring the performance and sustainability of existing water systems. Although information on sustainability and performance is scarce and not always entirely comparable, it is estimated that 40% of existing systems in rural areas are not in service. The low rate of service has generated a large volume of literature, mostly qualitative, that seeks to explain sustainability so that more effective

Although information on sustainability and performance is scarce and not always entirely comparable, it is estimated that 40% of existing systems in rural areas are not in service.
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interventions can be designed. In fact, sustainability concerns have even changed the intervention paradigm from an approach based on infrastructure to one based on service delivery.[6] Meanwhile, efforts to move forward in terms of quantifying the performance and sustainability of the systems have been more limited.

The purpose of this study is to contribute new information and data on the performance and sustainability of 100 rural water systems financed by the IDB in Paraguay. The study is built around two basic questions. First, eight to ten years after the water systems were installed, what is the operational status of the systems and what is the quality of service provided? Second, looking ahead, what are the challenges, both financial and operational, in terms of the medium- and long-term sustainability of the service?

This study contributes to the quantitative analysis of the performance and sustainability of the water systems.For the purpose of analyzing the performance and sustainability of the IDB-financed systems, the Office of Evaluation and Oversight (OVE) gathered information in the 100 communities that participated in the IDB program, including a sample of over 500 individual beneficiaries in 30 of these communities. The IDB supplemented this information with data collected in targeted surveys in 2003-2004, 2008, and 2010, as well as with information from the Permanent Survey of Households (EPH) 2000-2014. Although this study contributes to the quantitative analysis of the sustainability of rural water systems, there are some limitations inherent to the analysis. Specifically, both the regression analysis and the descriptive analyses in the section on results should not be interpreted as causal since the variability of the explanatory variables is not necessarily exogenous and there are compatibility issues between the various databases.

The increase in the coverage of water services over the past 30 years is one of the success stories of the millennium development challenges and can be attributed to the advance of urbanization, higher income levels, and, of course, greater investment in the sector.

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2 Context

With the significant expansion of coverage that has been achieved, there is growing interest in ensuring the sustainability of investments. The increase in the coverage of water services over the past 30 years is one of the success stories of the millennium development challenges and can be attributed to the advance of urbanization, higher income levels, and, of course, greater investment in the sector.[7] Yet, several studies have found the sustainability of the systems to be generally low, limiting the effectiveness of the billions of dollars invested to deliver safe drinking water to rural areas.[8] Although quantitative measures of sustainability are few and problematic, a body of primarily qualitative studies has emerged to explain why sustainability is low (Box 2.1).

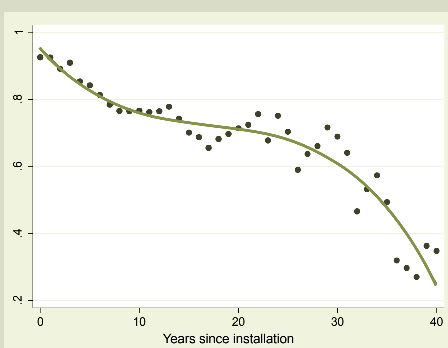
Sustainability concerns have led to greater emphasis on demand and service delivery, creating challenges in terms of how to define and measure sustainability. The focus of early intervention strategies was on physical infrastructure. Over time, as sustainability issues arose, the focus increasingly shifted to the role of the beneficiary community in management aspects and in the technical and economic scale of the systems. Since the 2000s, this demand responsive approach has been the standard for rural water interventions.[13] As these changes were occurring, the very idea of what makes a system sustainable evolved from an earlier concept based on the performance of the infrastructure to much broader perspectives that include considerations such as the delivery of service over time and even criteria related to equity.[14] In practice, the multitude and breadth of definitions of sustainability make the question of measurement more problematic.[15] First, many of the variables used in sustainability analyses cannot be directly observed (e.g. community commitment). Second, consolidating the myriad social, management, environmental, and economic dimensions into a single sustainability index requires complicated methodological decisions, none of which are beyond critique.[16] Lastly, the sustainability indexes proposed in much of the literature combine many factors, making it hard to distinguish between cause and effect.

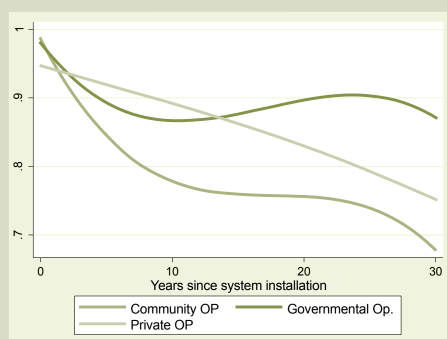
Box 2.1: Data on sustainability of water systems

Although it is generally agreed that the sustainability of rural water investments is low, the available body of statistical data is incomplete and not readily comparable. The evidence indicates that 30% to 40% of installed systems do not work.[9] For example, a meta-analysis of 124 sustainability studies finds that approximately 40% of (manual pump) water systems are nonoperational post-investment. Furthermore, there is no indication that these averages have improved in more recent studies (or systems).[10] In Latin America, the statistics on operating status vary widely. Sustainability studies have found unsustainability levels of 18% in the Dominican Republic, 23% in Peru, 38% in Ecuador, and 42% in Haiti.[11] In general, this information should be interpreted with caution as there are comparability problems.

In order to understand the pattern of performance over time, OVE used a database with information on more than 200,000 water systems, which revealed that roughly one quarter of rural water systems are no longer operational 10 years after installation. Beyond that 10-year horizon, the likelihood that they will be operational seems to stabilize around 70%. Lastly, operational status declines precipitously in systems that are older than 30 years, presumably due to the technical obsolescence of the investment (Figure 2.1). And a number of studies have found that systems that are run by the local community tend to become nonoperational sooner than systems run by the government or private agents. This is consistent with the distinction between community *administration* and community *participation.*[12]

FIGURE 2.1: Operating status of water systems around the world





Source: Prepared by the authors based on WaterPointDataExchange figures on 230,000 rural water systems in developing countries. The trend line was constructed with a cubic polynomial.
Note: Cubic polynomial regressions of the probability of a system being operational at a given point in time from installation. Not all coefficients of the adjusted polynomial are significant.

In general, the literature has identified key indicators to describe the performance and sustainability of water systems, and these can be grouped into six categories: (i) environmental; (ii) institutional; (iii) administrative and management; (iv) economic; (v) technical; and (vi) social. Environmental sustainability analyzes the capacity of the source to continue to supply the same quantity and quality of water over time. In this case, the process of drawing the water from the source must be analyzed (e.g. analysis of flows, contamination). A major challenge associated with the environmental sustainability of the water source is that it depends on the actions of third parties given its status as a public good, which makes it vulnerable to overexploitation and contamination due to problems of institutional coordination or regulatory failures. Institutional sustainability is related to the institutions, policies, laws, procedures, and regulations that affect sustainability over time. Administrative and management sustainability have to do with the capacity of the operator to plan and regularly operate the system. The economic dimension, which has been a focal point in the literature, has to do with the capacity to obtain and allocate the economic resources needed to guarantee uninterrupted service. An open question in the discussion about financial and economic sustainability is the role of rates. The technical dimension refers to the capacity to keep the system running smoothly and reliably so water can be delivered in the quantity and quality required (volume of flow from source, extraction and storage capacity, size of distribution network, characteristics of the electric power system, etc.). Lastly, the social dimension is related to the characteristics of the community that affect sustainability. Within the social dimension, two key elements are the value placed on safe drinking water—a dimension closely related to the culture of water—and the community's sense of ownership of the service. Some of the literature also emphasizes the importance of high rates of community participation in management as key to the performance of the systems.

The various dimensions of sustainability are not mutually exclusive; on the contrary, they are highly interdependent. Although isolating the sustainability dimensions is useful for learning purposes, it would be a mistake to view them as independent. On the contrary, they are highly interdependent. For example, the value that the community assigns to water resources translates into a willingness to pay, which in turn affects the economic sustainability of the system.

3

From 1990 to 2015, Paraguay increased its piped water coverage levels by 53 percentage points (30% to 83%), the fastest rate of expansion in the world during this period.

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3 IDB Support for the Rural Water Sector in Paraguay

Paraguay has made significant progress in expanding what were very low levels of coverage, particularly in rural areas. Around 1990, despite being well endowed with water resources (Guaraní aquifer, high rainfall), Paraguay had very low levels of coverage, even compared with the rest of Latin America and the Caribbean.[17] From 1990 to 2015, Paraguay increased its piped water coverage levels by 53 percentage points (30% to 83%), the fastest rate of expansion in the world during this period.[18] This progress is largely explained by the increase in coverage in rural areas. Whereas there was almost no water coverage in the Paraguayan countryside in 1990, a full 68% of the rural population had access to piped water by 2015. Just from 2008 to 2014, a period of heavy investment, improvements in rural coverage reached more than one million new people.[19]

Despite a sector reorganization in 2000, the National Environmental Health Service (SENASA) remained in charge of providing water services, for which it uses an intervention model based on an investment subsidy and support for the sanitation boards. SENASA, created in 1972 under the Ministry of Public Health and Social Welfare, is responsible for planning, promoting, and executing works to expand the delivery of water and sanitation services in rural areas (fewer than 10,000 inhabitants). It also facilitates the creation of sanitation boards (comprised of project beneficiaries) and provides technical and financial support to them. AfterSENASA builds the systems, they are transferred to the boards, which are responsible for managing them. Depending on the number of connections,

Since the first project, which was approved in 2001, the IDB has supported rural water and sanitation investments through three programs (PR0118, PR-L1022, and PR-L1094), with plans to build over 600 rural water systems benefitting over 275,000 people. © *IDB*

SENASA subsidizes between 40% and 82% of the investment costs and also offers concessional loans. In theory, SENASA does not have a regulatory role. That function corresponds instead to the Sanitation Service Regulatory Agency (ERSSAN), an autonomous entity created under the sector reform in the 2000s.[20]

The bulk of investment in Paraguay's water sector has been in rural areas with financing from international cooperation resources. Water and sanitation investment has increased significantly in the past decade, from US$10 million per year in 2003-2005 to US$80 million per year in 2006-2013. Much of these investments have gone to rural water and sanitation. In fact, SENASA has been the primary executing agency for these investments in the water and sanitation sector, having executed 67% of the total investment amount. Approximately 90% of SENASA investments are financed with loans and grants from international donors (IDB, World Bank, MERCOSUR Structural Convergence Fund, Spanish Cooperation Fund), which have financed or are financing the construction of 1,114 new systems since 2008. Since the first project, which was approved in 2001, the IDB has supported rural water and sanitation investments through three programs (PR0118, PR-L1022, and PR-L1094), with plans to build over 600 rural water systems benefitting over 275,000 people.

Although considerable progress has been made in Paraguay's water sector since 2000, challenges lie ahead. Broadly speaking, there are four: (i) to carry out the remaining coverage expansions; (ii) to set rates that ensure sustainability of service; (iii) to finalize the regularization processes established by law; and (iv) to strengthen sector institutions, particularly at the regulatory agency. Specifically, with respect to the model for delivering water and sanitation services in rural areas, the weaknesses have to do with the structure of subsidies, the dispersion of providers, and the low rates charged for service.[21]

From a technical perspective, the systems are fairly uniform in their construction, technologically simple, and low-cost. They consist of a well, an electric pump connected to an elevated tank, and a gravity distribution system.

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4 OVE's Survey

This study focuses on the rural water investment component of program PR0118, approved in 2001 (92% of the IDB investment). Following significant delays related to obtaining legislative ratification and hiring a management firm, physical execution of the project was launched in 2003. The investment component, which involved the construction of 100 rural water systems, was basically executed between 2004 and 2008 (80% of the IDB loan). During execution, although SENASA was able to handle the various problems that arose, the IDB was concerned about the lack of information, noting that there was little information on the actual physical, technical, financial, and administrative conditions of the existing systems.[22]

In order to verify the condition of the systems and identify factors correlated with sustainability, OVE collected information on each one of the 100 systems financed under the project. In June 2014, OVE conducted surveys of sanitation boards and beneficiaries and performed an independent technical review of the systems. Based on this survey, a database was created with information on organizational, community, and management aspects related to the 100 water systems (400 variables). The technical review of the 100 communities provided an opportunity to independently verify the condition and operational status of the IDB-financed systems and largely filled in the missing information noted by IDB Management. The sanitation board survey supplemented the technical review by providing the environmental, institutional, management, economic, technical, and social information needed to understand how the systems worked and their sustainability. Lastly, 545 questionnaires were administered in a sample pool of

30 communities in order to gather information on the perceptions of individual beneficiaries and validate some of the variables reported by the sanitation boards (see Table 4.1).

Table 4.1: Number of questions per topic – OVE survey, 2014

Topic – Sanitation board survey	Nº	Topic – Beneficiary survey	Nº	Topic – Technical review	Nº
Governance	36	Socioeconomic	33	Water source	6
Administrative management	30	Service	56	Tank	4
Financial management	66	Assessment of service	27	Shed	2
Technical capacity	40	Assessment of management	12	Chlorination	4
Service	24	Housing	10	Fence	2
Social capital	11	Health	14	Pump	3
		Social capital	9	Electrical system	4
				Distribution system	4
				Grounds	1
Total Questions	207		161		30

To assess sustainability, OVE drew on various databases (EPH, surveys conducted by SENASA as part of the program). The program and SENASA conducted informational surveys in the communities at the start of execution (2003-2004), during the midterm evaluation (2008), and during the final evaluation (2010). All surveys collected community-level information, including socioeconomic data on the communities and the sanitation boards. The midterm survey (2008) and the information gathered by OVE looked at technical aspects involved in operating the water systems (2014). In the case of the baseline survey (2003 2004), the only available information is on the socioeconomic characteristics of the area of intervention (Table 4.2). Because the surveys were carried out by different actors, at different points in time, with different objectives, methods, and levels of quality control, the information is not always consistent or readily comparable. The analysis supplemented the program surveys with questions from the water and sanitation module of the Permanent Household Survey (2000 2014).[23] The statistics describing the main variables used in the study are presented in Table 4.3.

A descriptive analysis of the databases indicates that the systems are primarily located in five departments—most in the central region of the country—and were installed between 2005 and 2007. More than 70% of the sanitation boards receiving program support were in five departments—four in central eastern

Paraguay (Caaguazú, Guairá, Caazapá, and Itapúa). The vast majority of the systems (74%) were installed between 2005 and 2007, which means they were eight to ten years old at the time of the survey.

Table 4.2: Description of databases

Survey year	Number of communities surveyed	Number of beneficiary questionnaires	Sociodemographic information	Technical review of operations
2003-2004	98	N/A	Yes	No
2008	30	149	Yes	Yes
2010	100	11,536	Yes	No(*)
2014	100	545	Yes	Yes

Note: (*) Contains information on the basic characteristics of the systems but not a review of individual operations.

The systems, initially small in size, expanded rapidly, and it was hard to keep up with demand. There were an average number of 90 connections per sanitation board at the time of installation, but 140 connections at the time of the survey (46% increase).[24] Nearly half of the sanitation boards report having users that would like to connect to the system but are unable to do so, either for technical or financial reasons.

From a technical perspective, the systems are fairly uniform in their construction, technologically simple, and low-cost. They consist of a well, an electric pump connected to an elevated tank, and a gravity distribution system.[25] All the systems have a well (85% have a single well and 15% have two) and an electric pump (12% have two) that delivers water to an elevated storage tank (5% of the sanitation boards have more than one tank) with an average capacity of 16,000 liters. After the water is chlorinated, it is piped by gravity to dwellings. The main differences between systems have to do with scale (average tank capacity is 16,150 liters, but three quarters of the systems have 10,000-, 20,000-, or 30,000-liter tanks) and the size of the distribution system (ranging from 1,200 to 23,000 meters). In terms of cost of the individual systems, the contributions reported by the sanitation boards averaged about US$67,000 per system, with systems serving more than 150 connections costing slightly more (US$77,000) than smaller systems (US$64,000).[26] The subsidy per connection ranged from US$350 for systems with more than 150 connections to US$650 for systems with fewer than 150 connections.

Rates for water service were around G 14,000 (US$2.50) per month. Water rates were generally comparable across the various surveys and with the information available from the household survey for rural areas (see Table 4.4).

Figure 4.1

Rural water systems financed by the IDB, and five communities with beneficiaries

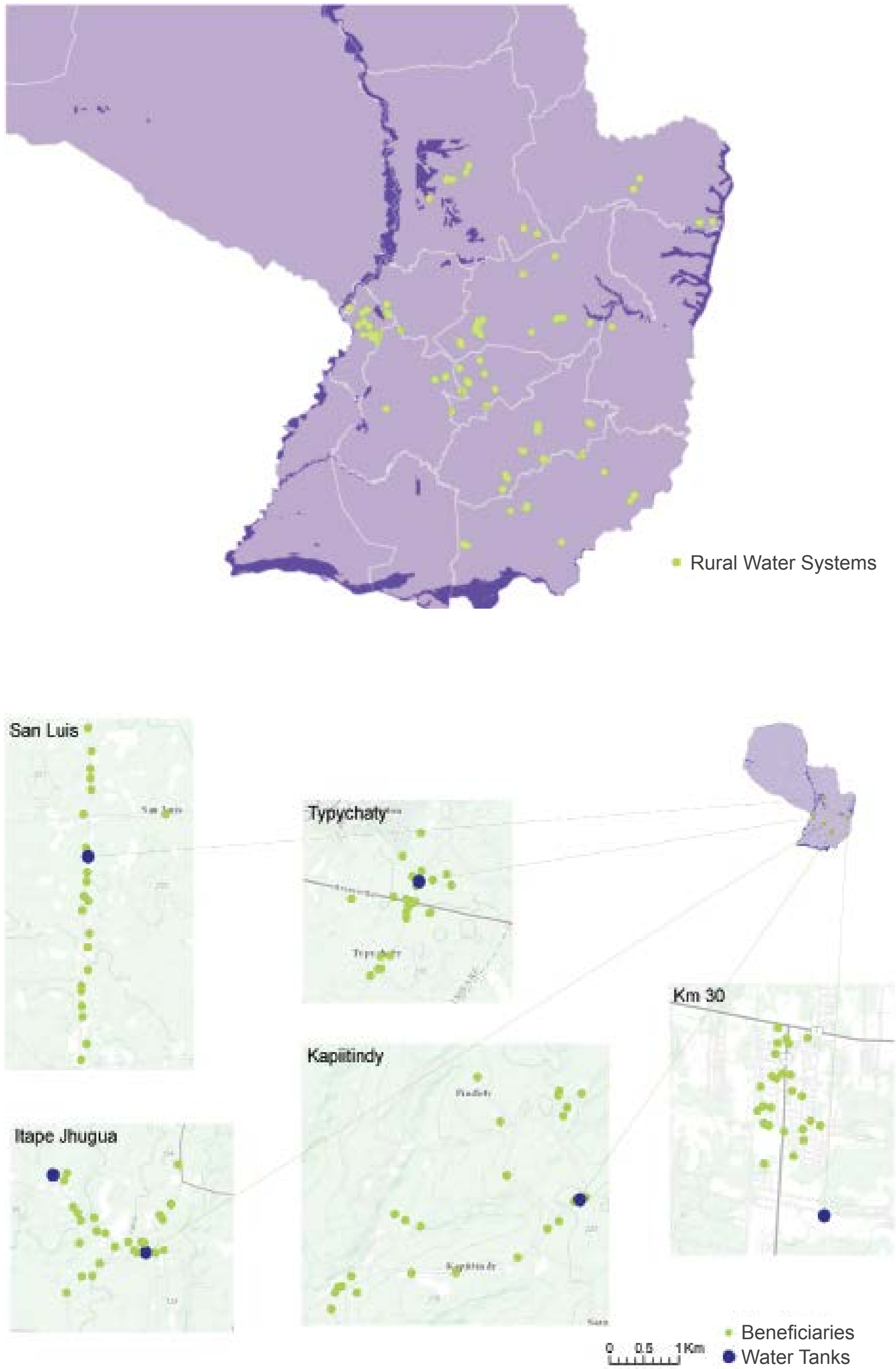

Table 4.3: Main variables used

Selected variables	Nº Obs.	Average	Std. dev.	Min.	Max.
Administrative					
Is the sanitation board legally constituted?	100	0.94	0.24	0.0	1.0
Does it have bylaws?	100	0.84	0.37	0.0	1.0
Does it have a taxpayer identification number?	100	0.57	0.50	0.0	1.0
Length of term of chairperson (years)	97	2.78	2.49	0.0	10.0
Average length of time in existence (years)	99	2.51	2.02	0.0	10.0
Number of members on the board	100	5.53	0.94	0.0	8.0
Women (% of total members)	99	0.23	0.26	0.0	1.0
Is there a manual of procedures?	100	0.73	0.45	0.0	1.0
Is there an operating manual and is it used?	100	0.47	0.50	0.0	1.0
Are administrative books kept? (% of total)	100	0.30	0.22	0.0	1.0
Registered with SEAM?	100	0.50	0.50	0.0	1.0
Registered with ERSSAN?	100	0.24	0.43	0.0	1.0
Registered with DIGESA?	100	0.23	0.42	0.0	1.0
Number of individuals employed by the board	99	2.57	1.66	0.0	9.0
Social					
Attendance at board meetings (individuals/number of connections)	98	0.43	0.23	0.1	1.2
Community confidence index (0-1)	100	0.62	0.25	0.0	1.0
Environmental					
Is the water source accessible?	100	0.93	0.26	0.0	1.0
Is the water source poor/contaminated?	100	0.11	0.31	0.0	1.0
Consumption per connection (% of potential volume of flow from source)	81	0.31	0.21	0.0	1.3
Consumption per connection (% of potential extractable volume)	82	0.33	0.27	0.0	1.9
Technical					
Initial number of connections	95	94.14	48.73	7.0	420.0
Number of connections in 2014	100	138.08	8.21	60.0	733.0
Is there a maintenance plan?	100	0.27	0.45	0.0	1.0
Frequency of tank maintenance (months)	97	7.71	5.33	1.0	24.0
Frequency of pump maintenance (months)	95	10.22	5.70	1.0	24.0
Percentage of meters	100	0.25	0.40	0.0	1.0
Is there a backup pump?	100	0.75	0.44	0.0	1.0
Was an investment made in a generator from the launch of operations?	83	0.83	0.38	0.0	1.0
Are pump failures the board's main problem?	100	0.67	0.47	0.0	1.0
Use of chlorine (liters per year per connection)	91	1.14	3.51	0.0	31.3
Has the maximum number of connections been exceeded?	48	0.29	0.46	0.0	1.0
Is there unmet demand?	100	0.48	0.50	0.0	1.0
Economic					
Total expenditures (millions of guaraníes)	87	18.63	18.58	1.7	122.6
Total revenue (millions of guaraníes)	88	23.16	24.50	0.0	168.0
Cash flow (2013, millions of guaraníes)	84	1.86	9.16	-64.7	24.6
Investment/maintenance since installation (millions of guaraníes)	82	13.88	16.41	0.5	100.0
Current expenditures/revenue	60	0.61	0.52	0.0	4.0
Construction subsidy (millions of guaraníes)	58	384.94	192.04	2.0	1000
Reserves (millions of guaraníes)	87	7.67	7.99	0.1	40.0
Reserves (months of operation)	76	7.63	11.25	0.1	65.0
Arrears > 12 months (% of users)	98	0.00	0.03	0.0	0.2
Total amount of arrears (millions of guaraníes)	96	2.05	3.00	0.0	15.0
Rate (*)	100	14146	4693.35	8000	8000

Note. All variables formulated as questions were encoded as Yes=1 and No=0. (*) For the systems that have a variable rate, consumption of 100 liters per habitant per day was assumed (12,000 liters per month).

Table 4.4: Water rates in Paraguay (guaraníes)

Rates	Average	Median
EPH 2010 (Paraguay, rural)	14,877	11,000
Survey of sanitation boards 2014 (fixed)	13,639	15,000
Survey of sanitation boards 2014 (fixed+variable)	14,146	14,500
Survey of users 2014	16,483	15,000

Household income climbed significantly during the period under analysis, which mirrored broader economic trends in Paraguay (Table 4.5). Based on a comparison of surveys of beneficiary households (2004, 2008, 2014), household income climbed by 300% (350% in dollars) during the period under analysis. These increases were consistent with the increases in rural income levels in Paraguay observed in the EPH and with the increase in per capita income observed during the same period.[27]

Table 4.5: Annual income growth rates

	EPH - Rural	OVE surveys (beneficiary communities)	GDP per capita (G) – World Bank
2004-2008	9.24%	9.16%	12.23%
2008-2014	12.22%	9.83%	7.87%
2004-2014	11.02%	9.58%	9.59%

Five indicators were used to assess the sustainability and performance of the systems: a performance index, a system quality rating, the perception of sustainability, the incidence of major failures, and the number of failures in the previous year. To construct the index, a weighted average of quality and reliability indicators was taken. For quality, users were asked to assign a rating (good, average, poor) for pressure, taste, smell, and color. For reliability, the number of hours during which water was available, in both winter and summer, was used as the indicator.[28] The main figures corresponding to these variables are presented in Table 4.6.

Table 4.6: Main sustainability indicators

Selected variables	N. Obs.	Average	Est. dis.	Min.	Max.
Performance index (0-1)	100	0.90	0.112548	0.28	1
Sanitation board rating (1-10)	100	8.42	1.512106	3	10
Major failure in the previous year?	100	0.65	0.479373	0	1
Failures in the previous year (number)	95	3.12	3.386026	1	12
Is there a perception of sustainability? (1=yes)	100	0.74	0.440844	0	1

5

Specifically, the percentage of households using water for their gardens and livestock increased significantly from 2008 to 2014 (from 20% and 9% to 30% and 54%, respectively). The increase in water use for livestock could nearly double again the amount of water consumed in the household.

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5 Results

Result 1: Since installation, the systems have had consistently high performance levels.

The majority of the water systems supported by the IDB as part of the project under review are in working order and providing a service that is perceived as being of acceptable quality (Figure 5.1). At the time of the OVE survey, only 4 of the 100 systems originally installed with IDB and SENASA support were not in working order. In addition, water quality is perceived as high, both as self-reported by the sanitation boards and as reported by the users independently. Over 90% of respondents said that color, taste, odor, and clarity were acceptable. The high rate of performance and perception of quality is consistent with the findings of the physical inspection of the systems. The tanks and distribution systems are, in general, in good condition. Although water sources are accessible, there are some problems with contamination, with 12% of the sanitation boards reporting evidence of damage or contamination at the source. In general, the assessment of service quality is very positive, with nearly 83% of the users who were interviewed reporting that they are satisfied with service and another 5% reporting that they are very satisfied.

Performance levels are quite high, especially compared with similar systems in other countries. Based on the statistical data available on water systems around the world, the expectation is that 20% to 25% of systems would be out of working order 8 to 10 years after entering into service. In contrast, in Paraguay, the figure is 4%.

FIGURE 5.1
Well and tank photos

Source: UCA, 2014.

Source: OVE, 2014.

Operational performance levels have been consistently high since installation of the systems. The high rate of systems in working order is consistent with the information gathered during the 2008 and 2010 surveys. In 2008, of the 30 sanitation boards that were surveyed, 25 already had systems that had entered into service and all but 3 were in working order.[29] In 2010, 97 of the 100 systems were in service and in good condition.[30] In other words, performance levels have been relatively constant since the systems were installed.

Both the users and the sanitation boards, while very positive, expressed concerns about service, especially as related to water pressure and to a lesser extent service interruptions. Eleven percent of the sanitation boards and 17% of users reported problems with water pressure in 2014. Although practically all boards and users reported receiving water service continually during the day (82% of users and 85% of boards), both groups reported relatively frequent outages due to failures. Indeed, two thirds of the sanitation boards reported having had a major failure that compromised continuity of service in the previous year, although the resulting service interruptions were typically short-lived (one day). In general, the boards report having failures that interrupt service every eight months on average. Users, meanwhile, reported a higher rate of outages (23% reported daily outages). Both the sanitation boards and the users concurred that the outages tended to be short in duration.

Owing in part to the high level of operational performance of the service, the performance index is very high, with a low level of variability. The performance index, which combines measures of operational performance and quality of service, averages 0.9 (with a minimum score of 0 and a maximum score of 1) and nearly 80% of the observations correspond to one of three values (1, 0.916, and 0.833). Seventy-five percent of the sanitation boards have service levels above 0.88, and 90% score above 0.8 (Figure 5.2).

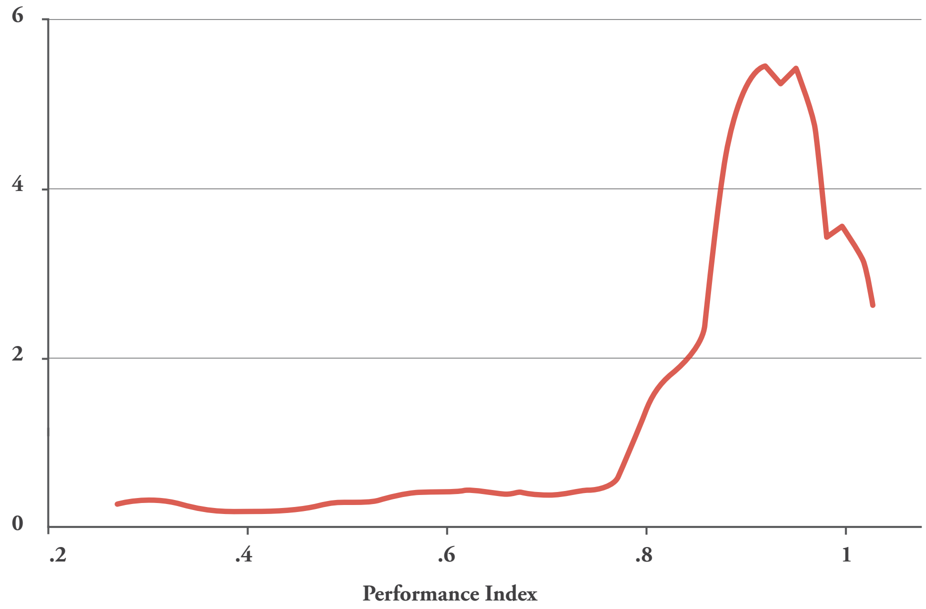


Figure 5.2

Distribution of the level of service

Note: kernel = epanechnikov, bandwidth = 0.0288

Result 2. Key to maintaining the systems in working order was ensuring that the sanitation boards had the capacity to resolve the main failures, mostly having to do with the electric pump.

In order to understand the high performance levels of the systems, the most frequent failures and their impact were studied. Failures were generally related to problems with the electric pump and were low impact despite their frequency. On average, technical failures occurred every 8.14 months (mean average of 6 months), and 65% of the sanitation boards reported having experienced a major failure that affected continuity of service in the previous year, although when the failures result in water outages, they tend to be of short duration (87% last for less than one day). In terms of the type of failure, the main problems have to do with the electric pump (reported by two thirds, or 66, of the boards), electric power outages (reported by nearly one quarter, or 24, of the boards), and broken pipes (reported by 12 boards).

The sanitation boards were able to adequately resolve problems related to the electric pumps. In fact, much of the post-construction investment is explained by investments to repair or replace pumps. Most of the sanitation boards report having invested some amount after bringing the system into service (83%), and in the vast majority of cases, the investment was to repair or replace motors (83%). The average post-construction investment is G 13 million (3.3% of the cost of the system). This is equivalent to the cost of 2.3 pumps on average, and 35% of the sanitation boards invested an amount equal to or less than the cost of one pump.[31] In this context, the performance of the systems can be understood as the capacity of the boards to fix the most common problem they faced—pump failures—by making investments in the systems.

Result 3. Aspects specific to the Paraguayan context (resource availability, culture of water) helped facilitate system performance.

First, the geographic conditions in eastern Paraguay are such that the costs of building, operating, and maintaining the systems tend to be relatively low compared with costs in other regions. According to WHO estimates, the average cost of providing a similar level of service runs between US$148 and US$232 per capita depending on the region, well above the average cost in Paraguay (US$108 per capita).[32] These cost differences are likely related to the fact that water is abundant and quality is good in Paraguay, which simplifies the technical aspects of the systems and facilitates sustainability.

Second, Paraguayans place high value on the resource, which can be inferred from water use, attitudes about water, and willingness to pay for the service.

In fact, households use a lot of water, both for domestic consumption and for economic activities. On average, households consume 350 liters per day, or an average of 91 liters per individual/day. These levels are 30% higher than the average for rural communities in Latin America and almost double the standard set by the WHO.[33] Distribution, too, skews toward high consumption levels, which is partly explained by water use for economic activities. Nearly one third of households use water for purposes other than domestic ones. Water consumption is higher among households that use water for commercial purposes than among households that do not (380 liters vs. 330 liters), and the difference is statistically significant.[34]

The few indicators available suggest that hygiene and the culture of water are very important for the community.[35] In 2008, although fewer than half of survey respondents had a modern bathroom, the vast majority of those bathrooms were found to be cleanby the person conducting the survey (87.5%). In addition, nearly two thirds of households had soap and, when requested, offered it to the person conducting the survey to wash his or her hands. In comparison, according to UNICEF, only half of urban households and one third of rural households have a spigot and soap available for handwashing.[36] Moreover, 99% of water basins were clean. In terms of behavioral attitudes with respect to water, 80% and 90% of respondents stated that the most important requirement for water for personal hygiene and for consumption was that it had to be clean and disinfected.[37]

When household water consumption is correlated with these attitudes towards hygiene, the soundest hygiene practices are found to be associated with greater water consumption. For example, although families with modern bathrooms and latrines consume similar volumes of water, those with clean bathrooms use 43% more water than those with dirty bathrooms. Likewise, families that have soap available consume 38% more water on average than those that do not have soap available.

Lastly, households are generally willing to pay more than the average rate for water service, though not enough to cover the costs of installation of the system. The average household offers to pay G 197,000 to install water service and G 22,000 per month for service. Households that use water for commercial activities are willing to pay more per month than households that do not (G 27,000 vs. G 17,000).

Calculating a simple willingness-to-pay model based on a series of demographic controls yields results averaging between G 11,500 and G 15,500 for monthly water service, depending on the model and water consumption specifications. If a consumption value of 100 liters per person is used, willingness to pay hovers around G 14,000 per month. If the same model is adjusted to gauge willingness to pay for installation costs, the results range between G 160,000 and G 270,000 depending on current water consumption. If the consumption value is set at 100 liters per person, the willingness-to-pay figure comes in around G 230,000 (US$40).[38]

In general, the greater the level of water consumption, the greater is the willingness to pay for both service and installation, though the relationship is relatively inelastic. People who consume more water express a greater willingness to pay, both for service and for installation, which makes intuitive sense. However, this relationship is relatively inelastic. For example, a 1% increase in water consumption translates into a smaller increase in willingness to pay (0.1% and 0.2%, respectively). See Figure 5.3.

Although willingness to pay for monthly service would appear to be slightly higher than the average rate, willingness to pay for installation (some US$40) is significantly lower than the actual subsidy per connection (between US$350 and US$650 per connection depending on the size of the system).

Result 4: A macro analysis reveals a weak correlation between the sustainability variables and possible explanatory factors, as evidenced by the lack of variability in the measures of performance and sustainability. However, the correlations that do exist are generally intuitive and consistent with what is suggested in the literature.

Social variables (confidence level in the community, participation in sanitation board meetings) and environmental variables (accessibility and contamination of the source) are consistently negligible in explaining the sustainability measures of the system. The lack of correlation with sustainability measures is consistent with the lack of empirical evidence in terms of the role of community management in the sustainability of the systems. In fact, if anything, OVE found that systems run by the community are more likely to be out of service, compared with systems run by the government or private sector. As with the social variables, environmental variables (contamination at source) are also not correlated in any way with the sustainability indicators.

Figure 5.3 A

Correlations between water consumption and willingness to pay for water and sanitation installation and service

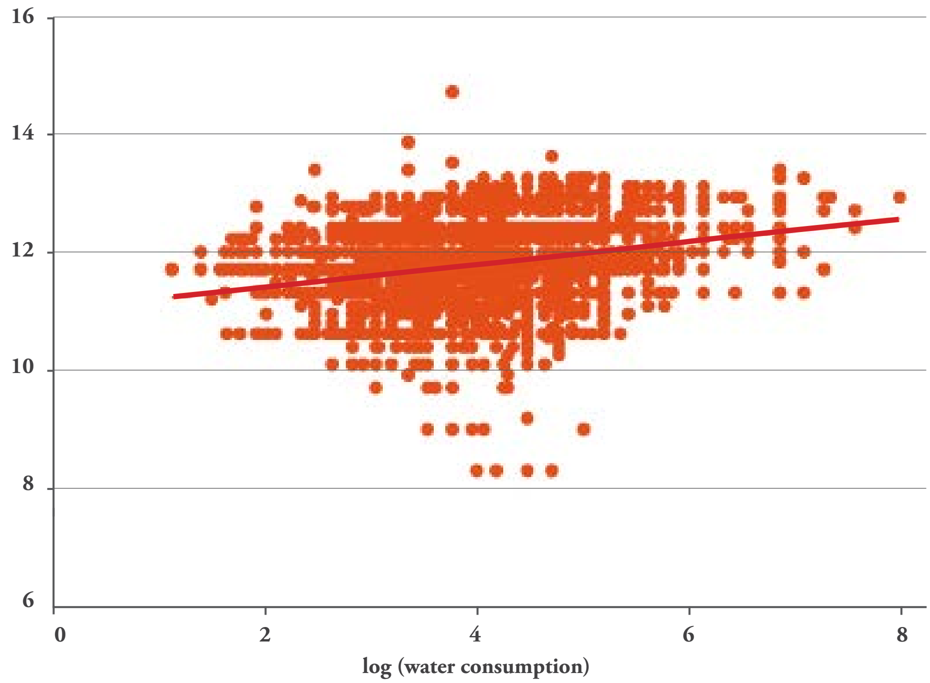
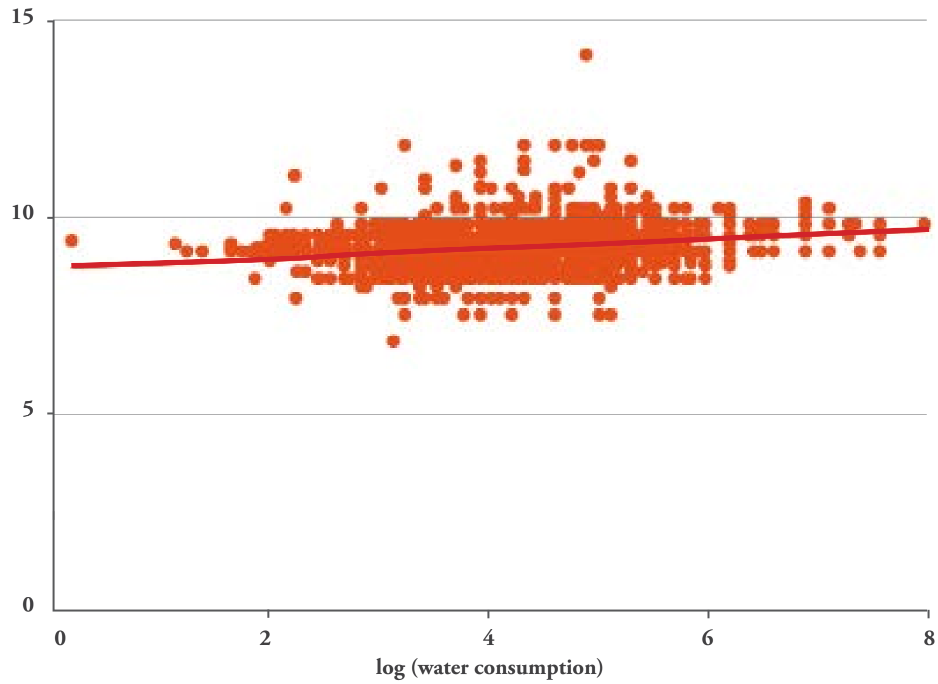


Figure 5.3 B

Correlations between water consumption and willingness to pay for water and sanitation installation and service



The technical variables would appear to suggest that system complexity and size are inversely correlated with performance and sustainability. Whereas the micro-metering percentage is correlated with a higher quality rating of the sanitation board, it also correlates with more system failures. Both results make intuitive sense inasmuch as micro-metering presumably introduces greater complexity to the system, which could lead to worse failures. Similarly, an increase in the number of connections is consistently related to poorer system performance and lower quality ratings for the sanitation board. The impact of connections on the assessment of the sanitation board is likely due to the fact that an increase in the number of connections affects some aspects of service (especially water pressure). Indeed, if the same regression is repeated using water pressure as a dependent variable, the increase in the number of connections is the only significant variable. In other words, an increase in the number of connections is correlated with water pressure problems.

Economic and financial variables are also intuitively correlated with the main measures of sustainability. Reserves (measured as months of operating expenses) are positively correlated with the performance index of the system, as well as with the perception of sustainability. Lastly, service rates are significant in two regressions. In one case, the interpretation is direct. Higher rates are associated with higher performance levels. In the other case, the relationship is counterintuitive, at least in principle, because in this case higher rates are associated with a greater number of failures per year. An alternate interpretation is consistent with inverse causality, where higher rates are charged in response to higher spending as a result of more failures. This interpretation is also consistent with the observation that rates are barely sufficient to cover basic operating and maintenance costs.

Although the quantitative results are not very strong, they are both intuitive and consistent across the various regressions.In general, greater sustainability is correlated with higher rates, reserves, and micro-metering, and more frequent pump maintenance. Meanwhile, factors that negatively affect sustainability are growth in the number of connections and an increase in arrears.

Result 5. There is evidence that systems are operating increasingly close to the limits of their capacity owing to the increase in the number of connections and in water use for agricultural purposes.

Due to population growth, many sanitation boards report being unable to meet demand, and excess demand is correlated with lower performance levels. Since the launch of most operations (2007), the boards have increased the number of connections by 40%. The number of connections in the systems averages 91% of the maximum number of technically feasible connections. Thirty percent of the boards have already exceeded the maximum number for which the system was designed, and 48% report demand that they are unable to meet. On average, the sanitation boards that report problems with water pressure tend to have experienced more growth in the number connections (47% vs. 37%).[39] Likewise, water consumption in the sanitation districts that have problems with water pressure is greater than in the districts that do not have pressure problems.[40]

In addition, there appears to be some evidence of greater water consumption due to agricultural use. The surveys reveal that a greater percentage of households report using water for agricultural purposes. Specifically, the percentage of households using water for their gardens and livestock increased significantly from 2008 to 2014 (from 20% and 9% to 30% and 54%, respectively). The increase in water use for livestock could nearly double again the amount of water consumed in the household.[41]

The challenges associated with meeting demand are technical but also economic in nature. The technical causes (61%) include having exceeded design capacity and specific technical problems with the houses to connect (distance, altitude differences). The economic challenges can be categorized as the economic problems of the users (including high connection costs) and the economic problems that the sanitation boards face in trying to expand the system.

All told, the delivery of a reliable, good quality, low-cost service would seem to have created a paradoxical situation in terms of the sustainability of the systems going forward, by having increased household demand for the resource.

Result 6. The sanitation boards have resources to operate and perform routine maintenance but not enough to finance system expansions. Eventually, if pressure to increase the number of connections does not abate, it could compromise sustainability.

Just as designed, the sanitation boards collect sufficient revenue to cover operating and basic maintenance costs of the systems but not the costs of the initial investment (or expansions), which is subsidized by SENASA. As previously noted, the majority of the sanitation boards report that they are covering their operating costs and generally have reserves. The subsidy reported by the boards (G 384,000,000) is practically the same amount as the average system cost reported by SENASA. Accordingly, as reported by the sanitation boards, virtually the entire investment in the systems is subsidized by SENASA.[42] This means that board revenue and expenditures go to basic operation of the system (lease, wages, electricity), with 30% of the boards spending 75% or more of revenue on basic operations. Repairs and scheduled maintenance consume another 9% and 10%, respectively, and are primarily used to fix problems with the pumps.

Rates are generally low, especially considering the gains in purchasing power made by the region's population. A comparison of surveys of beneficiary households (2008 and 2014) reveals that family income increased by 75% while the rate increased by just 43%. As a result, the cost of water as a percentage of income dropped from 1.6% to 1% during the period. This evolution is consistent with observations throughout the country, based on the survey of households (Figure 5.4). Compared with the average amount spent on water in Paraguay (1%-1.6%), the poorest 20% of the population in El Salvador, Jamaica, and Nicaragua spend over 10% of their income on water, and in the United Kingdom, any expenditure on water above 3% of household income is seen as a hardship.[43] In short, the cost of water in Paraguay is not only low but has fallen during the period.

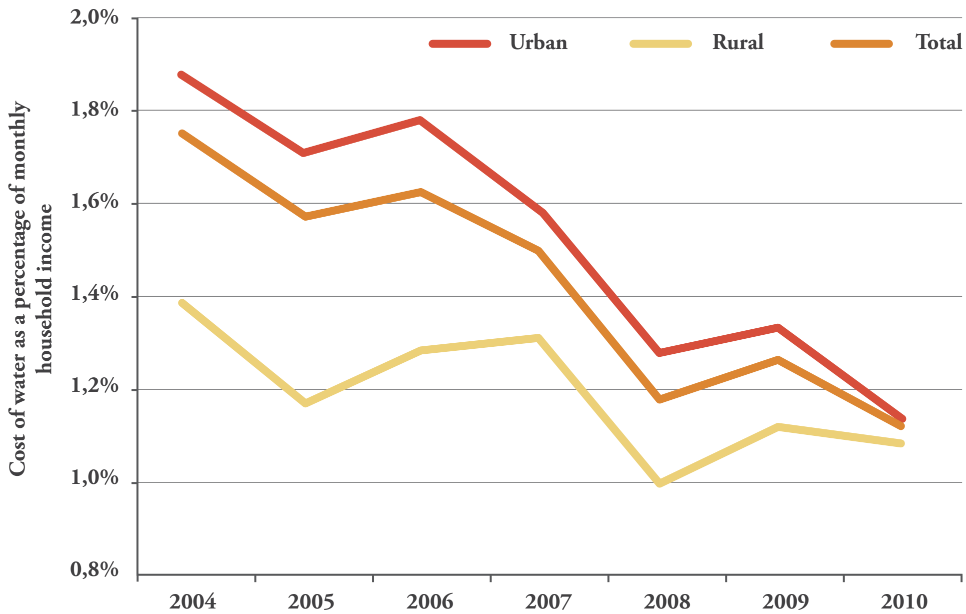


Figure 5.4
Water rate as a percentage of income

Structural (long-term) arrears were relatively low and are not correlated with rates. Despite low rates, the boards reported that between 0.4% and 15% of users were in arrears, whether long- or short-term (Table 5.1). In fact, nearly half the boards reported having shut off service for nonpayment, disconnecting an average of six users over the previous year for this reason. Arrears total 13% of average water sales and largely consist of short-term arrears. From the interviews with the beneficiaries and sanitation boards, overdue payments are due to lack of regular income in the families, which mostly rely on the sale of agricultural products. It is important to note that none of the arrears measurements are correlated with the rates charged by the sanitation boards, which is consistent with the assertion that the decision to go into arrears cannot be explained by rate levels.[44]

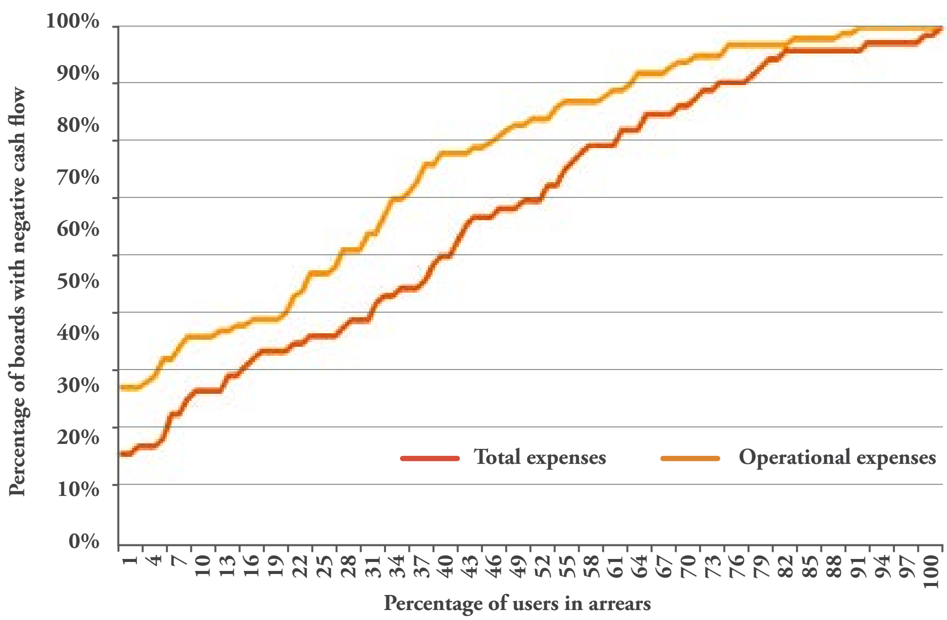
Table 5.1: Main arrears indicators

Variable	Average	Median
Arrears (1-3 months) (% of users)	15.35%	9.42%
Arrears (4 months - 1 year)	5.06%	0.00%
Arrears (12 months or more)	0.43%	0.00%
Arrears amount (% revenue)	12.84%	5.07%

Current levels of arrears and rates are consistent with the financial sustainability (positive cash flow) of operations at the majority of sanitation boards. A calculation of hypothetical revenue based on the established rates can be used to estimate the maximum arrears rate that the boards can sustain before their cash flow turns negative. Only 14% of the boards are unable to cover their operating expenses in a context of current rates and no arrears, although the figure rises to almost 30% when all expenses are taken into account (including repairs and scheduled maintenance). When the exercise is run for different levels of arrears, the finding is that with a 24% arrears rate, 50% of the boards are unable to cover their total expenses, and with a 40% arrears rate, 50% are unable to cover their operating expenses. Lastly, with arrears at 45% and 57%, 75% of boards are unable to cover their total costs and operating costs, respectively. Given that observed arrears rates are very low (5%-12%), the conclusion is that the sanitation boards are generally able to cover their operating expenses, including minor repairs.

Figure 5.5

Financial sustainability and arrears



Despite their financial sustainability, many sanitation boards report concerns about their ability to continue providing service in the future. Even though over 94% of sanitation boards are able to provide service today, more than one quarter (26%) do not believe they will be able to do so in the future. This perception is based on a combination of challenges both technical (insufficient water pressure, water supply, etc.) and financial (arrears, lack of resources). Users, meanwhile, are more optimistic, with 93% expressing confidence that they will continue to receive water service as it is currently provided for a long time to come.

Both the sanitation boards and users report board management of the water systems as satisfactory and identify the following as areas for improvement: system maintenance and expansion, rate review, reduction of arrears, and the introduction of micro-metering. A majority of users had favorable views of sanitation board operations. On a scale of 1 10, users gave the boards an average score of 7.95, a high score only slightly below the 8.40 self-reported by the boards. Discussing possible areas for improvement, the sanitation boards underscored the financial and technical challenges involved in expanding the systems, payment arrears, and in some cases, the need to introduce micro-metering. Meanwhile, user suggestions for improvements included better communication from the board (17%), improved maintenance (10%), longer hours of service (9%), and a rate adjustment (9%), although with respect to the latter, 5% were in favor of lowering rates and 4% were in favor of raising them so that better service could be provided.

All told, the sanitation boards generate enough revenue at present to cover operations, basic maintenance, and repairs. As a result, most have been able to cover pump repairs and keep the systems in service, generating the high performance levels reported above. However, the boards do not generate enough revenue to fund system expansions or improvements. An analysis of the balance sheets of the sanitation boards and arrears levels would seem to indicate that there is some room for raising rates without driving up arrears or creating undue hardship for the communities. This is consistent, in general, with the low cost of water in Paraguay.

Result 7. There is little information on or testing of water quality but some indication that there may be problems with quality.

Very few sanitation boards are knowledgeable about the quality of their water supply, conduct regular analyses, or use the chlorination tanks. Seventy-one percent report using the chlorination tank, but the average amount of chlorine used is just 160 liters per year, and 80% of the boards use less than 200 liters per year, well below what would be needed to properly chlorinate the full supply of water.[45]

Despite household satisfaction, the sanitation boards generally report that they do not check water quality.The average sanitation board has not conducted an analysis of its water supply in nearly five years. Although 73% of the boards reported having had a satisfactory water quality analysis, only 26% report having a certificate attesting to that result. Only 23% were visited by health authorities for purposes of water quality. Furthermore, in line with the literature, OVE found that the sanitation districts that use more chlorine have a smaller percentage of people with parasites, although the correlation is only marginally significant.

Although system failures were relatively common, they were mainly limited to problems with the pump, which the boards were able to address by drawing on reserves. Indeed, nearly the entirety of the post-construction investment went to resolving such failures. The efficacy of the sanitation boards and the availability of sufficient economic resources to deal with these problems explain the high performance level of the systems.

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6 Conclusions

This evaluation looked at the performance and sustainability of 100 water systems that were installed in Paraguay between 2004 and 2011 as part of a project supported by the IDB. For the evaluation, a technical review was conducted of the systems eight to ten years after entry into service, and interviews were held with users, sanitation boards, and the executing agency. After establishing the level of performance, the evaluation studied factors that are correlated with a higher level of performance and sustainability, relative to both the original design parameters and the changing needs of the beneficiary communities.

The evaluation found that the performance level of the systems was very high. Virtually all the systems built under the program were in service. Moreover, the users and the sanitation boards were satisfied with the quality of service in terms of water quality and reliability. Eight to ten years after installation, only 5% of the systems were not in service, compared with a global average of 20% to 25%.

A closer look at the reasons underlying the high performance levels reveals that a key factor is the capacity of the sanitation boards to respond to the main problem affecting the systems (i.e. broken pumps). Although system failures were relatively common, they were mainly limited to problems with the pump, which the boards were able to address by drawing on reserves. Indeed, nearly the entirety of the post-construction investment went to resolving such failures. The efficacy of the sanitation boards and the availability of sufficient economic resources to deal with these problems explain the high performance level of the systems.

Community attitudes towards water and the ready availability of the resource in the program areas also contributed to performance and sustainability. The fact that the water supply is so readily available and accessible contributes to sustainability inasmuch as the systems that are required are simple in design, have low construction costs, and are relatively easy to maintain. In addition, the communities use a lot of water and place a high value on the resource, which means they are willing to pay a relatively high amount, especially for monthly service. In contrast, the amount that they are willing to pay for installation, while positive, is much lower than the actual investment costs, which would seem to support the current strategy of subsidizing the initial investment and using the monthly rate to cover operating and maintenance costs.

More generally, an analysis of the correlations between five measures of sustainability and possible explanatory factors points up the importance of technical and economic factors while downplaying the importance of social and environmental factors. The economic variables (e.g. rates, arrears) and technical variables (e.g. micro-metering percentage, growth in the number of connections) consistently correlated with the measures of performance and sustainability. In contrast, social participation and environmental variables did not correlate with any performance measure, belying the emphasis placed on these variables in the literature.

The systems would appear to be operating within design parameters, with the main challenges being lack of information on water quality and low chlorination levels. In general, the systems appear to be operating in accordance with design conditions, except in one regard: water chlorination levels.

However, the future performance and sustainability of the systems could be affected by growth in the communities, which would put pressure on the existing systems. On average, the systems have expanded by 40% in terms of the number of connections that were initially installed, and many have already exceeded, or are close to exceeding, the technical limit for the number of connections. Although the sanitation boards have enough revenue to cover basic operating and maintenance costs, rates are not generating enough revenue to finance system expansions. As a result, the long-term sustainability of the systems depends on the availability of fresh resources to finance expansions. With this in mind, future investments should incorporate into the design phase possible strategies to contend with increases in demand, from both a technical and an investment financing standpoint.

Although rural water systems in Paraguay are operational and sustainable within design parameters, there is some room for improvement. One area that could be improved has to do with information. Work could be done to improve and systematize the information systems that SENASA keeps on the communities and the sanitation boards. With respect to communities, the consistency of sociodemographic data could be improved, as could information on other aspects, such as willingness to pay and attitudes regarding hygiene. With respect to sanitation boards, the capture of economic and financial data could be systematized. Also, more information on water quality and use could be collected from the sanitation boards.

Another area that could be improved is planning for system expansions, both from a technical and a financial viewpoint. The financing aspect of the expansion model has yet to be defined. If it is based on community financing, the current schedule of rates would need to be adjusted to that purpose. Alternatively, SENASA could incorporate criteria in its investment plans to prioritize financing for expansion initiatives. In addition, during design of the systems, the relationship between availability of the service and greater usage of water, particularly for economic activities, should be incorporated. Given the rapid growth seen in the communities supported by the IDB over the period of study, it would be wise to consider, during the design phase, technical and feasibility solutions for system expansions.

Lastly, studying the performance and sustainability of the systems in other contexts could be useful for identifying the main causal factors. All the factors that this study found to be associated with sustainability could well be specific to eastern Paraguay (an abundant supply of good quality, easily accessible water; high value placed on water). In order to deepen learning about the sustainability of water systems, further research could be carried out in diverse contexts in terms of the availability of the resource and the local culture.

1 In 2000, the United Nations established eight international development objectives known as the Millennium Development Goals, to be achieved by 2015. One of the 21 proposed targets (Target 7C) is to "halve, by 2015, the proportion of the population without sustainable access to safe drinking water and sanitation."

2 For example, see Benjamin F. Arnold and John M. Colford, Jr., 2007, "Treating Water with Chlorine at Point-of-Use to Improve Water Quality and Reduce Child Diarrhea in Developing Countries: A Systematic Review and Meta-Analysis," School of Public Health, UC-Berkeley, California; and Sebastian Galiani, Paul Gertler, and Ernesto Schargrodsky, "Water for Life: The Impact of the Privatization of Water Services on Child Mortality," Journal of Political Economy, 2005, 113(1), 83-120.

3 For example, see Annette Prüss-Üstün, Robert Bos, Fiona Gore, and Jamie Bartram, "Safer Water, Better Health. Costs, Benefits and Sustainability of Interventions to Protect and Promote Health," WHO, 2008.

4 An improved source of safe drinking water is defined as one that, by the nature of its construction and when properly used, adequately protects the source from outside contamination, particularly fecal matter. (WHO/UNICEF, Joint Monitoring Program for Water Supply and Sanitation, link).

5 See WHO/UNICEF, Progress on Sanitation and Drinking Water: 2015 Update and MDG Assessment (link). The goal for the region was to achieve a coverage rate by 2015 of 93% for safe drinking water and 85% for sanitation. As of 2015, the region had achieved a coverage rate of 95% for water and 84% for sanitation at the aggregate level.

6 For example, see P. Moriarty, S. Smits, J. Butterworth, and R. Franceys, 2013, "Trends in rural water supply: Towards a service delivery approach," Water Alternatives 6(3):329-349.

7 See Moriarty, op. cit.

8 The World Bank alone invested US$5.5 billion in the rural water sector between 1978 and 2003. ParamIyer, Jennifer Davis, ElifYavuz, and Barbara Evans, 2003, "Rural Water Supply, Sanitation and Hygiene: A Review of 25 Years of World Bank Lending (1978-2003)," Note 10, 2006.

9 For example, see Improve International, "Statistics on Water Point Failures" (online resource); Executive Steering Committee of the Rural Water Supply Network, "Myths of the rural water supply sector," in Perspectives No. 4 (St. Gallen, Switzerland, 2010); and P. Evans, "Paying the Piper: An overview of community financing of water and sanitation," (IRC International Water and Sanitation Centre, 1992).

10 For example, see Improve International, "Global Water Failures," accessed online in January 2016. These numbers should be interpreted with caution inasmuch as the information reported in the original studies is fairly diverse and the data are not weighted by number of observations. Moreover, neither the date of observation of the various systems nor the type of technology used in the systems appears to be the same across studies.

11 See Ryan W. Schweitzer and James R. Mihelcic,"Assessing sustainability of community management of rural water systems in the developing world" (Journal of Water Sanitation and Hygiene for Development, March 2012, Vol. 2 (1), 20-30); O. Blanc, F. Bertrand, and R. François, "Institutional strengthening and data reporting on key WASH indicators in rural Haiti," (Direction Nationale de l'Eau Potable et de l'Assainissement, Port-au-Prince, Haiti, 2012); PRONASAR, "Estudios de Base para la implementación de proyectos de Agua y Saneamiento en Áreas Rurales" (Lima, 2003); and "Criterios y Acciones en pro del cumplimiento de las metas del milenio en agua y saneamiento."

12 See P. A. Harvey and R. A. Reed, "Community-managed water supplies in Africa: Sustainable or dispensable?" in Community Development Journal, 42 (3) (2006), 365-378.

Notes

[13] The idea of community-based management has since lost momentum in the literature, and assumptions about greater buy-in have been described as a "cultural idealization of rural communities" (Moriarty, op. cit., 331). For more on the community-based management debate, see Harvey, op. cit., and Moriarty, op. cit. For a definition of the demand-responsive approach and its scope, see UNDP-World Bank, Proceedings of The Community Water Supply and Sanitation Conference, 5 8 May 1998, The World Bank: Washington D.C. Link. For the most up-to-date information on water intervention strategies, see Stef Smits and Harold Lockwood, "Reimagining rural water services: the future agenda," March 2015.

[14] For a review of the various concepts of sustainability in rural water, see Harold Lockwood, A. Bakalian, and W. Wakeman, "Assessing Sustainability in Rural Water Supply: The Role of Follow-Up Support to Communities," (BNWP-The World Bank); and J. Hodgkin, "The Sustainability of Donor-Assisted Rural Water Supply Projects," WASH Technical Report No. 94 (Water and Sanitation Project. USAID: Washington, D.C., April 1994).

[15] For a meta-analysis of 25 sustainability tools, see Ryan Schweitzer, Claire Grayson, and Harold Lockwood, "Mapping of Water, Sanitation, and Hygiene Sustainability Tools (Triple-S Working Paper 10, 2014). Based on the indicators that they contain, these tools can grouped into six categories (environmental, management, institutional, technological, financial, and social) although nearly two thirds of the 1,128 indicators contained in the tools focused on administrative, financial, and institutional aspects. A good recent example is the WASH Sustainability Index, developed by the United States Agency for International Development (USAID) and the Rotary Club, which calculates a weighted average of five dimensions (institutional, management, financial, technical, and environmental). See WASH Sustainability Index Tool, http://www.washplus.org/rotary-usaid, accessed in December 2015.

[16] Much of the methodological challenge involves finding a way to assign appropriate weights to the various factors. Methods run from constructing indices with relative weights on an ad hoc basis to more complex approaches (principal component analysis). None of the methods for reducing dimensionality and generating indices are without problems. For a critique of the indices (focusing on development indices), see Martin Ravaillon, "Mashup Indices of Development" (World Bank Working Paper 5432, September 2010).

[17] This statement essentially refers to the eastern half of the country, where 97% of the population lives.

[18] WHO/UNICEF, Progress on Sanitation and Drinking Water: 2015 Update and MDG Assessment (United Nations, New York, 2015).

[19] The estimate of the coverage expansion between 2008 and 2014 comes from the Permanent Survey of Households (EPH), specifically the questions on water and sanitation. According to the survey, coverage in rural areas expanded from 53% of the population in 2008 to 69% in 2014. These figures are generally consistent with the information reported by UNICEF-JMP for the period 1990-2015.

[20] In the late 1990s, the IDB prepared a water and sanitation program that was ultimately not approved, though it did pave the way for the approval of program PR0118 in 2001. This US$12 million program was executed in full between 2004 and 2011 and contributed to the creation of 100 new systems. Continuity was provided with the approval in 2009 of a second project (with a grant component from the Spanish Cooperation Fund for Water and Sanitation) for a total amount of US$52 million. Most recently, in December 2015, the IDB approved a new program for US$60 million, of which US$20 million came in the form of a loan from the Spanish government's Development Promotion Fund (FONPRODE).

[21] See OVE's Country Program Evaluation: Paraguay; Sector Note on Water and Sanitation; and IDB Country Strategy with Paraguay 2014-2018.

[22] Project completion report (PCR), page 13. The project also included investments in 10 indigenous communities in the Paraguayan Chaco. The OVE analysis is limited to the 100 systems developed in the eastern half of the country.

23 Inter-American Development Bank's harmonized data bank of household surveys.

24 The low number of connections per system was one reason why the project was unable to meet the target number of beneficiaries despite meeting the target number of new systems. See PCR.

25 The information in this paragraph is taken from the technical review carried out by OVE in 2014.

26 The OVE survey asked specifically about the contribution amounts made by SENASA, not about the total cost of the systems. However, the average contribution reported (G 384 million, or US$67,000) did, indeed, coincide with the average cost of comparable systems as reported by SENASA (G 391 million). See "Evaluación de Eficiencia de Programas-Subprogramas del Ministerio de Salud Pública y Bienestar Social. Informe Final. Lote 1." Ministry of Public Health and Social Welfare, Link.

27 Although the rates of growth are consistent, income levels vary considerably between the EPH and the OVE surveys. One possible reason is related to the monetary estimates of production for home consumption, which is especially important given the prevalence of subsistence production among the households included in the survey sample.

28 The index was constructed by calculating the simple average of three dimensions (functionality, quality, and reliability of service). Each dimension was constructed as a simple average of 1, 4, and 4 variables. The results are generally robust to changes in the weights assigned to the questions, among other reasons because the majority of the variables have a low rate of variability.

29 See midterm evaluation, 2008.

30 See PCR, 2010.

31 Based on a reference cost of G 6 million.

32 The "Global Water Supply and Sanitation Assessment 2000 Report" prepared by WHO-UNICEF provides the costs per capita of installing and operating various water and sanitation systems. Adjusting prices to 2005 levels, the year when the first systems were built, it would have cost US$148, US$164, and US$232 per residential connection to set up systems in Asia, Africa, and Latin America. The figure reported is based on total system costs as reported by sanitation boards in surveys (US$67,000), taking into account the average number of connections (138) and the average number of inhabitants in 2010 (4.5). The adjusted figures have been taken from "Regional and Global Costs of Attaining the Water Supply and Sanitation Target (Target 10) of the Millennium Development Goals" (WHO, Geneva, 2008). For other estimates of the unit cost of installing service in Paraguay, see "Drinking Water, Sanitation, and the Millennium Development Goals in Latin America and the Caribbean," IDB Water and Sanitation Initiative, June 2010.

33 See Improve International, "How much water is enough? Determining realistic water use in developing countries," accessed online in December 2015, Link.

34 Per day, one third of habitants consume more than 100 liters, 10% consume more than 160 liters, 5% consume more 250 liters, and 1% consume more than 500 liters.

35 The 2008 survey of households included specific questions to assess attitudes towards hygiene, particularly in relation to water.

36 UNICEF, Water and Sanitation Coverage: Handwashing, link, based on health survey tabulations (Demographic and Health Surveys, 2010-2014). In the case of the Demographic and Health Surveys, the data are self-reported and there is no independent verification, so the figures are likely slightly inflated with respect to the actual values.

37 However, virtually no households disinfect water in the home because they trust that the water provided is clean.

38 Two basic willingness-to-pay models were run (probit) based on different assumptions of the correlation of the error (normal, random effects grouped by respondent). The model included a basic series of demographic and social controls (type of dwelling, family income, number of residents) as well as current water consumption.

Notes

[39] However, the difference is not statistically significant due to the limited number of observations with regular water pressure (11 boards) and to the fact that water metering is fairly imprecise.

[40] In this case, too, the difference is not statistically significant due to the limited number of observations and the high degree of variability.

[41] Water consumption calculations are complicated by the limited reliability of household estimates of water use and the myriad assumptions needed to estimate water use for livestock, as illustrated by looking at the example of just cattle. In this case, the average household has eight heads of cattle. Assuming a conservative estimate of 40 liters of water per animal per day, water consumption would increase by 320 liters per household per day. Considering that the average consumption in 2010 was 350 liters per household per day, the effect of using water for livestock is significant.

[42] As mentioned previously, in theory SENASA subsidizes between 40% and 80% of the cost of the system, offering concessional loans to supplement the subsidy. In their responses to OVE, the sanitation boards likely did not distinguish between the part of the SENASA contribution that is a grant and the part that is a loan. Thus, the subsidy reported is equal to the cost of the system.

[43] UNDP, Human Development Report, 2006. Beyond scarcity: Power, poverty and the global water crisis.

[44] Based on regressions of the arrears indicators on rates (natural logarithm).

[45] Considering that 50-100 milligrams of chlorine is needed to disinfect 1 liter of water, based on the average consumption of water in the reporting districts (32,120 liters/day), between 580 and 1,160 liters of chlorine would be needed per year. Only 5% of the boards report chlorine consumption levels in this range.